SINTEA s.r.l.

SERVIZI INGEGNERIA E TECNOLOGIE AVANZATE

Via Filippo Juvara 9, I - 20129, Milano
Tel./Fax: +39 02/62065549

Website: http://www.sinteasrl.com
Email: info@sinteasrl.com

SISTEMI DI RISCALDAMENTO DA RISORSE IDRICHE SUPERFICIALI MEDIANTE L'UTILIZZO DI POMPE DI CALORE

FRIOTHERM

Website: http://www.friotherm.com

1. CONSIDERAZIONI GENERALI SULLA FILOSOFIA IMPIANTISTICA

L'utilizzo di pompe di calore di grande potenzialità e atte alla produzione di acqua calda a temperatura elevata è una tecnologia con molteplici applicazioni (diverse centinaia) su larga scala, alcune delle quali in funzione con successo da oltre un ventennio.

L'applicazione presuppone la disponibilità di una sorgente fredda costituita da acqua di fiume, di roggia, di lago, di falda, geotermica a bassa temperatura oppure di scarico da impianti di depurazione comunali o derivata da circuiti di processo (ad esempio, circuiti acqua di torre), a cui sia possibile sottrarre una potenza termica. Generalmente, per l'acqua derivata da corsi idrici superficiali viene recuperata energia termica con un salto di temperatura di solo 3 °C. Inoltre, è necessario che risulti disponibile un'utenza termica costituita da un circuito ad acqua calda. La temperatura che è possibile raggiungere per l'acqua calda in uscita dalla pompa di calore è di 78°C per potenze dell'unità fino a 9 MWt e addirittura di 90°C per potenzialità dell'utenza superiori a 9 MWt (pompe di calore con compressore centrifugo).

La pompa di calore è reversibile e può essere utilizzata, oltre che per produrre calore, anche per la produzione di un'energia frigorifera (acqua gelida a temperature di 6/12°C in uscita/ingresso dall'evaporatore della pompa di calore) per condizionamento ambientale.

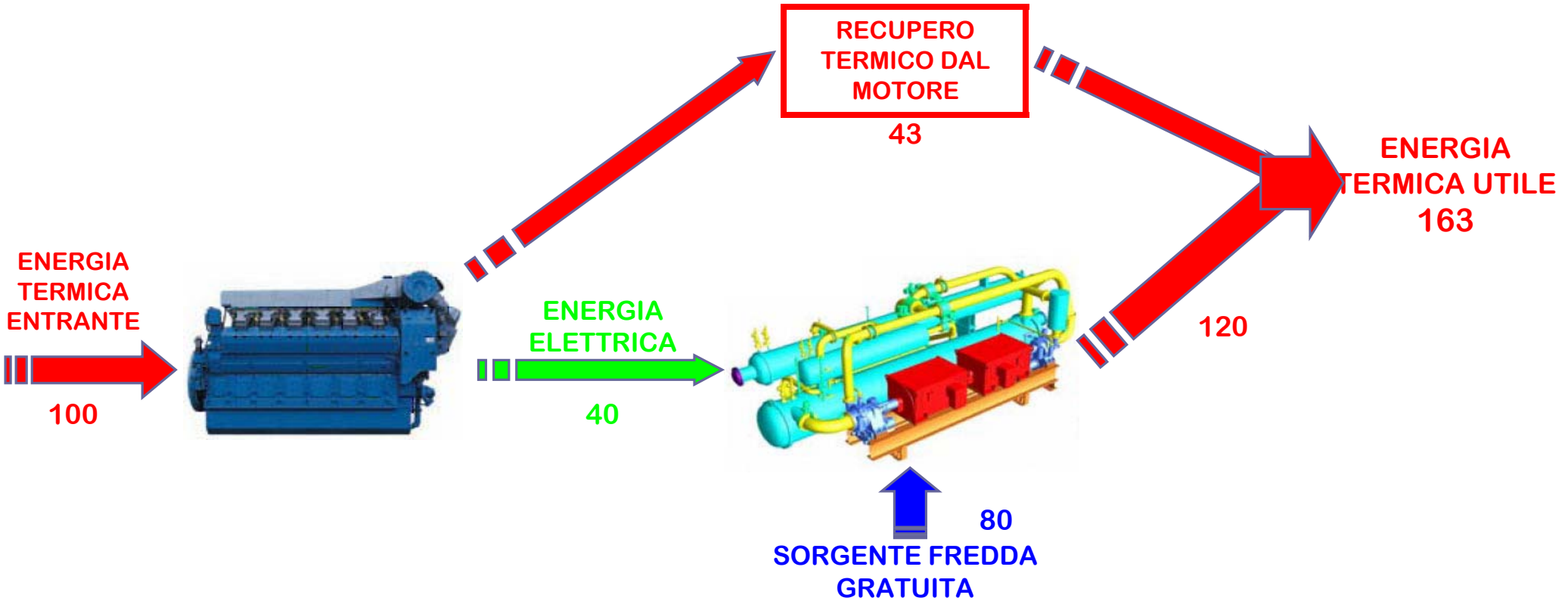
Valori tipici di prestazione (COP, coefficiente di prestazione) per la pompa di calore si attestano a circa 3 (cioè 3 kWh termici utili in corrispondenza a 2 kWh termici gratuiti sottratti alla sorgente fredda e 1 kWh elettrico consumato per l'azionamento del compressore) con temperatura dell'acqua calda all'utenza di 78°C oppure di 2,80 (cioè 2,80 kWh termici utili in corrispondenza a 1,80 kWh termici gratuiti sottratti alla sorgente fredda e 1 kWh elettrico consumato per l'azionamento del compressore) nel caso di temperatura dell'acqua calda all'utenza di 90°C. Se il COP è pari a 3 e se il prezzo dell'energia elettrica è di 9 cent €/kWh elettrico, il costo risultante energetico di produzione con la pompa di calore è di 3 cent €/kWh termico, che risulta molto inferiore rispetto al corrispondente costo dell'energia termica prodotta con caldaie a metano o a gasolio.

Inoltre è possibile affiancare la pompa di calore con un motore a gas cogenerativo, che non solo produca l'energia elettrica necessaria per alimentare la pompa di calore, ma produca anche una potenza termica integrativa e, con una disposizione in serie rispetto alla pompa di calore, possa consentire di innalzare, se necessario, il livello termico dell'acqua calda prodotta.

La soluzione proposta risulta estremamente flessibile: le pompe di calore possono lavorare a carico parziale con riduzione del carico sino al 20% e presentano un tempo di avviamento e messa a regime non superiore a 5 minuti.

Il costo di fornitura dell'unità, che si configura generalmente come un package su skid, dipende da caso a caso, essendo le unità stesse realizzate non a catalogo, ma "tailor made".
Trattandosi di unità che realizzano un risparmio energetico e consentono un beneficio ambientale, è possibile ottenere il "certificato bianco" per la produzione di tali unità.

SISTEMA INTEGRATO POMPA DI CALORE + MOTORE A GAS

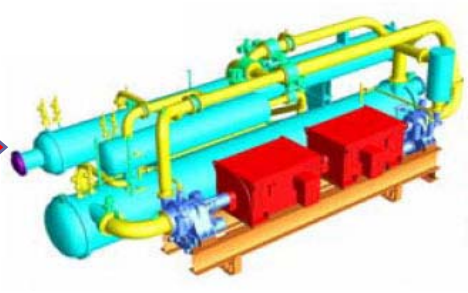


SISTEMA TRADIZIONALE A CALDAIA

POMPA DI CALORE CON SEMPLICE AZIONAMENTO ELETTRICO

1 kWhe

10 cent €/kWhe



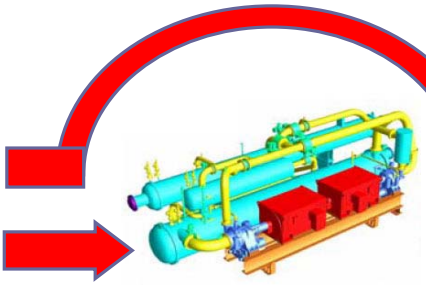
3 kWht

3,3 cent €/kWht

COP = 3

SISTEMA INTEGRATO POMPA DI CALORE + MOTORE A GAS

1 mc METANO
(9,6 kWht/mc)
0,28 €/mc
EQUIVALENTE A
2,92 cent €/kWht



15,65 kWht

1,79 cent €/kWht

CALDAIA

1 mc METANO
(9,6 kWht/mc)

USO
INDUSTRIALE
0,3 €/mc

USO CIVILE
0,55 €/mc

USO
INDUSTRIALE
3,68 cent €/kWht

USO CIVILE
6,7 cent €/kWht

8,16
kWht

2. REFERENZE DI INSTALLAZIONE

FRIOTHERM è uno dei maggiori costruttori di pompe di calore ed è leader mondiale per la costruzione di pompe di calore per alta temperatura, che costituiscono la tipologia ideale di macchine per alimentare impianti di teleriscaldamento.

All'estero esistono numerosissime referenze di impianti realizzati con pompe di calore prodotte da FRIOTHERM ed in particolare:

- a Stoccolma, n. 6 unità da circa 30 MWt cadauna per un totale di 180 MW operanti come sorgente fredda sull'acqua del mar Baltico e utilizzate per alimentare il sistema di teleriscaldamento della città (impianto realizzato all'inizio degli Anni Ottanta)
- a Zurigo, n. 2 pompe di calore da 7 MW cad operanti sull'acqua del fiume Limmat e utilizzate per il riscaldamento di un complesso terziario-residenziale
- impianti similari di grande potenza attualmente in fase di realizzazione a Oslo e Helsinki.

In Italia, è in fase di completamento (sarà pronto a fine luglio) per la città di Bergamo un impianto con pompa di calore da 3 MWt operante come sorgente fredda su acqua di roggia per alimentazione del sistema di teleriscaldamento del centro storico. Inoltre sono in fase di decollo vari progetti:

- AEM Milano intende realizzare n. 5 impianti di teleriscaldamento ognuno con n. 2 pompe di calore da 15 MWt cadauna;
- altre applicazioni sempre per sistemi di teleriscaldamento sono stati progettati e si apprestano a essere realizzati per ACSM Como, Comune di Livigno e per la città di Bergamo (altri 4 impianti);
- come esempio di applicazione ospedaliera, la soluzione a pompa di calore era stata adottata anche per il raddoppio dell'Ospedale Valduce a Como (con utilizzo come sorgente fredda dell'acqua di lago): la costruzione del raddoppio però poi non è stata realizzata.

Il rappresentante per l'Italia delle pompe di calore di costruzione FRIOTHERM è:
SINTEA Srl
Via Filippo Juvara, 9
I – 20129, Milano
Tel. / Fax: +39 02/62065549
Email: info@sinterasrl.com

3. POSSIBILI SORGENTI FREDDE PER POMPE DI CALORE

- CORSI D'ACQUA SUPERFICIALI (FIUMI , ROGGE, ETC.)
- LAGHI E BACINI IDRICI
- ACQUA DI MARE
- ACQUA DI FALDA
- ACQUE GEOTERMICHE
- ACQUA DI CIRCUITI DI TORRE DI RAFFREDDAMENTO
- ACQUA IN USCITA DA IMPIANTI DI DEPURAZIONE
- ACQUA DI CIRCUITO LAVAGGIO FUMI DI FORNI INCENERITORI

4. UTILIZZO DEL CALORE PER CIRCUITI AD ACQUA CALDA

- RETI DI TELERISCALDAMENTO
- RISCALDAMENTO AMBIENTI
- CONDIZIONAMENTO AMBIENTI MEDIANTE MACCHINE AD ASSORBIMENTO MONOSTADIO
- USI DI PROCESSO
- USI IGIENICO SANITARI

5. TEMPERATURE MASSIME OTTENIBILI SUL CIRCUITO DI UTILIZZO

- PER POTENZE DA 2 A 9 MWt 78 °C
- PER POTENZE > 9 MWt 90 °C

DOCUMENTAZIONE ILLUSTRATIVA DELL'IMPIANTO DI BERGAMO

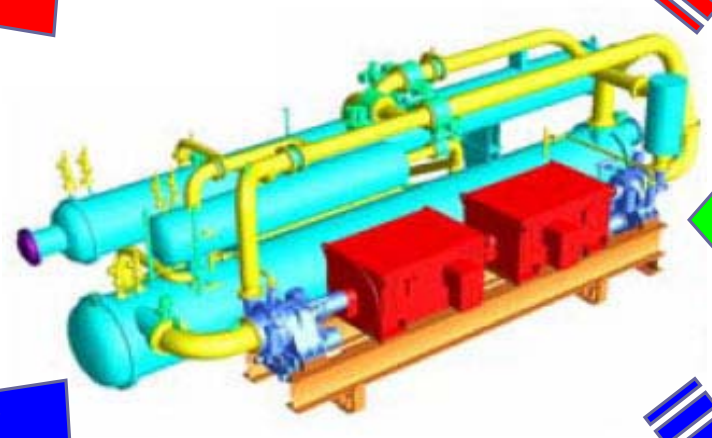
IMPIANTO DI TELERISCALDAMENTO DI BERGAMO

RETE TELERISCALDAMENTO 60°C

143 mc/h
3000 kWt

RETE TELERISCALDAMENTO 78°C

POMPA DI CALORE
COP = 3,00



ENERGIA ELETTRICA 1000 kW

2000 kWt
576 mc/h

ACQUA DI ROGGIA 13°C

ACQUA DI ROGGIA 10°C

IMPIANTO DI TELERISCALDAMENTO DI BERGAMO

RETE TELERISCALD. 60°C

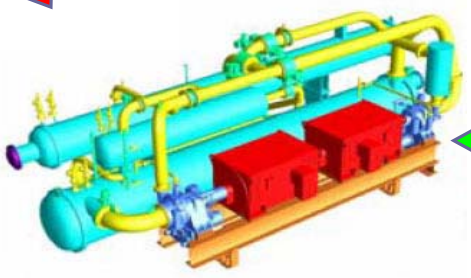
RETE TELERISCALD. 78°C

ENERGIA TERMICA DI RECUPERO 1640 kWt

RETE TELERISCALD. 88°C

3000 kWt
143 mc/h

POMPA DI CALORE
COP = 3,00



ENERGIA ELETTRICA 1000 kW

ENERGIA ELETTRICA 1547 kW

GAS NATURALE
3817 kW
398 Smc/h

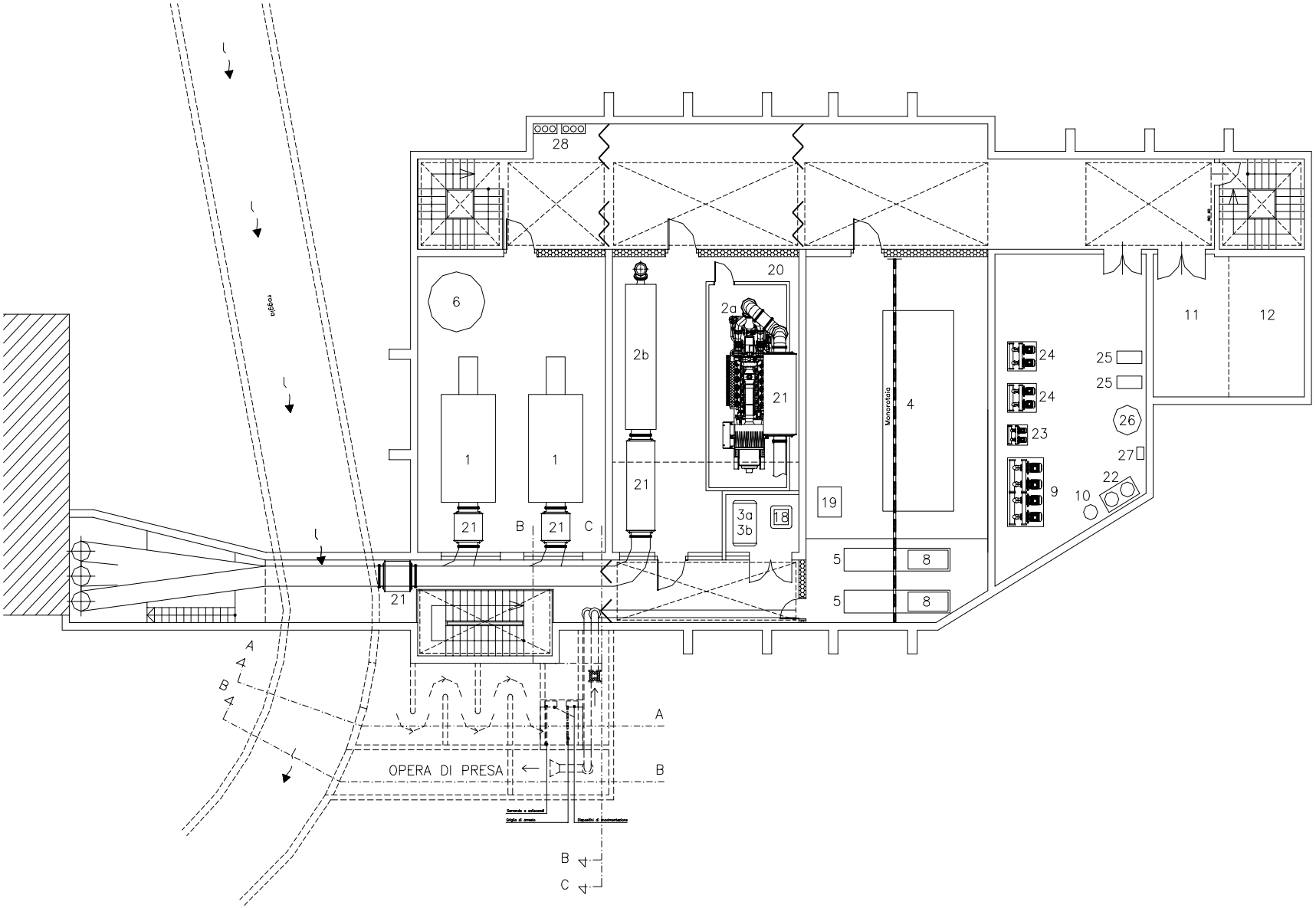
2000 kWt
576 mc/h

ALTRI AUSILIARI ELETTRICI DELL'IMPIANTO E CESSIONE A RETE 547 kW

MOTORE A GAS
RENDIMENTO ELETTRICO=40,53%
RENDIMENTO TERMICO=42,97%
RENDIMENTO TOTALE MOTORE=83,50%

ACQUA DI ROGGIA 13°C

ACQUA DI ROGGIA 10°C



IMPIANTO DI TELERISCALDAMENTO DI BERGAMO

POMPA DI CALORE DA 3 MW PER L'IMPIANTO DI TELERISCALDAMENTO DI BERGAMO

DOCUMENTAZIONE ILLUSTRATIVA DEI PRINCIPALI IMPIANTI REALIZZATI DA FRIOTHERM

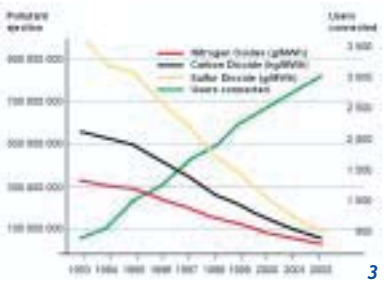
Värtan Ropsten – The largest sea water heat pump facility worldwide, with 6 Unitop® 50FY and 180 MW total capacity

Client

AB Fortum Värme samägt
med Stockholms stad
11577 Stockholm, Sweden

Stockholm's district heating system

Stockholm, the Royal Capital of Sweden, is situated on 14 islands and is considered as one of the most beautiful cities in the world. Its clean sea and air are the result of stringent environmental care. The district heating system is one vital part of the total energy supply in Stockholm.



Almost 60 percent of the customers on Stockholm's total heat market have chosen district heating. This is corresponding to approximately 5,700 GWh sold per annum to more than 6,000 customers and includes sales of 250 GWh to neighbouring municipalities. These transactions form part of long-term joint projects aimed at achieving rational district heat supply for the region. The distribution network has a length of 765 km.

In Stockholm there is no supply of natural gas, therefore district heating competes mainly with local oil heating as well as electric heating.

Heat supply for District Heating

Plant	Network	Heat
Värtan	Central	2,600 GWh
Hässelby	North-Western	1,100 GWh
Hammarby	Southern	800 GWh
Högdalen	Southern	1,200 GWh
	Total	5,700 GWh

Fortum, a leading energy company in the Nordic countries is responsible for heat/cold production and for the district heating/cooling systems installed in the greater Stockholm area.

High amount of natural sources

The heat supply system of Fortum uses a variety of energy sources:

- 35% Fossil fuels
- 26% Bio fuels
- 26% Waste water and sea water
- 13% Electricity used for heat pumps

The heat pumps (total 420 MW) are used for base load production along with the bio fuel-fired plants (total 200 MW). Oil-fired plants are used in times of high energy demand only.

Fortums district heating production system is increasing the use of bio fuels and solar energy sources. In addition, for large heat pumps, hydroelectric power is utilized. All these measures add up to nearly 50% of renewable energy used for the production of district heat.

Värtan Ropsten district heating plant

About 60% of the total energy input for the Central Network is provided by the Ropsten district heating plant. It has the capacity to operate autonomous during spring, summer and early autumn.

At the beginning of the 1980s, rising oil prices and cheap electricity led to a growing of interest in heat pumps. With a total capacity of 180 MW, the world's largest sea water based heat pump was installed at the Värtan Ropsten plant.

Unitop® 50FY heat pump unit

The 6 heat pump units Unitop® 50FY were commissioned between 1984 and 1986. Originally, all units were operat-

FRIOTHERM

ing with refrigerant R22. A permanently active seal oil system is preventing refrigerant losses during operation and standstill. The retrofit of the first heat pump unit to R134a took place in 2003.

Main features of the Unitop® 50FY

- Open-type double stage compressor
- Refrigerants: halocarbon/hydrocarbon
- Planetary or spur type gears
- Tough industrial design with vertically split casing for easy maintenance
- Suited for all drive systems
- High efficiency over the entire range
- Operating temperatures –40°C/+90°C
- Large capacity, small floor space

Heat source

In order to keep temperature drop low, large amounts of sea water are used as heat source. Warm surface water is taken during summer. In winter, the water inlet is in 15 m depth where the temperature is at constant +3°C.

A large pump supplies the sea water to falling-film type evaporators of the heat pumps. A thin, steady film of water trickles down the plate surface of the heat exchangers, with short contact time. It is for this reason that falling film evaporators can be operated with very low temperature differences.

Technical Data	
Heating capacity per unit	30 MW
Power absorbed per unit	8 MW
Evaporating temperature	–3 °C
Condensing temperature	+82 °C
Sea water temper. in/out	+2.5/+0.5 °C
Heating water temp. return	+57 °C
Heating water temp. supply	+80 °C
Capacity control	10–100 %

Plant control system

A Siemens PLC-type control system is used for local control and supervision of the heat pump units and for the superimposed control of the entire Värtan district heating plant.

Service and maintenance

Specialists of Fortum are supervising and maintaining the technical installations of the Värtan district heating plant. According to special agreements, Friotherm carries out the regular service works on the 6 heat pump units.

Legend

1 The City of Stockholm. District heating systems cover 60% of the heat market.

2 General view of a heat pump unit type Unitop® 50FY. Six of these units are installed.

3 Improvement of the air from 1963 – 2002, compared to no. of houses connected to the district heating system. © Fortum

4 Uniturbo® 50FY compressor, with base frame and integrated oil tank.

5 Arial view of Stockholm-Värtan, a high industrialised area, using district heating and cooling. © Fortum

6 Machine room building for the six heat pump units. Two sea water intake pipes are connected to each unit.

7 A sea water pump each per heat pump unit is installed in the pump house.

Friotherm AG
Langfeldstrasse 104
CH-8500 Frauenfeld / Switzerland
Tel. +41 (0)52 724 77 00
E-Mail info@friotherm.com
Internet www.friotherm.com

Akalla-Kista – Swedens science centre with District heating/cooling system and 6 Unitop® heat pumps/chillers

Client
AB Fortum Värme samägt
med Stockholms stad
11577 Stockholm, Sweden

Kista Unlimited

Kista and Akalla, two neighbouring suburbs in the north of Stockholm, are linked to the city by underground railway, commuter train and highway. Arlanda airport is only 15 minutes away.

Kista Science City is one of the most important ICT-clusters in Europe. The region extends across four municipalities, where business, academia and communities have agreed on a joint vision for the future.

In 2003, 18,435 people were working in the IT sector in Kista Science City. Ericsson, the telecom giant, is the dominating company with more than 10,000 employees.

Kista is world competence centre in the field of wireless communication and mobile Internet technology. In recent years, this has attracted a large number of international investments. Today, 400 IT companies are based in Kista Science City. More than 60 new ones have been added each year since 2000. Companies like Microsoft, Intel, Sun Microsystems, Nokia, IBM, etc. have established business centres in Kista.

Fortum – Swedens energy company

Fortum, a leading energy company in the Nordic countries, is responsible for heat/cold production and for the energy distribution in the greater Stockholm area. Alongside good economics for the customer, the products of Fortum also provide added value such as reliable supplies, simplicity and a strong environmental benefit.

Akalla-Kista's heating/cooling system

The district heating/cooling network of Akalla-Kista was always a step ahead of local urban development and therefore was growing in parallel with Science city. From the beginning, cooling played a vital role as IT companies require cooling of their computers at all times. Therefore the first four Unitop® units delivered were designed just for this purpose.

Today, 6 heat pumps/chiller units are installed. All operating with R134a.

Winter operation

The re-cooling cycle of each heat pump is connected to the district cooling system. Any of the heat pumps is only put into operation at times when absorption of the refrigeration capacity is ensured. In times of low cooling demand, the heat pumps are switched off one after another and heating capacity is provided by combustion or electrical boilers.

Summer operation

Because some heating capacity is required at all times, first the heat pumps are put into operation if there is a demand for cooling capacity. If the requirement for cooling capacity increases further, the chiller units are put into operation and heat rejection takes place in the cooling towers.

FRIOTHERM

5

6

6 Unitop® chiller/heat pump units

- **2 Unitop® 33/28CP heat pump units**
  The cold water side of both units is led in parallel, the warm side is connected in series.
- **1 Unitop® 33/28CP heat pump/ chiller units**
  Again, the cold water side is led in parallel. The warm side can either be led in series or in parallel, thus providing high versatility in regard to heating. Further, these units can be used for refrigeration purposes.
- **2 Unitop® 33C chiller units**
  Used for refrigeration purposes only.
- **1 Unitop® 33/33CP chiller unit**
  Used for refrigeration purposes only.

Main features of a Unitop®

- Open-type compressor
- Refrigerants: halocarbon/hydrocarbon
- Planetary type gears
- Tough industrial design with vertically split casing for easy maintenance
- Suited for all drive systems
- High efficiency (COP) over the entire performance range
- Operating temperatures –40°C/+82°C
- Large capacity, small floor space

Plant control system

A Siemens S7 PLC-Type control system is used for local control and supervision of the heat pump units as well as for the superimposed control of the entire Akalla-Kista district heating plant.

Service and maintenance

Specialists of Fortum and Termoekonomi are supervising and maintaining the technical installations. According to special agreements, Friotherm carries out the regular service works on the 6 heat pump/chiller units.

Legend

1 View of bustling Kista. In the center the Kista tower.

2 Kista Entré, the new high tech centre between Arlanda airport and Stockholm.

3 One of the Unitop® cooling units seen from the connecting side. Bottom the chilled water inlet and outlet, top the condenser inlet.

4 Arial view of the machine house. Clearly visible the 8 evaporative re-coolers.

5 A compact Unitop® type heat pump unit. Top the condenser, below the evaporator and on the left the subcooler.

6 View of a Unitop® 33/28CP heat pump unit. On the right the compressor type 33.

Technical Data

2 Unitop® 33/28CP heat pump units

Heating capacity per unit/s*	8.8 MW
Refrigeration capacity per unit/s	6.0 MW
Power absorbed per unit	2.8 MW
Evaporating/condensing temp.	3/82 °C

1 Unitop® 33/28CP heat pump/chiller unit

Heating capacity/s	8.6 MW
Refrigeration capacity/s	5.6 MW
Power absorbed/s	3.0 MW
Evaporating/condensing temp.	3/82 °C
Refrigeration capacity/p*	10.8 MW
Heat rejection capacity/p	13.5 MW
Power absorbed/p	2.7 MW
Evaporating/condensing temp.	3/45 °C

2 Unitop® 33C chiller units

Refrigeration capacity per unit	6.0 MW
Heat rejection capacity	7.0 MW
Power absorbed per unit	1.0 MW
Evaporating/condensing temp.	3/34 °C

1 Unitop 33/33CP chiller unit

Refrigeration capacity per unit/p	13 MW
Heat rejection capacity/p	16 MW
Power absorbed per unit/p	3 MW
Evaporating/condensing temp.	3/42 °C

*p = parallel s = series

Friotherm AG
Langfeldstrasse 104
CH-8500 Frauenfeld / Switzerland
Tel. +41 (0)52 724 77 00
E-Mail info@friotherm.com
Internet www.friotherm.com

FRIOTHERM

Invisible refrigeration plant is cooling the centre of Paris
8 Unitop® refrigeration units in subterranean machine room

Client
Climespace
75579 Paris, France

Climespace

Climespace, a company of the Suez-Group, is partner of the city of Paris since 1992. Climespace is producing 269,000 MWh/a refrigeration energy in five production centres and distributes it to a storage centre for cold water and finally, over a 50 km network running in sewage and energy channels below the Paris roads, to 262 clients in the very heart of the city.

With its centralized management system and delivery stations, Climespace guarantees continuous service under most reliable conditions at all times.

Refrigeration centre Place du Canada

The commissioning of this plant with a refrigeration capacity of 52 MW took place in May 2002. Remarkable are its invincibility and inaudibility. Below the Place du Canada, a machine room was built on five subterranean levels, the lowest floor at 30 m below street level.

River water for re-cooling

The 8 refrigeration units are re-cooled with water from the river Seine. A pump station located on the banks of the river with a total supply capacity of 11,200 m^3/h is feeding the secondary re-cooling cycle of five plate type heat exchangers. The primary cycle of these heat exchangers is connected with the condensers of the refrigeration units. The re-cooling capacity of each of the heat exchangers amounts to 12.4 MW; or 62 MW for the entire installation.

Cold water generation

The eight refrigeration units are installed on the lower two levels of the production centre.

The cold water circuits of two of the four refrigeration units per level are connected in series with the heat exchangers of the district cooling system located on the second-upper level.

In the first refrigeration unit, the water is cooled from 10°C to 6°C and in the second unit from 6°C to 2°C. The specific refrigeration capacity of each unit amounts to 6.5 MW.

Electrical supply

The total electrical power absorbed is 1350 kVA. The main electrical installation is located on the first level of the production centre.

Power is provided by three 20 kV cables from two independent supply stations by EDF.

The low voltage station has eight 2000 kW transformers (one per refrigeration unit) and three 1350 kW transformers for auxiliary equipment (Pumps, fans, etc.).

Protecting the environment

The water of the river Seine is warmed up by re-cooling with 0.5°C average in temperature. On the other hand, re-cooling with water from the river will cut treatment and use of 500,000 m^3/a water from the cities fresh water supply. Furthermore, installation of cooling towers in the city centre is not required, therefore eliminating problems like the generation of fog plumes typical for cooling towers, and possible risks regarding bacteria which

FRIOTHERM

thrive in a warm and moist environment.

Buildings and architecture

Since it was commissioned, the production centre serves impressing buildings like the Hotel George V and the Plazza-Athénée as well as the Museum Guimet. Also the Petit Palais and the Grand Palais will, after completion of the renovation work, be connected to the district cooling system.

Tousands of independently working small cooling units can be omitted, thus preserving the architecture of buildings and city.

The future of district cooling systems

Since district heating systems are common for several decades, the realisation of district cooling systems is relatively new.

Especially in northern Europe, cities like Stockholm are operating district cooling systems for several years now. Often heat pumps, originally used for heating purposes only, are now engaged for the production of refrigeration capacity during summer.

Through this service the clients connected make profit from safe and flexible utilization, significant energy savings and substantial space gains on their premises.

District cooling systems make good economic sense, where the use of independently working small cooling units can be ommited. As direct result, the peak load of domestic electricity supply lines during summer time will be more balanced. In addition, large plants are operated by trained personnel and serviced regularly whereas malfunctions of small domestic cooling units are noticed mainly after loss of the entire refrigeration charge.

Legend

1 The completed shaft: 30 m deep and 21 m diameter below the Place du Canada. © Construction consortium

2 The Petit Palais, a Museum, will in future be connected to the district heating system.

3 The subterranean machine room. The 8 refrigeration units are place at the lower two levels.

4 Some of the eight Unitop® refrigeration units. On the left of each unit, the white endcover of the evaporators and on the right the condensers.

5 Uniturbo® 33 compressor with clearly visible guide vanes. They are used for capacity control.

6 The Louvre is also connected to the Paris district cooling system.

Friotherm AG
Langfeldstrasse 104
CH-8500 Frauenfeld / Switzerland
Tel. +41 (0)52 724 77 00
E-Mail info@friotherm.com
Internet www.friotherm.com

High demand for district cooling and heating in Stockholm 4 Unitop® 33/28CPY for the Nimrod power station

Client/End user

AB Fortum Värme samägt
med Stockholms stad
11577 Stockholm, Sweden

The Stockholm district heating and cooling system

The district heating system is a vital part of the total energy supply of Stockholm. Almost 60 percent of the customers of the city's total heat market have chosen district heating. The distribution network has a length of 765 km.

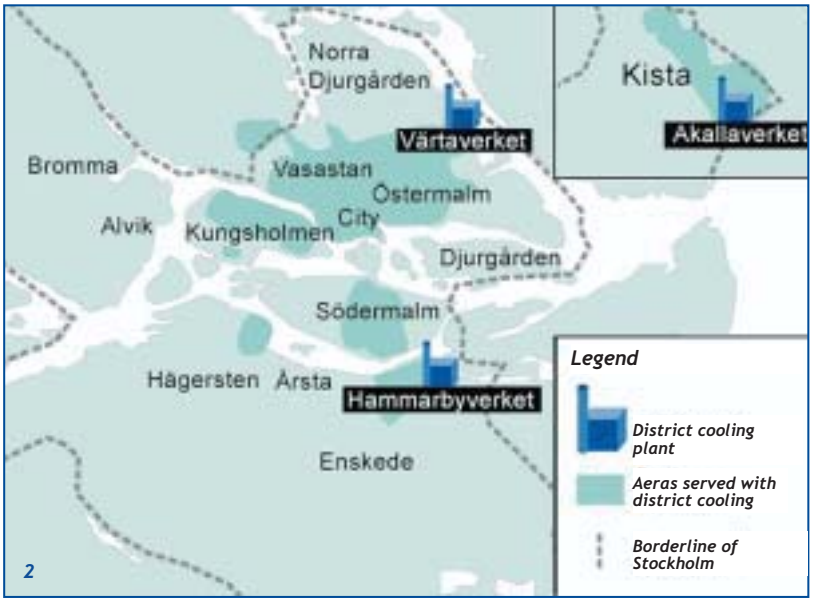
The Stockholm City environmental programme has set very ambitions targets until 2006, such as:

- *Reduction of fossil fuel use by 20% by further development of district heating*
- *Increasing the proportion of renewable fuel in district heating from 65% to 80%*

In 1995, Stockholm Energy started supplying properties in central Stockholm with cooling from its new district cooling system. Most of the cooling energy is produced by using cold water from the Baltic Sea. Recent developments made it necessary to install additional mechanical cooling equipment to cope with the continuously growing demand.

Fortum – Swedens energy company

Fortum, a leading energy company in the Nordic countries, is responsible for heat/cold production and for the district heating/cooling systems in the greater Stockholm area.



Alongside good economics for the customer, the products of Fortum also provide added value such as reliable supplies, simplicity and a strong environmental benefit.

District heating developments

Every year, new connections of approx. 100 GWh to the district heating network of Stockholm contribute to a carbon dioxide reduction in the range of 33,000 tons.

The demand for peak load capacity has increased during the last decades. If the ambient temperature drops from +10°C to –10°C, the additional heating capacity required is just above 1,200 MW, thus equivalent to the demand of 100,000 self-contained houses – or the production of a large nuclear reactor.

District cooling developments

The demand for district cooling capacity is increasing steadily. District

FRIOTHERM

3

4

5

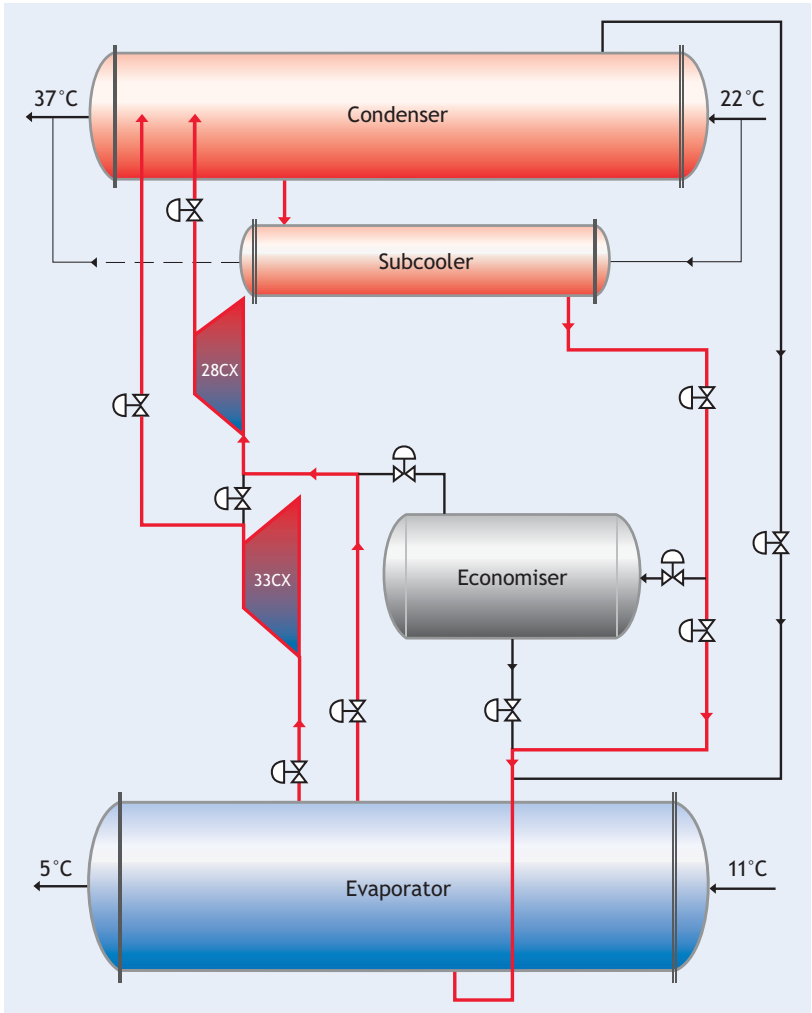
cooling replaces electrically powered local AC-units of any size. Connection is often made to the existing air distribution systems and is therefore easy to manage for the property owner.

District cooling is produced in a more environmental friendly manner than other forms of cooling. Even in case mechanical cooling is required, a district cooling system is reducing the total amount of refrigerant and also minimises the emissions which contribute to the greenhouse effect.

Apart from the system for central Stockholm based on cooling with sea water, the company operates two additional large-scale systems in the Stockholm area. Both are equipped with Unitop® units from Friotherm.

"Best collective value for customers"

The customers for heating and cooling are real estate companies in private and public ownership as well as industrial companies. District heating and district cooling are currently of higher importance than investments in possible alternatives. Prices of Fortum's products are determined by comparing market alternatives; principally oil and electricity.

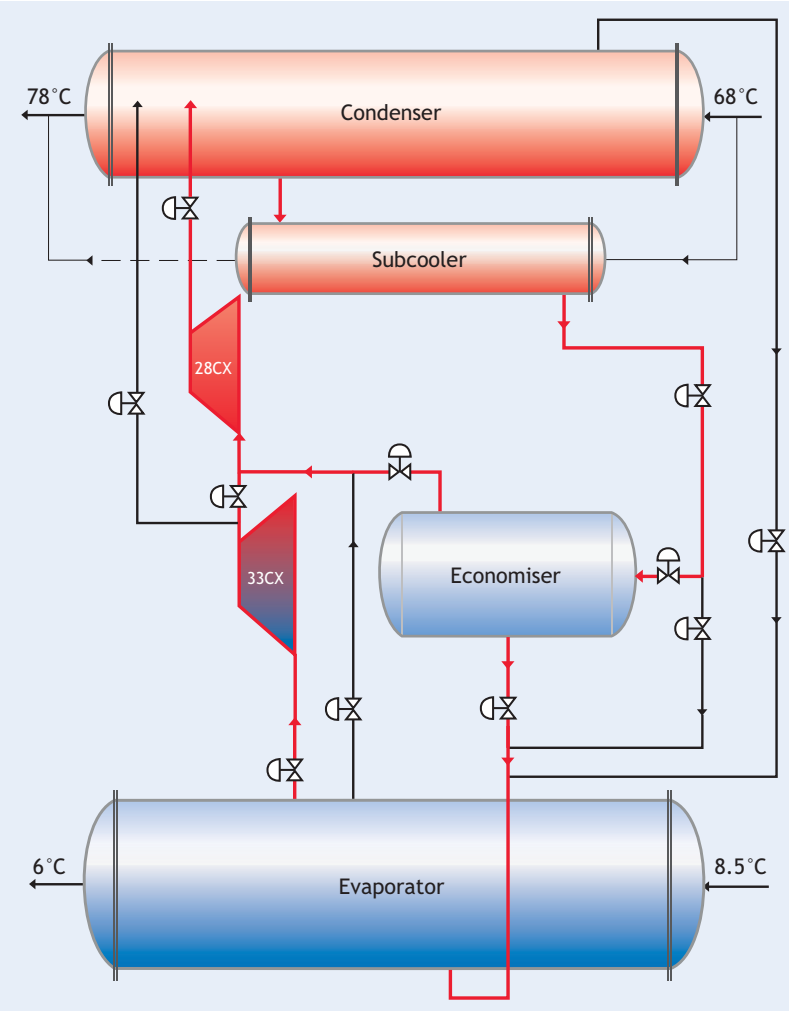


Case 1: Cooling 7 MW + 5 MW = 12 MW without heat recovery 6

The Nimrod power station

Today's Stockholm's Nimrod quarter is close to the centre of the town and far from being the suburb it was in the early 1900's, when the Nimrod power station was commissioned. The industrial touch of the red brick buildings is considered a national heritage, with little changes allowed on the outside.

7



Case 4: Cooling 6 MW with heat recovery 9 MW **8**

One of the buildings, formerly housing steam turbines, was chosen to accommodate the new district cooling units.

Friotherm AG delivered four Unitop® Turbo units, with a refrigeration capacity of 12 MW each and a chilled water supply temperature of 5°C.

Various operation modes

For the production of the refrigeration capacity required during summer, two compressors type Uniturbo® 33CX and 28CX are operating in parallel, type 33CX with a refrigeration capacity of 7 MW and type 28CX with 5 MW respectively. At times with low cooling load, the capacity of both units is reduced to approx. 20% of full load, resulting in excellent part load values. During summer, heat is rejected to sea water flowing through the condensers of the Unitop's®.

In spring, autumn, winter and – if required – also in summer, the combined refrigeration and heating mode operation of one or several units is possible.

In this case, the Uniturbo® 33CX and the Uniturbo® 28CX are operating in series, the first and larger 33CX as 1st stage unit and the second, smaller 28CX as second stage unit, thus reaching the 78°C supply temperature required.

Pressing a push button is sufficient to change the operating mode by actuating the respective valves (see diagrams 6 and 8).

FRIOTHERM

9

Unitop® 33/28CPY district cooling units

Three district cooling units type Unitop® 33/28CPY were commissioned in 2000; another one in 2001. The two compressors of each unit can operate either as standalone, in parallel or in series, depending on the actual requirement. To optimise the efficiency of the three Uniturbo® 33CX even further, it is possible to operate these units in heat pump mode only. The design of the plant allows the use of 35°C waste heat originating from the flue gas cleaning process of the power station. (This feature is an option and not yet operational).

Main features of the Unitop® 33/28CPY

- Open-type double stage compressors
- Refrigerants: halocarbon/hydrocarbon
- Planetary or spur type gears
- Tough industrial design with vertically split casing for easy maintenance
- Suited for all drive systems
- High efficiency (COP) over the entire performance range
- Operating temperatures –40°C/+80°C
- Large capacity, small floor space

Plant control system

A Siemens PLC-Type control system is used for local control and supervision of the district cooling units at the Nimrod power station as well as for the superimposed control of the entire Värtan district heating plant to which Nimrod belongs.

Service and maintenance

Specialists of Fortum and Termoekonomi are supervising and maintaining the technical installations of the Nimrod district cooling and heating plant. According to special agreements, Friotherm carries out the regular service works on the 4 district cooling units.

Operating data:

Operating mode	Summer	Winter
Capacities	36,000 kW	17,700 kW
Cold water in/out	11/5°C	11/5°C
Cooling/heating cap.	43,300 kW	26,700 kW
Cold/heat water in/out	22/37°C	68/78°C

Legend

1 Birds eye view of Stockholm seen on a summer day. The city boosts the largest district heating- and disctrict cooling networks worldwide, with a yearly increase in capacity demand of approx. 100 GWh. © Staffan Trägårdh

2 Map indicating the greater Stockholm area with district cooling facilities and the area served. The Nimrod facility is part of Värtan and therefore is not shown independently. © Fortum

3 View of the Nimrod site during erection. The 4 district cooling units are installed inside a sound reducing cabinet, one behind another. © Termoekonomi

4 One of the Unitop® 33/28CPY ready for transport to Sweden. Dim. (LxWxH): 13.2 m x 4.5 m x 4.2 m. Operating weight: 65 tons/unit.

5 The ancient building at Nimrod power station in which the 4 district cooling units Unitop® 33/28CPY are installed.

6 Principle diagram of a two stage district cooling unit operating in cooling mode only. Both compressors are working in parallel, with single step compression and expansion of the refrigerant.

7 A Unitop 33/28CPY arriving on site. The unit is completely factory insulated and pre-wired, thus reducing erection time and costs.

8 Principle diagram of a two stage district cooling unit operating in combined cooling and heating mode. The compressors are working in series and the expansion of the refrigerant is done in two stages.

9 Older parts of Stockholm are changing rapidly as former industrial quarters are transformed into quiet living areas.

Friotherm AG
Langfeldstrasse 104
CH-8500 Frauenfeld / Switzerland
Tel. +41 (0)52 724 77 00
E-Mail info@friotherm.com
Internet www.friotherm.com

FRIOTHERM


1


2

Oslo – Fornebu: Sustainable development with a district heating/cooling system using a Unitop® 28/22CY

Client
Baerum Fjernvarme AS
1338 Sandvika, Norway

Baerum Fjernvarme

Located in the vicinity of Oslo, Baerum Fjernvarme AS is selling district heating and district cooling. The company is owned by the Finnish Fortum group.

IT Fornebu

Norwegian Investors launched an industry policy initiative in 1995 which included the establishment of an IT and knowledge centre at Oslo's former Fornebu airport.

In the following year the IT Fornebu vision company was established. The Baerum community approved a master plan for Fornebu, which specified that the area should accommodate a knowledge-oriented centre for high-tech industrial activity at international level.

From airport to sustainable community

The 340-hectare Fornebu site is situated 10 kilometres from downtown Oslo with its strong commercial and financial community.

The development plan for the area includes housing for a population of 5,000 and 15,000 work places in an area of 1,350,000 m².

The Fornebu development site is equipped with a district heating/cooling system.

District heating…

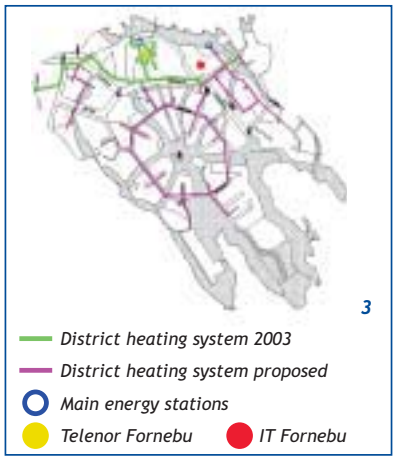
Baerum Fjernvarme estimates a total heating demand of 57,300 kW of which heat pumps shall generate 26,000 kW. 21,300 kW heating capacity depends on electricity and oil but is required only during the coldest period of the year. The main distribution lines for district heating will have a length of 8 km and a main diameter of 400 mm.

…and district cooling

Cooling is required by the commercial sector with a capacity of 23,500 kW. Cold sea water is used as source during spring and autumn. In summer, the Unitop® 28/22CY is also used as chiller. For district cooling, the main distribution lines have a length of 4 km, the diameter of the headers is 500 mm.

The Unitop® 28/22CY was installed in the new head office building of Telenor Fornebu, which is operating since autumn 2002.

In order to enhance operating flexibility and security even further, Baerum Fjernvarme linked Fornebu's district heating/cooling system with the systems of neighbouring Lysaker, where another Unitop® 28/22CY of similar capacity is installed.



3

Heating and cooling – the natural way

80 percent of the total capacity required for heating and cooling of the Fornebu development site has its origin in renewable sources. Sea water from the Oslo fjord is exploited for the heat pump during the cold period of the year. It is also used for cooling purposes in summer.

Therefore, Fornebu's district heating system is preventing emissions from conventional heating installations to a large extent.

FRIOTHERM

A major step in minimising the release of artificial refrigerant to the atmosphere has been accomplished by implementation of the district cooling system, with centralised generation of the refrigeration capacity required.

Unitop® 28/22CY for heating and cooling

The Unitop® 28/22CY is equipped with shell and tube type heat exchangers for evaporation and condensation of the Refrigerant R134a. It allows for various modes:

Summer *Cooling mode*

28 or 22 CY supporting natural cooling

28 or 22 CY "stand alone" cooling unit

Winter *Heat pump mode*

28 and 22 CY in series

Main features of the Unitop® 28/22CY

- Open-type single stage compressor
- Refrigerants: halocarbon/hydrocarbon
- Integrated planetary type gears
- Heavy industrial design with vertically split casing for easy maintenance
- Multiple compressor units available
- Suited for all drive systems
- Large capacity, small floor space
- High efficiency over the entire range
- Operating temperatures –40°C/+80°C

Plant control system

A SattCon type PLC control system supplied by Friotherm is used for local supervision. It is connected to the central building control system.

Service and maintenance

Maintenance and Service works on the Unitop® 28/22CY is done on demand by specialists of Friotherm.

Legend

1 The main runway of the former airport. © Fjellanger Widerøe AS

2 Birds view of IT Fornebu's project. © IT Fornebu AS

3 Fornebu district heating/cooling system network. © Baerum Fjernvarme AS

4 Unitop® 28/22CY unit, assembled in the works of Friotherm. On top the condenser, bottom right the evaporator, left the sub cooler.

5 Main entrance to the Telenor head office, where the Unitop® 28/22CY is installed. © Telenor AS

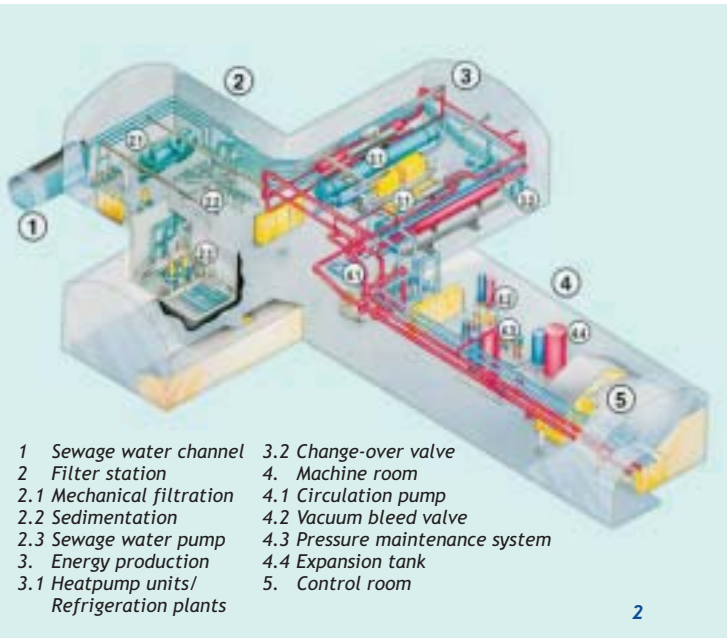
Technical Data

Summer, cooling with Unitop® 22	
Cooling capacity	2650 kW
Power absorbed	515 kW
COP	5.14
Cold water temp. in	+7.5 °C
Cold water temp. out	+5.0 °C
Cooling water temp. in	+25 °C
Cooling water temp out	+31.5 °C
Summer, cooling with Unitop® 28	
Cooling capacity	4100 kW
Power absorbed	797 kW
COP	5.14
Cold water temp. in	+7.7 °C
Cold water temp. out	+5.0 °C
Cooling water temp. in	+25 °C
Cooling water temp out	+35 °C
Winter, heating with Unitop® 28/22	
Heating capacity	5400 kW
Power absorbed	1795 kW
COP	3.0
Cold water temp. in	+5.0 °C
Cold water temp. out	+2.5 °C
Heating water temp. in	+50 °C
Heating water temp. out	+75 °C
Capacity control	10–100%

Friotherm AG
Langfeldstrasse 104
CH-8500 Frauenfeld / Switzerland
Tel. +41 (0)52 724 77 00
E-Mail info@friotherm.com
Internet www.friotherm.com

FRIOTHERM

1



1 Sewage water channel
2 Filter station
2.1 Mechanical filtration
2.2 Sedimentation
2.3 Sewage water pump
3. Energy production
3.1 Heatpump units/ Refrigeration plants
3.2 Change-over valve
4. Machine room
4.1 Circulation pump
4.2 Vacuum bleed valve
4.3 Pressure maintenance system
4.4 Expansion tank
5. Control room

2

Energy from sewage water – District heating and district cooling in Sandvika, with 2 Unitop® 28C heat pump units

Client
Baerum Fjernvarme AS
1338 Sandvika, Norway

Baerum Fjernvarme AS

Located in the Oslo region, Baerum Fjernvarme AS is the leading supplier of energy in Norway, with distribution networks for district heating and district cooling. Originating from a local electrical company, Baerum today is part of the Finish Fortum group.

Distributing energy

Sandvika, a suburb of the Norwegian capital Oslo, is using energy recovered from sewage water for heating and for cooling purposes.

The production plant is of high importance to Baerum Fjernvarme AS, as well as to their customers: The security of supply is granted at all times and the energy prices are very moderate (compared to local level); both of importance to the consumers. For Baerum on the other hand, the district heating and district cooling networks provide a good and stable business. The exploitation of energy from waste water also pays an important contribution to the good quality of the air around Sandvika.

The best solution is a heat pump

During the 1980's, Sandvika showed a strong grow rate. A new urban centre was built on 300,000 m², with offices, housing and recreational facilities. According to a decree of the local parliament, a district heating system had to be provided for the entire area.

Baerum Fjernvarme AS received the order for this project. Starting point for the engineering was a study comparing various possibilities of energy provisions. The most favorable costs finally resulted for the solution with the double use of the heat pumps.

Both networks, one for district heating and one for district cooling are led in parallel, thus providing the supply required by each consumer in Sandvika.

Adapted to the needs of northern communities, heating energy is further used to defrost pavements in winter; this in contrast to a country like Switzerland where the use of energy for this purpose is not allowed.

Besides purely economical advantages, the solution chosen also is favorable towards ecology: The total amount of refrigerant required is reduced and the generation of air pollutants (SO_2, NOx) is minimised.

One of the largest waste water channels of Norway, connecting a major part of Oslo, is the source of the energy for the heat pumps. The average waste water flow rate is 3000 l/s. The plant is operating since 1989.

3

4

Subterranean machine rooms

The main machine room with the two heat pumps is next to the waste water channel, inside a subterranean cavern, excavated from bedrock. To cope with peak load times, an already existing heating station, with 3 oil burning vessels and a conventional refrigeration unit were integrated into the Sandvika energy production network. These plants are within a distance of a few hundred meters of the cavern.

The two heat pump units, each with a capacity of 6.5 MW (heating) and 4.5 MW (cooling) cover approx. 80% of the capacity required. The part of energy, originating from waste water is 52% of the total energy supply.

Pre-cleaning the waste water

Due to the big extraction capacity, a heat exchanger submerged in the waste water channel, as installed in smaller plants in Switzerland and Germany, would have resulted in a surface requirement too large to handle.

FRIOTHERM

5

6

It is for this reason, that the amount of waste water required is pumped from the main channel, cleaned in a two step process (mechanically and by sedimentation) and finally is passing through the shell and tube heat exchangers of the two heat pump units.

After extraction of the energy the waste water is lead back to the main channel.

Advantages of a double use strategy

The simultaneous use of the heat pumps in order to cover heating and cooling requirements is of high importance in regard to basic investment and costs for regular service and maintenance. The additional costs resulting for the production of chilled water are relatively low compared to a plant installed exclusively for this purpose.

According to the engineers in Oslo, the equivalent refrigeration capacity generated by decentralised, local air-conditioning units would result in a power requirement ten fold compared with the Sandvika plant.

Unitop® 28C: reliable and durable

Both heat pump units Unitop® 28C were commissioned in 1989, at that time with Refrigerant R500. Refurbishment to R134a took place in 1993.

Main features of the Unitop® 28C

- Open-type single stage compressor
- Refrigerants: halocarbon/hydrocarbon
- Integrated planetary type gears
- Heavy industrial design with vertically split casing for easy maintenance
- Multiple compressor units available
- Suited for all drive systems
- Large capacity, small floor space
- High efficiency over the entire range
- Operating temperatures –40°C/+82°C

Technical Data

Buildings served heating/cooling	56/18
Total length of district - heating network - cooling network	 10 km (final) 4 km (final)
Heating capacity (heating mode)	13 MW (2x6.5 MW)
Refrigeration capacity (cooling mode)	9 MW (2x4.5 MW)
Annual heating capacity	47 GWh
Annual cooling capacity	11 GWh
Energy from sewage	52 % (of total)
Basic connection price	550 Fr./a (355 €/a)
Energy rate	6.5 Rp/kWh (4.2 Cents)
Annual demand rates - for heating - for cooling	 59 Fr./kW (38 €/kW) 70 Fr./kW (45 €/kW)

Plant control system

A SattCon type PLC control system is used for local supervision. It is connected to the central building control system.

Service and maintenance

Specialists of Baerum are supervising and maintaining the technical installations of the Sandvika plant. Friotherm carries out regular service works on the two heat pump units according to special agreements.

Legend

1 Sandvika, a suburb of Oslo, is situated on the idyllic Oslo fjord.

2 52% of the heating/cooling demand of Sandvika are covered by the plant which is installed completely underground in a cavern.

3 Piping for district heating/cooling and circulation pumps visible centre right. On the left, one of the Unitops.

4 The waste water tunnel (3 m diameter). In the center the return feed pipe of the branch current used for energy recovery.

5 The two heat pumps type Unitop® 28C operating with availability at all times since commissioning in 1989.

6 Mechanical filtration of the waste water preventing contamination of the heat exchangers of the two heat pump units.

Friotherm AG
Langfeldstrasse 104
CH-8500 Frauenfeld / Switzerland
Tel. +41 (0)52 724 77 00
E-Mail info@friotherm.com
Internet www.friotherm.com

FRIOTHERM

1

2

STMicroelectronics – Reliable cooling of a production facility with 2 x Unitop® 22BX, 1 x Unitop® 28CX and 3 Unitop® 33CX

Client

STMicroelectronics
38921 Crolles, France

STMicroelectronics

is a global independent semiconductor company and a leader in developing and delivering semiconductor solutions across the spectrum of microelectronics applications.

The ST group was formed as a result of the merger between SGS Microelettronica of Italy and Thomson Semiconducteurs of France. Corporate Headquarters is in Geneva, Switzerland.

The group totals more than 45,000 employees, 16 research and development units, 39 design and application centres, 17 main manufacturing sites and 88 sales offices in 31 countries.

Leading edge production facilites

In 2004, ST has five 8-inch fabs in operation in: Rousset (France); Agrate Brianza, R2 (Italy); Crolles (France); Phoenix (Arizona); Catania (Italy); and Singapore. Furthermore, a 12-inch manufacturing facility will commence manufacturing in Catania. In partnership with the semiconductor arms of Philips and Motorola, ST is starting production from a 12-inch pilot line in Crolles. The Crolles 2 operation will also host the joint development program between the three companies to develop leading-edge CMOS process technology.

Environmental responsibility

ST's commitment to environmental responsibility has resulted in substantial reductions in the consumption of energy, water, paper and hazardous chemicals, increased recycling of waste products and a significant cut in CO_2 emissions. In 2000, ST was ranked first in environmental management among 14 semiconductor companies by Innovest Strategic Value Advisors and received the only AAA ranking in eco-efficiency. Most recently, ST was awarded the "Best Industrial Renewable Energy Partnership" as part of the European Commission's "Campaign for Take-Off for Renewable Energy Awards 2003".

Reliable production cooling

The production of ST depends to a high extent on reliable cooling of its manufacturing plants. Failure would culminate in a daily financial loss of about € 1 Mio. Thus, the Unitop® chillers of Friotherm have been chosen for the cooling of the facility process water. The Unitop® chillers were installed in two steps between 1992 and 1999 – 2 Unitop® 22BX (1992) – 1 Unitop® 28CX (1995) – 3 Unitop® 33CX (1997, 1998, 1999). The heavy industrial design of the Unitops®, their high reliability combined with the outstanding isentropic efficiency made the choice easy for the client.

Hybrid dry coolers

For the heat rejection of the first 3 chillers, open type cooling towers have been installed. With the cooling capacities increasing, the client wished to prevent the forming of swathes, usually seen with standard cooling towers.

Together with the 3 Unitop® 33CX chillers, Friotherm delivered a total of 12 hybride type cooling towers.

Main features of the Unitop® chillers

- Open-type single stage compressor
- Refrigerants: halocarbon/hydrocarbon
- Planetary or spur type gears
- Tough industrial design with vertically split casing for easy maintenance
- Suited for all drive systems
- High efficiency (COP) over the entire performance range
- Operating temperatures –40°C/+90°C
- Large capacity, small floor space

FRIOTHERM

Legend

1 STMicroelectronics, Crolles Facility © STMicroelectronics

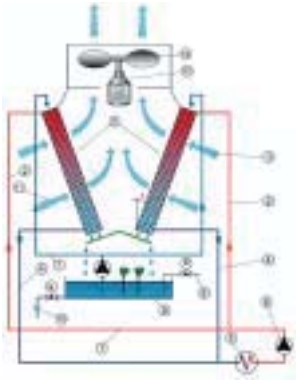
2 Typical ST Products: System on Chip devices are increasingly being used in equipment like set-top boxes © STMicroelectronics

3 Uniturbo® 33CX-compressor assembly

4 The hybrid type dry coolers on the roof of the Crolles Facility © Güntner

5 Uniturbo® 22BX-compressor assembly

***The hybrid dry cooler** combines dry cooling and evaporation cooling. In a closed circuit **(1)**, the warm process fluid is transported by a pump **(6)** from the heat source **(5)** to the finned type heat exchanger elements **(3)**. In a cross-over counter-current process, the hot process fluid and the cool air **(11)**, from the air intake of the fan **(12)** exchange the heat load on the finned heat exchanger elements. Pure dry cooling takes place. With chillers at part load, in cool weather conditions and at night, this process is often sufficient. High ambient temperature causes a loss of effect for which dry cooling cannot compensate. The hybrid cooler uses the principle of evaporation in order to achieve the capacity increase required. A pump connected to the water collector tray **(9)** conveys water via a "wetting circuit" **(7)** to the upper end of the cooling element. The cooling element is evenly wetted. The air flowing past causes the water*



*to evaporate on the finned surface, taking up heat from the process fluid. Thus, the water level in the tray falls. Fresh water is added **(8)**. Due to evaporation and the addition of fresh water, the salts dissolved in the water become more concentrated. In order to avoid an over-concentration, a sludge drain valve **(10)** is installed.* *© Güntner*

Technical Data

Total cooling capacity	32.8 MW
Evaporating temperature	+2 °C
Condensing temperature	+37 °C
Chilled water temp. in	+8 °C
Chilled water temp. out	+4 °C
Cooling water temp. return	+29 °C
Cooling water temp. supply	+35 °C
Capacity control per unit	10–100 %
Unitop® 22BX, no. of	2
Cooling capacity, each	4.4 MW
Power absorbed, each	0.92 MW
Unitop® 28CX, no. of	1
Cooling capacity	6 MW
Power absorbed	1.2 MW
Unitop® 33CX, no. of	3
Cooling capacity, each	6 MW
Power absorbed, each	1.2 MW
Hybrid dry coolers, no. of	12
Total capacity	21,750 kW
Coolant: Water/Glycol	35 %
Medium Temp. in/out	35/29 °C
Ambient air temperature	35 °C
Rel. humidity (t_f = 23,2 °C)	37 % rH
Wet bulb temperature	23.2 °C

Friotherm AG
Langfeldstrasse 104
CH-8500 Frauenfeld / Switzerland
Tel. +41 (0)52 724 77 00
E-Mail info@friotherm.com
Internet www.friotherm.com

FRIOTHERM

Waste-to-Energy Plant Sysav Malmö, enhancing the overall Energy Efficiency with 2 Unitop® 28C heat pump units

Client/End user

Sysav AB
20213 Malmö, Sweden

The waste issue managed in Sweden

A combination of cutting-edge environmental technology and innovative local initiatives is helping Sweden's municipalities to manage and treat their waste and wastewater. From monitoring waste in large industrial production systems to examining the impact today's lifestyles have on recycling and waste minimization, various methods are used to adapt waste management policy to local situations.

Sysav, the solid waste company

Sysav is a solid waste company owned by fourteen local authorities in the southernmost part of Sweden. A variety of methods are used for dealing with waste management. As a consequence Sysav is able to take care of every kind of waste in the best possible way: The company has opened a new head office, built entirely from recycled materials. Sysav's success is built on partnerships with local authorities and the producer/consumer within a legal framework.

Waste-to-energy plants

The Sysav waste management plant, situated just north of Malmö is a good example of how this policy works.

The company treats and recycles domestic and industrial waste every year from a population of 620,000 people.

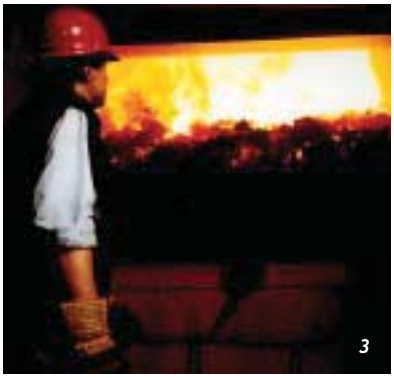
Combustible waste from both households and industrial sources is collected from the southernmost region of Sweden. The total energy produced through combustion amounts to approx. 1,000 GWh annually. In the new line 3 plant it is used to generate 135,000 MWh electricity and 540,000 MWh hot water for the district heating system. Thus, approximately 40% of the heating requirements of Malmö and its Burlöv suburb (population ~300,000) are covered and electricity for 17,000 households is generated.

The new plant manages some 200,000 tons of combustible household and industrial waste per year. Together with the older Sysav waste-to-energy plant, Sysav manages 400,000 tons of waste per year.

Operating 24 hours a day and almost 365 days a year, incineration temperatures are exceeding 900°C. No additional fuel is necessary to support the process.

The cleaning process

When incinerating waste, a careful and effective cleaning process of the flue gases is necessary. Therefore an advanced cleaning process has been installed within the system.



If there is heat, why use a heat pump?

The steam generated by incineration energy is expanded in the turbines, producing electricity. Then it passes through the heat exchanger of the district heating system, where it is heating the water to 80°C–115°C while condensing. In a closed cycle, the water flows back to the incineration heat exchanger and is transformed to steam again.

As the flue gas passes through a series of filter systems, it heats up water in the wet type scrubber. Using this water as source for a heat pump, the district heating return temperature is lifted from 50°C to 59.3°C, thus enhancing the overall efficiency of the entire waste-to-energy plant.

FRIOTHERM

Unitop® 28C heat pump

The Unitop® 28C is equipped with shell and tube type heat exchangers for evaporation and condensation of the refrigerant type R134a.

Main features of the Unitop® 28C

- Open-type single stage compressor
- Refrigerants: halocarbon/hydrocarbon
- Integrated planetary type gears
- Tough industrial design with vertically split casing for easy maintenance
- Suited for all drive systems
- High efficiency over the entire range
- Operating temperatures – 40°C/+80°C
- Multiple compressor units available
- Operation in series or in parallel
- Large capacity, small floor space

Plant control system

A Siemens S7 type PLC control system supplied by Friotherm is used for local control and supervision of the heat pump units. It is connected to the central building control system type ABB Avant.

Service and maintenance

Specialists of Friotherm are maintaining the two Unitop® 28C. They also carry out the regular service works.

Legend

1 View of the two waste-to-energy plants at Sysav, Malmö. © Göran Buhre

2 View from the crane cabin into one of the waste silos. © Göran Buhre

3 A Sysav employee is controlling the proper operation of the fire grid. © Göran Buhre

4 One of the two Unitop® 28C units, in the works of Friotherm. Right the water cooled motor, left the sound cover with the compressor inside. Behind, the heat pump condenser and below the evaporator.

5 Sysav staff in the control room of the waste to energy plant. © Göran Buhre

6 Principle of the waste-to-energy plant, with district heating and power generation. © Lars Werstam

Technical Data

Incineration plant

Incineration capacity	25 t/h
Operating time	8,200 h/year
Primary heat exch.	40 bar, 400 °C
Energy equivalent elect.	16 – 19 MW
and Energy equivalent heat	45 – 65 MW

Flue gas cleaning steps

1. Separation of solid particles with electrical filter
2. Wet type scrubber for separation of chlorides, SO_2, heavy metals, etc.
3. Electro-Venturi filter for separation of organic matters
4. Electro-Venturi filter for separation of nonorganic matters
5. Catalytic cleaning from Nitrogen oxids

2 Heat pumps Unitop® 28C, each

Heating capacity	9,500 kW
Power absorbed	1,750 kW
COP	5.43
Heat source temp. in	+34.2 °C
Heat source temp. out	+24.3 °C
Heating water temp. in	+50 °C
Heating water temp. out	+59.2 °C
Capacity control	10 – 100%

Friotherm AG
Langfeldstrasse 104
CH-8500 Frauenfeld / Switzerland
Tel. +41 (0)52 724 77 00
E-Mail info@friotherm.com
Internet www.friotherm.com

FRIOTHERM

1

2

Upgrading waste heat from the flue gas cleaning process of Umeå's Dåva power station, with 2 Unitop® 28C heat pumps

Client

Umeå Energi AB
90105 Umeå, Sweden

District heating conquers Umeå

Umeå is an innovative town in the north of Sweden, with 107,000 inhabitants, two universities and an expanding business sector. Approx. 70% of the buildings in Umeå are served with the district heating network. In 2002 alone, 400 private houses were connected. At the same time, district heating has expanded across the city borders. It has to compete mainly with small heat pumps and pellet-fuelled boilers owned by private households.

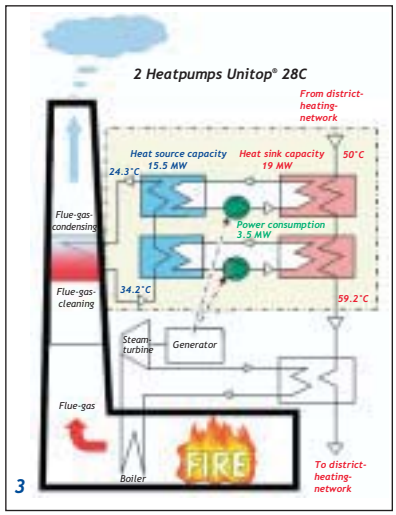
Umeå Energi AB

Operating in the very dynamic energy business, Umeå Energi AB consists of the four business areas: District heating, Electricity Network, Electricity trading, and UmeNet. Deregulation and growing competition are challenging but also open up new opportunities. Expanding operations in all business areas, it is the goal of Umeå Energi AB to remain strong on the domestic market.

Owned by the local municipality, Umeå Energi AB has 260 employees and serves 53,000 customers.

The Dåva heat and power plant

Situated 15 km north-east of Umeå, the Dåva combined heat and power plant is one of the world's most energy-effective waste-fuelled plants, complying with the most stringent environmental requirements regarding emissions. By converting waste into energy, it creates a valuable additional source of electricity and has enabled Umeå Energi AB to enhance its heat production capacity.



3

The incineration plant has a capacity of 175,000 tons (20 t/h) of waste per year and incineration of bio fuel is possible simultaneously. Approx. 80 GWh/a of electricity is produced. With heat recovery from flue gas condensation the total energy performance is raised from 94% to 107%.

Energy efficiency of fabulous 107%

Standard calculation of the heating value of any fuel does not consider the energy lost in the flue gas. Thus, the heating capacity gained from partial condensation of the flue gas stream enables a performance factor above 100%. The low temperature energy is transformed into valuable heat with the two heat pumps and fed into the district heating network of Umeå.

The district heating network supplies a capacity of approx. 750 GWh/a. With 350 GWh/a, the Dåva heat & power station covers 46% of the requirements, of which the heat pumps provide around 20%, thus improving the profitability of the plant considerably.

Network temperatures correspond to normal European conditions, i. e. supply temperatures of 70 to 110°C and return temperatures of 40 to 70°C.

The process of flue gas cleaning uses several steps: bag filter, acid scrubber, SO_2-scrubber and finally flue gas condensation, which besides heat also extracts condensate. The condensate is added again to the upstream cleaning stages in the process. Thus, the plant is basically self supporting with respect to process water. The moisture content of the flue gas is reduced from 12 vol-% to 4.3 vol-%.

FRIOTHERM

Unitop® 28C heat pump

The Unitop® 28C is equipped with shell and tube type heat exchangers for evaporation and condensation of the refrigerant type R134a.

With the electric motor and the oil cooler being water cooled with water from the heat source, the entire energy input to the heat pump system is transferred to the district heating network.

The two heat pumps are connected in series on both, the evaporator side and the condenser side. This supports flexibility and considerably improves the overall COP. With some operating points being at low district heating temperatures, a COP above 5.0 is achieved.

Main features of the Unitop® 28C

- Open-type single stage compressor
- Refrigerants: halocarbon/hydrocarbon
- Integrated planetary type gears
- Tough industrial design with vertically split casing for easy maintenance
- Suited for all drive systems
- High efficiency over the entire range
- Operating temperatures – 40 °C / +80 °C
- Multiple compressor units available
- Operation in series or in parallel
- Large capacity, small floor space

Plant control system

A SattCon type PLC control system is used for local control and supervision of the heat pump units. It is connected to the central building control system.

Service and maintenance

Specialists of Friotherm are maintaining the two Unitop® 28C and carry out the regular service works.

Legend

1 The city of Umeå; 70% of the buildings are connected to district heating. © Umeå Energi

2 General view of the environmentally friendly Dåva heat and power plant. © Umeå Energi

3 Principle of heat recovery from flue gas and temperature upgrading for district heating.

4 Rear view of a Unitop® 28C in the works of Friotherm. The condenser on top, below the evaporator and the refrigerant subcooler.

5 Front view of the unit; on the right the compressor and the partly visible motor, the electrical control panel on the left and the heat exchangers in the back.

Technical Data

Incineration plant

Incineration capacity	61 MWth
Boiler capacity	55 MWth
Turbine generator	+15 MWel
Turbine condenser	+40 MWth
Heat pump capacity	+13.7 MWth
Heat pump + utilities	–3.3 MWel
Total capacity	65.4 MW
Plant efficiency (65.4 / 61)	107 %

Emissions of the incineration plant

Dust	5 mg/Nm³	NH_3	5 mg/Nm³
HCl	5 mg/Nm³	Cd+Tl	0,05 mg/Nm³
HF	1 mg/Nm³	Hg	0,05 mg/Nm³
SO_2	25 mg/Nm³	Dioxin	0,1 mg/Nm³

2 Heat pumps Unitop® 28C, each

Heating capacity	13,700 kW
Power absorbed	3,360 kW
COP	4.08
Heat source capacity	10,340 kW
Heat source temp. in/out	+38/+28 °C
Heat. water temp. in/out	60/70–75 °C
Capacity control	10–100 %

Friotherm AG
Langfeldstrasse 104
CH-8500 Frauenfeld / Switzerland
Tel. +41 (0)52 724 77 00
E-Mail info@friotherm.com
Internet www.friotherm.com

FRIOTHERM