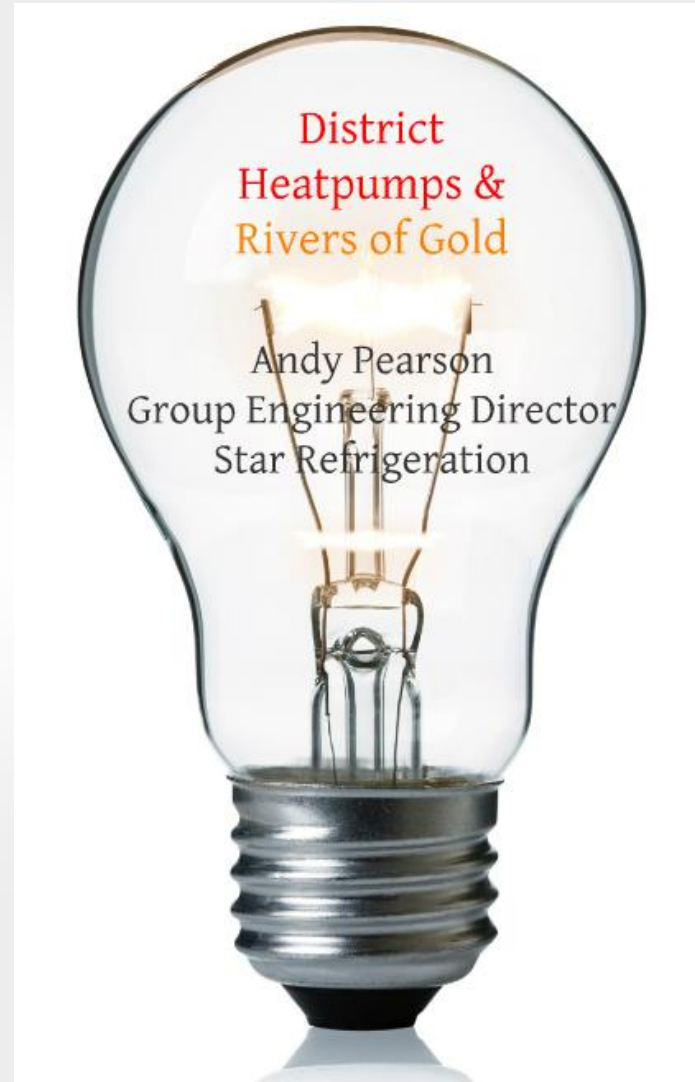


 **ATMO**
sphere
solutions for europe
natural refrigerants
15-16 October 2013, Brussels



www.tinyurl.com/nh3-totalenergy

#1

Who are Star?

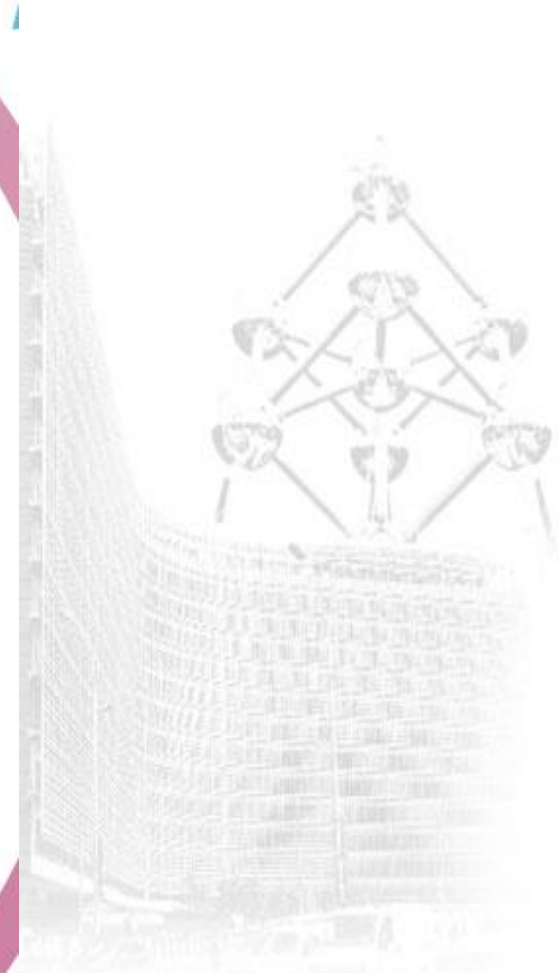
Founded 43 years ago

Who are Star?

Founded 1970

300+ team

Privately owned



#2

Who do we work with?

What do they have in common?



#3

They get it!

Opex is the key



Capital



Maintenance



Operating

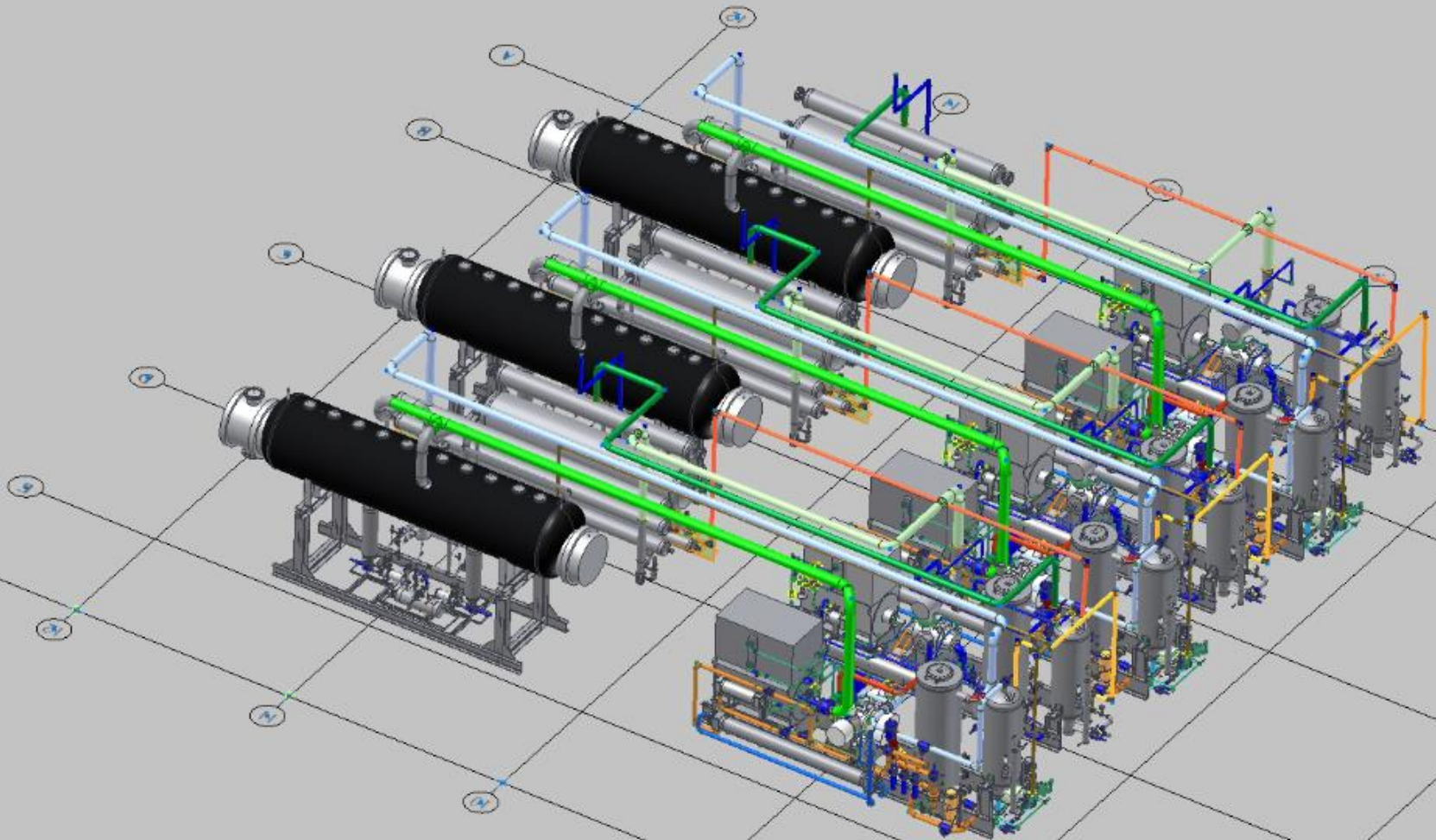
#4

District heating

Throwing away cooling!



Drammen
14MW@90C
from Seawater





Technical specifications and safety information label on the top left of the machinery.

MOBIL KULDE
CE mark

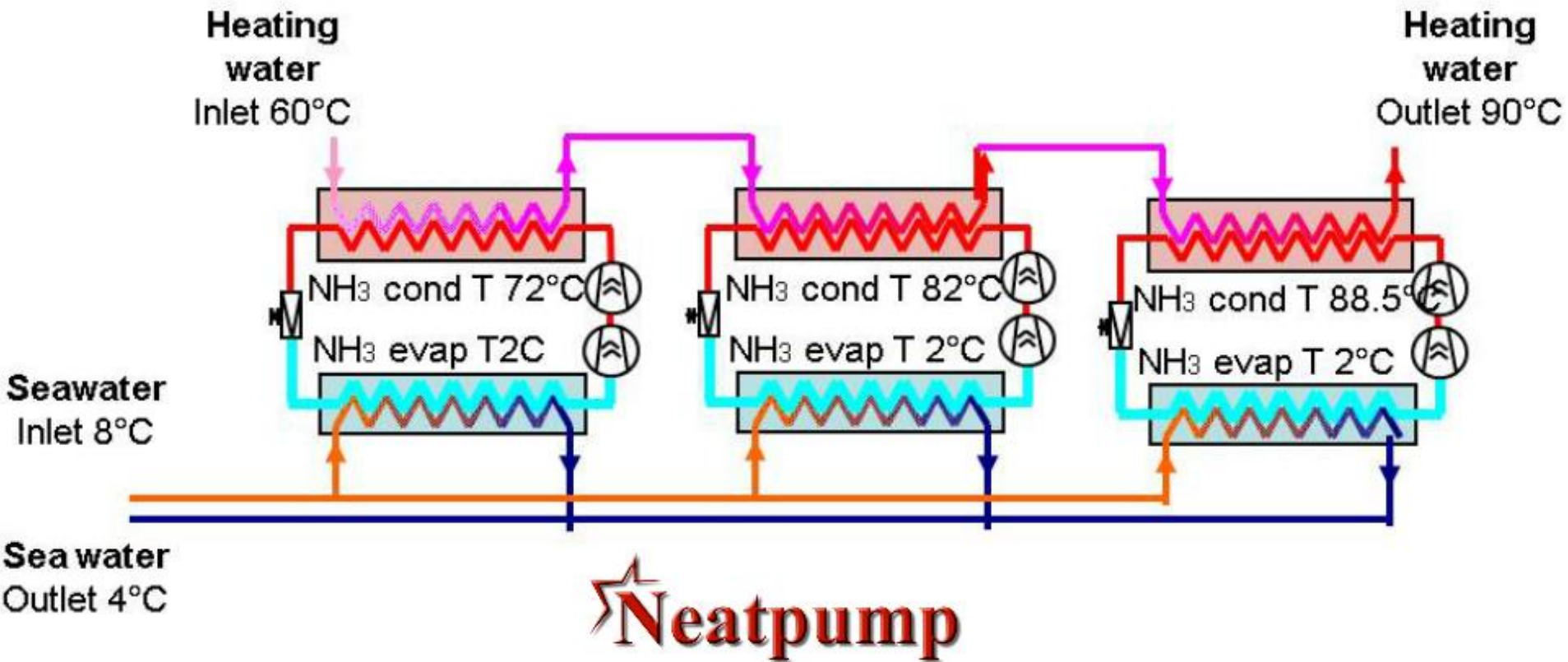
- Supervisor
- Overview
- Calculations
- Sea Water Pump
- Heat Pump
- Low Stage
- High Stage
- Intercooler
- Spray Chiller
- Condenser
- Water System
- Glycol System
- Calculations
- Ethernet Fault
- Stopped / Off
- Running
- Fault

Heat Pump	Compressor	Pressure	Temperature	Motor	Condenser	More Info					
1 	Capacity 98.0 % Volume 43.5 % Pressure Ratio 3.9	Suction 3.6 °C Discharge 48.1 °C Rotor 13.1 B(D) Bearing Oil 13.5 B(D)	Suction 3.4 °C Discharge 87.4 °C Rotor 63.0 °C Bearing 68.6 °C	Current 55.5 A Power 833 kW	Inlet 57.57 °C Outlet 69.46 °C	Working duty Set point Active 71.0 °C Target 71.0 °C HP Sequence: Lag					
	Running										
2 	Capacity 87.1 % Pressure Ratio 1.8	Suction 46.8 °C Discharge 71.0 °C Rotor 18.4 B(D) Bearing Oil 19.0 B(D)	Suction 62.2 °C Discharge 105.5 °C Rotor 68.1 °C Bearing 66.9 °C	Current 28.7 A Power 431 kW		Working duty Set point Active 80.9 °C Target 80.9 °C HP Sequence: Middle					
	Duty Required										
3 	Capacity 98.7 % Volume 46.1 % Pressure Ratio 4.3	Suction 3.9 °C Discharge 52.0 °C Rotor 14.7 B(D) Bearing Oil 15.5 B(D)	Suction 5.2 °C Discharge 95.1 °C Rotor 67.6 °C Bearing 63.1 °C	Current 60.8 A Power 930 kW	Inlet 69.46 °C Outlet 79.16 °C	Working duty Set point Active 90.0 °C Target 90.0 °C HP Sequence: Lead					
	Duty Required										
	Capacity 78.6 % Pressure Ratio 2.0	Suction 50.9 °C Discharge 81.0 °C Rotor 21.9 B(D) Bearing Oil 22.7 B(D)	Suction 61.7 °C Discharge 114.4 °C Rotor 72.4 °C Bearing 64.0 °C	Current 35.1 A Power 544 kW		Working duty Set point Active 90.0 °C Target 90.0 °C HP Sequence: Lead					
	Running										
	Capacity 98.7 % Volume 57.7 % Pressure Ratio 5.1	Suction 3.8 °C Discharge 58.6 °C Rotor 18.4 B(D) Bearing Oil 19.1 B(D)	Suction 5.6 °C Discharge 102.0 °C Rotor 71.1 °C Bearing 60.9 °C	Current 68.0 A Power 1061 kW	Inlet 78.65 °C Outlet 87.07 °C	Working duty Set point Active 90.0 °C Target 90.0 °C HP Sequence: Lead					
	Duty Required										
	Capacity 62.9 % Pressure Ratio 2.0	Suction 57.9 °C Discharge 89.2 °C Rotor 25.5 B(D) Bearing Oil 26.9 B(D)	Suction 65.0 °C Discharge 117.4 °C Rotor 75.0 °C Bearing 39.2 °C	Current 36.8 A Power 576 kW		Working duty Set point Active 90.0 °C Target 90.0 °C HP Sequence: Lead					
	Running										
Ammonia Detection Pump 18.12 mA Ammonia 3.39 ppm		Common Flow Inlet 362.2 m³/h		District Water Inlet 57.13 °C Outlet 89.79 °C		Heating Duty SCADA 90.0 °C Total 13424.4 kW		Power Consumed Running Compressors 4375.0 kW		COP 3.068	

#8

Clever configuration

Plus as much extra as possible!



#9

NH₃

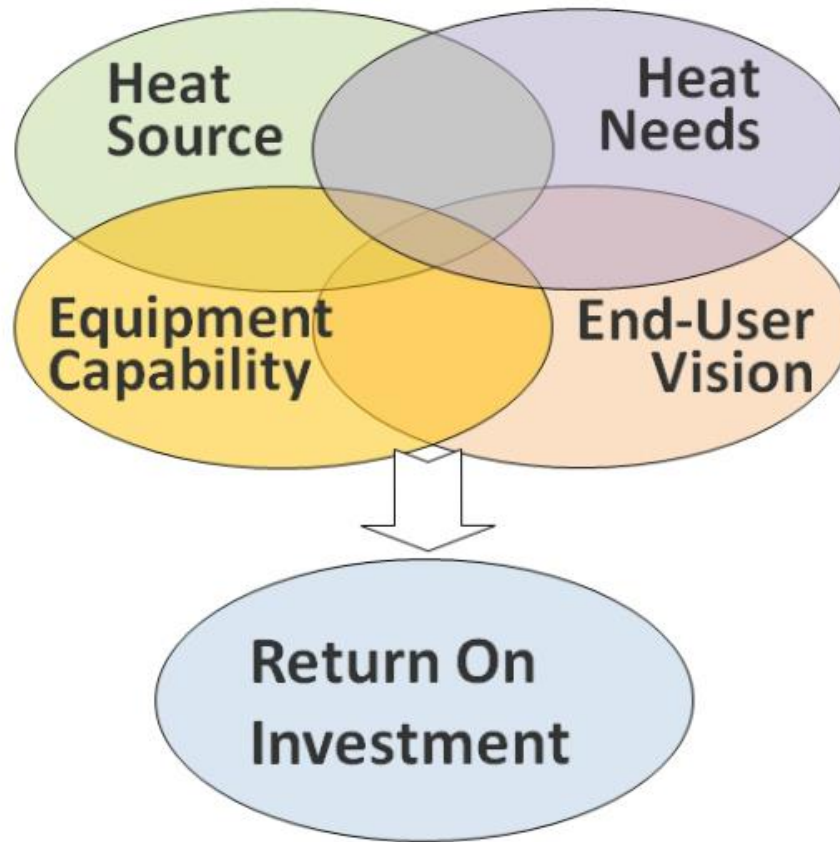
Delivering District Heating

NH₃ Delivering District Heating

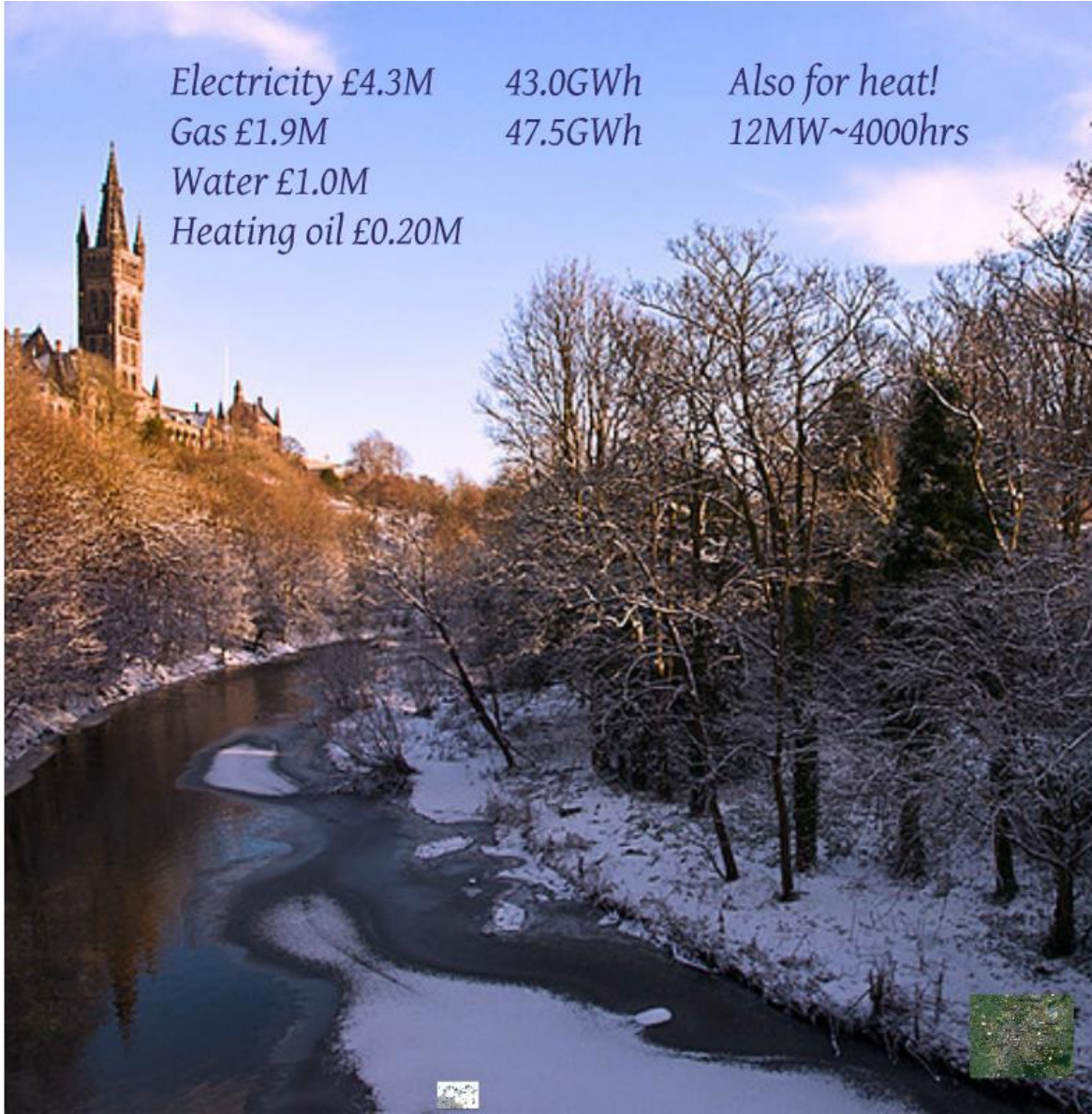


#10

But why ammonia?



Electricity £4.3M 43.0GWh Also for heat!
Gas £1.9M 47.5GWh 12MW~4000hrs
Water £1.0M
Heating oil £0.20M







solutions for europe

natural refrigerants

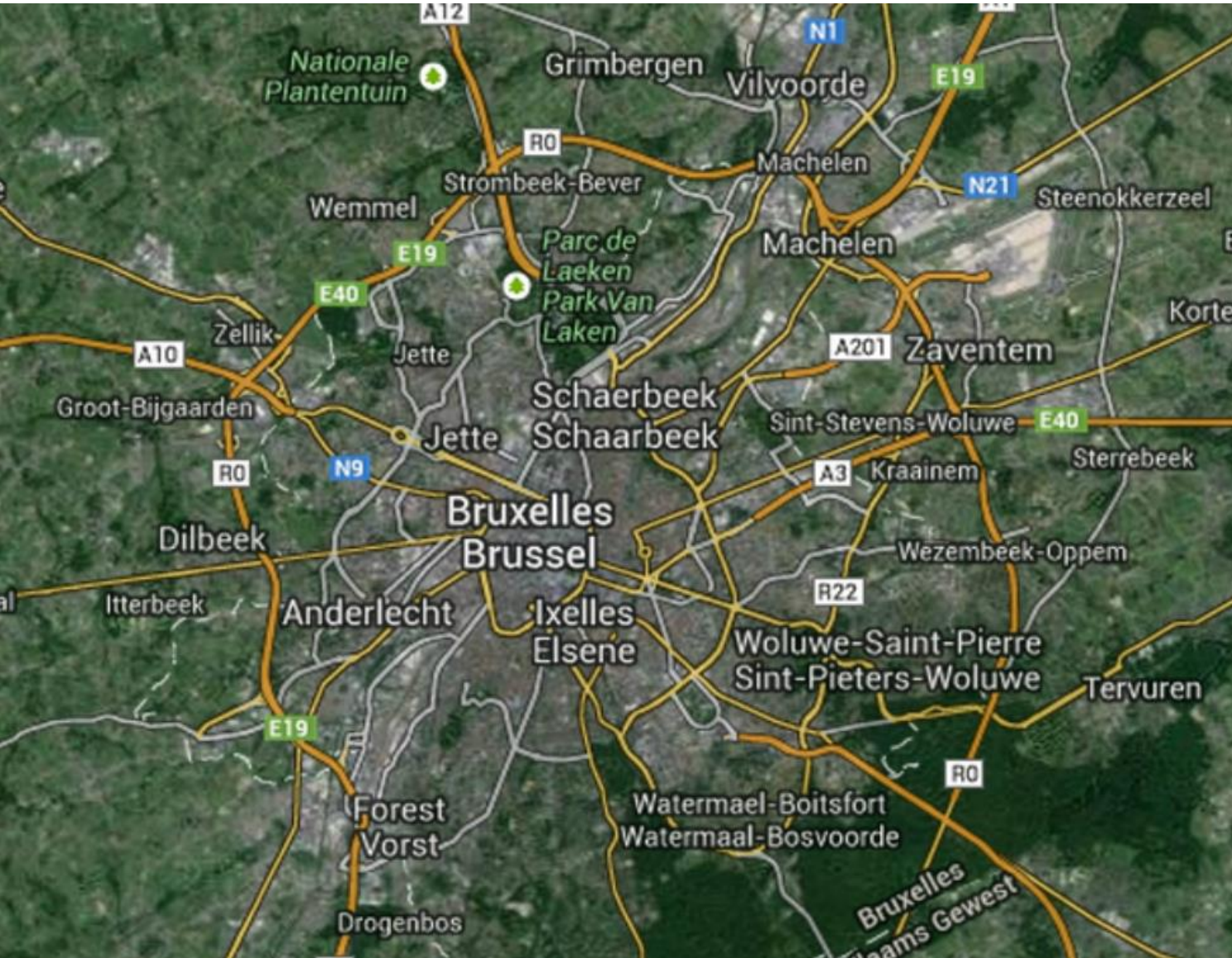
15-16 October 2013, Brussels



#14

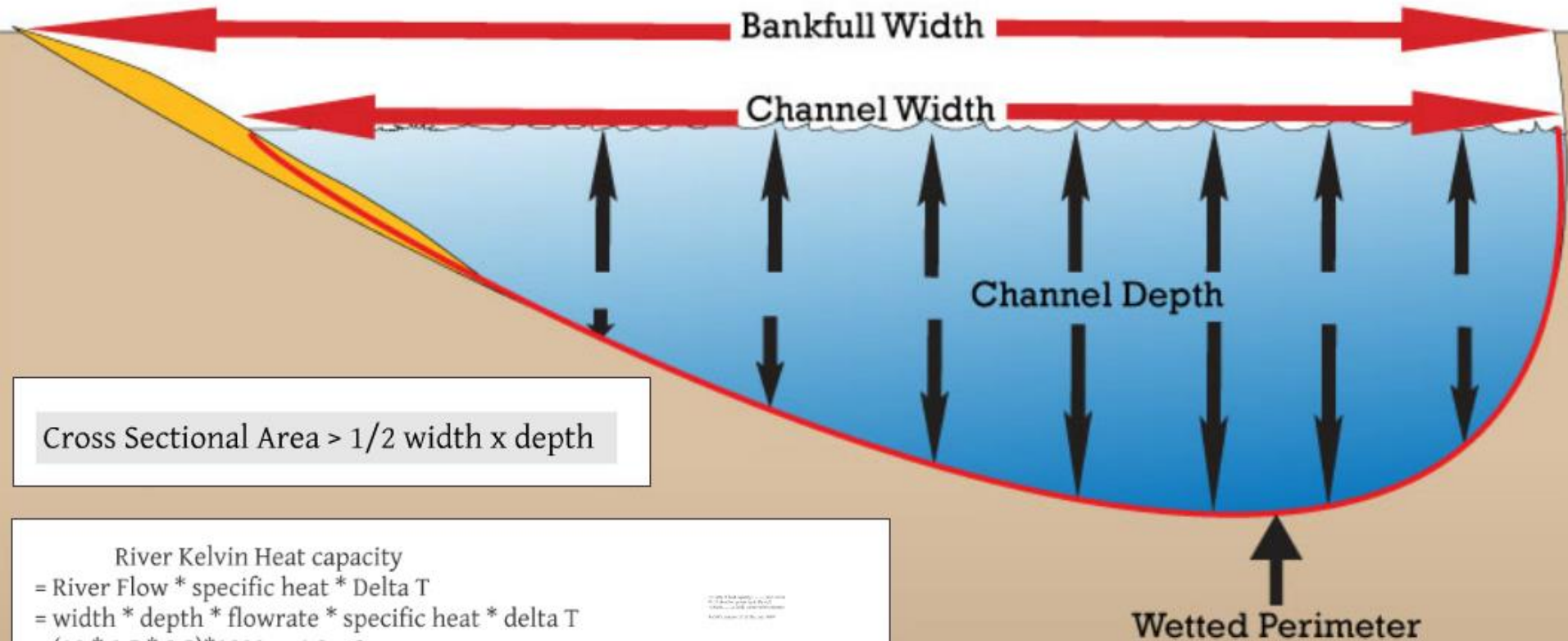
What about Brussels?

All big cities are built on rivers!



#15

The Maths



Cross Sectional Area > 1/2 width x depth

River Kelvin Heat capacity
 = River Flow * specific heat * Delta T
 = width * depth * flowrate * specific heat * delta T
 = (10 * 0.5 * 0.5) * 1000 x 4.2 x 2

Copyright © 2013 by i-study.co.uk
 All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or by any information storage and retrieval system, without the prior written permission of i-study.co.uk

The total length of the river channel in contact with water in the cross section.

Cross Sectional Area $> 1/2$ width x depth

River Kelvin Heat capacity

= River Flow * specific heat * Delta T

= width * depth * flowrate * specific heat * delta T

= $(10 * 0.5 * 0.5) * 1000 \times 4.2 \times 2$

=21 MW of heat capacity.....heat source
PLUS absorbed power typically +1/3
=28 MW.....a fairly conservative estimate

but let's assume 1/3 of this, say 10MW

#18

The Maths

A 10MW district heating example

Worked example: 10MW district heating in UK

	Centralised heat pump	Gas District Heating	Gas CHP
Capital	~£4.0M	~£0.5M	~£7.0M
Usage/pa	4000 hrs	4000 hrs	4000 hrs
Gas/kWh		4p/kWh	4p/kWh
Elec/kWh	9p/kWh		
Efficiency	4.0	0.85	0.37e/0.43th
OPEX/pa	£0.90M (-44%/+45%)	£1.6M	£0.62M
			£3.72Mth -£3.1Me
CO2/pa	4,498 T (-39.3%)	7,400 T	17,120 T -16650 T 470 T
ROI	17.5% (+25%)		14.0%
RHI	£0.035/kWh * 10,000 * 4,000 = £1.4M/a for 20 years		Nil

As the grid cleans this facility is "clean". this facility is "dirty".

"THIS BOOK IS A
TOUR DE FORCE ...
AS A WORK OF
POPULAR SCIENCE
IT IS EXEMPLARY"

THE ECONOMIST

"THIS IS TO
ENERGY AND CLIMATE
WHAT FREAKONOMICS
IS TO ECONOMICS."

CORY DOCTOROW,
BOINGBOING.NET



“Setting fire to chemicals like gas should be made a thermodynamic crime,” he said. “If people want heat they should be forced to get it from heat pumps. That would be a sensible piece of legislation.”

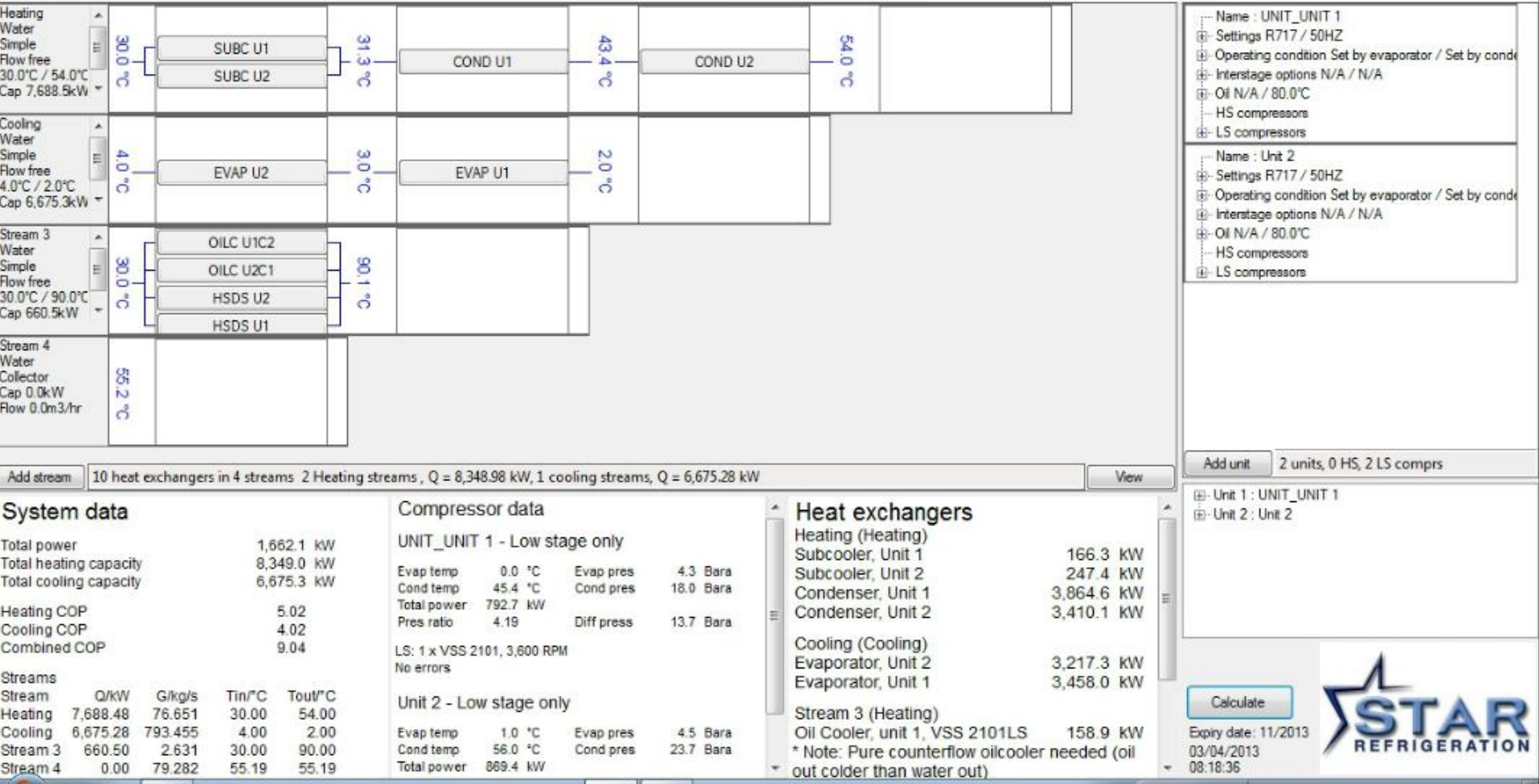
David JC MacKay



Gas



Heat

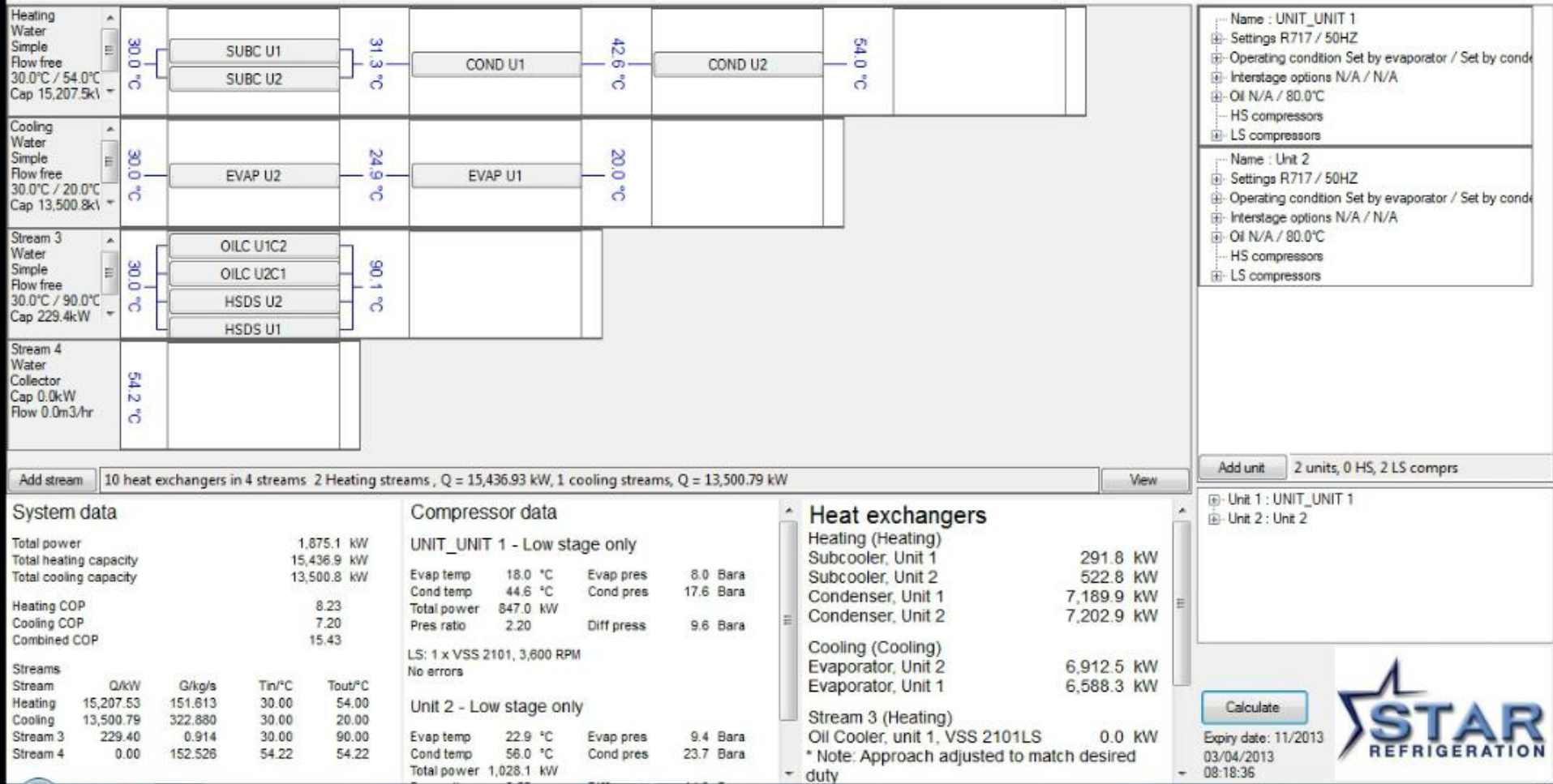


System data

Total power	1,662.1 kW
Total heating capacity	8,349.0 kW
Total cooling capacity	6,675.3 kW
Heating COP	5.02
Cooling COP	4.02
Combined COP	9.04

Streams

Stream	Q/kW	G/kg/s	Tin/°C	Tout/°C
Heating	7,688.48	76.651	30.00	54.00
Cooling	6,675.28	793.455	4.00	2.00
Stream 3	660.50	2.631	30.00	90.00
Stream 4	0.00	79.282	55.19	55.19



System data

Total power	1,875.1 kW
Total heating capacity	15,436.9 kW
Total cooling capacity	13,500.8 kW
Heating COP	8.23
Cooling COP	7.20
Combined COP	15.43

Streams

Stream	Q/kW	G/kg/s	T _{in} /°C	T _{out} /°C
Heating	15,207.53	151.613	30.00	54.00
Cooling	13,500.79	322.880	30.00	20.00
Stream 3	229.40	0.914	30.00	90.00
Stream 4	0.00	152.526	54.22	54.22

project 1- evaluating the demand for a networked heating system across the campus.

The campus has a huge energy bill. Not only is this a drain on the finances of the University, with ever increasing pressure to reduce carbon footprint, the real cost is only set to rise.

Campus or district heating systems offer a way of reducing this cost and even reduce the carbon footprint to zero.

The aim of this project is initially to determine the loads of each of the main buildings and then the existing infrastructure in each building. In addition the heat load needs to be determined across as long a period as possible, logged versus ambient temperature.

This will be presented as a 4D map of location, quantity and time of use.

The second part of the project will take this data and the preliminary output from project2 (heat sources) and propose a campus wide system meeting the bulk of the load with large heat pumps sourcing the heat from the river Kelvin. (if driven by renewable energy this will be deemed zero carbon). As this scheme would be eligible for the renewable heat incentive, the support available is adequate to finance such a project over a short period.

The project should conclude with an estimate of capital, and operational cost and therefore present an ROI (return on investment) to be considered by the Estates Director and Finance Director.



Project 2 - evaluating the sources of heat available on campus. The principal source being the river Kelvin.

The campus has a huge energy bill. Not only is this a drain on the finances of the University, with ever increasing pressure to reduce carbon footprint, the real cost is only set to rise.

Campus or district heating systems offer a way of reducing this cost and even reduce the carbon footprint to zero.

The aim of this project initially to determine the quantity of heat that could be extracted from the Kelvin. Principally this means measuring flow rate and temperature. Once this data capture is established to record across 3 months, the focus of the project will shift to an assessment of the operation criteria for the heat pump. Dialogue with project will provide preliminary data.

The project will then begin to assess feasibility of distributing heat around the campus. There are several techniques to be considered from high temperature networks at 90C to ambient loops at 15C (each local then drawing heat via a local heat pump.)

The second part of the project will take this data and the preliminary output from project1 (heat sources) and propose a campus wide system meeting the bulk of the load with large heat pumps sourcing the heat from the river Kelvin. (if driven by renewable energy this will be deemed zero carbon). As this scheme would be eligible for the renewable heat incentive, the support available is adequate to finance such a project over a short period.

The project should conclude with an estimate of capital, and operational cost and therefore present an ROI (return on investment) to be considered by the Estates Director and Finance Director.

Conclusions:

- *strong evidence that heatpumps work*
- *strong evidence they are lowest carbon*
- *strong evidence they are economical*
- *reasonable evidence the Kelvin flow is considerable*
- *reasonable evidence the University heat demand is significant*
- *Ammonia is the key to the economics*

It is likely that there is enough useable heat in the Kelvin for bulk of demand.....even if it is high temperature demand at ~80/90C



solutions for europe

natural refrigerants

15-16 October 2013, Brussels

Thank you.

apearson@star-ref.co.uk

www.tinyurl.com/nh3-totalenergy





ATMO
sphere
solutions for europe
natural refrigerants
15-16 October 2013, Brussels

Thank you very much!