

# **PERFORMANCE INSPECTIONS SAVES ENERGY AND EXTEND LIFE OF AIR-CONDITIONING AND REFRIGERATION EQUIPMENT**

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Edinburg, Jan 21, 2011

- Urgent need to get system to work as intended
- First step is to document how they actually work
- Analysing of performance in the field neglected area
- Potential to save energy is high at low cost
- Practical experiences show decreased cost extended life

# Refrigeration is everywhere!

use 15-20% of all electricity

up to 70% in hot climates where biggest growth is



# Significant potential to save Energy

## **Growing awareness of waste of electricity**

Legislations and certifications are spreading

- EU Directive - Energy Performance in Buildings Directive (EPBD)
  - Require "performance Inspections" in all AC equipment > 12 kW
  - 10% Energy Savings expected in AC and Refrigeration in Europe  
= **Electricity Generation of Denmark or Portugal**

**or all**

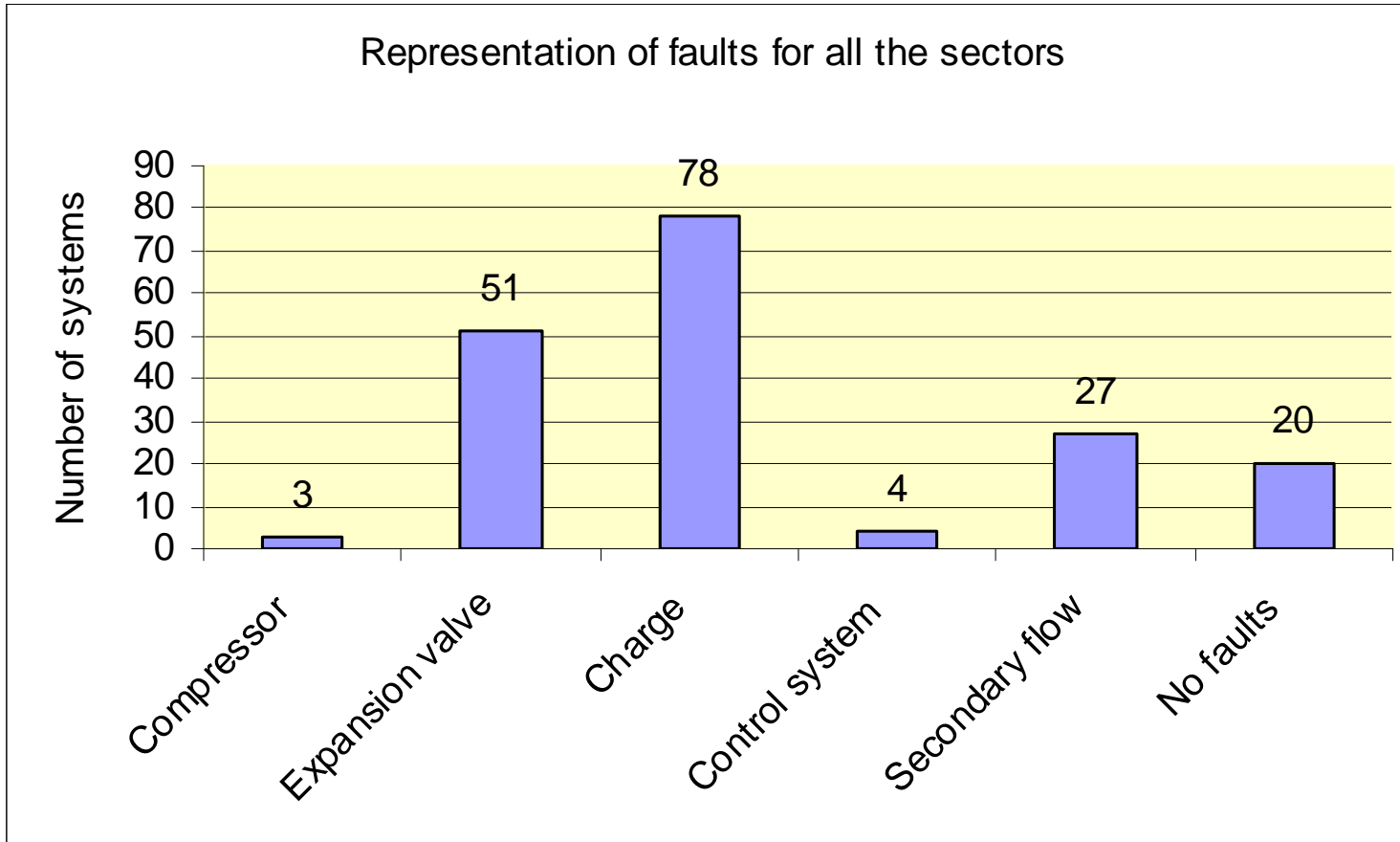
**Wind Power Generation for EU25.**

**Huge savings often 20 - 40% achieved at minimal cost**

**Many failures can be avoided**

# 13% of 164 systems were OK!

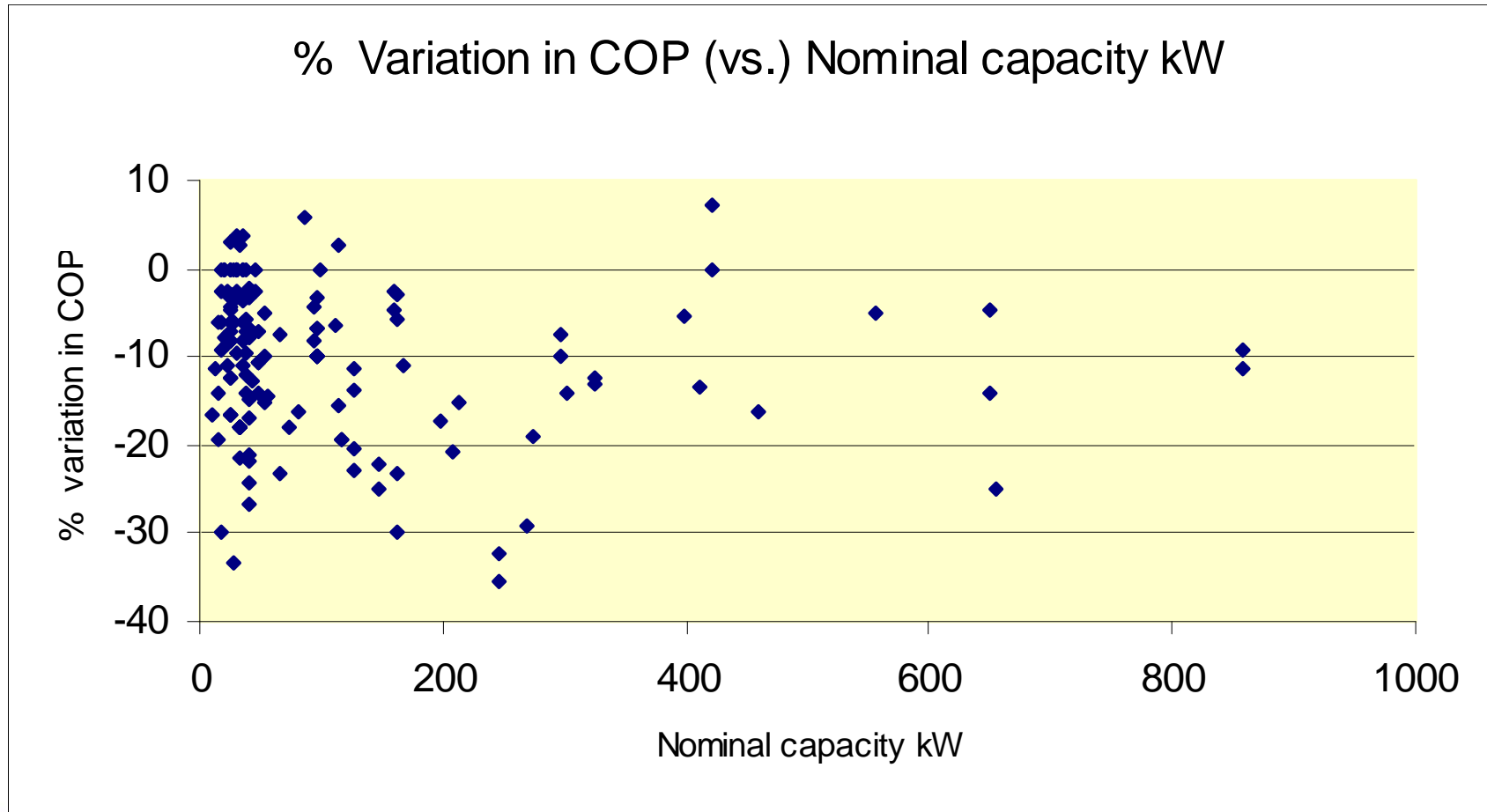
Source: Master Thesis by John Arul Mike Prakash, , KTH Stockholm 2006



**Inspections were planned and contractor informed**  
**Huge difference between theory and practice!**

# Huge variation in COP

Source: Master Thesis by John Arul Mike Prakash, , KTH Stockholm 2006



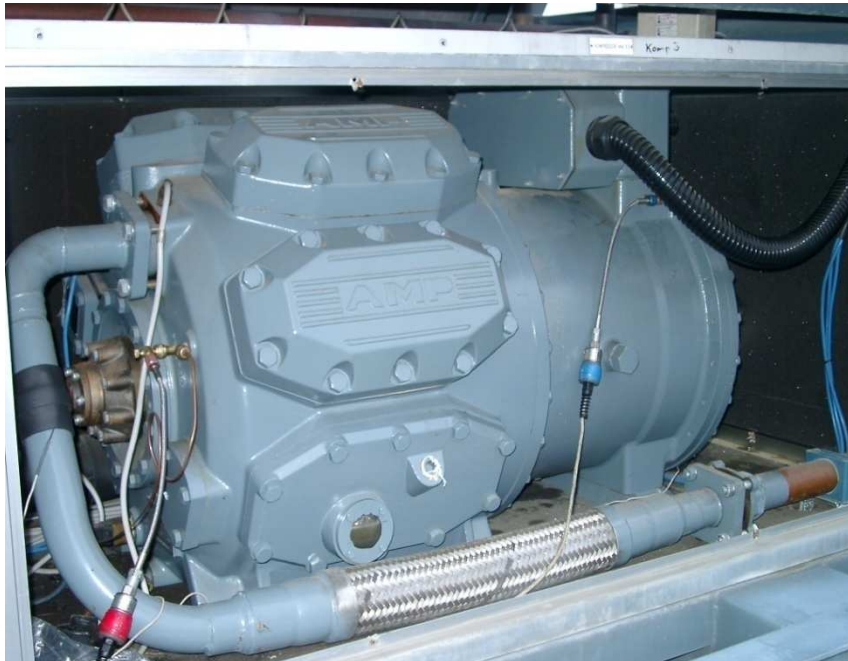
## Energy Performance in Building Directive (EPBD)

### **All AC-system with more than 12 kW capacity**

The inspection is to include  
“an assessment of the air conditioning efficiency  
and the sizing compared to the cooling requirements  
of the building”.

Advice is also to be provided to the users on  
“possible improvement or replacement of the air-  
conditioning system and on alternative solutions”.

Easy to apply –  
to standard service “points”



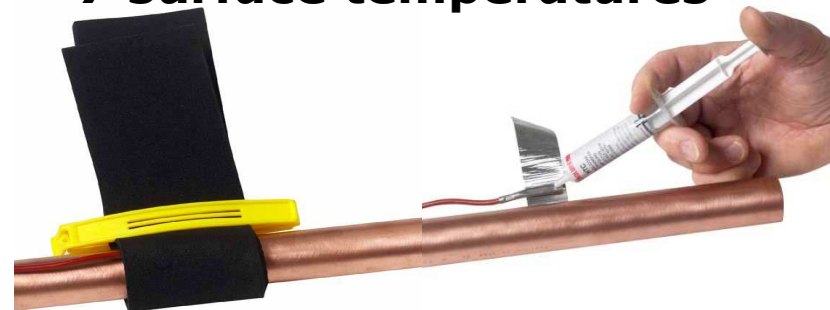
**2 pressures from  
service ports**



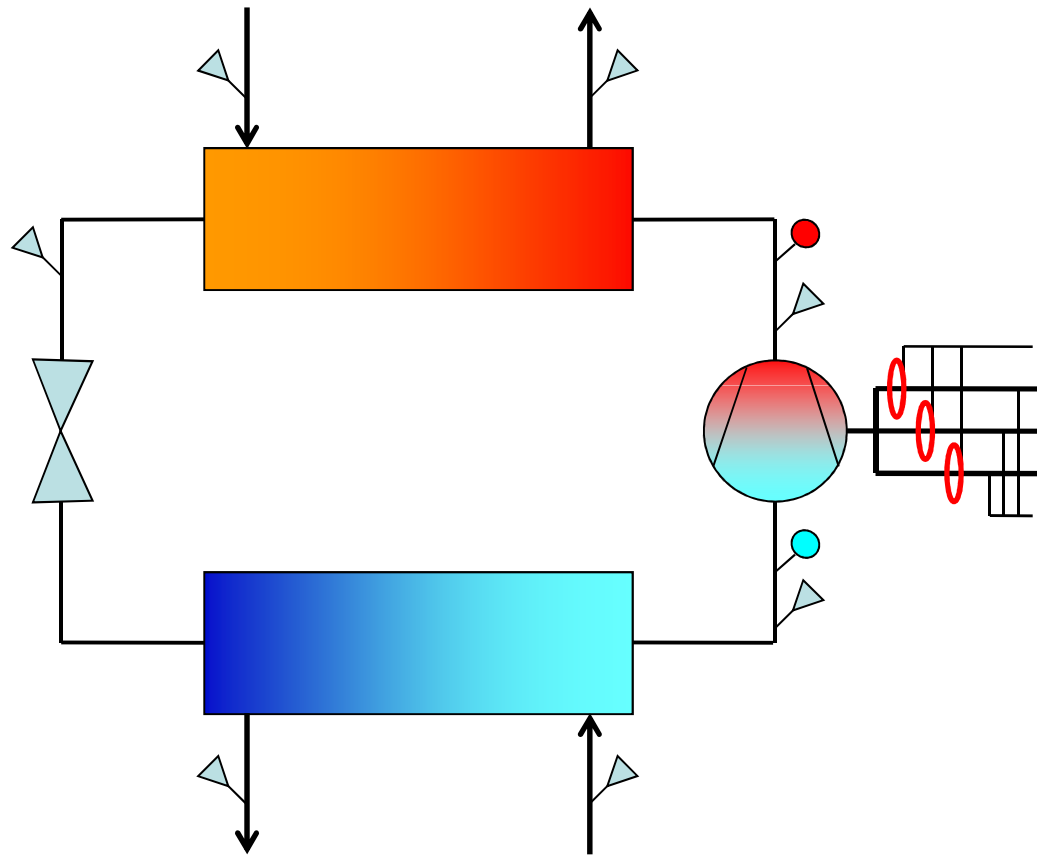
**Electrical input**



**7 surface temperatures**



## Application of sensors to standard system (typically done in 20-30 minutes)

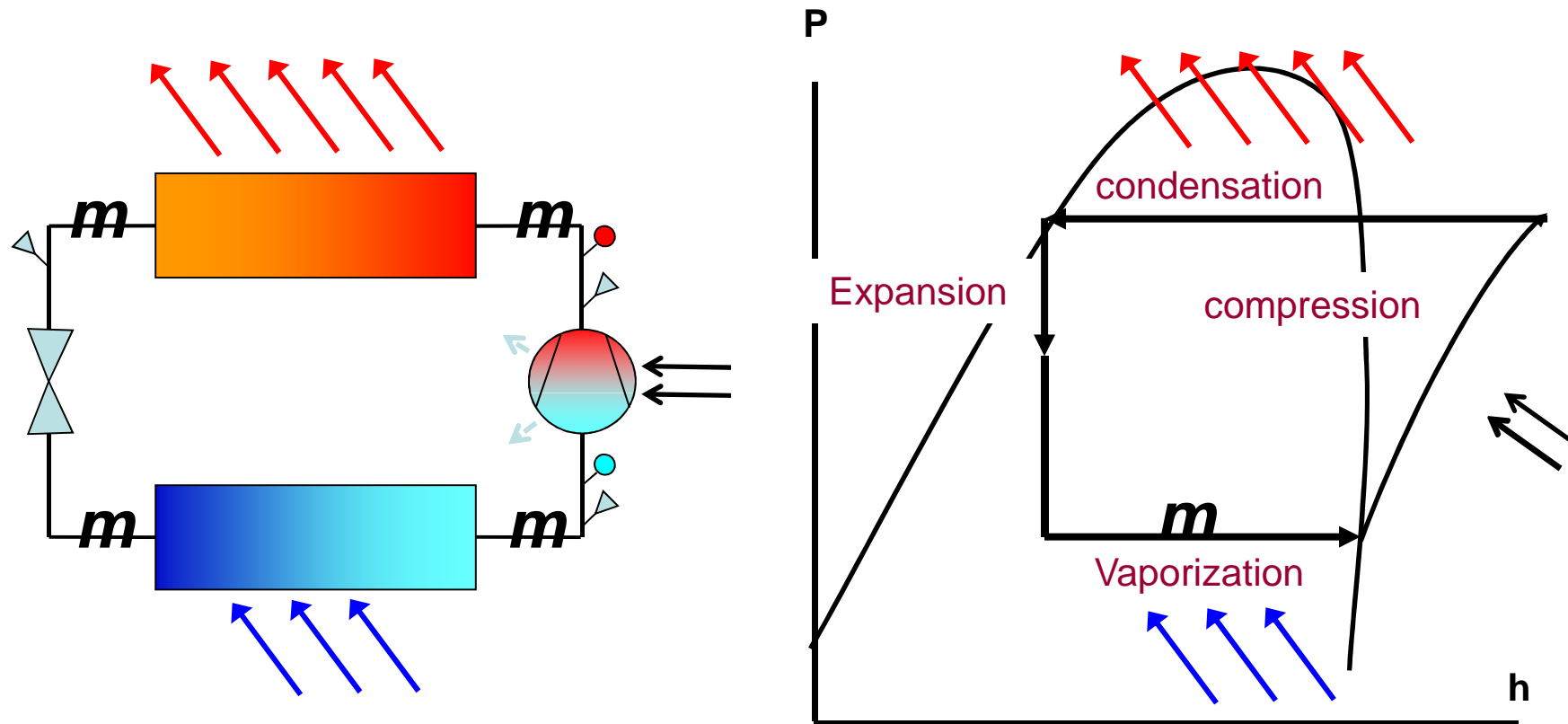


- 2 pressures
- 7 temperatures
- 1 power input

No information about system or compressor added



# Simple Refrigeration Cycle

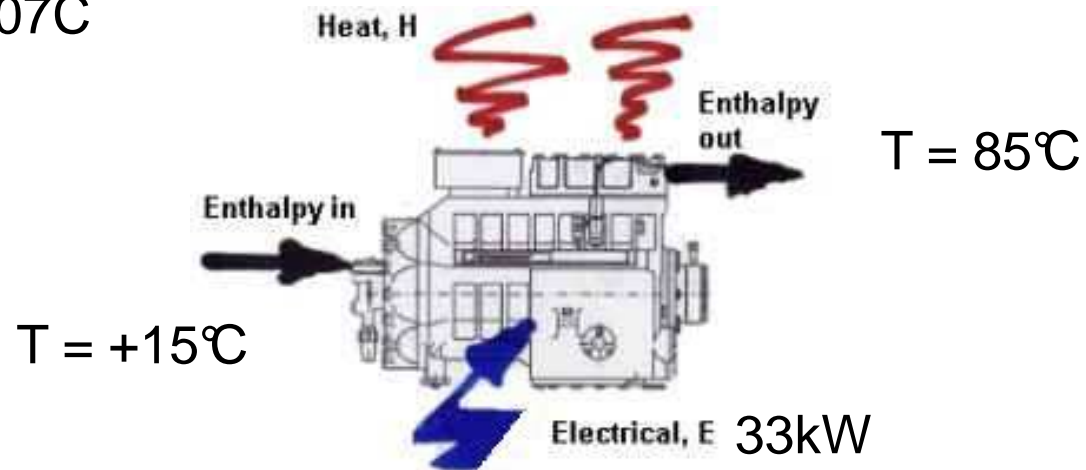


$$m = \frac{\text{power} - \text{heat losses}}{\text{enthalpy diff compressor}}$$

# What about error in the heat loss estimate?

Conditions

+5/50°C R407C



Heat Loss	Enthalpy	Mass Flow	Capacity
%	Increase	Rate kg/s	kW
5	48.5	0.653	100
7	48.5	0.641	98.2

**40% error in the Heat Loss results in <2% Capacity Error**

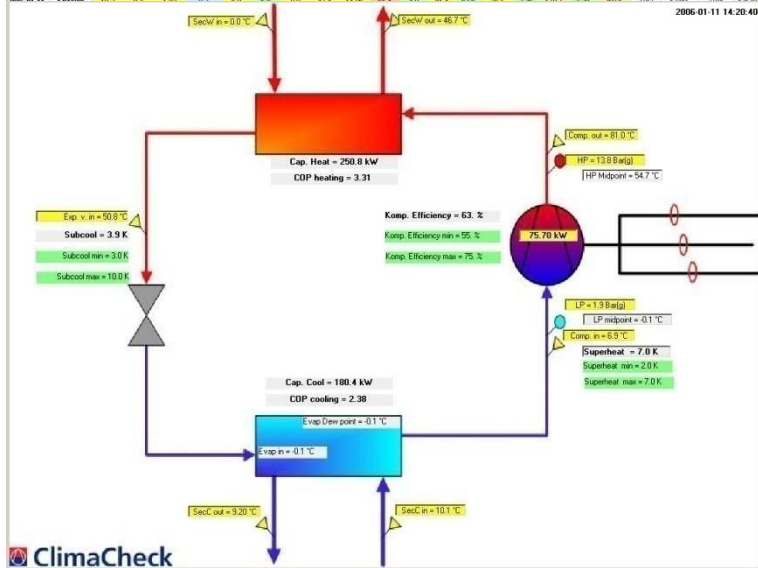
# Key Results

- **Cooling capacity** ( $\pm 7\%$  accuracy)
- **Heating capacity** ( $\pm 7\%$  accuracy)
- **COP** ( $\pm 5\%$  accuracy)
- **Compressor efficiency**
- **Super heat and sub cooling**
- **Functionality of Control**
  
- Evaporation, Condenser pressure and temperature
- UA and mean temperature differences in evaporator and condenser
- Flow of secondary systems based on Capacity and temp. difference

Listed are only key information – standard template consist of > 40 outputs allowing detailed analyses of each component

# Presentation of data is key for analyses

Tested Equipment		Performance Inspection with ClimaCheck																													
Refrigerant		R134A																													
		Term. Elec. Stab. Accept Auto Annual Electrical Annual																													
		0.93 1.00 0.10 1.00 500000 0.20 700000																													
Min	No of Scans	2.0 3.0 66 55 0.1 1.0 1.8																													
Max	58	7.0 10.0 120 75 1000 4.0 8																													
		4.7 3.8 58.78 0.8-7.0 1.8-8.0																													
		Equip. Sec.					Low Pres. Ref.					Cond. Sec.					High Pressure Ref.					Compressor					Operating cost				
Mean		10.1	9.2	1.92	0.0	6.9	6.9	0.0	47.1	13.94	55.1	4.0	01.2	63.5	75.6	2.37	179.7	3.30	250.2	279.3	421.96	279.0	42419								
Max		10.2	9.3	1.94	0.2	7.0	7.0	0.0	47.8	14.28	55.0	4.1	01.5	64.4	76.5	2.38	180.7	3.32	251.3	281.7	422.57	280.0	42656								
Min		10.1	9.2	1.91	-0.1	6.8	6.7	0.0	46.7	13.70	54.7	3.8	01.0	63.2	74.3	2.35	175.6	3.28	244.7	276.7	419.97	278.5	42209								
Date	Time	SecC Evap in (°C)	SecC Evap out (°C)	Ref Low (Bar(g))	Ref Low Midpoint (°C)	Ref Evap (°C)	Super heat (K)	SecW Cond in (°C)	SecW Cond out (°C)	Ret High (Bar(g))	Ret High Midpoint (°C)	Sub cool total (K)	Ret Comp (°C)	Comp isen. eff. (%)	Power Input (kW)	COP Cool	COP Heat	Cap. Cool (kW)	COP Heat	Cap. Heat (kW)	Annual operate hours (h)	Annual operate cost (€)	Annual operate hours (h)	Annual operate cost (€)							
2006-01-11	14:20:00	10.1	9.2	1.91	-0.1	6.9	7.0	0.0	46.7	13.70	54.7	3.9	01.0	63.4	75.7	2.38	180.4	3.31	250.8	277.1	419.98	279.1	42254								
2006-01-11	14:20:10	10.1	9.2	1.91	0.0	6.9	7.0	0.0	46.7	13.81	54.7	4.0	01.0	63.4	75.6	2.38	180.3	3.31	250.6	277.4	419.97	279.4	42209								
2006-01-11	14:20:20	10.1	9.2	1.91	0.0	6.9	7.0	0.0	46.7	13.82	54.8	4.0	01.0	63.5	75.6	2.38	180.4	3.32	250.7	277.1	419.97	279.2	42209								
2006-01-11	14:20:30	10.1	9.2	1.91	0.0	6.9	7.0	0.0	46.7	13.82	54.8	4.0	01.0	63.5	75.7	2.38	180.7	3.32	251.1	276.7	419.97	278.0	42209								
2006-01-11	14:20:40	10.1	9.2	1.91	0.0	6.9	7.0	0.0	46.7	13.84	54.8	4.1	01.0	63.5	75.7	2.38	180.5	3.31	250.9	277.0	419.98	279.0	42209								
2006-01-11	14:20:50	10.1	9.2	1.91	0.0	6.9	6.9	0.0	46.7	13.82	54.8	3.9	01.0	63.3	75.7	2.38	180.1	3.31	250.5	277.7	420.43	279.5	42315								
2006-01-11	14:21:00	10.1	9.2	1.91	-0.1	6.8	6.9	0.0	46.7	13.82	54.8	3.9	01.0	63.3	75.6	2.37	179.5	3.30	249.8	276.5	420.59	279.2	42363								
2006-01-11	14:21:10	10.1	9.2	1.91	0.0	6.8	6.9	0.0	46.8	13.84	54.8	3.9	01.0	63.4	75.7	2.37	179.8	3.30	250.2	276.1	420.60	278.8	42362								
2006-01-11	14:21:20	10.1	9.2	1.91	0.0	6.8	6.8	0.0	46.9	13.90	54.9	4.0	01.1	63.4	75.9	2.37	180.2	3.30	250.8	277.5	421.16	279.1	42269								
2006-01-11	14:21:30	10.1	9.2	1.91	0.0	6.8	6.8	0.0	46.9	13.86	54.9	3.9	01.1	63.3	75.9	2.37	180.0	3.30	250.6	277.9	421.74	279.4	42410								
2006-01-11	14:21:40	10.1	9.2	1.91	0.0	6.8	6.8	0.0	47.0	13.89	55.0	3.9	01.1	63.4	75.9	2.37	179.8	3.30	250.4	278.0	422.04	279.5	42431								
2006-01-11	14:21:50	10.2	9.2	1.92	0.0	6.8	6.7	0.0	47.0	13.88	54.9	3.9	01.1	63.2	75.9	2.36	179.4	3.29	250.0	276.7	422.00	279.0	42501								
2006-01-11	14:22:00	10.2	9.2	1.92	0.1	6.8	6.8	0.0	47.0	13.94	55.1	4.0	01.2	63.4	75.9	2.37	179.6	3.30	250.2	276.4	422.54	279.6	42468								
2006-01-11	14:22:10	10.2	9.2	1.92	0.1	6.8	6.8	0.0	47.1	14.01	55.3	4.1	01.2	63.6	76.1	2.37	180.4	3.30	251.1	277.2	423.93	278.7	42423								
2006-01-11	14:22:20	10.2	9.3	1.93	0.1	6.8	6.7	0.0	47.2	14.01	55.3	4.0	01.3	63.5	76.3	2.36	180.4	3.29	251.3	277.2	422.99	278.5	42500								
2006-01-11	14:22:30	10.2	9.3	1.93	0.1	6.8	6.8	0.0	47.3	14.02	55.3	4.0	01.3	63.6	76.1	2.36	179.8	3.29	250.7	277.3	422.95	279.2	42487								



Report from Performance inspection:

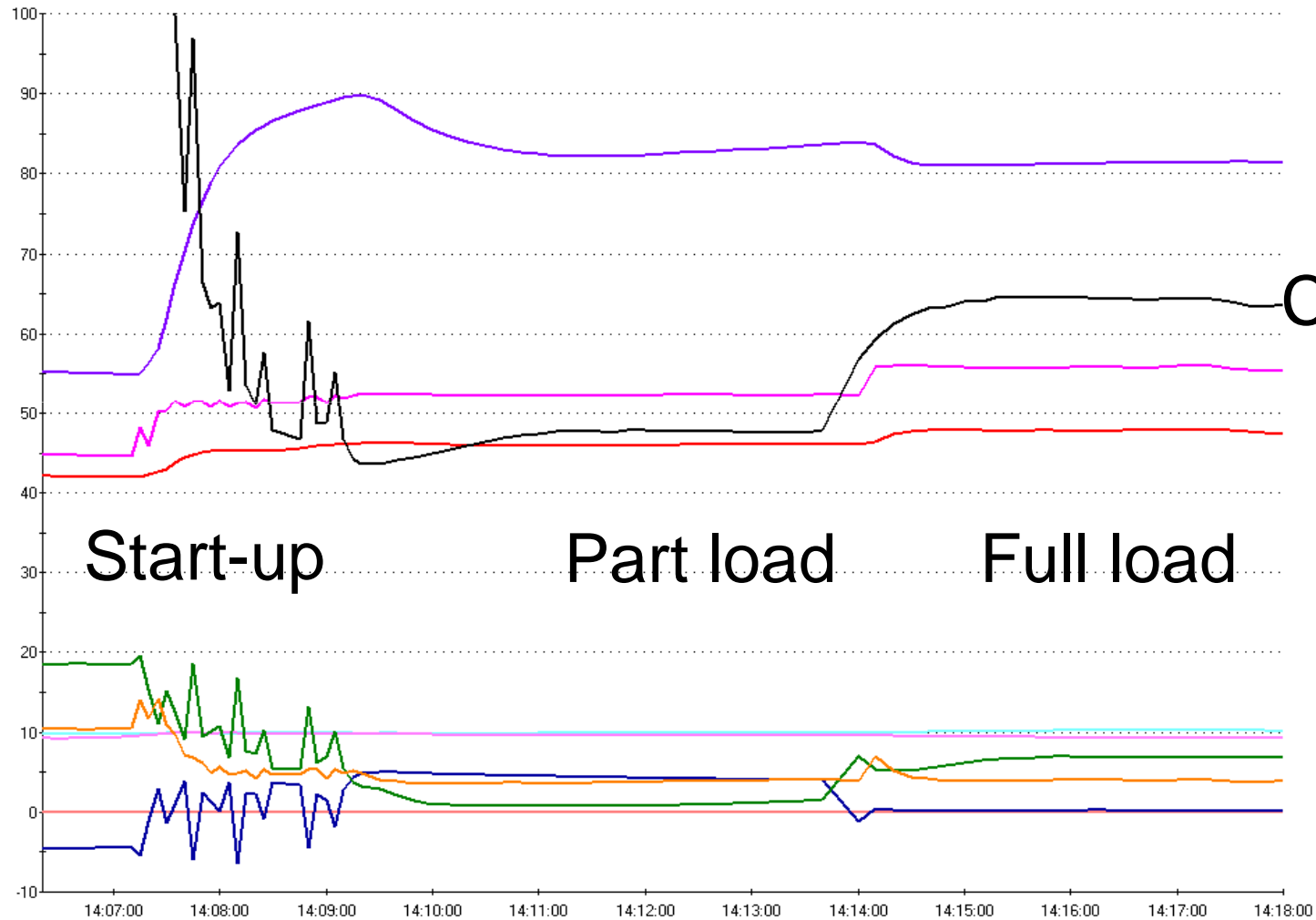
Tested Equipment:

Date:	2006-01-11	Uppmätt värde	Nominella Data	Avvikelse	Kommentarer
Time for measurements	14:21:10				
Secondary Cold in	10.1 °C	12.0	-1.89 K		
Secondary Cold out	9.2 °C	7.0	2.18 K		
Evaporation	0.0 °C	2.0	-1.97 K		
Super heat Comp.	6.9 K	5.0	1.89 K		
Secondary Warm in	0.0 °C	40.0	-40.00 K		
Secondary Warm out	46.6 °C	45.0	1.60 K		
Compressor discharge	81.0 °C	80.0	1.03 K		
Condensing	54.7 °C	50.0	4.68 K		
Sub cool before exp.	3.9 K	5.0	-1.05 K		
Power Input	75.7 kW	70.0	5.70 kW	8.1 %	
Comp isen. efficiency	63.1 %	64.0	-0.90 %		
Cooling Capacity	180.2 kW	190.0	-9.80 kW	-5.2 %	
COP Cooling	2.38	2.60	-0.22	-8.4 %	
Heating Capacity	250.6 kW	260.0	-9.40 kW	-3.6 %	
COP Heating	3.31	3.50	-0.19	-5.4 %	
Stability*	0.03	0.10	0.00		

\* If unstable this must be taken into account when evaluating

Selected Data Stability Semi Part load test 2006-01-11 14:18:10

Data Setup



Comp. eff

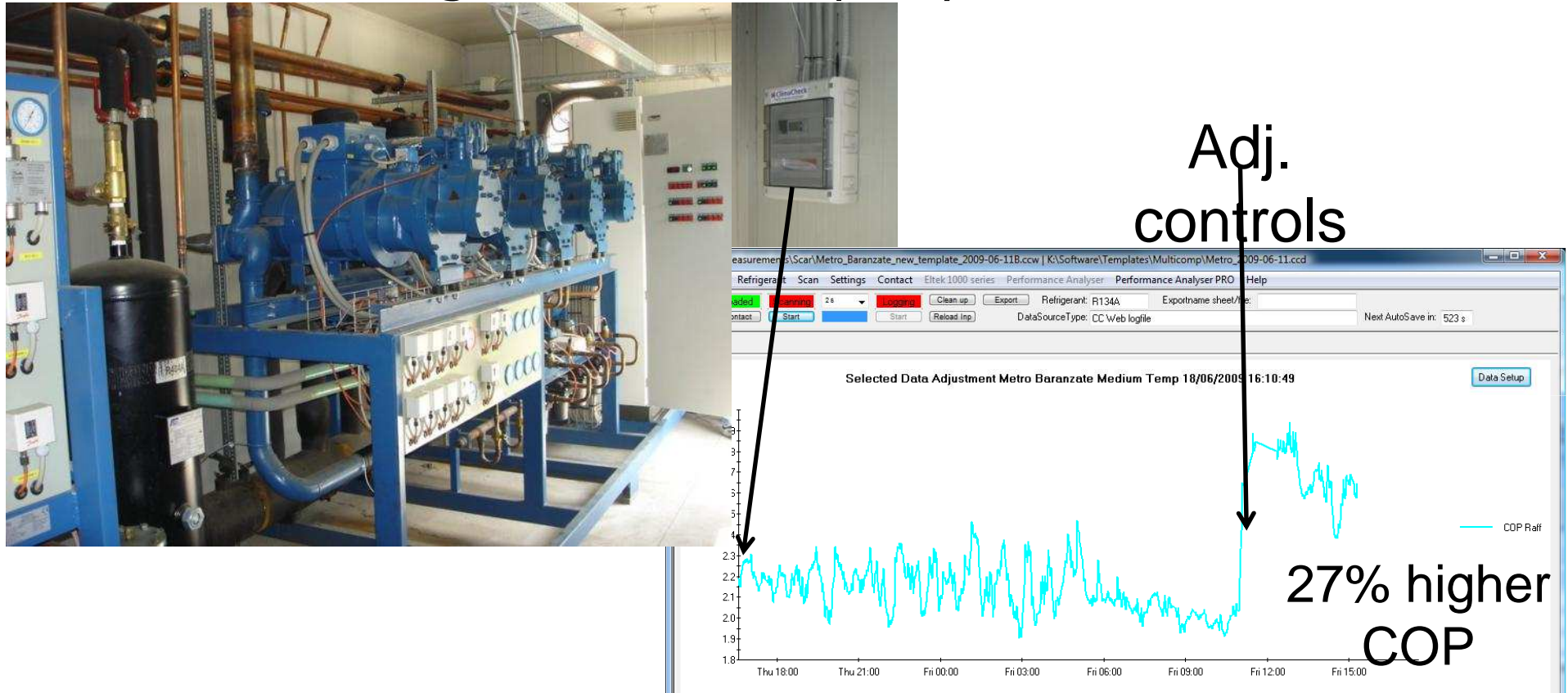
Start-up

Part load

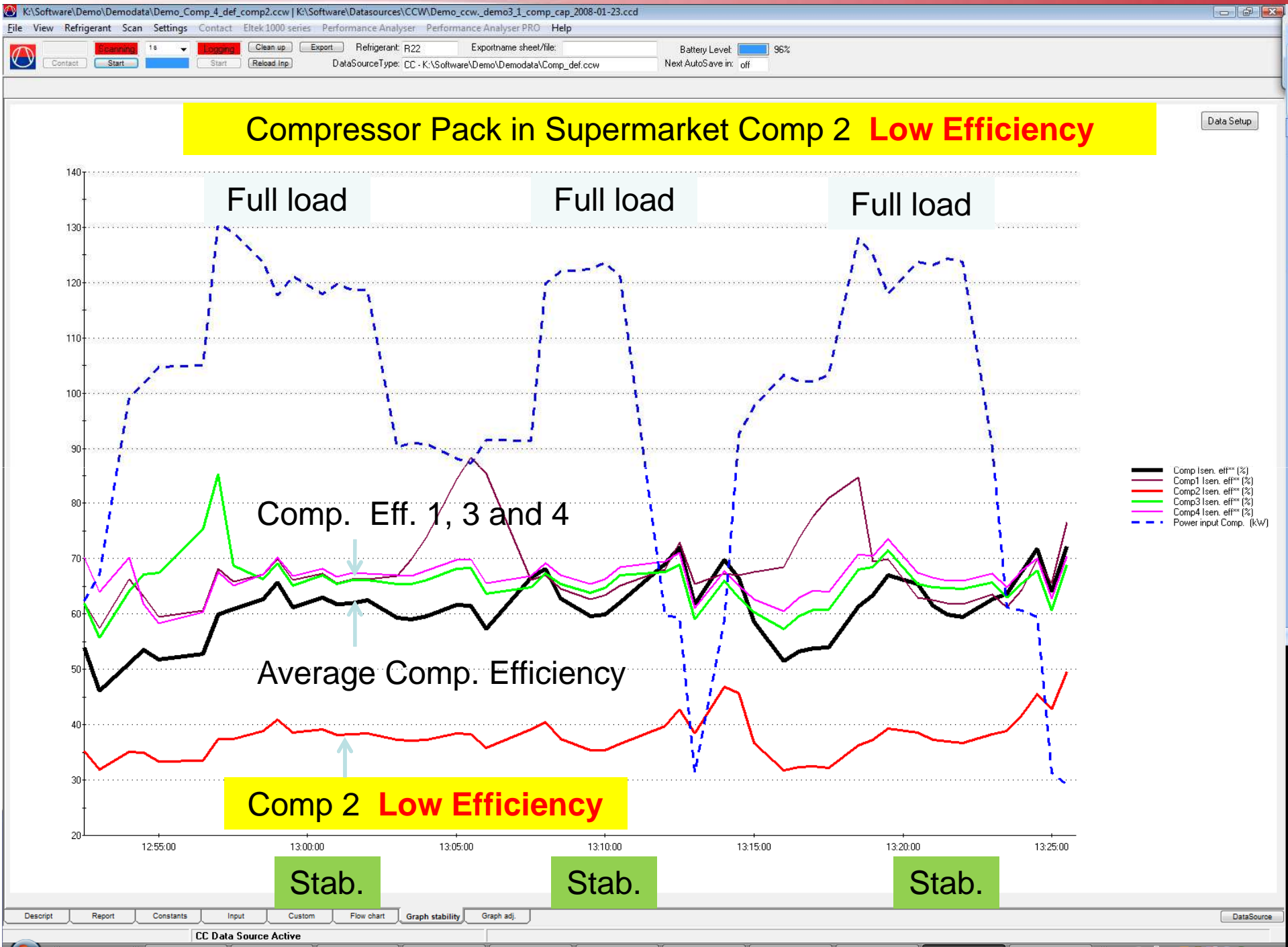
Full load

- SecC Evap in (°C)
- SecC Evap out (°C)
- SecW Cond in (°C)
- SecW Cond out (°C)
- Ref Cond Midpoint (°C)
- Ref Evap Midpoint (°C)
- Ref Comp out (°C)
- Super heat (K)
- Sub cool total (K)
- Comp Isen. eff\*\* (%)

# Italian Supermarket Metro Baranzate in Milano saving 16 000 Euro per year



Energy consumption over test periods showed corresponding improvement



# Report from Carrier site inspection



## Carrier Performance Analyser

Site:	TrioPlast, Landskrona KM11
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Datum:	20100426
Tidpunkt start:	11:57
Tidpunkt stopp:	13:17

Title	Measured Value		Nominal Data	Deviation		Comment
COOL_EWT	9.5	°C	9.5	0.00	K	
COOL_LWR	5.7	°C	5.7	0.00	K	
COND_EWT	35.6	°C	35.6	0.00	K	
COND_LWT	45.1	°C	45.1	0.00	K	
POWER KW	350.2	kW	342.0	8.20	kW	ap 2,3 % negativ deviation
COOLING CAPACITY	1177.4	kW	1160.0	17.40	kW	ap 1.5 % positiv deviation
EER	3.36		3.39	0.03		
HEATING CAPACITY	1503.2	kW	1484.0	19.20	kW	ap 1.3 % positiv deviation
COP	4.29		4.41	0.12		ap 2,8 % negativ deviation

Nominal data is the values we get from running E Cat with actual values from the measurement.

Measurement made by: Stefan Orwén, Carrier AB, Malmö

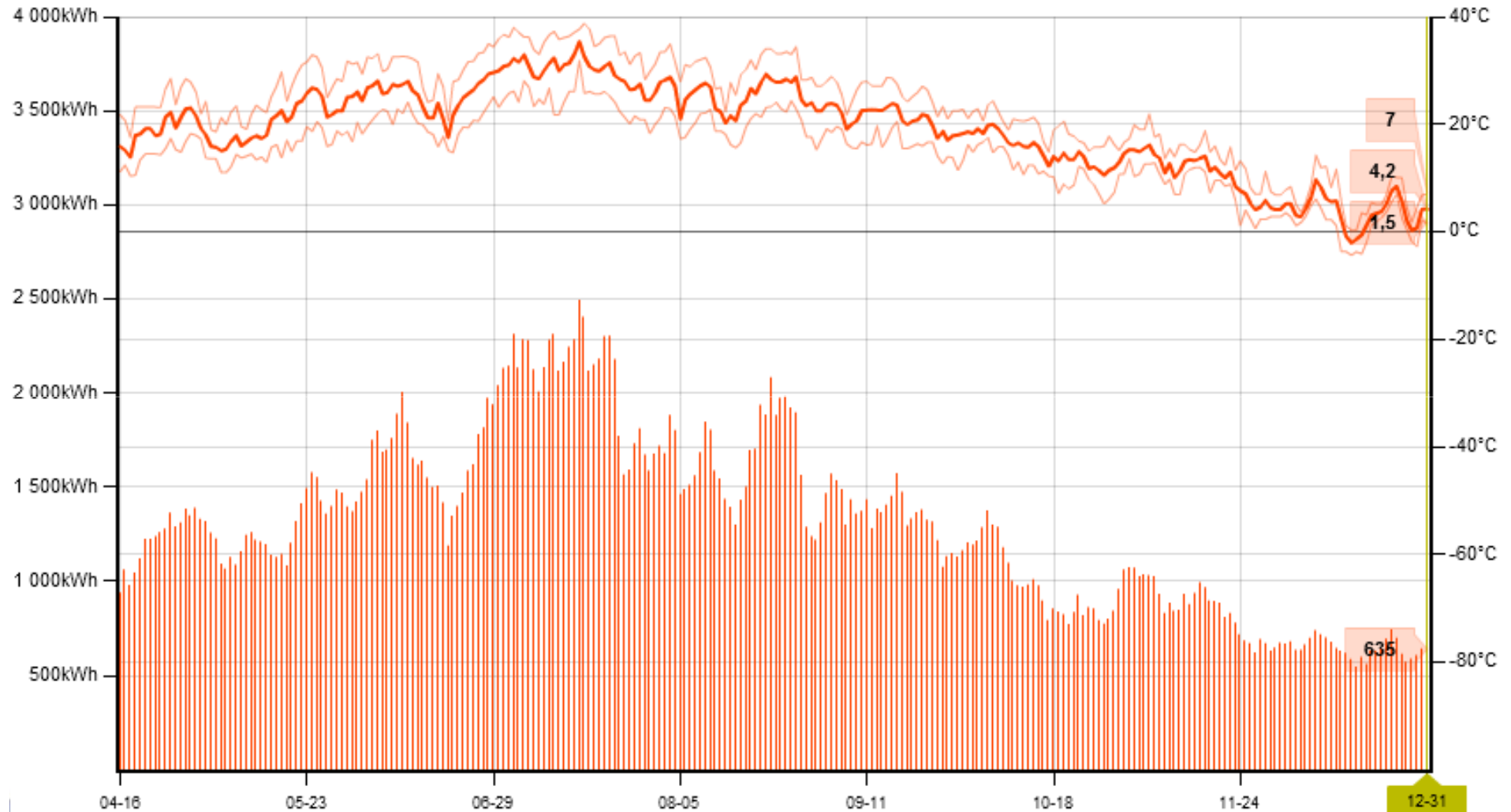
**Un-biased validation of  
Performance – no Carrier inputs**



# Energy statistics Supermarket

SCAR Assago 2 of 3 2010-01-01 2010-12-31

Utomhus max temp 1  Utomhus avq temp 1  Utomhus min temp 1  Energiförbr



# Energy statistics Heat pump/Chiller

Time interval to view / resolution

Date in interval

Date in interval 2

Options for second interval

Day  Week  Month  Year  
 Hour  Day  Week  Month

2010-12-07

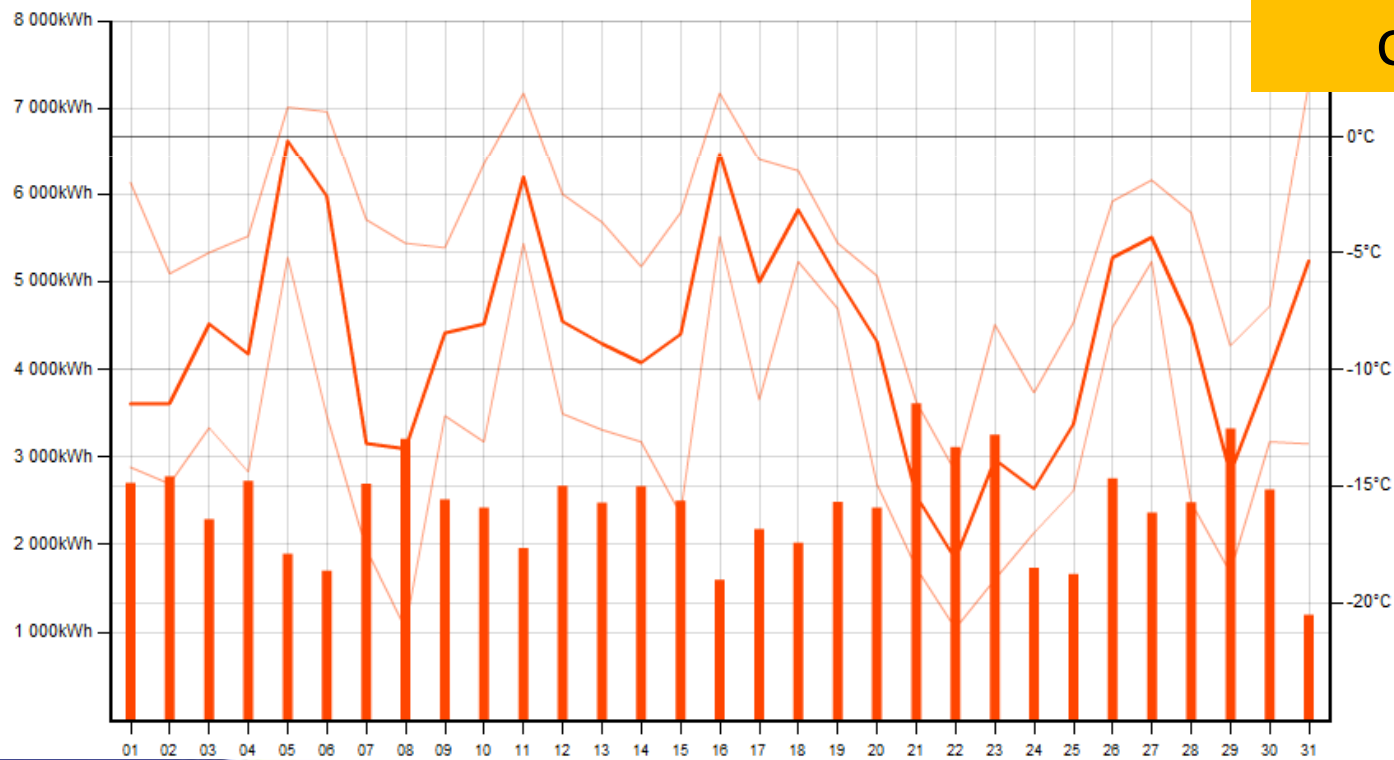
Interval 2

Same plant  Other plant

Total energy  Energy  Aux energy

IKEA Karlstad Krets A 2010-12-01 2010-12-31

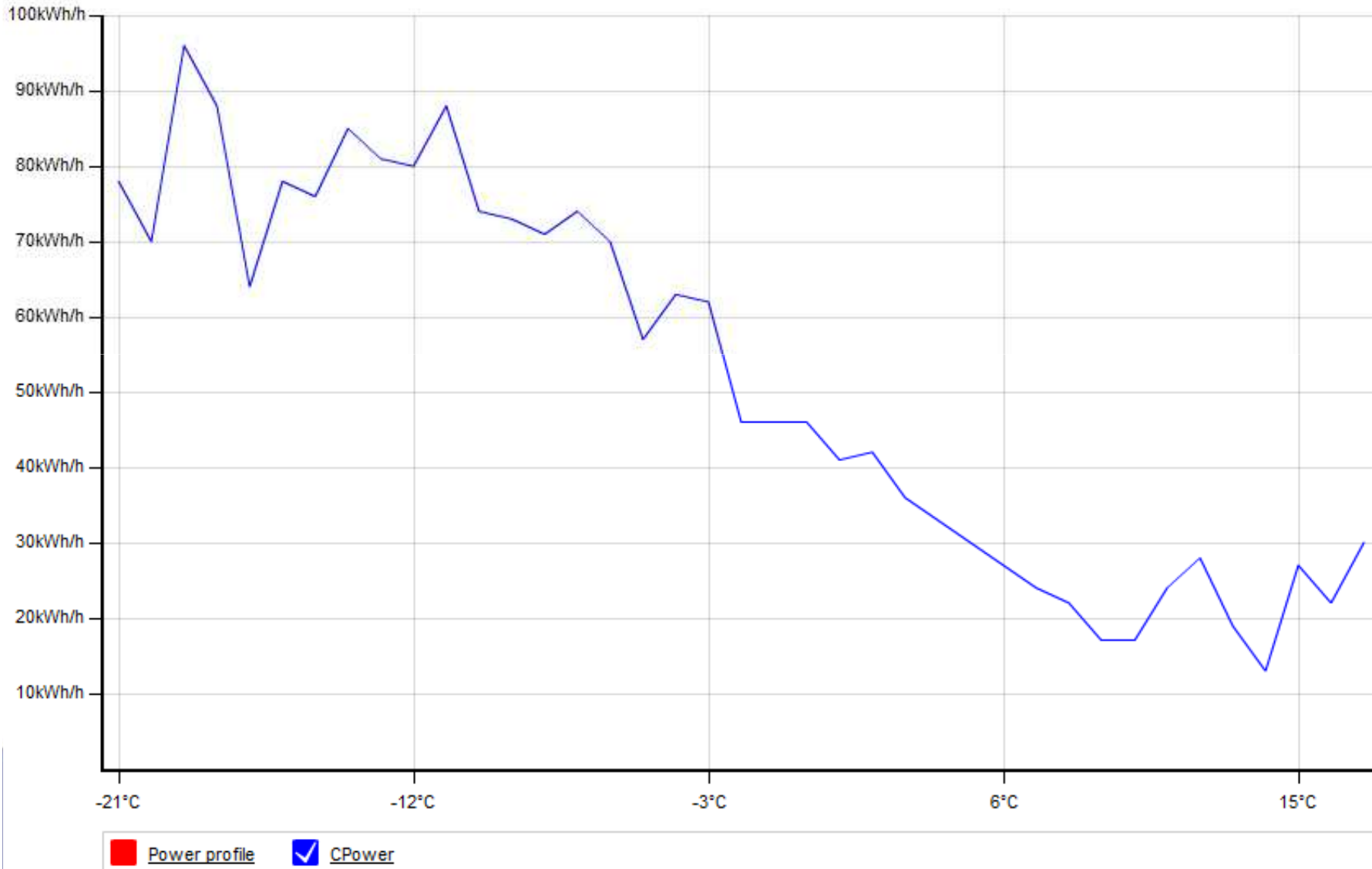
- Outdoor max temp 1
- Outdoor avg temp 1
- Outdoor min temp 1
- Energy consumption 1



Compare  
two time periods  
or two plants

# Energy Profile Heat pump/Chiller

Power profile for IKEA Karlstad Krets A  
Oldest data: 2010-10-08, newest data: 2011-01-15



# We need performance analyses

Local and remote – temporary and fixed



On site and Web based for:

- ✓ Commissioning – minimize warranty cost
- ✓ Performance inspection – optimisation
- ✓ Preventive maintenance
- ✓ Trouble shooting
- ✓ Decision support – optimisation, expansion, retrofit

**If you cant measure you cant control it!**

Global  
Industry need  
tools  
and training  
to  
optimise



Dynamics in real systems not  
well taken care off or understood

# It works - Validated and well proven

- Experience since 1986 when it was patented
- Method validated by SP - Swedish National Testing and Research Institute
- 500 + field measurement systems in use around the globe
- Method used in education
  - Sweden, Germany, Slovakia, UK, Italy ++
- Used by 40+ manufacturers of heat pumps, dehumidifiers, refrigeration and air conditioning equipment
  - Carrier, Copeland, DuPont, Danfoss Heat Pumps, GEA, Carrefour, Sainsbury, TESCO, IKEA
  - Development and production test rigs at manufacturers plants
  - Commissioning, trouble shooting, warranty inspections and aftermarket



Thank you!