
IDEA2021
Powering the Future: District Energy/CHP/Microgrids
Sept. 27-29 | Austin Convention Center | Austin, Texas

Oil-free Turbo Compressor Technology in Symbiosis District Energy Systems

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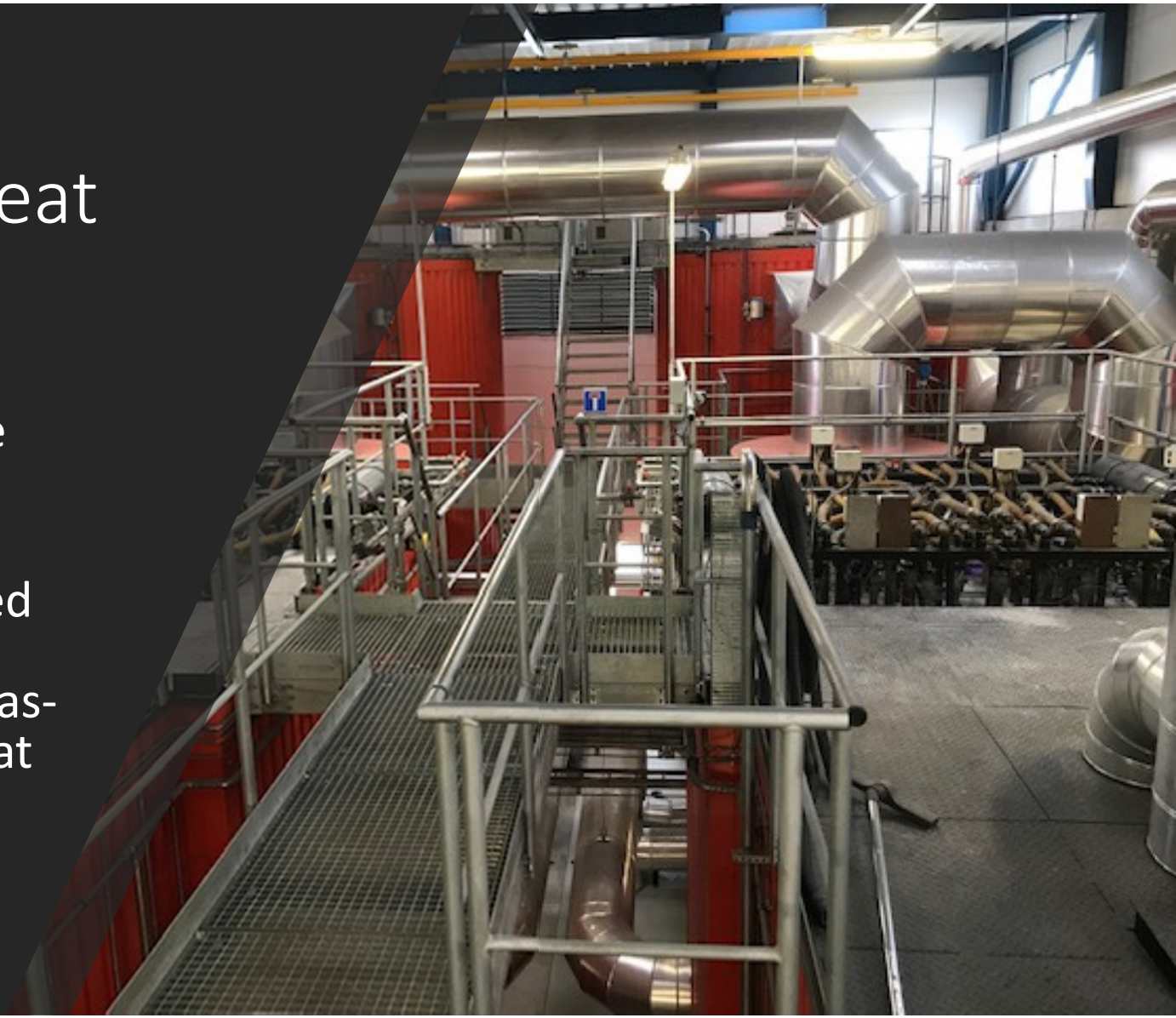
ENGINEERING TOMORROW

Danfoss

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Achieving 97% Carbon-Free Heat

- Ringsted, Denmark District Heating Utility commitment to achieve 97% carbon-free heat supply by 2020
- Heat previously provided by two straw-fired biomass boilers and a gas-powered Combined Heat & Power (CHP) plant – 75% carbon-free



Increase From 75% to 97% Carbon-Free Heat

- Add large capacity air-water heat pump
- Recover all possible heat via cooling –
  - Air-water heat pump drives
  - Flue gas scrubber (remove SO2)
  - CHP engine jacket water
  - Equipment room
- Maximize capacity & efficiency - Minimize heat price

The Solution –

- 3 new Heat Pumps Utilizing Oil-Free Technology
- Increase heat plant…
  - Capacity up to 31%
  - Efficiency up to 21%

Outdoor temperature	**-5°C**	**0°C**	**12°C**
Forward temperatur from HP*	60°C	55° C	60°C
	kW	**kW**	**kW**
Heat capacity HP01 (outdoor air)	6,829	7,958	9,500
HP02 (35C) surplus heat from boiler scrubber	962	962	962
Scrubber surplus possible from **HP02** cooling	850	850	850
Heat capacity **HP03** cooling HP01 drives	310	310	310
Total heat capacity	8,951	10,080	11,622
Capacity increase with oil-free technology	**31%**	**27%**	**22%**
Power consumption HP01	2,262	2,219	2,317
Power consumption HP02	136	136	136
Power consumption HP03	50	50	50
Power comsumption scrubber	22	22	22
Total power comsumption	2,448	2,405	2,503
COP HP 01	3.0	3.6	4.1
COP HP 02	7.1	7.1	7.1
COP scrubber	38.6	38.6	38.6
COP HP03	6.2	6.2	6.2
Total heat pump system COP	3.7	4.2	4.6
COP increase with oil-free technology	**21%**	**17%**	**13%**

Why Oil-Free Technology Was the Best Solution

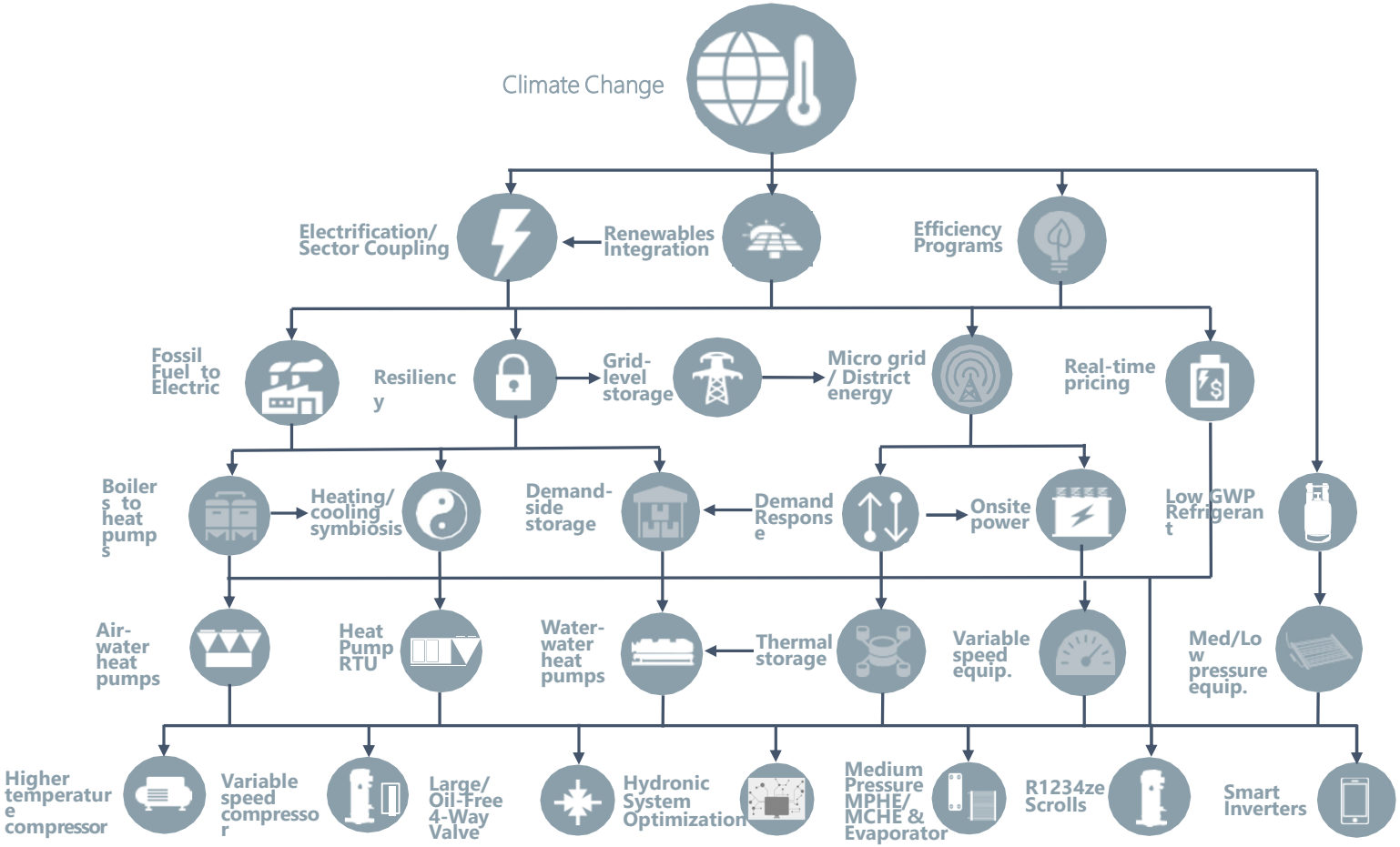
- Efficiency – Optimized to application & maintained
- Operating temperature flexibility (efficiency-related)
- Footprint – Limited space available
- Install/startup/commission – 1 week vs 2 months
- Maintenance/cost – Downtime & heat price
- Refrigerant – A2L, low-charge & pre-packaged
- Sound levels
- OEM partner (Geoclima) installation, startup & service support

Lessons Learned

- Oil-free technology value proposition optimized for symbiosis (combined heating/cooling) applications
- Symbiosis opportunities exist in centralized and not just decentralized applications
- 'Full monte' is not critical – Optimized system add-ons are sometimes better
- DHUs take holistic view to solutions which minimize risk & long-term heat price

- More information on Ringsted –
  - dh.dk/event/webinar-about-super-efficient-heat-pumps-in-ringsted/
  - http://www.e-pages.dk/dbdh/79/

Setting the Stage



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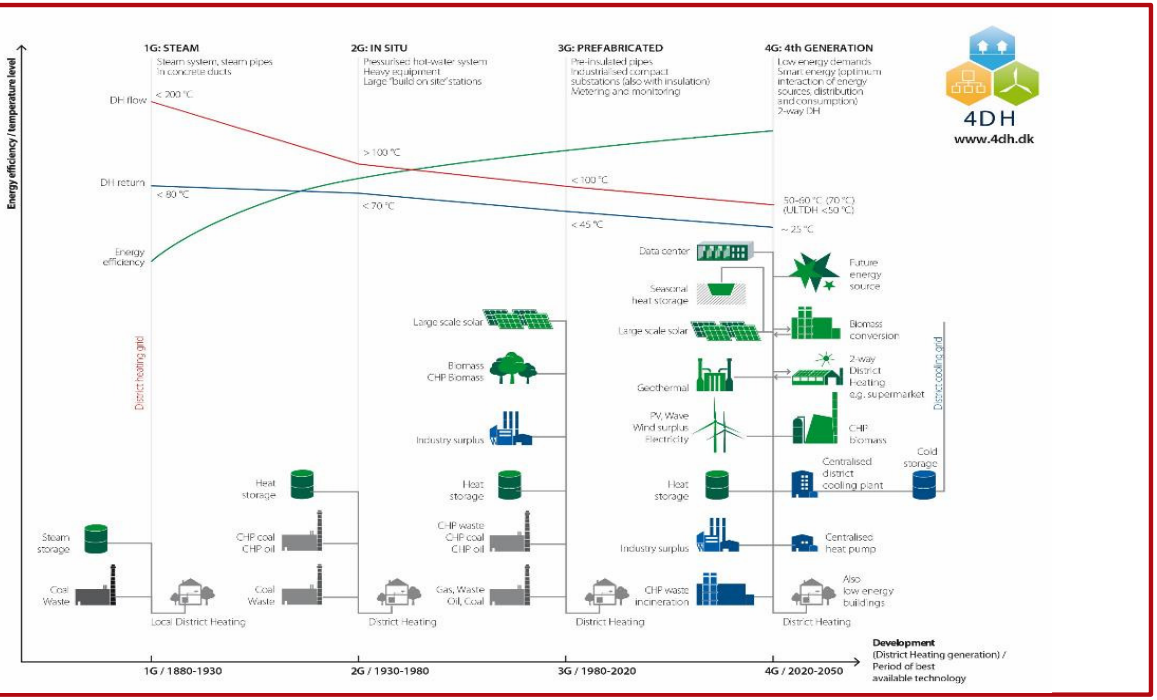
INTERNATIONAL DISTRICT ENERGY ASSOCIATION

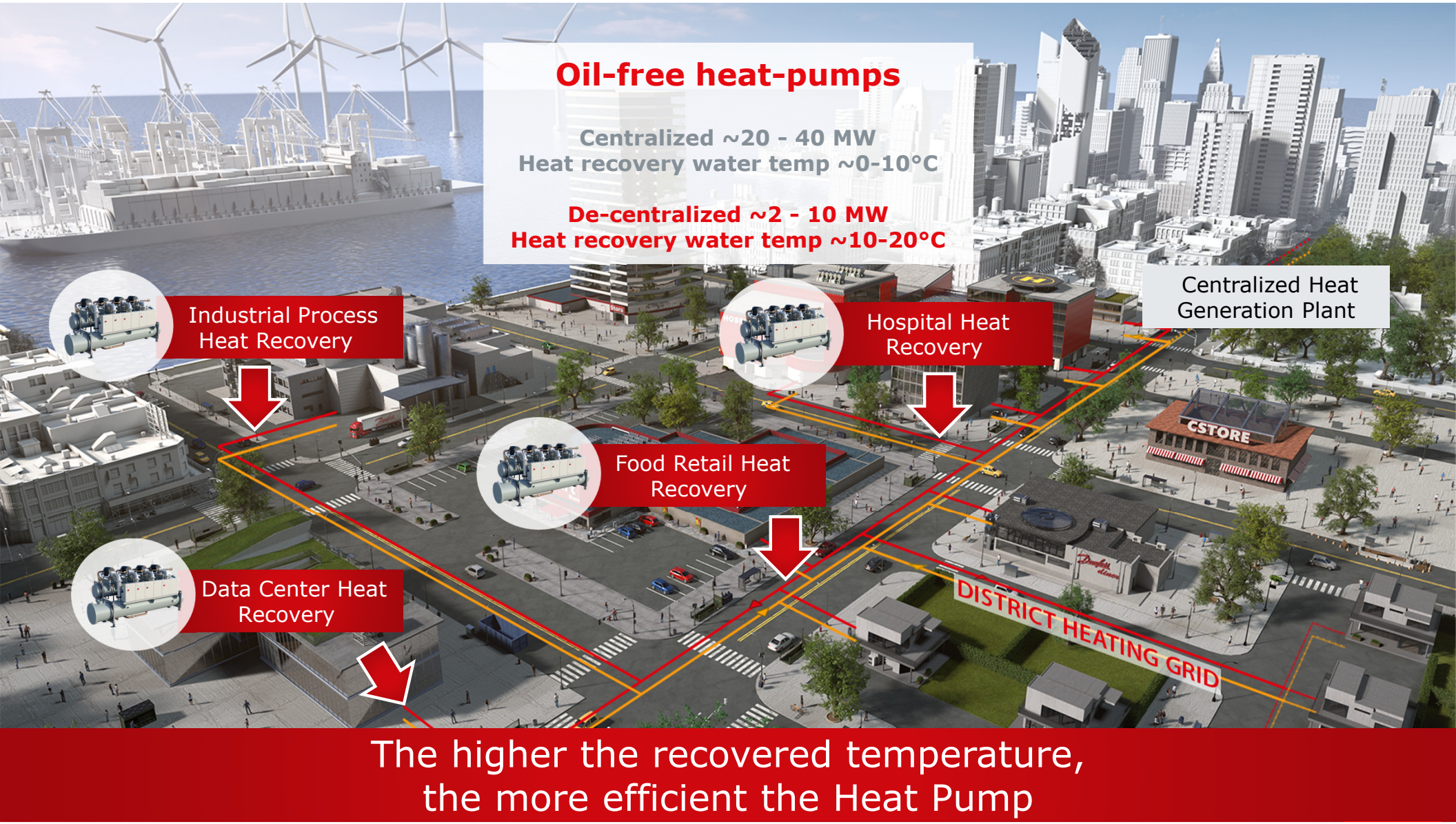
District Heating networks develop constantly



- DH has long history and a strong tradition
- Efficiency increase while temperature drops
- The lower the temperature the more sources to connect
- Challenge the need for high temperature

Table 9: Marginal costs for changing the heat demand in individual heating

Fuel type	Heat efficiency	Fuel price for indv. heating incl. handling costs [€/kWh]	Resulting heat price [€/kWh]
Oil	0.80	0.071	0.089
Natural Gas	0.85	0.044	0.052
Biomass	0.69	0.037	0.054
Electricity (boiler)	1.00	0.077	0.077
Electricity (heat pump)	3.10	0.077	0.025



The higher the recovered temperature,
the more efficient the Heat Pump

The Evolution of **Danfoss Turbocor®** Compressors

The idea of using oil free magnetic bearing technology began with the 1st prototype built in 1995. Since then, over 80,000 Danfoss Turbocor® Compressors have been built, confirming the commercial success of oil free compressor technology.

1st oil free magnetic bearing compressor built

1995

Full range of oil free, magnetic bearing centrifugal compressors up to 200 tons offered

2001

1st installation of oil free, magnetic bearing TT centrifugal compressor

2010

VTT compressor up to 400 tons

2013

TG compressor launched – 1st centrifugal compressor using ultra low GWP HFO1234ze

2014

2019

TTH / TGH compressor, world's 1st oil free magnetic bearing compressor optimized for higher lift applications

2020

TGS490 compressor, world's 1st oil free magnetic bearing compressor using low GWP, non-flammable R515B

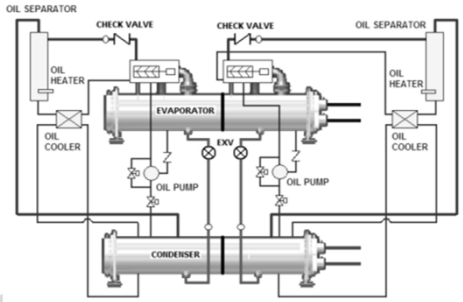
VTX compressor up to 450 tons for high efficiency, large capacity oil free chillers

The benefits of Oil-Free Compressor Technology

vs Oiled Compressors

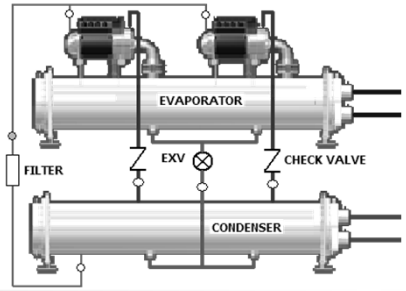
Reduced Complexity

Oiled system



vs

Oil-free system

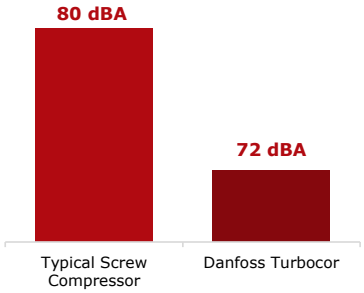


High Efficiency vs Screws

Up to 40% improvement in part load efficiency (IPLV) vs traditional fixed speed screws

Quiet Operation vs Screws

- Up to 8 dBA quieter vs typical screw compressor
- No expensive sound attenuation required
- No pure tone noise effect in 1/3 octave bands



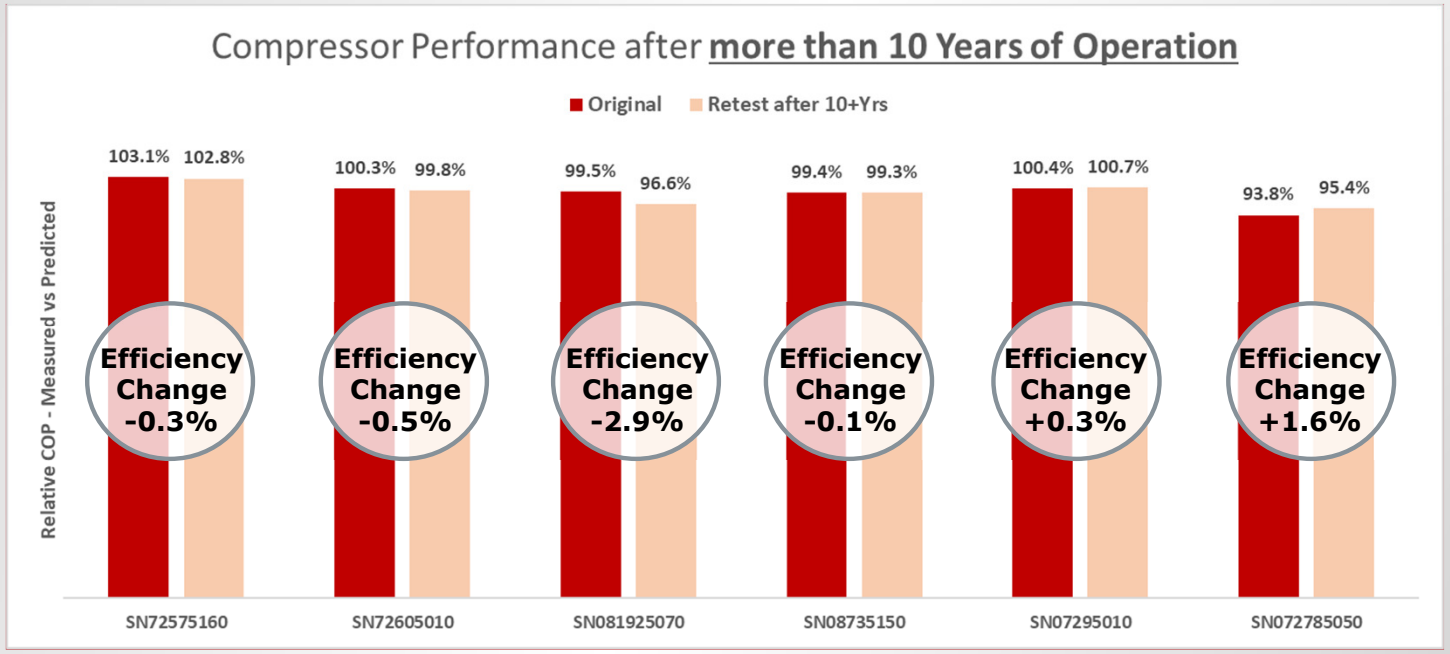
Less Maintenance

Required Maintenance	Frequency
Check Oil Pressure	Daily
Check Oil Level	Daily
Oil Filter Change	Twice/year
Conduct Oil Analysis and Submit to OEM	Quarterly
Inspect and Confirm Oil Pump Operation	Every Week
Inspect Oil Sump Heaters	Every Week
Oil Change	Annual
Inspect Oil Sump Strainers	Every 5 years
Acidity Test on Oil	Annual

Danfoss Turbocor® Advantages

Consistent Performance over the Lifetime

- No Variation Above Any Measurement Uncertainty!!!
- Turbocor® Magnetic Bearing Compressors Means No Wear In & No Wear Out

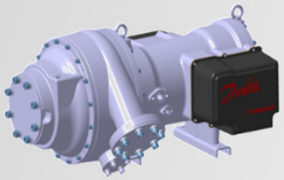


Measurement error +/-3%

Danfoss Oil-Free Compressor Technology

Dynamic Compression 'Lift' Defined

- Lift – Temperature difference between Saturated Suction (SST) and Saturated Discharge (SDT)
- Three main groups with application overlap



Standard

Up to 50°C

~32 K design (~57F)

~42 K max (~76F)

Down to ~4°C

Applications:

- Water-cooled chillers
- Evap-cooled chillers

Compressors:

- TTS400, TTS700
- TGS390, TGS520
- VTT1200
- VTX1600

Medium

Up to 63°C

~42 K design (~76F)

~57 K max (~103F)

Down to -10°C

Applications:

- Air-cooled chillers
- Water-cooled chillers
- Evap-cooled chillers
- W-W heat pumps
- High-temp process

Compressors:

- TTS300, TTS350
- TGS230, TGS310, TGS490

High

Up to 69°C

~55 K design (~99F)

~65 K max (~117F)

Down to -18°C

Applications:

- Air-cooled chillers
- W-W heat pumps
- A-W heat pumps
- Med-temp process
- Thermal storage

Compressors:

- TTH375
- TGH285

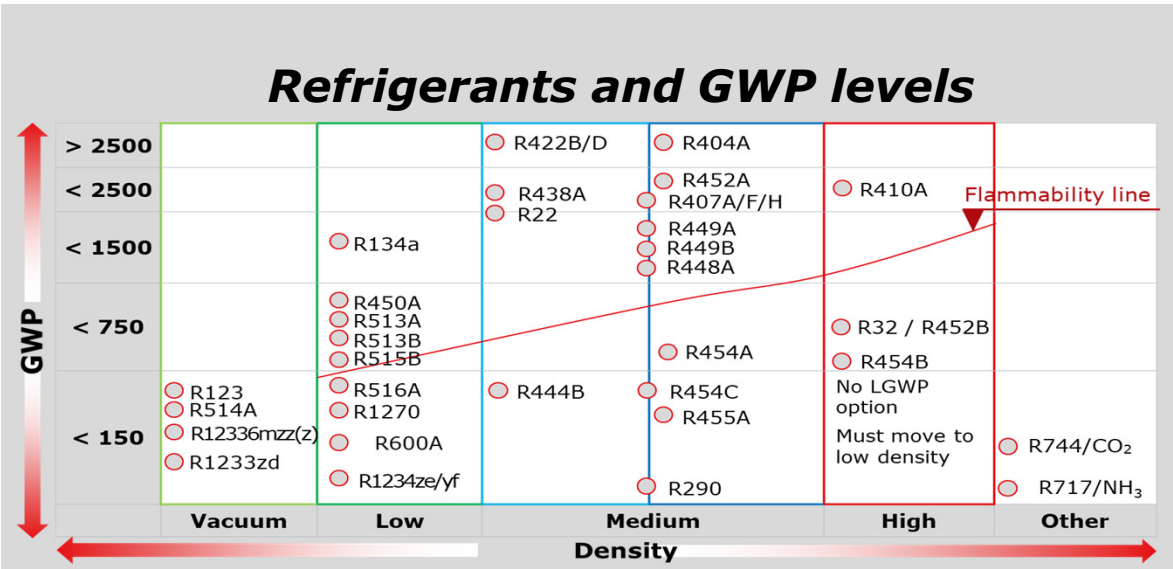
Oil-Free Technology

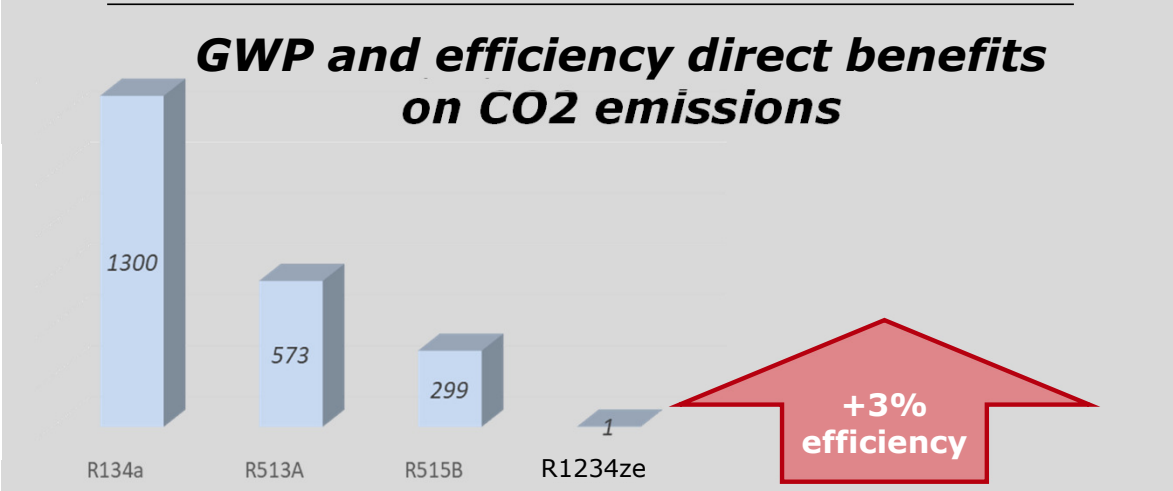
Environmental Benefits

Low and ultra-low GWP

- R513A
- R515B and R1234ze
- Result in reduction of direct CO2 emissions

A1 and A2L safety classifications

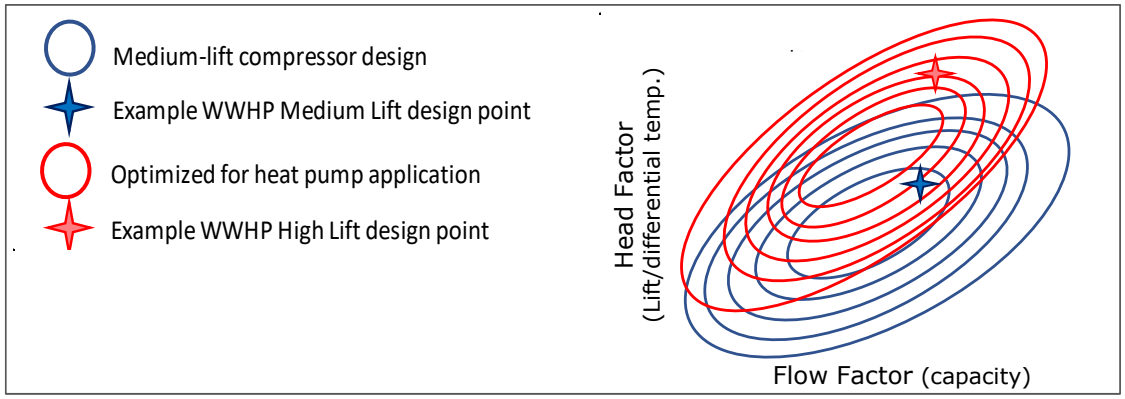


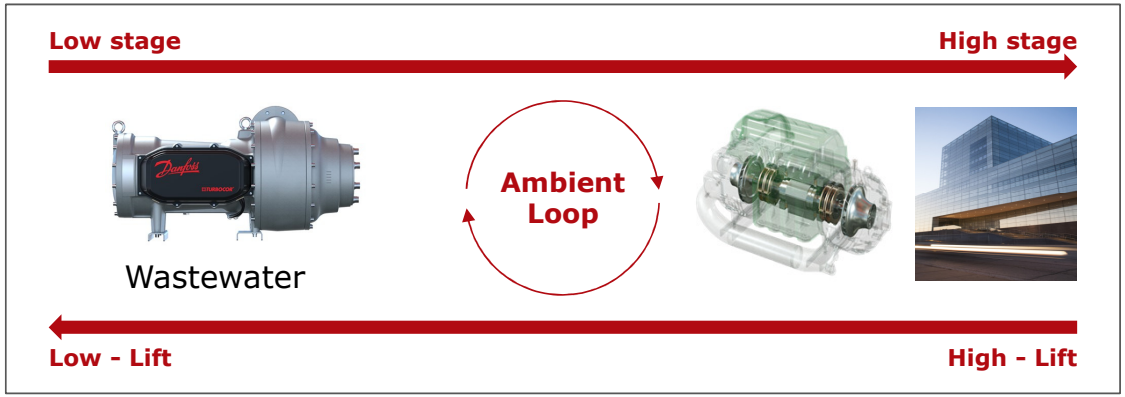


Oil-Free Compressor Technology

Optimized Performance for Various Applications and Requirements

- Two different compressor designs required for Ringsted performance
- Different temperature capabilities & optimization (closer to center = more efficient)
- Portfolio flexibility is critical
- Alternative (5th Generation of District Heating) system concept, utilizing low-lift & high-lift combination





Critical Refrigeration Components – Designed for Oil-Free Operation

EXVs Main, economizer, staging, load balance. Oil-free qualified

ETS/KVS

ETS-C

ICM

Sensors & System Protection
Temperature & pressure sensors, switches, transmitters & relief valves

PT1000

P110

AKS

ACB

KP

Danfoss Cloud Services

Remote Monitoring & Service Tools
Ensure reliable & efficient operation & service productivity

What we have today

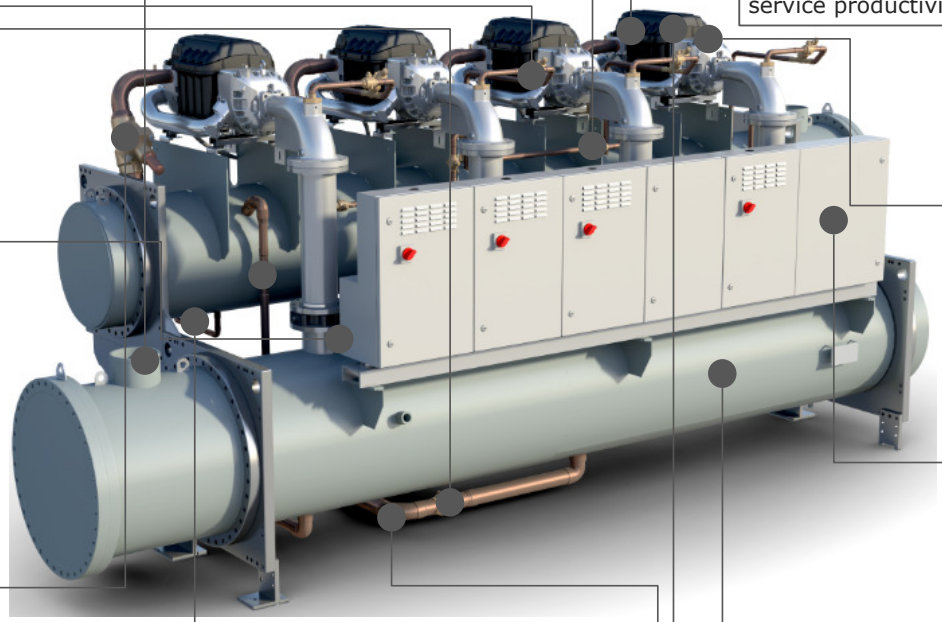
What's coming soon

Microplate heat exchanger (MPHE), for modular and/or economizer. Medium pressure refrigerant-optimized and low approach

Dimple plate

MPHE

Medium pressure refrigerant-optimized



High efficiency Turbocor© oil-free centrifugal compressors: standard and high lift, optimized for HFC & HFO

TGS

TTS

TTH/TGH

Optimized

Electronic controls
Subsystem and unit-level with pre-configured application code

MMIGRS

MMITSC

MMILDS

MCX152V

Check & Ball valve
Isolation & prevent backflow. Oil-free qualified, minimized pressure drop

CHV

SCA

GB

Solenoid valve
Liquid line shut off. Oil-free & medium pressure refrigerant-qualified

EVR 2-22

EVR 25-40

Filter Drier / Sight Glass
Safe operation with all refrigerants

SGP

DCR

Level Sensors
Accurate liquid level measure. Oil-free qualified

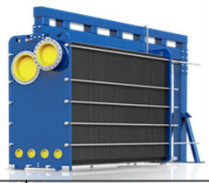
AKS 4100

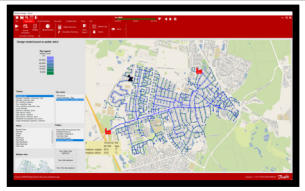
Inverter Drives
Integrated compressor & standalone hydronic and fan control

VLT

Critical Hydronic Components – Real-Time Optimization

Hydronic Heat Exchangers
Heavy duty, efficient heat transfer for energy reuse





Supply temperature optimization in DHC networks

DP optimization in networks / lower pumping costs and dT improvement

Optimization tools for DC networks

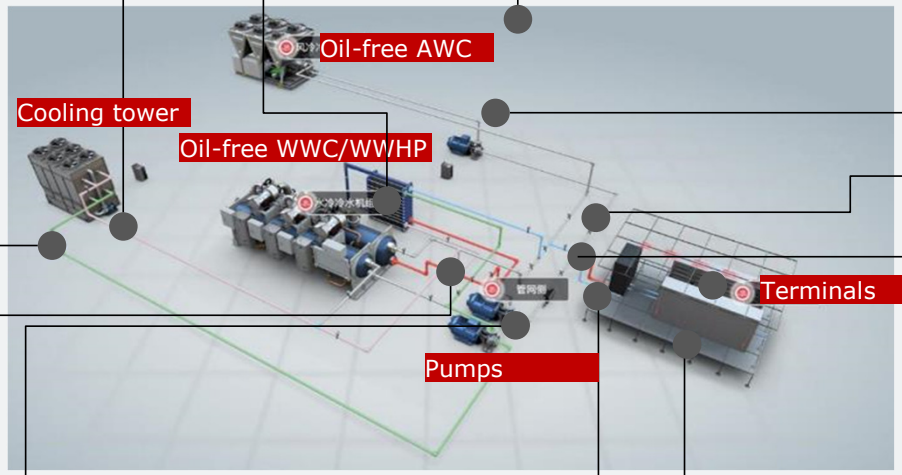
Leanheat Production Leanheat Network + Virtus iNET

Δp relief control
Placed in a bypass of pumps to achieve protection through limiting of max differential pressure
AVPA/AFPA

Precise control of cooling network
Precise control of chilled water with PICV enabling perfect control and effcient operation
AFQM, AFQMP

Cooling tower control
Precise control of cooling water from cooling towers
VF3/ VFY

Active pressure optimization of colling network
Precise control of cooling water from cooling towers
iNet, iSet



FVF & FVR **Strainers**
(cast iron & brass)
DN15-300; t:-10°C +300°C

BRV **Ball valves**
(Brass)
DN15-300; t:-20°C +120°C

VFY **Butterfly valves**
(with Manual gearbox and Electric actuator)
DN25-600; t:-10°C +120°C

NVD **Non-return valves**
(brass, cast iron or SS)
DN15-600; t:-10°C +100°C

Air-vents
(Brass)
DN10-15; t:0°C +110°C

All products are high-runners in HVAC applications

Water flow control Motorised valves or PICV with electical actuators

For precise flow control of water flows in cooling systems

AMV/E 65x, 55, 855, 20/23, ...

Rotary mixing valves and actuators
Maintining a chosen minimum temperature through a mixing loop

ECL comfort temperature control
Weather compensation & heat/cold transfer control on a heating/cooling substation.
ECL 210/310/296

Accessories
- Temp. sensors (PT1000)
- Room units

Safety temperature monitor
Controller closes on rising temperature and has a spring that ensure the valve closes if the thermostatic sensor malfunctions
STM

Q&A

Thank You!

Drew Turner

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