Optimized Scroll Compressor for Green Heat Pump Unit in Retrofit Buildings

Bachir.Bella@emerson.com

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The GreenHP Partners

Austrian Institute of Technology, Project Coordinator

Emerson Climate Technologies GmbH, Germany

Fraunhofer Insitute for Solar Energy Systems, Germany

AKG Group, Germany

Royal Institute of Technology, Sweden

Ziehl-Abegg, Germany

European Heat Pump Association, Belgium

Gränges AB, Sweden

Hesch Schröder GmbH, Germany

Project Info

- **Description**: The GreenHP project investigates a new highly efficient heating system based on high-capacity air/water heat pumps for retrofitting multi-family houses and commercial buildings in cities.

- **Targets**: The project aims at developing a new system level (interaction with electric grids, other energy systems and different system components) as well as a new heat pump unit and component units (refrigerant, compressor, evaporator, fan and air duct, condenser)

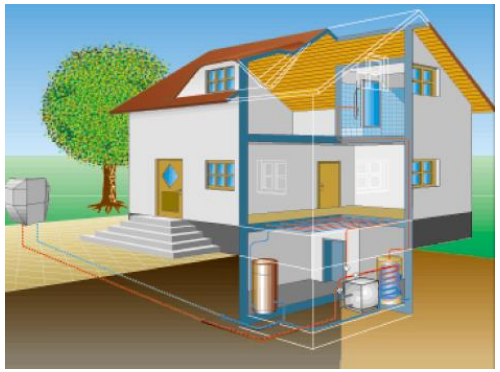
Application
Heat Pump Unit for large retrofitting buildings in average climate
System: Air/water output up to 100 kW

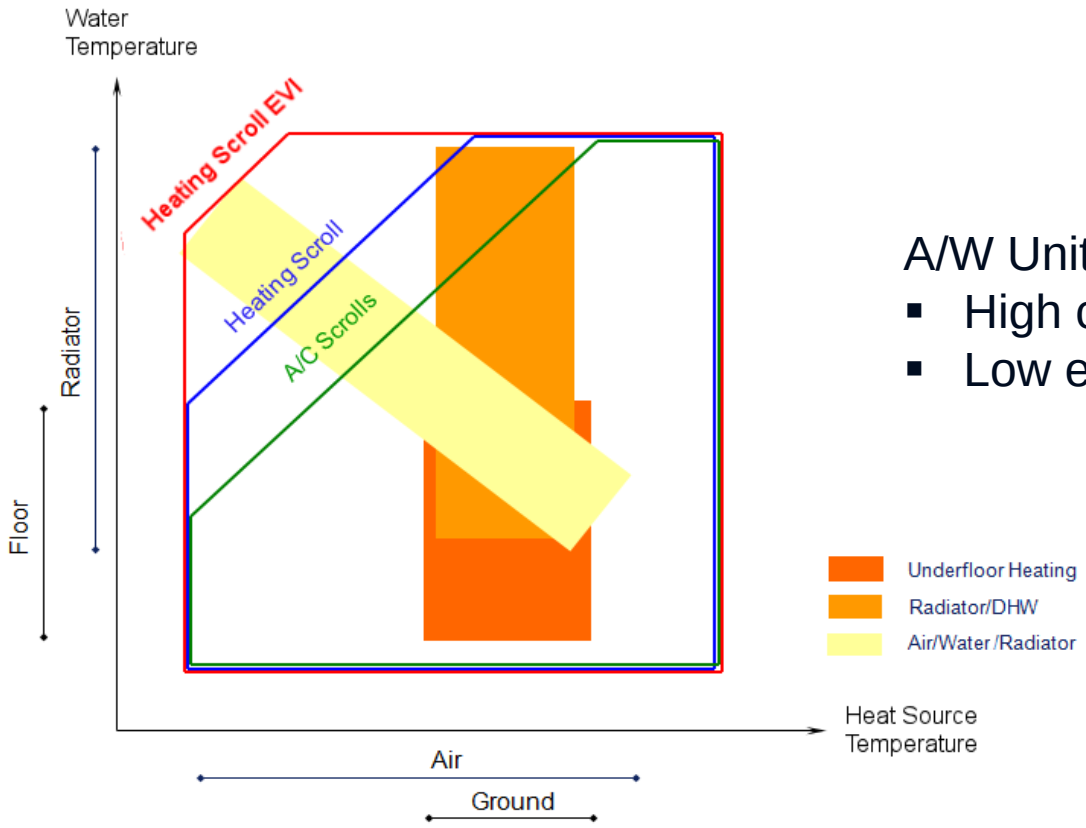
High Efficiency Prototype
Heating capacity 30kW at (A -10/W 55)
Capable of water heating up to 65° C
COP (A7/W55) ≥ 3.5
SCOP* ≥ 3.1

Low GWP refrigerant with Charge target 1 kg
GWP < 150
High Efficiency
Reduced Oil charge in the compressor

Air/Water and Water/Water Heat Pump

Radiators & Underfloor Heat Distribution





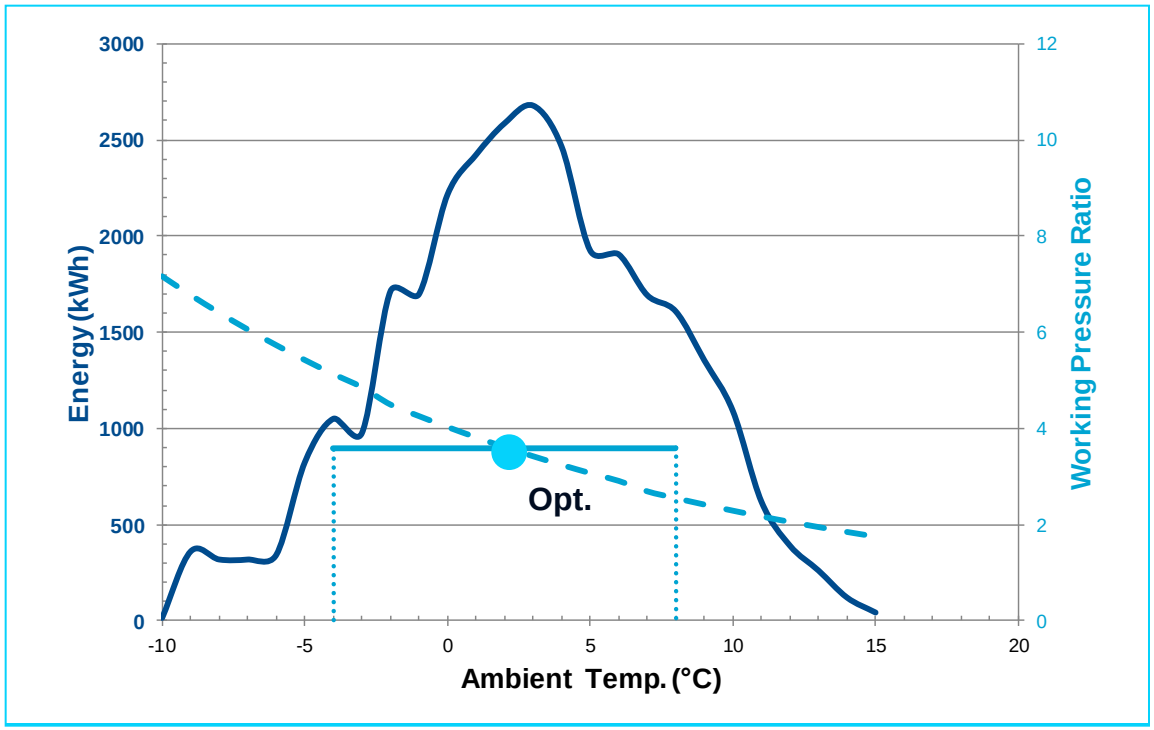
A/W Unit for retrofit require both:

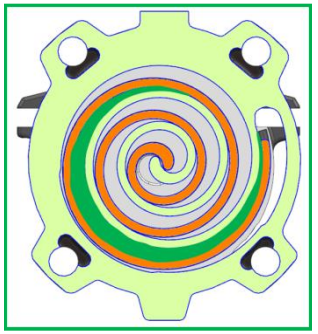
- High condensing temperature
- Low evaporating temperature

- **A/C Scroll: ZR/ZP**
- **Heating Scroll: ZH**K4E**
- **Heating Scroll EVI: ZH**KVE**

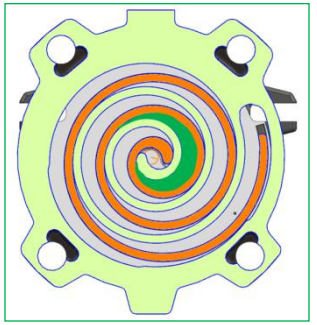
Compressor Design

Scroll Design





V_i Compression Start



V_f Compression End

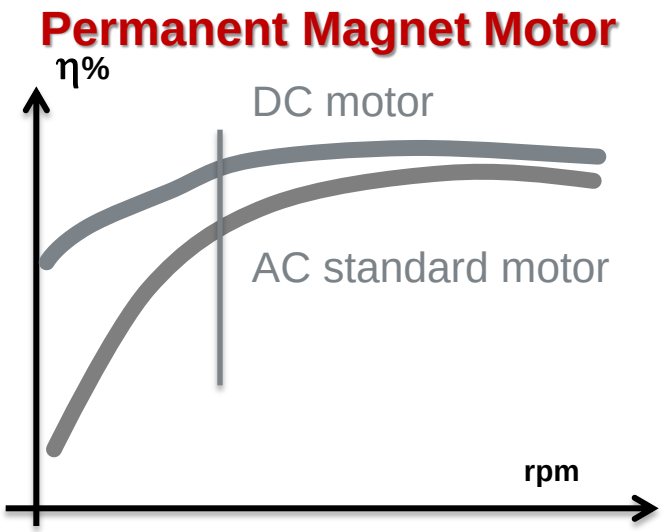
$$BIVR = \frac{Vi}{Vf}$$

- Heating Energy weighted to operation hours according to EN14825
- Compressor working pressure ratio varying with ambient Temperature:
  - Pressure ratio P.R. = 3.6 results in Optimized BIVR design for SCOP

- 30 kW Maximum Heating Load at A-10/W55 (-18 ° C Evap./58° C Cond.) determines a Displacement of 96 cc

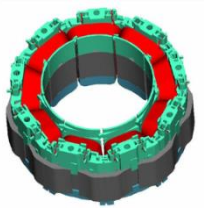
Optimization elaborated for average climate

Compressor Design
DC motor Variable Speed



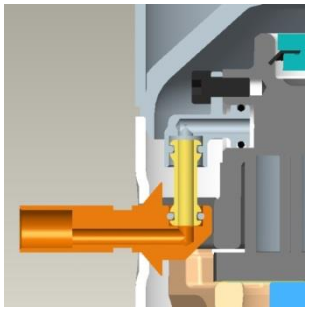
- More efficient over a large speed range
- Some efficiency decrease at full load related to inverter losses
- Requires special design consideration:
  - Inverter generates electro-magnetic interference (EMI)
  - Necessitates piping circuits to ensure Oil return
  - Requires special consideration to avoid resonances
  - Oil delivery required for speeds less than 2400 rpm

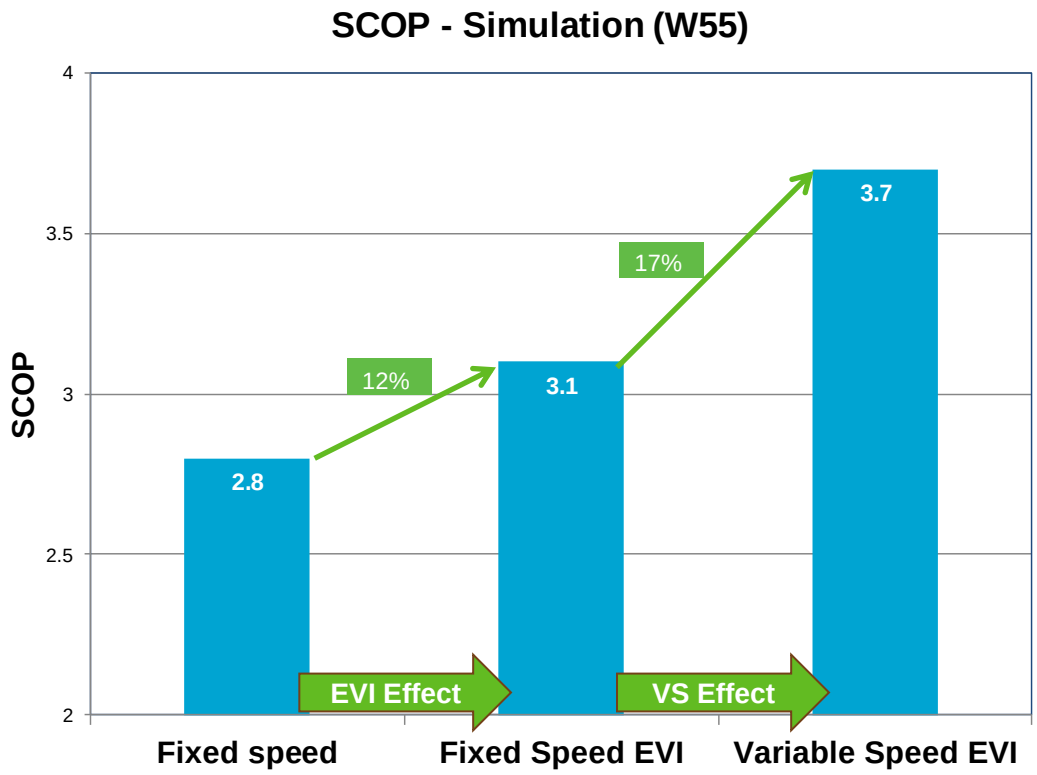
- DC Motor with higher Efficiency over a wide range
- Speed range 1800-7200rpm (30-120Hz)



Compressor Design

Variable Speed and EVI Benefits for SCOP



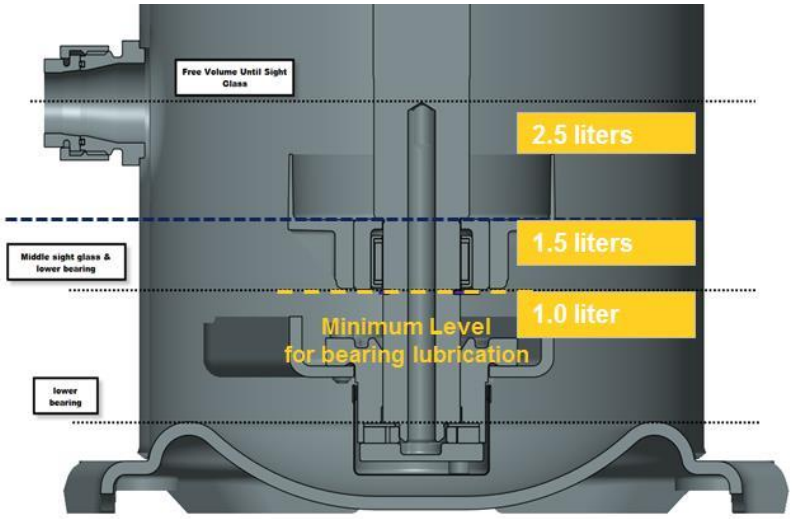


- EVI (Enhanced Vapour Injection) Gives +12% SCOP
- with Variable Speed another +17% SCOP
- (Variable Speed) + (EVI Scroll) give an increase of +30% in SCOP

Simulation elaborated with R410A

Compressor Design
Oil Charge Reduction

- Oil charged inside the compressor depends:
  - Internal oil management inside compressor
  - Amount mixed with refrigerant and circulating inside the system
- GHP compressor targeting 1.0 liter (Similar size standard Scroll have 2.5 liters)



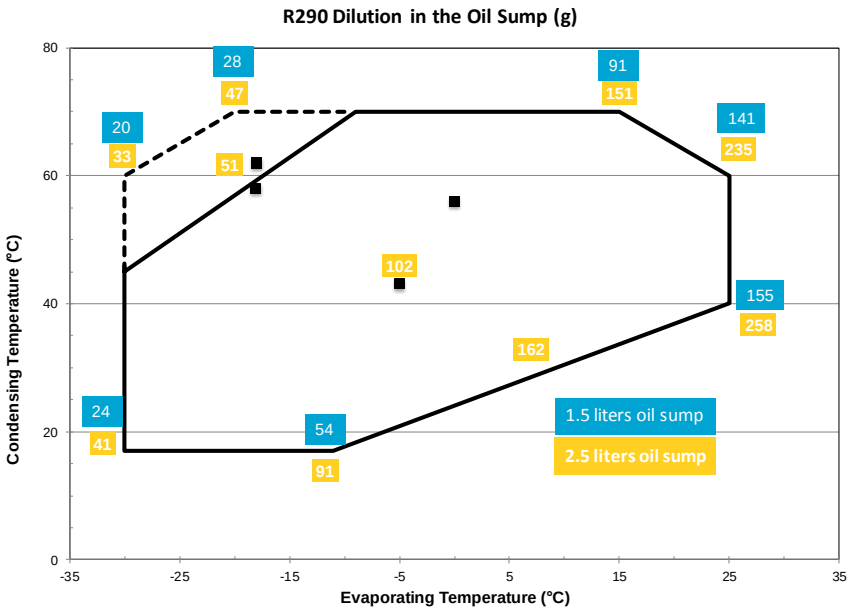
ZHW0961U New design to decrease oil level:

- Lower bearing designed to the lowest position inside the shell
- Optimize Suction gas port position to decrease the oil pump out from the compressor

Minimum oil required is 1 liter, higher charge will be only for system management

Oil Charge Reduction

Impact on Refrigerant Charge



The refrigerant diluted varies with the operating conditions:

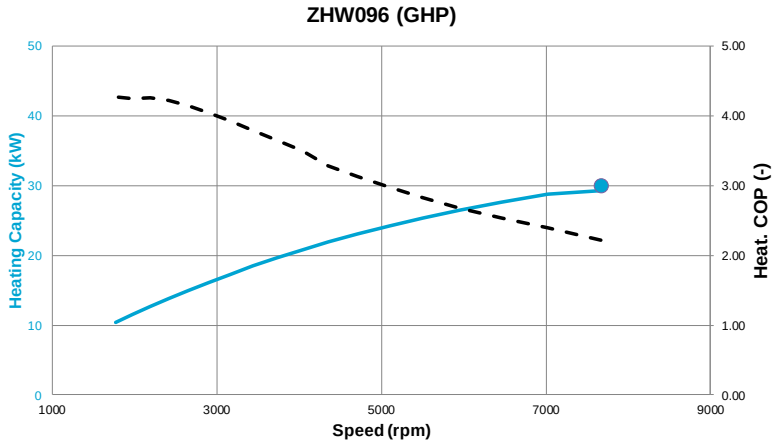
- Higher the evaporating temp., higher is the oil mass diluted
- Lower the evaporating temp., lower is the oil mass diluted
- Lower is the gas return temperature higher is the oil mass diluted

Oil Charge	Refrigerant Diluted in Oil			
	25/40°C	0/56°C	-18/58°C	Oil Reduction
	(g)	(g)	(g)	(%)
2.5 l	258	83	44	-
1.5 l	155	50	27	-40%
1.0 l	103	33	18	-60%

- Refrigerant decreases from 83 g to 33 g at rating Conditions (0/56° C)
- Maximum R290 diluted 155 g w/ 1.5 liters and 103 g w/ 1.0 liter

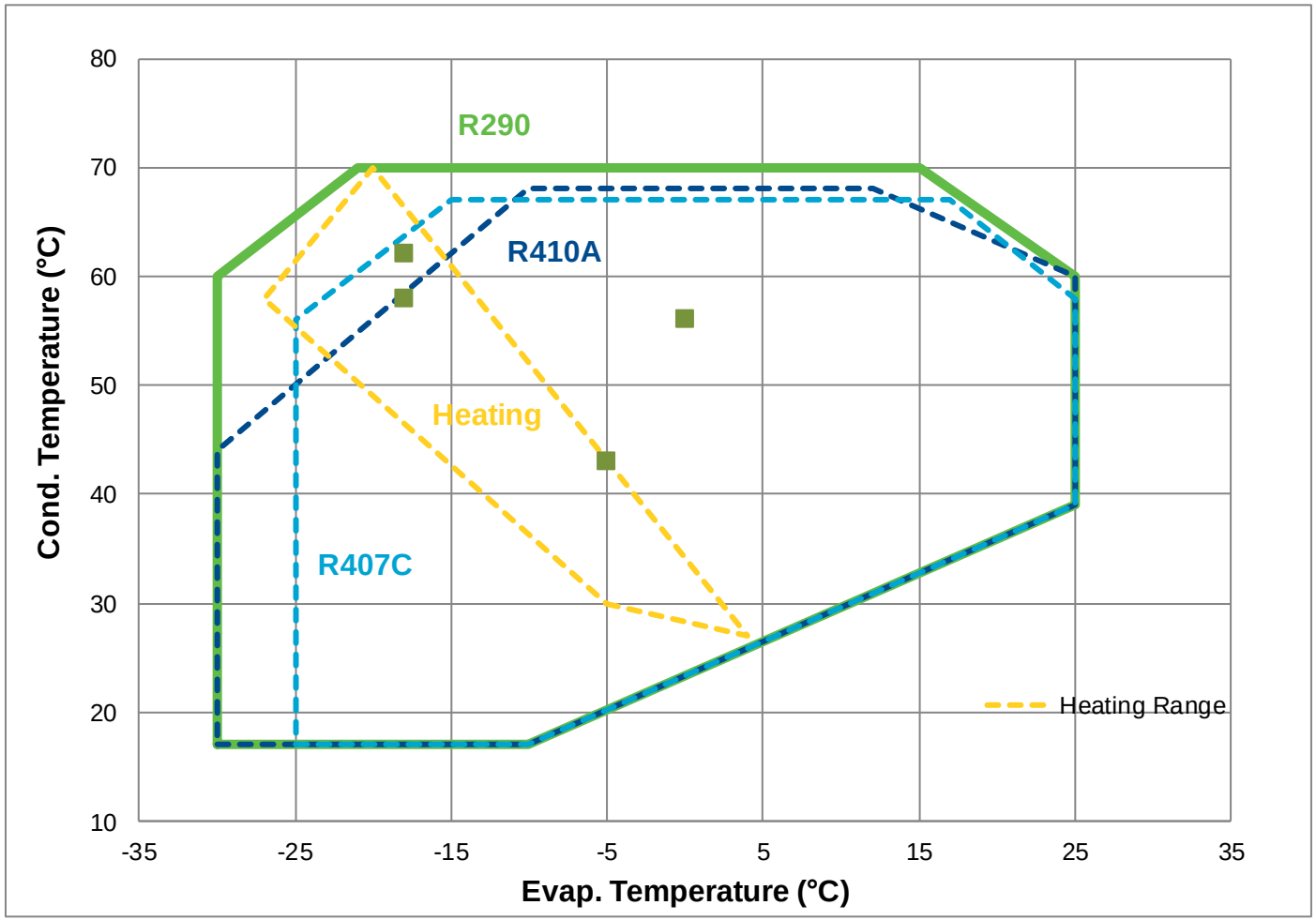
ZHW096 Performances

	Comp. Cond.	Target	Achiev.
Max Heating Capacity	(-18/58°C)	30 kW	28.2 kW
COP (A7/W55)	(0/56°C)	3.50	3.50
SCOP (EN14825)	Avg. Climate	3.1	3.3



Heating capacity and COP calculated according to EN14825 average climate and based on compressor performances

R290 allows to reach extreme conditions



Overview Package R290 Solution

Variable Speed Scroll

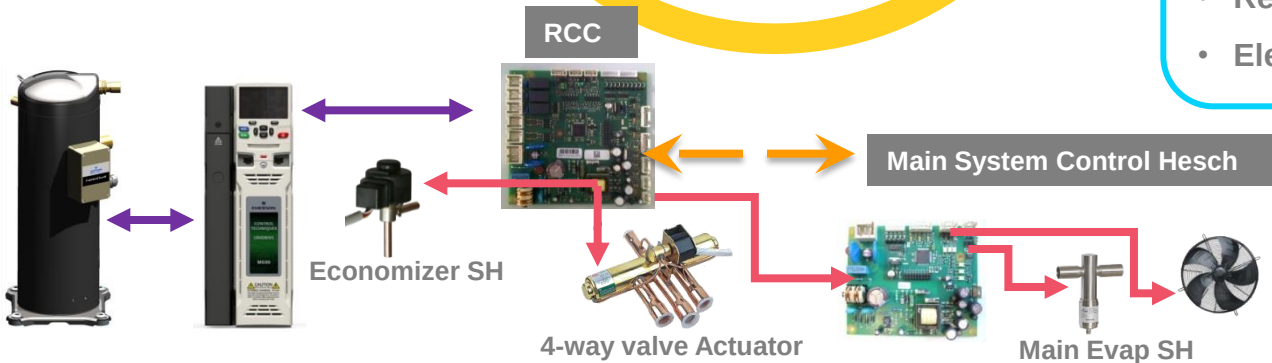
- Range 1800 – 7200rpm
- BPM motor
- High Efficiency
- Drive 18.5kW
- Modbus comunication

Vapor injection Scroll

- Swept volume 96cc
- 30 kW Heating @ -18/58C
- HCOP (A7/W55) = 3.5
- Oil charge ≤ 1.5 liters

System Flow Controls

- Electronic Ref control module
- Refrigerant Circuit controller
- Electronic Alco Exp. Valve



Conclusions

- New compressor design developped for GHP Unit
- Design Optimized to meet GHP Targets:
  - Optimized Scroll Design
  - Variable Speed Technology with BPM motor
  - Oil Charge Reduction

- Results:
  - Combination R290 and Vapor Injection allow high water temperature at extreme conditions (Retrofit heating system)
  - Compressor High Efficiency (SCOP =3.3, HCOP (A7/W55) = 3.50)
  - Oil charge Reduction by at least 40%

Thank you for your Attention !

Contact

Project Coordination

ANDREAS ZOTTL

Engineer

Energy Department

Sustainable Thermal Energy Systems

AIT Austrian Institute of Technology GmbH

Giefinggasse 2 | 1210 Vienna | Austria

T +43(0) 50550-6309 | F +43(0) 50550-6679

andreas.zottl@ait.ac.at | http://www.ait.ac.at