HVACC 4.0 - A Green Field Approach -

Expert meeting
SHC Task 53
Abu Dhabi, 29.10.2017

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TNT (Thomas Noll Technologies)

HVACC 4.0 =
Heating
Ventilation
Air Conditioning &
Chilling (fridges, freezers)
4.0: Smart Grids
Sector coupling

Similar to SHC task 44:
ST and Heat Pumps
Agenda

Personal: About TNT and Next steps
Intro #1: HVAC megatrends, VRF and Comments
Intro #2: Requirements on a future proof HVAC system
HVACC 4.0 #1: Thermal management and Description
HVACC 4.0 #2: Chiller process and Description
HVACC 4.0 #3: Difference to SHC task 53 and DG 4G
Results: Efficiency improvement potential and Carbon footprint
Summary #1: Business model and driving forces
Summary #2: Review of requirements on a future proof HVAC system
Annex: Shortcuts and Literature
HVACC 4.0
Personal #1: Curriculum vitae

1954: Born 14.5.54 in Frankenthal/Pfalz (Germany)
1987: PhD in Physics @ Univ. Kaiserslautern
1988: Post-Doc (Univ. Kaiserslautern)
2011-2014: Leader Task 1 of „Enlight“-Projekt
2014: Enlight Innovation Award
2014-2017 Passive phase of early retirement
9/16-today: Patent application and founding easy-tnt
Introduction #1
HVAC megatrends: Summary

Megatrends:
• (Extra) Low temperature District Grids (≥4G) for heating and cooling

Managing the energy transition:
• Phase out firing Hydrocarbons by 2050
• Sector coupling: Electricity, Traffic & HVAC
• Smart electric grid coupled to thermal DG

Regulations for Heat Pumps:
• Ban of F-gases with GWP
e.g. R404A, R422, R227ea,…
  > 150: mobile chillers 2020
  > 2500: service stop 2020
  > 150: Central > 40kW 2023
  > 750: mono split < 3kg 2025
**HVAC megatrends** (Ochsner, heat summit, Cologne, 20.11.17)

“Simultaneous” heating & cooling (VRF)

**Heizen & Kühlen**

**Gleichzeitig**

'Bisher'

**Ziel**

Winterbetrieb  
Heizen

'Ziel'

Sommerbetrieb  
Kühlen

'Store heat'

'Evaporator'

'Source: [O17]'
HVAC megatrends

VRF: Separating facts from fictions

- Strongly promoted as „The future HVAC-technology“.
- Simultaneous H&C @ HP only in case of Classic VRF - with usually >> 3kg refrigerant - and use of special indoor units.
- No simultaneous H&C @ HP in case of water based systems, only “toggling source and sink” between “Hydrobox” and “outdoor device”.
- Simultaneous H&C @ consumers only in case of additional hot & cold BS serving circuits for space heaters & coolers.
- Mainly air based systems -> high $T_w$ and low $T_c$.
- Not suitable for DHW.
- No storing of excess heat/chillness in BS, but in contrast to HVAC C 4.0 release to environment.

**Source:** Yanmar

**VRF System Market** worth 22.79 Billion USD by 2023

**Source:** Bauherrenwissen

**Source:** van der Hoff/TripleAqua
Introduction #2
Requirements on future proof HVAC systems

Legal & Design goals
- Focus on RE
- Compliance F-gas regulation
- Scalable
- Overcome paradigms Apply Triz
- System simple and reliable

Cost & efficiency
- Efficiency first
  - low carbon footprint
- Fulfill future Eco design requirements

(Technical) Capabilities
- Acceptable RoI
  - even w/o funding
- Heating & Cooling (no VRF)
- Including PV and chilling
- Building Stock DG
- 100% heat recovery from used air
- Ease of control
- SG ready LT-Heat, chillness, electricity
HVACC 4.0
Thermal management and functional blocks

**H&C circuits:**

**Heating:**
- Radiators (W)
- DHW (S/W)

W: \( T_{\text{supply}} = 40^\circ \text{C} \)
S: \( T_{\text{back}} = 30^\circ \text{C} \)

**Space heating (W):**
- FH, Radiators
- Fresh air (AC)

**Space cooling (S):**
- FH, Radiators
- Fresh air (AC)

S: \( T_{\text{supply}} = 10^\circ \text{C} \)
W: \( T_{\text{back}} = 20^\circ \text{C} \)

**Heat recovery (W):**
- Used air (AC)
- Waste water
- Supercooling
- De-Superheating

\( \Delta T = 20^\circ \text{C} \)

**Collector cascade (KV):**

- Output (S@D):
  - Unglazed collectors e.g. ACPV, SPC, ELT
  - 8a, 8b, 8c

- Input (S @ D&N):
  - Unglazed collectors

- Output (W@D & S@N):
  - ELT-collectors

- Output (W@D):
  - ELT-collectors

- Input (W@D):
  - ELT-collectors

- Output (W@D):
  - Unglazed collectors

D=Day; N=Night

**Daily storage 3**
for „thermally useless medium“

S: 30…>70°C
W: 40…60°C

**TMD #1**
S: 10…30°C
W: 20…40°C

**TMD #2**

S: 5…10°C
W: 0…20°C

S=Summer; W=Winter

**PSV with PSK**
**HVACC 4.0**

**Thermal management: Description and what is new**

The “heart” of HVACC 4.0 is the buffer storage cascade PSK, consisting of preferably three hydraulically coupled storages BS1, BS2 and BS3 with predefined temperature profiles, which are seasonally different. They range from about 70°C on top of BS1 in summer and may fall below -20°C in BS3 in winter by the action of TMD#2. BS2 is designed as a daily storage for chillness, which is needed for operation of water and air based chillers and optionally for active PV cooling. The size of BS2 for AC should be ±3500 l for a 100m² building @ 100kW/a*. BS2 could be e.g. a modified oil tank in the building stock, if refurbishment of the heater system is necessary.

The PSV is basically identical with the PSK, but includes additional, preferably PSK-integrated components like HEX for energy exchange with collectors of the KV and condensers & evaporators of TMD#1/2 (not shown). The two TMDs work like heat pumps with the difference, that in a first step there is no dissipation of waste heat or chillness to ambient like in case of water based VRF. And they are only active if the KV is not able to maintain the desired T-profiles in the PSK. In difference to SotA, the T-lifts are low (<30°C), resulting in high COP and EER. For each °C the KV or the DG lifts T(BS2) above 5°C in winter (=T_{Brine}) or lowers T(BS2) below 40°C in summer (=T_{T outside}=30°C), the efficiency is 3% ahead of a brine-water HP or an air based chiller.

The PSK acts as heat and chillness source for serving the H&C circuits for space heating and cooling. Radiators are supplied with hot medium from top of BS1 and floor heaters with medium from top of BS2. The backflow of thermally useless medium ends in the middle part of BS2.

BS3 is the source for HEX like e.g. for heat recovery from used air in winter and waste water. Boosting efficiency above 100% if T(BS1) is below T_{outside}, which is much ahead of SotA (<80%). Other examples are HEX for heat recovery from superheated compressed refrigerant via DSH and from condensed refrigerant via SCD, refer to slide 10.

The PSK may be coupled to a 4G DG, which is operated between 50...60°C for heating. Alternatively, a new heating & cooling 5G DG, refer to slide 13, could be designed with two pipes operated @ a ΔT of 20°C by exchanging medium from the top resp. bottom of BS2 with the DG. This may be done in summer @ 30/10°C and in winter @ 20/40°C as consumer, producer or prosumer of energy.

The KV consists of different types of preferably unglazed ST collectors like Actively Cooled Photo Voltaic collectors ACPV, cheap Swimming Pool Collectors SPC, or new collectors designed for Extra Low Temperatures ELT, which are not explained here.

ACPV collectors are basically modified PVT-collectors with an additional evaporator on the back side, allowing 8 different operation modes, refer to the table below. The most important ones are evaporation of excess refrigerant in winter and regenerative cooling of BS2 over night.

Unglazed collectors are preferred over glazed ones due to their ability to boost the collector efficiency >100% if T_{input} < T_{outside}. In summer and during night, BS2 is chilled down to 10...25°C, depending on the climate zone. Like in SHC task 53, this is done mostly regeneratively. The cooling power is boosted by the NRC-Effect @ a cooling power 50...100W/m² allowing EER values up to 60 [POK15].

<table>
<thead>
<tr>
<th>#</th>
<th>Task</th>
<th>BS</th>
<th>8 hybrid operation modes (ext. to SotA PV1)</th>
<th>Day/Night</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>3</td>
<td>Evap. of excess refc (M3) (in cold regions)</td>
<td>D+N</td>
<td>Wi</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
<td>2/3</td>
<td>RE cooling utilizing air cooling + NRC effect</td>
<td>N</td>
<td>Su</td>
</tr>
<tr>
<td>3</td>
<td>H</td>
<td>2</td>
<td>Boosting COP by rising T_{cold} &gt; T_{Brine}</td>
<td>D</td>
<td>Wi</td>
</tr>
<tr>
<td>4</td>
<td>H</td>
<td>1</td>
<td>WW-production (T&gt;50°C)</td>
<td>D</td>
<td>Su+Wi</td>
</tr>
<tr>
<td>5</td>
<td>PV</td>
<td>2/3</td>
<td>Maximize PV output by active cooling (M2)</td>
<td>D</td>
<td>Su</td>
</tr>
<tr>
<td>6</td>
<td>H</td>
<td>J</td>
<td>Preheat outside air for AC</td>
<td>D</td>
<td>W</td>
</tr>
<tr>
<td>7</td>
<td>C</td>
<td>2/3</td>
<td>Active cooling by evaporation of refrigerant</td>
<td>N</td>
<td>Su</td>
</tr>
<tr>
<td>8</td>
<td>PV</td>
<td>1/2</td>
<td>Max. PV output by evaporation of refrigerant</td>
<td>D</td>
<td>Su</td>
</tr>
</tbody>
</table>
HVACC 4.0
Chiller process: Log p(h)

Cycle:

1. Evap#1 (no overheating needed): T in °C
   4°, 1°: 10
2. Comp#1 (15°C Superheating): 55
3. De-Superheating (via DSH-Device): 7b 41
4. Cond#1 (SC 30°C via SCD): 7a 10
5. Comp#2 (15°C Superheating): 85
6. Cond#2 (SC 60°C via SCD): 7a 10

Formulas:

\[ \text{COP} = \frac{Q_h}{P_v} = \frac{h_2' - h_3'}{h_2' - h_1'} = \frac{T_w}{T_w - T_k} \]

\[ \text{EER} = \frac{Q_c}{P_r} = \frac{h_1' - h_4'}{h_2' - h_1'} = \frac{T_w}{T_w - T_k} \]

Efficiency improvement potential:

<table>
<thead>
<tr>
<th>T-Hub</th>
<th>Definition Enthalpie (kJ/kg)</th>
<th>Definition Tw/Tk °C</th>
<th>COP/EER für R1234yf (Fig. 3a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enthalpie [kJ/kg]</td>
<td>Tw/Tk</td>
<td>°C</td>
</tr>
<tr>
<td>h_1'</td>
<td>371 Tk (PS3)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>h_2'</td>
<td>406 Tw(PS2)</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>h_3'</td>
<td>357 Tw(PS1)</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>h_2''</td>
<td>424 T_fre (PS1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h_3', h_3', h_4'</td>
<td>214 2°-2° EHS/NGK -&gt; PS1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h_1'</td>
<td>253 SCS Kond. 1 (hK1-h3')</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>h_2'</td>
<td>248 SCS Kond. 2 (hK2-h3')</td>
<td>34</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>T-Hub</th>
<th>Definition Enthalpie</th>
<th>Definition Tw/Tk</th>
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<tbody>
<tr>
<td></td>
<td>°C</td>
<td>EER</td>
</tr>
<tr>
<td>10°-70</td>
<td>2,96</td>
<td>3,96</td>
</tr>
<tr>
<td>10°-40</td>
<td>4,49</td>
<td>5,49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COE für T-Hub</th>
<th>COE ber.</th>
<th>COE/EER</th>
<th>Std</th>
<th>Potenzial</th>
</tr>
</thead>
<tbody>
<tr>
<td>ηWP 10...70</td>
<td>69%</td>
<td>134%</td>
<td>45%</td>
<td>54%</td>
</tr>
<tr>
<td>ηWK 10...40</td>
<td>53%</td>
<td>122%</td>
<td>45%</td>
<td>17%</td>
</tr>
<tr>
<td>ηKMK 10...70</td>
<td>52%</td>
<td>122%</td>
<td>33%</td>
<td>51%</td>
</tr>
<tr>
<td>ηKMK 10...40</td>
<td>43%</td>
<td>134%</td>
<td>33%</td>
<td>32%</td>
</tr>
</tbody>
</table>
HVACC 4.0
Chiller process: Description

The process can be best described by looking at the log p(h) diagram as shown for e.g. R1234yf with a GWP of 4. Once the process is defined via the points 1'…4', the enthalpies h1'…h4' can be taken as readings from the x-axis. COP, EER and the efficiency \( \eta_{HP} \) of the heat pump and \( \eta_{CM} \) of the chiller can be calculated straightforward using the formulas shown. The following specific features are worth mentioning:

1. There is a 2-stage compression process 1'→2' and 2''→2'''.
2. Compressor #1 enables a T-lift of \( \geq 30^\circ \text{C} \) from e.g. 10\(^\circ\)C, which is the upper temperature in BS3, to 40\(^\circ\)C, which is the upper temperature in BS2 in winter. This T-level is needed for operation of e.g. floor or wall heaters.
3. Compressor #2 enables a T-lift of \( \geq 30^\circ \text{C} \) from 40\(^\circ\)C, which is the upper temperature in BS2, to 70\(^\circ\)C, which is the upper temperature in BS1. This T-level is needed for DHW production and operation of radiator heaters.
4. Between the 1st and 2nd compression De-Superheating (DSH) takes place \( [7a] \) by means of a HEX, which is supplied with medium of 40…45\(^\circ\)C from BS1. This “sequential cooling” allows to store „high value heat” of 19 kJ/kg in BS1 instead of BS2 and reduces the work of TMD#1 in winter.
5. If condensation takes place @ 40\(^\circ\)C in BS2, subcooling \( [7b] \) is from 40→10\(^\circ\)C with a heat release of 34 kJ/kg. If condensation takes place @ 70\(^\circ\)C in BS1, subcooling is from 70→10\(^\circ\)C with a heat release of 79 kJ/kg. Compared to SotA, where subcooling is typically <5\(^\circ\)C, the PSV concept allows strong subcooling close to 0\(^\circ\)C - or even lower if the medium in BS3 is with antifreeze - due to the availability of cold medium in BS3.
6. The thermal energy is exchanged in a liquid-liquid HEX, which is preferably integrated in BS3. While the released heat is stored in BS3, cooling the refrigerant increases the cooling power and lowers the risk of flash gas formation, which should not happen in the tubing of liquid refrigerant. In addition, heating of BS3 helps to avoid freezing of the medium by the action the evaporator of TMD#2.
7. As a consequence, flash gas formation, which would be up to 50% w/o subcooling, can be totally avoided. This is the reason for the much higher EER, where the difference h1'•h4' is in the nominator of the EER formula.
8. Strong subcooling \( [7b] \) is essential for refrigerants like HFOs and natural refrigerators like R433A, where the liquid-vapor curve has in the relevant pressure range often “flat shape”, especially if condensation takes place @ high temperatures close to the triple point.
9. In contrast to SotA, there is generally a pressure drop of \( \geq 0.5 \) bar in the evaporator necessary as driving force for refrigerant 
   flow \[SBT0x]\, in case of HVACC 4.0 evaporation takes place preferably in an “evaporator spiral” located inside BS2 or BS3 and with a much higher cross section as e.g. in plate HEs. The evaporation process is therefore mostly isobar.
10. In contrast to SotA, where an overheating of typically 5\(^\circ\)C is needed to avoid a compressor damage due to liquid refrigerant \[Vi11]\, in case of HVACC 4.0 at the point of evaporation the compressor is „far away” and will heat up anyway in the tubing.
11. As can be seen in the table, the efficiency of the heat pump \( \eta_{HP} \) is increased between 17%…54% if compared with an anyway efficient brine-water HP with \( \eta_{HP}=45\% \ [Zo09] \). In case of anyway efficient water based chillers with \( \eta_{CM}=33\% \), \( \eta_{CM} \) is increased between 32%…59%. The efficiency improvement potential is higher for the higher T-lift due to the additional savings from DSH \( [7a] \) and the higher supercooling \( [7b] \). In absolute values, the efficiency \( \eta_{HP} \) of the heat pump is 69%, and \( \eta_{CM} \) of the chiller is 52%. Both would be world record for cost optimized domestic applications.
12. Further optimizations of the COP and EER should be possible, if the refrigerant is a zeotropic mixture of HFOs or a HFO with other HFC like R452 and R454, so that the T-glide of the refrigerant is adapted to the T-glide the condenser \[ZBE17]\, which is also preferably located inside BS1 or BS2.
HVACC 4.0
Difference to SHC task 53

In SHC task 53 for solar cooling basically two possibilities are investigated:

1. EER up to 60 if produced over night with unglazed collectors instead 3.5 if produced during day using a PV driven water based chiller
2. Affordable, unglazed collectors + NRC effect (50…100 W/m² free of cost)
3. The price to pay is the more complex PSK and the size of BS2 (daily storage)
   But: Additional active PV cooling is possible

Source: [Mu14]
HVACC 4.0
Difference to DG 4G

4G: 4th GENERATION
Low energy demands
Smart energy (optimum interaction of energy sources, distribution and consumption)
2-way DH

5G: 5th generation extra low temperature DG for heating & cooling of buildings utilizing HVAC 4.0

Summer: $T_{\text{supply}}=10^\circ\text{C}$ -> Cooling
Winter: $T_{\text{supply}}=40^\circ\text{C}$ -> Heating
$\Delta T_{\text{in/out}}=20^\circ\text{C}$

Source: [P17]
HVACC 4.0: Results #1
Efficiency improvement potential

<table>
<thead>
<tr>
<th>Techn.</th>
<th>Mode</th>
<th>Type</th>
<th>Heat source</th>
<th>Twarm</th>
<th>Tcold</th>
<th>ΔT</th>
<th>η</th>
<th>COP/EER</th>
<th>Eff.-Potential</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>SotA</td>
<td>HP</td>
<td>WW</td>
<td>Tssole</td>
<td>65</td>
<td>5</td>
<td>60</td>
<td>45%</td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HVACC 4.0</td>
<td>HP</td>
<td>WW</td>
<td>TBS2</td>
<td>65</td>
<td>12.5</td>
<td>52.5</td>
<td>69%</td>
<td>4.5</td>
<td>76%</td>
<td>10.1%</td>
</tr>
<tr>
<td>SotA</td>
<td>Chiller</td>
<td>AW</td>
<td>Toutside</td>
<td>30</td>
<td>7.5</td>
<td>22.5</td>
<td>33%</td>
<td>4.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HVACC 4.0</td>
<td>Chiller</td>
<td>WW</td>
<td>TBS2</td>
<td>20</td>
<td>12.5</td>
<td>7.5</td>
<td>43%</td>
<td>16.8</td>
<td>282%</td>
<td>18.8%</td>
</tr>
<tr>
<td>SotA</td>
<td>HP</td>
<td>AW</td>
<td>Toutside</td>
<td>65</td>
<td>10</td>
<td>75</td>
<td>35%</td>
<td>1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HVACC 4.0</td>
<td>HP</td>
<td>WW</td>
<td>TBS2</td>
<td>65</td>
<td>10</td>
<td>55</td>
<td>69%</td>
<td>4.3</td>
<td>170%</td>
<td>8.5%</td>
</tr>
<tr>
<td>SotA</td>
<td>Chiller</td>
<td>WW</td>
<td>Triver</td>
<td>20</td>
<td>7.5</td>
<td>12.5</td>
<td>33%</td>
<td>7.7</td>
<td></td>
<td></td>
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<tr>
<td>HVACC 4.0</td>
<td>Chiller</td>
<td>WW</td>
<td>TBS2</td>
<td>20</td>
<td>12.5</td>
<td>7.5</td>
<td>43%</td>
<td>16.6</td>
<td>120%</td>
<td>23.9%</td>
</tr>
</tbody>
</table>

Efficiency improvement potentials:
- Baseline = COP sole-water heat pump: ±76%
- Baseline = EER air based chiller: ±282%
- Baseline = COP air based HP: ±170%
- Baseline = EER water-water chiller: ±120%

➢ Fulfillment of stringent requirements of next gen. chillers [EC12]

The efficiency improvement potential is a direct result of
- The lower T-lift ΔT=T_w-T_c due to the buffer storage architecture: ±3% per °C
- The improvement of η_{HP} resp. η_{CM} due to the special cooling process with R1234yf

Source: [UBA07]
HVACC 4.0. Results #2
Carbon footprint of different technologies

**Achievable with HVACC 4.0:** 68g CO$_2$/kWh
- same level as biomass in district grids
- close to glazed ST-collector

**Energy saving potential in Germany by switch from combustion to HVACC 4.0 (Baseline = WSVO95):**
- 77% energy saving compared to combustion of oil/gas @ 300 g CO$_2$/kg
- 57% energy saving compared to water-water heat pump @ COP≈4,0 for T-Hub 10°C → 70°C (= worst case)
- Saving ≈100 Mio t oil-equivalent resp. ≈350 kg CO$_2$/person
- Fulfillment of climate goals 2030 by change over to HVAVV 4.0 for 55% of building stock
- Additionally needed electricity for HP operation i.e. via 15,000 windmills of 6 MW class @ 40% full load

**Data source:** Öko-Institut
Excel: Misc#18
Summary #1: Business model
“What will be the mainstream in future?”

Technical, economical and ecological:
1. **Efficiency first**: This is not negotiable (if RoI ok)
2. \[ \text{COP}_{\text{total}} = \% \text{COP}_{\text{heat}} + \% \text{COP}_{\text{cool}} \] due to simultaneous heating & cooling (no VRF)
3. **Cost**: No boreholes, ice or seasonal storages or PCM, cheap unglazed collectors

Political:
1. **F-gas regulation**
   -> ban of F-gases GWP>750; use of HFO or zeotropic mixtures with 1 digit GWP
2. **More stringent requ. on Ecolabel and BAT-Approach (Best Available Technology)**
   -> phase out air based systems with lower \(T_{\text{cold}}\), fan & defrosting
3. **Funding**: Stop discrimination of unglazed ST collectors

Win Win Win:
1. **Customers**: Homeowners, building operators: RoI, contracting, …
2. **Environment**: Fulfillment of climate goals, stop firing HC
3. **Grid**: Sector Coupling, Electricity ↓, Smart Grid, 5G DGs for H&C
Summary #2: Requ. on future proof HVAC systems
Does HVAC 4.0 meet the requirements?

Legal & Design goals
- Focus on RE
- Compliance with F-gas regulation
- Scalable
- Overcome paradigms by applying Triz
- System simple and reliable

Cost & efficiency
- Efficiency first
  - Low carbon footprint
- Fast market penetration
  - -> climate goals 2030
- Acceptable RoI even w/o funding

(Technical) Capabilities
- Heating & Cooling (no VRF)
- Including PV and chilling
- Building Stock DG
- 100% heat recovery from used air
- Ease of control
- SG ready
  - LT-Heat, chillness, electricity

Verification via demonstrator
- Expected fulfillment

Fulfill future Eco design requirements
HVACC 4.0
Personal #2: LinkedIn Profile

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Entrepreneur & Founder of €ASY - TNT - HVACC 4.0 -
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Thinking in systems and consequent application of Triz-methodology offer opportunities to overcome paradigms, which is a prerequisite for boosting COP and EER of today’s heat pumps & chillers towards double-digit values. A "Green Field Approach" opens the door for reduction of carbon footprint from today 300 mg CO₂ to about 70 mg CO₂ per kWh. The solution is HVACC 4.0, patent pending.

Missions & Visions:
- To realize a highly efficient water based chiller process for simultaneous heating & cooling w/o need for exploitation of a heat source like drillings.
- Use of future proof refrigerants with GWP<10 w/o conflict with F-gas act.
- To keep the system cost down by avoiding seasonal/ice storages and PCM.
- To fulfill Paris protocol for building sector and make the energy transition to happen.
- To invite first movers for collaboration @ free license.

Efficiency first is not negotiable!
HVACC 4.0
Annex #1: Shortcuts

HVACC modules:
1. PSV:  Puffer-Speicher-Vorrichtung (=Buffer Storage Device, including integrated components like HEX, condenser, evaporator, …)
2. PSK:  Puffer-Speicher-Kaskade (=Buffer Storage Cascade, consisting of up to three hydraulically coupled BS)
3. H&C:  Heating & Cooling (e.g. via FH/RH and warm/cold medium from PSK or via AC and warm/cold air supplied from BS-sourced HEX)
4. CRS:  Central Refrigerant Supply (for consumers of KM as part of KMV) (not described here)
5. KMV:  Kälte-Mittel-Verbraucher (=consumers of liquid refrigerant like HPs, chillers, fridges, VRF indoor units, …) (not described here)
6. KV:  Kollektor-Vorrichtung (Collector Device) for regenerative charging of PSK with heat or chillness
7. BM:  Building Module (for system control and operation, not described here)

System components and other:
AC:  Air Conditioning (e.g. via air-liquid or liquid-liquid HEX sourced with warm/cold medium from PSK)
ACPV:  Actively Cooled PV-Collector (modified PVT-Collector with additional evaporator for refrigerant)
BS:  Buffer-Storage #i (with defined T-profile Ti=[Tib,Tib], Tib>Tib, i=1,2,3)
COP/EER:  Coefficient of Performance (heat pumps) resp. Energy Efficiency Ratio (chillers and freezers)
DG:  District Grid (e.g. 4G for heat 50...60°C or 5G for heat & chillness 10...40°C in combination with HVACC 4.0
DHW:  Domestic Hot Water (e.g. produced via BS1-integrated HEX)
DSH:  De-Super-Heating (cooling of superheated compressed refrigerant close to condensation temperature)
FH/RH:  Floor Heaters resp. Radiator Heaters (for space heating & space cooling)
HX:  Heat Exchanger (either integrated in BS or external like e.g. plate or micro channel heat exchangers)
HFO/HFC:  Refrigerant of the groups Hydro-Fluoro-Olefine resp. Hydro-Fluoro-Carbon
GWP:  Global Warming Potential (use regulated in F-Gas regulation)
KM:  Kälte-Mittel (=Refrigerant used in HP or CM)
LWR:  Leit-Wert-Regler (=device for pressure regulation during evaporation process)
NRC:  Nocturnal Radiation Cooling (for cooling e.g. BS2 over night)
PV/PVT:  Photo Voltaic resp. Photo Voltaic & Thermal
RE:  REnewable energies like ST, PV,…
SotA:  State of the Art (e.g. HVAC vs. HVACC 4.0)
SCD:  Super Cooling Device (for strong subcooling of condensed KM)
SG:  Smart Grid (electric, DG for heat and chillness)
SPC:  Swimming-Pool-Collector (as e.g. low cost unglazed ST collector for cooling BS2 over night)
ST:  Solar Thermal collector for HT (High Temperature), LT (Low Temperature) and ELT (Extra Low Temperature) applications
T_w/T_c:  T_warm resp. T_cold in condenser resp. evaporator of HP/CM
TMD:  Temperature-Modification Device (=pair of condenser and evaporator, which may be integrated in BS)
VAF/VRF:  Variable Air Flow resp. Variable Refrigerant Flow
WW:  Waste Water (heat recovery via HEX sourced with cold medium from BS3)
HVACC 4.0
Annex #2: Literature

[SBT0x] Siemens Building Technologies, Zug (Schweiz): Kältetechnologie (Auszug aus dem Trainingsmodul "B08RF - Kältetechnik")
[UBA07] Umweltbundesamt: Zukunftsmarkt für solares Kühlen
[V11] Viessmann: Planungshandbuch Wärmepumpen