# ENERGY - RECOVERY
# for Air-Handling-Units

By: Martin A. Kohler

# ENERGY – RECOVERY for Air-Handling-Units


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# ENERGY – RECOVERY for Air-Handling-Units


- Why do we need to recover energy after all?

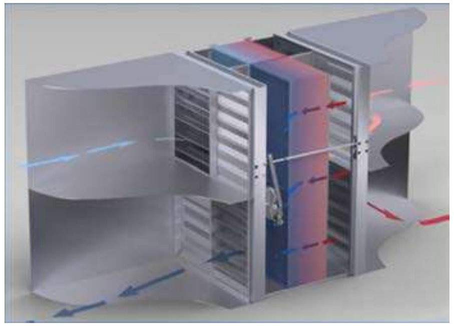
  - Environmental Footprint


  - Increasing costs for energy

  - Air Quality / Living Quality

# ENERGY – RECOVERY for Air-Handling-Units


- How to recover Energy ?
  - **<u>Recuperative Systems</u>**
  - Run Around Coils / AccuBlock
  - **<u>Regenerative Systems</u>**



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# ENERGY – RECOVERY for Air-Handling-Units

- How do these solutions work?

  - Recuperative Systems

https://en.wikipedia.org/wiki/Recuperator

Recuperative Systems may only transfer **sensible** heat.

The Air Streams are seperated to each other by a metallic Separator.
This Separator (also called „Plate“) will be transferring Heat from one side to the other.

Most commong units are classical cross-flow and counter-flow **PLATE HEAT EXCHANGER. (PHX)**

# ENERGY – RECOVERY for Air-Handling-Units

- How do these solutions work?

  - Run Around Cois

https://en.wikipedia.org/wiki/Run-around_coil

Run Around Coils Systems may only transfer **sensible** heat.

The Air Streams are seperated to each other by certain distance. Both Air Streams are NOT close to each other.

By including coils into both air streams paired with a pumped liquid inbetween, temperature difference will be transferred inbetween both coils.

(„Refrigerator“)

# ENERGY – RECOVERY for Air-Handling-Units

How

Regenerative Systems may equally transfer **<u>sensible and latent</u>** heat.

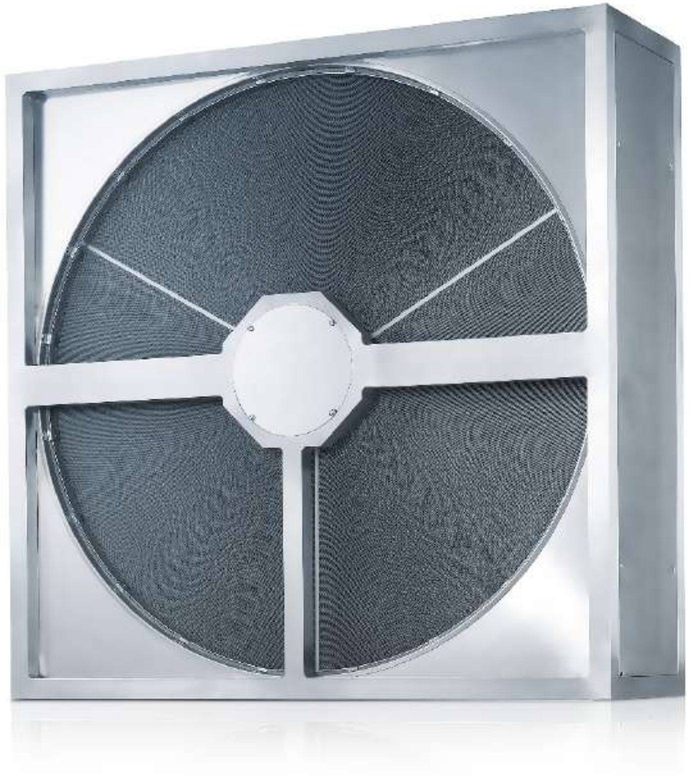
A rotating storage mass is installed inbetween both air streams, which are located close next to each other.

By passing through the storage mass, air stream will condition the material for both, temperature and humidity.

By revolving, this energy will be transferred to the second air stream

- How do these solutions work?
  - Regenerative Systems

https://en.wikipedia.org/wiki/Regenerative_heat_exchanger



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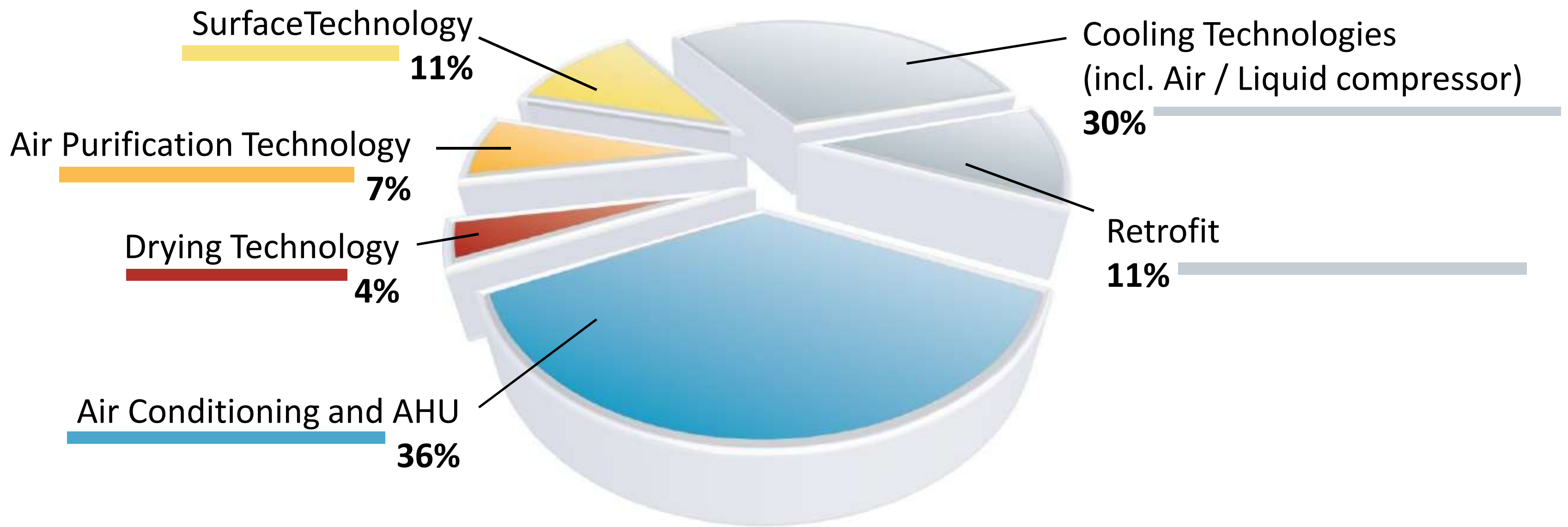
# ENERGY – RECOVERY for Air-Handling-Units

- Who is using this technology ?




Quelle: CCI / Herstellerverband / UCB

# ENERGY – RECOVERY for Air-Handling-Units


- Any application is suitable for energy saving projects. Though the main reason for the use of this technology may vary.

- For some the only reason may be the CO2 Footprint, as this is getting expensive over time.
- For others it may be a political decision to get “green” as a strategy for the future
- And even others simply may have the goal to supply best quality air to the user.

- The reason may differ. The Benefit though is valid for any of these (!)

# ENERGY – RECOVERY for Air-Handling-Units

Who

- Environmental Footprint (Saving future Costs)
- Very common and the main reason for almost any “heavy metal”

Texas General Motors (Arlington ; USA)

Daily Costs for energy approx 1Mio USD (!)

**Upcoming next : Surplus-costs for $CO_2$ emission (!)**

Energy Recovery mainly is focused to $CO_2$ emission reduction.

Saving USD is a nice sideeffekt.

# ENERGY – RECOVERY for Air-Handling-Units

Who

- Reduction of Production / Operational Costs
- High importance for prime-energy production for power plants

Ljungström
(Sweden ; Europe)

Highest energy ressources can be found at any kind of power production plant. Nuclear, Caloric or other.

Huge air volumes, High temperatures, enormous costs of opeation.

ANY recovery here just HELPS for any aspect given.

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# ENERGY – RECOVERY for Air-Handling-Units


- Simple desire of AIR QUALITY
- This is more and more important for any building for working humans.

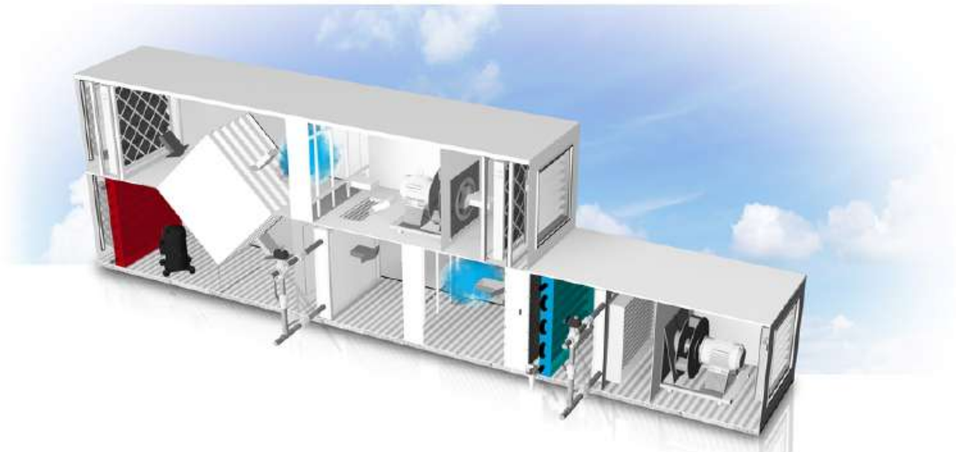
Indoor Air Quality (IAQ) today is more than temps and humidity. Well beeing and „Health“ is the new titel.

Air Quality today needs to consider particle concentration for gems, gases, bacteria and alike. Without energy recovery, IAQ cannot be treated in all aspects.

Corona did not „kill‘“ the industry as many have feared, to the contrary, it made us stronger, better knowing and helped in evolution (!)

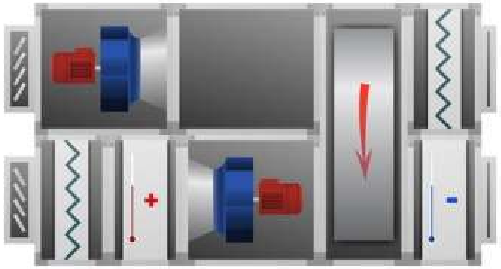
# ENERGY – RECOVERY for Air-Handling-Units

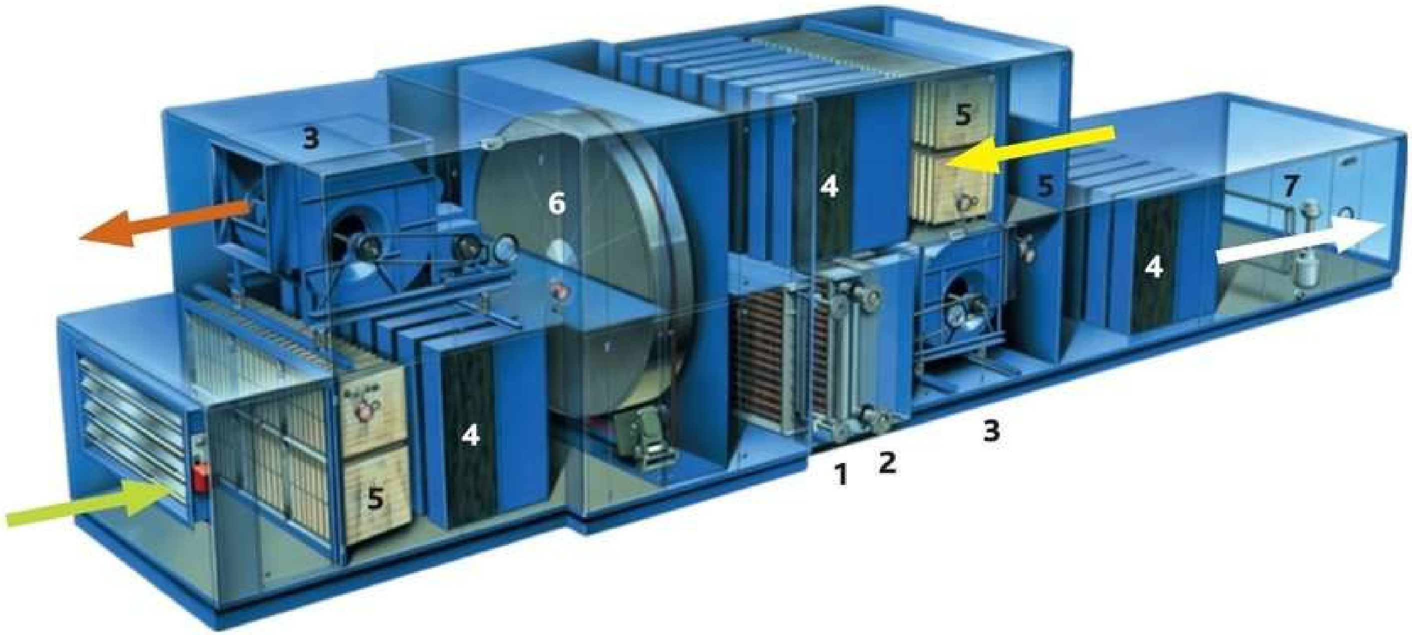

- Where are these solutions installed?
  - In order to work properly, all mentioned solutions need “help”, they do not work as a stand alone product.
  - “Help” in this aspect is understood as the AIR HANDLING UNIT



# ENERGY – RECOVERY for Air-Handling-Units


- Where are these solutions installed?





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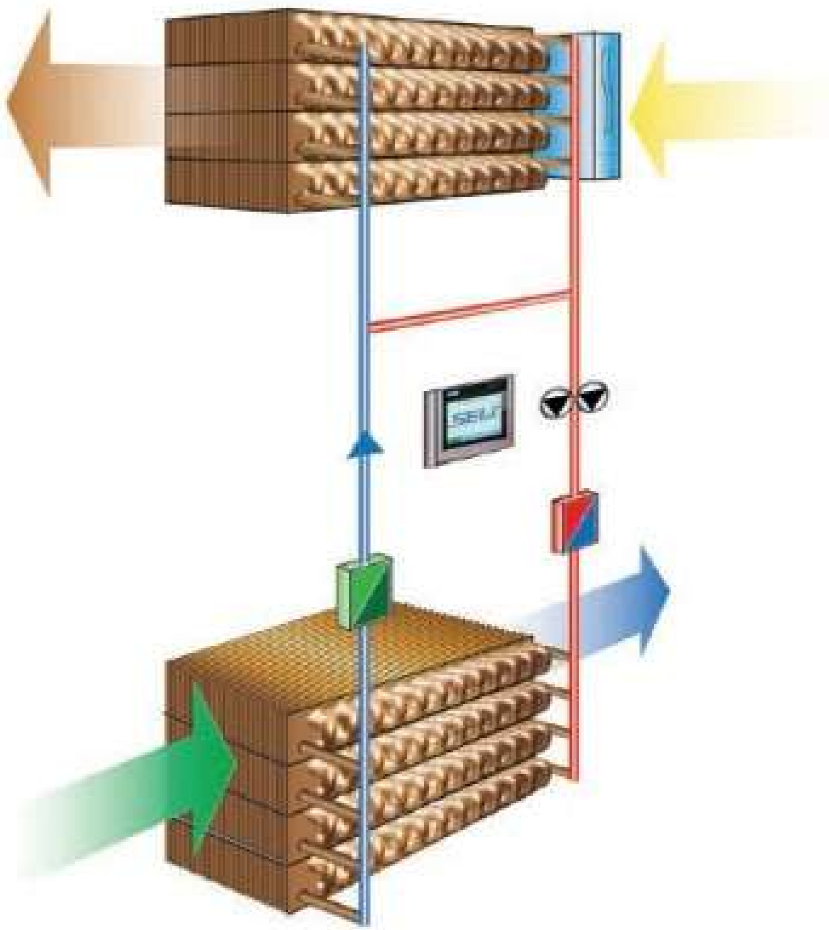
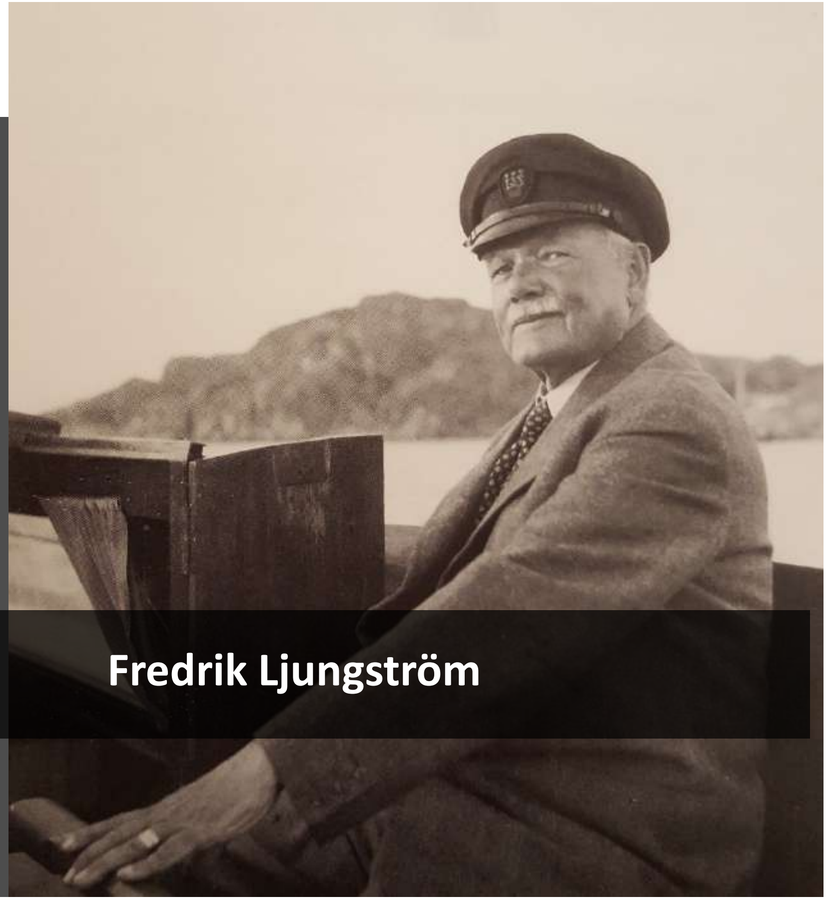


# ENERGY – RECOVERY for Air-Handling-Units

- Most Important Invention for energy recovery: THE ROTOR

Fredrik Ljungström developed the so called
Ljungström-Turbine,
the first ever automated gear box,
the Svea-Bike
… and more …

*Schwedish Engineer, construciton professional*



**Fredrik Ljungström**

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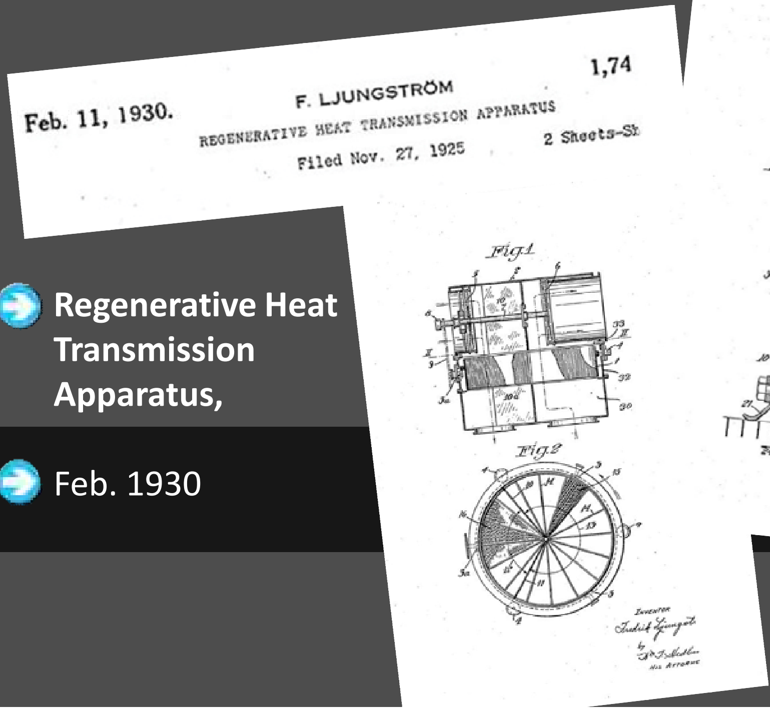
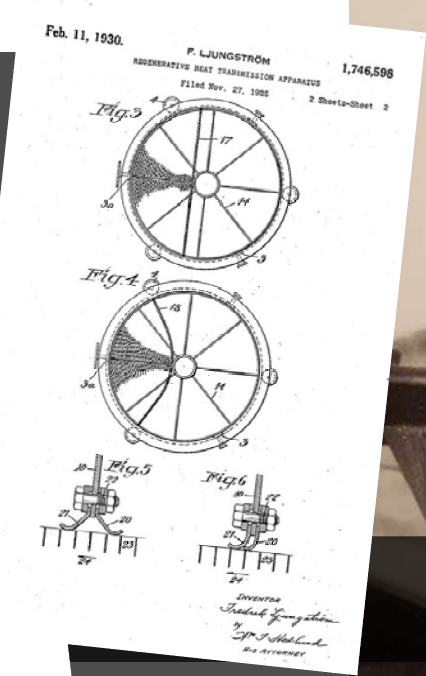
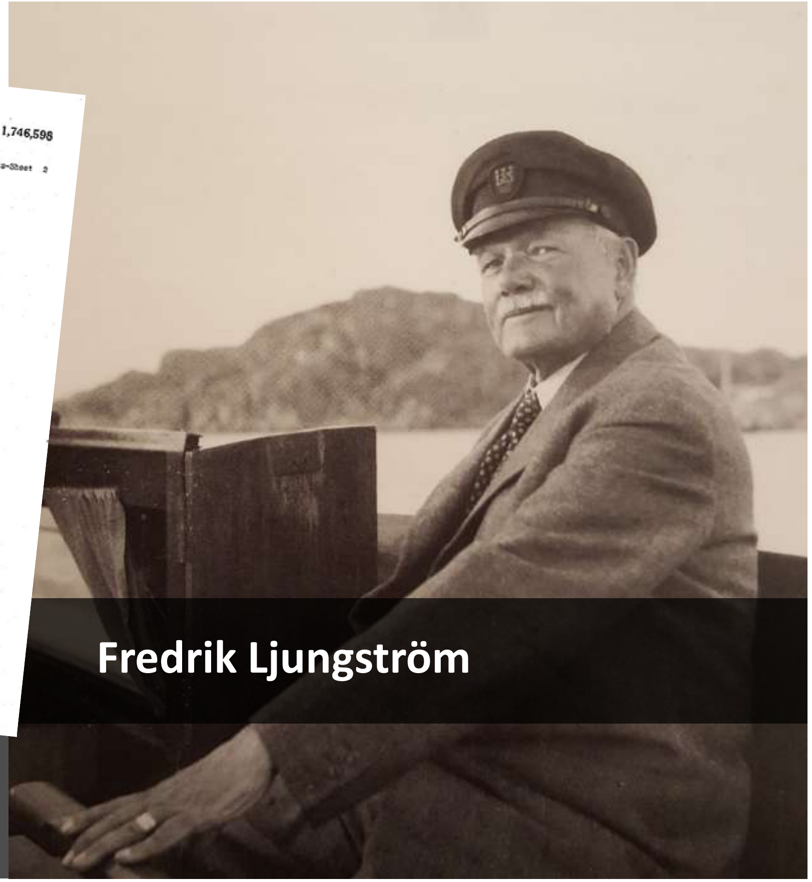



- Regenerative Heat Transmission Apparatus,
- Feb. 1930



Fredrik Ljungström

# ENERGY – RECOVERY for Air-Handling-Units


- Most Important Invention for energy recovery: THE ROTOR

Invention made in 1930 → the biggest units in 2023 are still made
With the same base construction and philosophy.

But different to the combustion engine, there is no shame
in energy recovery using established technology (!) ☺

# ENERGY – RECOVERY for Air-Handling-Units


- Some End-User Installations

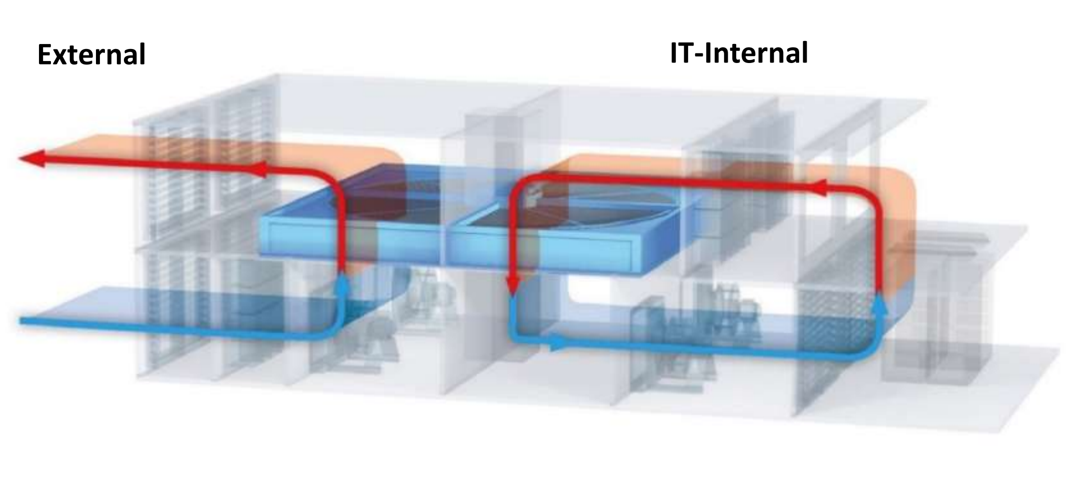
**Reference: Paint Booth Shop**

# ENERGY – RECOVERY for Air-Handling-Units


- Some End-User Installations

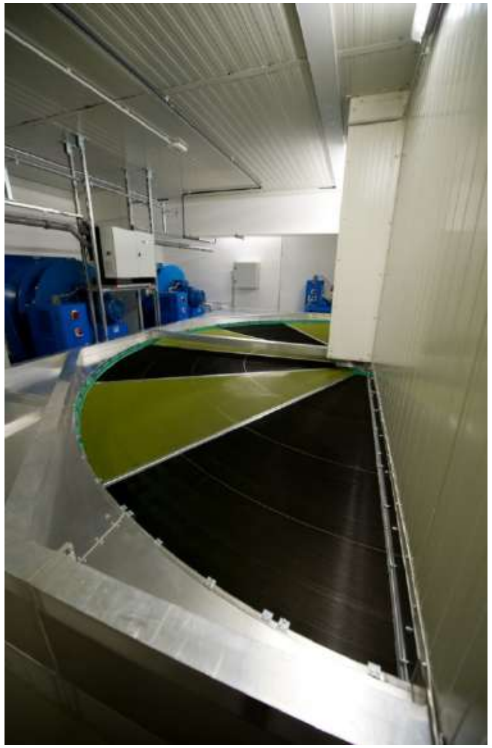
**Data-Center – Cooling (Kyoto-cooling)**

- 70% reduzed energy consumption for cooling
- 93% of the year no additional compressor cooling is needed
- Optimization of Air Flow / Volume



# ENERGY – RECOVERY for Air-Handling-Units

- Some End-User Installations



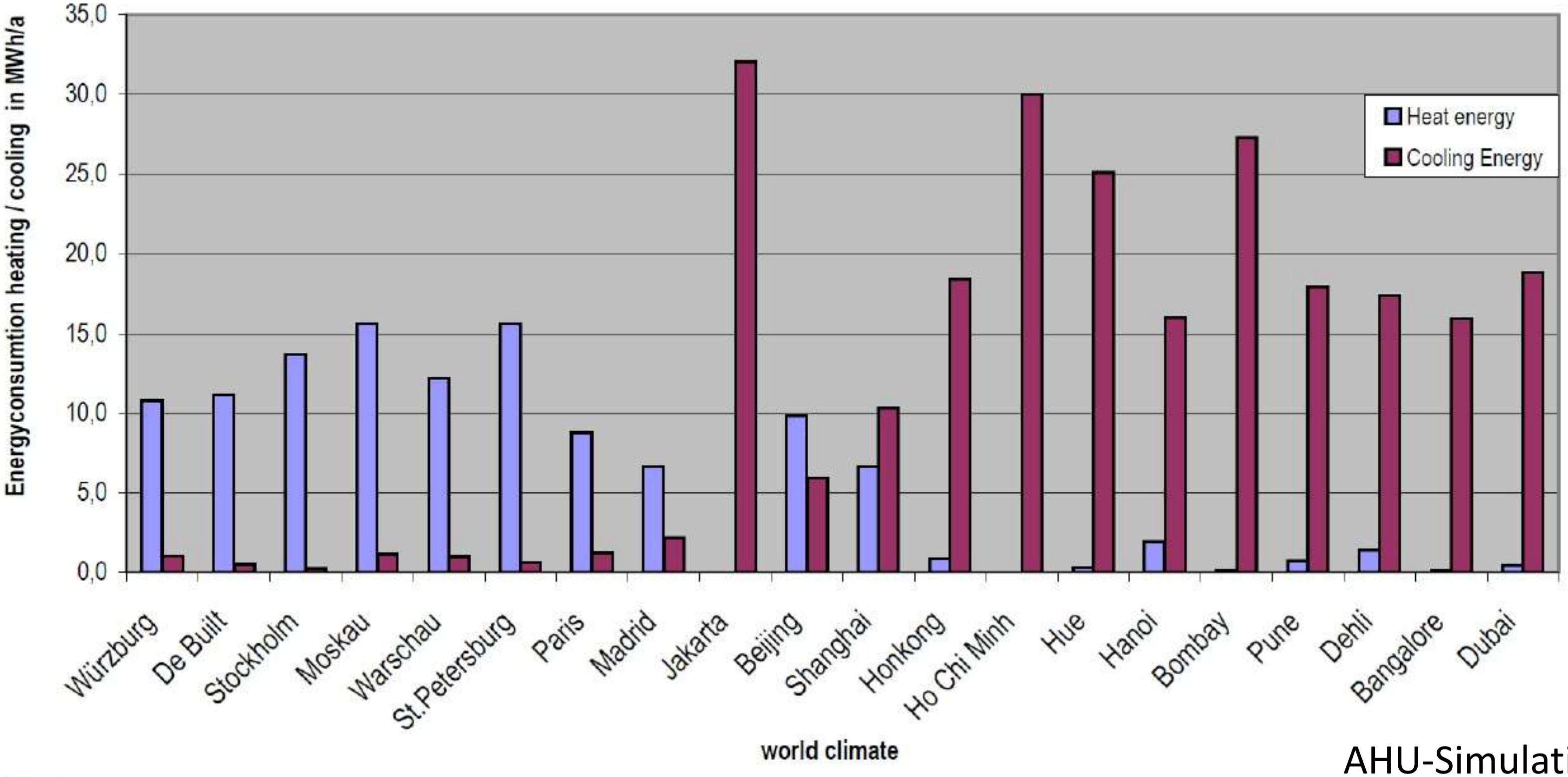
# ENERGY – RECOVERY for Air-Handling-Units

- Some End-User Installations

High Temperature Solution all SS (!)
Power Plants or Steel-Production.

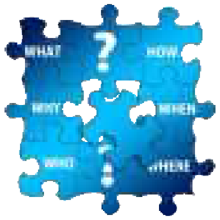
# ENERGY – RECOVERY for Air-Handling-Units

- How can we decide the best choice (which system can help best)

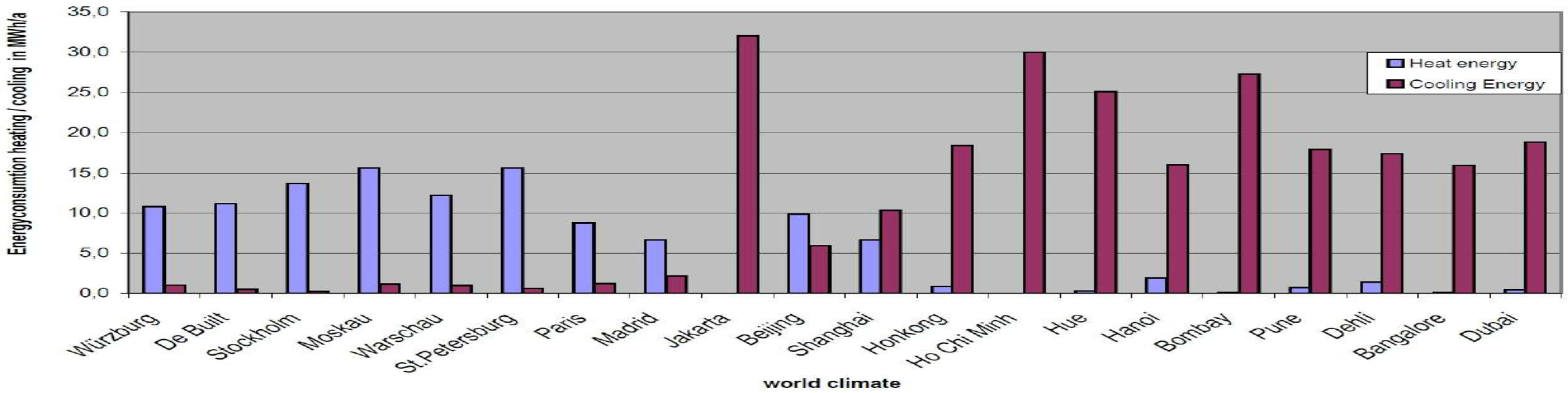



AHU-Simulation
12 h/d – 5 d/w
10000 $m^3/h$

# ENERGY – RECOVERY for Air-Handling-Units




- How can we decide the best choice (which system can help best)

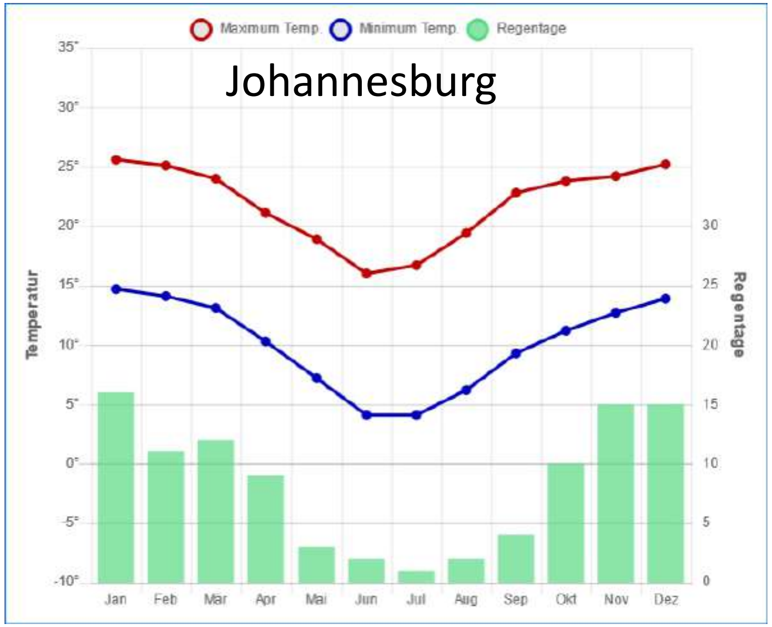


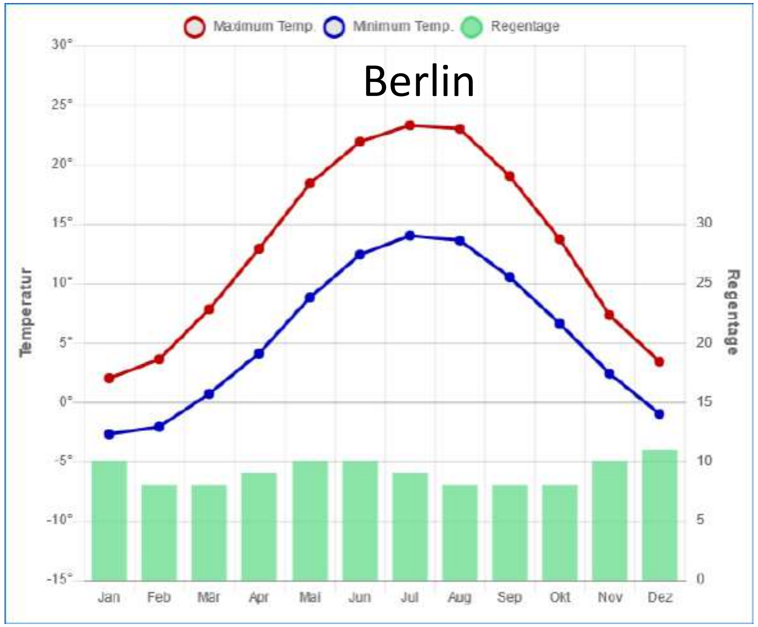

Considering „**Temperature**“ as a major parameter for energy recovery, the above Overview clearly shows different needs for different regions world wide.

- Cold regions vs. Hot regions → the hotter the region, the more energy needed (!)

# ENERGY – RECOVERY for Air-Handling-Units


- How can we decide the best choice (which system can help best)

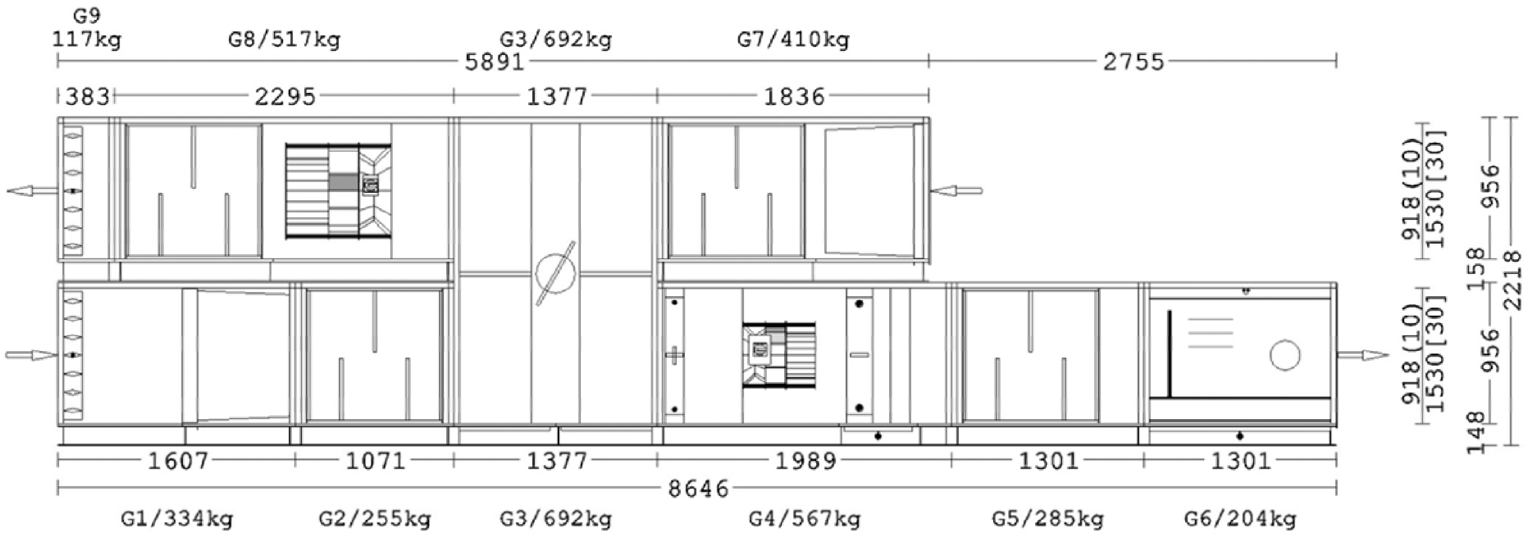



Though „Temperature“ is not the only aspect we need to focus, equally important will be „Humidity“, which has the most impact on comfort for humans.

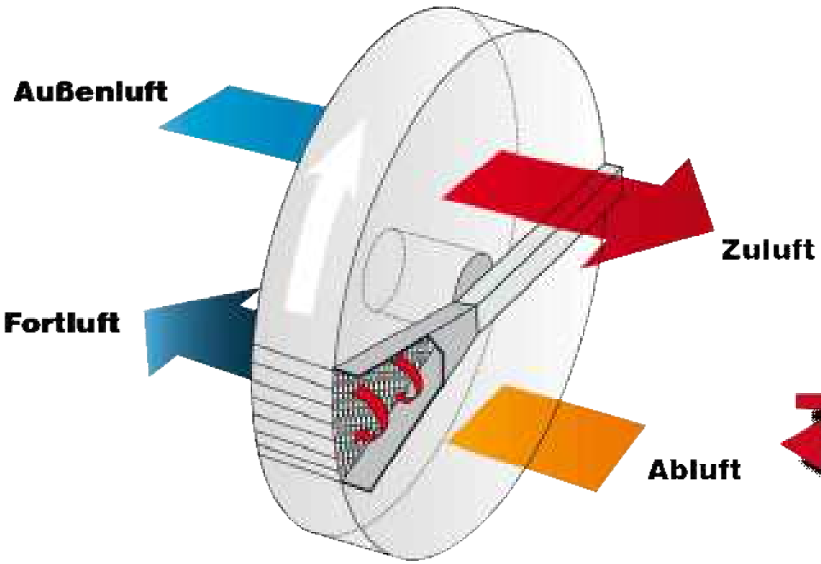
→ The more humidity to deal with , the higher the costs for energy (!)

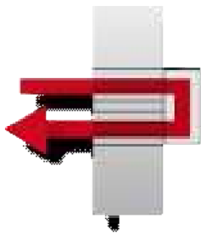
Example of an AHU with Rotor installed



# Leakage rate optimisation

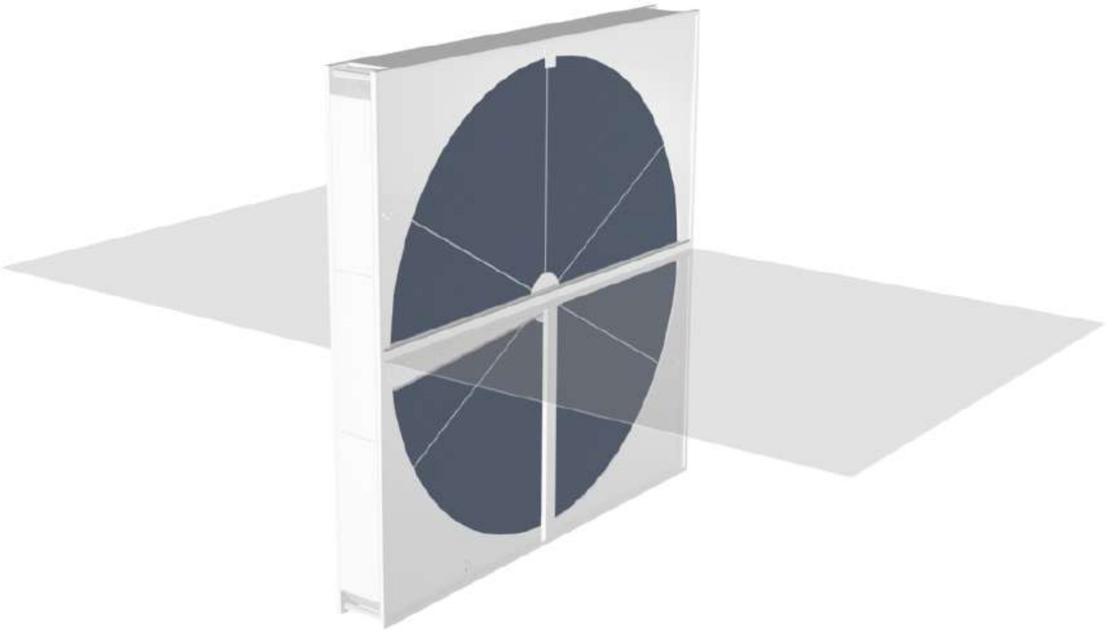
**Key Figures for Energy Recovery acc. VDI 3803, Blatt 5**



| Differential Pressure | |
|---|---|
| 0 – 200 Pa | Functionality of Purge not given, do not use purge |
| 200 – 500 Pa | Functionality given for a std. purge sector on 5° |
| 500 – 800 Pa | Functionality given for a big purge sector on 10° |
| > 800 Pa | Functionality „too“ high, loss of volume to be anticipated, thus no purge should be installed |

# Rotating Heat Exchanger – Performance Key Figures



$$\Phi_t = \frac{t_{ZU} - t_{AU}}{t_{AB} - t_{AU}}$$

**Sensilbe**
()

$$\Phi_x = \frac{x_{ZU} - x_{AU}}{x_{AB} - x_{AU}}$$

**latend**
()

$$\Phi_h = \frac{h_{ZU} - h_{AU}}{h_{AB} - h_{AU}}$$

**Enthalpy**
()

# ENERGY – RECOVERY for Air-Handling-Units


- Comparing two systems based on Johannesburg (average)

| | Temperatur °C | | Niederschlag | | relative |
|---|---|---|---|---|---|
| | max. Ø | min. Ø | mm | Tage | Feuchte |
| Jan | 25,6 | 14,7 | 125 | 16 | 70 |
| Feb | 25,1 | 14,1 | 90 | 11 | 71 |
| Mär | 24 | 13,1 | 91 | 12 | 70 |
| Apr | 21,1 | 10,3 | 54 | 9 | 66 |
| Mai | 18,9 | 7,2 | 13 | 3 | 57 |
| Jun | 16 | 4,1 | 9 | 2 | 53 |
| Jul | 16,7 | 4,1 | 4 | 1 | 49 |
| Aug | 19,4 | 6,2 | 6 | 2 | 45 |
| Sep | 22,8 | 9,3 | 27 | 4 | 48 |
| Okt | 23,8 | 11,2 | 72 | 10 | 55 |
| Nov | 24,2 | 12,7 | 117 | 15 | 65 |
| Dez | 25,2 | 13,9 | 105 | 15 | 67 |
| Jahr | - | - | - | - | - |

**Recuperative versus Regenerative**

Simulating both systems for Johannisburg average temperatures and humidities

(24 / 7 operation ; Simplified)

Recuperative == Plate Heat Exchanger
Regenerative == Rotary Heat Exchanger

# ENERGY – RECOVERY for Air-Handling-Units


- Comparing two systems based on Johannesburg (average)

| | | | PLATE | | ROTOR | |
|---|---|---|---|---|---|---|
| | T max average | Rel. Humidity | kW dry | kW wet | kW dry | kw wet |
| January | 25,60 °C | 70 r.H. | -3,19 kW | 0,00 kW | -4,54 kW | -31,64 kW |
| February | 25,10 °C | 71 r.H. | -2,19 kW | 0,00 kW | -3,27 kW | -30,48 kW |
| March | 24,00 °C | 70 r.H. | -3,98 kW | 0,00 kW | -5,52 kW | -34,37 kW |
| April | 21,10 °C | 66 r.H. | 1,79 kW | 0,00 kW | 1,92 kW | -18,37 kW |
| May | 18,90 °C | 57 r.H. | 6,15 kW | 0,00 kW | 7,56 kW | -5,57 kW |
| June | 16,00 °C | 53 r.H. | 11,89 kW | 0,00 kW | 14,83 kW | 2,77 kW |
| July | 16,70 °C | 49 r.H. | 10,50 kW | 0,00 kW | 13,12 kW | 3,70 kW |
| August | 19,40 °C | 45 r.H. | 5,16 kW | 0,00 kW | 6,43 kW | 1,27 kW |
| September | 22,80 °C | 48 r.H. | -1,59 kW | 0,00 kW | -2,11 kW | -8,11 kW |
| October | 23,80 °C | 55 r.H. | -3,58 kW | 0,00 kW | -4,73 kW | -17,19 kW |
| November | 24,20 °C | 65 r.H. | -4,37 kW | 0,00 kW | -5,93 kW | -29,24 kW |
| December | 25,20 °C | 67 r.H. | -6,37 kW | 0,00 kW | -8,53 kW | -36,18 kW |

10000 $m^3/h$
24 / 7
22°C / 40% Exhaust

# ENERGY – RECOVERY for Air-Handling-Units

- Comparing two systems based on Johannesburg (average)

| PLATE | | ROTOR | |
|---|---|---|---|
| kW dry | kW wet | kW dry | kw wet |
| -25,27 kW | 0,00 kW | -34,63 kW | -211,15 kW |
| 35,49 kW | 0,00 kW | 43,86 kW | 7,74 kW |

PHX :
→ 25kW cooling energy saved
→ 35kW heating energy saved

→ NO energy effect for humidity (!)

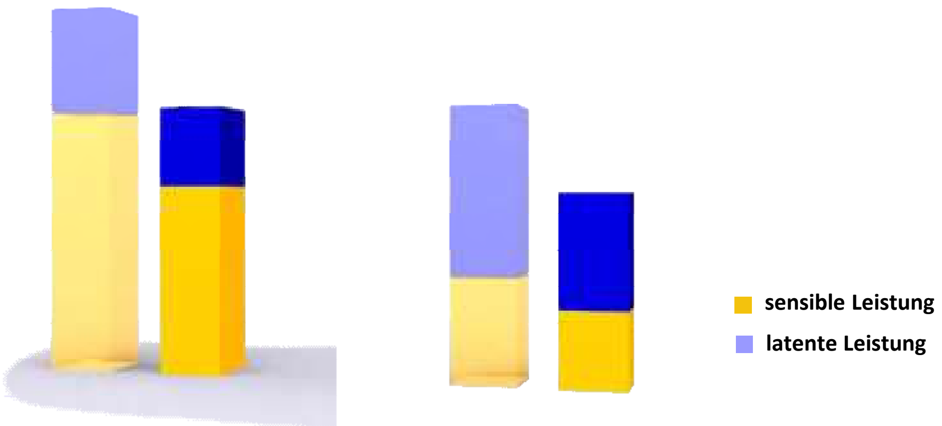
RHX :
→ 34kW cooling energy saved
→ 43kW heating energy saved

→ Humidity is treated!
211kW saved for drying (!)

# ENERGY – RECOVERY for Air-Handling-Units

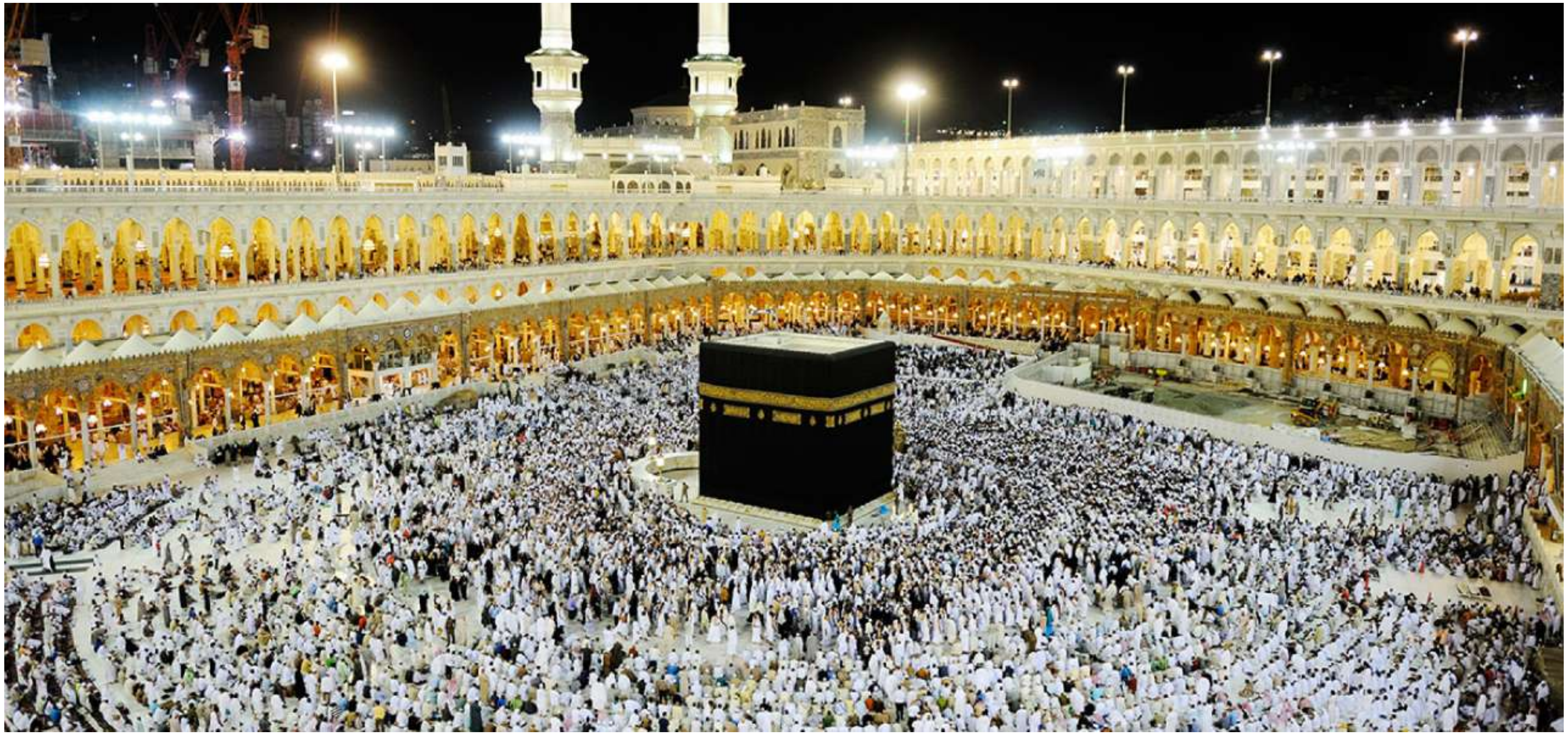

- Comparing two systems based on Johannesburg (average)

| PLATE | | ROTOR | |
|---|---|---|---|
| kW dry | kW wet | kW dry | kw wet |
| -25,27 kW | 0,00 kW | -34,63 kW | -211,15 kW |
| 35,49 kW | 0,00 kW | 43,86 kW | 7,74 kW |



# ENERGY – RECOVERY for Air-Handling-Units


- Some End-User Installations (to better understand sensible / latent)



**Reference: Mecca, Al-Shamiya**

Humid Conditions → Sorption-HX

# ENERGY – RECOVERY for Air-Handling-Units


- Some End-User Installations (to better understand sensible / latent)


Humid Conditions → Sorption-HX

# ENERGY – RECOVERY for Air-Handling-Units


- 25kW → worth the effort?
  Short trip out of the box.

Everything starts at the source.
Oil field somwhere on the planet.

Followed by multiple methods of
Shipping and transportation

To finally be refined into ist end product
At SAPREF Refinary in South Africa (example)

# ENERGY – RECOVERY for Air-Handling-Units


- 25kW → worth the effort?
  Below scenario is no CGI or "fake".
  This happens on a regular base.
  AVIALABILITY will be one of the key parameters

Oil Rig on fire. Maximum loss of everything
Thus including the source, the grid, ……
Not to mention nature and lifes.

Oil tankers getting bigger and bigger
With more and more risks of total fail.

Even companies and facilities may impact
Availability. SAPREF closed above facility
In March 2022 for production. *)

*) https://www.engineeringnews.co.za/article/sapref-to-halt-operations-by-end-march-2022-02-10

# ENERGY – RECOVERY for Air-Handling-Units


- 25kW → worth the effort?
  Short trip out of the box.

| Assumption : | | |
|---|---|---|
| | 9,80 | kWh per liter crude oil |
| | 11,40 | kWh per kilogramm crude oil |
| $ | 1,12 | per liter crude oil |

| AHU : | | |
|---|---|---|
| 4 | hours / daqy | |
| 6 | days / week | |
| 7 | months / year | |

POI : Plate Heat Exchanger
Cooling Mode only (Summer period)

(20% losses considered within mechanical chiller for Pel vers. Pcooling.)

| Month | Cooling-Capacity | Run - Time per Month | hours in total | Total Capacity needed | Liter Crude Oil | Price in USD [$] |
|---|---|---|---|---|---|---|
| January | -3,19 kW | --> 4 h/d \|\| 6 d/w \|\| 4 weeks | 96 hours | -306,24 kW/h | 37,50 L / crude Oil | $ 42,00 |
| February | -2,19 kW | --> 4 h/d \|\| 6 d/w \|\| 4 weeks | 96 hours | -210,24 kW/h | 25,74 L / crude Oil | $ 28,83 |
| March | -3,98 kW | --> 4 h/d \|\| 6 d/w \|\| 4 weeks | 96 hours | -382,08 kW/h | 46,79 L / crude Oil | $ 52,40 |
| September | -1,59 kW | --> 4 h/d \|\| 6 d/w \|\| 4 weeks | 96 hours | -152,64 kW/h | 18,69 L / crude Oil | $ 20,93 |
| October | -3,58 kW | --> 4 h/d \|\| 6 d/w \|\| 4 weeks | 96 hours | -343,68 kW/h | 42,08 L / crude Oil | $ 47,13 |
| November | -4,37 kW | --> 4 h/d \|\| 6 d/w \|\| 4 weeks | 96 hours | -419,52 kW/h | 51,37 L / crude Oil | $ 57,53 |
| December | -6,37 kW | --> 4 h/d \|\| 6 d/w \|\| 4 weeks | 96 hours | -611,52 kW/h | 74,88 L / crude Oil | $ 83,87 |
| | | | | | | $ 332,70 |

*Remark : All simulations are extremly simplified (!)*
*This is a linear approach without considering technical aspects or any dynamic within the prozess.*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# ENERGY – RECOVERY for Air-Handling-Units


- 25kW → worth the effort?
  Short trip out of the box.


| | | |
|---|---|---|
| $CO_2$ per Liter Crude Oil : | | 2,65kg $CO_2$ / kg Oil |
| Total Amount of Crude Oil : | | 297,05 L / crude Oil |
| QTY of Barrels in total saved : | | 1,9 Barrel of Crude Oil |
| Price of 1 Barrel (WTI) (https://www.finanzen.net/rohstoffe/oelpreis/chart) | $ | 90,00 |
| Savings on Barrel of Oil | $ | 180,00 |

# ENERGY – RECOVERY for Air-Handling-Units


- 25kW → worth the effort?
  Short trip out of the box.

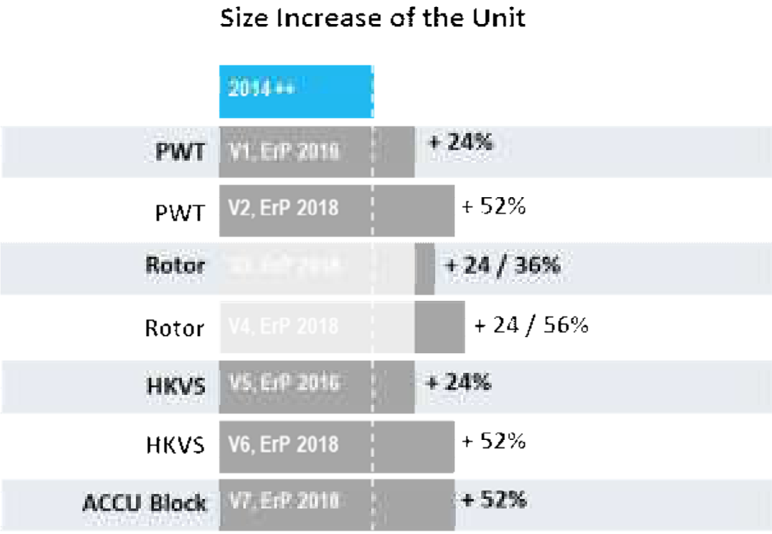
2,65 kg $CO_2$ are emitted for each and every liter of Crude Oil
This is a total of 423,96 kg of $CO_2$ emitted for each barrel (!)

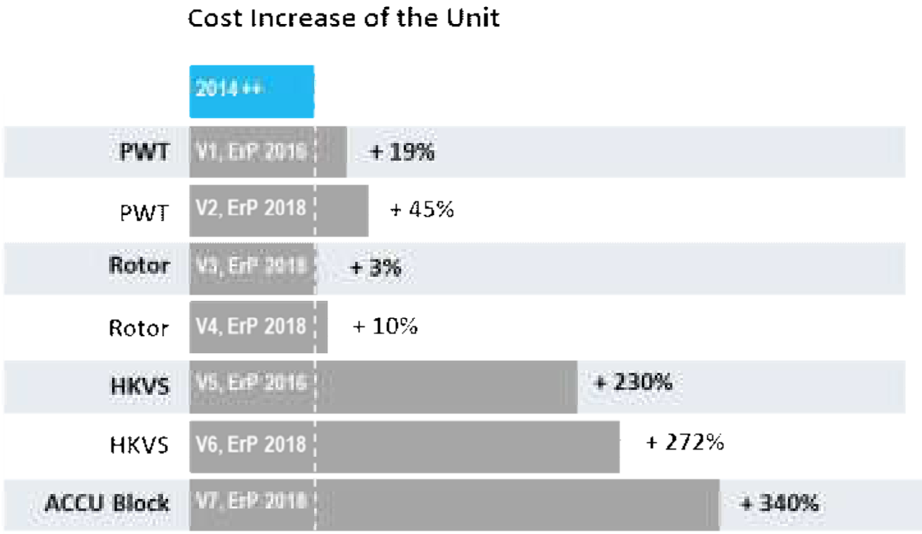
One single unit is god for 2 barrels, equals roughly 850kg $CO_2$ saved in emission.

Looking into the qty of sales per year, this easily is in the TONS (here 1,69MT !!) of $CO_2$ reduction for environment.

# ENERGY – RECOVERY for Air-Handling-Units


- How did the costs develop in the past ?




Due to continuously rising demands for efficiency and performance, the unit size of the AHU is increasing significantly in the past years. This has been leading to partly dramatical Price Increases depending on the technology.

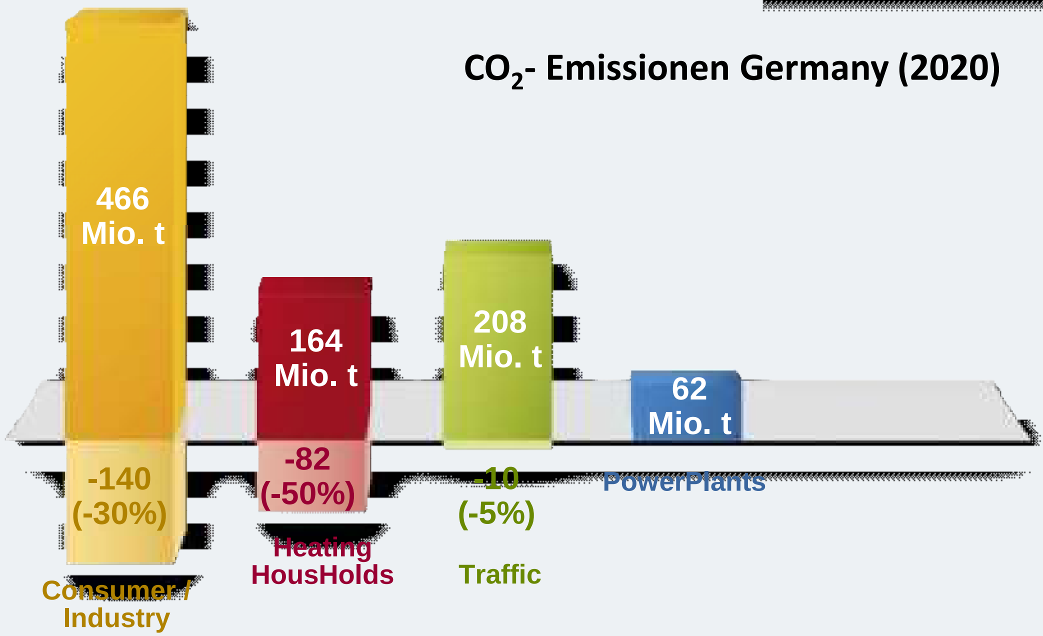
→ the higher the demand, the better the Rotor (!)

# ENERGY – RECOVERY for Air-Handling-Units


- Is this worth all the effort?

**Energy Recovery is known for it´s potential to save CO2**

**$CO_2$- Emissionen Germany (2020)**




By using high efficient energy recovery systems, already in 2020 a total of 25% CO2 emission could be saved (!)

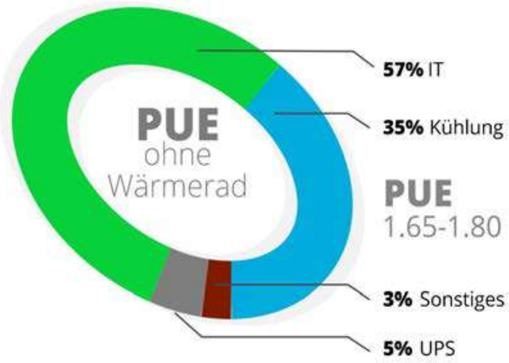
**$CO_2$-Emissions in Germany:**

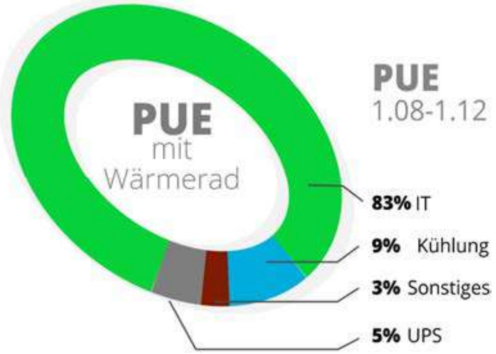
900 Mio. Tons $CO_2$ Total

**-232 Mio. Tons $CO_2$ possible reduction (-25%)**

# ENERGY – RECOVERY for Air-Handling-Units


- Is this worth all the effort?



Federal Chancellery, Berlin


Heat exchangers for paint booth systems
Reference: Sport arenas

Shopping Mall Limbecker Platz, Essen


RES SEVERA VERUM GAUDIUM
Orchestra & Opera at Leipzig


Airport Schiphol, Amsterdam

# Thank you for your attention

- Any Questions ?

- Any Remarks ?