Multi-Functional, High-Performance Run Around Energy Recovery Systems in Cold Climate Zones

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Contents

- The basic run-around energy recovery system
- Multifunctional run-around energy recovery systems
- Control Strategy

Advantages of RAER-Systems

- No cross-contamination Exhaust – Intake
- Location of Intake and Exhaust
- Number of Intakes and Exhausts variable
- Energy Recovery Efficiency
- Many existing HVAC-Systems can be retrofitted

System Components

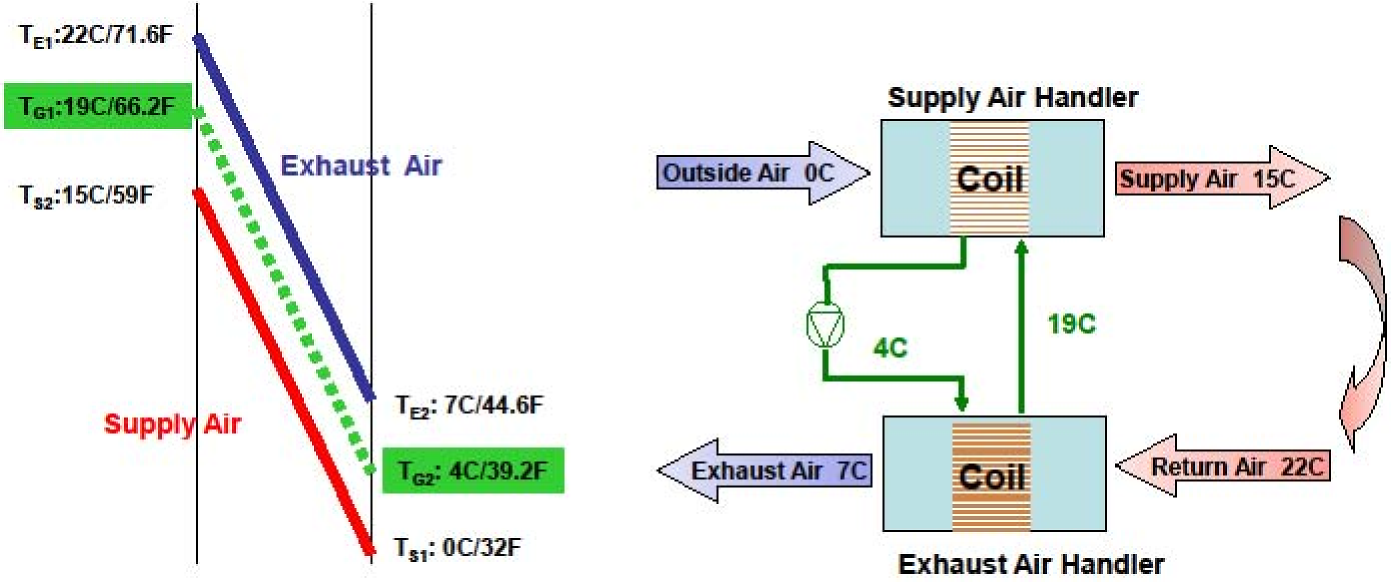


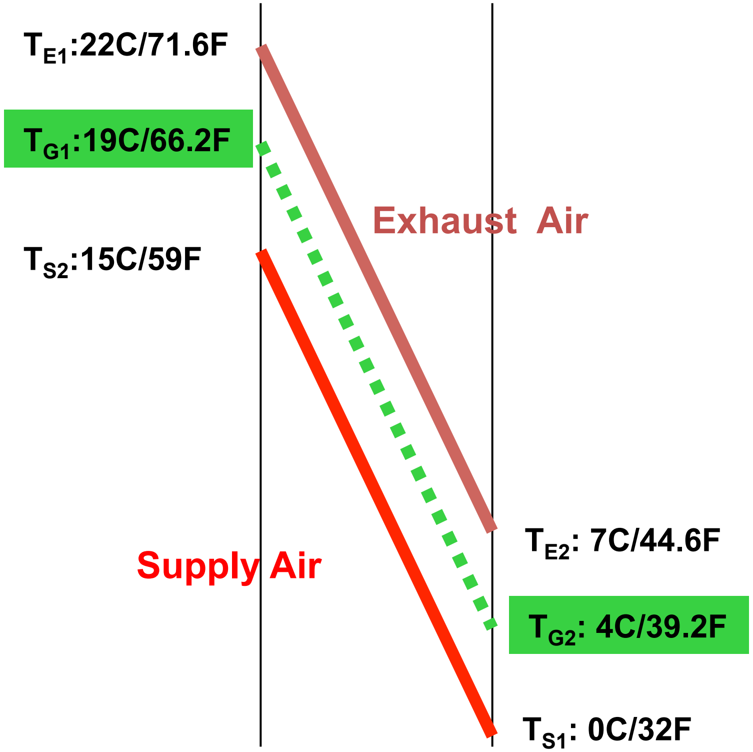
Figure 1: Temperature diagram and components of a basic run-around energy recovery system

Thermodynamics

$$Q = k * A * \Theta_m$$

- Q: exchanged energy duty [W]
- k: heat transfer coefficient [$W/(K*m^2)$]
- A: heat exchanger surface area [m^2]
- Θ_m: logarithmic mean temperature difference [K]

Log Mean Temperature Difference



Θ_m [counter current]

$$= [(T_{E1} - T_{G2}) - (T_{E2} - T_{G1})] / \ln [(T_{E1} - T_{G2}) / T_{E2} - T_{G1})]$$

$$= (dT_1 - dT_2) / \ln (dT_1/dT_2)$$

Θ_m [counter/cross-current]

$= \Theta_m$ [counter current] * RFAK

RFAK: correction factor for counter/cross current flow; $0 < \text{RFAK} < 1$

Heat Transfer Coefficient

Heat transfer processes involved:
- convective transfer air-fins, fluid – tubes
- conductive transfer in fins & tubes

Most critical with respect to controls: convective transfer fluid - tubes

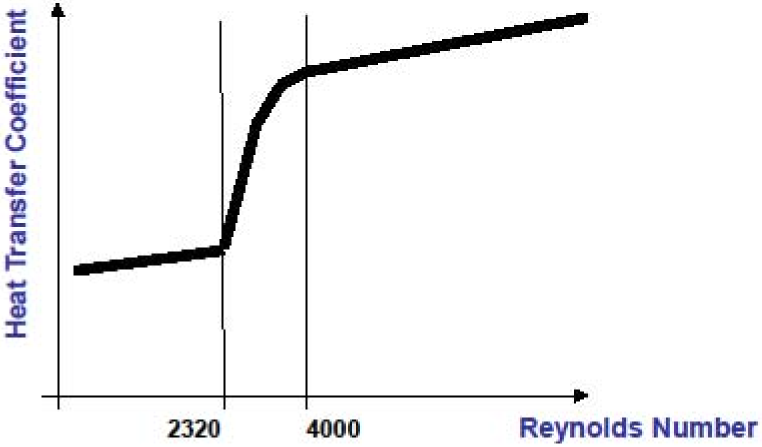


Figure 2: Dependence of heat transfer coefficient and Reynolds number

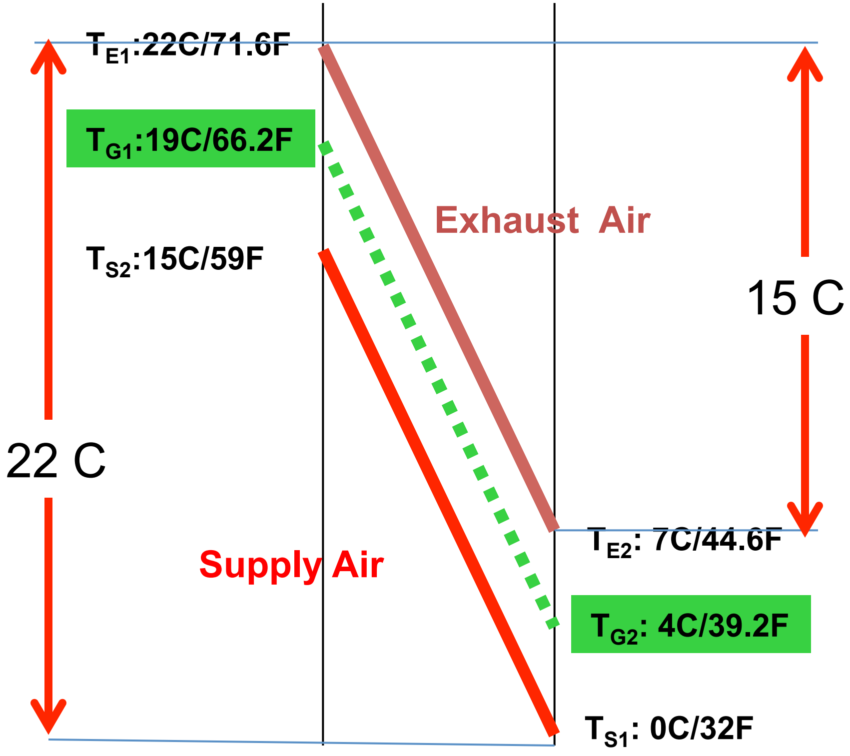
Reynolds number: Re [pipe] = $(F * D_H) / (\nu * A)$

F: flow rate D_H: hydraulic diameter ν: kinematic viscosity A: pipe cross section

Efficiency

Temperature Transfer Efficiency:

$$\mu_T = (T_{E1} - T_{E2}) / (T_{E1} - T_{S1})$$

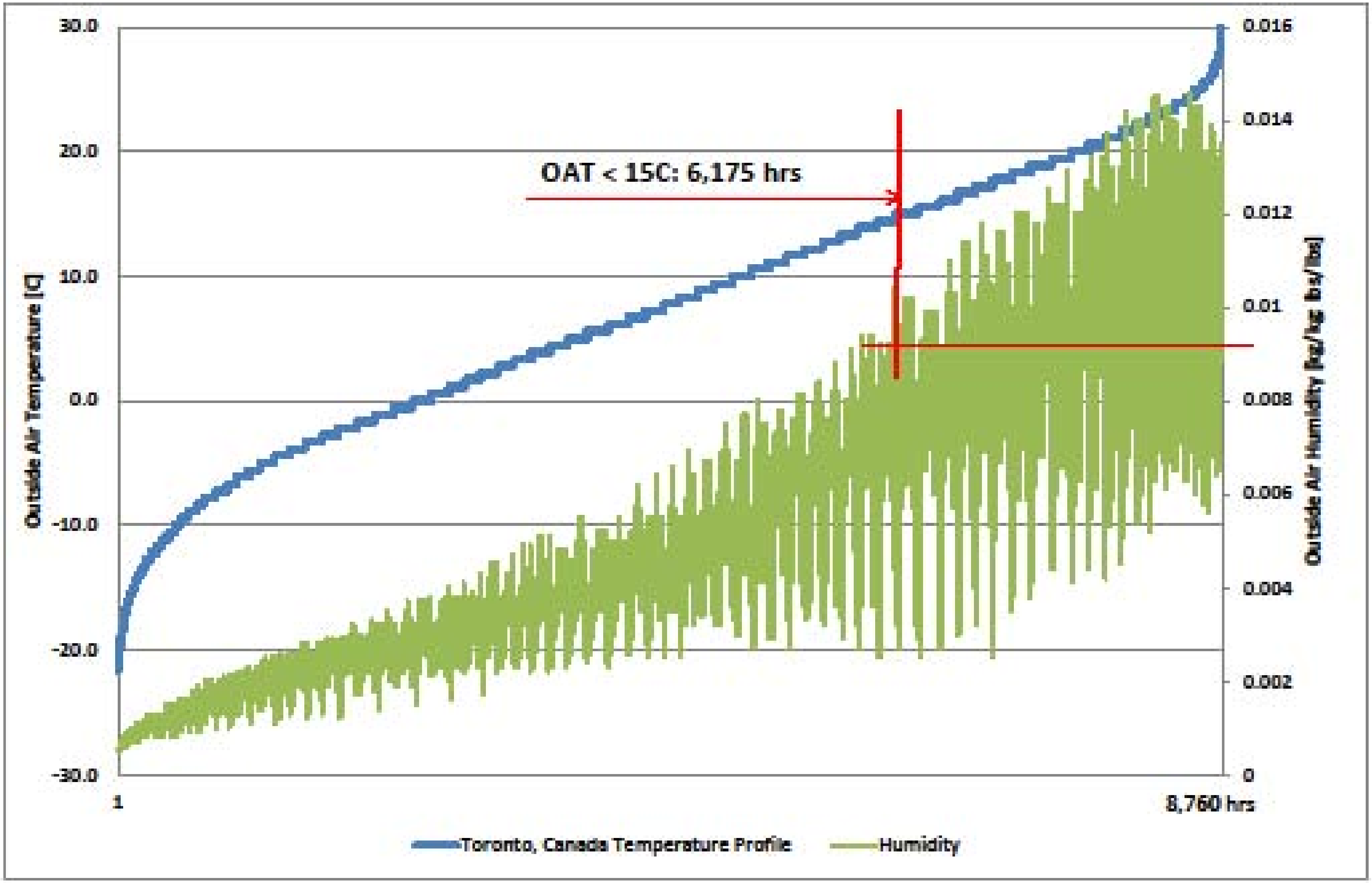


μ_T = 68%

Shortcomings:

- Measures one operating point only
  - OA temperature variable
  - operating parameters variable

Designing according to local annual Climate



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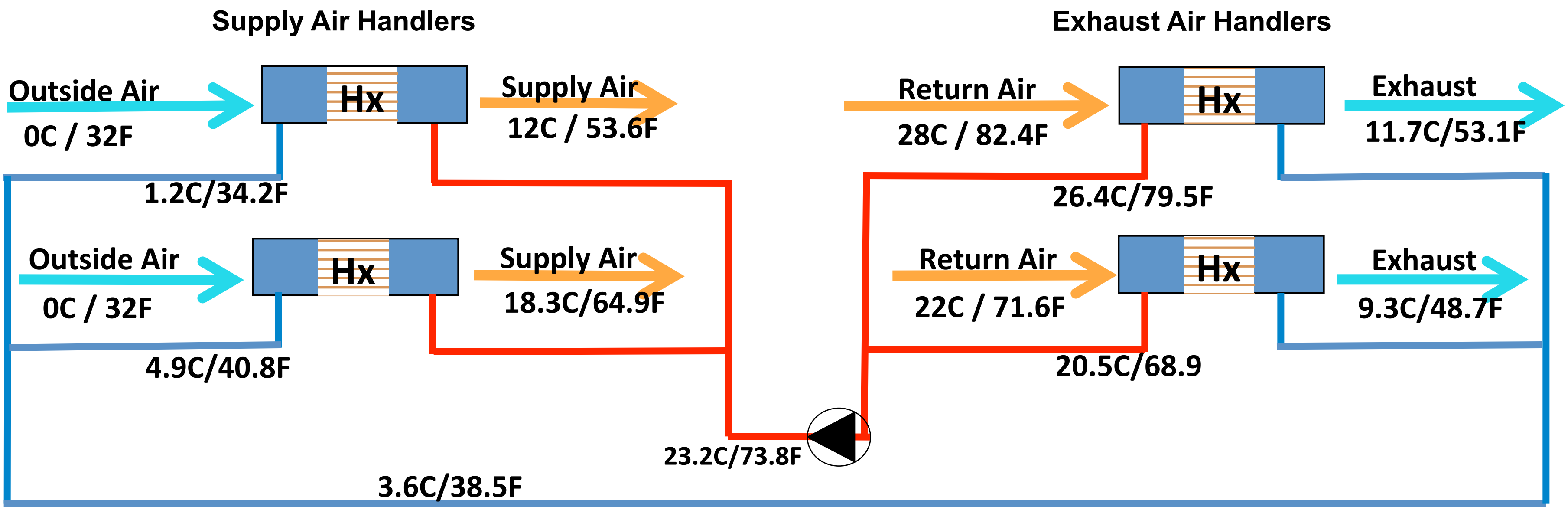
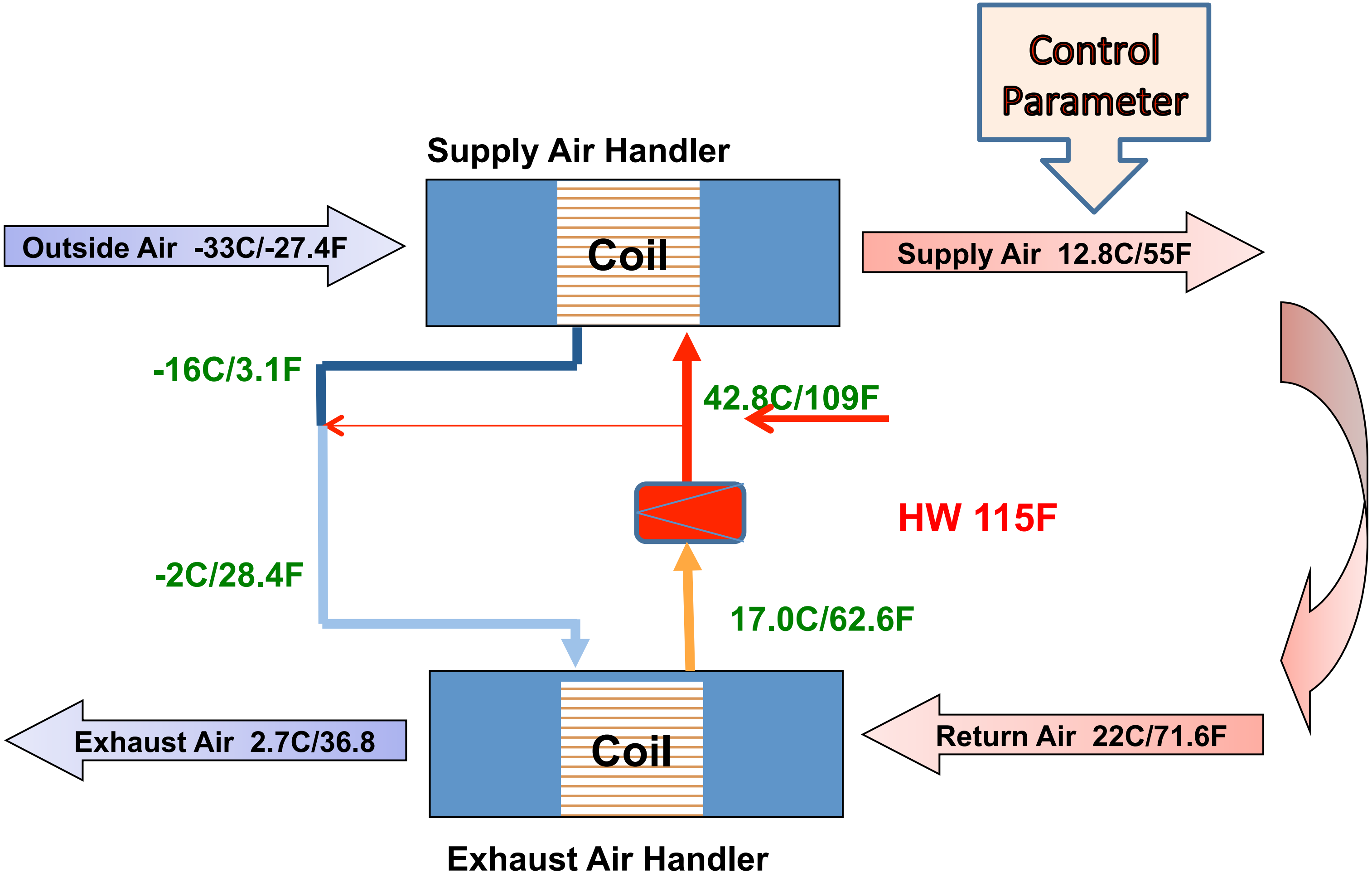
Combining Several Airhandlers in one Energy Recovery System

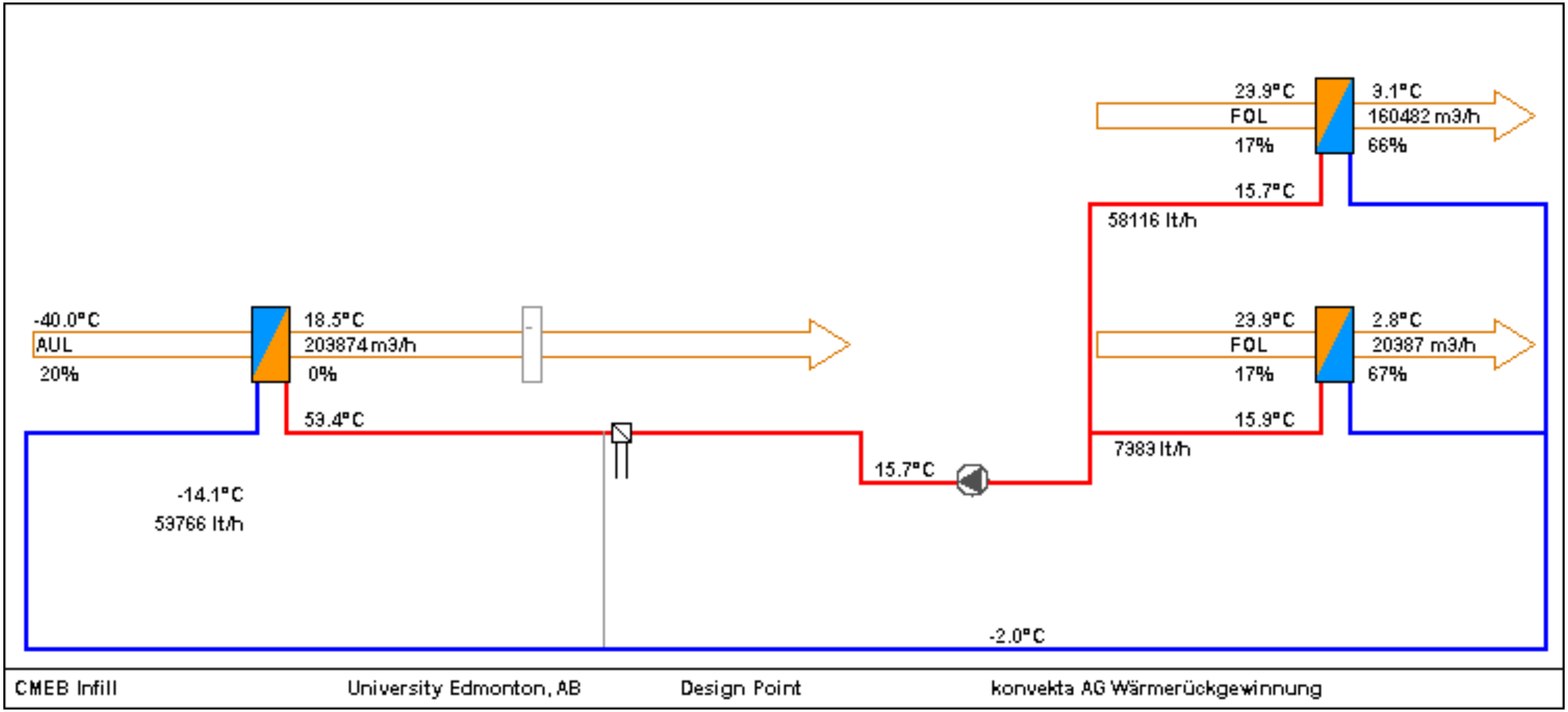


Energy Recovery Power (2 x 40,000 m3/h):
Combined System: 387.4 kW
Single Systems: 343.6 kW -11%

Adding Heat to Fluid System



Example: ICE Building at the University of Alberta, Edmonton



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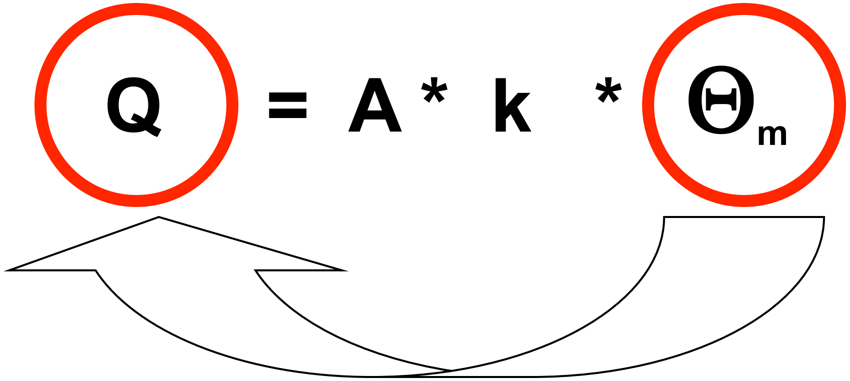
Energy Recovery Controller with Performance Grid Simulation

Optimal Recovery of the Energy in the Exhaust Air

⇨ **Optimum Quantity Circulated at all Operating Conditions**



$$Q = A * k * \Theta_m$$

Q = optimal ← Θ_m = maximum

Demand-dependent Circulation Volume

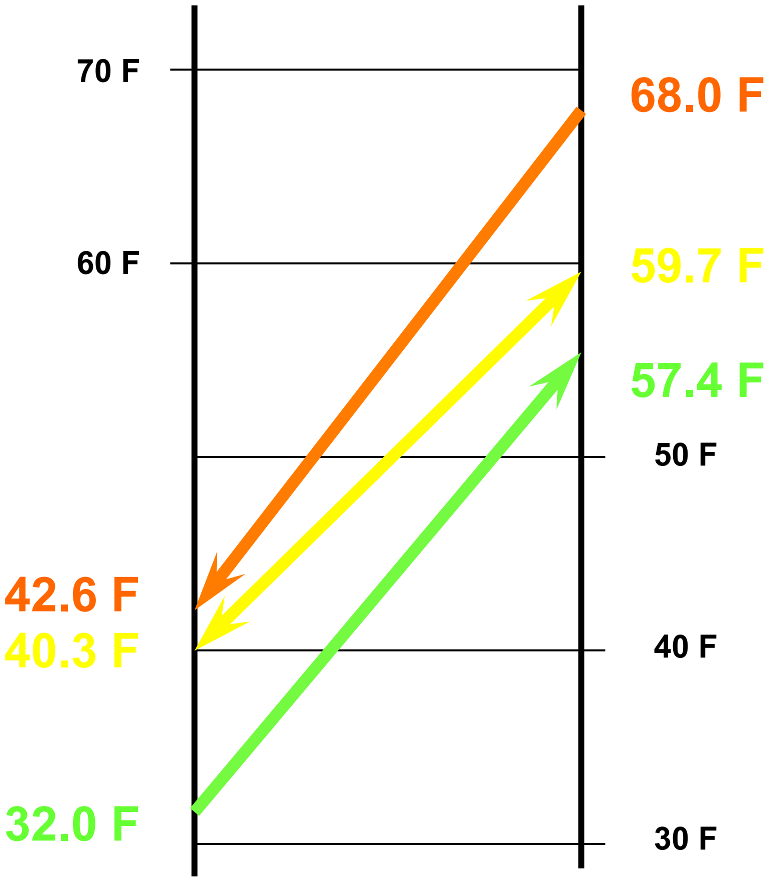
Design Point:

100 % Air
100 % Glycol/Water Flow Rate

ΔT-Air = 10.6 F
η = 70.5 %

Exhaust Air
Glycol Circuit
Outside Air

Temperature Diagram



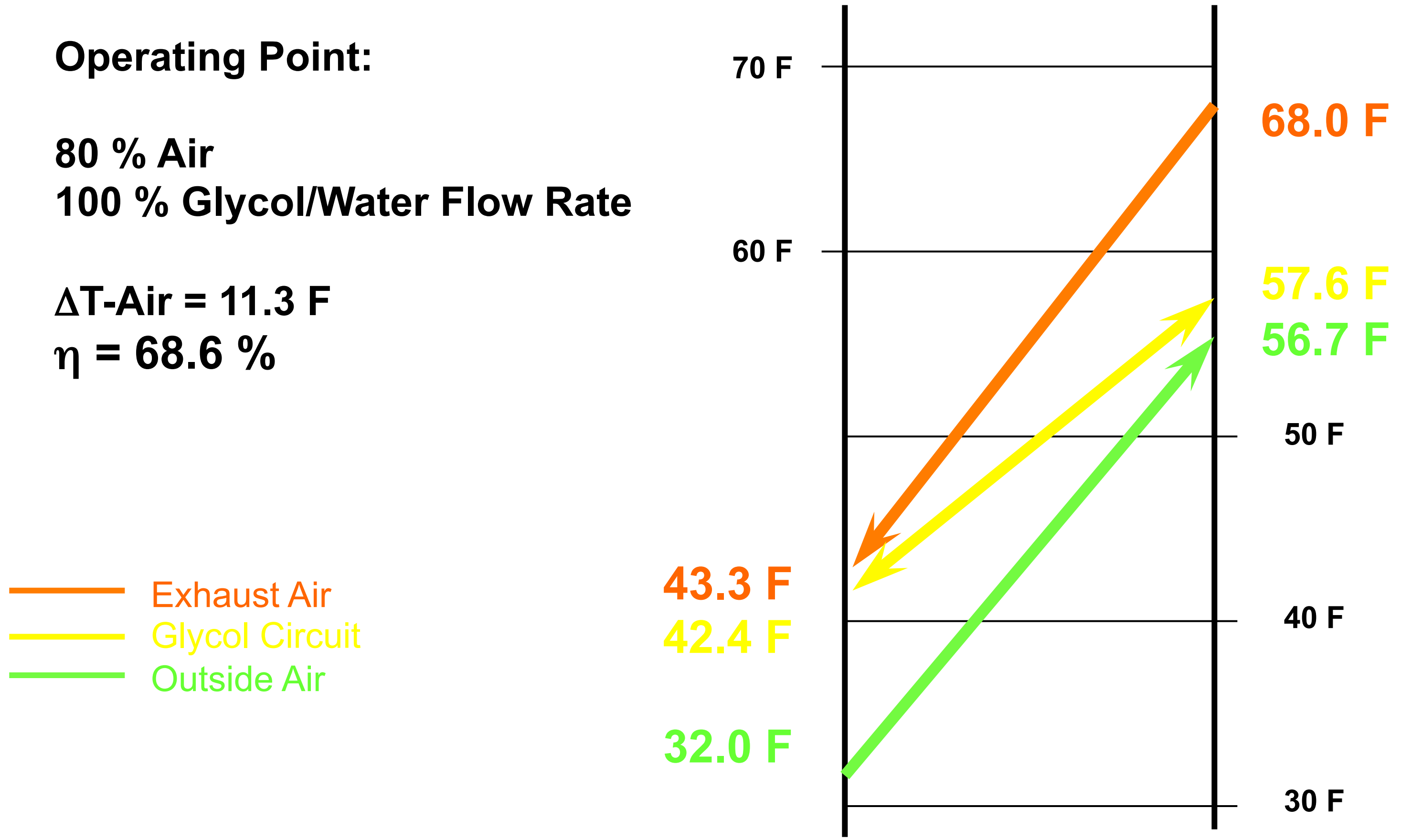
Demand-dependent Circulation Volume

Operating Point:

80 % Air
100 % Glycol/Water Flow Rate

ΔT-Air = 11.3 F
η = 68.6 %

Temperature Diagram



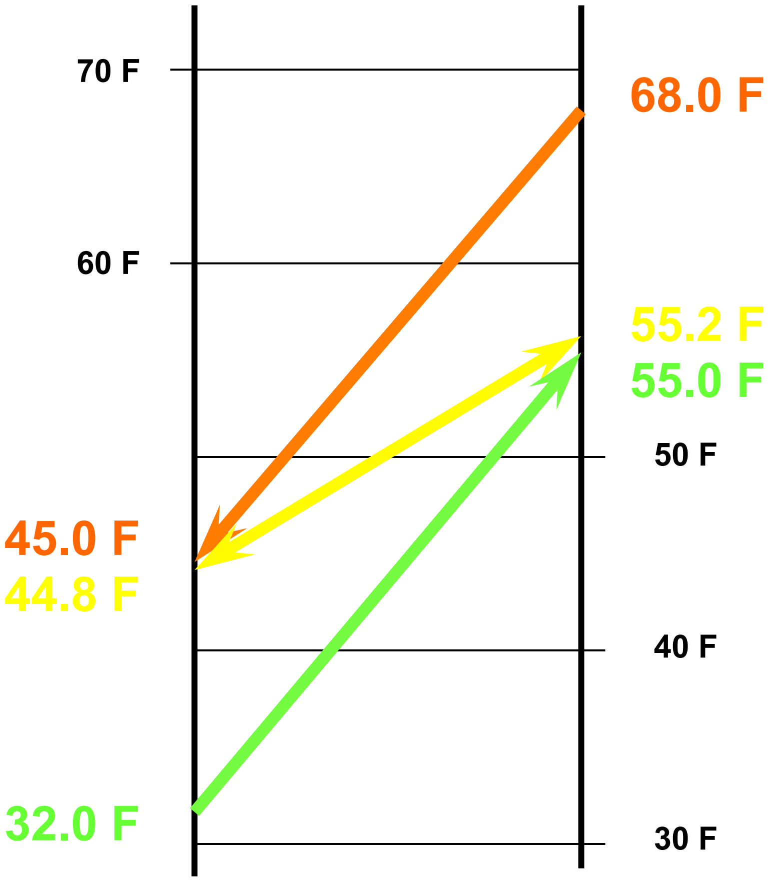
Demand-dependent Circulation Volume

Operating Point:

60 % Air
100 % Glycol/Water Flow Rate

ΔT-Air = 13.0 F
η = 63.9 %

Temperature Diagram



Exhaust Air
Glycol Circuit
Outside Air

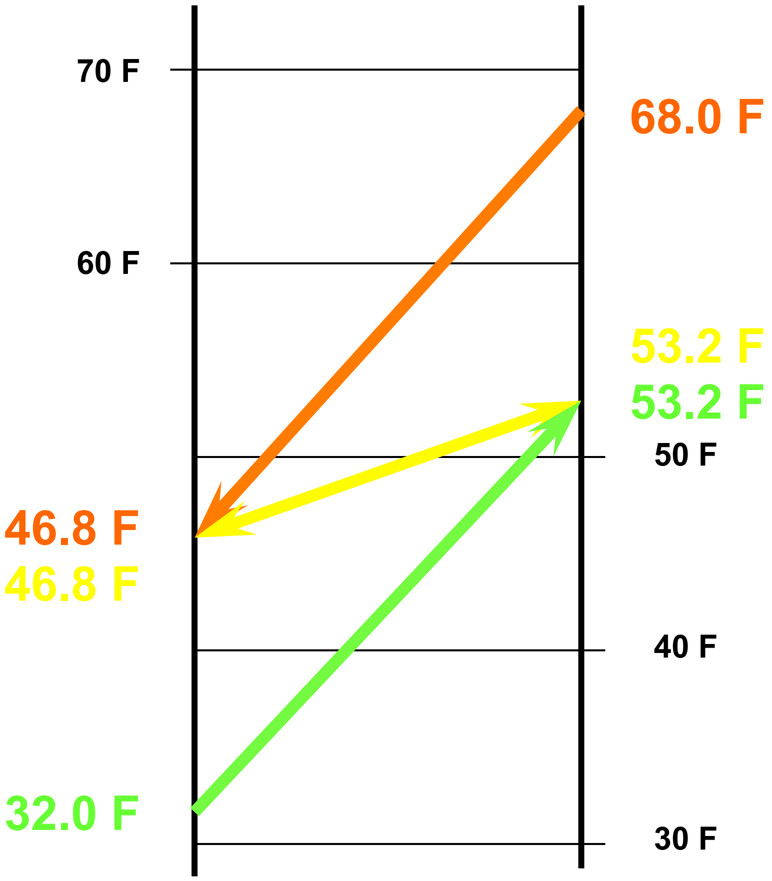
Demand-dependent Circulation Volume

Operating Point:

40 % Air
100 % Glycol/Water Flow Rate

ΔT-Air = 14.8 F
η = 58.9 %

Temperature Diagram



Demand-dependent Circulation Volume

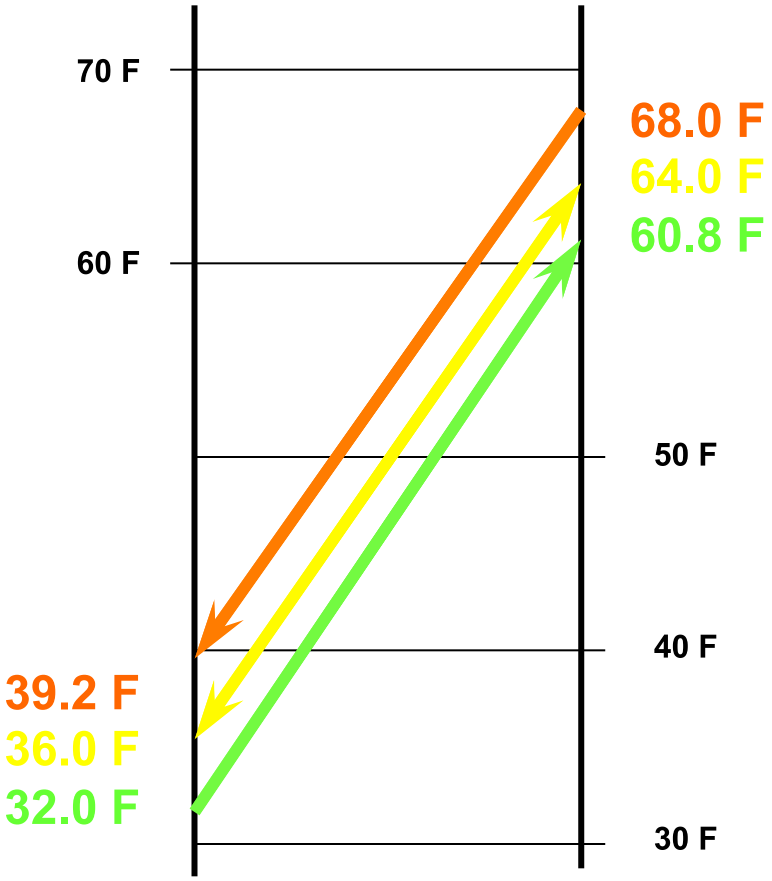
Operating Point:

40 % Air
54% Glycol/Water Flow Rate

ΔT-Air = 7.2 F
η = 80.0 %

Exhaust Air
Glycol Circuit
Outside Air

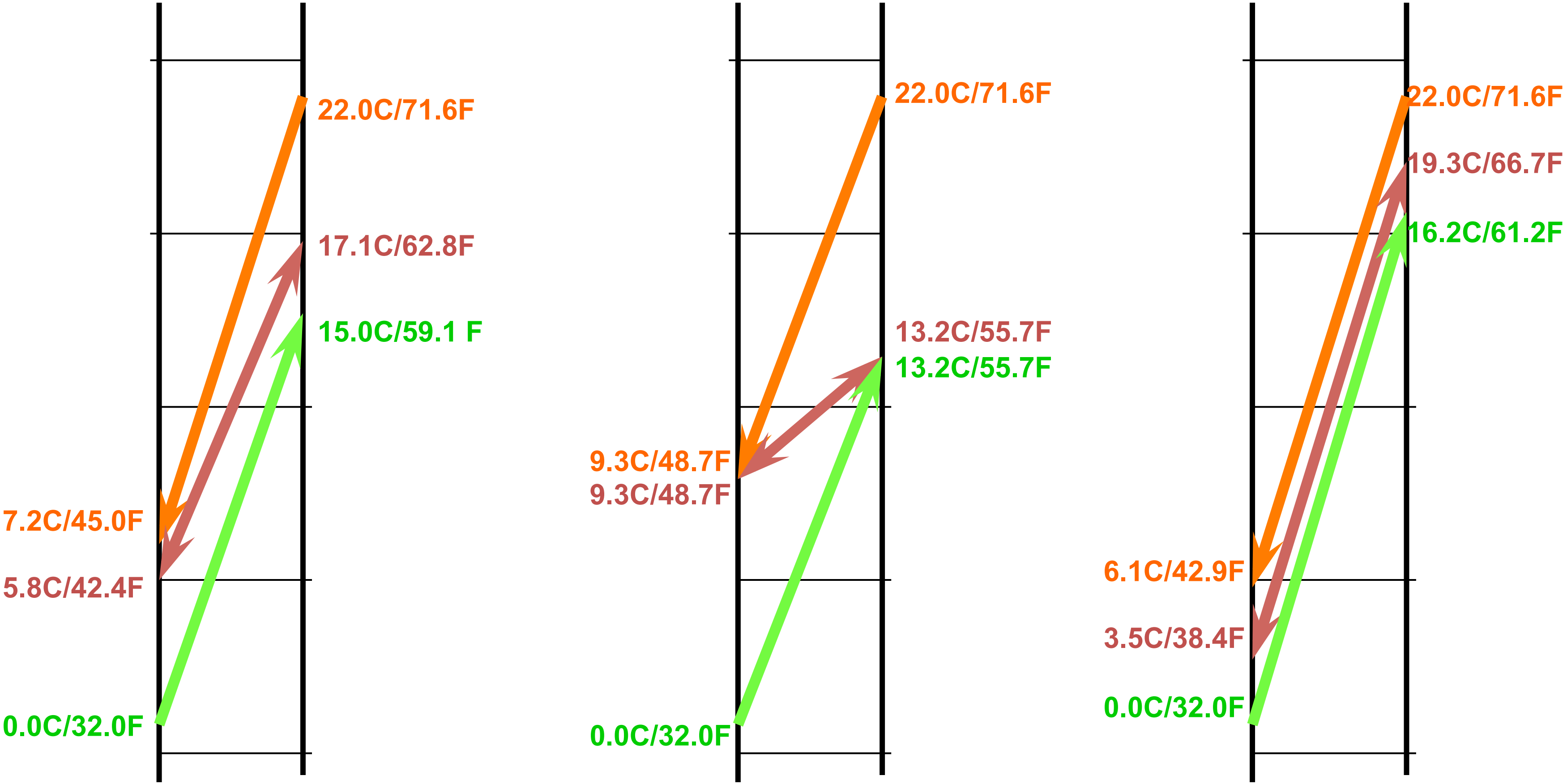
Temperature Diagram



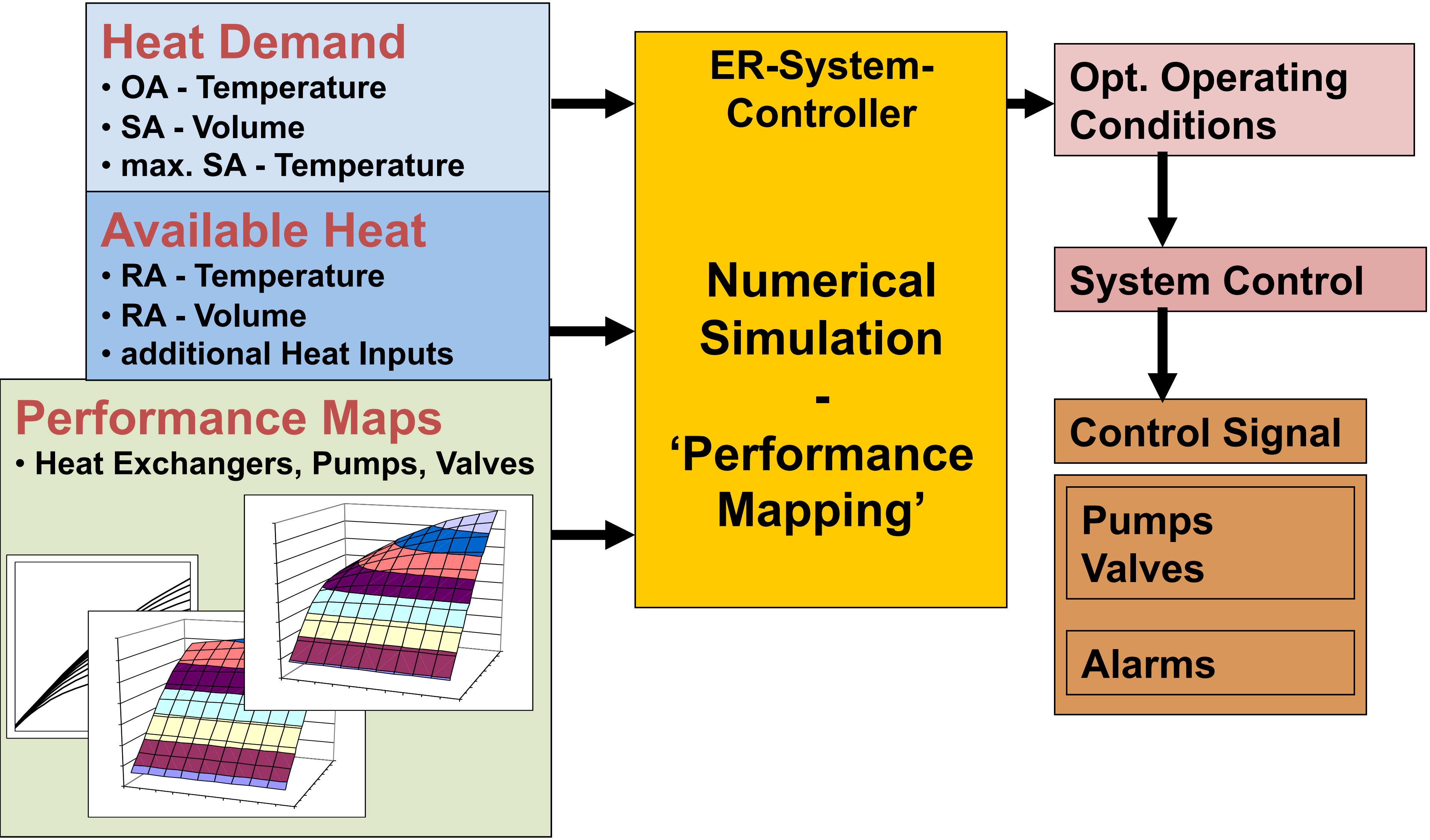
Optimizing $k * \Theta_m$

Operating parameters:

Air Volume [m3/h]	10,000	4,000	4,000
Fluid Volume [m3/h]	4,000	4,000	1,250
μ_T	67%	58%	72%
Energy rec. [Wh/m3 air]	4.8	4.2	5.1



Control Concept



Heat Demand
- OA - Temperature
- SA - Volume
- max. SA - Temperature

Available Heat
- RA - Temperature
- RA - Volume
- additional Heat Inputs

Performance Maps
- Heat Exchangers, Pumps, Valves

ER-System-Controller

Numerical Simulation
-
'Performance Mapping'

Opt. Operating Conditions

System Control

Control Signal

Pumps
Valves

Alarms

Questions?

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