Membrane Dehumidification

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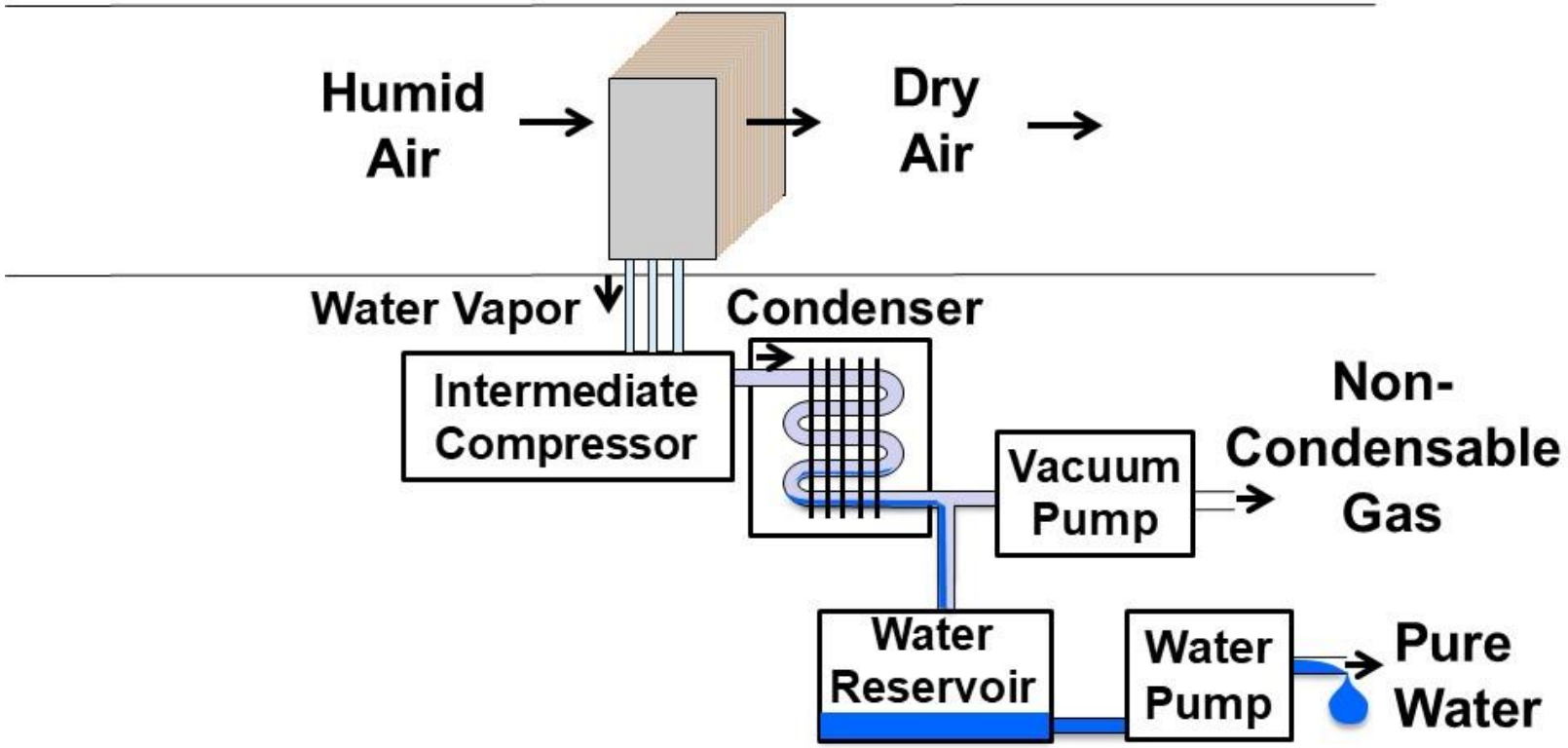
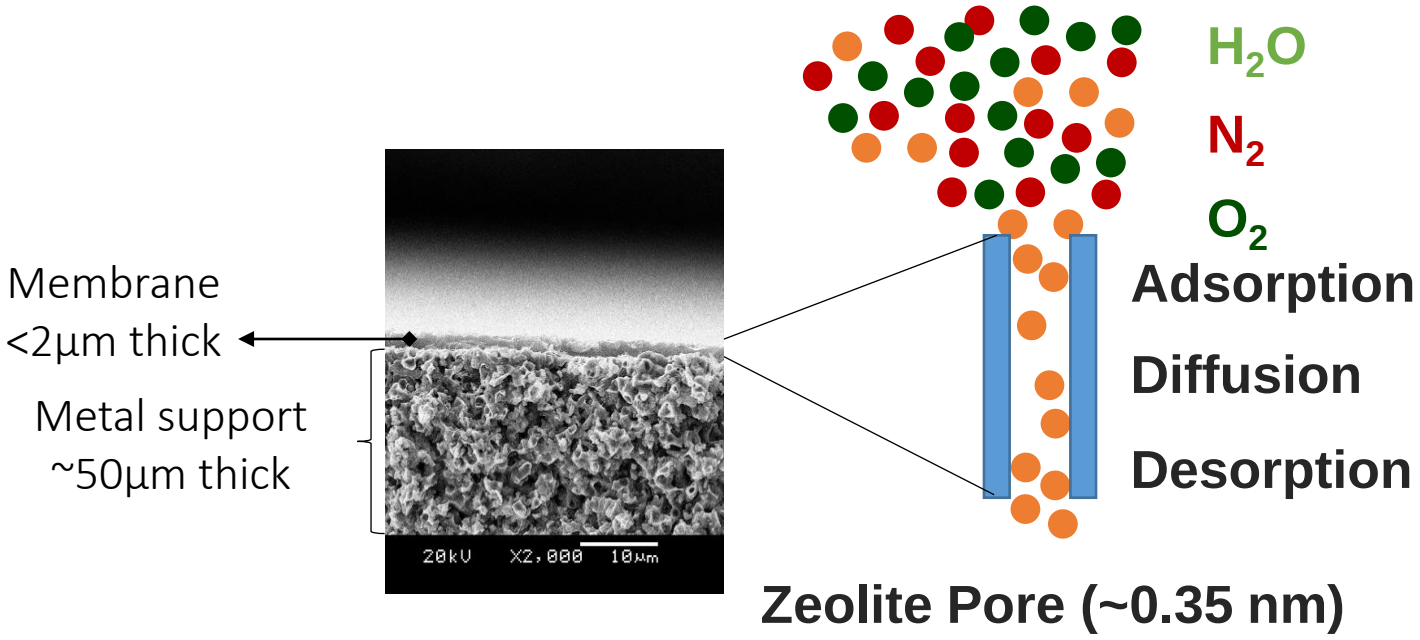
- Systems discussed covered by 7 issued US patents and 20 international patents

Membrane Dehumidifier

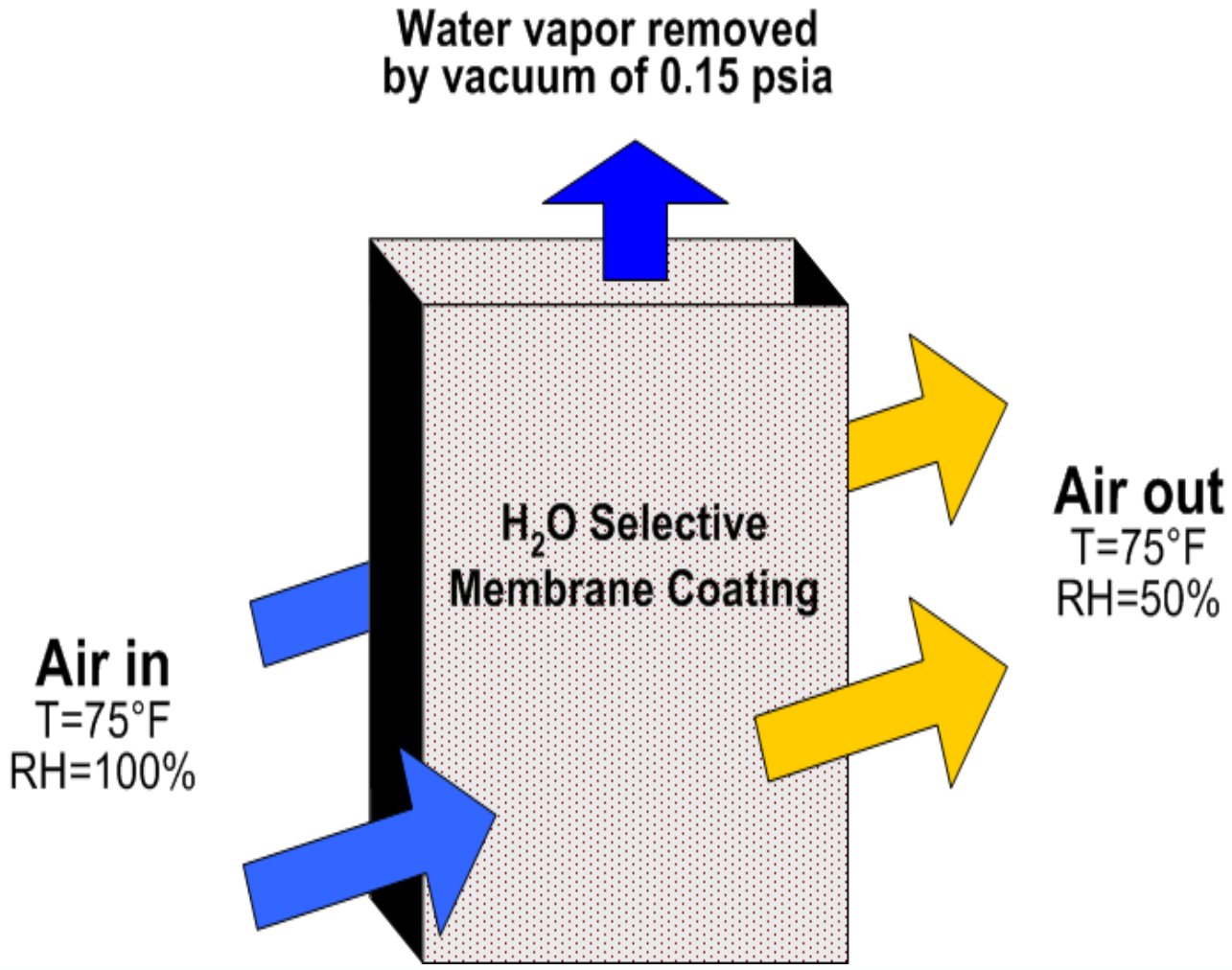


The Membranes

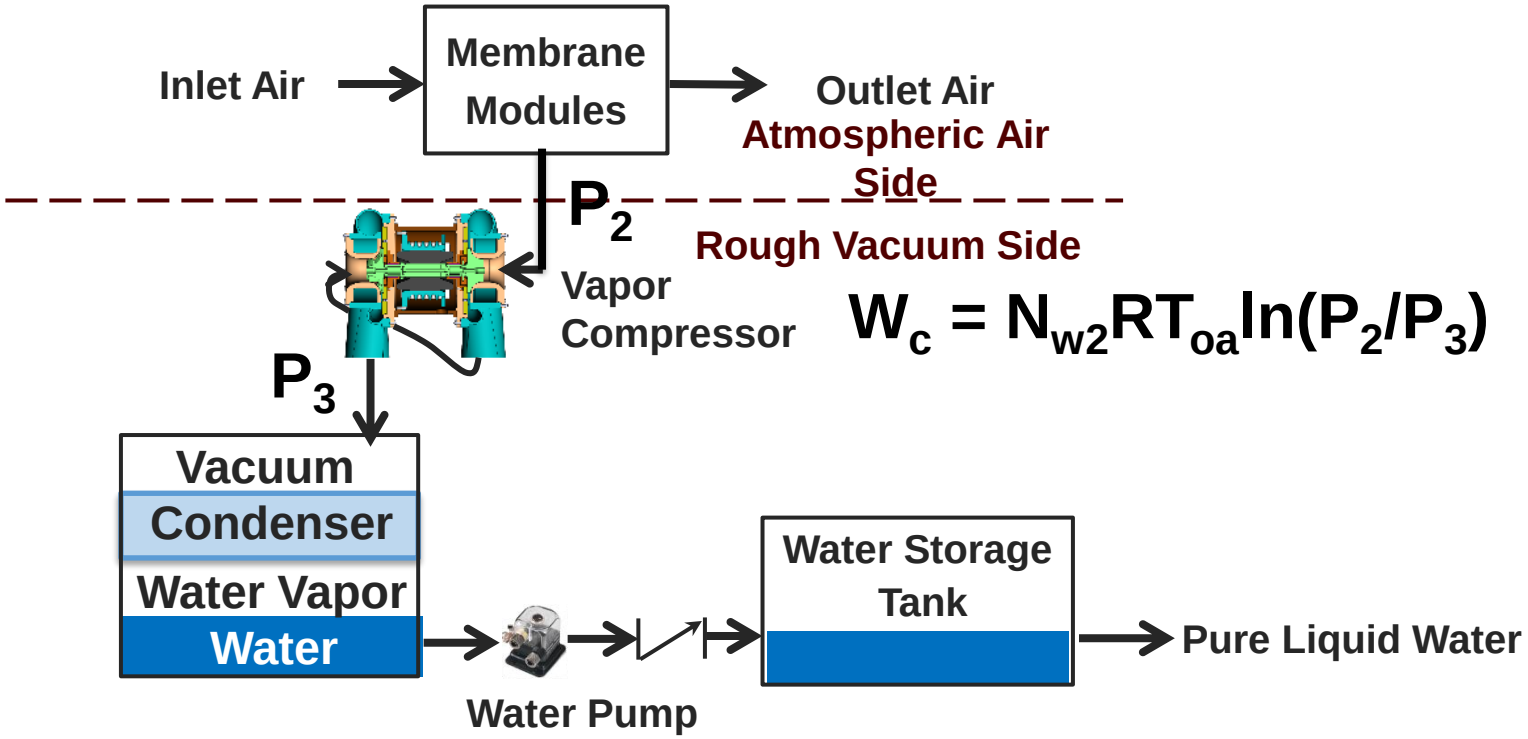
Zeolite membrane developed by Liu (PNNL) acts as a “sieve” for water vapor to dehumidify air at constant temperature without desiccants



The “Fins”


Water vapor removed
by vacuum of 0.15 psia
H_2O Selective
Membrane Coating
Air in
T=75°F
RH=100%
Air out
T=75°F
RH=50%

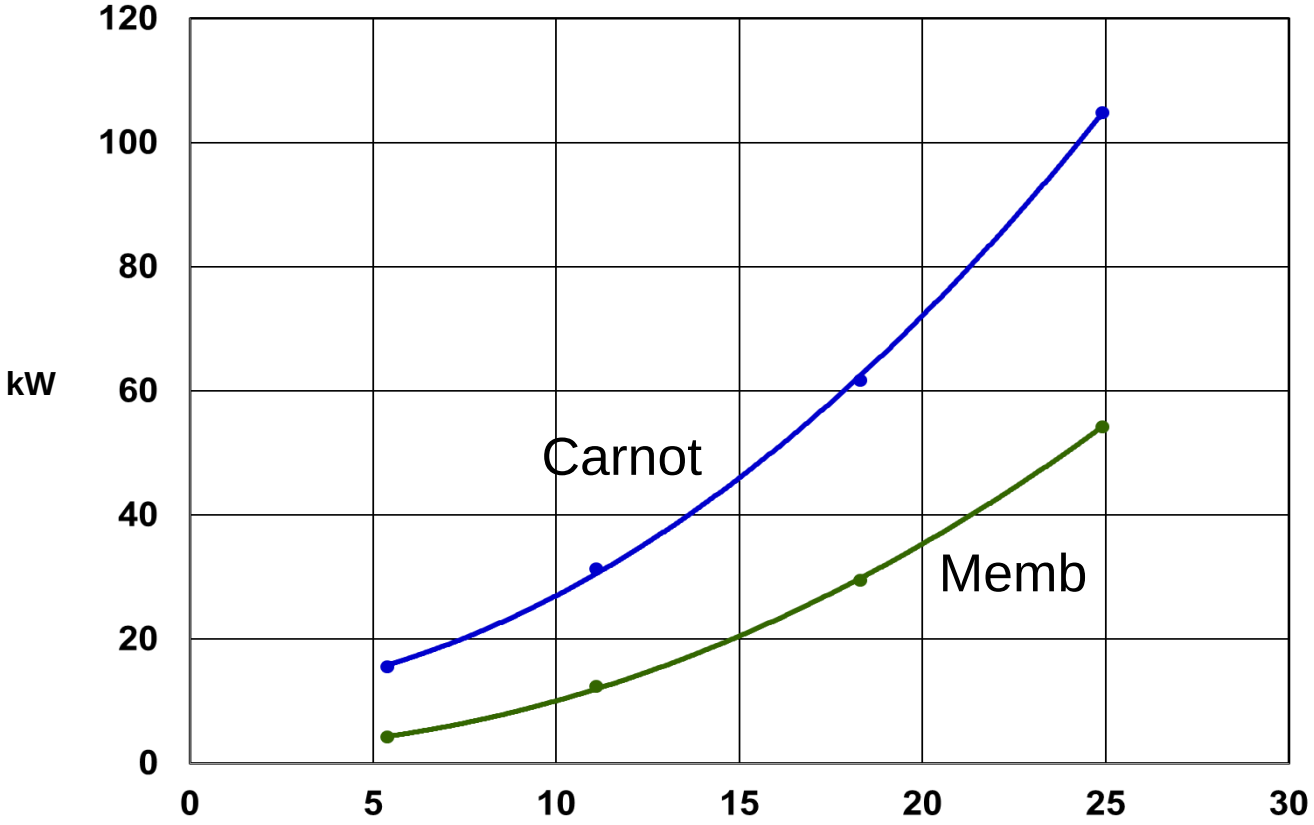
Ideal Membrane Dehum. System



$$W_p = V_{liq}(P_{oa} - P_3) \sim 0.001 W_c$$

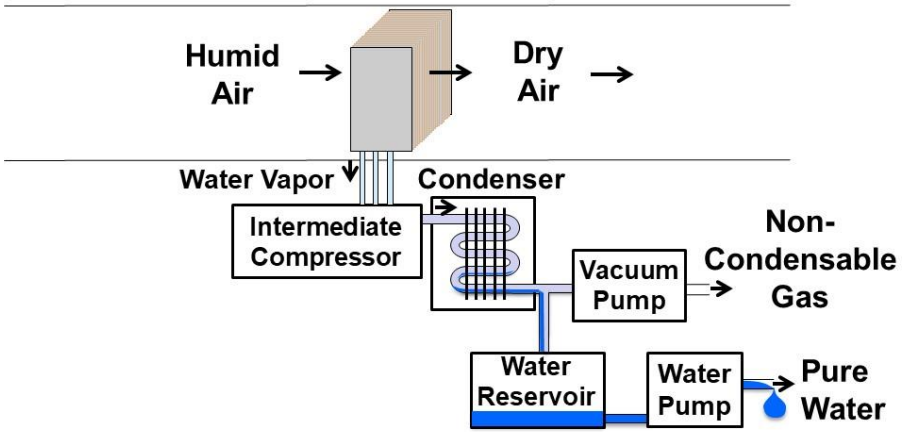
Carnot vs Ideal Memb. System

kW for 100,000 cfm air at 94°F, 52% RH, Carnot w/o reheat

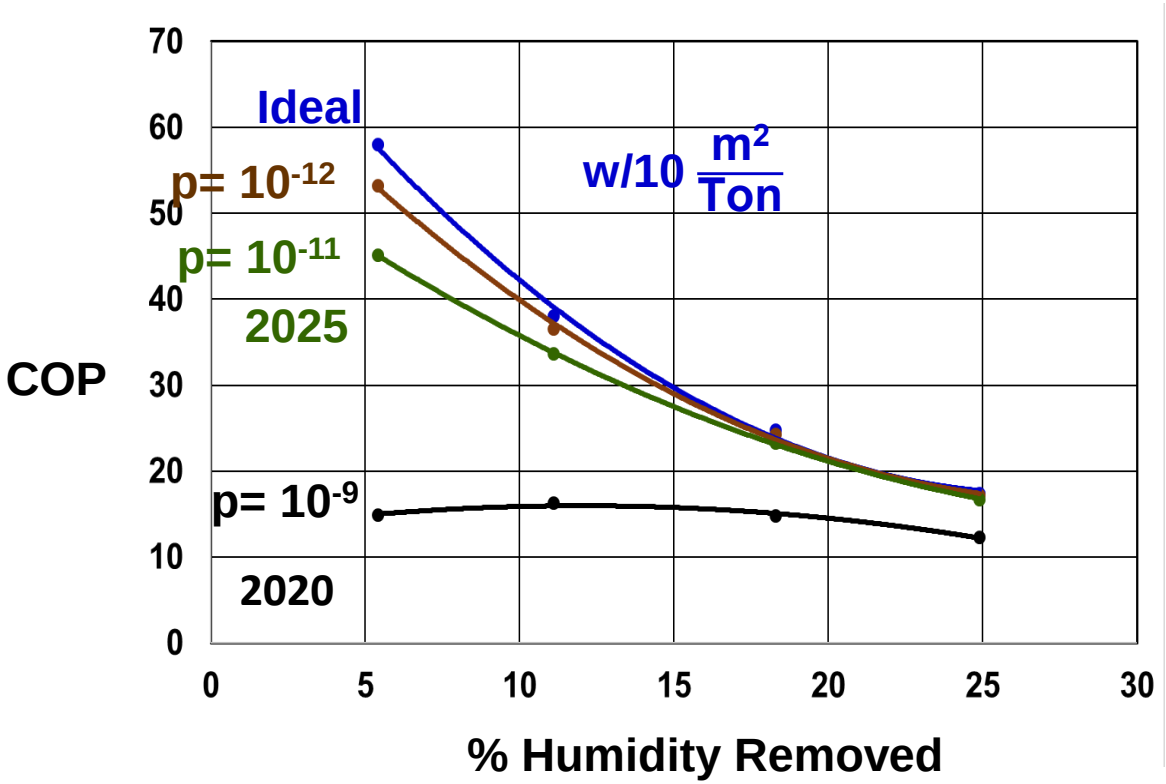


System Efficiency Lowered by:

Membrane Size/Water Permeance
Membrane Air Leakage
Non-ideal Compressor
Non-ideal Vacuum Pump
Non-ideal Condenser
Condenser Pump/Fan
Air Pressure Drop in Membrane Module



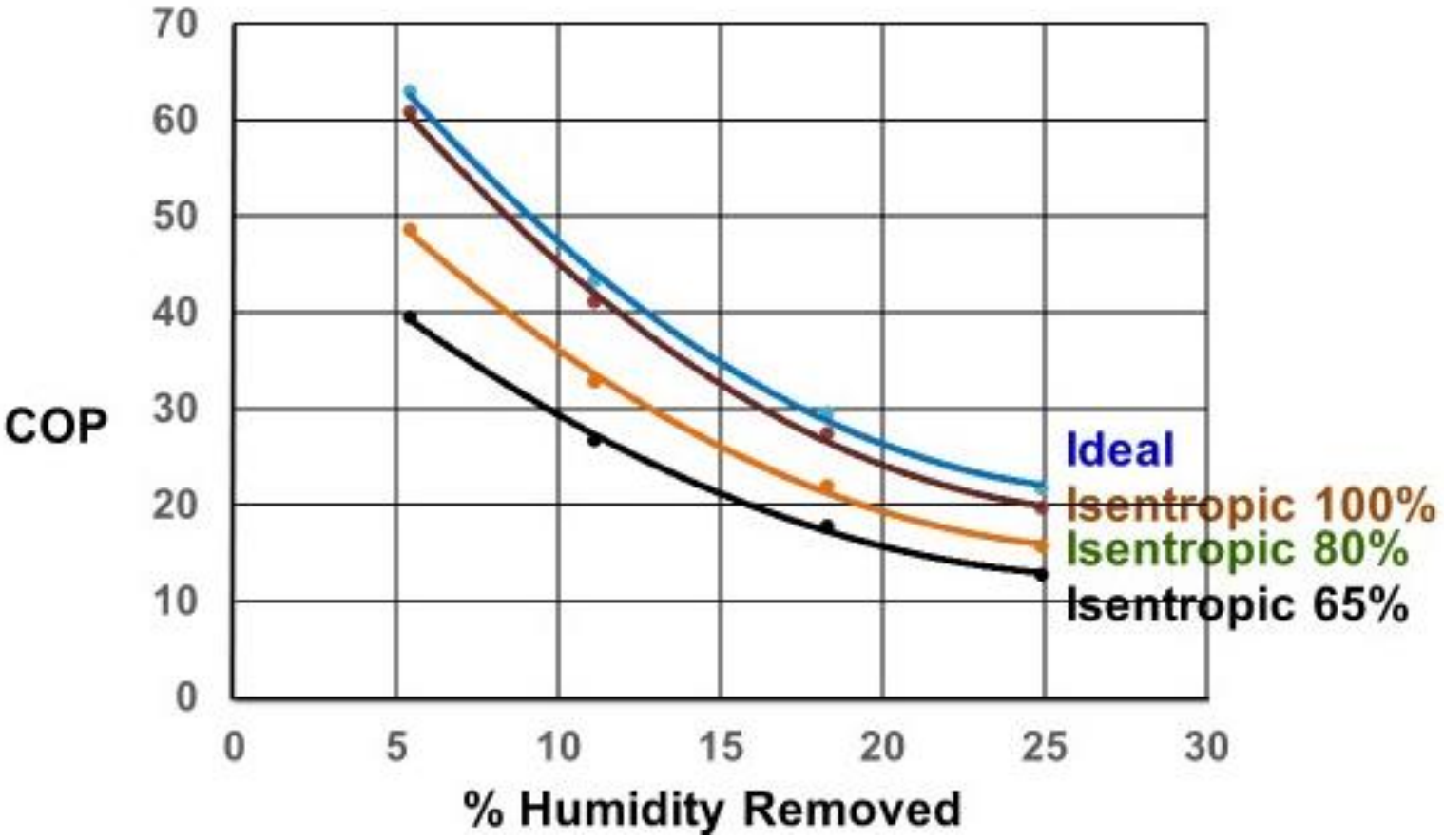
Air Permeance



Key Membrane Development Needs

- Membrane production with air permeance ~10^{-11} – 10^{-12} kmol/(kPa-m^2-s)
- Low cost production process
- Lower cost substrate

Effect of Compressor and Vacuum Pump



Compressor Development

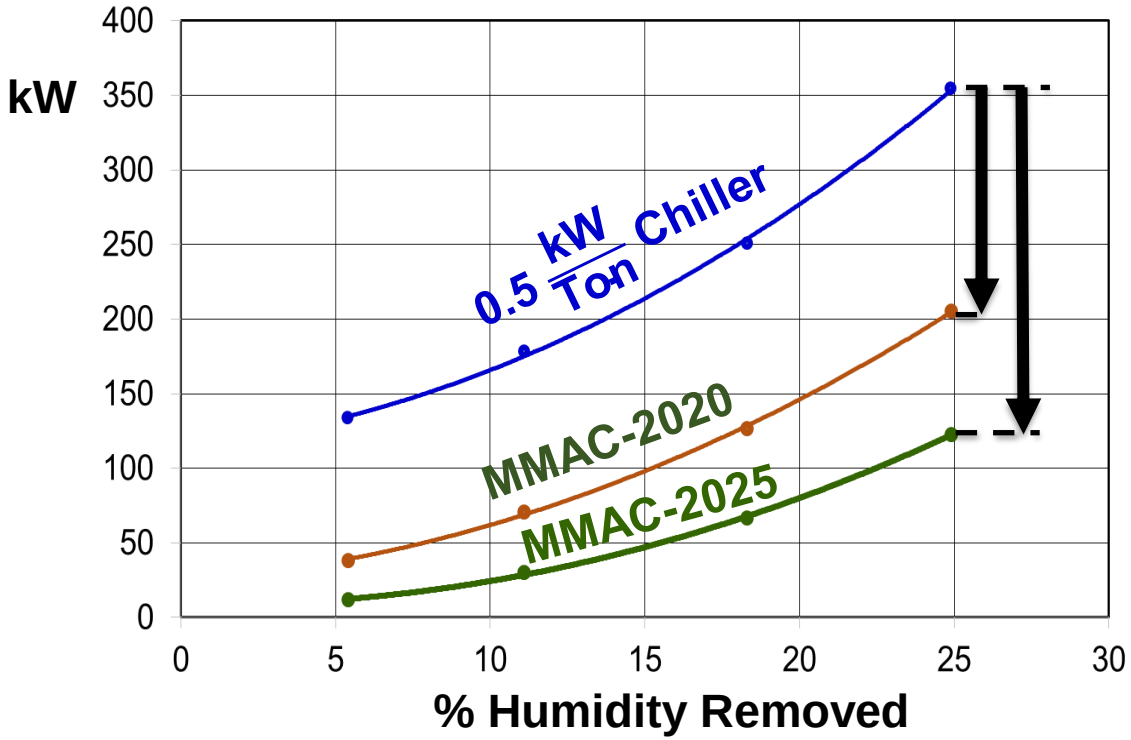
- No small production compressors suitable for this application
- One large limited production compressor

Working Prototype

- Operated at 0.5 Tons
  - Efficiency is low, COP 2.1
- Calibrated model shows
  - COP above 5 when membrane assembly leaks fixed and condenser fans improved

Membrane vs. 0.5 kW/ton Chiller @ 100,000 cfm

40% Reduction Now 65% Reduction In 2025



Conclusions

- Membrane system has excellent potential for removing moisture from moist air flows from room temperature to higher temperatures at very high efficiency.
- Major development needs
  - Leak-free membranes
  - Low-cost membrane production
  - Efficient compressors for range from ~ 1 kPa to 7 kPa absolute