Low Cost Desiccant Wheels AND Heat Pump Liquid Desiccant Regeneration

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Heat Pump Liquid Desiccant Regeneration

- NREL 3/01 RFP
- 7/02 – 12/02 schedule
- $34,780 funding
- Project goal:
  - prototype designs via CFD
  - Primary COP ≥ 1.0
  - RSHI ≤ 1000 Btu/lb
- TAT & IES impact:
  - higher efficiency TAT
  - more cost effective IES
- Project team:
  - UIC/ERC
  - DryKor

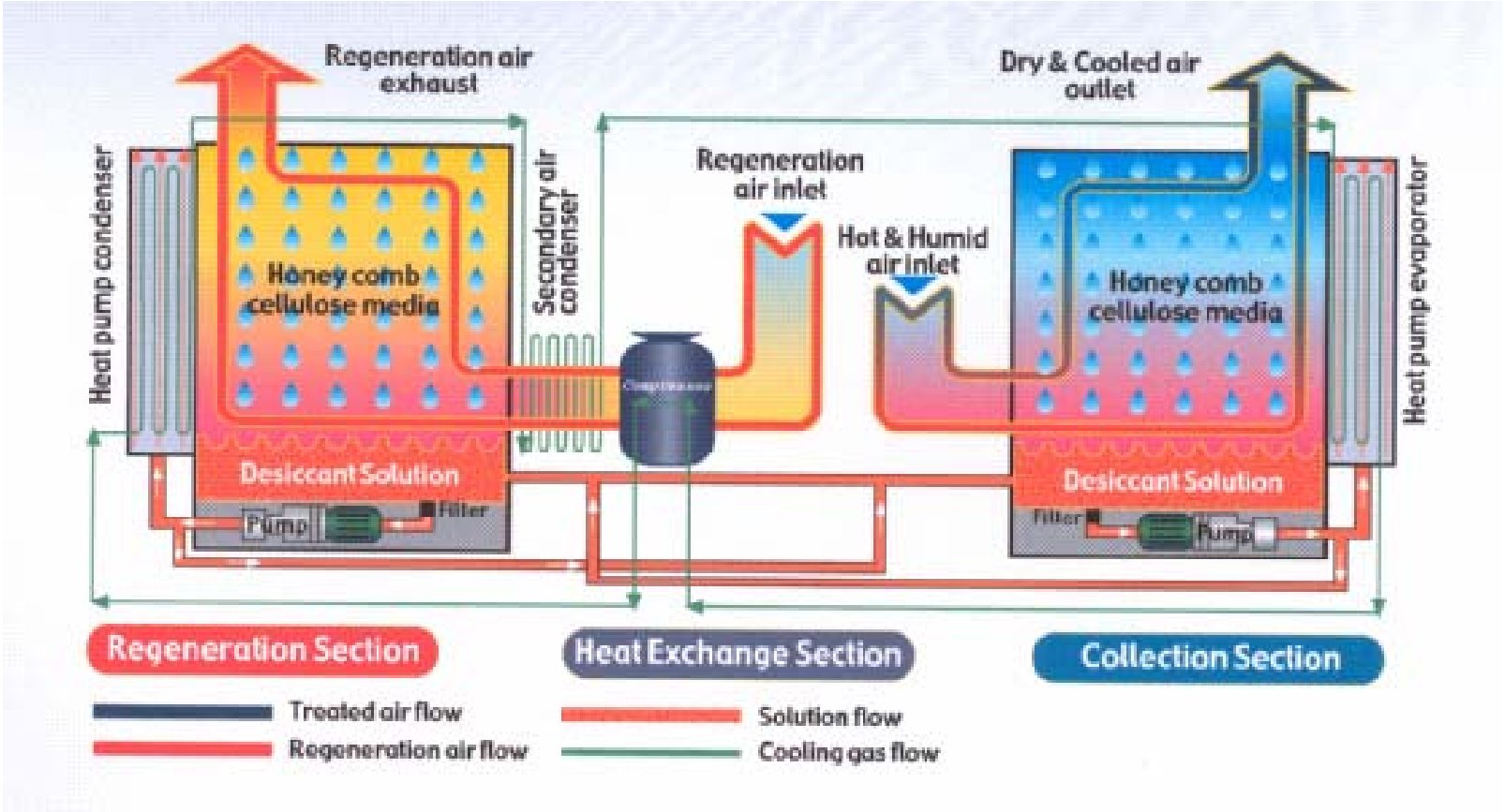
Low Cost Desiccant Wheels

- NREL 4/01 RFP
- 7/02 – 4/03 schedule
- $115,220 funding
- Project goal:
  - prototype rotor(s)
  - Δ gr/lb > 50 (@600 fpm)
  - 50% $/cfm reduction
- TAT & IES impact:
  - lower cost TAT
  - more cost effective IES
- Project team:
  - UIC/ERC
  - RotorSource
  - ProFlute
  - IRE & NRG

Liquid Desiccant Heat Pump (LDHP)

NREL testing

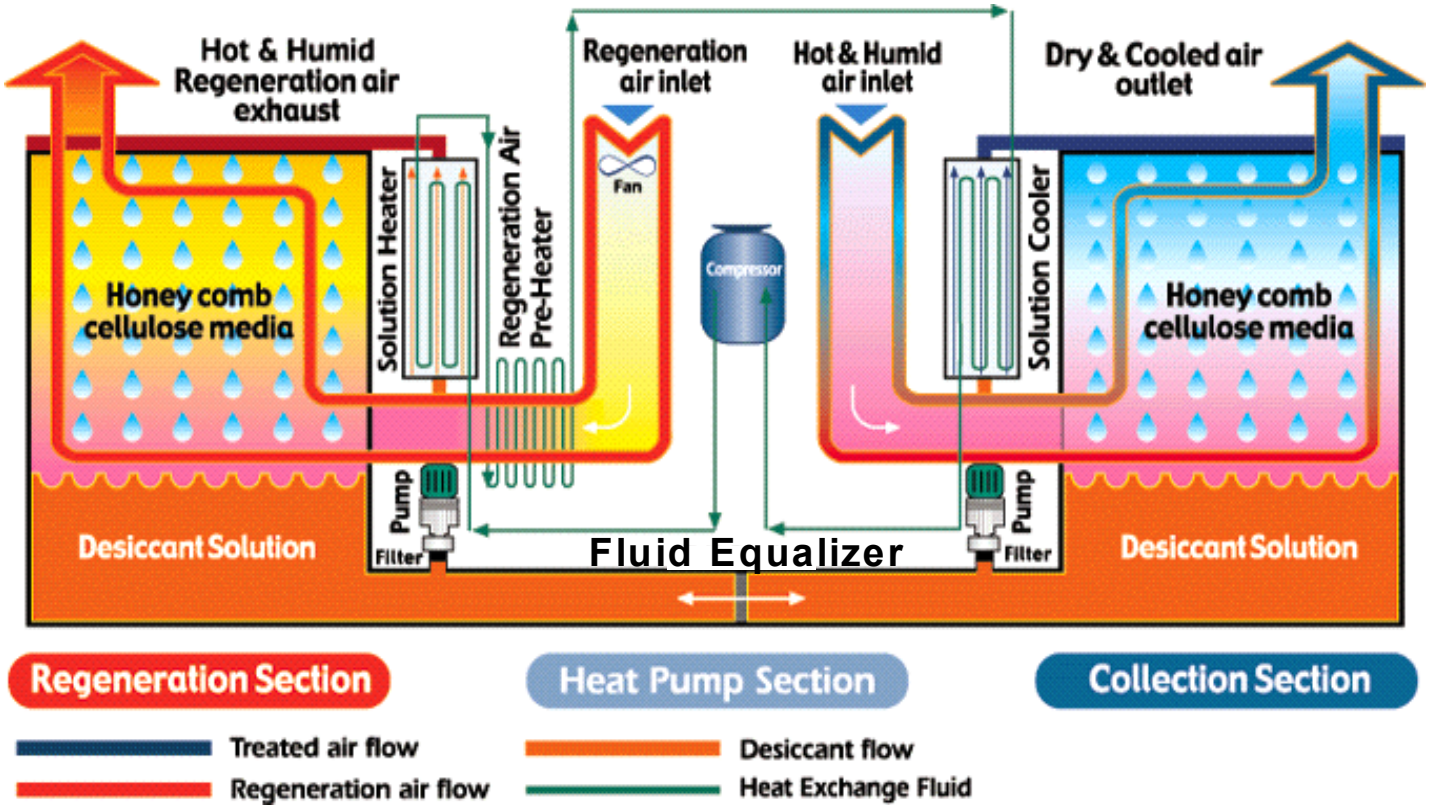
- COPs up to 3.0 (0.84 PCOPs)
- Energy efficiency promising/potential for high COP



Advanced LDHP

Theoretical COPs up to 7.0

- 1 unit of energy into compressor
- 3 units of heat into evaporator
- 4 units of heat out of condenser (into regenerator)



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Advanced LDHP "Fluid Equalizer"

Double Diffusion (DD)

- Solute (LiCl) diffusion and solvent (water) osmosis
- Reductions in thermal mass of liquid desiccant solution cycled between collector and regenerator

Thermal Mass Reductions (%)	Equipment COP	Primary COP	Equipment RSHI (Btu/lb)	Comments
0	3.40	0.95	1413	DryKor catalog data for Model DL 4.0. Power plant to site efficiency = 28%. **Prototype targets:** Primary COP = 1.0 RSHI = 1000 Btu/lb **NREL targets**: Primary COP = 1.4 RSHI = 700 Btu/lb
10	3.67	**1.03**	1271	
20	3.94	1.10	1130	
30	4.22	1.18	**989**	
40	4.49	1.26	848	
50	4.76	1.33	**707**	
60	5.03	**1.41**	565	

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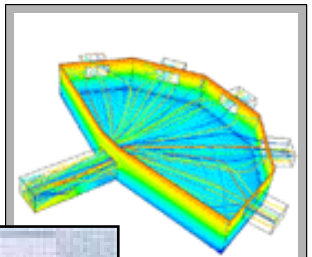
Advanced LDHP Project Team

- ERC at UIC
  - 40 years desiccant experience
  - Fluent CFD modeling
  - www.erc.uic.edu



- DryKor
  - Israeli based
  - Atlanta distribution
  - 500 systems installed
  - schools, hotels, QSRs supermarkets, hospitals, industries, etc.
  - www.drykor.com

Advanced LDHP Tasks & Milestones

- 7-12/02: Task 1 High Efficiency System Design
  - Modeling Algorithms (including but not limited to DD)
  - Fluent CFD Simulations and Evaluations
  - DryKor Feedback
- 12/02: Deliverable from Single Task Phase 1
  - High Efficiency LDHP Design Report
  - 0.5 inch ΔP, 1.0 ARI PCOP, & 1000 Btu/lb ARI RSHI
- 1/03: Phase 2 Go/No-Go Decision
  - Task 2 Advanced Regeneration Bench-Scale Experiments
  - Task 3 Manufacturing Cost Analysis
  - Task 4 High Efficiency Full Scale Prototype

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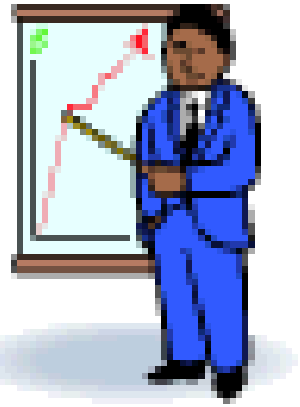
Advanced LDHP Summary
noting Technical Approach & Barriers/Risks

- Potential advancement in LDHP energy efficiency using double diffusion (DD) reductions in amount of solution regenerated



- Much scientific debate with multiple DD theories in play that presents barriers/risks

- UIC Chemistry Department faculty expertise in diffusion and osmosis theory will overcome barriers and minimize risk during CFD modeling project

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SOA Desiccant Wheel Media

SOA Rotor Costs	$/cfm
• Formed Matrix @ $18/lb ($.50 to $14/lb materials)	$.06
• Desiccant in Matrix@ $9/lb ($.50 to $10/lb materials)	$.12
• Hub/Spoke/Rim/Face	$.06
• Total Cost of Rotor	$.24

Specification: 8 inches deep @
15 lb/ft3 density 600
80% desiccant fpm

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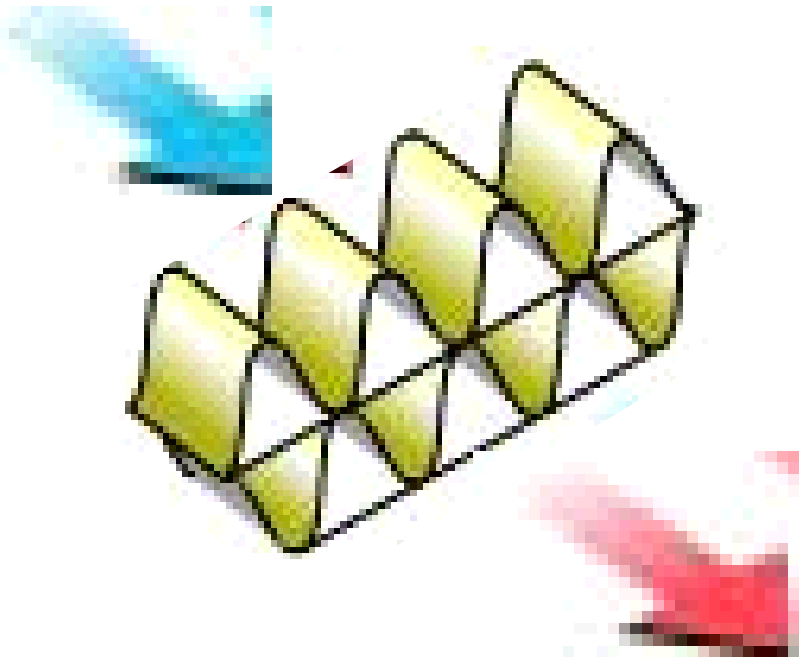
Low Cost Desiccant Wheels (LCDW)
Design Parameters



- Flute size
  - NTUs
  - Pressure drop
- Media Depth
- Media density
  - Matrix wall thickness
  - Desiccant type
  - Desiccant loading
  - Binder level
- Media strength/stability
  - Manufacturing stress
  - Thermal cycling

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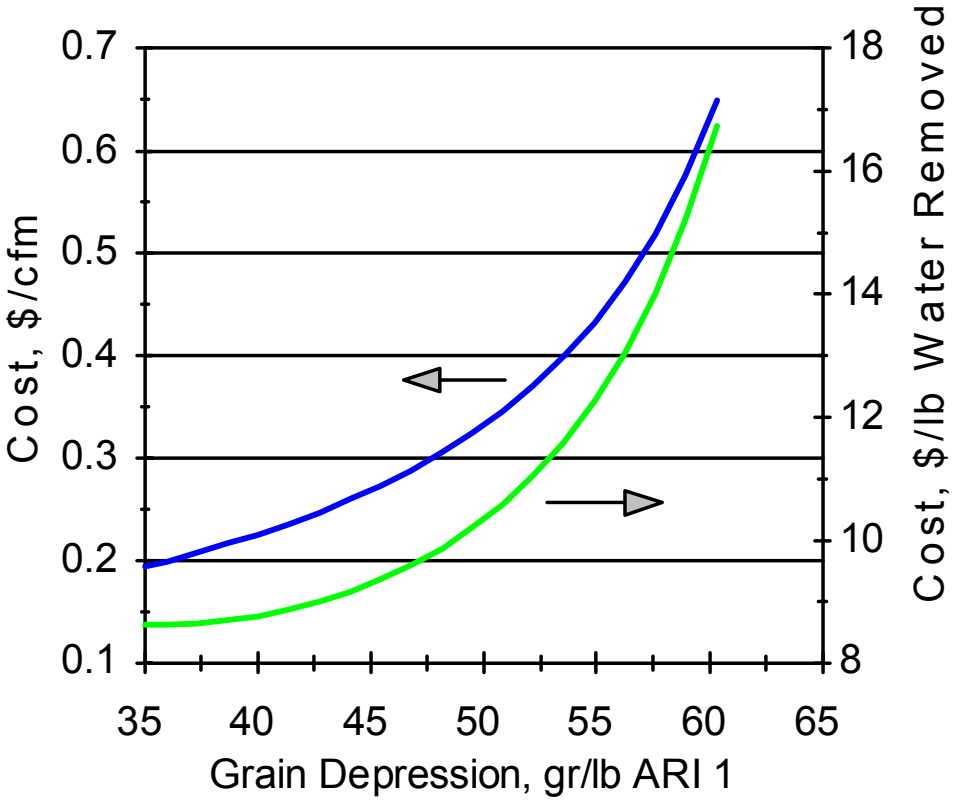
LCDW with High Performance
Cost vs. Performance Tradeoffs



From 40 to 45 gr/lb: 23% increase in cost
From 45 to 50 gr/lb: 26% increase in cost
From 50 to 55 gr/lb: 30% increase in cost

- NREL Goals
  - Δ gr/lb > 50 (@600 fpm)
  - 50% $/cfm reduction from SOA wheels
- Incremental improvements in grain depression are costly in the 50 gr/lb range

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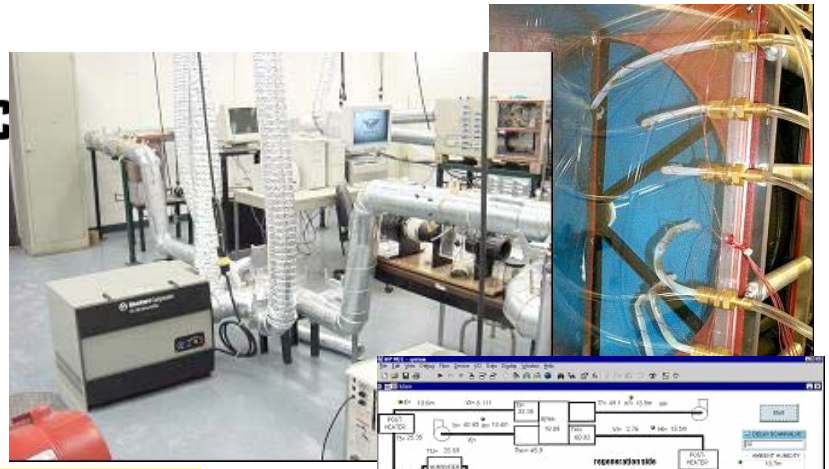
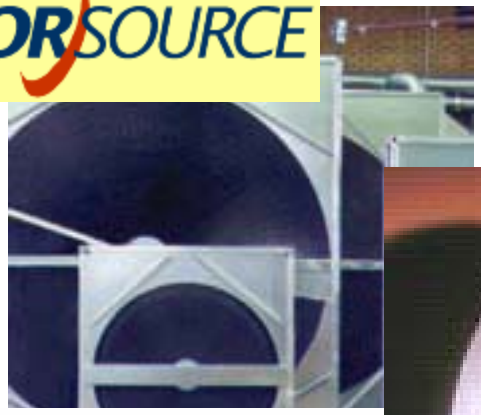
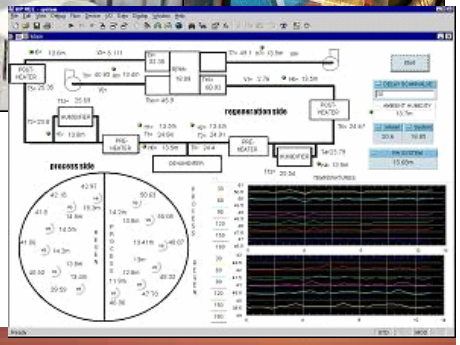
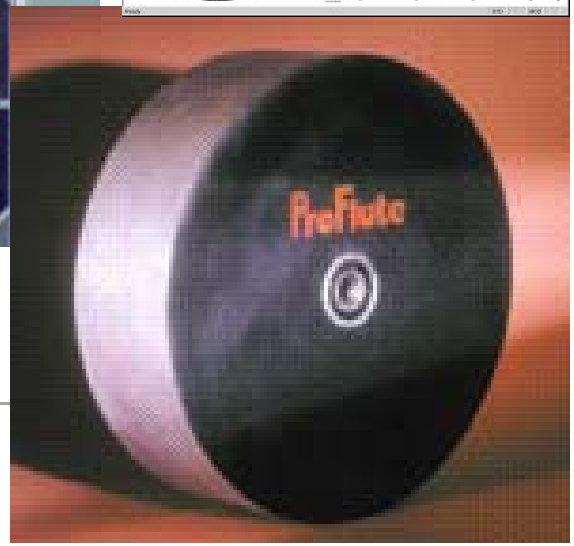
LCDW Project Team

- ERC at UIC
  - 40 years desiccant experience (14 testing)
  - Sorption Test Facility
  - www.erc.uic.edu
- Rotor Source
  - US cassette & unit manufacturer
  - www.rotorsource.com
- ProFlute
  - Swedish supplier to RS
  - www.proflute.se
- Consultants
  - NRG/Dr. Collier
  - IRE/Dr. Belding









LCDW Tasks & Milestones

- 7-9/02: Task 1 SOA Review/Advanced Modeling
- 9-12/02: Task 2 Media/Rotor Experiments
- 1/03: Task 3 Manufacturing Cost Analysis
- 2/03: Task 4 Low Cost/High Performance Design
- 3-4/03: Task 5 Rotor Prototype
  - NREL test of prototype in 4/03
  - Summary report/presentation deliverable in 4/03
- 4/03: Phase 2 Go/No-Go Decision
  - Cassette cost reduction tasks
  - Seals, drives, frames, etc.

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LCDW Summary
noting Technical Approach & Barriers/Risks

- Potential low cost/high performance rotor with
  - Shorter depth wheel
  - Smaller height flute
  - Thinner paper matrix
  - Higher performance desiccant/binder
- 50% SOA cost reduction very challenging at
  - Grain depression of 50 gr/lb
  - Face velocity of 600 fpm
  - ARI 940 Rating #1 of 95Fdb/75Fwb (99 gr/lb)
- Possible, but at what
  - Pressure drop?
  - Regeneration Sensible Heat Input (RSHI)?

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