Problem Statement

- Two global problems:
  - Fresh water scarcity
  - Global warming
- 2030 stress prediction
- Many high stress areas near oceans

[1]
Sponsor Solution

● Solar desalination

● Benefits
  ○ Renewable fresh water production
  ○ Freshwater lakes, growth of vegetation, increase CO2 capture

● Solar desalination process:
  ○ Cold seawater enters the system
  ○ Solar energy evaporates water
  ○ Water vapor is condensed to create fresh water
  ○ Heat exchanger recovery
  ○ Collect salt from brine solution
Existing Systems

Reverse osmosis
- Uses high pressure to force seawater through a semipermeable membrane
- 5 kWh/m^3

Multi-stage flash
- Uses multi-stage flash distillation
- different pressures to reduce boiling point
- Counterflow heat exchanger
- 20 kWh/m^3
Project Objectives

**Modeling**
- Interactive model of evaporation and condensation
- Variable input capable of producing estimated evaporation and condensation rates

**Experimentation**
- Modular coupled experimental design
- Variable input capable of producing estimated evaporation and condensation rates

**Coupling Modeling with Experimentation**
Modeling - Condensation

- Heat Transfer and Heat Mass Transfer
- Variable input humidity, flow rate, and temperature to measure output of liquid water and energy recovered
- Use cross sectional averages,
- Assume uniform surface temperature, steady state
Modeling - Evaporation

- Similar to Condensation Modeling
- Measures output of water vapor and energy required to maintain equilibrium
- Use cross sectional averages,
- Assume uniform surface temperature, steady state
Modeling - Results

Comparison of Mass Transfer Rates

Percentage of Energy Recovered

Volumetric Flow Rate (L/min)

Flow Rate (L/min)
Modular Design

1. Three-way manifold to evenly distribute air flow
2. Variable Volumetric flow meters to set flow rate (x3)
3. 500W Electric Heater set at 40°C
Modular Design - Walkthrough

Video already taken in lab
Reaching Steady State - 15L/min

Temperature and Humidity vs Time at 15L/min

- Line = temperature
- Dashed = humidity

T1 Evaporation
T2
T3 Condensation
T4
Volumetric Flow Rate Effect

- Inlet temperature and RH constant for all flow rates (32°C, 50%RH)
- T2 and T3 similar values
- Evaporation rate increase with increased flow rate
- Evaporation and condensation temperature decrease slightly
- At all flow rates, difficult to pull moisture out of air
Coupling Modeling and Experimentation

- Effects of Developing flow
  - Temperature
  - Flow Rate
- Margin of Error on scale
- Using averaged values of cross sectional areas
# Project Budget

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Future Steps

- Improve efficiency of condensation chamber
  - Increase surface area of fins
- Perform scans with Labview temperature system
- Test full prototype with seawater
- Implement system to remove residual brine from evaporation chamber
- Add glass cover to evaporation chamber
  - Run tests with infrared solar lamp as heater
Summary

- Address increasing problems with water scarcity
- Proof of Concept
- Experimental Data with Modeling
- Room for improvement
References


[3] “Multi-Stage Flash Distillation.” Https://Www.ee.co.za/Wp-Content/Uploads/2014/12/09-Mr-Water-Desalination-Final-Fig.021-600x333.Jpg.

