ALLANA BUICK & BERS

Making Buildings
Perform Better

Alternative Energy Applications

of Solar Thermal Collectors

Presented By

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ALLANA BUICK & BERS
Making Buildings Perform Better

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CEO / Senior Principal

EDUCATION: **B.S., Civil Engineering, Santa Clara University**

REGISTRATION: **P.E., Civil Engineering - Hawai'i, California, Washington, Oregon, Nevada**

CERTIFICATION: **Registered Roof Consultant (RRC), Roof Consultants Institute (RCI); Registered Waterproofing Consultant (RWC), Roof Consultants Institute (RCI)**

OVERVIEW:

- Former Turner Construction Employee (Project Engineering and Superintendent).
- Over 32 years experience providing superior technical standards in all aspects of building technology.
- Principal consultant in forensic investigations of building assemblies, failure analysis, evaluation and design of building infrastructure and building envelope evaluation and design.
- Expert in all aspects of building envelope technology.
- Completed numerous new construction, addition, rehabilitation, remodel and modernization projects for public and private sector clients.
- Specialization in siding, roofing, cement plaster, wood, water intrusion damage, window assemblies, storefronts, below grade waterproofing, and complex building envelope and mechanical assemblies.

Joseph Higgins, P.E.
Mechanical Engineering Services Manager

EDUCATION: **B.S., Mechanical Engineering, University of Washington**

REGISTRATION: **P.E., Mechanical Engineering - Hawai'i, Washington, Oregon**

CERTIFICATION: **EPA Universal Refrigeration Certification**

AFFILIATIONS: **American Society of Heating, Refrigerating and AC Engineers (ASHRAE)**

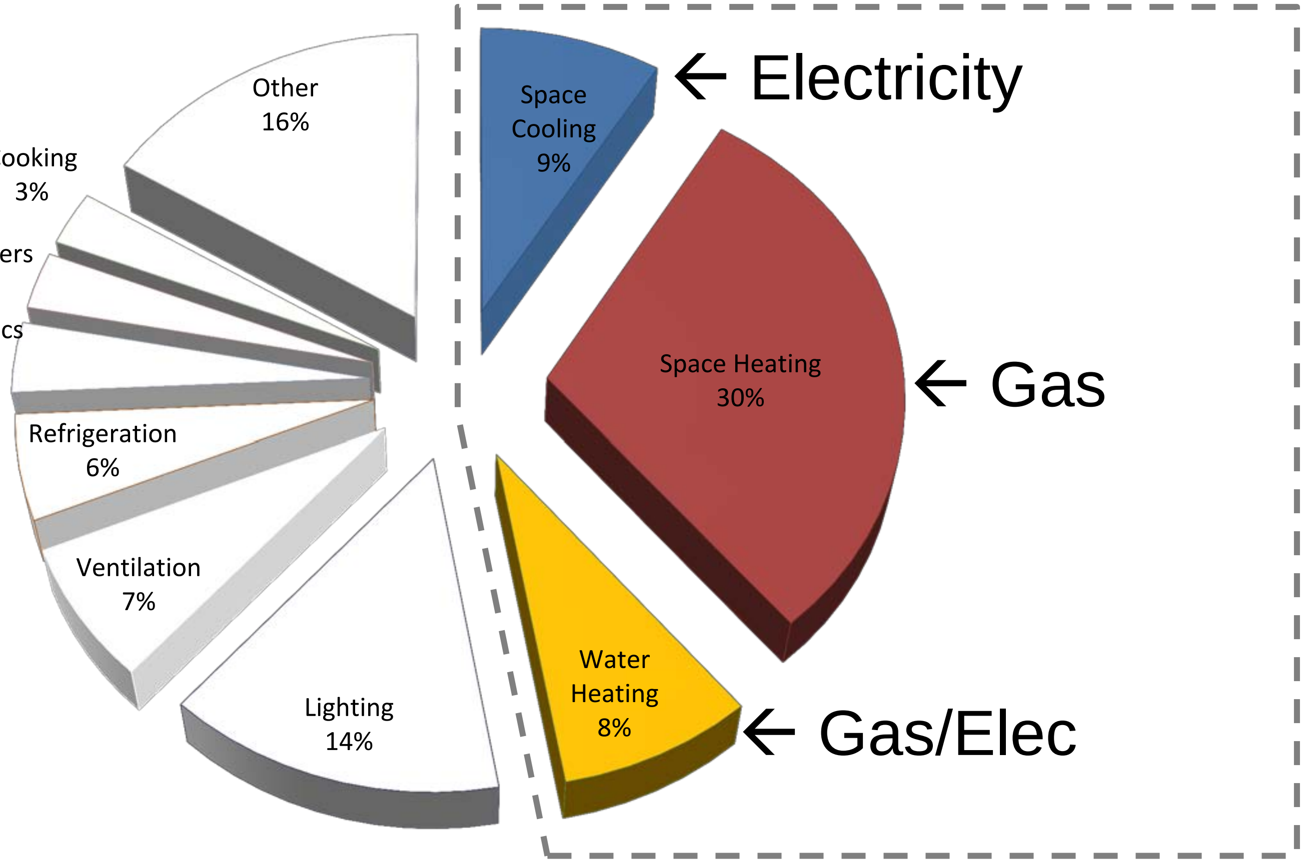
OVERVIEW:

- 24 years experience with the engineering and operation of building mechanical systems.
- Initial project investigation, the supervision of field monitors and technicians, sampling and testing analysis, quality assurance, construction documents.
- Managing and monitoring all aspects of building construction with special attention towards the replacement and upgrade of:
  - Building HVAC systems
  - Plumbing and Piping Systems
  - Energy Management Systems
  - Solar Thermal and Solar PV systems
  - Energy Audits

Objectives

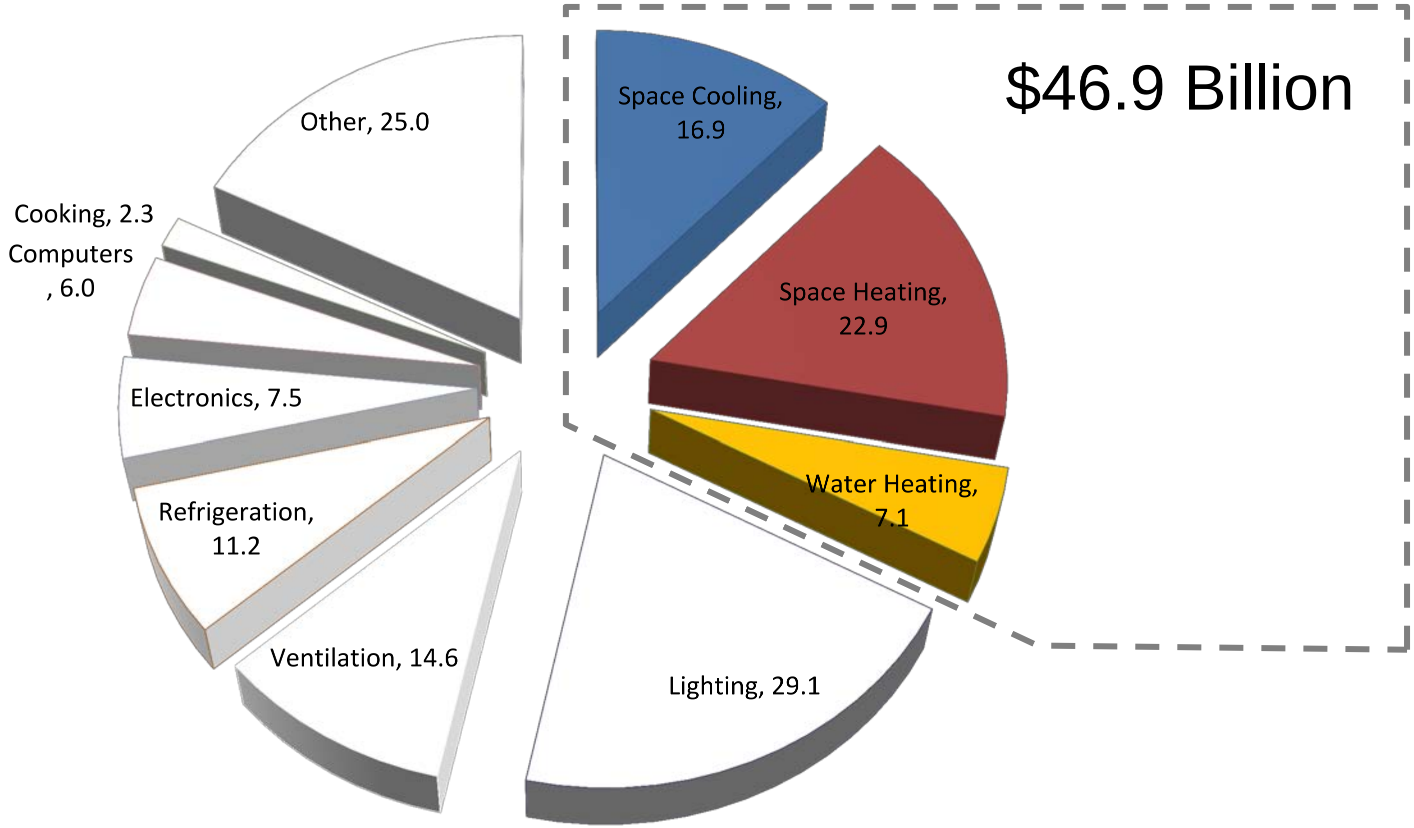
- **How can we save money by improving building performance?**
- **Solar Thermal Heat Pump – What is this?**
- **How can the Solar Thermal Heat Pump be integrated into the Hot Water Production Plant?**
- **How can Solar Thermal Heat Pump be integrated into the Chilled Water system?**
- **Look at a case study of:**
  - **Santa Clara University – Benson Hall**
  - **A recent AOAO project**
- **Understanding the economics of Solar Thermal Heat Pump – The potential savings?**

Heating and Cooling Energy is 45% of Building Usage



DOE US 2010 Commercial Energy End-Use Splits, by Fuel Type

Heating and Cooling $ Spent in Building - USA

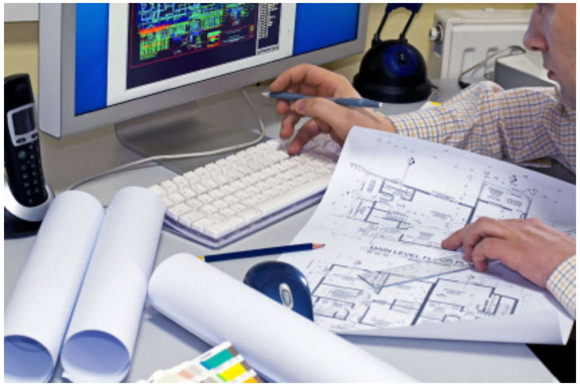


US 2010 Buildings Energy End-Use Expenditure Splits, by Fuel Type (2009 $'s)

Six Ways to Improve Building Performance

1. **Electrical conservation through lighting, power conditioning, and mechanical retrofits.**
2. **Solar PV electrical generation.**
3. **Water savings through reduced flow components**
4. **O & M savings over time from reduced costs and longer life-cycle.**
5. **Equipment downsizing through improved modeling techniques and load matching.**

6. Solar Thermal Heat Pump (STHP)



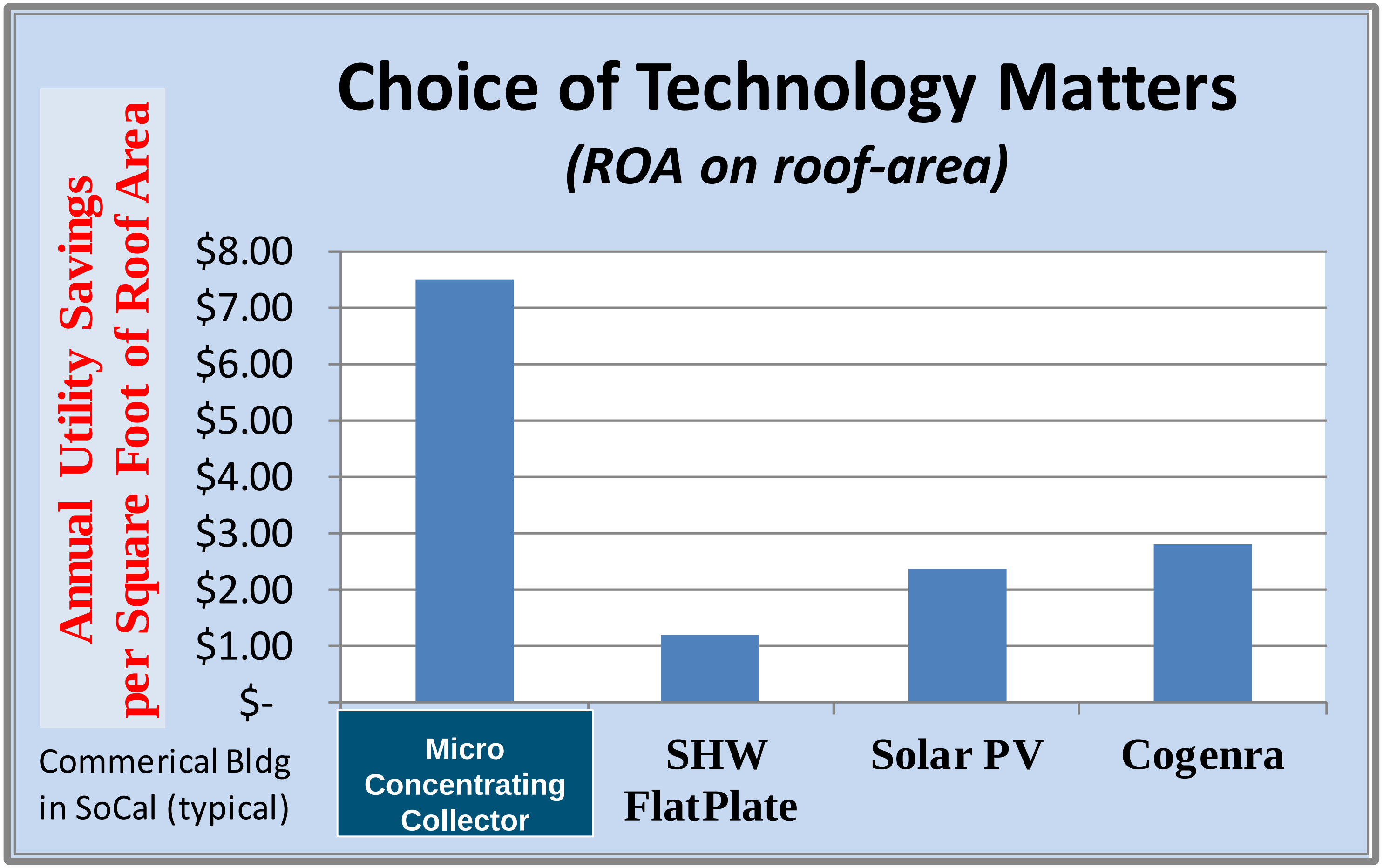
- **Why Invest In Solar Energy Generation?**
  - Because this investment yields the highest rate of return!

Investment Type	Estimated Yields
Us Treasury Bonds	1 percent
Bank Savings & CD's	1 to 4 percent
Income Real Estate	3 to 7 percent
Energy Savings	10 to 15 percent

Solar Thermal Heat Pump

15 plus percent

Savings Created Per Area of (limited) Roof Space



Comparative Analysis with typical energy costs and existing building equipment efficiencies in a Southern California hospitality setting. All technologies limited to the same footprint of roof area to compare utility savings results.

What Is Solar Thermal Heat Pump?

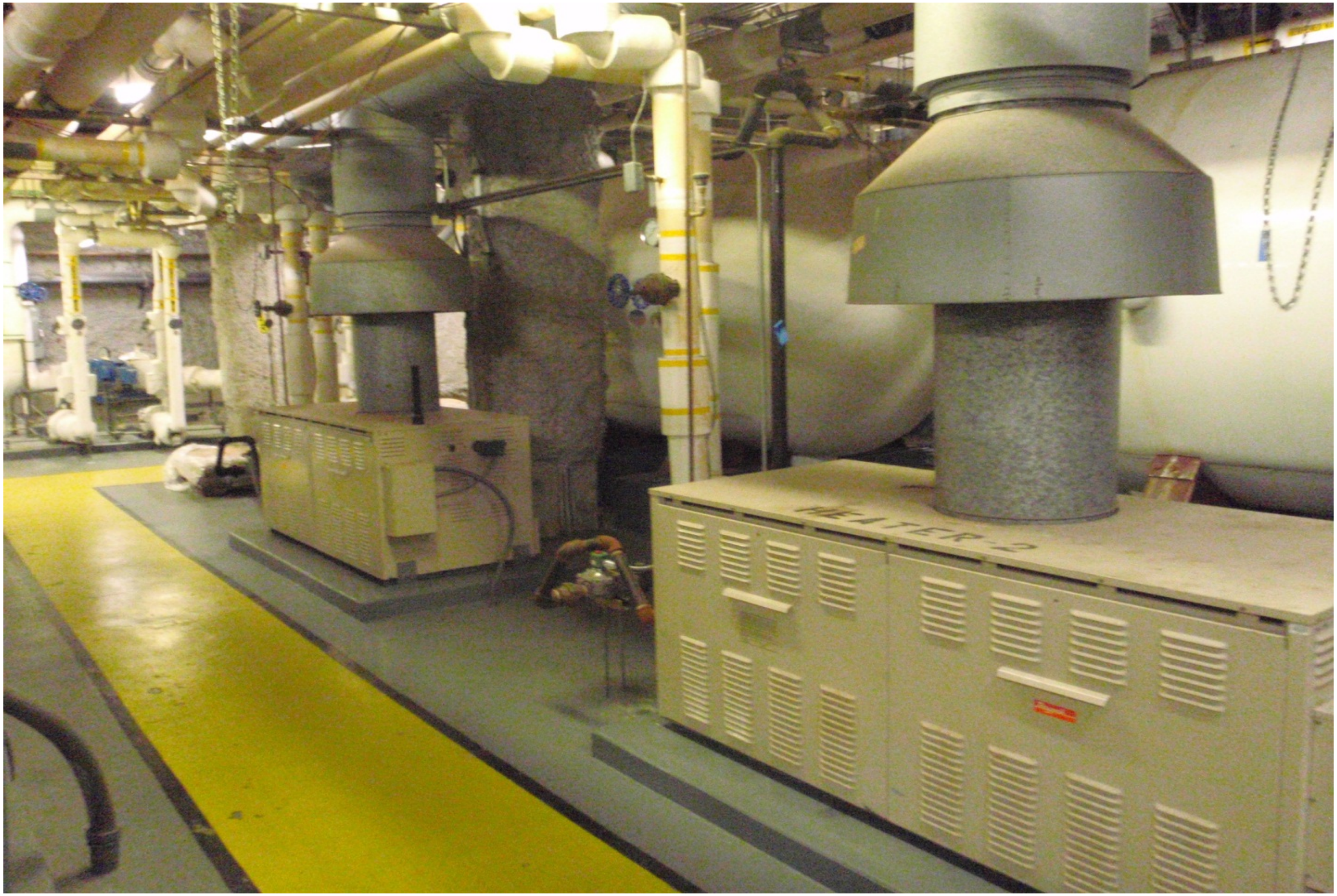
- **Utilizing the suns energy to create fluid temperatures which can be used to heat water and drive a refrigeration system**

Components of Solar Thermal Heat Pump

1. An existing hot water production system
2. An existing cooling system…. either air or water
3. **A roof mounted solar collector array capable of producing fluid temperatures of 240 to 250 degrees F**

Components of Solar Thermal Heat Pump

1. An existing hot water production system (Boilers)



Components of Solar Thermal Heat Pump

1. An existing hot water production system
2. **An existing cooling system… either air or water chiller**

Components of Solar Thermal Heat Pump

1. An existing hot water production system
2. An existing cooling system… either air or water
3. A solar collector array capable of producing fluid temperatures of 240° to 250° F
2. **An absorption heat pump**

Components of Solar Thermal Heat Pump

1. An existing hot water production system
2. An existing cooling system… either air or water
3. A solar collector array capable of producing fluid temperatures of 240° to 250° F
4. An absorption heat pump
5. **A thermal storage mass (tanks)**

Components of Solar Thermal Heat Pump

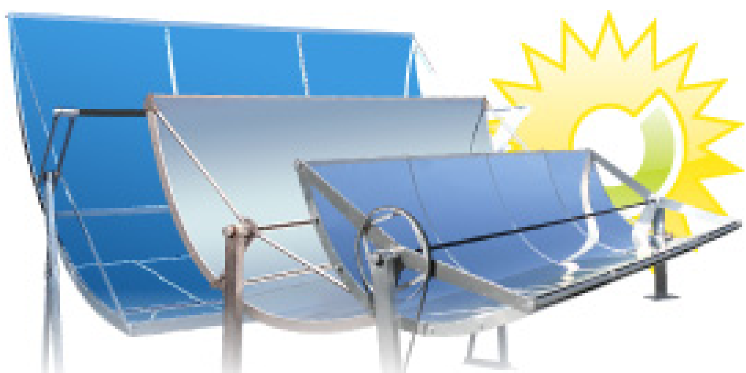
1. An existing hot water production system
2. An existing cooling system… either air or water
3. A solar collector array capable of producing fluid temperatures of 240° to 250° F
4. An absorption heat pump
5. A thermal storage mass
6. A backup heat generator
7. **Variable speed fluid circulation pump**

Types of Commercial Scale Solar Collectors

		
Traditional Flat Plate	**Evacuated Tube**	**Concentrating**
Up to 165 degrees F	**Up to 240 degrees F**	**Up to 400 degrees F**

Concentrating Solar Collectors

- **Manufacturers:**
  - Chromasun
  - Sopogy
  - and others



Solar Thermal Heat Pumps Deployment Track Record

- **Worldwide Installations – Proven Technology**


Chromasun (50RT) California


Festo/DLR (500RT) Europe

Over 300 commercial / industrial systems worldwide.
(IEA 2009 study)


Proterra (40RT) Canada


Solid (50RT) Europe

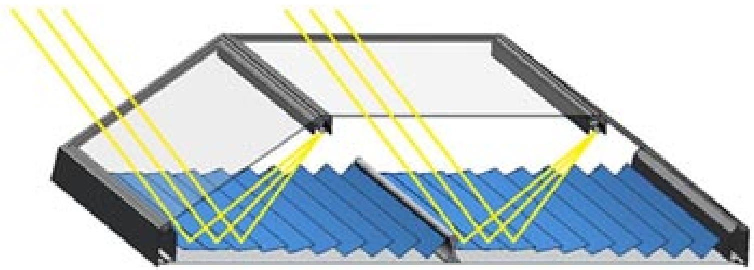

Solid (175RT) Europe

Chromasun: Roof Mounted Products

Certified by SRCC – Solar Rating and Certification Corporation

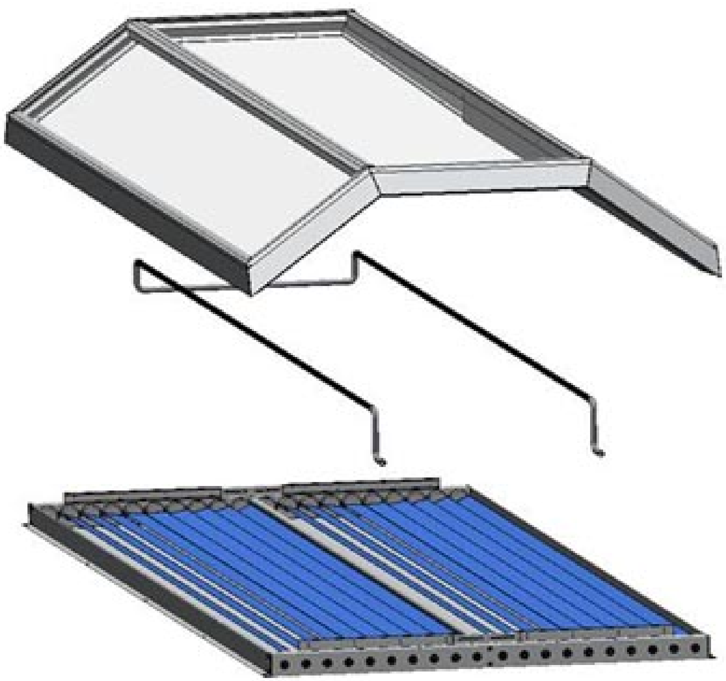
Mechanics of a Collector

How it Works



Solar Light Path

Exploded View



Hermetically Sealed Glass Enclosure

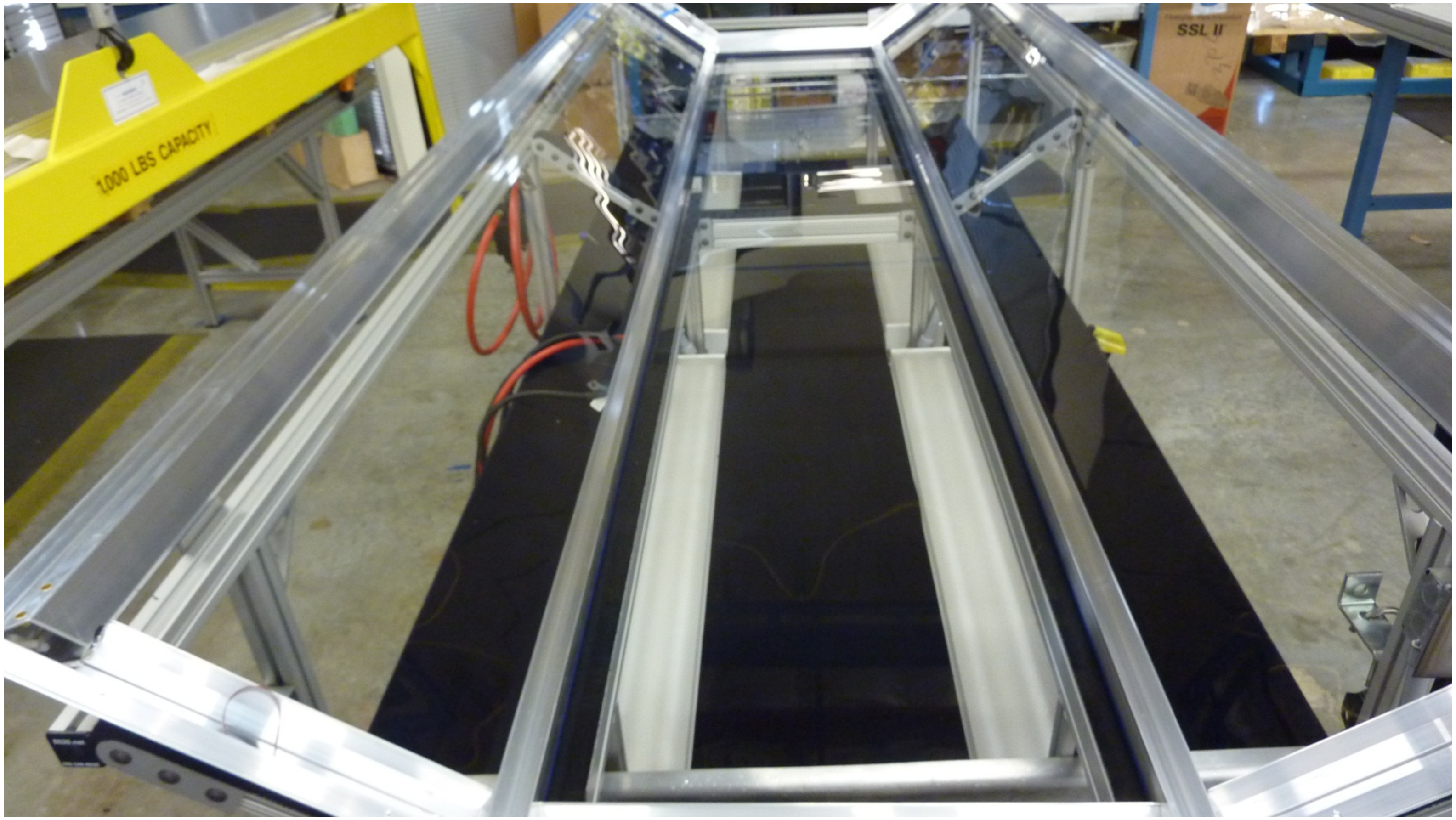
Stainless Steel Receiver Pipe

Self Tracking Fresnel Mirrors

Micro Concentrating Collector Assembly

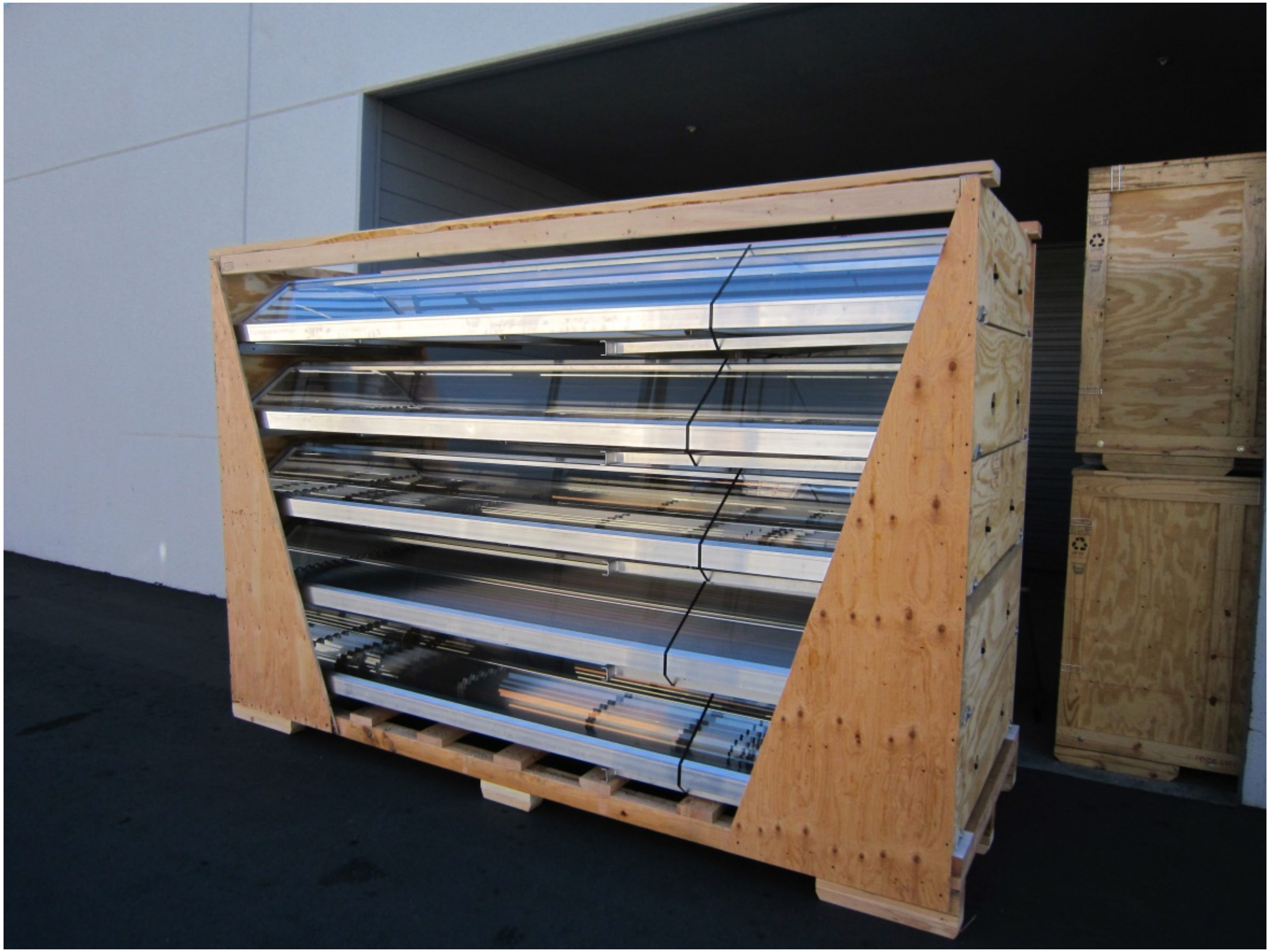
Built watertight like a skylight: Clean environment required for assembly to keep mirrors clean for optimal performance

Outer Shell Assembly



Built like a skylight: Sealed glazing and aluminum framing

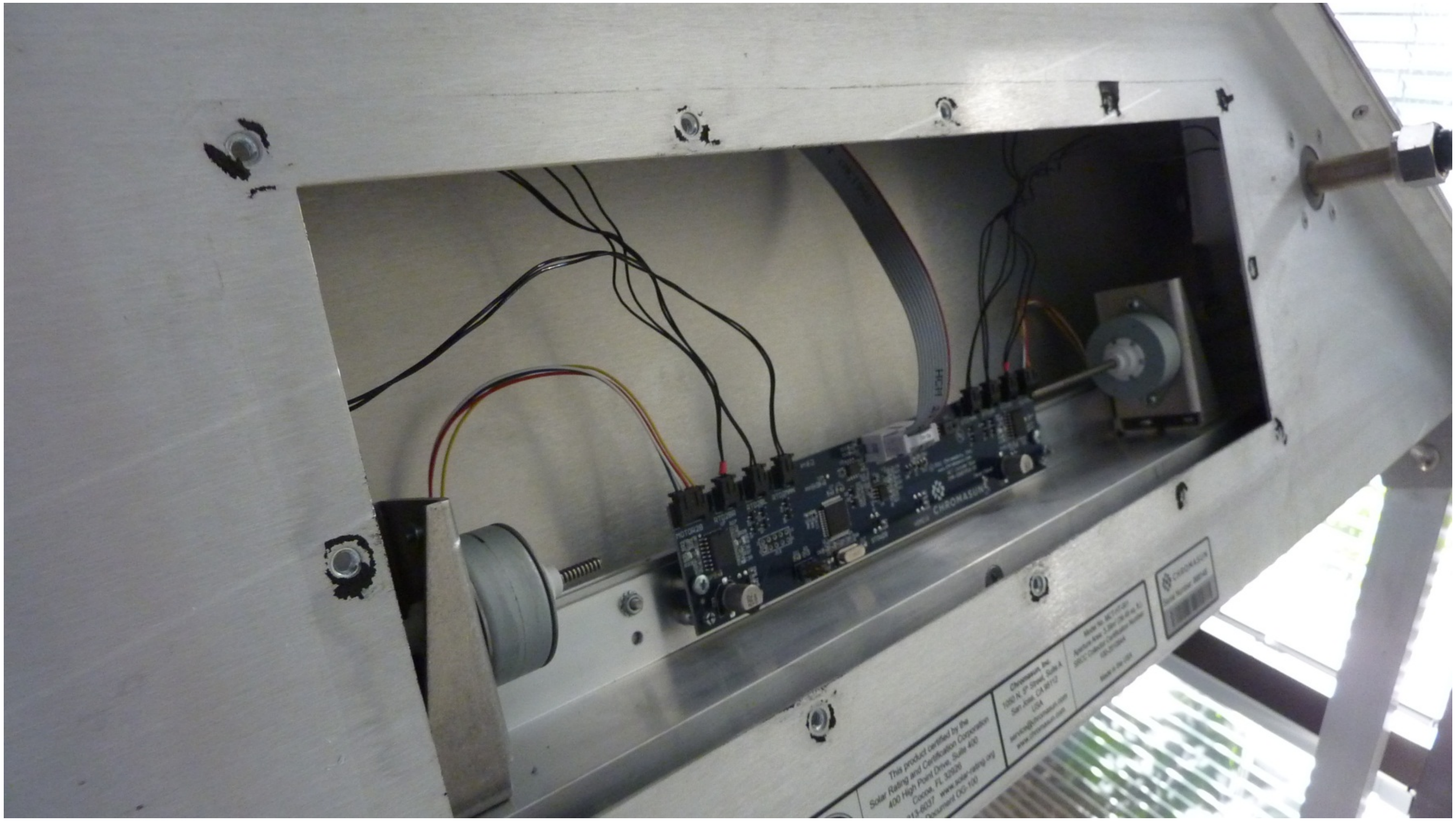
Solar Collector Panels Packed for Shipping



Interior of Assembled Collector

Series of Angled Fresnel Mirrors

Digital Tracking Mechanism



Sensors Adjust Mirror Angles For Optimal Heat Collection

Installed Array

Back of Racking System

Poor design of sleeper location results in ponding water

Racking System Solution

Racking system allows for access to roof for maintenance

Roof Integration System - Sleeper

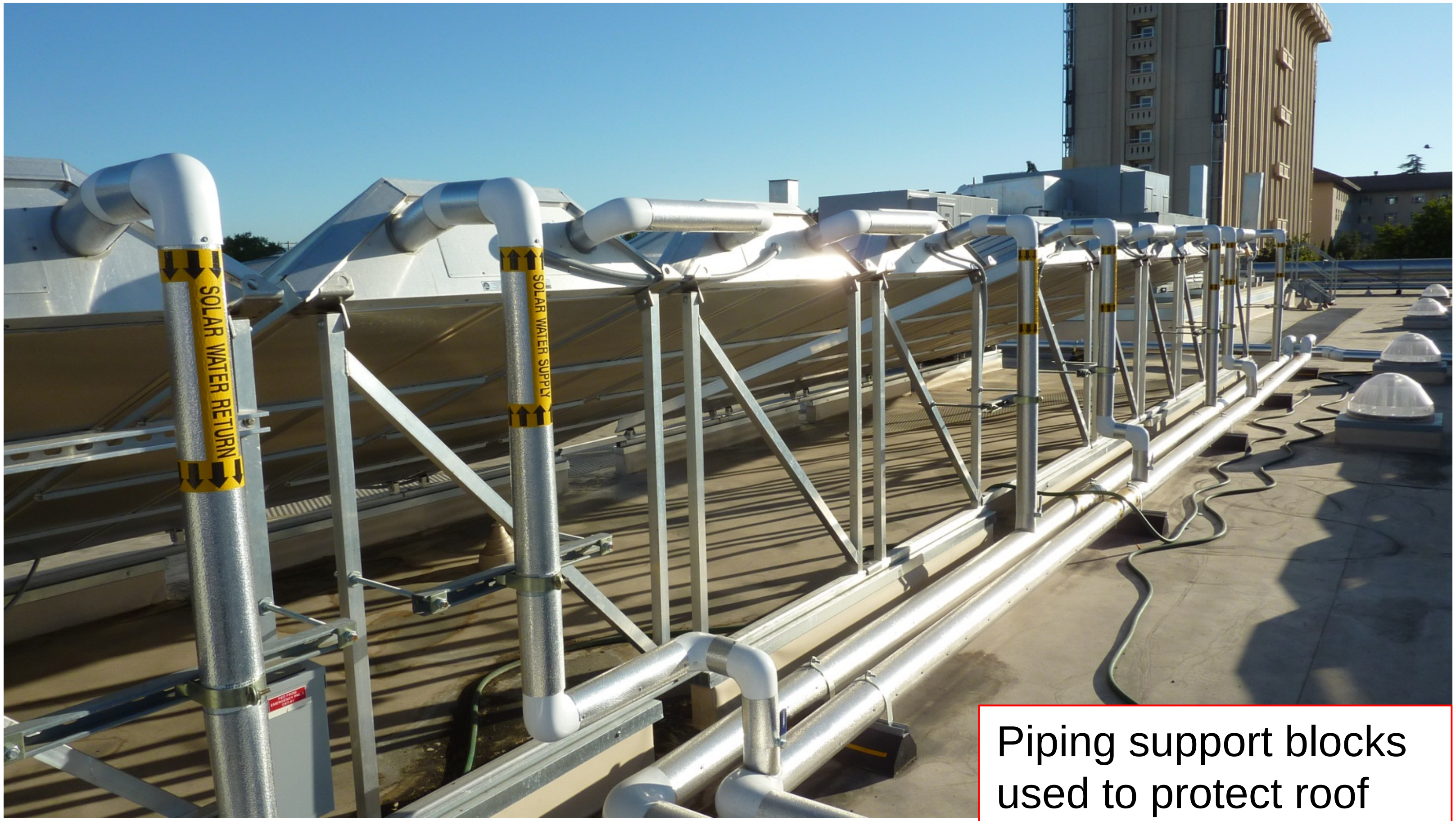
Front Rail Assembly

Similar design to back rail assembly. Adequate room for roof replacement and servicing

Array Integration Controller

Allows for Internet-based monitoring

Hot Water Collection Piping



Piping support blocks used to protect roof membrane

Collection Piping Is Arranged In Array Segments

Each Panel Assembly is Pressurized

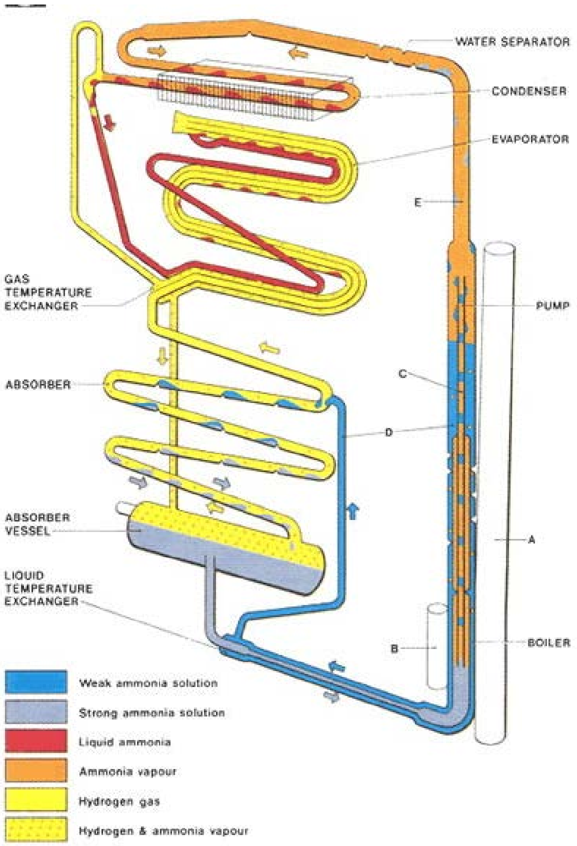
Desiccant is used as drying agent to keep interior moisture free

What is Absorption Refrigeration?

- **Absorption refrigeration was invented by Ferdinand Carre in 1858.**
- **In 1923 AB Arctic began commercial production of home refrigerators using absorption refrigeration. It was the alternative to the ice box until the advent of the electric refrigerator in the 1950's.**

Absorption Refrigeration Mechanics

- **The absorption refrigeration machine requires only a small pump to facilitate fluid movement.**
- **It involves the use of heat energy rather than electric energy to create refrigeration.**
- **The process involves changing a liquid to a gas which either absorbs heat (cooling) or a gas to a liquid which rejects heat (heating).**
- **The two most popular systems are ammonia/water and lithium/bromide.**



Absorption Refrigeration Systems

- **The system which appears to be most attractive today in commercial DHW applications is an ammonia water absorption heat pump being manufactured by Energy Concepts in Maryland specifically for integration into domestic hot water systems.**

What Are Thermal Storage Mass Systems?

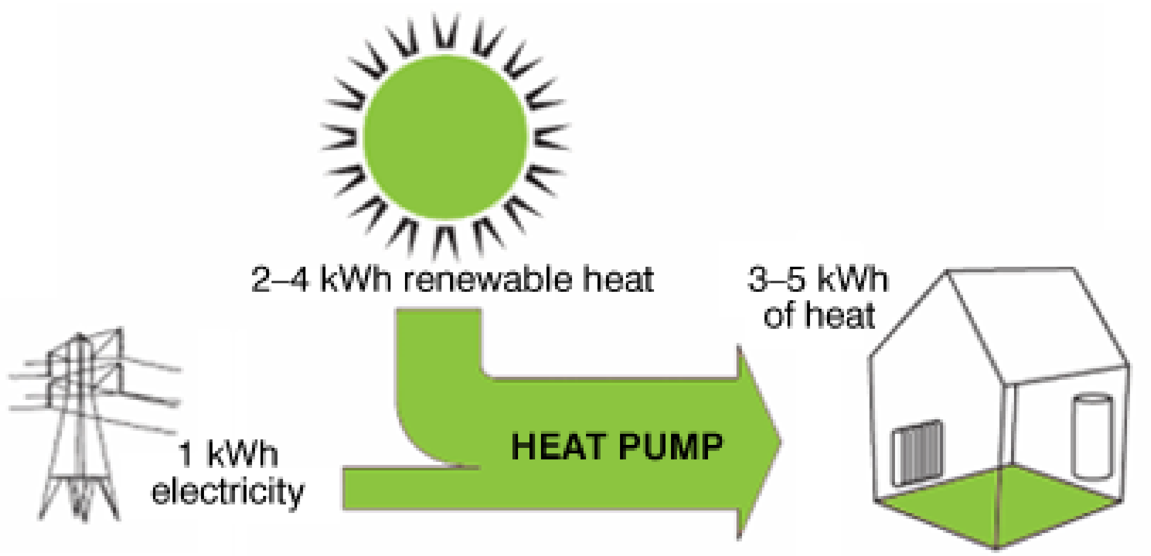
- **Thermal storage mass is the battery that stores the heat collected from the sun which allows the system to operate past day light hours.**

How Big Are Thermal Storage Mass Systems?

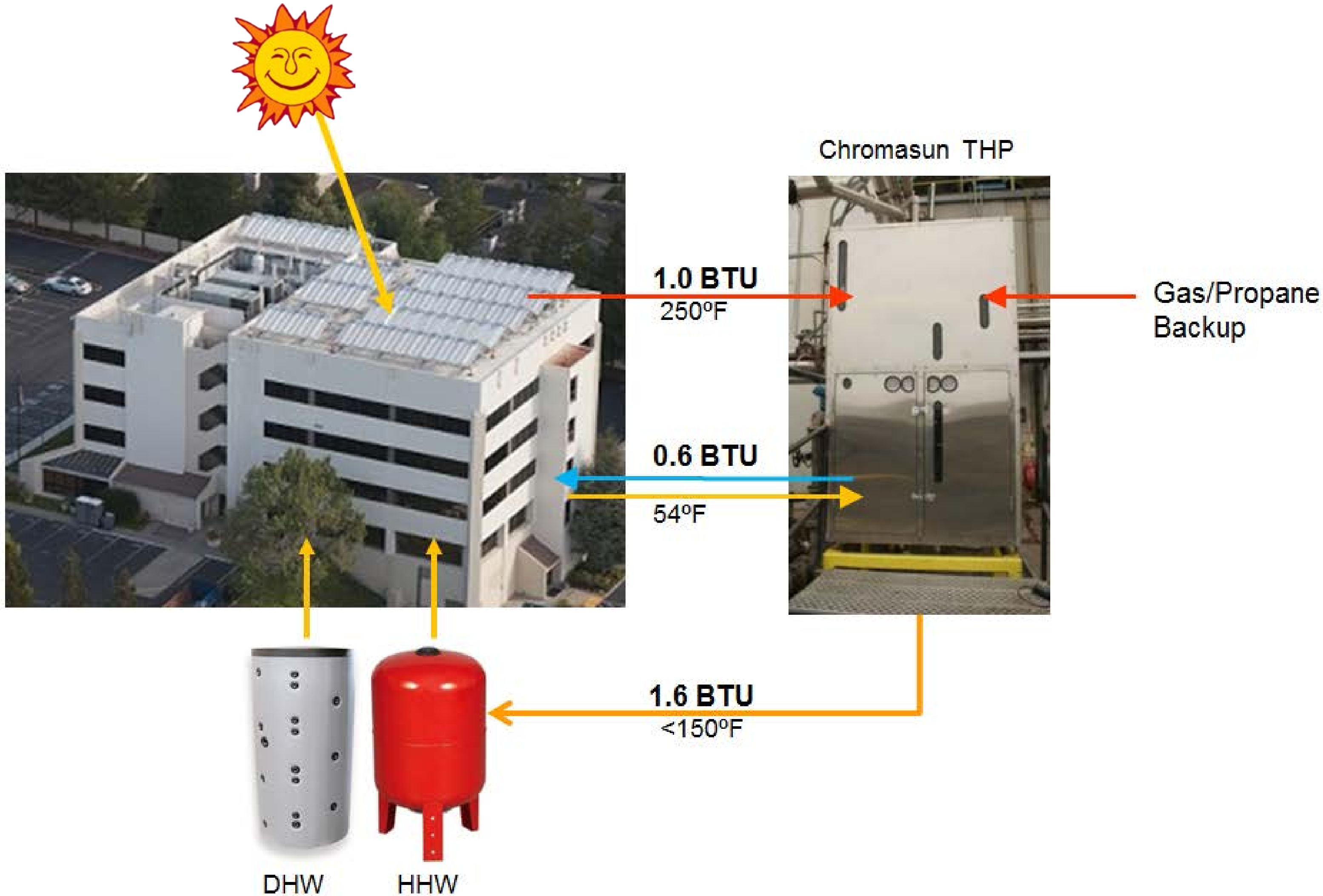
- **Three thousand gallons can be stored in an insulated tank which measures 10 feet tall and 7.5 feet in diameter.**
- **3000 gallons weighs 24,990 lbs. It is best left on the ground.**

Why Use a Heat Pump?

- **A heat pump moves heat from a colder temperature to a warmer temperature using refrigeration.**
- **A heat pump can lower annual energy costs for both chilled water production and hot water production.**



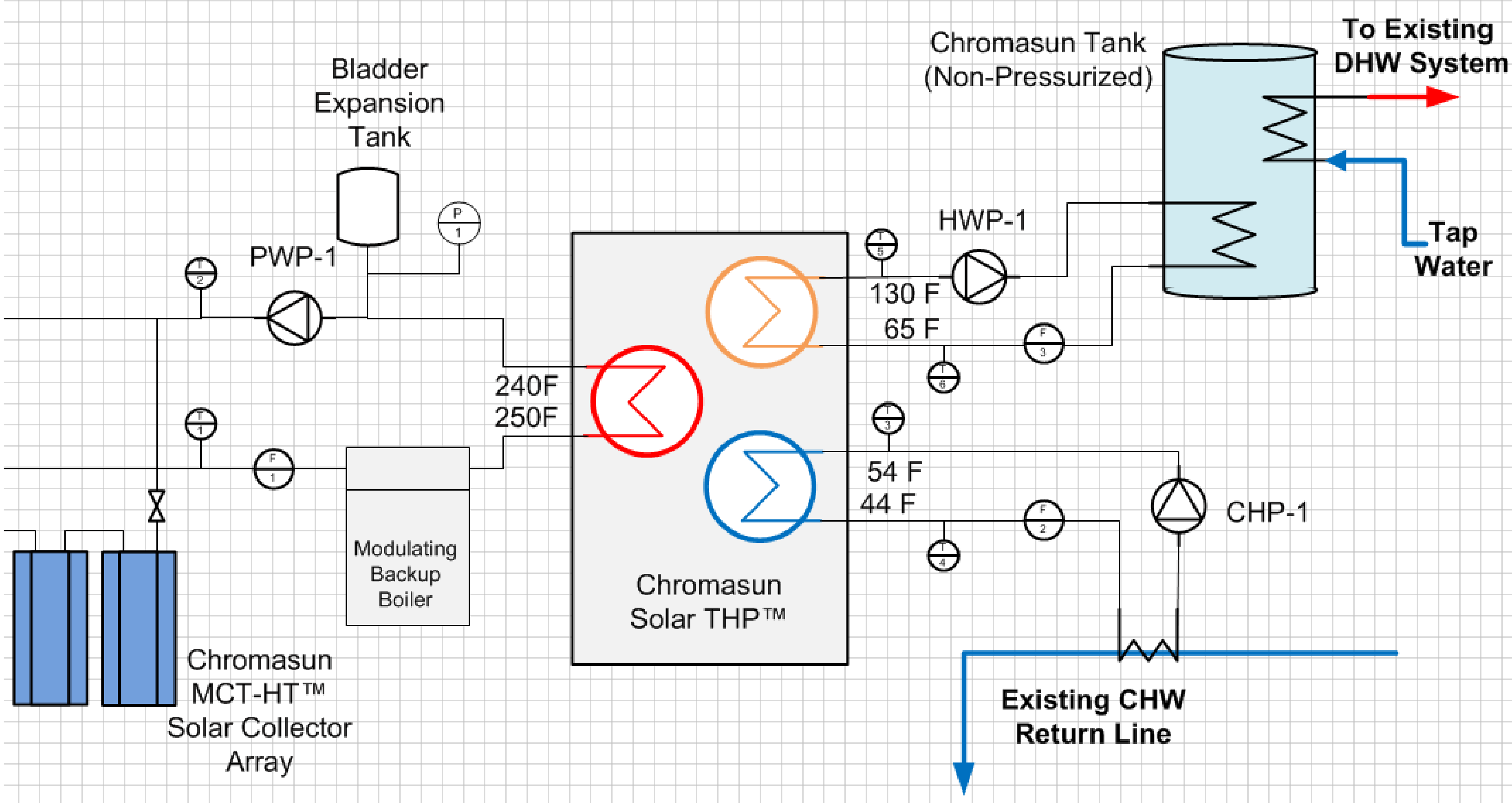
Thermodynamics of STHP



How do we integrate the

Solar Thermal Heat Pump (STHP)

into a building?



Case Study: Benson Hall – SC University

Santa Clara University Benson Building

- 60 MCT panels
- 2,682 square feet
- 120KWt peak
- 410 Mbtu/h
- 6,727 therms PA

Boiler feedwater preheat application

- HHW and DHW (2,880 GPD) for main cafeteria

Installed 2010

Case Study Results

- **Installation of 60 Micro-Concentrator collectors.**
- **The MCT panels will produce an estimated 6,727 therms of energy annually and heat water to 200 degrees Fahrenheit for dining services.**
- **Heating water with solar energy rather than with natural gas will reduce the building's water-heating bills by as much as 70 percent and offset 34 tons of CO2.**
- **The system will help SCU reach its goal of becoming climate neutral by the end of 2015.**
- *"With its 25-year lifespan and six-year payback period, the Chromasun solar thermal system is an excellent capital investment. Energy security was a major driver of our decision to undertake this project. Per the terms of our ten-year leasing agreement, we will pay a fixed price for the energy the system produces, shielding the university from natural gas price volatility. We'll also own the system when the lease is up."*
  - Joe Sugg, Assistant VP of University Operations at SCU

SYSTEM AT A GLANCE	
Location	Santa Clara, CA
Building	Benson Center
Collectors	60 MCTs
Total Collector Area	2,682 square feet
Collector Loop Capacity	300 gallons
Hot Water Load	2,880 GPD (peak)
Therms Offset (1 Year)	6,727 (estimated)
System Size	120 KWt
Thermal Output	410 Mbtu/h


Aerial view of Benson Center


Rear view of MCT collectors & piping at the Benson Center

Case Study : Oahu AOAO

- **21 stories**
- **126 2-bed, 2-bath units**
- **Annual HECO Billings $403,000**
- **5976 gallons per day hot water**
- **Chilled Water Plant**
- **Waste Heat Recovery Heat Pump for Hot Water**
- **Electric Rates - 29.9 cents/KWH**
- **SNG Rates – $ 4.05/Therm converts to 13.8 cents per kWh**

Oahu AOAO: Hot Water Energy Usage

- **5976 gallons per day = 2,181,240 gallons per year**
- **Cold water from street = 72° F**
- **Hot water to unit = 128° F**
- **BTU = 2.18 MM gallons X 8.33 lbs/gallon X 56° F delta T**
- **1017.2 MMBTU per year of heat required**
- **Converts to 298,126 KWH per year**


Oahu AOAO: Projected Savings

WHR Heat Pump Offset = 121,189 KWH

Chilled Water Offset = 31,942 KWH

SNG Gas Consumed = 35,662 KWH

VFD Pump Power Consumed = 15,313 KWH

Annual Electric Power Offset =

102,156 KWH =

$30,545 First Year

Oahu AOAO: Return on Investment

- **Out of Pocket - $166,100**
- **First Year Savings - $30,545**
- **5% Utility Escalation Rate**
- **30 year life cycle**

Internal Rate Of Return 22%

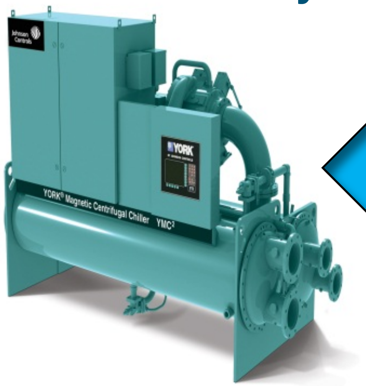
Cash On Cash 18.4%

How Does System Generate The Required Heat?

120,661 kWh
Annually

65,667 kWh
Annually

111,797 kWh
Annually



COP = .6

Absorption Heat Pump

COP = 1.6

298,126 kWh
Annually

Chilled Water Production Offset

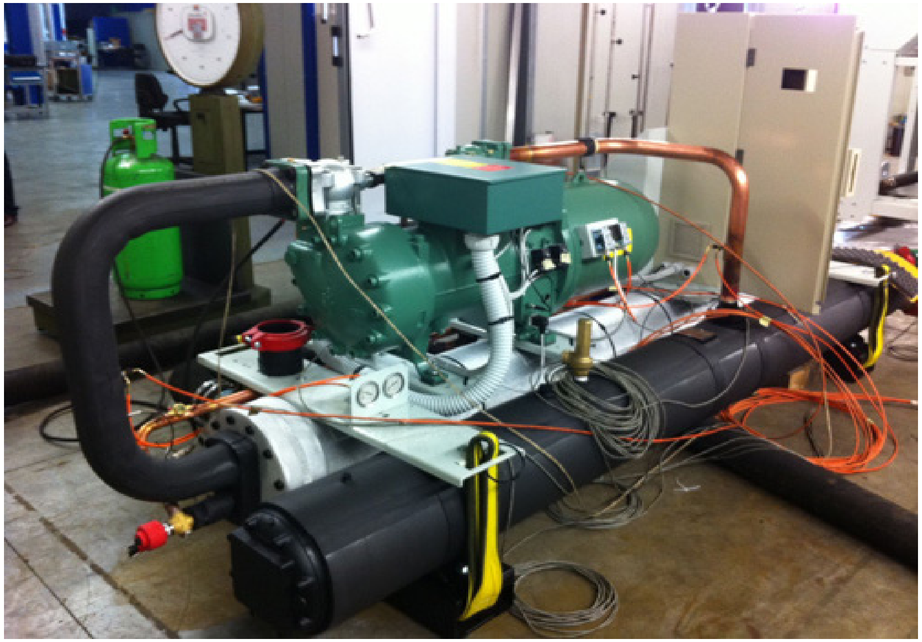
111,797 kWh Annually

COP = 3.5

31,942 kWh
Reduced Chiller Operation

Hot Water Production Offset

298,126 kWh Annually



COP = 2. 46

121,189 kWh
Waste Heat Recovery
Heat Pump Offset

Synthetic Natural Gas Consumption

65,677 kWh Needed to Offset Cloudy Days

AFUE = .85

77,267 kWh
SNG Consumed

But Gas and Electric Don’t Cost The Same.

Gas = 13.8 cents per kWh

Electric = 29.9 cents per kWh

77,267 kWh gas =

35,662 kWh
Electric Consumed

It Only Gets Better If You Are Heating With Gas

- **Lets change from a waste heat recovery heat pump to 85% gas boilers?**

142,845 kWh Saved

$42,711
First year savings

What Is The Cost Of This System?

Current Installation Budget Before Tax Incentives

~ $700,000

Incentives

State Tax Incentive – Grant in lieu of tax credit

$176,250

Federal MACRS w/ 50% bonus

$125,000

Federal ITC

$232,650

Total Incentives

$533,900

What Is The Final Cost To Install This System?

Budget - $700,000

Incentives - $533,900

Out Of Pocket

$166,100

Three Options for Ownership

- **Owner can purchase it and take advantage of the incentives**

- **Owner can lease the system from a bank which can utilize the incentives**

- **Owner can sign a PPA with an investor who can take advantage of the incentives**

Mahalo Nui Loa and A Hui Hou

Questions

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