Solar Heating and Cooling Conference

Hawaii Hotel CHW and DHW case study

CHROMASUN

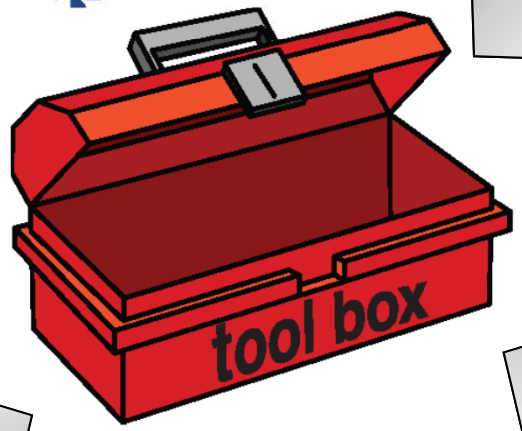
Agenda

1. **Chromasun Overview**
2. Principles of Solar-Enhanced Heating & Cooling
3. Hawaiian Hotel Case Study
4. Economics in Other States
5. Q & A

So what's in the Chromasun toolbox?

Experienced team
engineering and solar experience

CHROMASUN



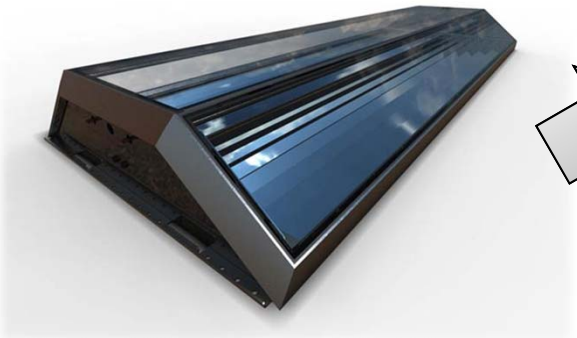
TRANE

THERMAX

Johnson Controls

BROAD AIR CONDITIONING

HVAC and Heat Pump makers
a reliable gas/solar alternative to electric.



Efficient Chromasun MCT-HT
the only flat panel suitable for high temperature heat pumps

ADROIT SOLAR

AZTEC SOLAR POWER

SUNWATER SOLAR

Solar Installers

Chromasun: solar-enhanced heating & cooling for commercial & industrial facilities

Three Technical Approaches

Segment A

Process Heat

- **Steam, pressurized H_2O**
- **Boiler pre-heat**
- **Hydronic Heating**
- **Domestic Hot Water**

Large market (some segments better developed than others)

Segment B

Solar Heat-Pumping

- **CHW & DHW, or**
- **CHW & HHW, or**
- **CHW & process heat**
- **Single-effect Absorption Chillers (COP 2.20)**
- **Co-fired with NG**

Under-developed market

Segment C

Solar Cooling

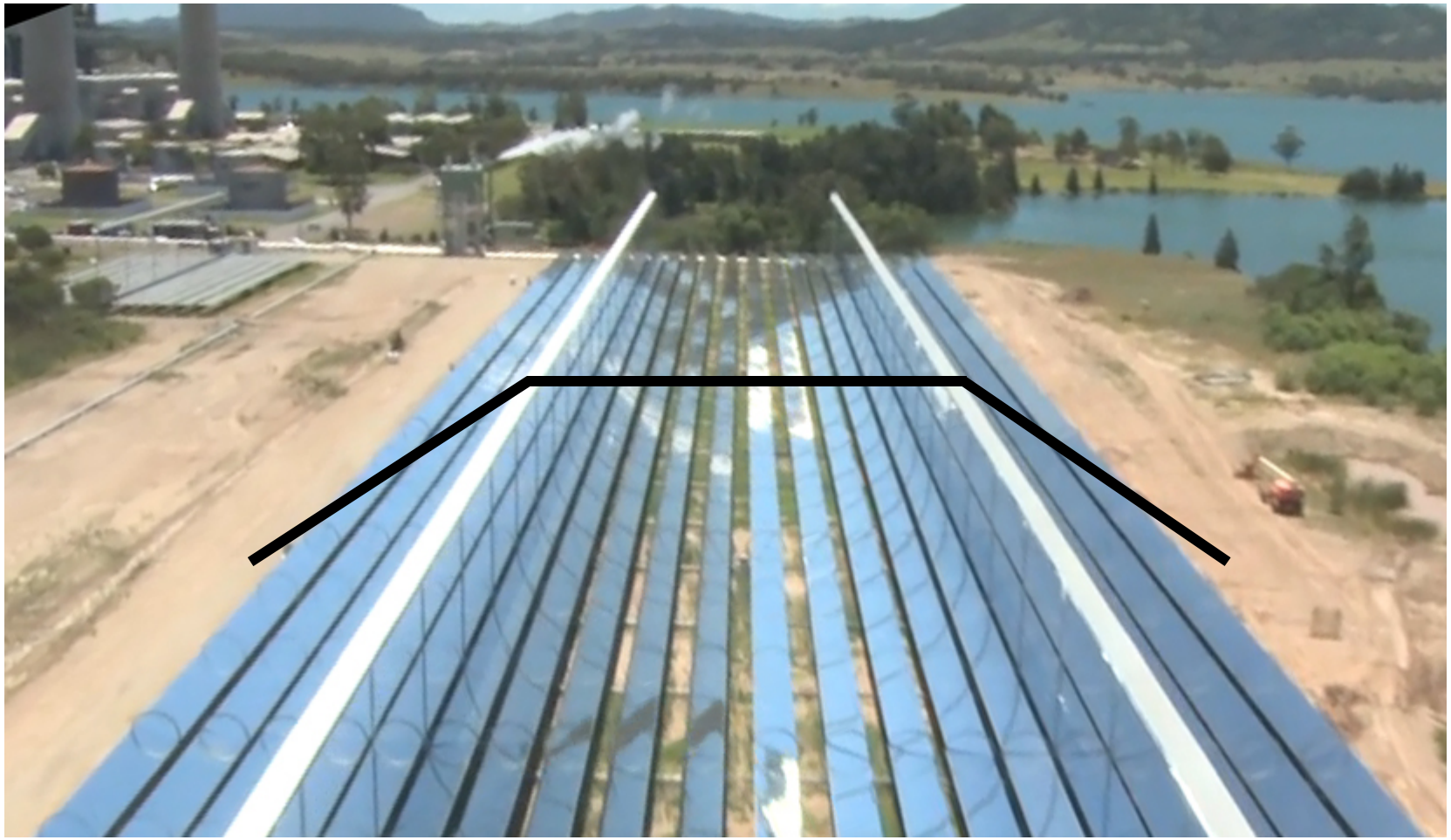
- **Chilled Water (heat reject to outside)**
- **Double-effect Absorption Chillers (COP 1.35)**
- **Co-fired with NG for reliability & economics**

Under-developed market

Chromasun's Previous Solar Experience

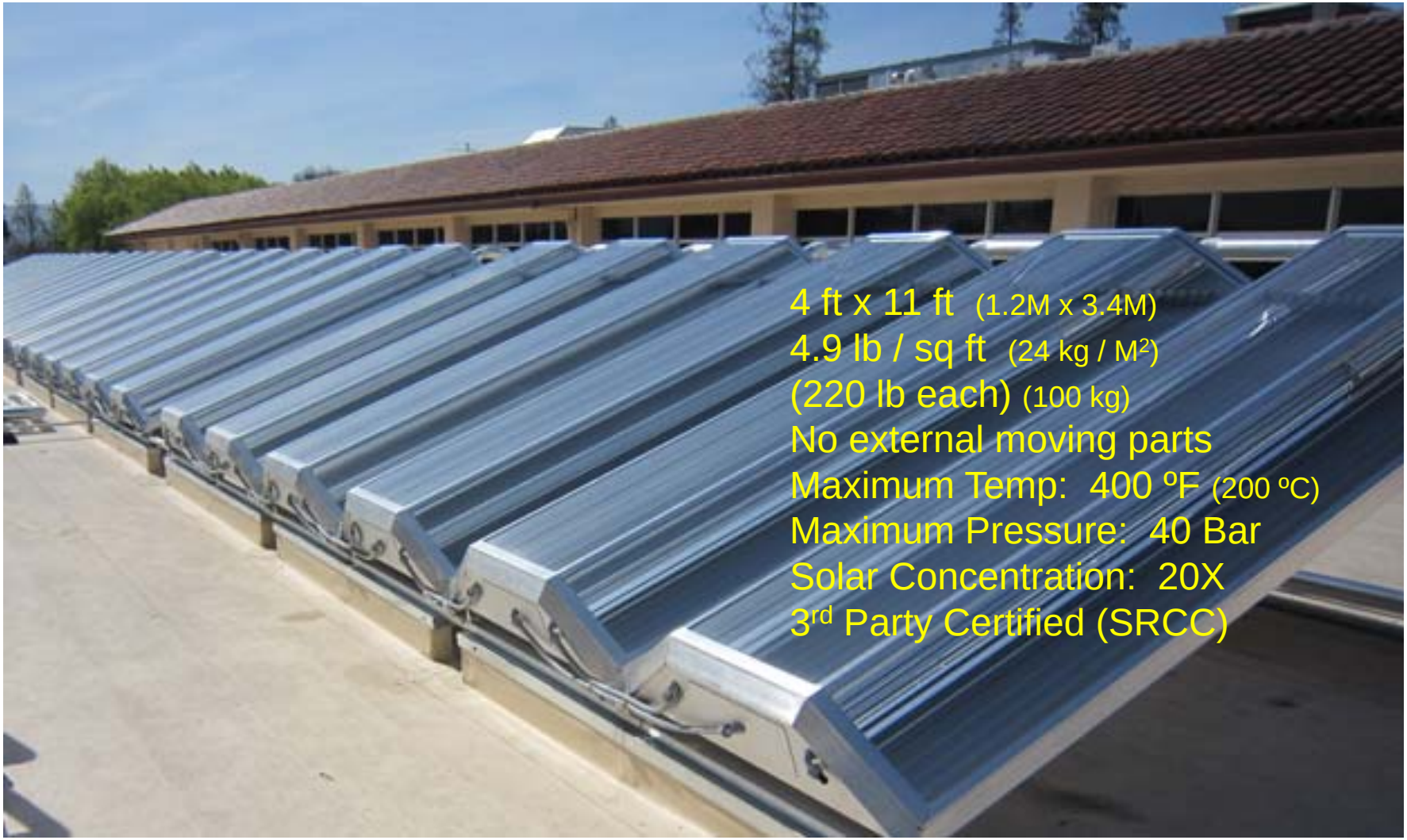
- **Peter Le Lievre (CEO) and Andrew Tanner (VP of Engineering)** were co-founders and engineers at Ausra, now Areva Solar.

2008 Chromasun Formed



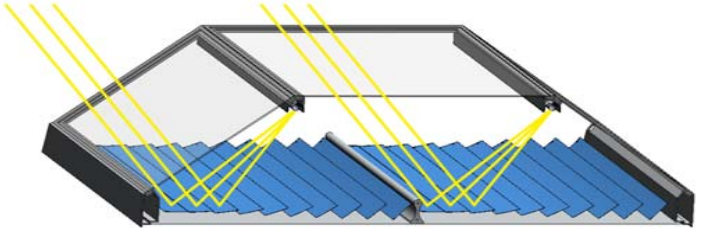
Objective: miniaturize the successful utility-scale Fresnel concentrating optic and make it into a rooftop-friendly product

Chromasun's Micro-Concentrator (MCT)



How the MCT Collector Works

Solar Light Path

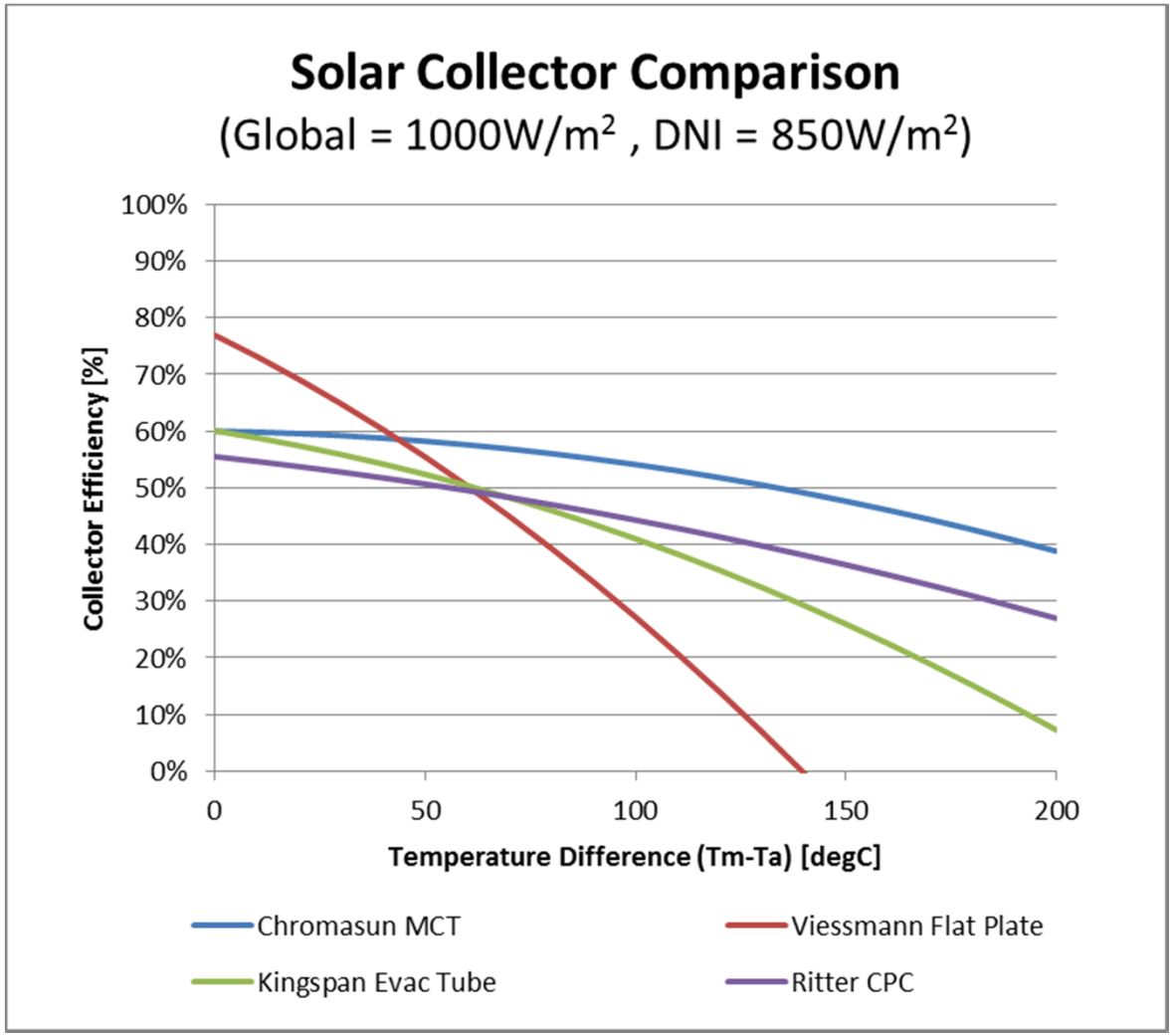


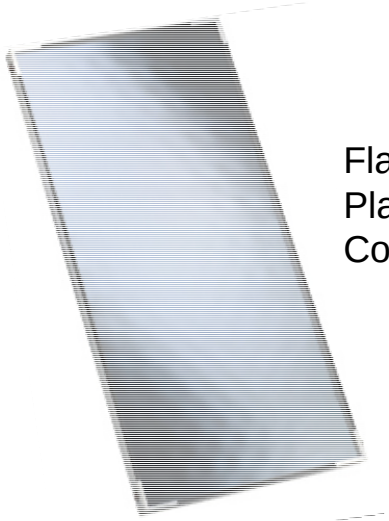
Hermetically Sealed Glass Enclosure

Stainless Steel Receiver Pipe

Self Tracking Fresnel Mirrors

The MCT: Superior Efficiency at Higher Temperatures

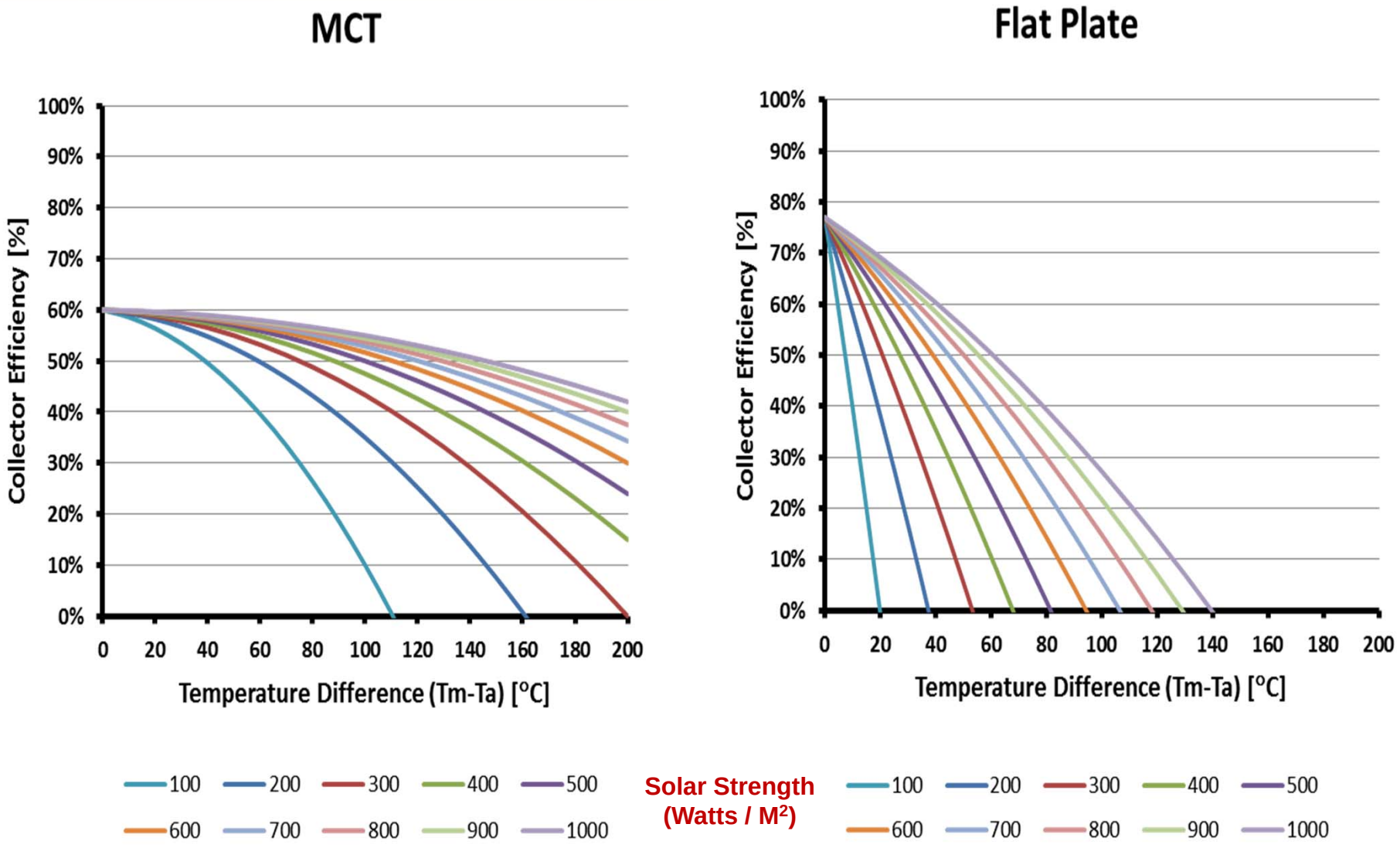




Flat Plate Collector

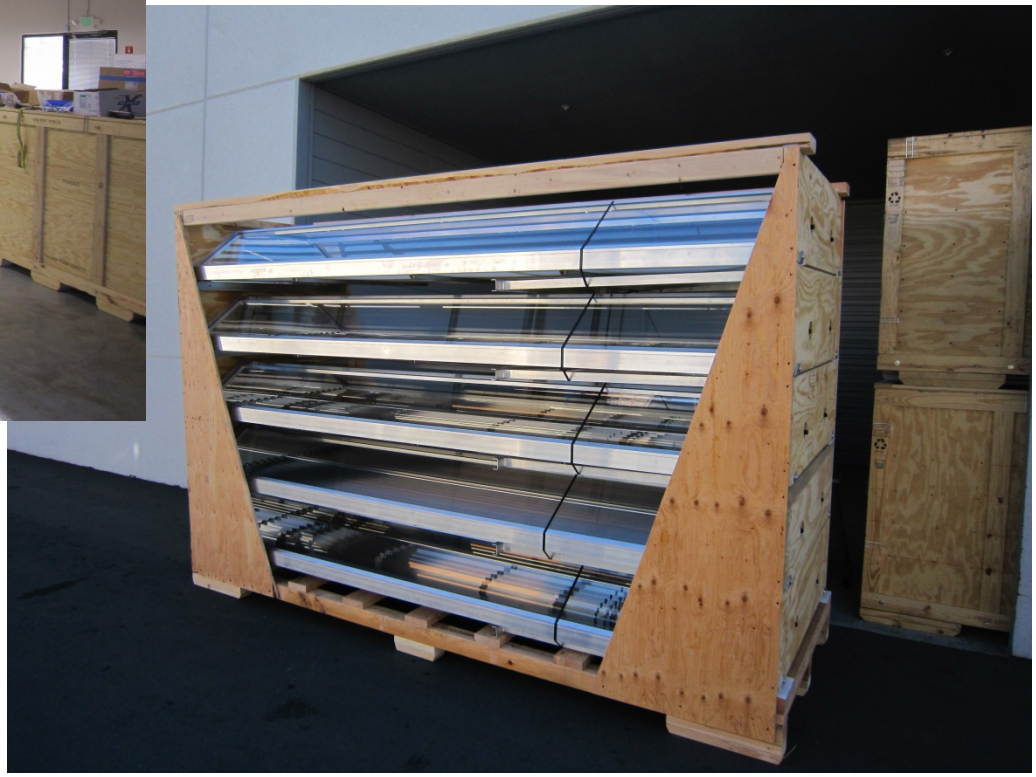
Evacuated Tube Collector

The MCT: Superior Efficiency at Full and Partial Sun



Chromasun 10 MW* Capacity Factory (San Jose, CA)

Chromasun MCTs are made in the USA



* Single Shift

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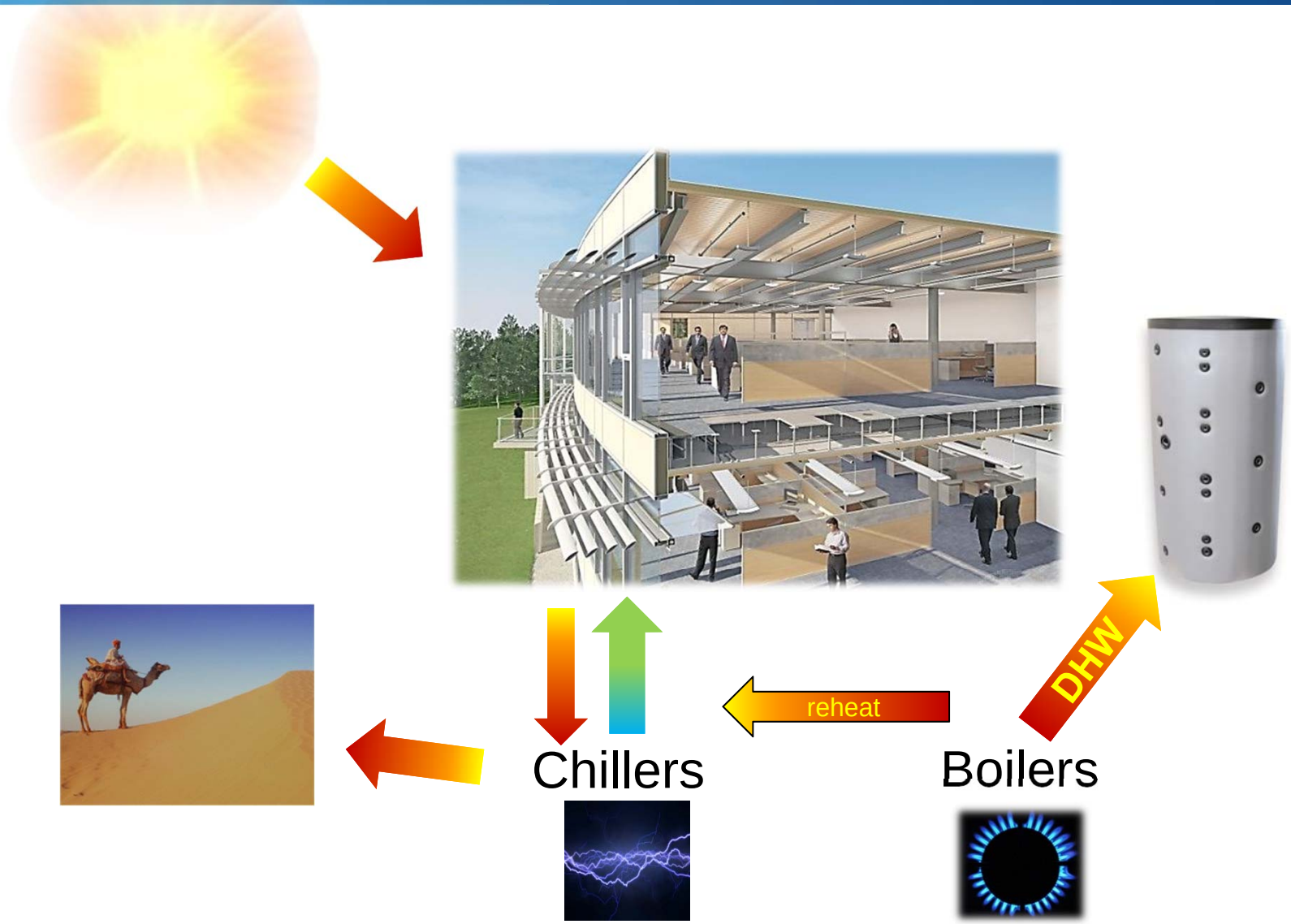
Re-Examine an Old Paradigm

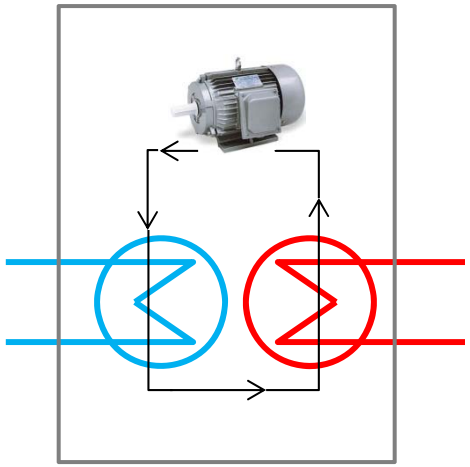
The Typical Commercial HVAC Setup



How do traditional Heat Pumps work? (e.g. an air-conditioner)

Heat pumps push heat in the “wrong” direction

Electro-mechanical force drives the process



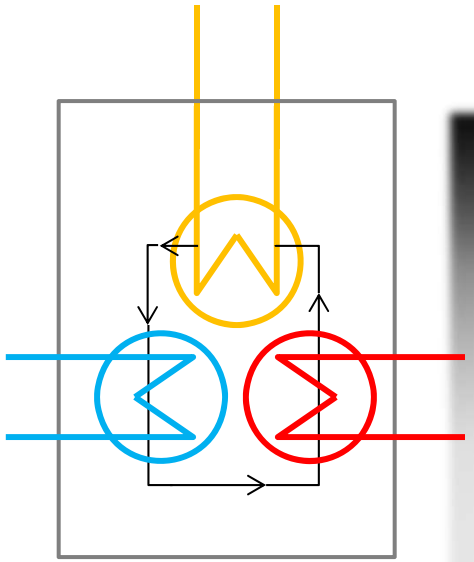
We experience this as cool air inside

Heat

Heat is pumped into an already warm environment <u>as a waste product</u>

How does our Solar Thermal Heat Pump work?

Difference #1:
Thermal energy drives the system

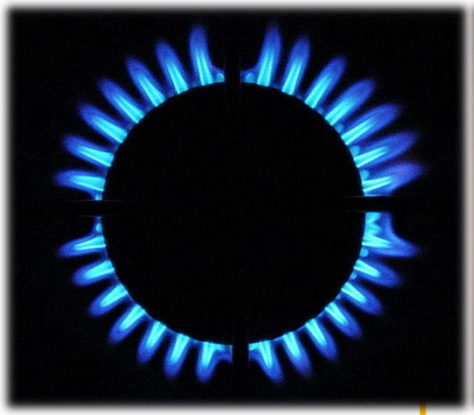


Heat

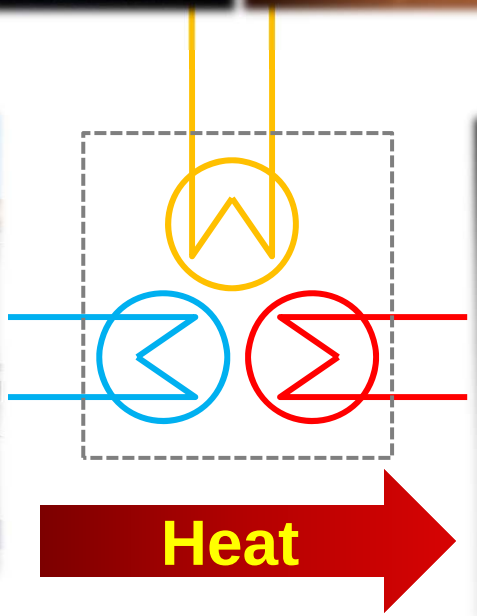
Difference #2:
Pumped heat is <u>used</u>, not wasted

How do Chromasun Systems work?

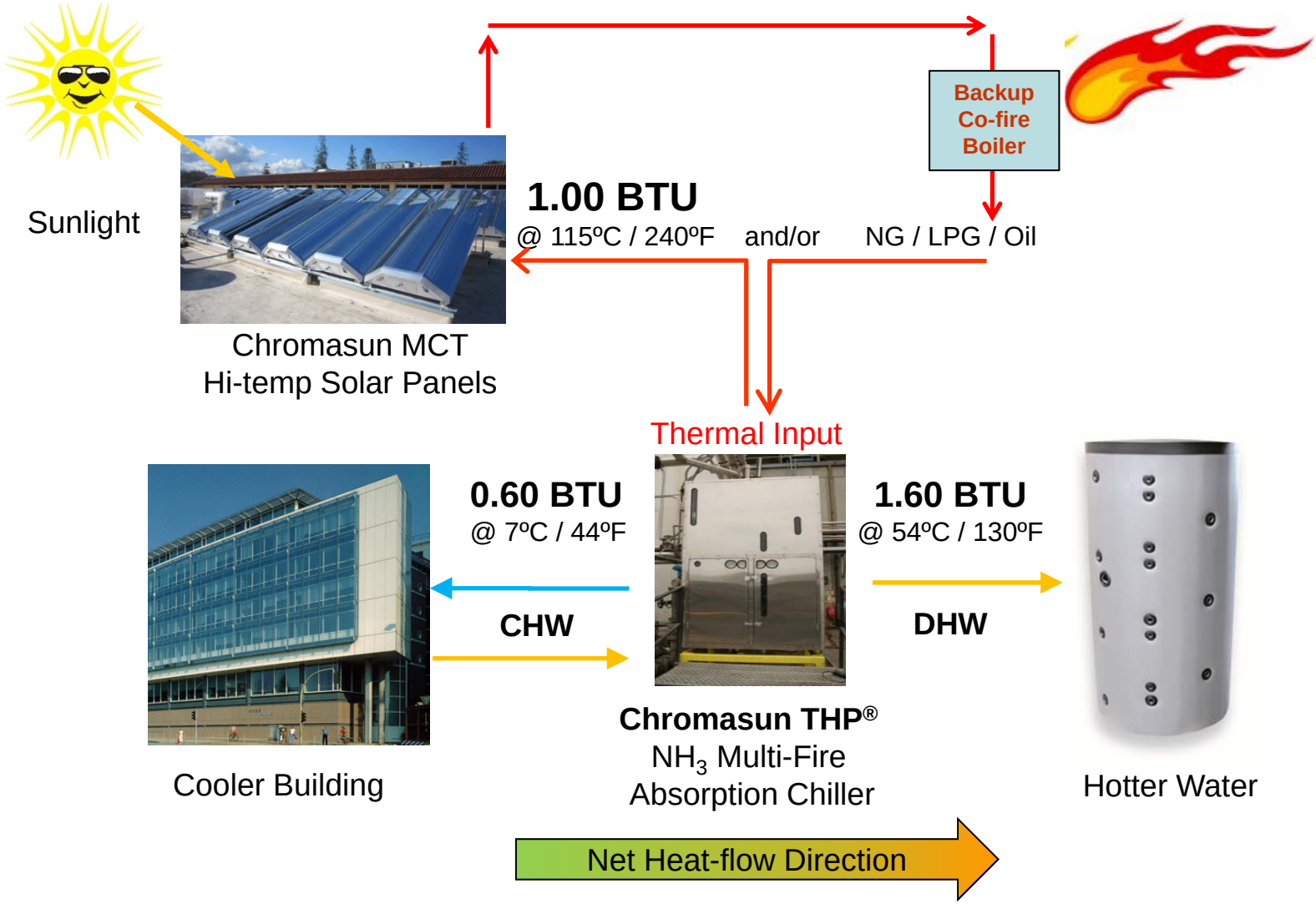
Gas can drive the heat pump...



...or solar energy, or both!



Segment B: Solar Heat Pumping (Heating & Cooling)
(DHW focused)



Heat Balance Equation: 1.00 + 0.60 = 1.60

Chromasun MCT Showcase

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 2011

Crow Canyon Medical Center

Danville, CA

50RT Thermax Chiller

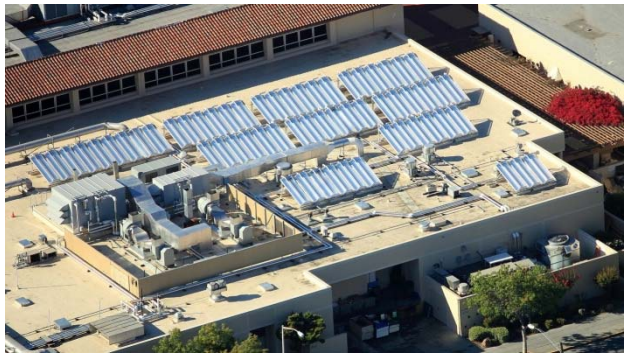
- 75 MCT panels
- 3,352 square feet
- 150KWt peak

Annual Outputs
- 340 MWH CHW
- 3,840 therms DHW

Installed 2012

Tour available at this conference!

Solar/Heat Pump Installations



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

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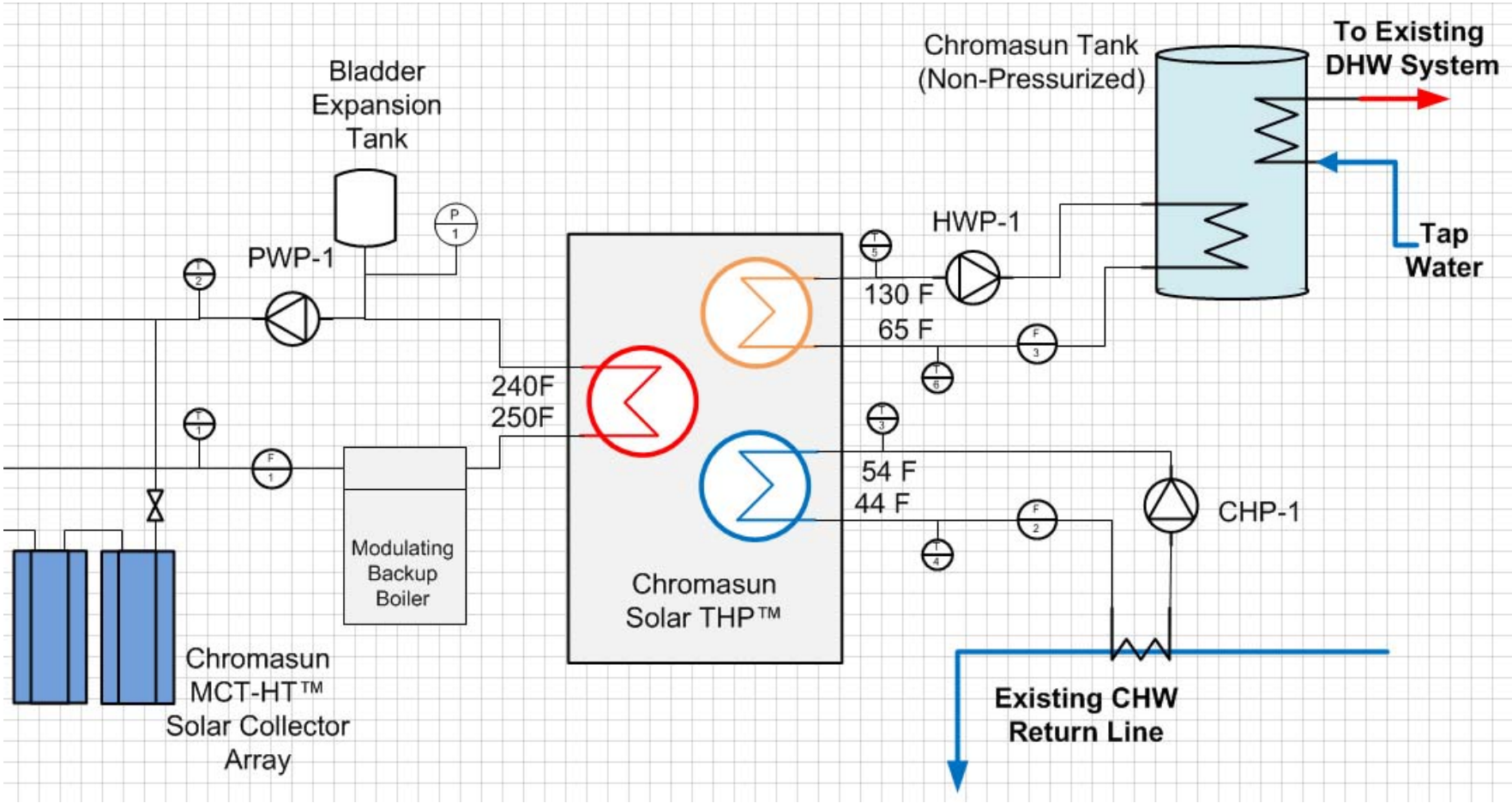
Beachside Resort, Hawaii

Hawaii Hotel Case Study

- 50 RT gas/solar heat pump solution (150 MCTs)
- Annual Electricity offset : 278 MWh*
- Propane Gross Offset: 177,700 gallons (before absorber consumption)
- Net LPG Consumption cut by 58%

Chromasun Technical Integration with Facility – P&ID



Hawaiian Hotel Solar Contribution

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Solar Array Production

Total Array Size 9,000 Ft^2 / 836 M^2

Weather Data-file

Hawaii (SW island)

Solar Array Operational Availability

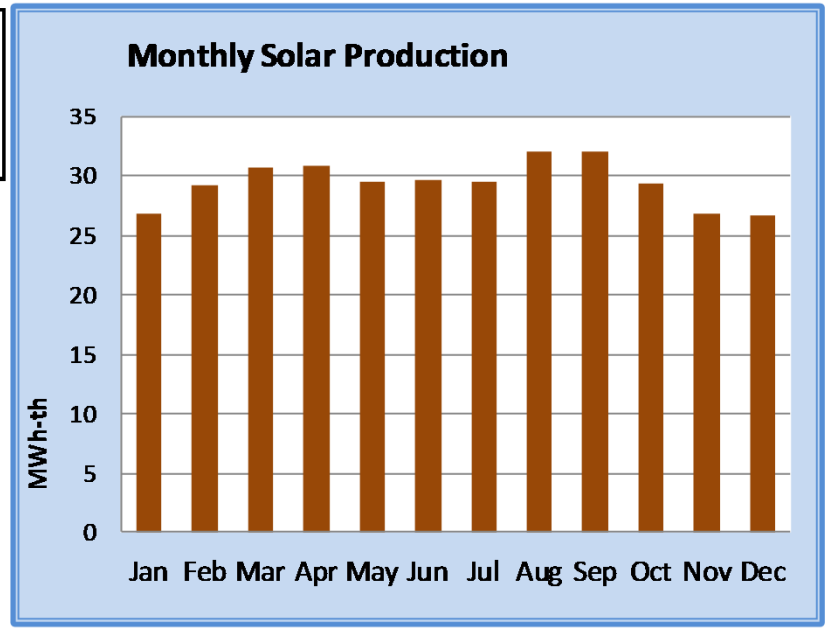
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CF	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Chromasun Collectors

Count 150 Oper. Temp. 120 ºC / 248 ºF

Model MCT-HT235

Peak Rating 1.9 kW_{TH}



Production Potential (MWh_{TH})

			Load Factor
Jan	January	26.8	100%
Feb	February	29.2	100%
Mar	March	30.7	100%
Apr	April	30.8	100%
May	May	29.5	100%
Jun	June	29.6	100%
Jul	July	29.5	100%
Aug	August	32.1	100%
Sep	September	32.0	100%
Oct	October	29.4	100%
Nov	November	26.8	100%
Dec	December	26.7	100%
	Total	**353.0**	**100%**

Key Metrics	MWh_{TH}
Average Monthly	29.414
Max Monthly	32.088
Min Monthly	26.704
Peak Output	0.285

Hawaiian Hotel – Thermal Dynamics (Int'l units)

Heat-Pump Thermal Input

kWh

Solar Portion	352,968
Gas Portion	2,036,842
Combined	2,389,811

121 °C

116 °C

CHW

7.0 °C

13.0 °C

21.1 °C

54.4 °C

DHW or HHW

Chromasun's Thermally-Driven Heat-Pump (Absorption Chiller)

Cooling Results

Heat-Pump Fuel Offset (kWh)	*Existing Chiller Efficiency (COP)*	Heat-Pump Production (kWh)	*H-P Cool Efficiency (COP)*	
47,062	*4.500*	211,781	*0.600*	Solar
230,842	*4.500*	1,038,790	*0.510*	Gas
277,905	*4.500*	1,250,571	*0.523*	Total

Heating Results

	H-P Heat Efficiency (COP)	Heat-Pump Production (kWh)	*Existing Boiler Efficiency (COP)*	Heat-Pump Fuel Offset (kWh)
Solar	*1.600*	564,749	*0.700*	806,785
Gas	*1.360*	2,770,105	*0.700*	3,957,293
Total	*1.395*	3,334,855	*0.700*	4,764,078

Direction of Net Heat Flow

v3.65

Hawaiian Hotel – Thermal Dynamics (US units)

Heat-Pump Thermal Input (Therms)

Solar Portion	12,047
Gas Portion	69,517
Combined	81,564

250 °F

240 °F

44.6 °F

55.4 °F

70.0 °F

130.0 °F

CHW

DHW or HHW

Chromasun's Thermally-Driven Heat-Pump (Absorption Chiller)

Cooling Results

Heat-Pump Fuel Offset (kWh)	*Existing Chiller Efficiency (COP)*	Heat-Pump Production (Therms)	*H-P Cool Efficiency (COP)*	
47,062	*0.154*	7,228	*0.600*	Solar
230,842	*0.154*	35,454	*0.510*	Gas
277,905	*0.154*	42,682	*0.523*	Total

Heating Results

	H-P Heat Efficiency (COP)	Heat-Pump Production (Therms)	*Existing Boiler Efficiency (COP)*	Heat-Pump Fuel Offset (Therms)
Solar	*1.600*	19,275	*0.700*	27,535
Gas	*1.360*	94,543	*0.700*	135,061
Total	*1.395*	113,818	*0.700*	162,597

Direction of Net Heat Flow

v3.65

Hawaiian Hotel Economics

Chromasun System Turnkey Economics

	Assumptions	*Approx. Amount*
Total Installed Cost		***$ 1,740,000***
HI Grant in lieu of State Tax Credit		$ (350,000)
HI (Hawaii Energy) HEEP SHW CBI		$ (30,000)
Federal MACRS w/50% bonus	*IRS: Sec. 48; Bulletin 2011-16; Pub 946*	$ (600,000)
Federal ITC 30%	*IRS Sec. 48(a)(3)*	$ (500,000)
Total Cash Cost (net of incentives)		***$ 260,000***
Utility Savings Cash Flows		
Boiler Energy Savings	*Year 1*	$ 458,466
Absorber Energy Purchases	*Year 1*	$ (196,013)
Electricity Savings	*Year 1*	$ 91,709
Year 1 Savings		***$ 354,161***
Key Economic Assumptions		
Cooling Energy	*$0.330 / kWh (inflation factor = 5% / yr)*	
Heating Energy	*$2.58 / LPG-gal (inflation factor = 5% / yr)*	
Existing Boiler / Chiller COPs	*0.70 / 4.50*	
DHW Consumption	*Avg 62,368 GPD, with a 60.0 ºF temperature gain*	
Chromasun Solar THP Capacity	*50 TR (cooling) @81% capacity factor*	
Combined Tax Rate	*40%*	
Simple Payback		***1.2 Years***
Project IRR		***50%***

Chromasun Comparison to Solar PV and SHW Flat-plate

	Chromasun	Solar PV	SHW Flat-plate
Net Utility Offset (annual)	- - - - - - - $354,161 - - - - - - -		
Total Collectors	150	3937 (787 kW_{DC})	930
Array Size (sq.ft.)	9,000	75,590	71,640

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Typical Chromasun THP Economics (with combined heating & cooling) (Hospitality Sector)

Cuts heating fuel consumption in half + electricity savings
Offsetting 100% of DHW and a portion of CHW loads

- **TurnKey Purchase Option**
  - 1½ - 3 year paybacks (HI); 2-4 year payback (CA & AZ)
  - Significant offset to chiller electricity
  - Strongest economic value requires appetite for tax incentives
  - Performance Guarantee & O&M options available

- **Power Purchase Agreement**
  - Zero-capital outlay, immediate savings from day 1
  - Pay-as-you-go by the meter; means equipment and performance risk is on Chromasun
  - Pricing based a negotiable discount to public tariff: Chromasun takes all risk for all utility price changes. Client discount remains the same, regardless of the market.
  - Substantial utility discounts available
  - Financing resources available now

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7/10/2012

THANK YOU

CHROMASUN

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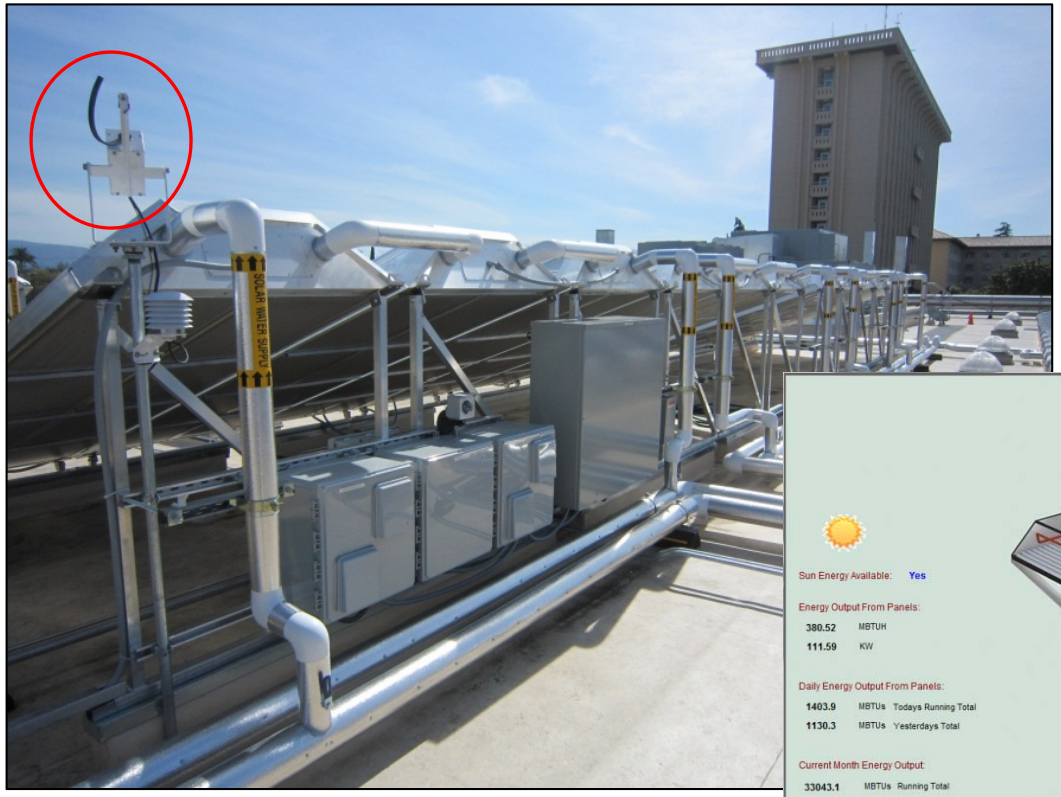
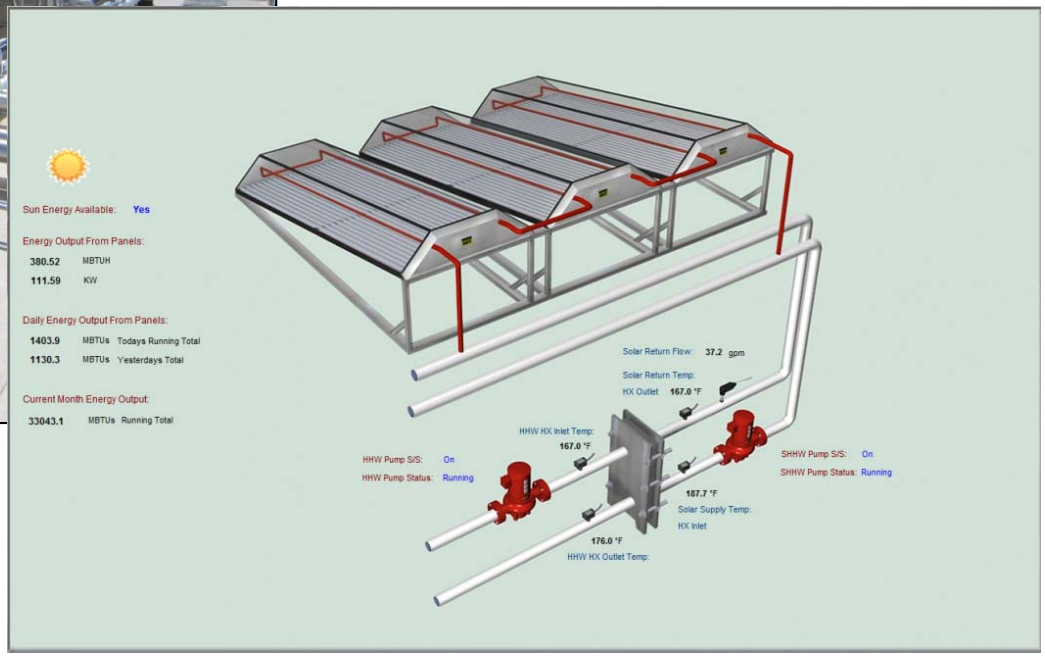
Performance Tracking

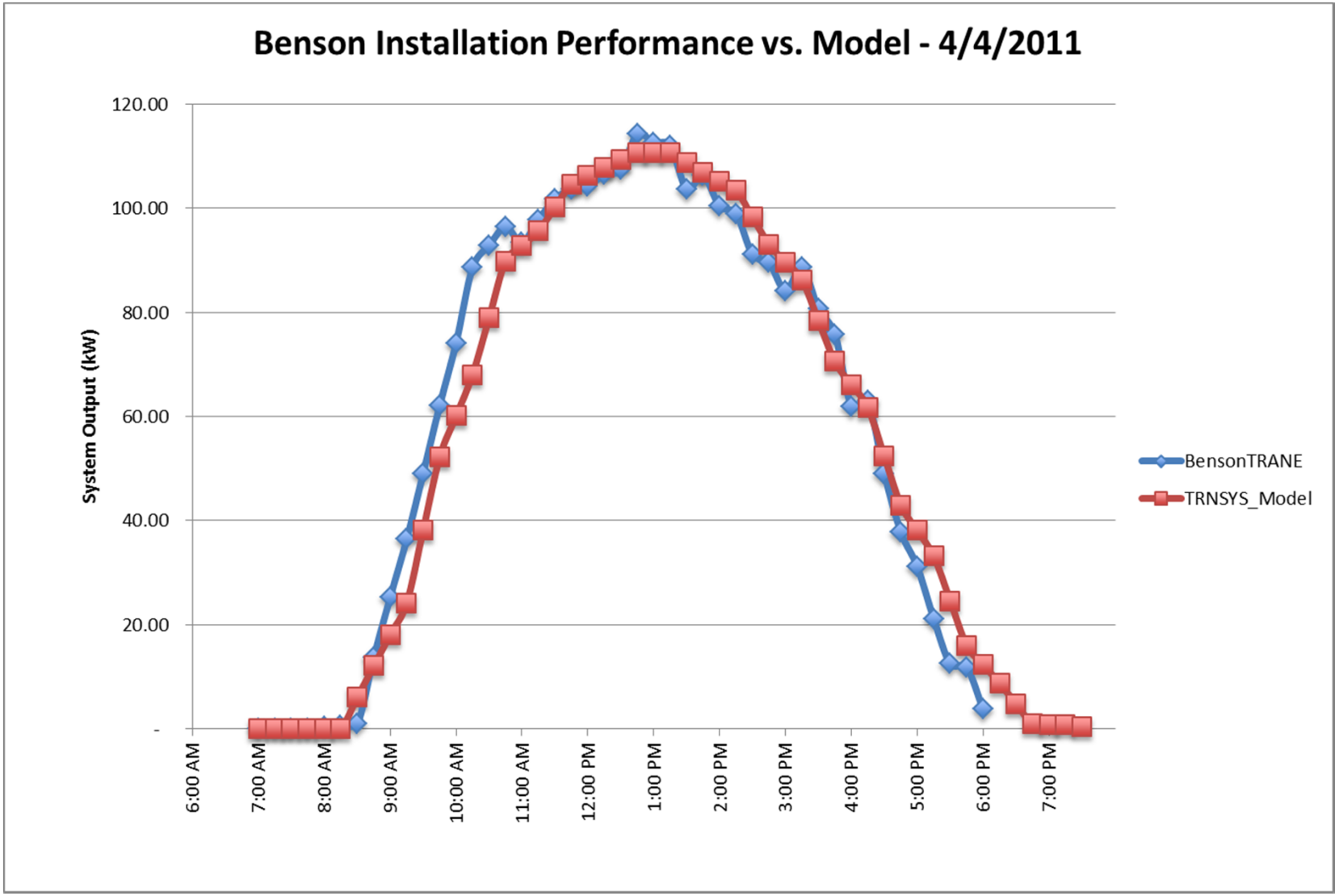
Solar Resource Monitoring



BTU Metering by TRANE



Production: Modeling vs. Performance
(independently verified by TRANE)



Testing program – began 2009

Santa Clara University, California

SoCalGas - Los Angeles

SRCC – Menlo Park, California

GE Global Research – Bangalore, India

Australian National University

GE Global Research - Munich, Germany