COGENRA SOLAR

Heat. Power. Savings.

SOLAR COGENERATION

Accelerate Commercialization in California of Hybrid Concentrating Photovoltaic Thermal and Tri-Generation

Ratson Morad

COO and VP R&D

December 12 2012

Acknowledgment

Funding provided by California Solar Initiative's (CSI) – Research, Developme and Deployment (RD&D) Program

http://www.calsolarresearch.ca.gov/

Cogenra also wants to thank

The CPUC

CPUC Program Manager Amy Reardon

Itron Program Manager Ann Peterson

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SOLAR COGENERATION

- Cogeneration and Market Opportunity
- Company Introduction
- CSI RD&D Grant
- Case Studies
- Next Step
- Benefits to California and Conclusions

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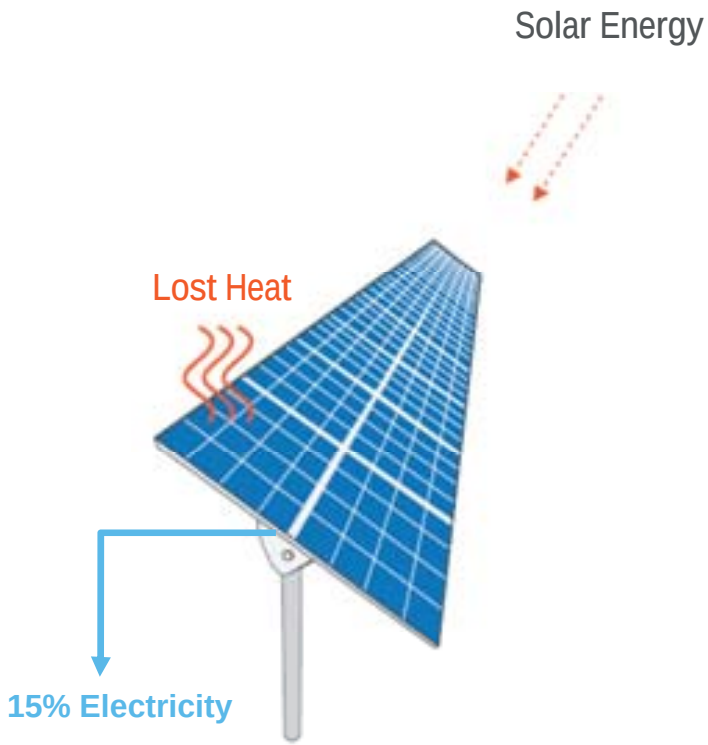
Solar Cogeneration

Photovoltaic Electricity + Solar Hot Water



Traditional 1-Axis PV
~ 15% Efficiency

Cogeneration
~ 75% Efficiency

Cogenra Delivers 75% Efficient,
Renewable Electricity and Heat with 5 Year Payback

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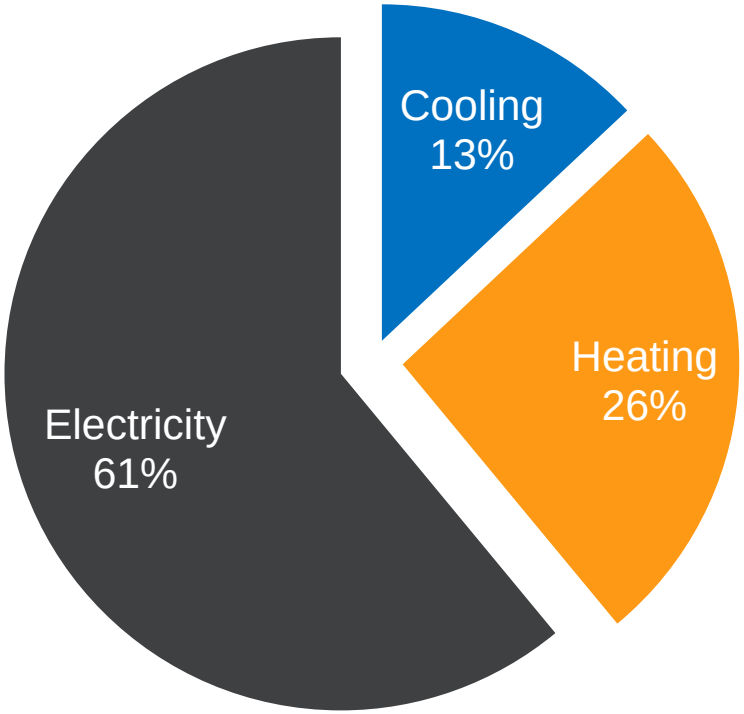
Distributed Generation



2009 World Energy Consumption by End Use (Excluding Transportation)

Total Cooling & Heating Market 2Trillion USD

- Sources: Derived from Energy Information Administration (EIA), International Energy Annual (IEA) Reports.

Reduce Local Emissions, Peak Demand and Grid Loading

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More Savings than PV or SHW

	Solar Electric PV	Solar Hot Water	Solar Cogeneration
Energy			
CO_2 Reduction			
Value			

Solar Cogeneration = Highest Value, Highest GHG reduction

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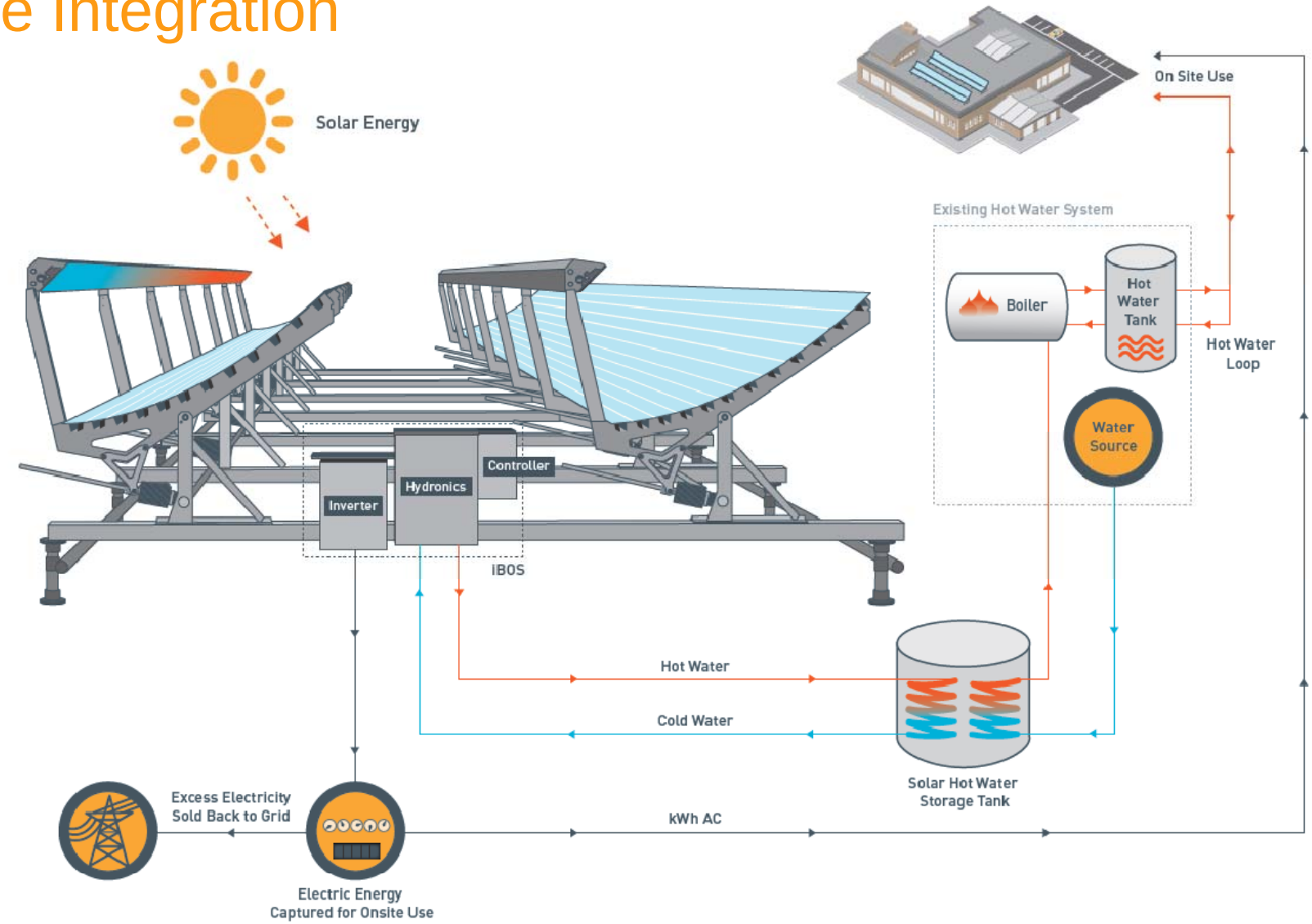
Typical Solar Cogeneration
Site Integration



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Solar Cogeneration Applications

Food

Meat, Dairy
Fruits & Vegetables

Wine, Beer, Milk

Pharmaceuticals

People

Hotels, Resorts, Apartments, Hospitals, Colleges

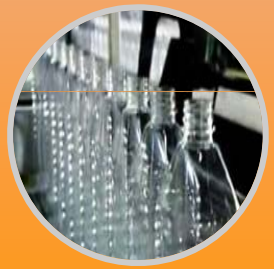
Military & Correctional

District Heating

Process

Desal, Wastewater
Power Plant

Textile, Mining, paper



Plastics, Metal Etching

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Cogenra at a Glance

TECHNOLOGY	Cogeneration of solar heat & electricity at 75% efficiency
SOLUTION	Solar electricity, heating and cooling on demand
BENEFIT	Lowest cost renewable energy and storable energy
CERTIFICATIONS	**PV** – IEC 62688 IEC 62108 **Thermal** – SRCC, Keymark
CUSTOMERS	Commercial and industrial installations on four continents

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3 Years: From Inception to Rapid Expansion

2009	2010	2011	2012	2013
June	October	July	Dec	July
▪ **Funding**	▪ **1st Customer** Installed	▪ **Rooftop system** Certified, Listed	▪ **>30 WW Projects** Ramping up production	▪ **>Storage and Energy on Demand**

2012 Focus

Segments | Performance | Proliferation

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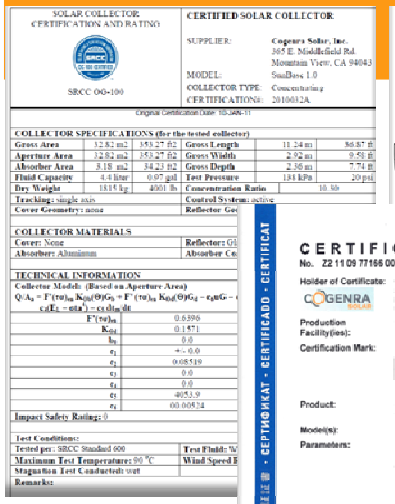
Certifications & Testing

World's First Concentrating to Complete PV & Thermal

Unites States



SRCC OG100

IAPMO

PV Certification
IEC 62688, 62108

Europe

Keymark

Australia GlobalMark

GlobalMark

Certified Worldwide for Performance and Reliability

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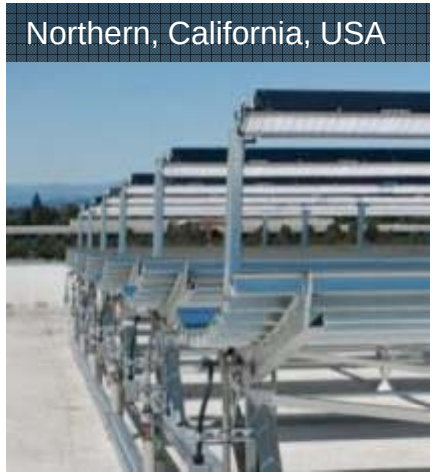
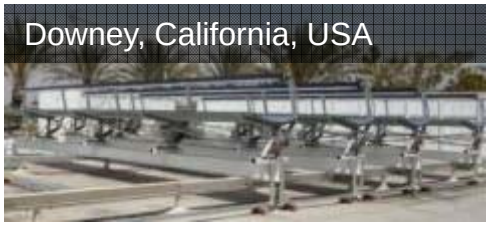
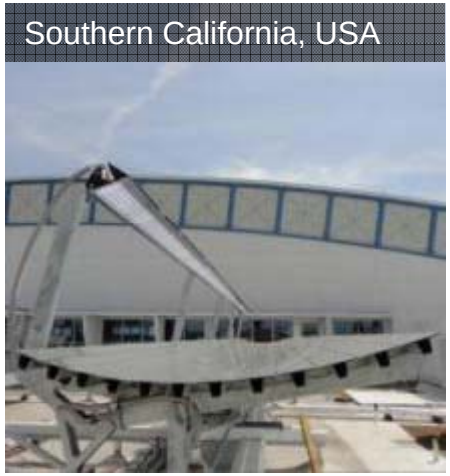
20+ Solar Cogeneration Sites Operational







Southern California Gas Company · PEPSICO · facebook · Real InterContinental San Salvador · The University of Arizona · Clover Stornetta Farms · General Hydroponics · Kendall-Jackson · Sonoma Wine Co. · Juniper Networks · La Posada · Tucson Medical Center · Marines

Established Proof Points for Technology, Performance & Manufacturing

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SEVEN KEY PRINCIPLES OF THE CSI RD&D PROGRAM

Marking Solar Smarter, Stronger and Sustainable

- Improve the economics of solar technologies by reducing technology costs and increasing system performance
- Focus on issues that directly benefit California
- Fill knowledge gaps to enable successful, wide-scale deployment of solar distributed generation technologies
- Overcome significant barriers to technology adoption
- Take advantage of California's wealth of data from past, current, and future installations to fulfill the above
- Provide bridge funding to help promising solar technologies transition from a pre-commercial state to full commercial viability
- Support efforts to address the integration of distributed solar power into the grid in order to maximize its value to California ratepayers

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Project Tasks
Key for Accelerating Commercialization

- Design second generation system that that will reduce overall system cost by up to 20%
  - Design a system that reduces cost and can be installed on different sites
  - Develop merge-at-customer planning system and site integration
  - Design 'BOS' (Balance Of the System) for the hydronics that reduces site engineering and permit requirements and can be easily connected on site
- Increase customer saving and enable incentive free renewable energy
  - Design and deploy instrumentation
  - Track and analyze system performance
  - Measure field performance and refine economic and financial models
  - Optimize control logic to maximize delivered energy value.
- Adapt system to enable advanced flexible energy delivery capabilities
  - Demonstrate feasibility of Tri-Generation system

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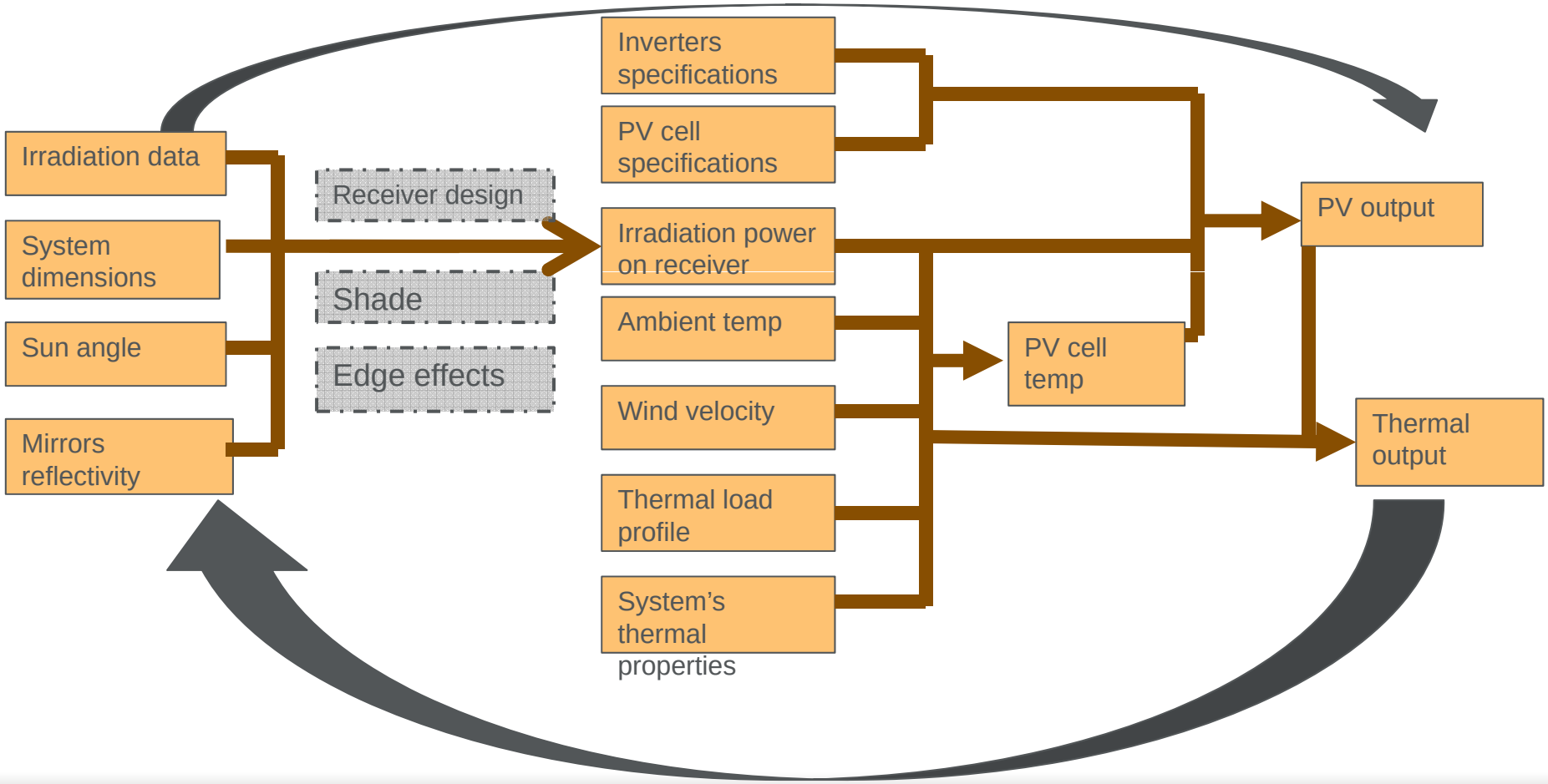
Cogenra's Thermal and PV Output Model

- Cogenra developed simulation capabilities of PV-thermal hybrid concentrating-collector models
- Enables modeling and detailed report of SunBase system output through a year including customer usage
- A good tool for array sizing, and for input to the financial model



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Design and Deployment of Instrumentations

Cogenra deployed weather station instrumentation to track meteorological conditions and insolation.

Cogenra is collecting the following data in 5 min intervals:

- DNI – Direct Normal Insolation
- Diffused Light
- Ambient temp
- Wind
- Water temperature into the solar system
- Water temperature out of the solar system
- Water flow rate
- Water temperature customer side In/Out
- Water Flow- customer side.
- Electricity generated
- Tracker angle.
- Water Storage tank temp.

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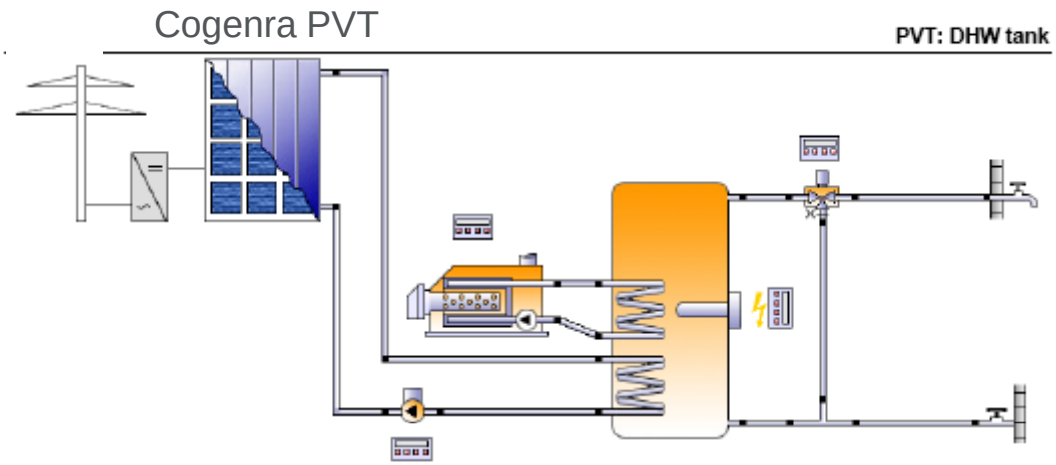
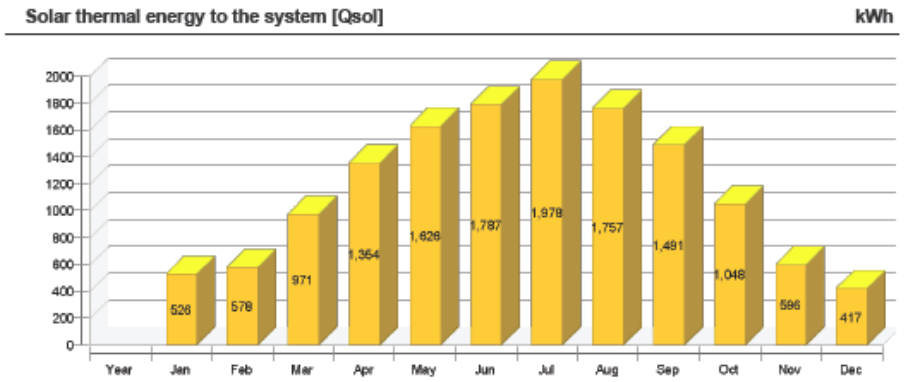
Analyzing Performance and Sizing Installation



Location of the system

USA
CA Mountain View
Longitude: -122.04°
Latitude: 37.39°
Elevation: 32 m



- Cogenra implemented its simulation program of PV-Thermal hybrid concentrating collector models in latest version of PolySun, which is a commercially available software
- PolySun enables modeling and detailed report of Cogenra system output through a year taking into account predicted weather conditions and customer's usage
- Cogenra and installers are using this tool to analyze system performance and to optimize output based on customer's hot water usage

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SunBase® at Sonoma Wine Company

System size

120 **SunBase®** PVT modules

Capacity

272kW (50kW$_e$ + 222kW$_{th}$)

Percent energy offset

70% of energy offset by solar cogeneration

SONOMA WINE CO

Industry

Wine

Installed

November 2010

Application

Tank & barrel wash

Bottling line – CIP

*"We found Cogenra was the **perfect match—high impact without high cost…** hot water and electricity"*

- Derek Benham, founder and owner

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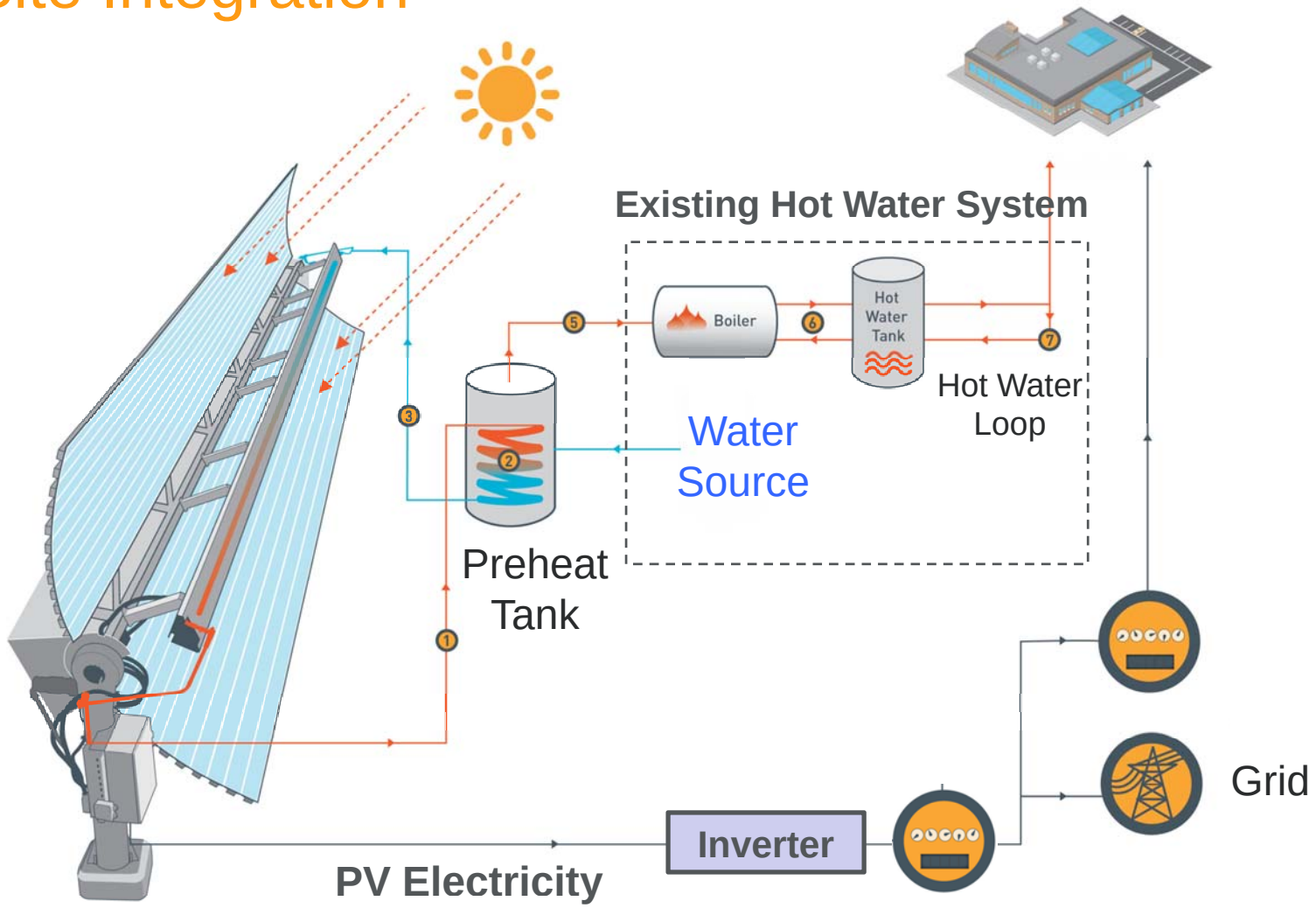
Sonoma Wine Company (SWC) Installation
Site Integration



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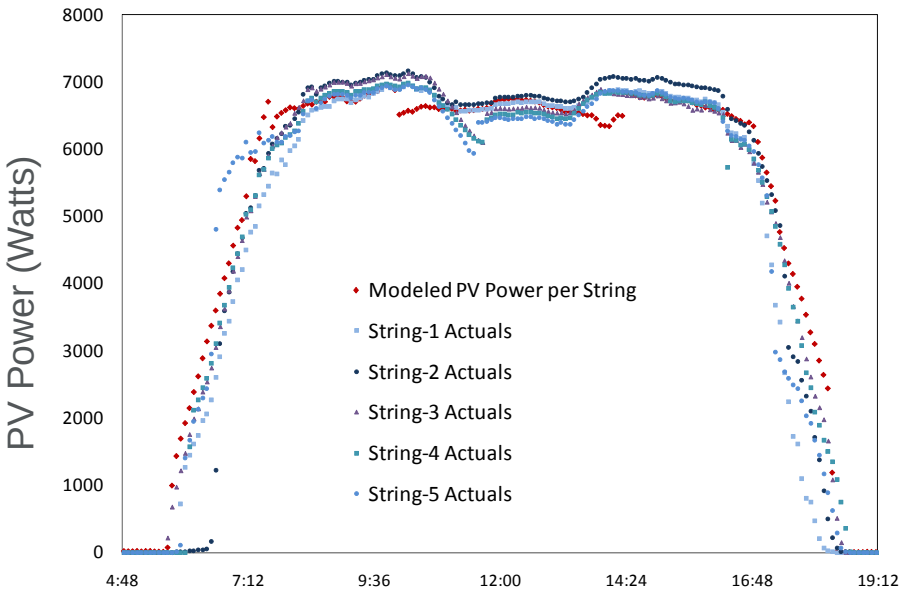
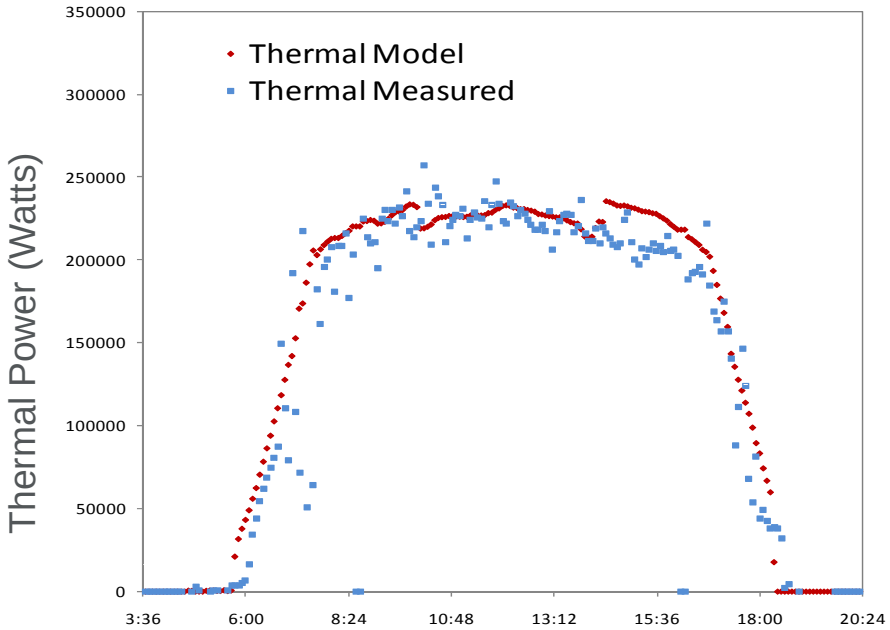
SWC PV and Thermal Production vs. Model





Actual PV and thermal power in excellent agreement with model

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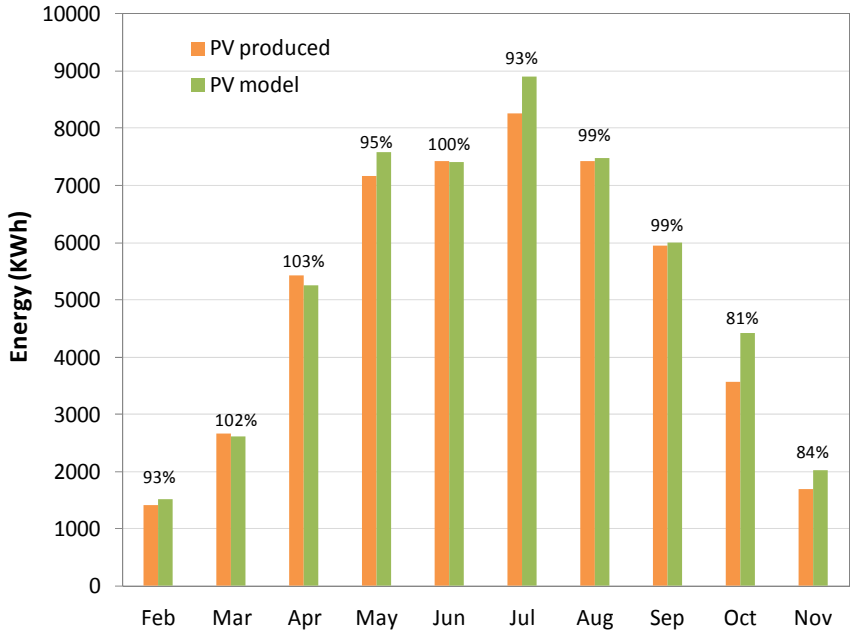
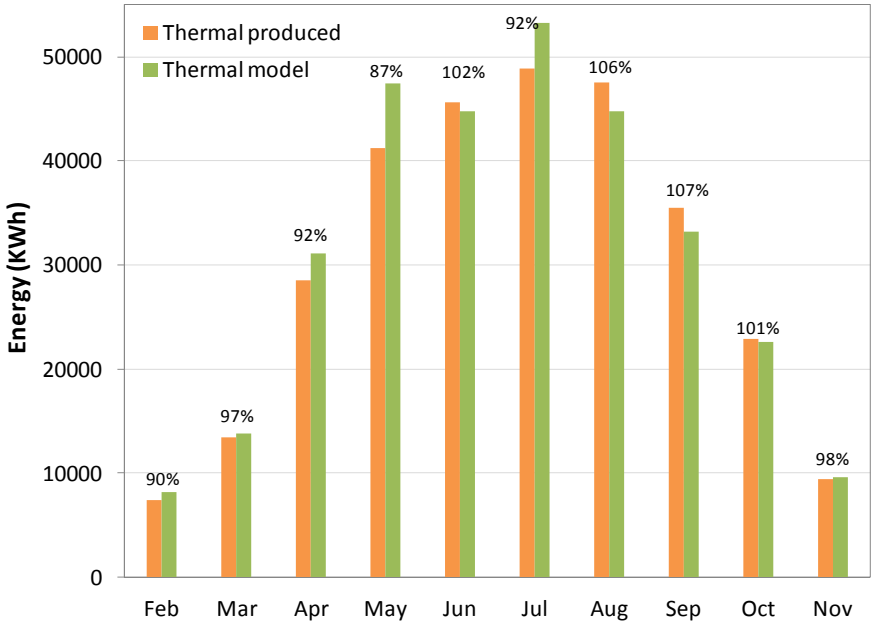
SWC Demo Array Performance – PV & Thermal

PV and Thermal Energy Output



PV Energy Output, KWh



Thermal Energy Output, KWh

Energy Produced at SWC in excellent correlation to model

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Heavy Equipment → 2 Person Turnkey

SunBase® Installation

SunDeck® Installation

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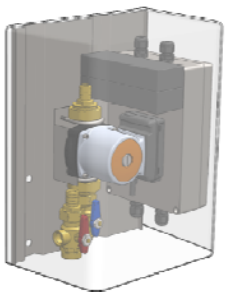
SunDeck® Turnkey Solution
iBOS – integrated Balance Of System

+



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iBOS™	SunPack-6*
• Integrated Hydronics & Control • Remote monitoring & diagnostics • Plug and Play Design	• 3 KWe + 14KWth • 5.5 lb/ft2 • 77.6 KWh/ft2

Sundeck ® + iBOS™ = Turnkey Solution
Enables lower project cost and faster deployment

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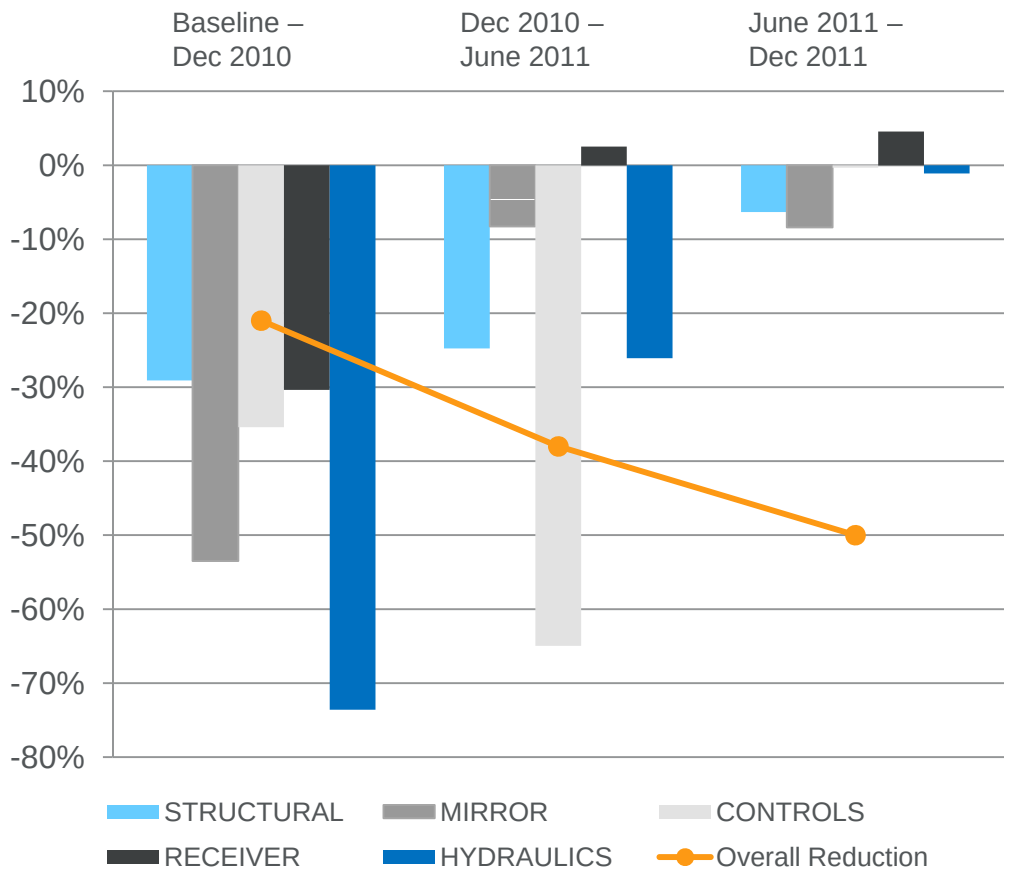
Cost Reduction

SunBase® → SunDeck®



Achieved 50% total cost reduction

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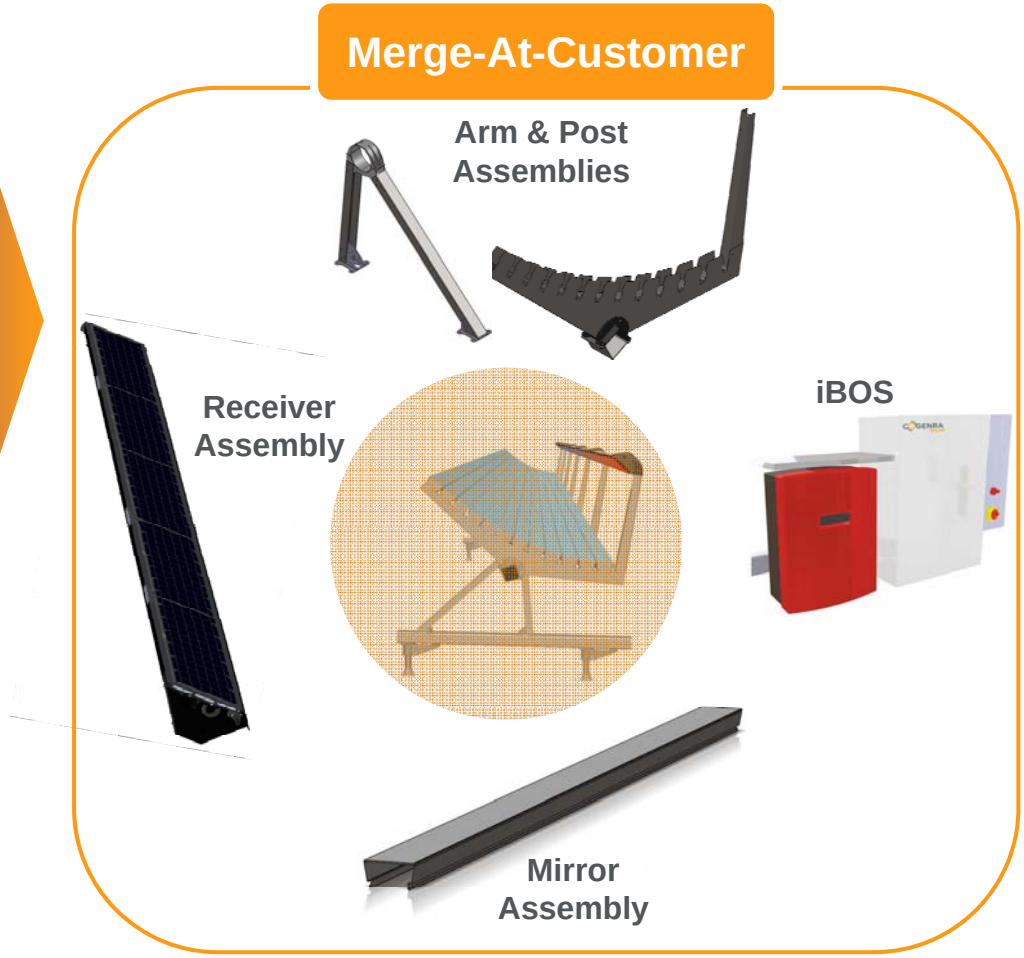
Capital Light Contract Manufacturing

PVT Panel

Integrated into receiver assembly

- Cogenra developed suppliers within California which manufacture the receiver (high IP), the controller and software for optimizing the power harvesting of the system



Localization Enables Rapid Scaling, Fast Installation, Lower Cost

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Cogenra Remote Monitoring System

- Cogenra developed monitoring systems which tracks the PV (electrical) and Thermal output of the system
- This remote monitoring capability enables the customer to view the saving and the GHG (Green House Gases) reduction

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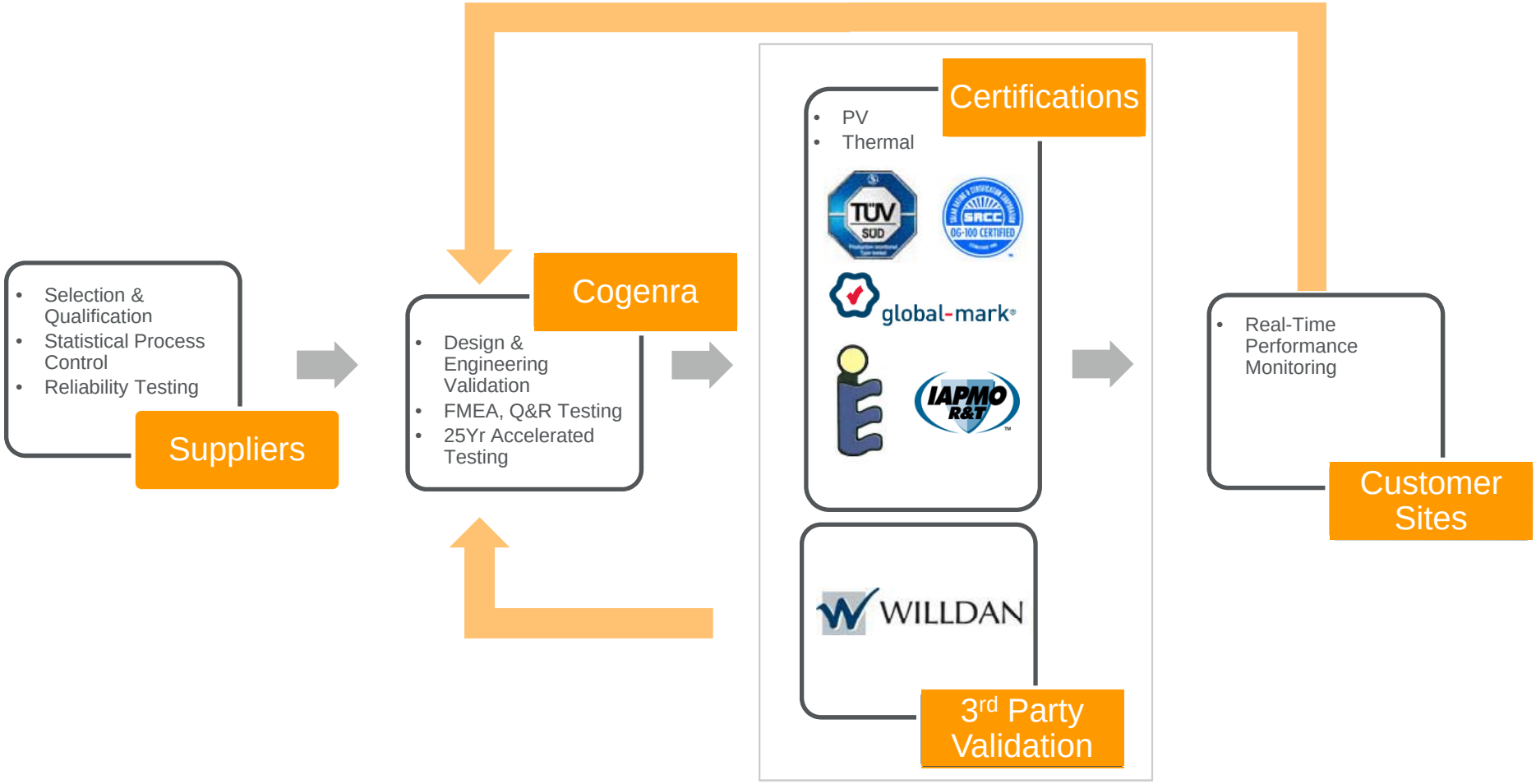
Comprehensive Approach to Quality & Reliability

25Yr+ Lifetime Tested and Guaranteed



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Lessons Learned and Whitepapers

- Cogenra captured and published the following lessons and whitepapers from this project at http://www.cogenra.com/support/cogenra-resources/
- Heat & Power Purchase Agreement Flyer
- LEED with Solar Cogeneration Flyer
- Cooling with Solar Cogen White Paper
- Solar Cogen in Context White Paper
- Mitigating Stagnation White Paper
- GHG Reduction with Solar Cogen White Paper
- Renewable Energy Use in Breweries and Wineries Webinar

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Financing Options
Purchase & HPPA

TURNKEY FACILITY PURCHASE

- Attractive IRR, NPV
- Tax benefits

HEAT & POWER PURCHASE AGREEMENT (HPPA)

- Immediate savings on gas & electricity
- No debt or upfront expense

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Economic Model

Robust economic model offers economic analysis and customer proposal generation

Customer Inputs

- *Usage*
- *Utility rates*
- *Boiler efficiency*

Incentive Inputs

- *Federal*
- *Upfront for PV and/or solar hot water production*
- *CSI Thermal Rebate*
- *Electricity and thermal feed-in tariffs*
- *Electricity and thermal RECS*
- *Carbon incentive*

Outputs

- *Payback*
- *ROI*
- *Greenhouse gas emissions reduction*
- *Savings and cash flow*

Inputs

Size, Performance & Evaluators	
Number of SunDeck® Modules	Site specific
Elec Prod / Mod (kWh)	Location dependent
Therms Prod / Mod (therms)	Location dependent
Space Required	Location dependent
Installation Price	Varies by array size
Weighted Average Cost of Capital	Varies

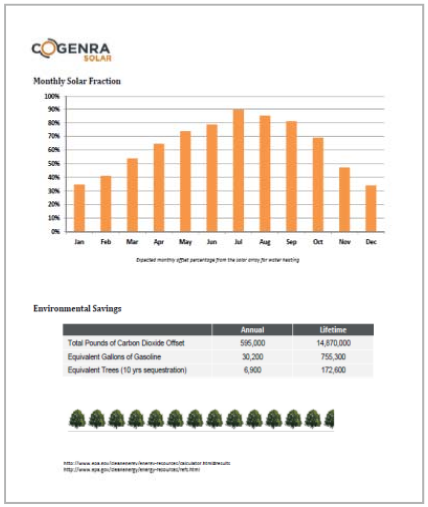
O&M, Insurance & Boiler Efficiency	
O&M ($/Module)	$50
O&M Escal. Rate	3.0%
O&M Warranty Period	5.00
Insurance Rate	0.2%
Insurance Escalation	-1.0%
Boiler Efficiency	Site specific
Rebate Boiler Efficiency	82% (CSI Thermal)

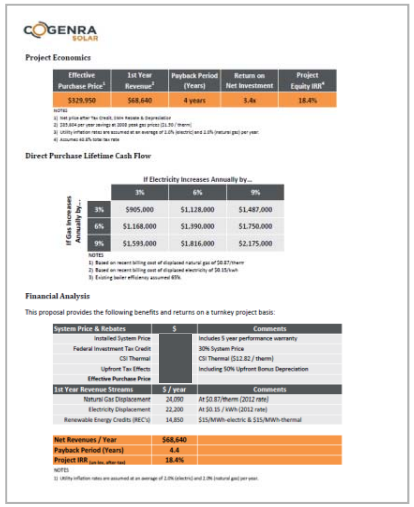
Thermal & Electric Rebates	
Thermal EPBB ($/Therm Offset)	$12.82 (CSI Thermal)
True Up/100% Upfront?	100.0%
Electric EPBB ($/W)	$0.00
Electric PBI ($/kWh)	$0.00
Electric PBI Duration (Yrs)	0
Thermal PBI ($/therm)	$0.00
Thermal PBI Duration (Yrs)	0

Depreciation, Taxes & Credits	
Federal Tax Rate	35.0%
State Tax Rate	5.8%
Fed Depreciation	50% Upfront
State Depreciation	Straight Line
Tax Credit Name	0
Tax Credit Cap	$0
Tax Credit Percent	0.0%
Tax Credit Carryover	1.0
Federal Grant or Credit?	Tax Credit

Utility Rates	
Electricity Price	$0.148
Electric Escalation Rate	2.0%
Natural Gas Price	$0.87
Nat Gas Escalation Rate	2.0%
Heating System Type	natural gas

Carbon, PBI & REC Value	
CO_2 Price ($ / ton)	$0.00
CO_2 Escalation Rate	0.0%
Electric REC ($/MWh)	$0.00
Thermal REC ($/MWh)	$0.00
REC Escalation Rate	0.0%





Business Models

Heat & Power Purchase Agreement

COGENRA SOLAR

Provide Renewable Energy

- Turnkey facility & operations
- Real-time monitoring

CUSTOMER

Purchase Energy

- Predictable energy expense

Benefits

- Savings & hedge
- Reduced emissions
- Environmental statement

Without Risk

- No capital outlay
- No debt
- No performance risk
- No maintenance

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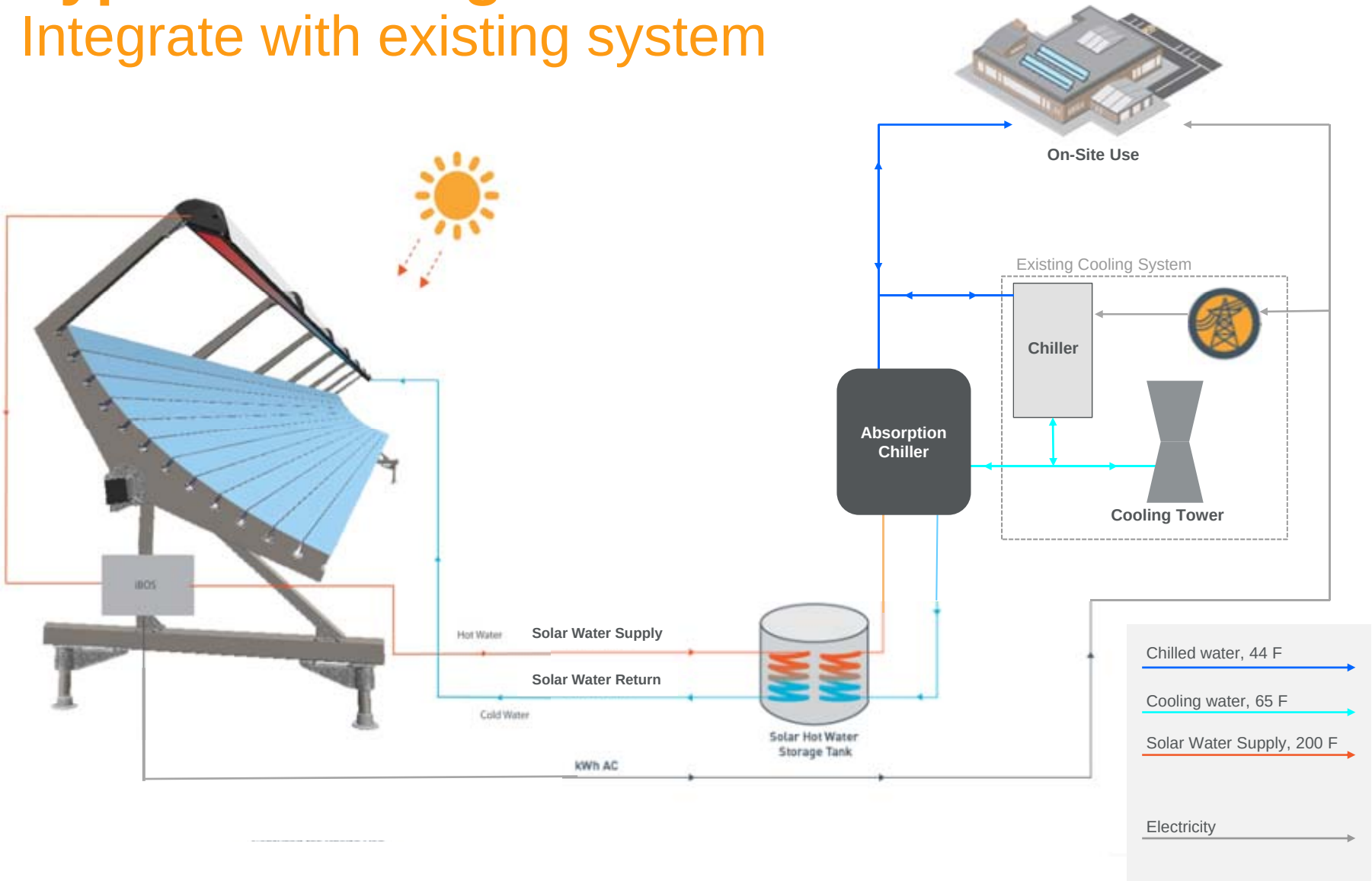
Typical Cooling Installation

Integrate with existing system



Southern California Gas Company

Southern California Gas Company

A Sempra Energy utility®

System size

20 SunDeck® PVT modules

Production

50.2kW

Industry

Utility

Installation Date

May 2012

Application

Absorption chiller

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Solar Cogeneration for Air Conditioning

More Output than PV. Simpler & Safer than High Temperature SHW

	PV	Solar Hot Water	Solar Cogeneration		
	AC Electricity	200C- 400C Hot Water	AC Electricity	100C Hot Water	Total
Energy	**15%**	**60%**	**15%**	**60%**	**75%**
Integration Equipment		*Double Effect Absorption Chiller*		*Single Effect Absorption Chiller*	
COP*	5X	1.2X	5X	0.7X	
Cooling Performance	75%	72%	75%	42%	117%

*COP: Coefficient of performance

** Cooling performance defined as heating power delivered relative to solar power landing on aperture

Reduce Peak Summertime Demand

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Case Studies

- Clover
- Facebook
- Kendall-Jackson Wines
- General Hydroponics, Inc.
- Department of Defense

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Clover

System size

20 SunDeck® PVT modules

Production

51 kW (9 kW_e + 42 kW_{th})

CLOVER STORNETTA FARMS

Location

Petaluma, CA

Industry

Dairy

Installation Date

June 2012

Application

Clean-in-place processes

*"With the latest addition of the solar cogeneration system **we are now saving money on our energy bills**. It's a win-win for us—and our customers."*

- Marcus Benedetti, President and CEO at Clover Stornetta.

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Facebook

System size

24 SunDeck® PVT modules

Capacity

60kW (10kW$_e$ + 50kW$_{th}$)

Percent energy offset

60% of energy offset by solar cogeneration

Industry

Commercial

Installation Date

March 2012

Application

Hot water + Power for fitness facility

*"We believe these kind of projects can **help facilitate further innovation**, while also advancing our own understanding of what these kind of investments mean for our business".*

- Marcy Scott Lynn, Sustainability Lead

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Kendall-Jackson Wines

System size

96 SunDeck® PVT modules

Capacity

241 kW (41 kW_e + 200 kW_{th})

Percent energy offset

60% of energy offset by solar cogeneration

Industry

Wine

Installation Date

December 2011

Application

Tank washing/cleaning

*"**We're thrilled to take this leadership position with Cogenra** by installing the largest rooftop solar electricity and hot water system rooftop array to date. **It's a win for the environment and our bottom line**."*

- Robert Boller, VP of Sustainability

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General Hydroponics, Inc.

System size
36 SunDeck® modules

Capacity
75kW ($15kW_e + 60kW_{th}$)

Percent energy offset
65% of energy offset by solar cogeneration

GENERAL HYDROPONICS®
Bringing Nature and Technology Together

Industry
Agriculture

Installed
July 2011

Application
Hot water used in nutrient products

*"Cogenra's solution is a **core element in reaching our sustainability goals**, in addition to meeting our **longer-term financial objectives.**"*

- Larry Brooke, Founder & Owner

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Department of Defense: In Progress

Capacity

- 242 kW – Port Hueneme
- 121 kW – Camp Parks

Segment

Military (Army & Navy)

Installation Date

2012

Application

- **Technology evaluation** for future expansion to other DoD sites
- **Dining Hall** at Port Hueneme Naval Base, Ventura County, CA and Camp Parks Reserve Forces Training Area in Dublin, CA

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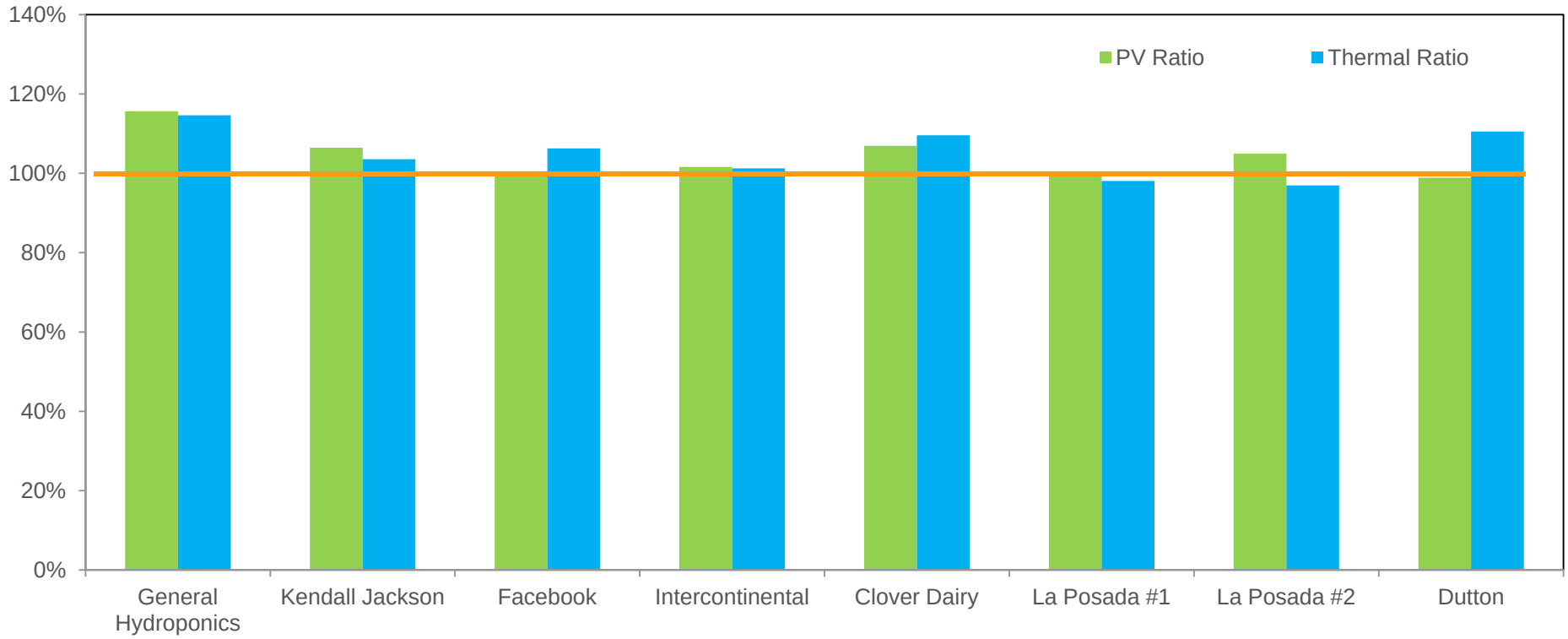
Installed Base Performance – PV & Thermal



Thermal and PV Performance Exceed Prediction

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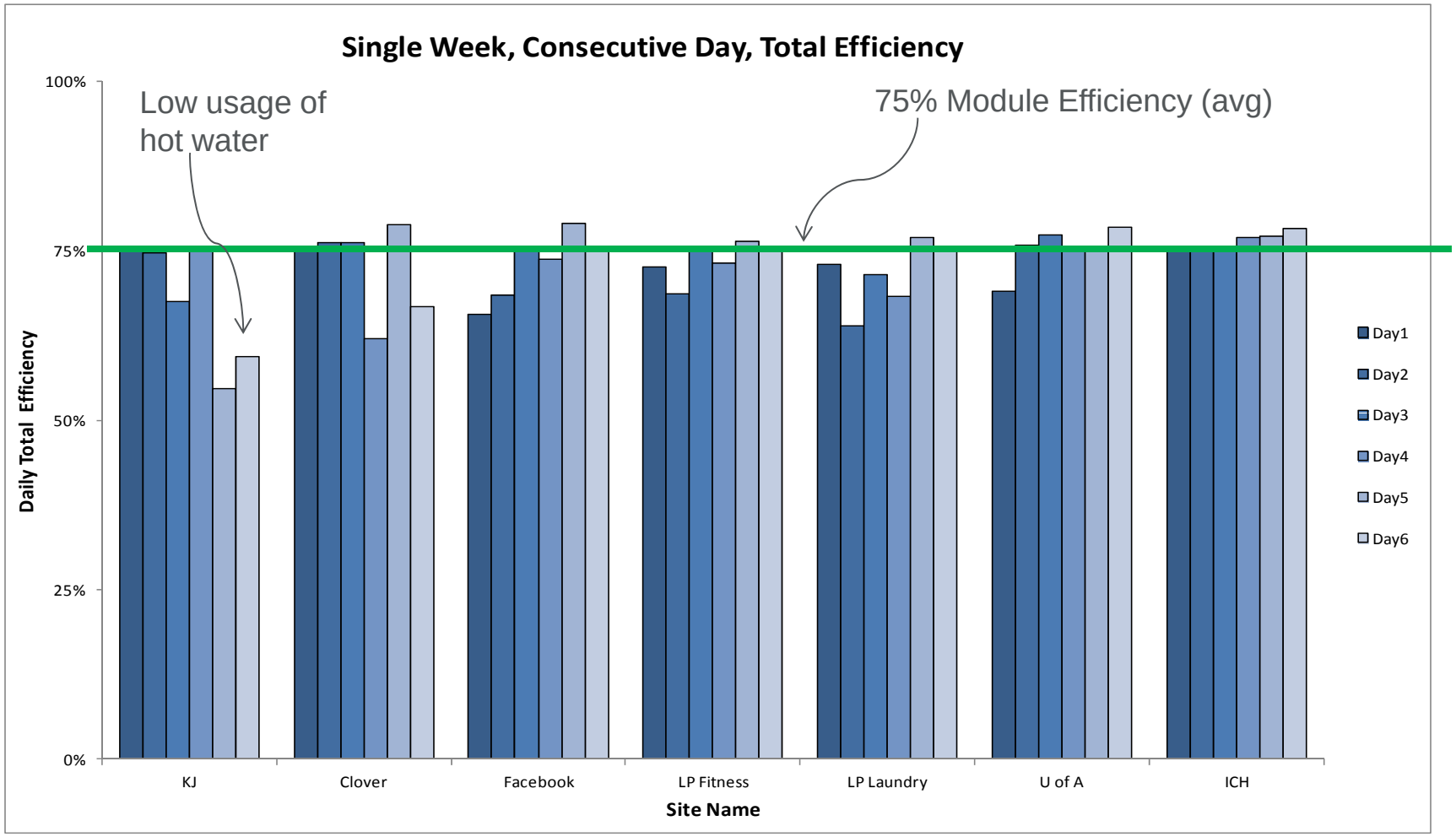
Total Efficiency - Field Performance



75% PVT Efficiency Certified, Established, Proven at Multiple Customer Sites

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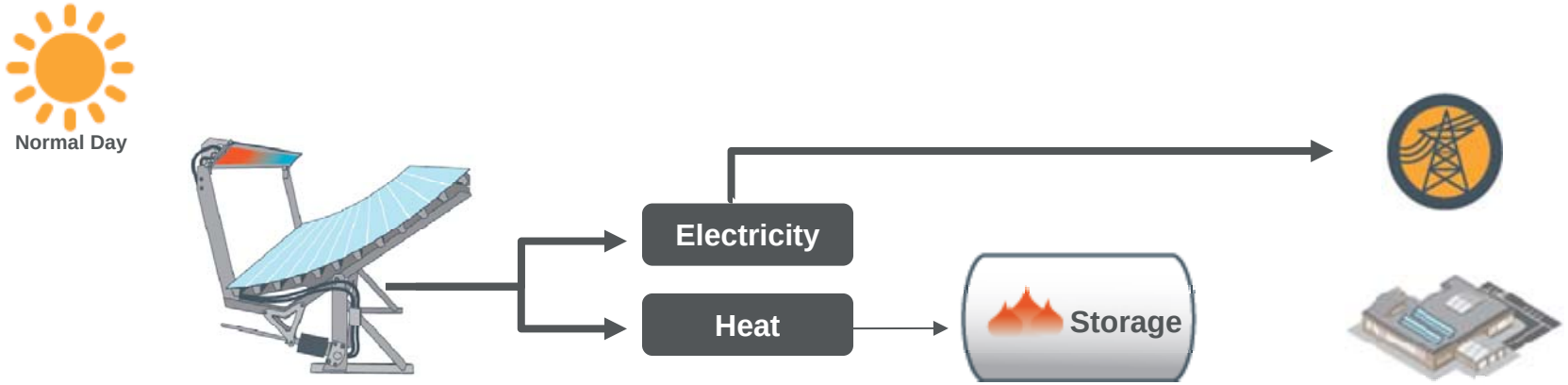
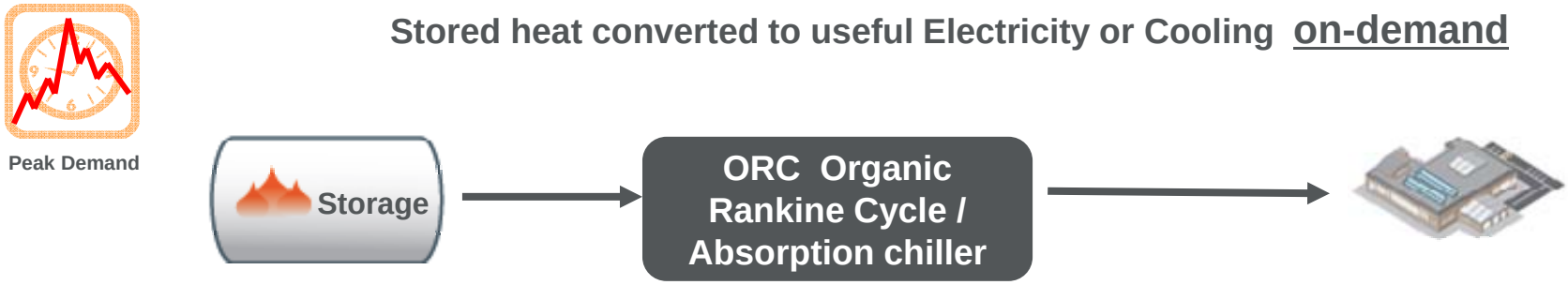
Storable Heat → Energy On-Demand





Addressing Solar Intermittency and Demand Charges

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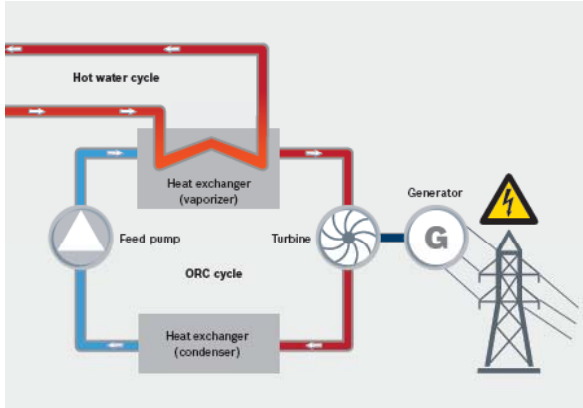
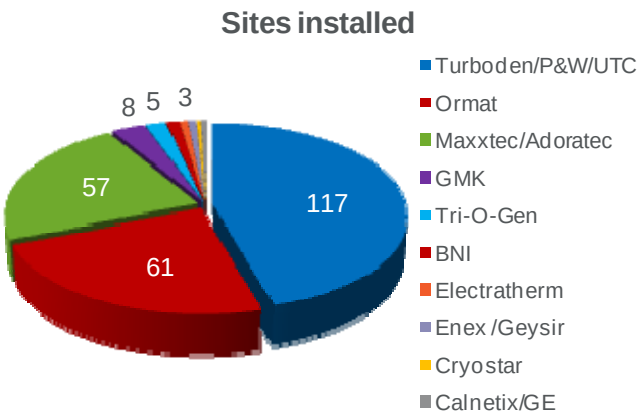
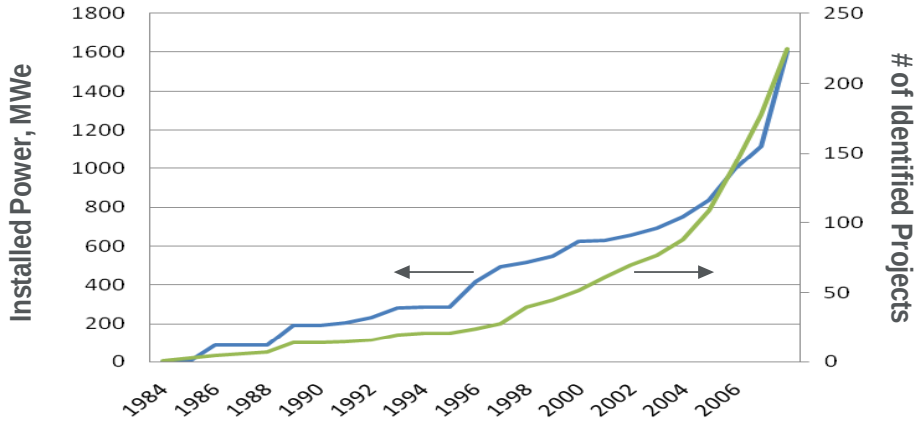
Background - Converting Waste Heat to Power

SunDeck Array



- **Technology**: Electricity production from low temperature heat sources using an organic working fluid
- **Applications**: Geothermal, Biomass, Waste heat recovery, solar
- **Working fluids**: Refrigerants (100-180ºC), Hydrocarbons (180-250ºC), Siloxanes (250-400ºC)
- **Efficiency**: 10% at 100ºC source to 20% at >200ºC





Growing Utilization of 'Low Grade Heat'

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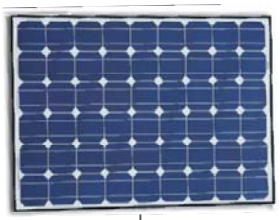
Hot Water Vs. Battery Solar Power Storage

PV + Battery System



$1.5 / W
installed

3-5 yr Lifetime

$700 / KWh$_{el}$

Limited charge-discharge cycles

Power electronics

$300 / KW

$6 / W with 6hrs storage

Solar Cogeneration

$1.5 / W
installed

PV Electricity

'Free' Solar Heat

25yr lifetime

Infinite charge - discharge cycles

Thermal Storage

$50 / KWh$_{el}$

ORC turbine

$1500 / KW

+

$1.8 / W with 6hrs storage

PVT + Waste Heat Recovery → Lowest Cost 'Firm' Renewable

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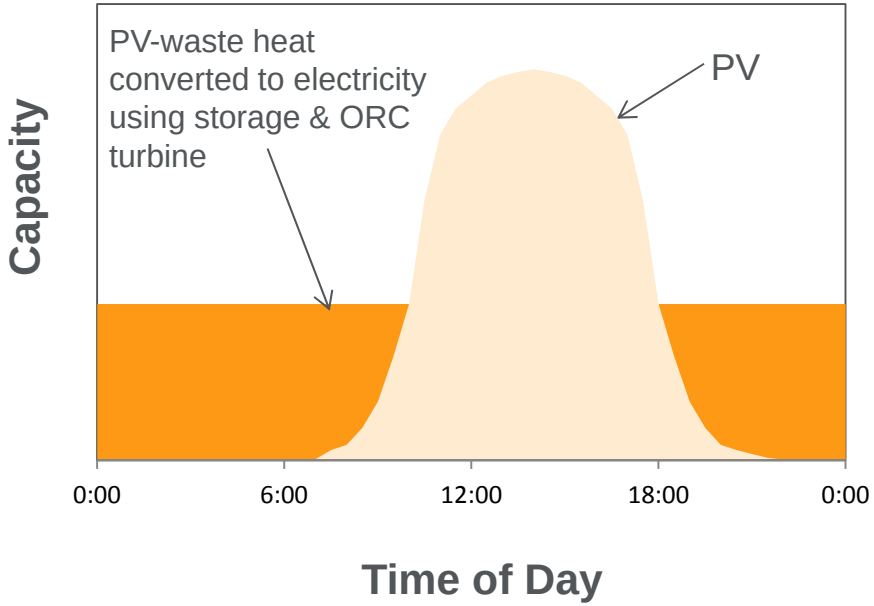
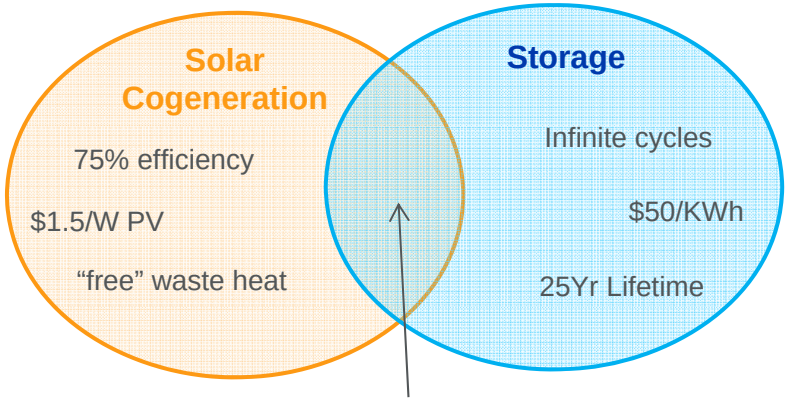
Energy Security & Reliability

Enable Microgrid through Grid Parallel & Islanding Capability

Uninterrupted 24/7 Distributed Generation





- Stand-alone system
- No PV intermittency
- Peak load reduction
- Year-round solution with IC
- Fast ramping
- Quick start
- Dispatchable

PVT + ORC Waste Heat Recovery → Microgrids for Energy Security

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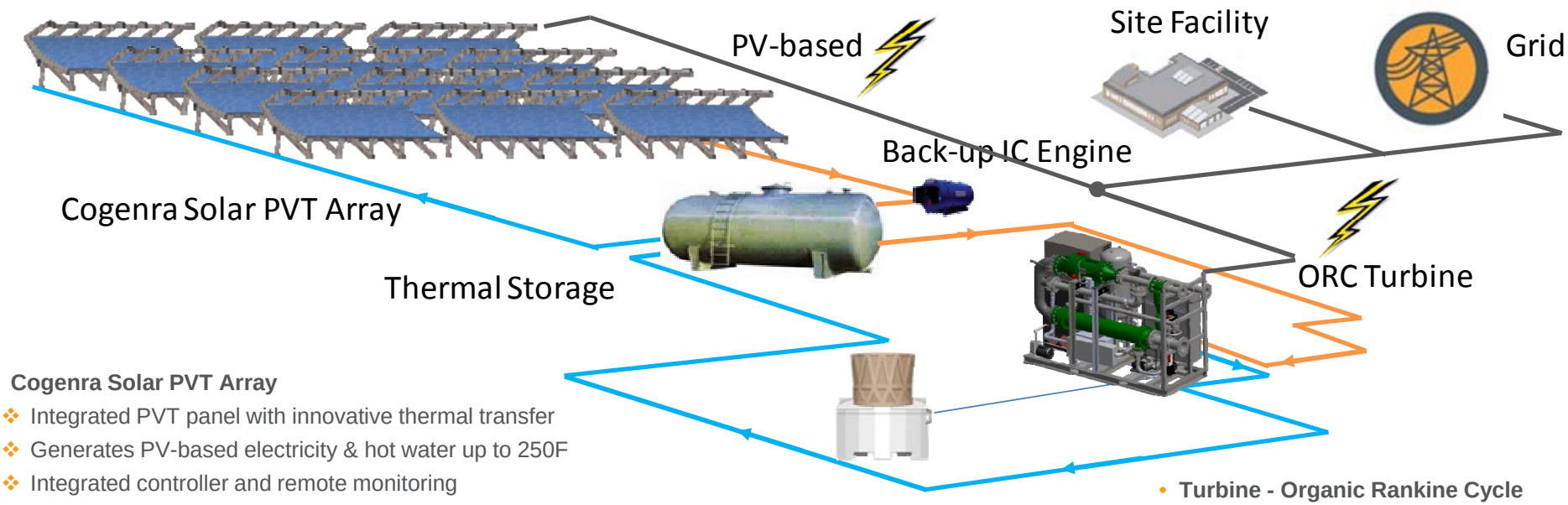
Energy Security & Reliability



- **Cogenra Solar PVT Array**
  - Integrated PVT panel with innovative thermal transfer
  - Generates PV-based electricity & hot water up to 250F
  - Integrated controller and remote monitoring
  - Field proven in >20 projects

- **Thermal Storage**
  - Low cost steel tanks
  - Low pressure & temperature
  - Unlimited charge-discharge cycles

- **Turbine - Organic Rankine Cycle**
  - Low temperature power conversion
  - Robust, low maintenance

Year-round 24/7 Solution with Reciprocating IC Engine (Option)

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Benefits to California

- Demonstrated the integration of Distributed Solar Cogeneration at customers sites while lowering grid congestion and local GHG emissions
- Developed software tools that enables the calculations of the energy output from a cogeneration system and supporting the financials models including the California CSI Thermal Rebate
- Developed California suppliers for high technology solar panel especially in this difficult time in the solar industry
- Used and developed California wealth of human capabilities, mainly in engineering and Software
- Demonstrated financial viability for solar system with improved economics when doing cogeneration
- Demonstrated Tri-generation, which can lower electrical usage for air-conditioning, on hot days, on peak demand when the grid is congested

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Conclusions: Cogeneration -

- Captures **5 times** more energy than PV
- **Reduces** emissions
- **Faster payback** than PV
- Building integration for efficient, Solar Heating and Cooling
- Better utilization of roof space
- Stored heat converted to useful Electricity or Cooling on-demand

Get the Most from the Sun with Solar Cogenenaration

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COGENRA SOLAR

Heat. Power. Savings.

Thank You

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