



Cogenra

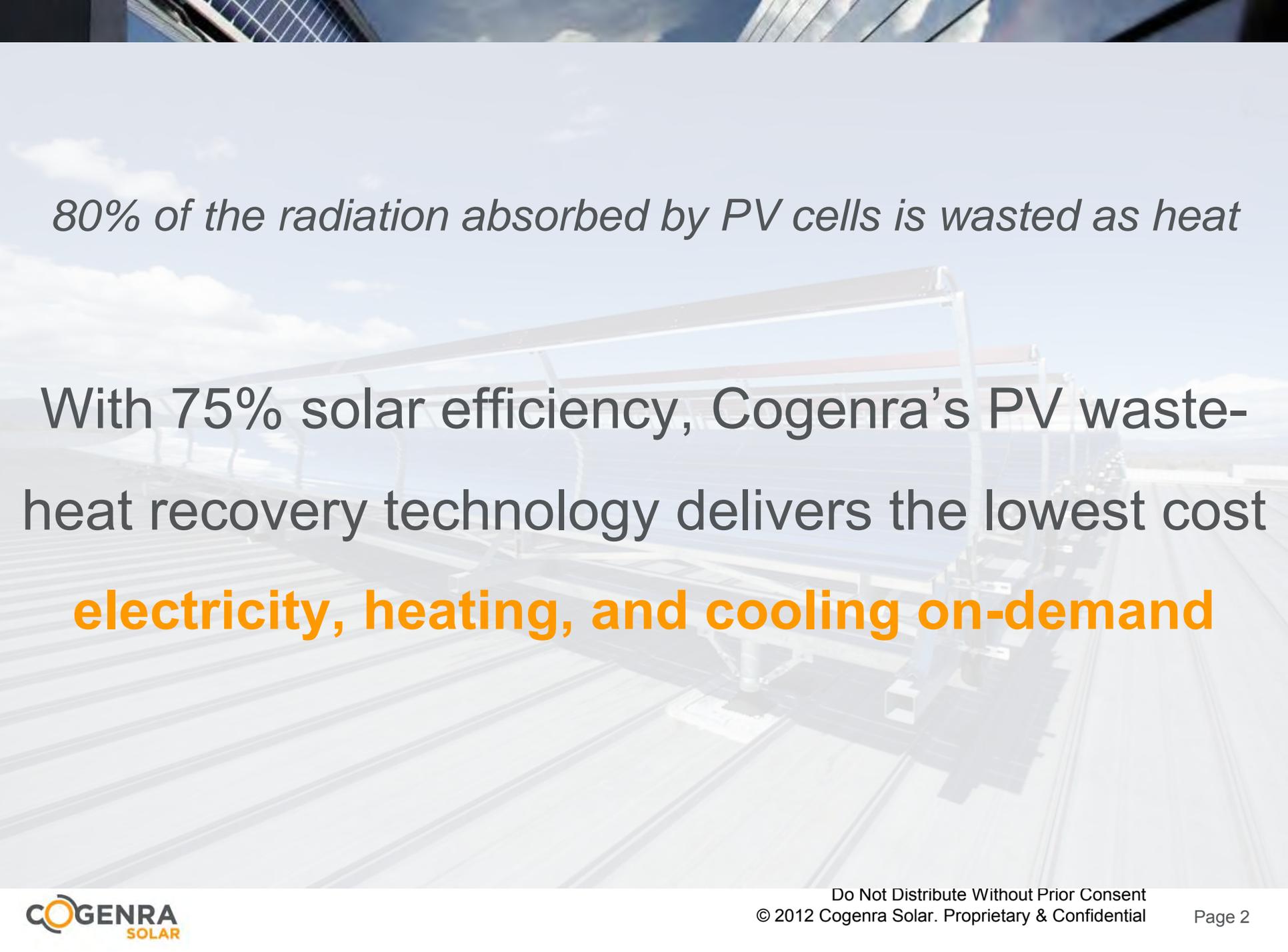
Introduction

Presented at CEC Workshop



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80% of the radiation absorbed by PV cells is wasted as heat

With 75% solar efficiency, Cogenra's PV waste-heat recovery technology delivers the lowest cost **electricity, heating, and cooling on-demand**

Overview: Cogenra

- Cogenra is an equipment provider of solar cogeneration solutions that generate solar electricity (*Photovoltaics based*) and solar heat from the same module
- Cogenra expanding innovative hybrid PVT technology use to include:
 - » Waste-heat to cooling via thermal chillers (offset electricity)
 - » Waste-heat to electricity via organic rankine cycle (ORC) turbines
- Thermal storage enables on-demand electricity generation to reduce peak power demand at customer sites

PV “Waste-Heat” Conversion to On-demand Distributed Power

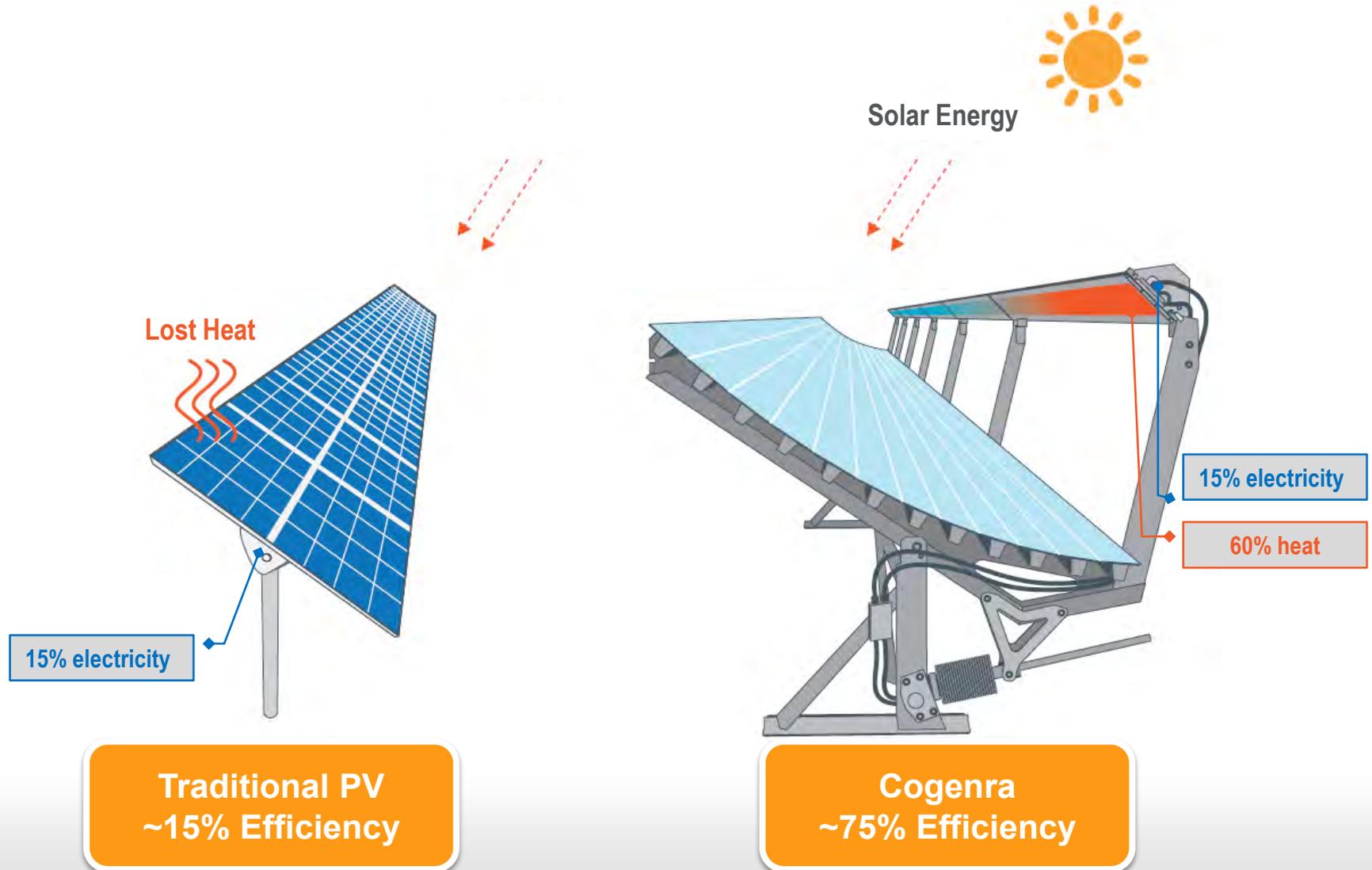


Introduction

On-Demand Electricity

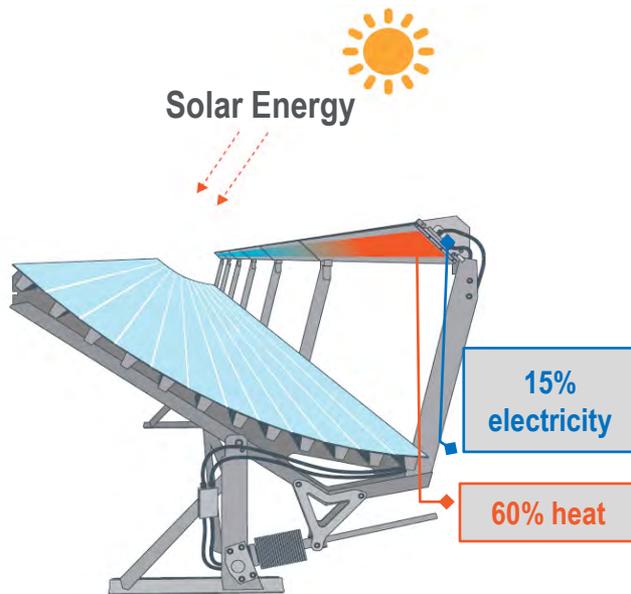
Technology

75% Efficient Distributed Cogeneration



Addressing Diverse Energy Needs

75% Efficiency



+

Dispatchable *Energy*

Direct /
Heat Pump

=



Absorption
Chiller

=



Organic
Rankine Cycle

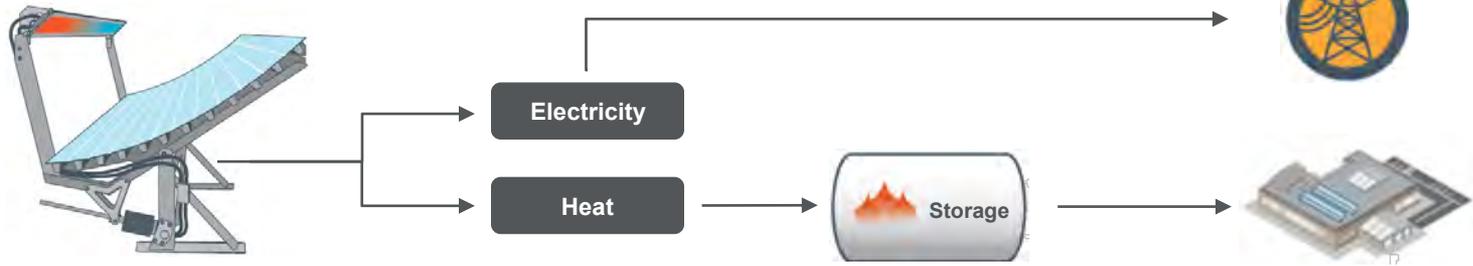
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Storable Heat → Energy On-Demand



Normal Day



Peak Demand

Stored heat converted to useful energy on-demand



Addressing Solar Intermittency & Peak Demand Charges

>20 Worldwide Sites in Production

Pordenone, Italy



Santa Rosa, California, USA



San Salvador, El Salvador



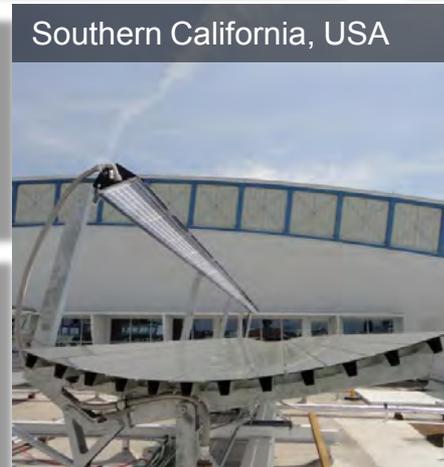
Northern, California, USA



Windsor, California, USA



Southern California, USA



Green Valley, Arizona, USA



Downey, California, USA



Nashik, India



Flagship Customers Across Target Market Segments



Introduction

PVT + ORC = On-Demand Electricity

Technology

The Problem: Grid intermittency as PV accelerates

“The goal is to reduce the variability of the solar energy production and to reduce the rapid and large ramp ups in the morning and ramp downs at sunset. Existing molten salt thermal storage is both expensive and operationally challenging. **New technologies are needed now before the large solar plants are all designed and built**”

Final recommendation for California Energy Commission

Source: Research evaluation of wind generation, solar generation, and storage impact on the California grid, Prepared By KEMA, Inc. For: California Energy Commission, June 2010

PV Proliferation → Grid Challenges

50% of the country's mid-day electric needs met by PV



Germany breaks world record for solar power generation with 22GW

<http://www.pv-tech.org/news/19241>

By Nilima Choudhury - 28 May 2012

With highs of 23°C and cloudless skies on May 26, Germany produced 22GW of electricity, meeting nearly 50% of the country's midday electricity needs. The [Renewable Energy Industry](#) (IWR) estimated this equaled the amount of power generated by 20 nuclear power plants.

Director of IWR, Norbert Allnoch, said, "Currently there is no other country on earth, with solar power plants producing a capacity of over 20,000MW of electricity. Germany came close to the 20GW mark a few times in recent weeks, but this was the first time we made it over."

The electricity demand in Germany in the diurnal cycle follows a bell curve, i.e. little power is needed at night, daytime demand for electricity increases steeply until noon and by evening falls evenly again. Allnoch said, "It is often underestimated, that the sun brings significant power if and when it is needed most."

According to [Reuters](#), Germany has nearly as much solar power generation capacity as the rest of the world combined, with 4% of its overall annual electricity needs from the sun alone. It aims to cut its greenhouse gas emissions by 40% from 1990 levels by 2020.

Grid intermittency as
PV accelerates

Customer-side peak
demand charges not
addressed

Heat Storage & On-Demand Conversion = "Firm Renewable"

Highest Solar Efficiency at Lower Cost

33% Storable Boost to PV

| | PV | Hot Water | Cogeneration | | |
|---------------------|-------------|-----------------|--------------|----------------|------------|
| | Electricity | 300C heat | Electricity | 120C heat | Total |
| Collection | 18% | 60% | 18% | 60% | 78% |
| Integration | | ORC - High Temp | | ORC - Low Temp | |
| Conversion* | 1X | 0.2X | 1X | 0.1X | |
| Efficiency** | 18% | 12% | 18% | 6% | 24% |

* Heat-to-electricity conversion efficiency (1.0 for electricity-to-electricity)

** Electrical efficiency defined as electric power delivered relative to solar power landing on aperture

Best of both worlds: Cost of PV + Storage of CSP

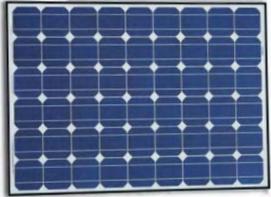
Best of Both Worlds

Electricity

Cogen

Heat

PV + Battery



- PV only, heat wasted
- Expensive, unproven storage
- Low capex; High Maintenance
- **18% Efficiency**

Cogenra



- PV + Heat (~120C)
- Low capex; Proven storage
- Utility & distributed scale
- **24% Efficiency, proven storage**

CSP



- Super-heated steam (>400C)
- High capex; High maintenance
- Utility scale, high distribution costs
- **12% Efficiency, proven storage**

Cost & Modularity of PV + Storage of CSP



Introduction

PVT + ORC: On-Demand Electricity

Technology

Core Technology: High-Efficiency PV-Thermal



Modular Concentrator

- Low-cost single-axis tracking
- Planar optics*
- Snap-in-place assembly*



High-eff with Integrated Heat-Recovery

- High efficiency (15% PV + 60% heat)
- Proprietary thermal-electrical stack*
- Direct-laminated extruded channel*

* Patent-pending: 12/712,122 , 12/788,048 , 12/622,416 , 12/744,436 , 12/781,706 , 61/347,585 , 13/291,531

Low Cost. Efficient PV. Valuable Heat.

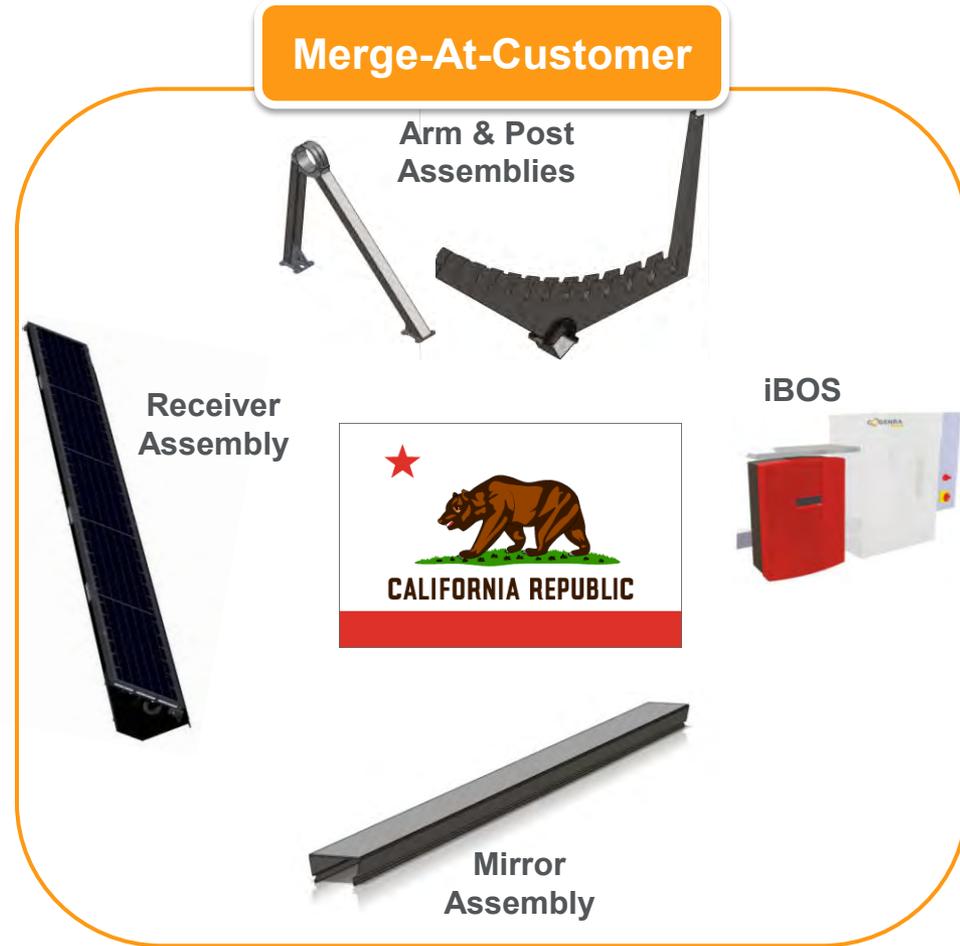
Capital Light Contract Manufacturing



PVT Panel

Integrated into receiver assembly

Merge-At-Customer



Enables Rapid Global Scaling

Summary

- Award-winning, 75% efficient solar cogeneration product
 - » First company to receive both PV and thermal certification
- Strong growth with marquee customers
 - » Installations in 5 countries
 - » Expand to solar cooling
- On-demand distributed power: PV waste-heat recovery to power using ORC turbine





Thank You

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