



# **CONCENTRATED SOLAR POWER CHEMICAL USE CASES:**

## **HYDROTHERMAL PROCESSING**

## **HYDROGEN PRODUCTION**

### **Unlocking Solar Thermochemical Potential: Markets, Opportunities, and Challenges**

Concentrating Solar Power Program  
United States Department of Energy  
Solar Energy Technologies Office

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# CSP Driven Hydrothermal Processing

# Hyperlight Hylux™

## Linear Fresnel Concentrated Solar Power System

From 2016 – 2019, SoCalGas collaborated with the California Energy Commission and the U.S. Department of Energy in supporting the development and demonstration of **Hyperlight Energy's** novel, **low-cost** linear Fresnel CSP system (**Hylux™**)

**Motivation:** Demand for a CSP system that can be competitive with low-cost North American natural gas



# Linear Fresnel Primary Solar Receiver

(Delegates From Energir, GRDF, GRTgaz, SoCalGas)

The **Hylux™ primary receiver** consists of mirrors attached to “D-shaped” PVC tubes

The tubes are supported by water contained in a polymer “pond-liner” material, framed by rebar cages

Thus, the structural materials are inexpensive:

- **Water**
- **Plastic**



# Linear Fresnel Primary Receiver Control Mechanism

The **Hylux™** primary receiver tracks the sun using a simple computer-controlled, off-the-shelf actuator



# Linear Fresnel Secondary Receiver

The **Hylux™ secondary receiver** consists of a stainless steel pipe containing thermal oil, inside a carefully designed evacuated reflective parabolic concentrator

Secondary receiver papers published as a result of this project by the Thermal Systems Group, National Renewable Energy Laboratory (NREL), Golden, CO, USA:

- [Evaluation and comparison of an adaptive method technique for improved performance of linear Fresnel secondary designs, Applied Energy \(2017\)](#) Madeline Hack, Guangdong Zhu, Tim Wendelin
- [New adaptive method to optimize the secondary reflector of linear Fresnel collectors, Solar Energy, \(2017\)](#) Guangdong Zhu



# Thermal Oil Control Valves and Heat Exchanger



# Thermal Oil Control Valves, Heat Exchanger & Reservoir



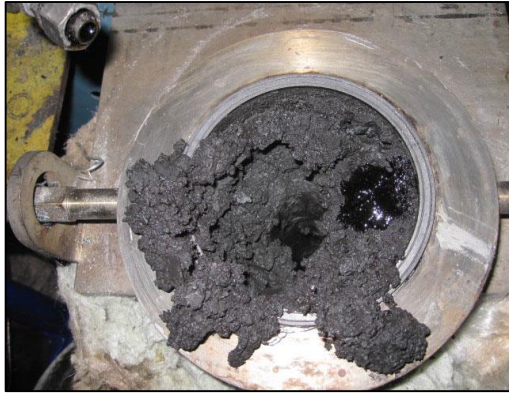


# Containerized Hydrothermal Processing System



Onsite tests with various wet biomass wastes—e.g. dairy cow manure

# HTP Output Products



Solids with Phosphorus



HTP Oil



Water



RIN & LCFS  
Eligible

# Highlights from a recent project proposal based on Hylux™ (Current Cost/Performance)

**Application:** boosting a geothermal power plant, direct heating of geothermal produced fluid. Very simple integration, no heat exchanger. Carbon steel heat collection elements with geothermal fluid passing through directly.

**Project size:**

- 50 Hylux™ units
- ~25 acres
- ~30 MW<sub>t</sub>

**Project lifetime:** 25 years

**Estimate of LCOH:** \$3.50/MMbtu

Hylux™ CSP System Cost (price per m<sup>2</sup>)

	No ITC	22% ITC
Collector	\$82	\$64
Receiver	\$57	\$44
Solar field	\$139	\$108

# CSP Driven Hydrogen Production

# STARS Hydrogen Generation

## Solar Thermochemical Advanced Reaction System

### Cost of H<sub>2</sub>

- Current Cost in California: ~\$14-16/kg at pump
- STARS Production Cost: ~ \$2-3/kg based on low-to-moderate volumes of hardware mass production

### Efficient Use of Solar Energy

- STARS: 70% World Record Solar-to-Chemical Energy Efficiency (Demonstrated)
- Solar PV + Electrolysis: ~16%

### Carbon Intensity (CI) of H<sub>2</sub> Product

- STARS: ~60 g CO<sub>2</sub>/MJ based on fossil NG with solar augment
- Both Cases with All-Renewable Resources (Renewable NG, Renewable Electricity & Solar): ~0 g CO<sub>2</sub>/MJ
- STARS pathways have not yet been certified by CARB



Methane-Steam Reforming is Augmented with Concentrated Solar (Thermal) Energy



# STARS Compact SMR

This is our compact steam-methane reformer.

It's a 3D printed microchannel chemical reactor with a 3D printed microchannel heat exchanger.

It can operate on solar-thermal or electric induction heating, or both.

In our tests, we achieved over 70% efficiency in converting solar energy into chemical energy.

This was developed by DOE and Pacific Northwest National Laboratory in collaboration with SoCalGas and others.

A laboratory spin-off: Stars Technology Corporation is leading the commercialization efforts.



Inches

**One more thing...**

# **Opportunity: Repurposing Existing Solar Dish Concentrators**

## **Tooele Army Depot, Utah**





## 432 Dish Concentrators at Tooele Army Depot, Utah

Could they be repurposed  
for hydrogen production?



These Infinia PD-4 dish concentrators once powered Stirling heat engines

They could be adapted for the purpose of solar SMR hydrogen production