SolarGas™ - Syngas & Hydrogen for India's Petrochemical Industry (& beyond)

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Background – Existing Process

Conventional steam reforming

- High temperature (800ºC) process to produce hydrogen or syngas for the chemical industry, transport and liquid fuels.
- Highest demand in petrochemical and fertilizer manufacture
- Inefficient…. cheap to build but high operating costs

  Uses 2 x Natural Gas 50% combustion & 50% chemistry.

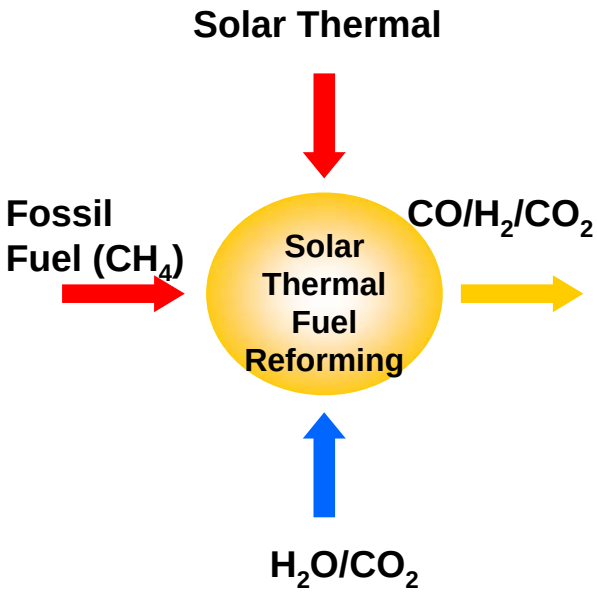
  Uses 3 x Water.

  Recovers only ca. 80% of the product

Technology challenges

- Decrease Temperature
- Decrease Water consumption
- Decrease Fossil Fuel requirement
- Improve Energy Efficiency
- Reduce CO_2 from the process
- Reduce operating cost
- Improve product recovery

Background



$CH_4 + H_2O(l) + 206kJ \rightarrow CO + 3H_2$

AND / OR

$CH_4 + CO_2 + 247kJ \rightarrow 2CO + 2H_2$

$CO + H_2O \rightarrow CO_2 + H_2$

Considerations for solar reforming process

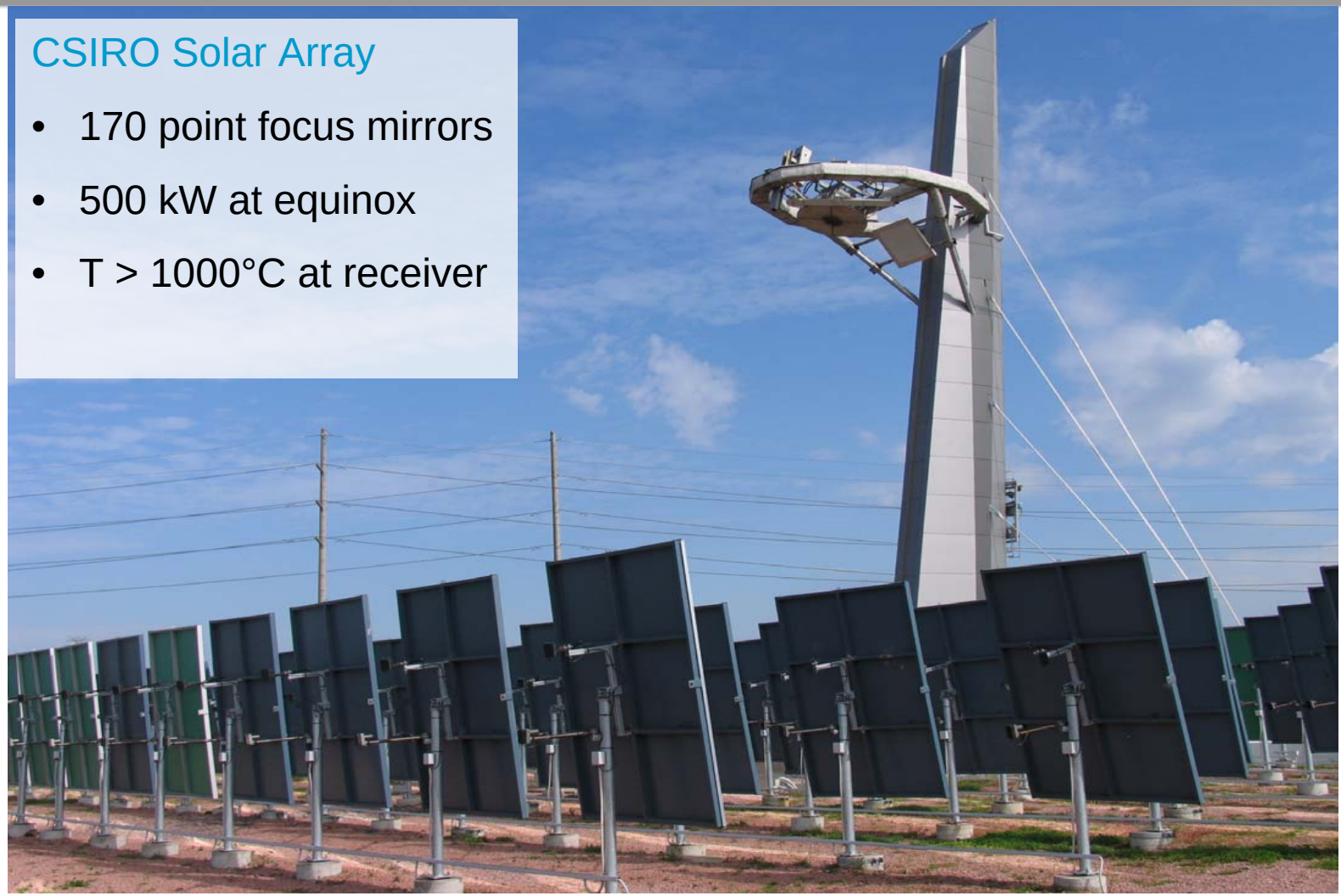
- **Solar Energy**
  - ✓Abundant, clean and renewable energy
  - ✓Sufficient to replace fossil fuel and meet a rising global energy demand
- **Water**
  - ✓Conservation of a precious Natural Resource
- **CO_2**
  - ➢The biggest contributor to global warming
- **Science solutions:**
  - ✓Using solar energy drives Water / CO_2 reforming to produce solar-rich H_2 and syngas.
  - ✓Improve Resource Use Efficiency
  - ✓Lower Temperature for Process

CSIRO

Solar thermal tower facility in CSIRO, Newcastle

CSIRO Solar Array

- 170 point focus mirrors
- 500 kW at equinox
- T > 1000°C at receiver



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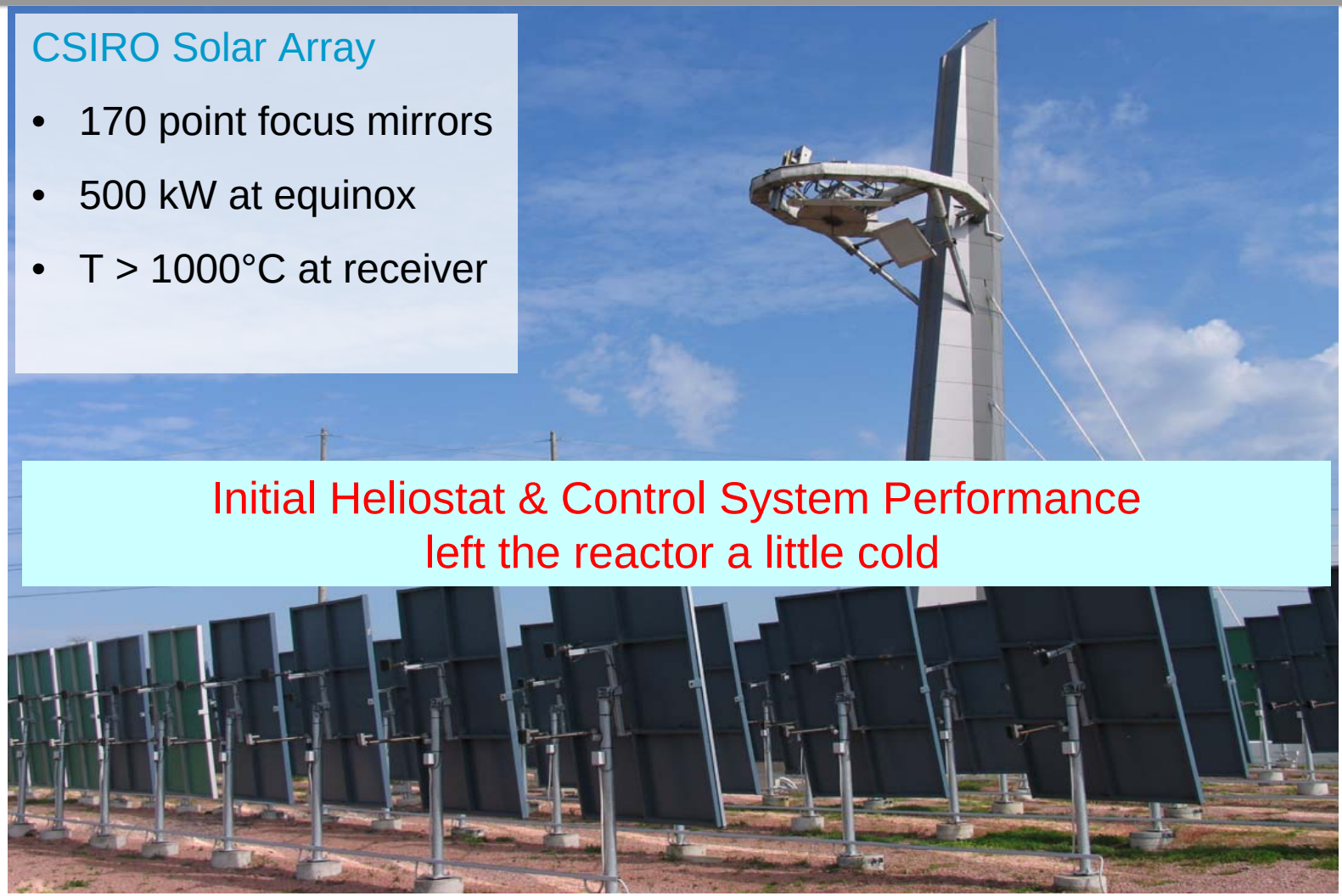
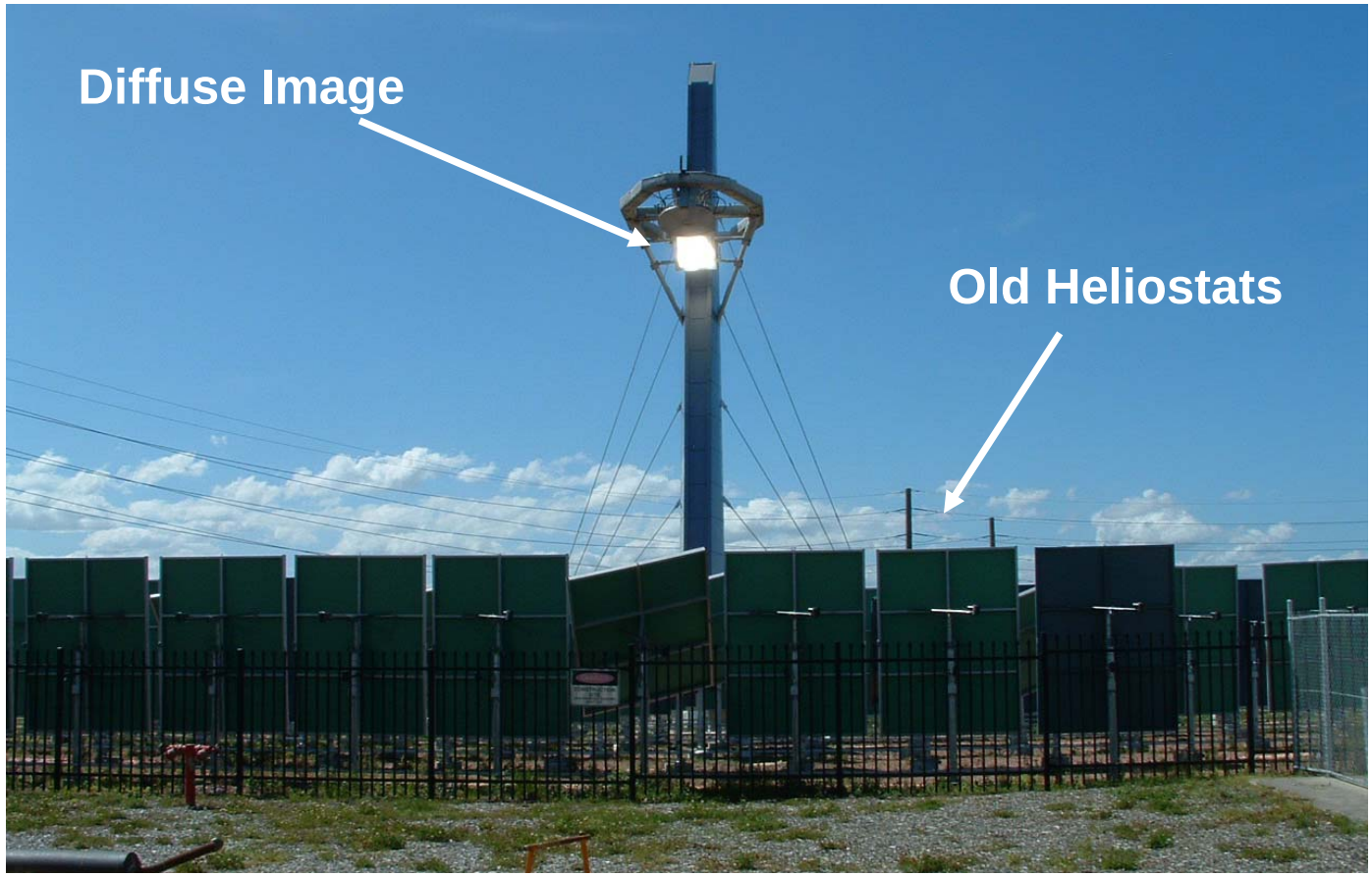


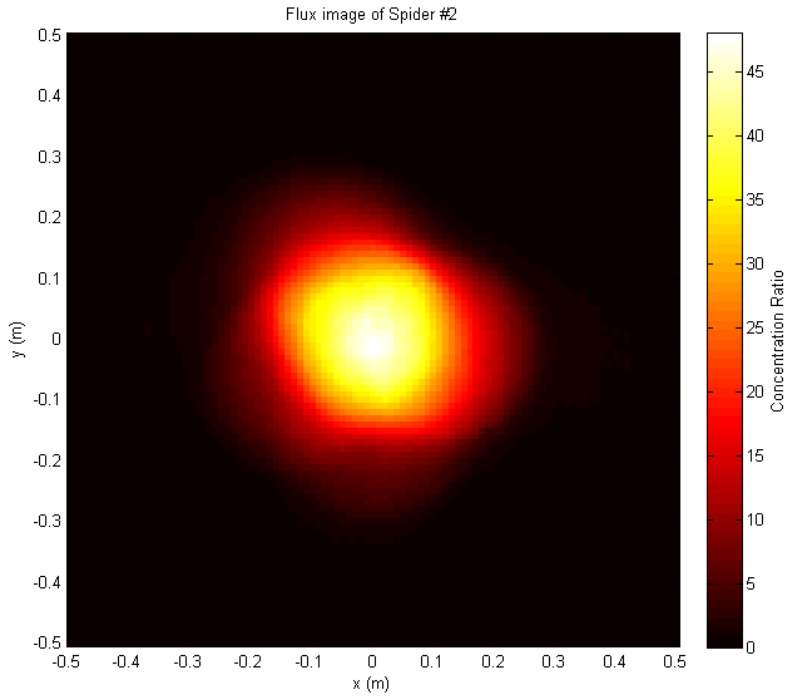
Initial Heliostat & Control System Performance
left the reactor a little cold

Field Development – Heliostats and Control System

- Initial Field Heliostats were underperforming
- Control System was unreliable / under engineered



New Heliostat design provides excellent performance



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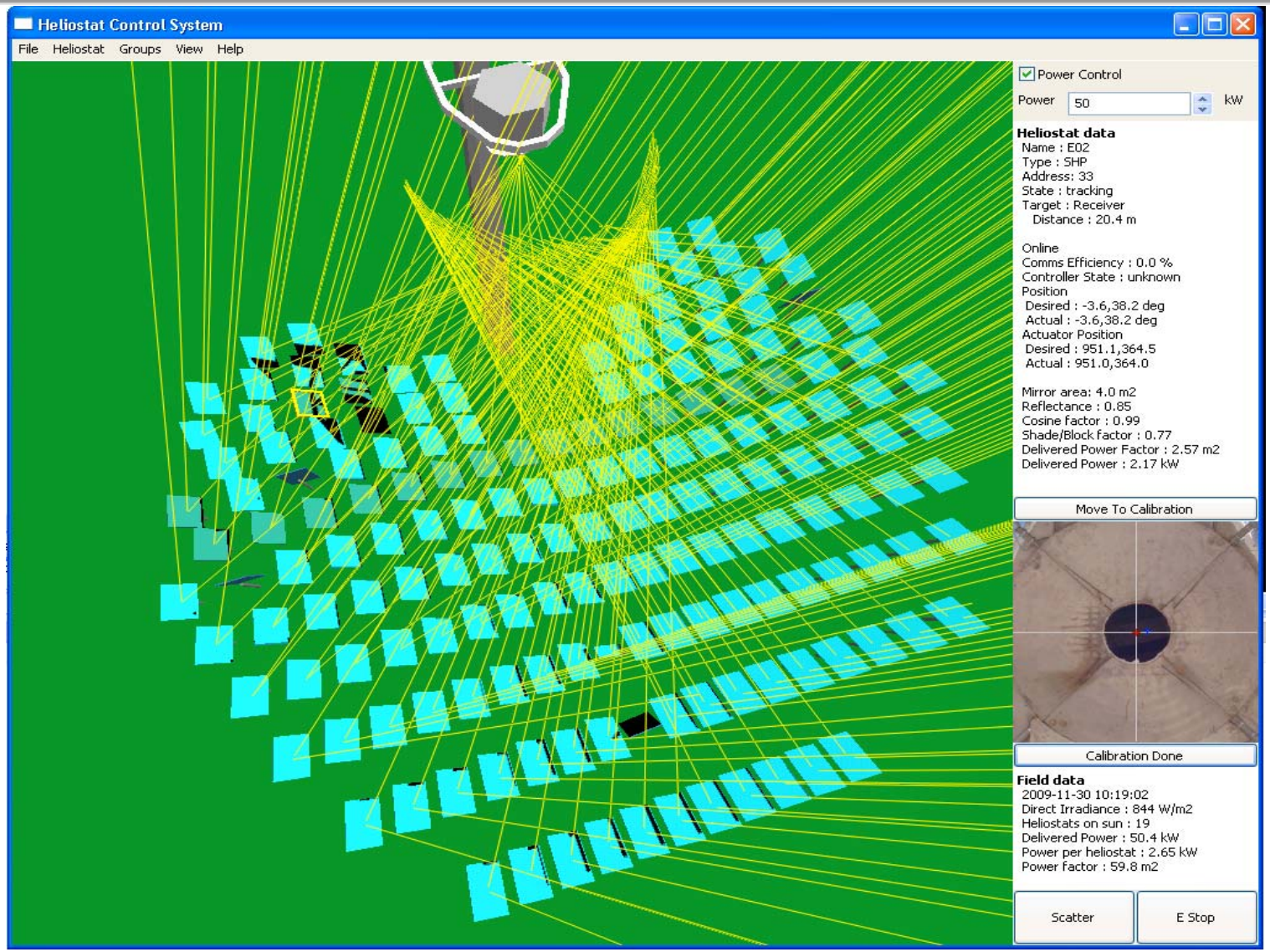
New field software & tracking provides excellent power control



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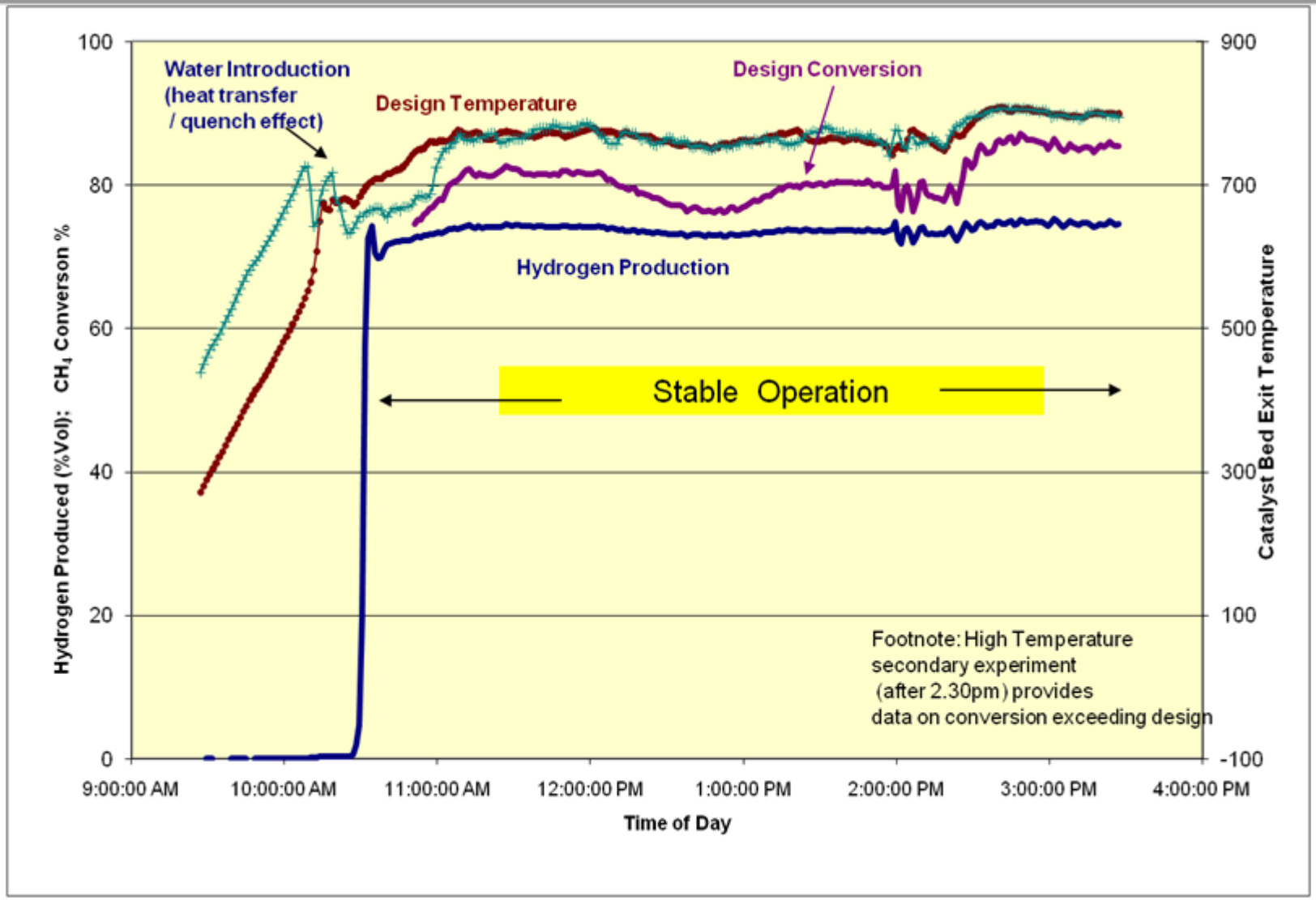
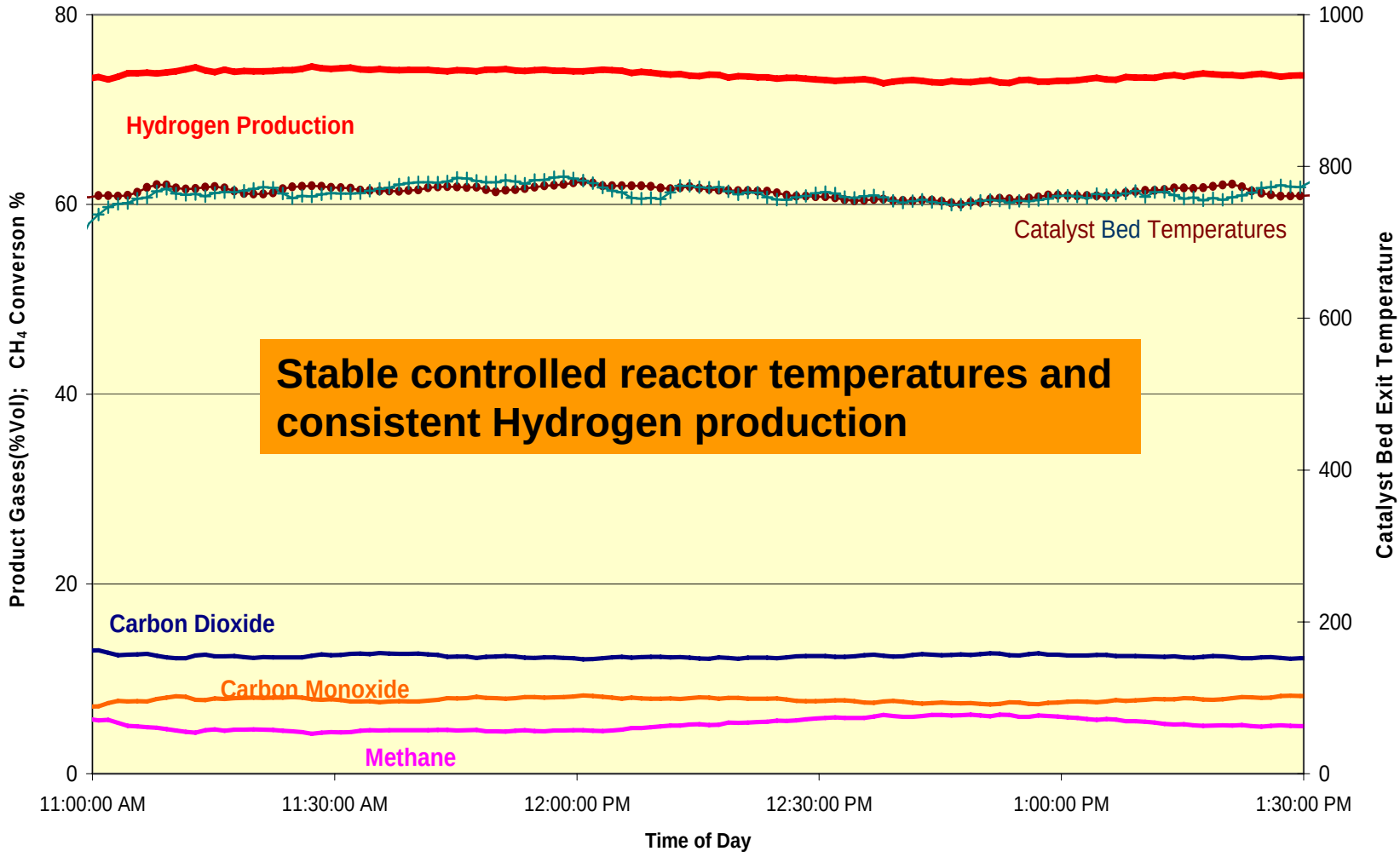
SolarGas™ Experiments proved highly successful

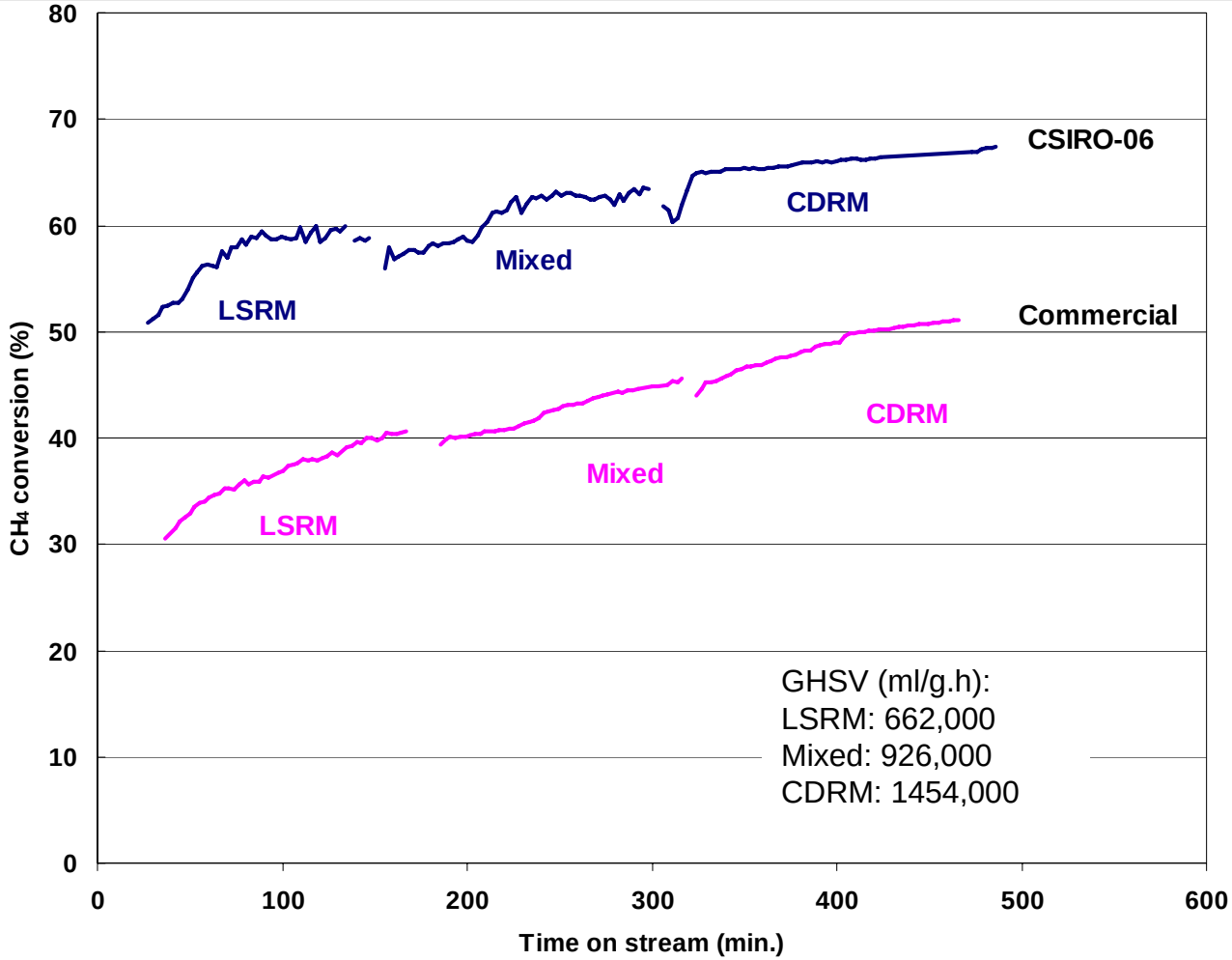


Reactor at Temperature



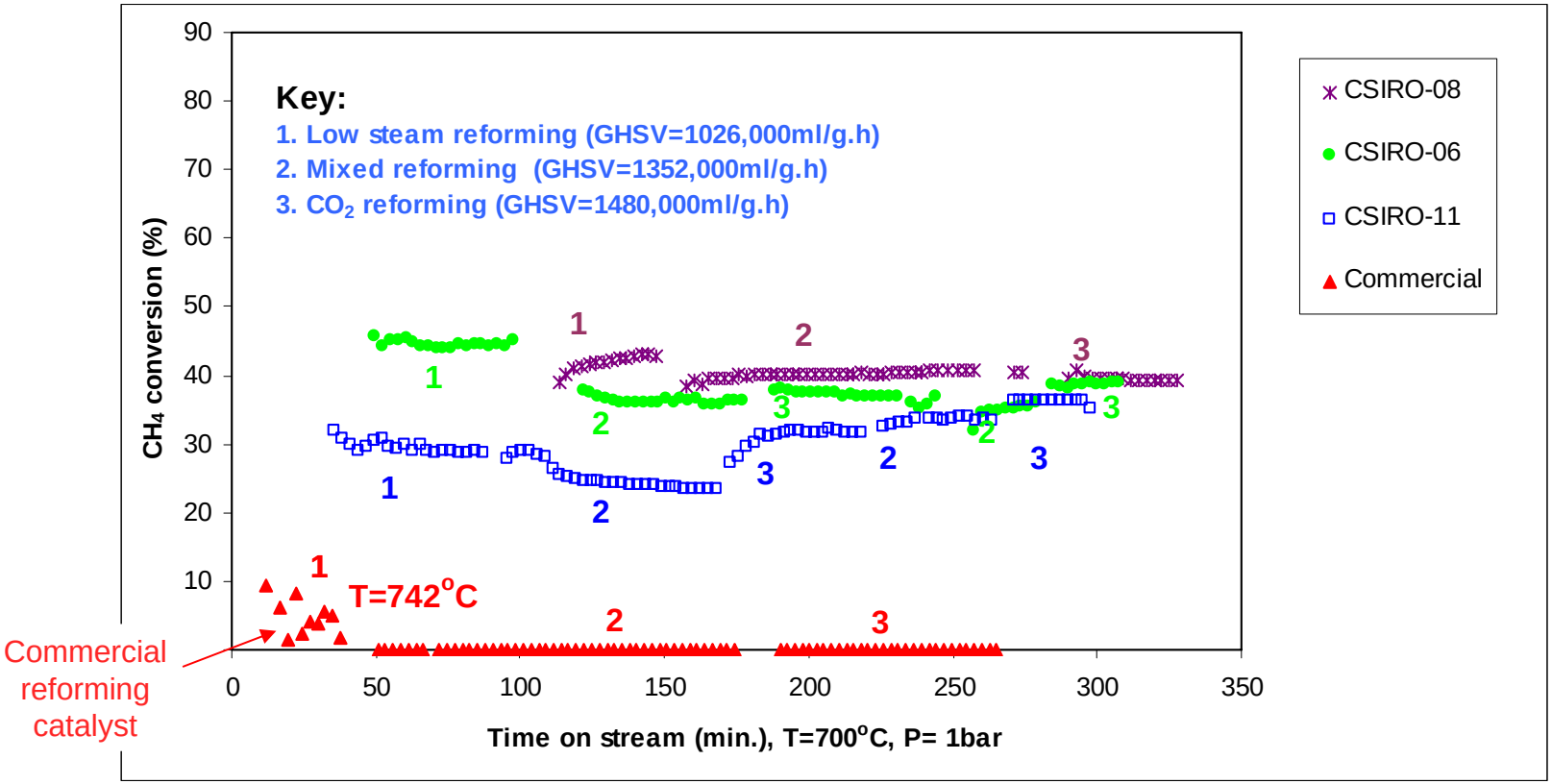
Improving Process Efficiency

CSIRO catalysts have 30-50% higher activity at 800°C



CSIRO solar reforming catalysts have significantly higher activity operating at 800°C compared to commercial reforming catalyst

Operate at lower temperatures
without high water demands



- CSIRO solar reforming catalysts show excellent activity and stability for three reforming modes operating at **700ºC** as compared to commercial reforming catalyst operating at **742ºC**

Hydrogen Production and Utilisation

- World consumption in 2009 of about 70 million tonnes, growing at about 7% pa.
  i.e. about 440 Million Tonnes of Natural Gas consumed producing 1.3 Billion Tonnes of Carbon Dioxide*
- Almost 50% of production converts low-grade crude into transport fuels.
- Most of remaining production used in making nitrogen fertilisers
- Minor uses for transport and fine chemicals
- India uses hydrogen in Transport
  ("Hythane™" fuel is hydrogen enriched natural gas)
- Western Australia trialled Hydrogen Buses
  (these were fuel cell rather than combustion driven)

*3x Australia's and close to India's current annual total CO_2 Emissions

India - Why does SolarGas™ work ?

- Production is capacity constrained & demand is high & increasing
- Solar availability is high in most of India
- Natural Gas prices are high
  operating cost savings are commensurately higher
- Supply Constrained Resource
  India has significant Natural Gas dependent projects approved and funded – but awaiting supply contracts
- Balance of Payment
  reduce India's energy import dependence
- Capital Reduction (65% of AUD – 50% with new catalysts)
- Thermal Efficiency improvements (55% with new catalysts and membrane product recovery)
- Carbon Intensity (50% of current technology)

India - Steps to a SolarGas™ Industry

- APP Project to Develop a 1MW demonstration facility in India
  (SEC & MNRE India, CSIRO & DCCEE Australia)
- Provide Technology Development & Transfer to India
- Secure commercial collaboration in India
- Develop a manufacturing industry for Solar Hydrogen production in India using tower and heliostat system

Technology + Market + Political Will

Jawaharlal Nehru National Solar Mission set targets

in the 11th 12th and 13th 5 year Plans

- **1GW by 2012, 5-10 by 2017 & 20GW installed by 2022**
- **20 million solar lighting systems**
- **10,000 new villages electrified**
- **2GW off grid solar**

Backed by Funding:

- **$242M to MNRE this year (up 61%)**
- **50Rps/tonne coal 'cess' to Clean Energy Fund ($700M/yr)**
- **$120M to remote distributed power development**
- **many budget measures; tax reductions feed-in tariffs etc.**

COMMITMENT TO BUILD 2 or 3 x 1MW DEMONSTRATION FACILITIES
MNRE National Solar Energy Centre would like to host a 1MW demonstration plant of our design in Gurgaon near Delhi..

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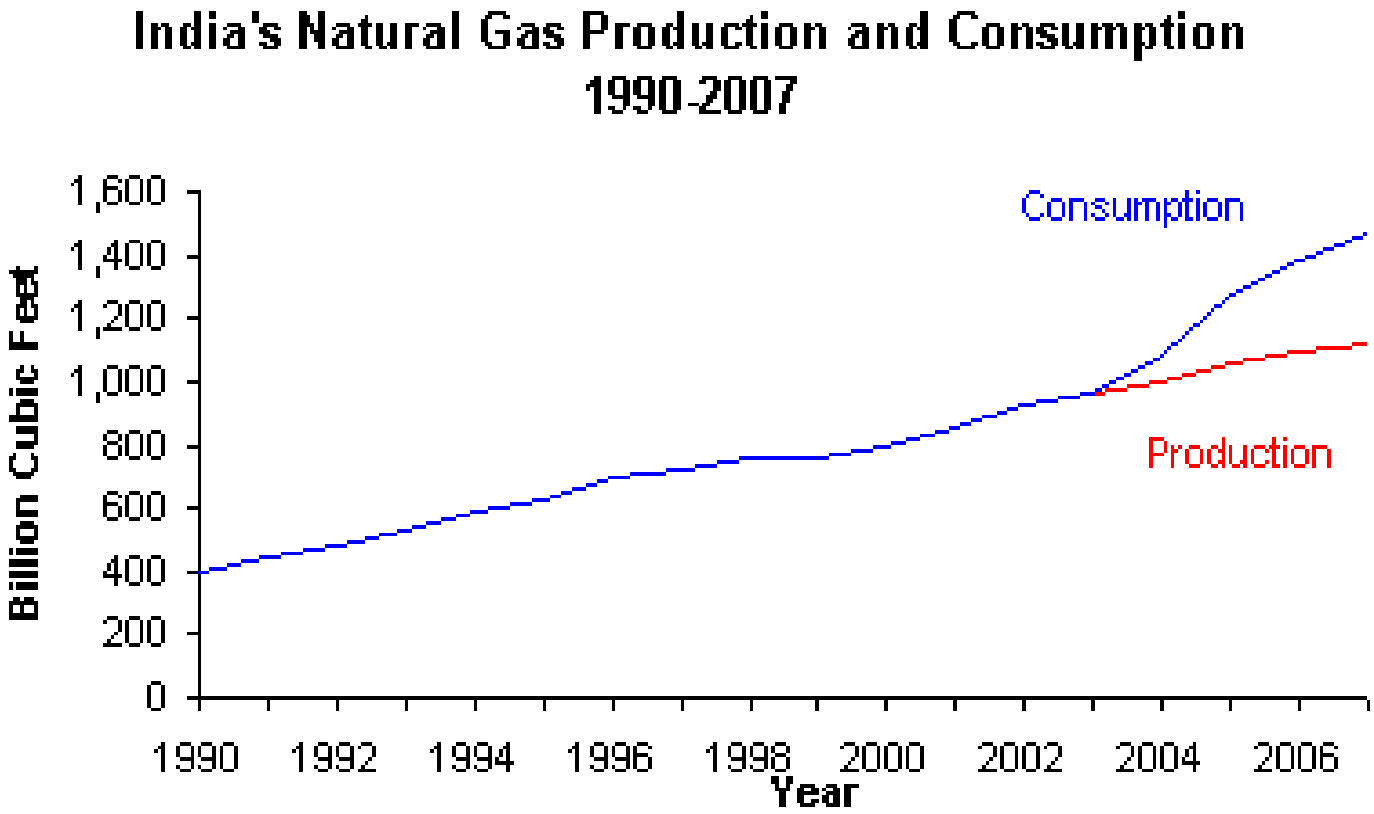
Questions??



Source: U.S. Energy Information Administration

Thank you

Australian Government
Department of Resources, Energy and Tourism
Department of the Environment, Water, Heritage and the Arts
Department of Climate Change

asia-pacific partnership on clean development & climate

National Research FLAGSHIPS
Energy Transformed

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To the Hosts and Convenors of this Forum

& my Colleagues

Wes Stein (our National Solar Centre Manager)
Glenn Hart (Project Leader APP SolarGas)
Yanping Sun (our Catalyst Expert) &
Alex Burton (our Heliostat and Control Software Expert)
Rob McNaughton & Ken Wong, Facility Engineering

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