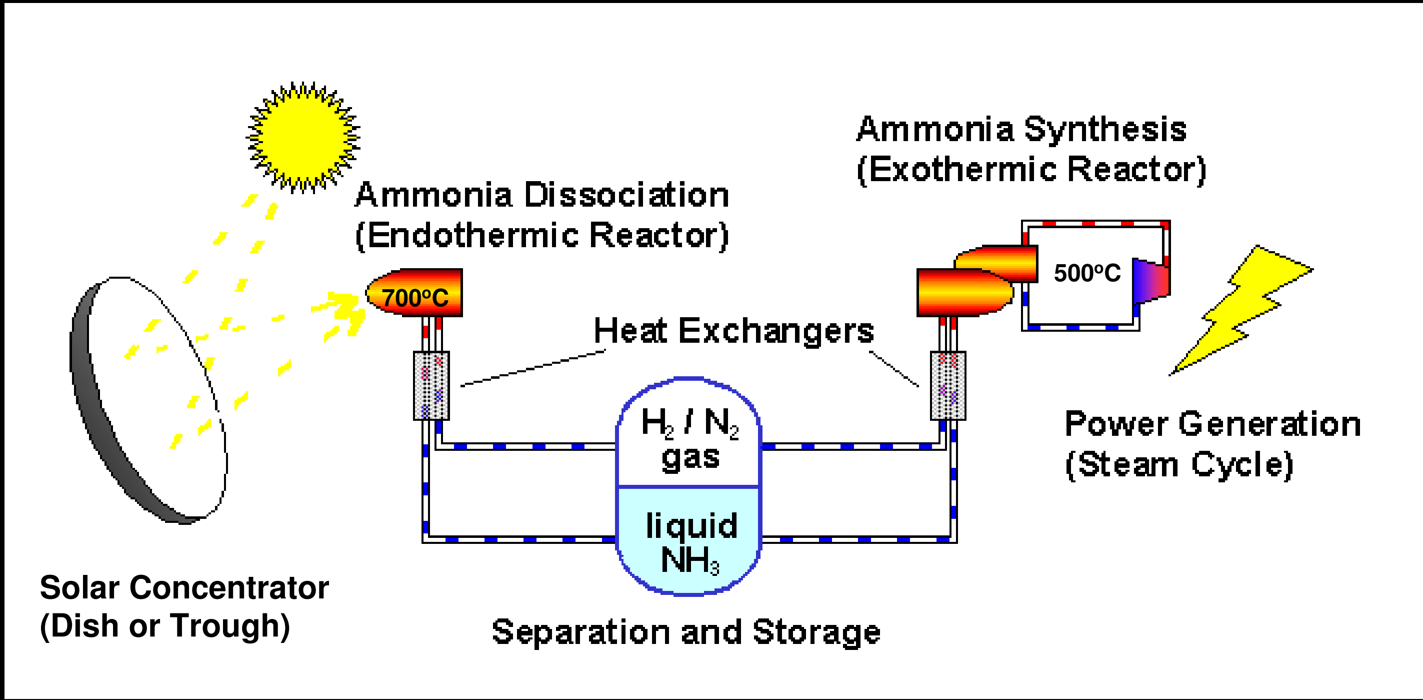
Ammonia Production &
Baseload Solar Power



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Overview

- Concentrating Solar Power
- Ammonia-based Storage for Solar Power
- Happy snaps of new Big Dish
- Ammonia Fuel Production & Solar Power

Concentrating Solar Power – The Basics

- Nevada Solar One – 64 MW
- Typical coal power station ~ 2000 MW
- Home photovoltaic array ~ 2 kW

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Concentrating Solar Power – The Basics

1. Parabolic mirror.
2. Receiver at focus.
3. Solar Radiation heats fluid (oil).

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Types of Concentrated Solar Power

Linear Fresnel Arrays
(Concentration Ratio ~ 20)

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Types of Concentrated Solar Power

Parabolic Troughs
(Concentration Ratio ~ 80)

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Types of Concentrated Solar Power

Power Towers
(Concentration Ratio ~ 1500)

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Types of Concentrated Solar Power

Dishes
(Concentration Ratio > 1500)

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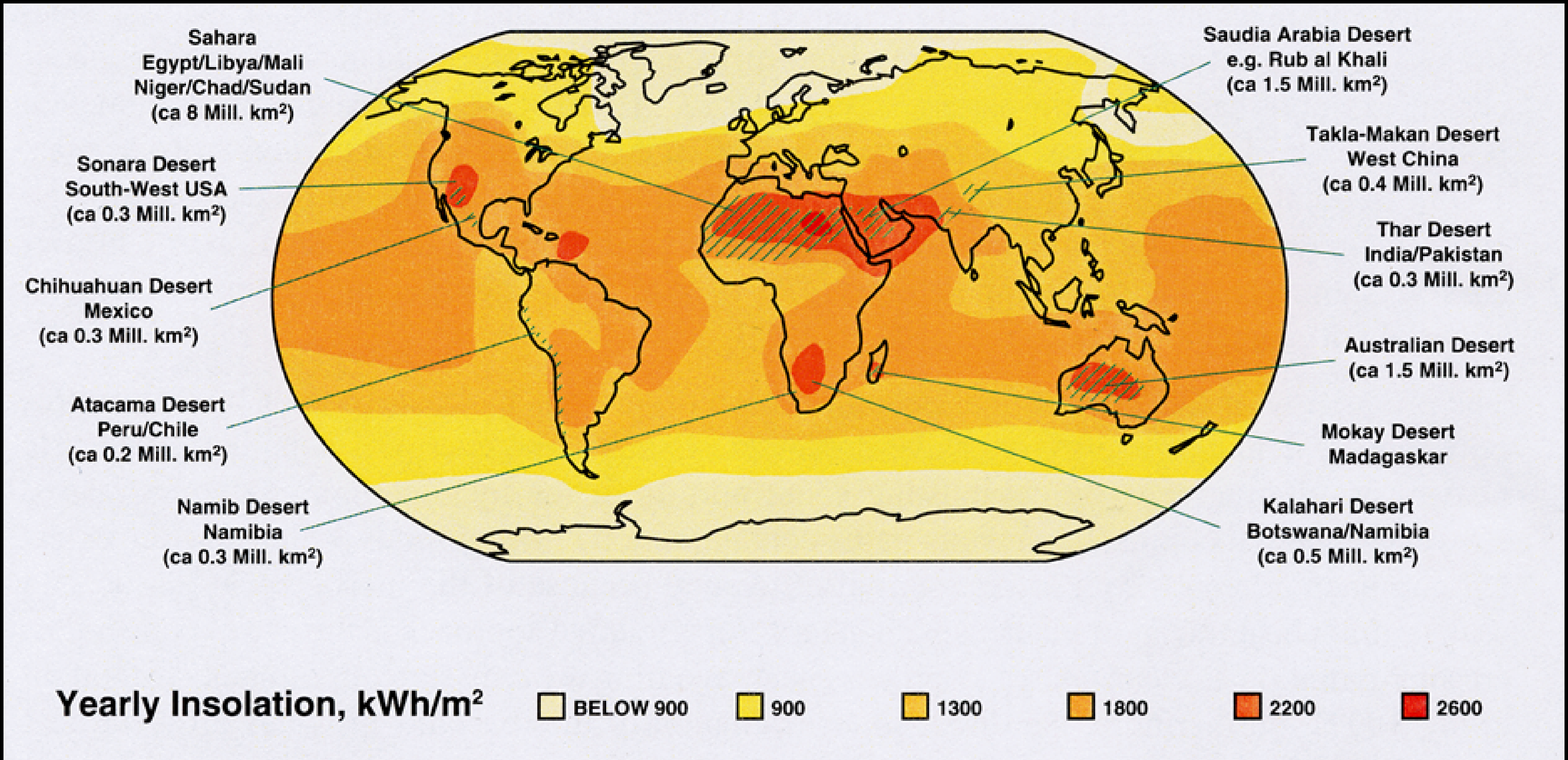
Concentrating Solar Power –
at the Australian National University

1. Parabolic dish - 400m^2.
2. Receiver at focal point.
3. Solar Radiation drives a chemical reaction - dissociation of ammonia.

Global Solar Resource



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Area of the USA and Australia

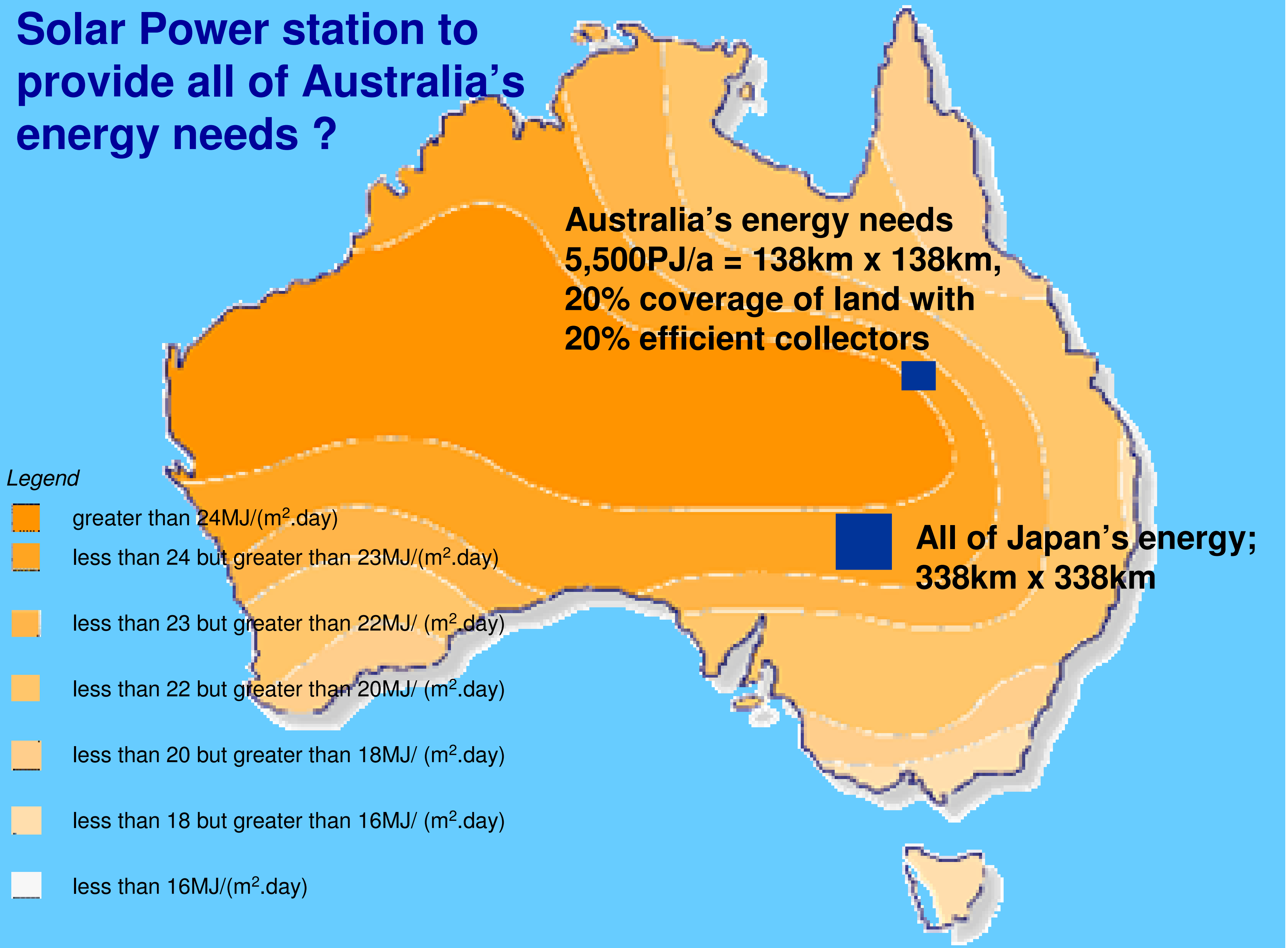
US mainland land area

= 7,981,610 km^2

Australian land area

= 7,617,930 km^2

Solar Power station to provide all of Australia's energy needs ?

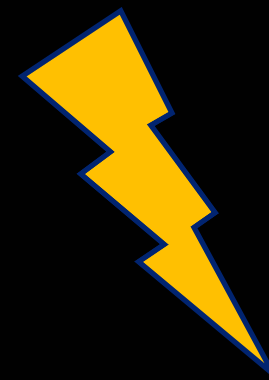


Current Storage Methods

concentrator

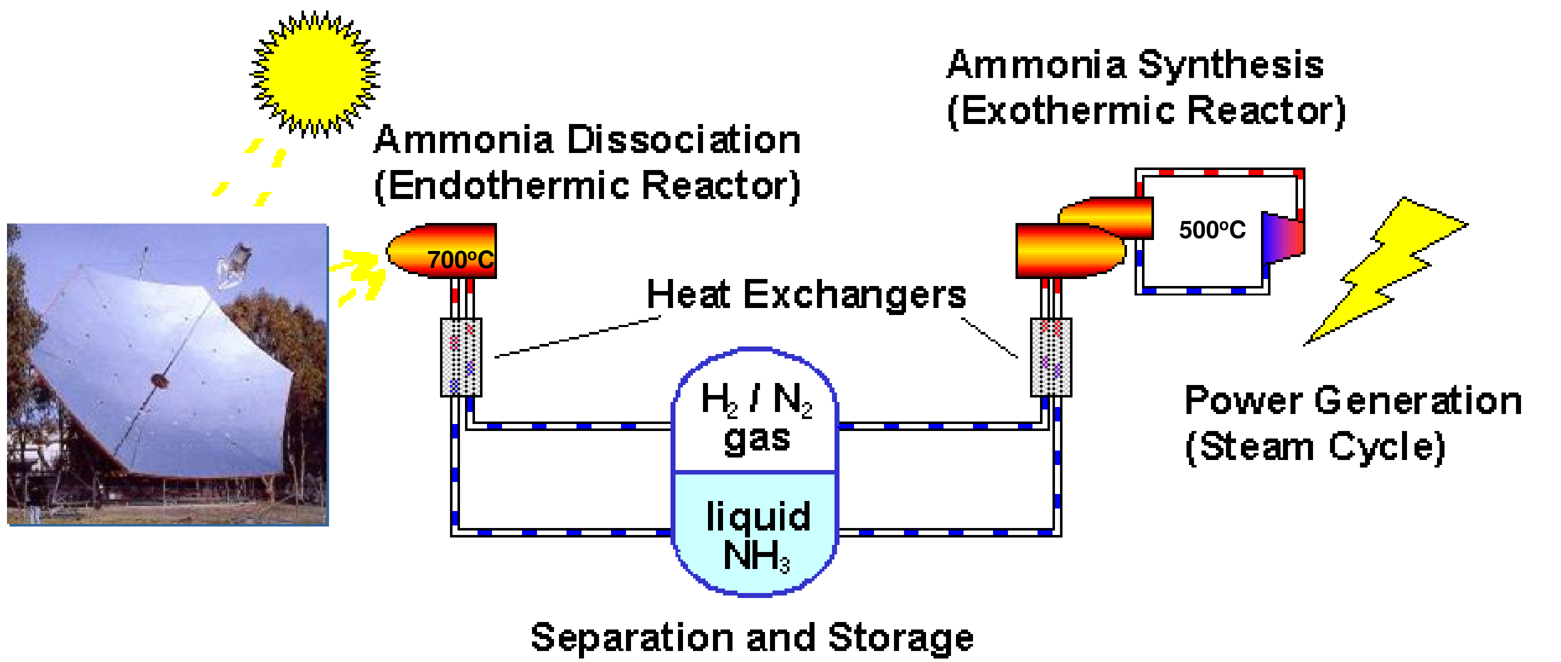
storage

- Molten salt
- Hot oil
- Superheated steam



24 hour electricity

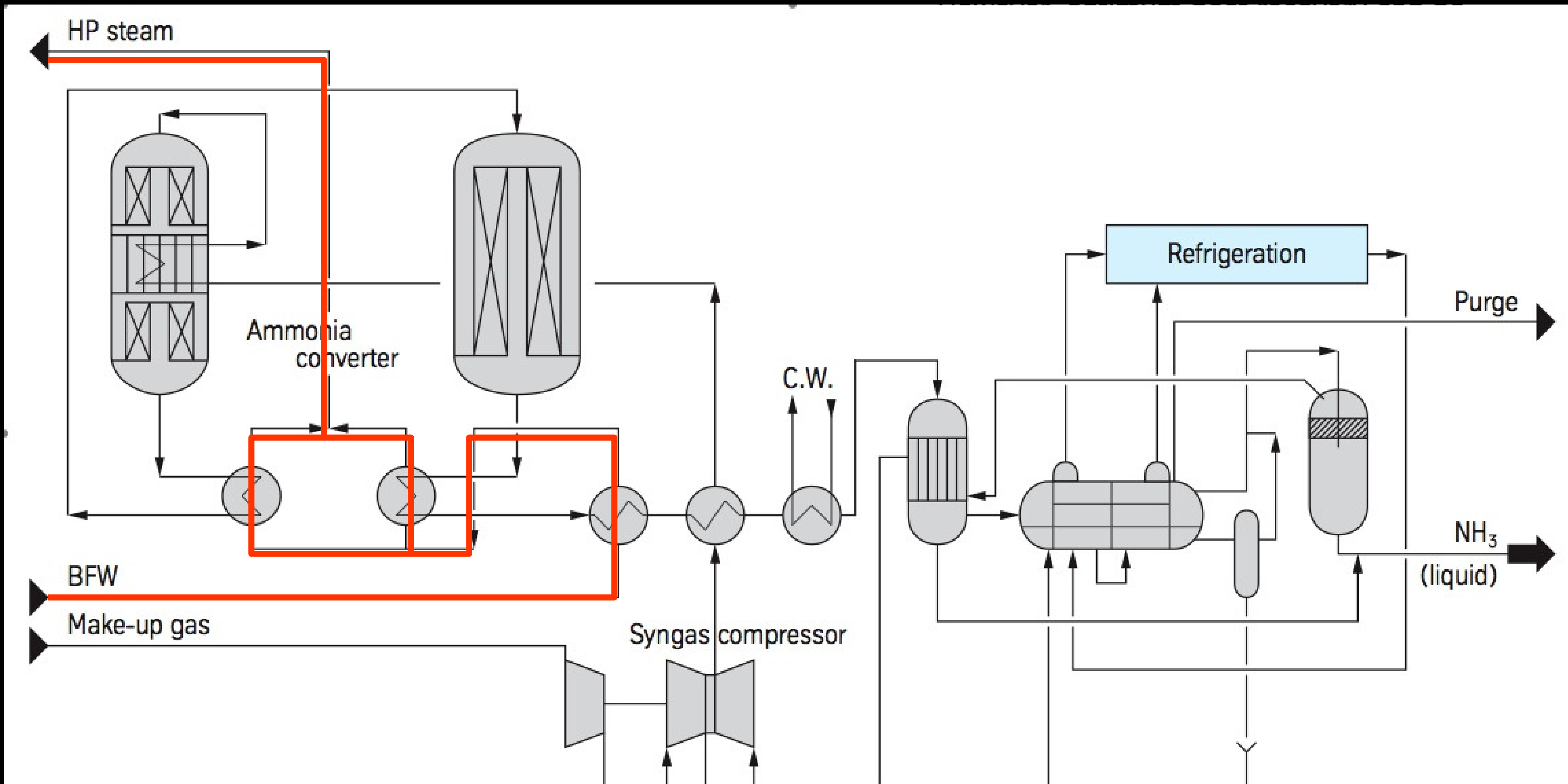
Ammonia-based storage



$$2NH_3 + \Delta H \xleftrightarrow{\text{iron catalyst}} N_2 + 3H_2$$

ammonia (liquid) | heat | nitrogen (gas) | hydrogen (gas)

Heat recovery from synthesis reaction



Source: UHDE

ANU Solar-Ammonia Lab

Ammonia thermochemistry

$20m^2$

(Big Dish $400m^2$)

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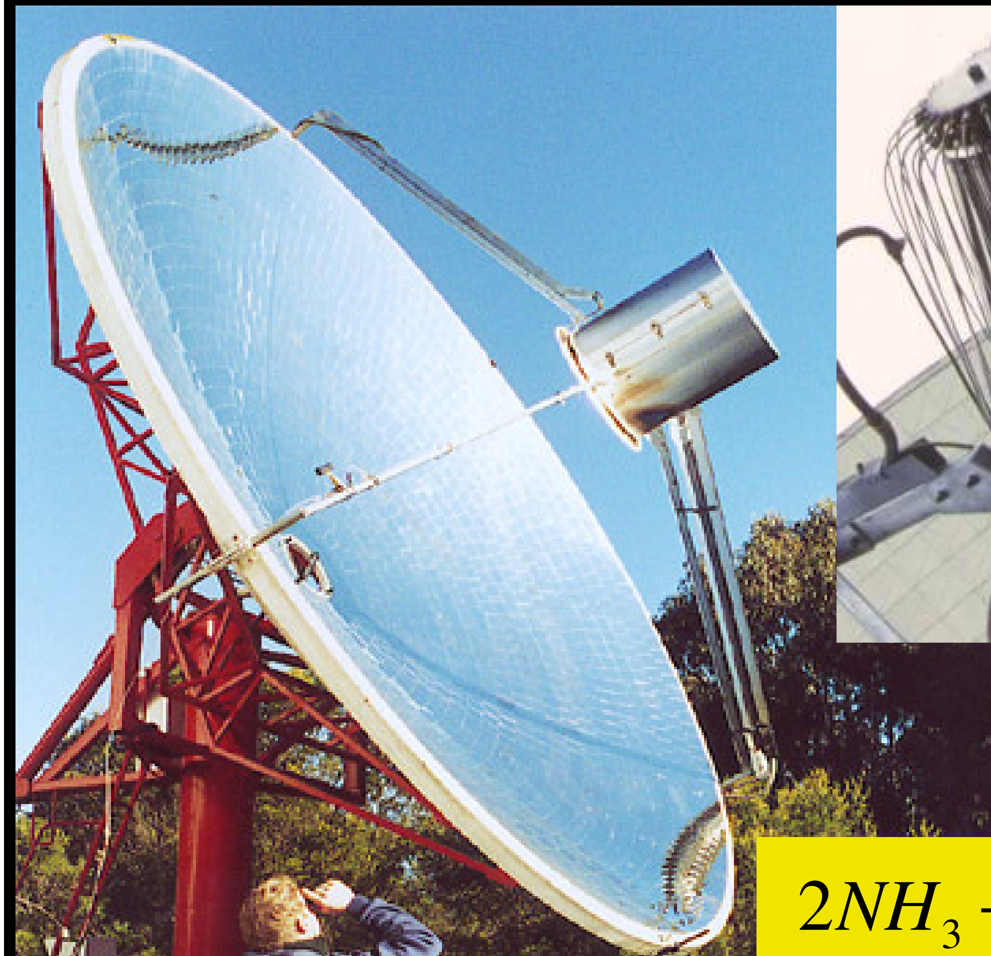

$$2NH_3 + \Delta H \leftrightarrow N_2 + 3H_2$$

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ANU Commercial Partner

- Wizard Power Pty Ltd www.wizardpower.com.au
- Exclusive licence to ANU dish technology

- AusIndustry REDI project:
  - $3.5m to a $7m project over 06-08
  - Build new dish
- Australian Greenhouse Office AEST project:
  - $7.4m to a $14.8m project over 4 years
  - Demo array of dishes with ammonia based energy storage


The old dish looks like this


CPS CONCRETE PUMPING

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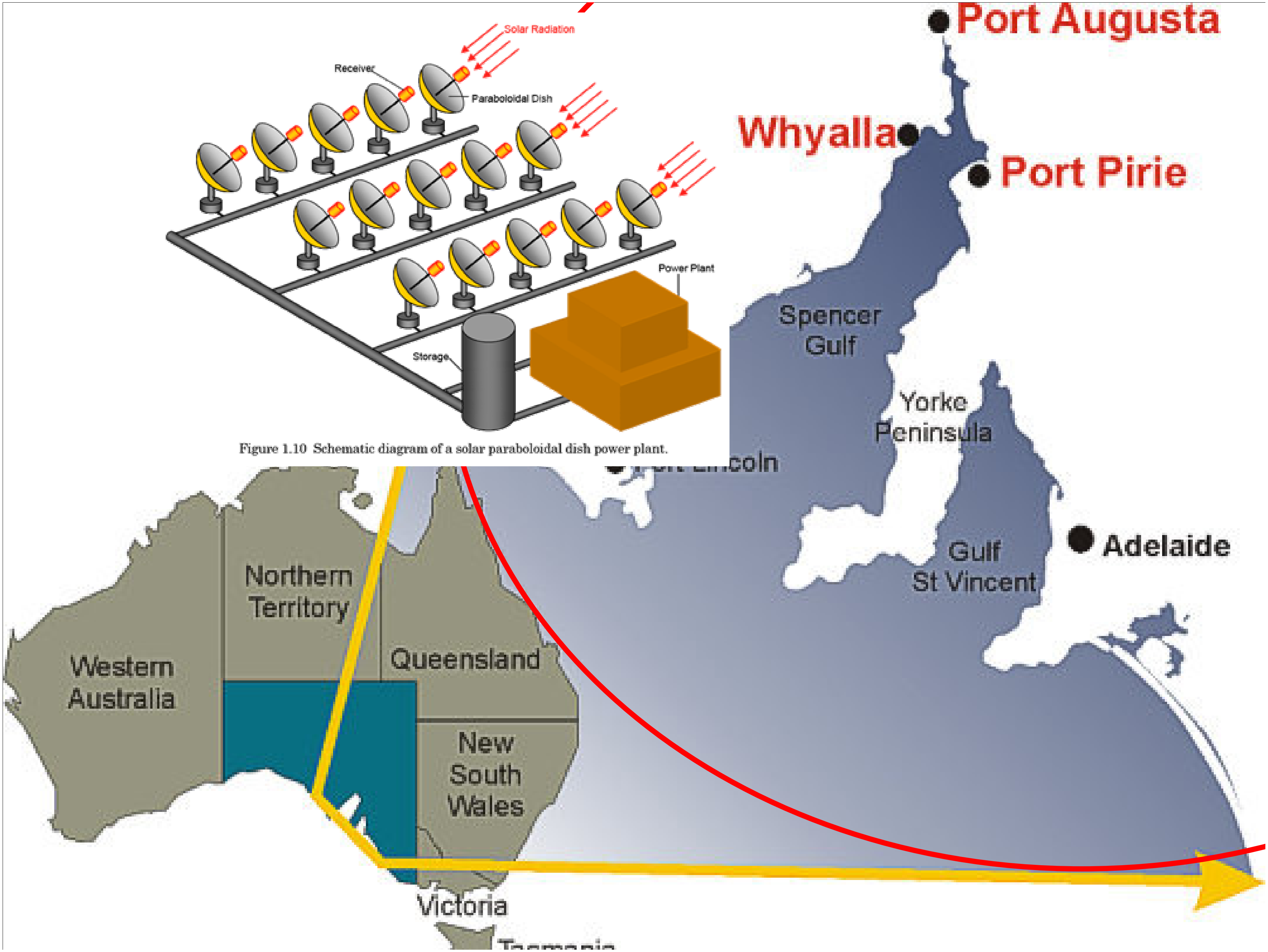
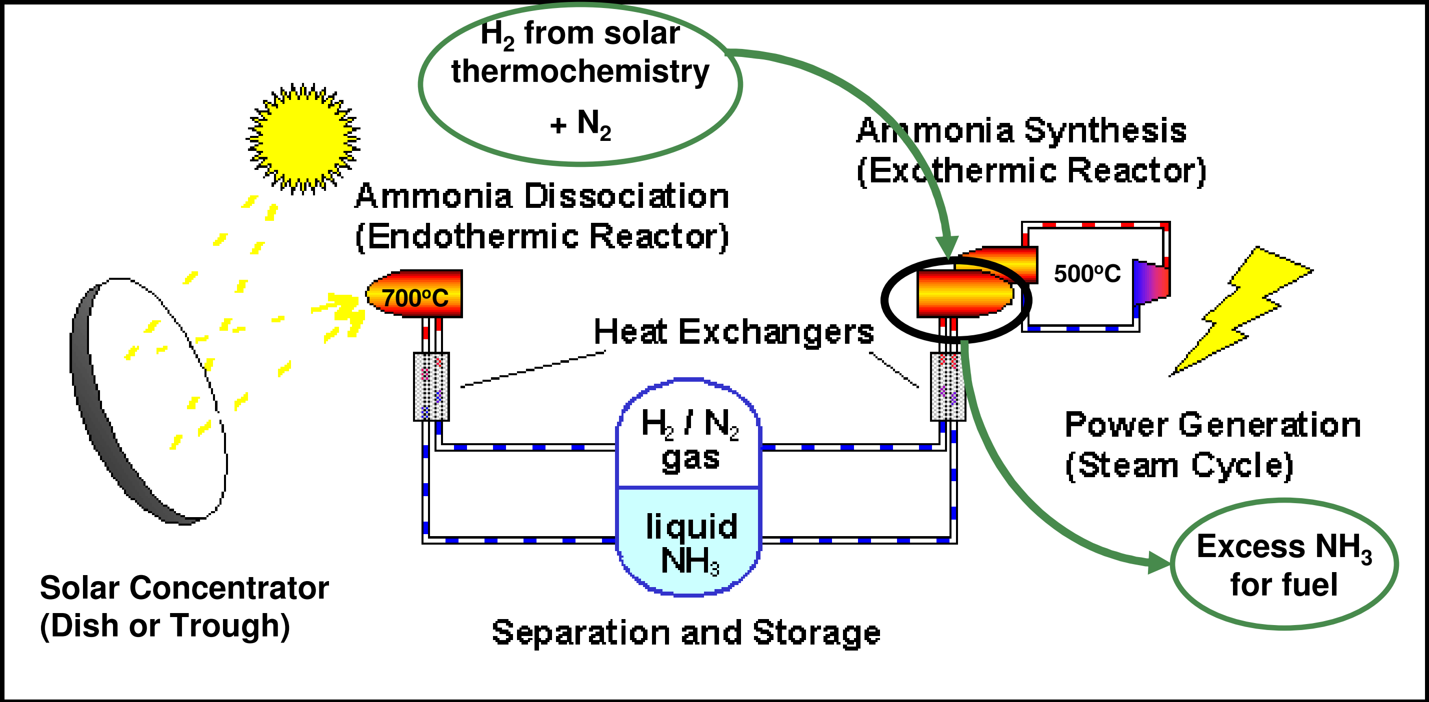


Figure 1.10 Schematic diagram of a solar paraboloidal dish power plant.

Baseload Solar Power & Net production of ammonia?

- Oversize synthesis reactor.
- Produce hydrogen via solar thermochemistry.



Producing hydrogen with solar thermochemistry

- Thermochemical water splitting
  (similar to electrolysis, but uses high temperature and catalyst rather than electricity)

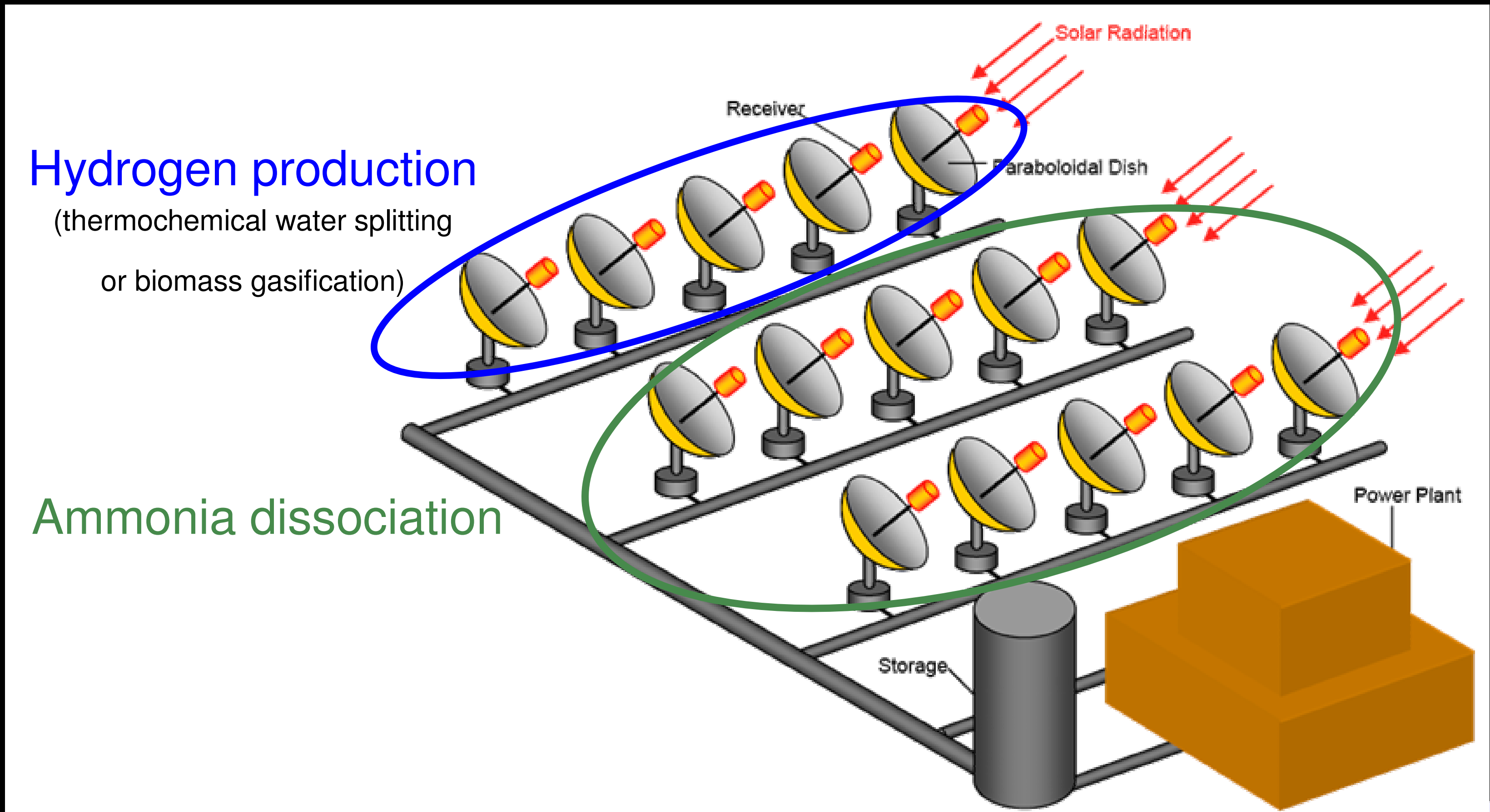
  $$2H_2O \rightarrow O_2 + 2H_2$$

- Biomass gasification:

  $$C_xH_y + XH_2O \leftrightarrow XCO + (X+Y/2)H_2$$

  $$CO + H_2O \rightarrow CO_2 + H_2$$

Baseload Solar Power & Net production of ammonia?



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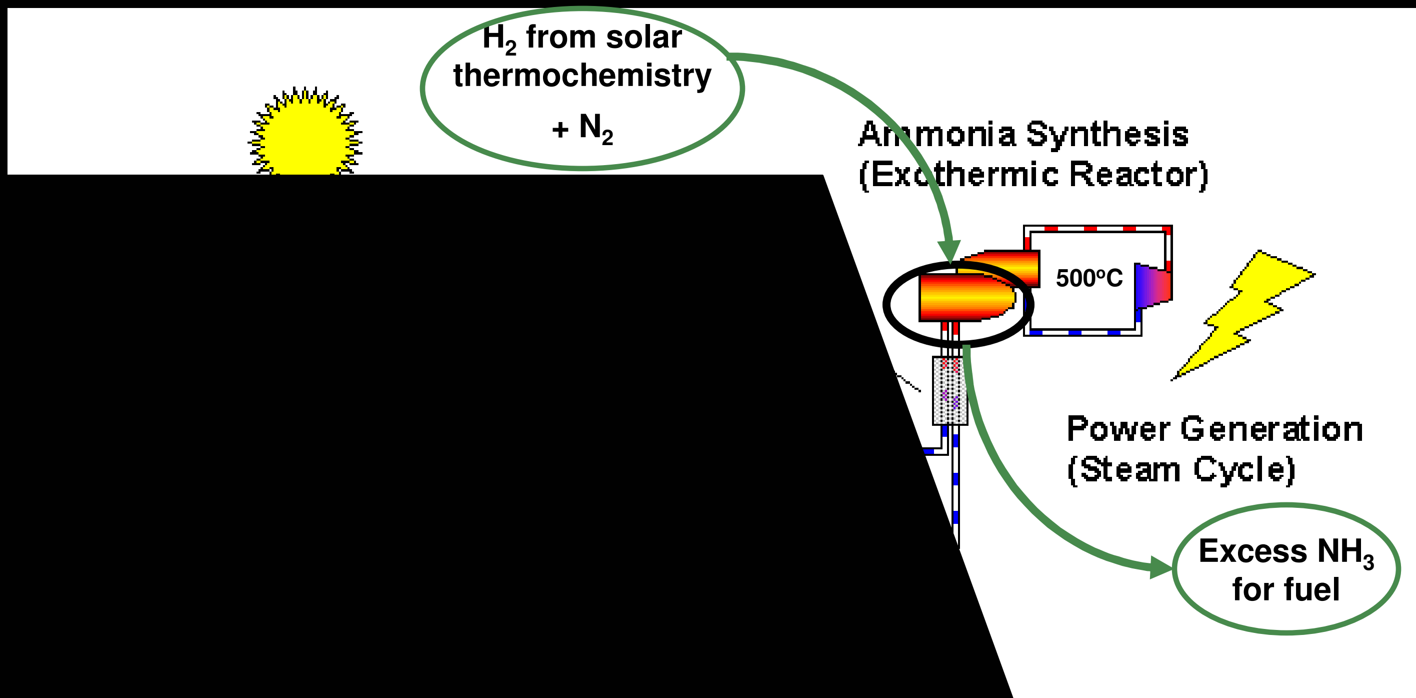
Trade-off between producing H_2 and dissociating ammonia



Questions?

Solar Gasification

- $C + 2H_2O \leftrightarrow CO_2 + 2H_2$
  take 176kJ/mol from solar energy
- The hydrogen can be burnt / oxidized
  $2H_2 + O_2 \leftrightarrow 2H_2O$ giving off 570 kJ/mol
- Compared to just burning coal
  $C + O_2 \leftrightarrow CO_2$ giving off 394kJ/mol
- Ie solar enhanced gas is 176/570 = 30% solar energy,
- Other hydrocarbons are gasified according to:
  $C_xH_y + XH_2O \leftrightarrow XCO + (X+Y/2)H_2$

Some clues...

- Its bigger (from 400m^2 to 500m^2)

- Joining frames like this is bloody expensive

- Square mirrors rule

Land Area for a Solar Future

- Assume:

  $5000 Wh/m^2/day$ average insolation

  $5000 PJ = 5x10^{18} J$ required per year

  Conversion of solar energy at 20% efficiency

- $5000 Wh/m^2/day \times 365 days \times 0.2 = 1314 MJ/m^2/year$
- $(5 \times 10^{18} J/year)/(1.314 \times 10^9 J/m^2 /year) = 3.81 \times 10^9 m^2$

  $=3805 km^2 = 61.7 km \times 61.7 km$

- Allowing for spacing between collectors:

  @ 10% coverage; $38052 km^2 = 195 km \times 195 km$

  @ 20% coverage; $19026 km^2 = 138 km \times 138 km$