Solar Thermal Power: Trends and Prospects

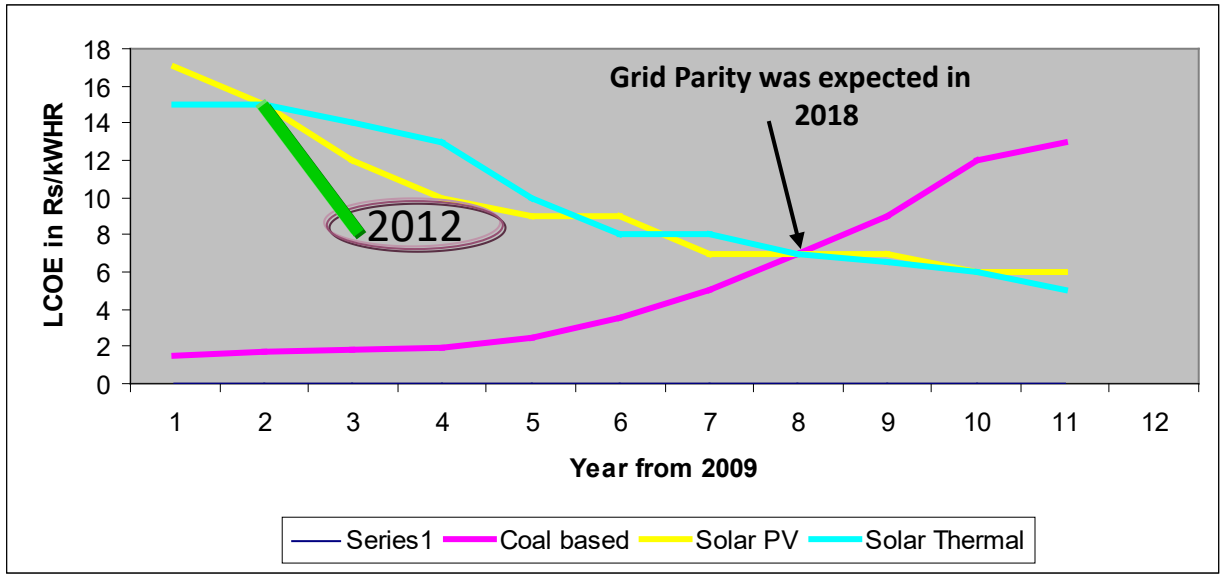
Pradip Dutta

Indian Institute of Science, Bangalore, INDIA

Worldwide trends in solar power: PV vs. CSP

- Between 1985 and 1991, about 354 MW capacity of CSP was commercially installed in California.
- After a brief period of inactivity between 1991 and 2005, interest in CSP had picked up again worldwide, primarily due to cost reduction and favourable government policies.
- *Since 2012, because of steeper decline in PV prices, the relative growth rate of CSP has not been phenomenal.*

  → *Deployment of CSP technologies is not as widespread as photovoltaics.*



Source: Thermax

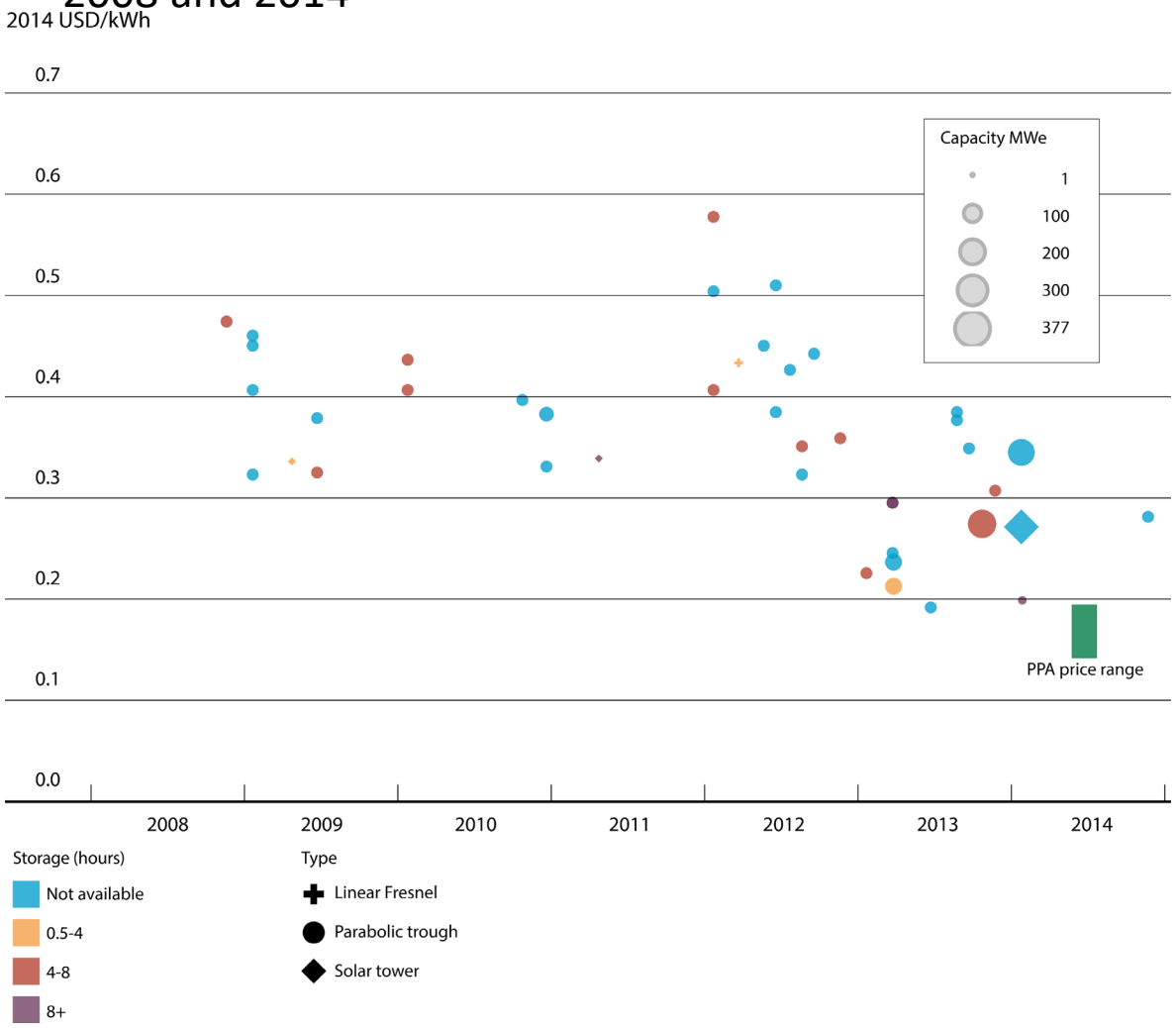
Worldwide trends in CSP

- As of now, Spain has been largest producer of CSP electricity, followed by USA .
- Lately, China, South Africa and UAE have laid out ambitions plans in CSP installations.
- Why renewed interest in CSP? Mainly due to affordable *storage technologies*, making it potentially *cost competitive* with PV.

LCOE trends:

- LCOE change was nearly flat during the period 2008-2012
- Downward during the period 2012-2014, as the number of CSP installations and capacity addition grew worldwide.
- However, growth of CSP installations declined due to drop in PV price.
- Solar tower CSP configuration with molten salt as the receiver fluid and storage medium most promising

Evolution of LCOE for CSP projects installed between 2008 and 2014



Source: Handbook of Solar Thermal Technologies, Jane H Davidson et al., World Scientific Book, 2022

Viability conditions for CSP

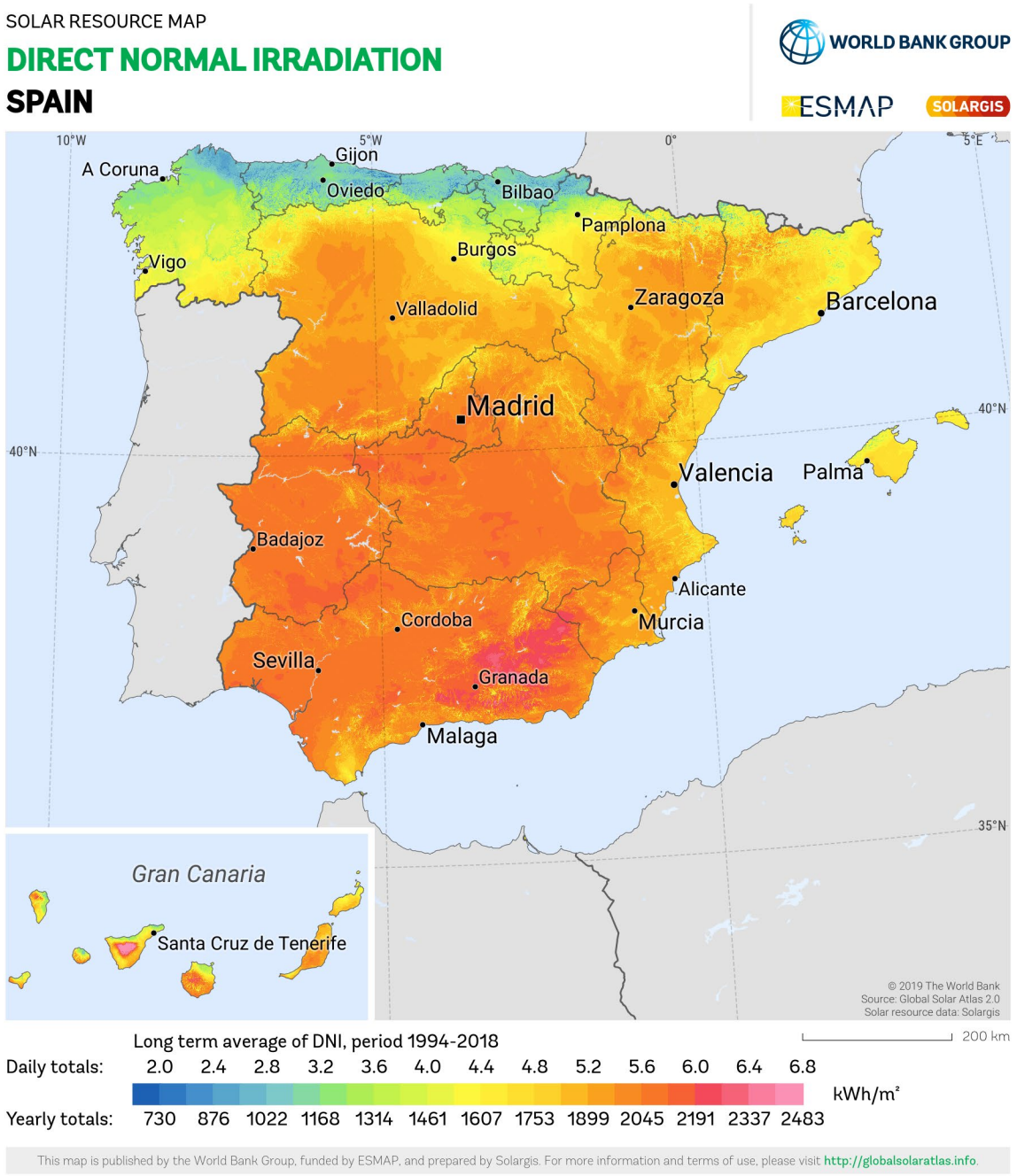
- Deployment CSP plants in a particular region depends on two key factors:
  1) availability of appropriate solar resources
  2) policies favouring CSP - sustainable eco-system for the CSP industry.
- DNI is an important parameter to assess the potential markets in different regions.
- Minimum DNI value of 2000 kWh/m^2/year is required for a CSP plant to be considered commercially viable.
- Water requirement (~2-3 m^3 water per MWh energy generation)
  1) to clean heliostat mirrors, and
  2) as condenser coolant in a steam Rankine power cycle.
- In semi-arid and arid regions with water scarcity, closed loop s-CO2 based Brayton power cycles may be considered

There is a region-wise distribution of potential CSP market

Spain – dominant CSP market in Europe

- Abundance of solar radiation and favourable policies
- Abengoa Solar developed Planta Solar 10 (PS10) central-receiver CSP system in 2007 -- world's first commercial grid-connected central receiver CSP.
- Between 2007 and 2013, Spain commissioned more than 40 CSP plants, having a capacity of 50 MW each *(One third with storage)* .
- Favourable feed-in tariff (FIT) led to growth of CSP.
- Recently the reduction in the FIT has negatively impacted the country's CSP market with no new projects.

Source: Handbook of Solar Thermal Technologies, Jane H Davidson et al., World Scientific Book, 2022



United States – high potential for CSP growth

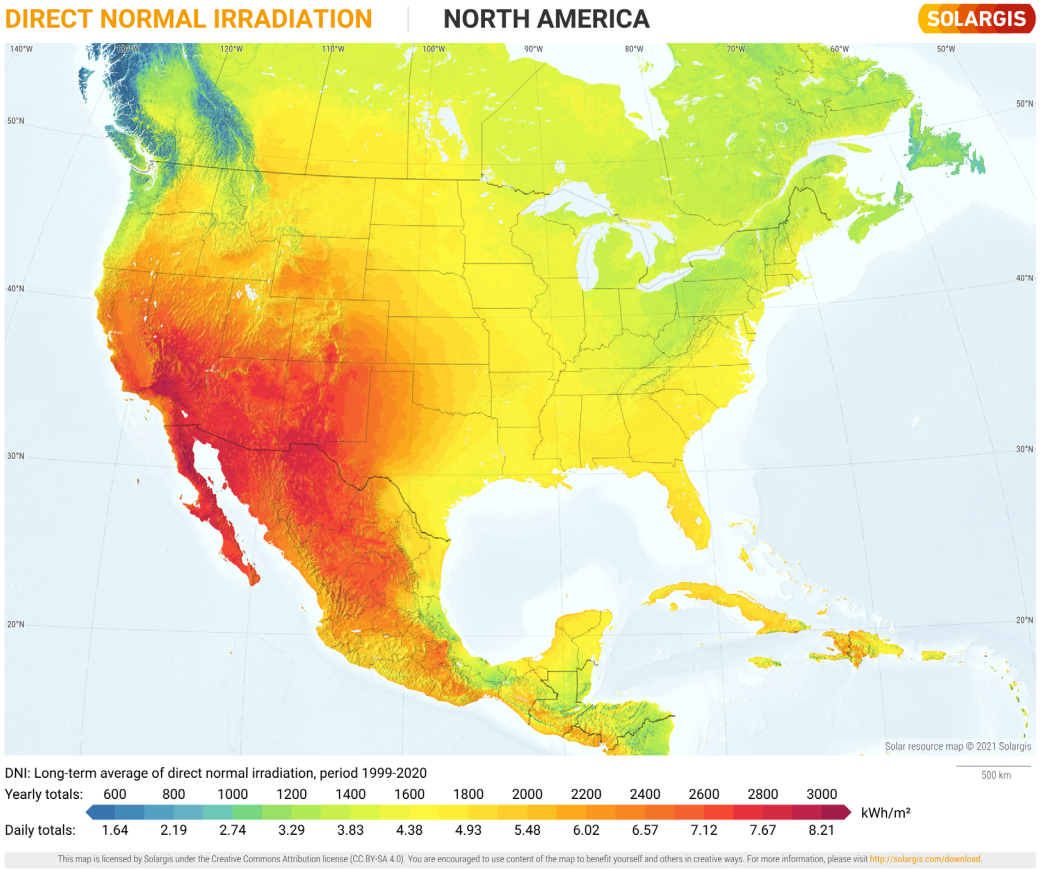
- Adequate DNI in southwestern states - California, Arizona, Nevada, New Mexico, Colorado, Utah and Texas
- Water availability is an issue - Dry cooling is an option
- In 2010, the US DOE set SunShot LCOE targets - $0.05-0.06 per kilowatt hour without subsidies by 2020.
- Solar PV met the target around 2017, but CSP fell behind.

Some recent installations of CSP plants (central tower):

- 2014: 377 MW Ivanpah CSP System (no storage, but hybridization as back-up)
- 2015: 110 MW Crescent Dunes Solar Energy Project (10 hours of molten salt storage)

DOE's Gen 3 Roadmap for CSP (2030 target)

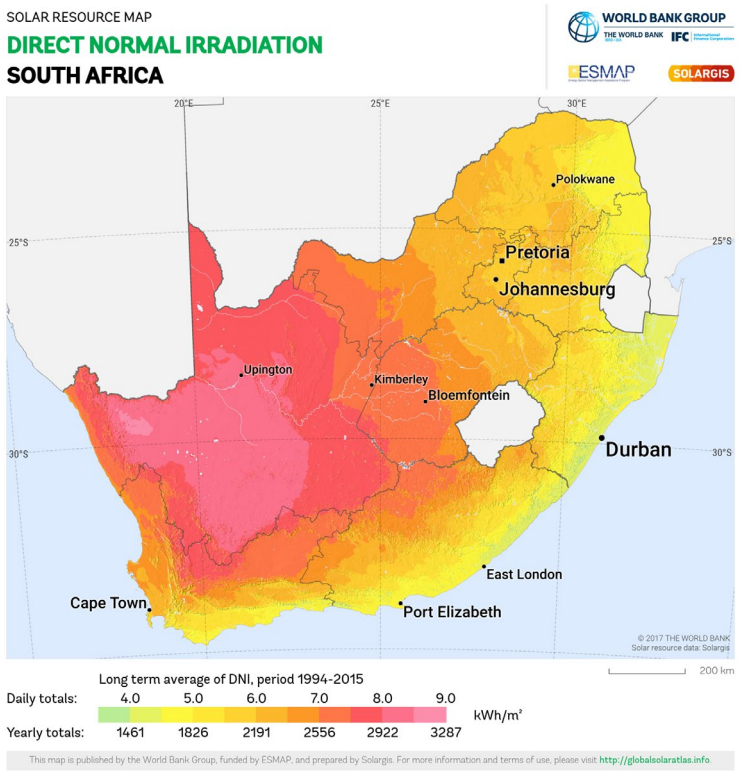
- aggressive targets for high temperature high efficiency CSP plants to make CSP cost competitive
- Supercritical carbon dioxide (s-CO2) Brayton cycle with dry cooling is a major thrust



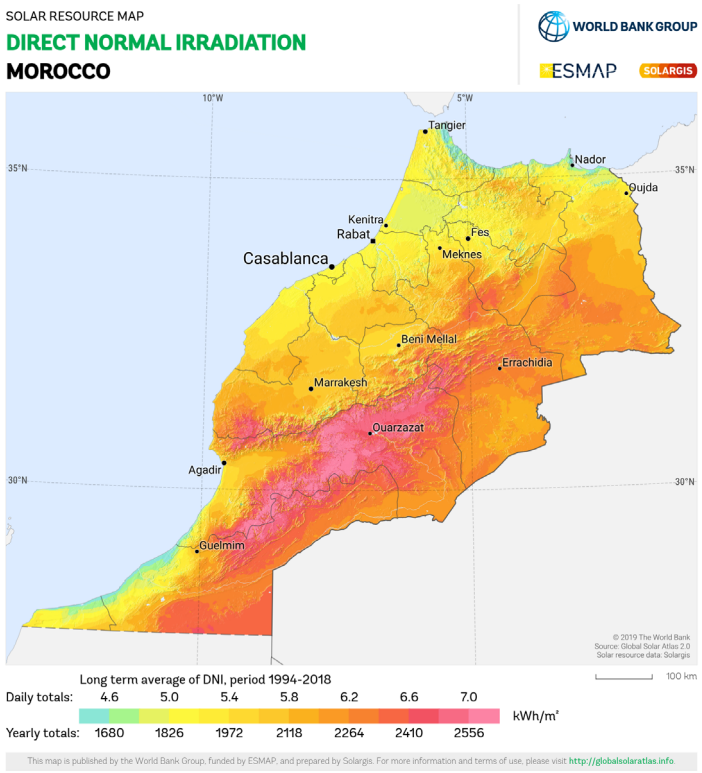
Source: Handbook of Solar Thermal Technologies, Jane H Davidson et al., World Scientific Book, 2022

Other potential CSP markets

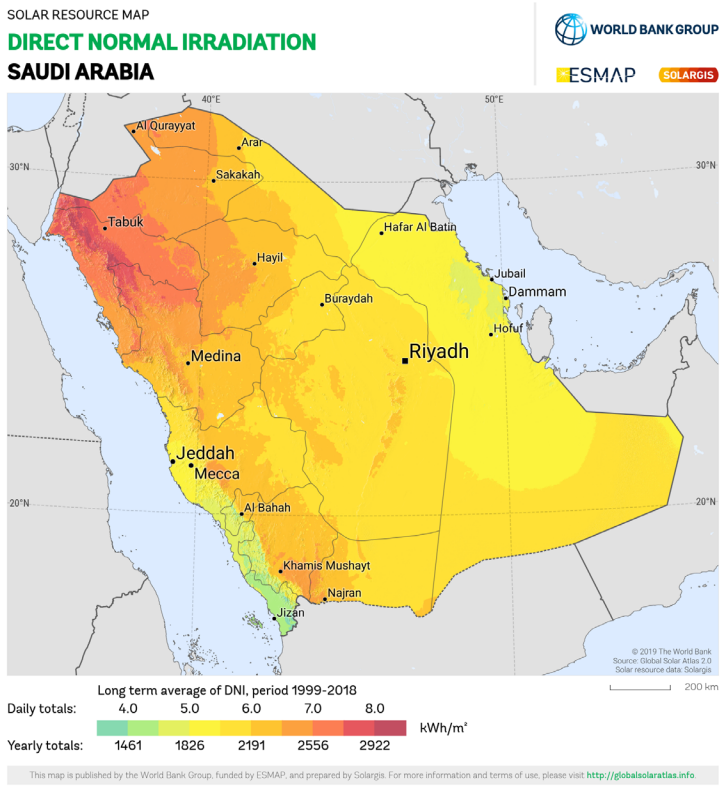
SOUTH AFRICA



MOROCCO



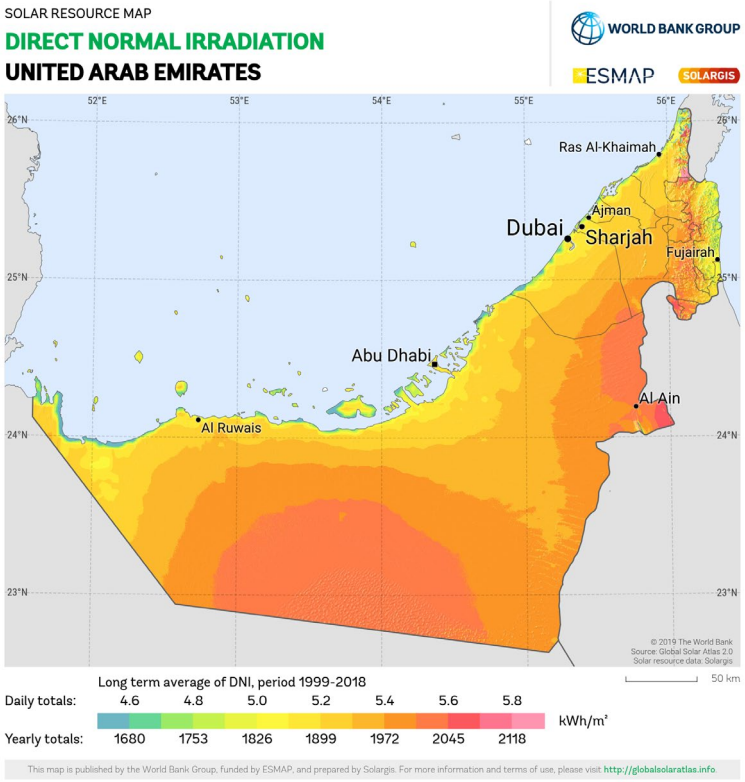
SAUDI ARABIA



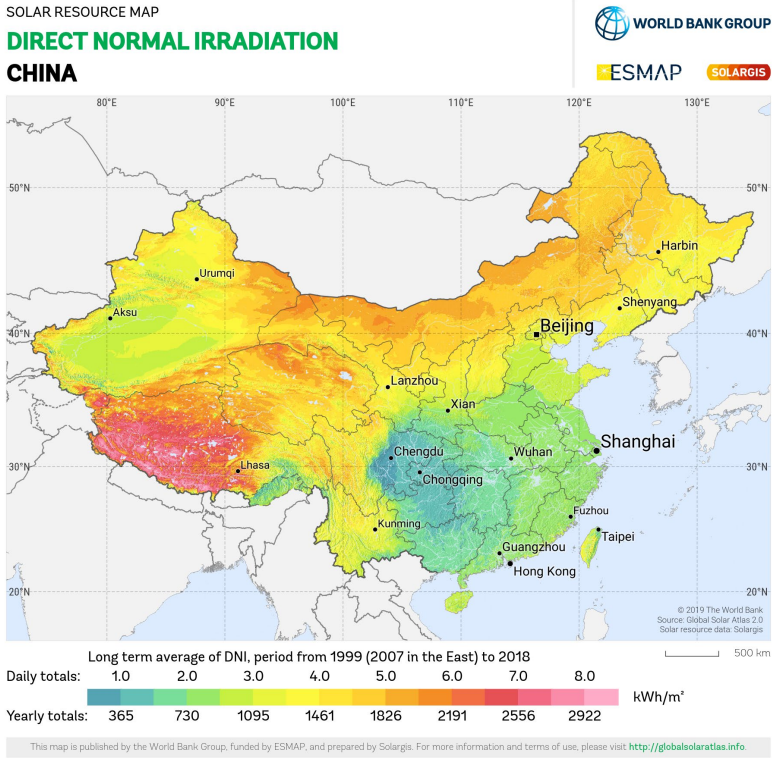
Source: Handbook of Solar Thermal Technologies, Jane H Davidson et al., World Scientific Book, 2022

Other potential CSP markets

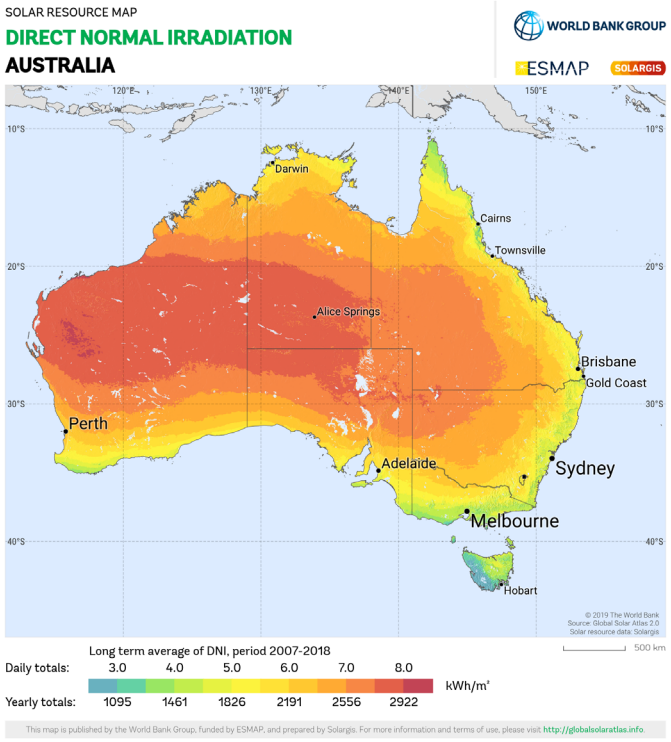
UAE



CHINA

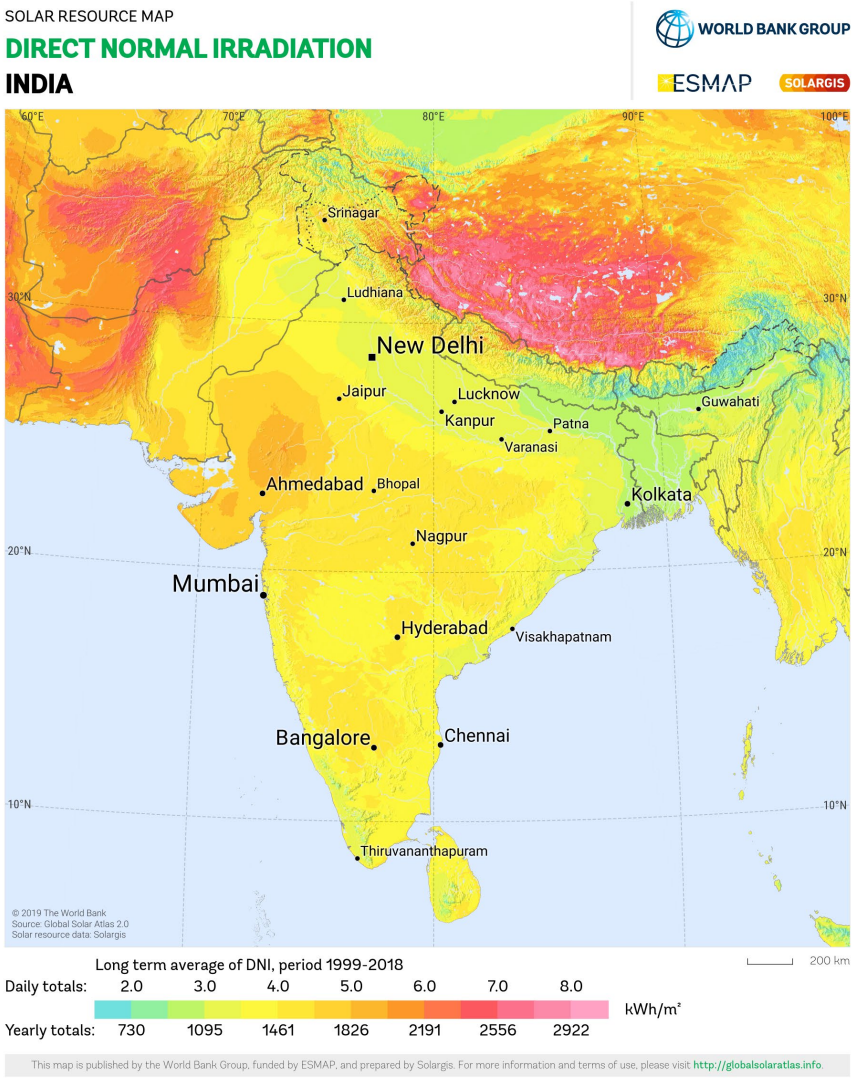


AUSTRALIA



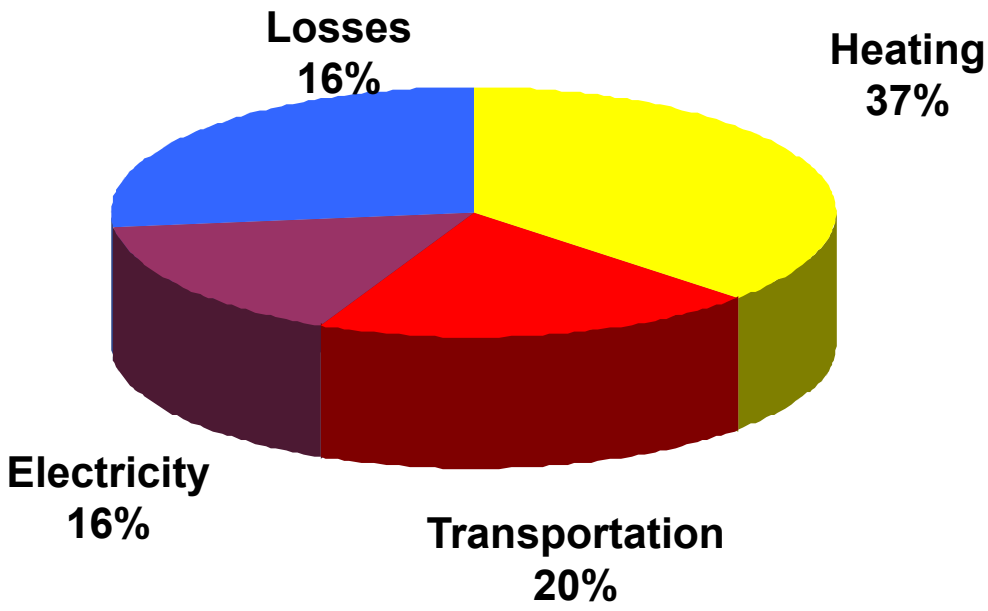
Scenario in India

- The DNI map shows potential in the states of Gujarat, Rajasthan, Madhya Pradesh, Andhra Pradesh, Maharashtra, Haryana and Ladakh.
- In 2010, India launched its National Solar Mission –with targets for PV as well as CSP
- In the first phase, seven CSP proposals were launched with a total capacity of 470 MW (e.g. 125 MW linear Fresnel at Dhursar in Rajasthan, 50 MW parabolic trough basedMegha solar plant in Andhra Pradesh).
- After these projects, no new additions have resulted, a major reason being steep fall in PV panel prices.



Source: Handbook of Solar Thermal Technologies, Jane H Davidson et al., World Scientific Book, 2022

Present Energy Use Pattern in India

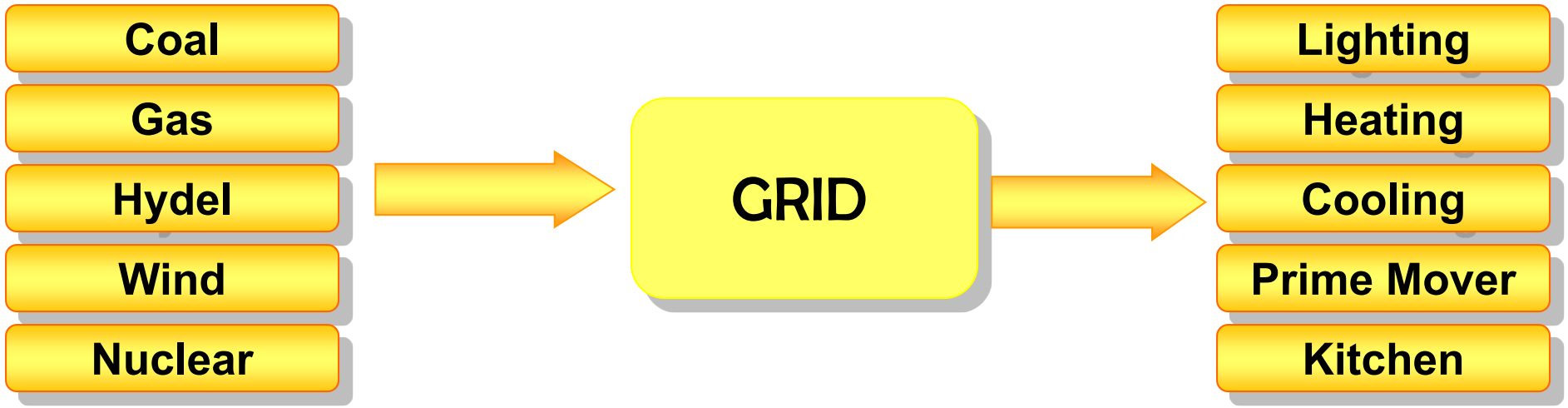


- Electricity accounts for 16% of the energy consumption
- Thermal requirement is 37% and often along with electricity requirement
- The electricity and thermal requirements are *largely distributed*

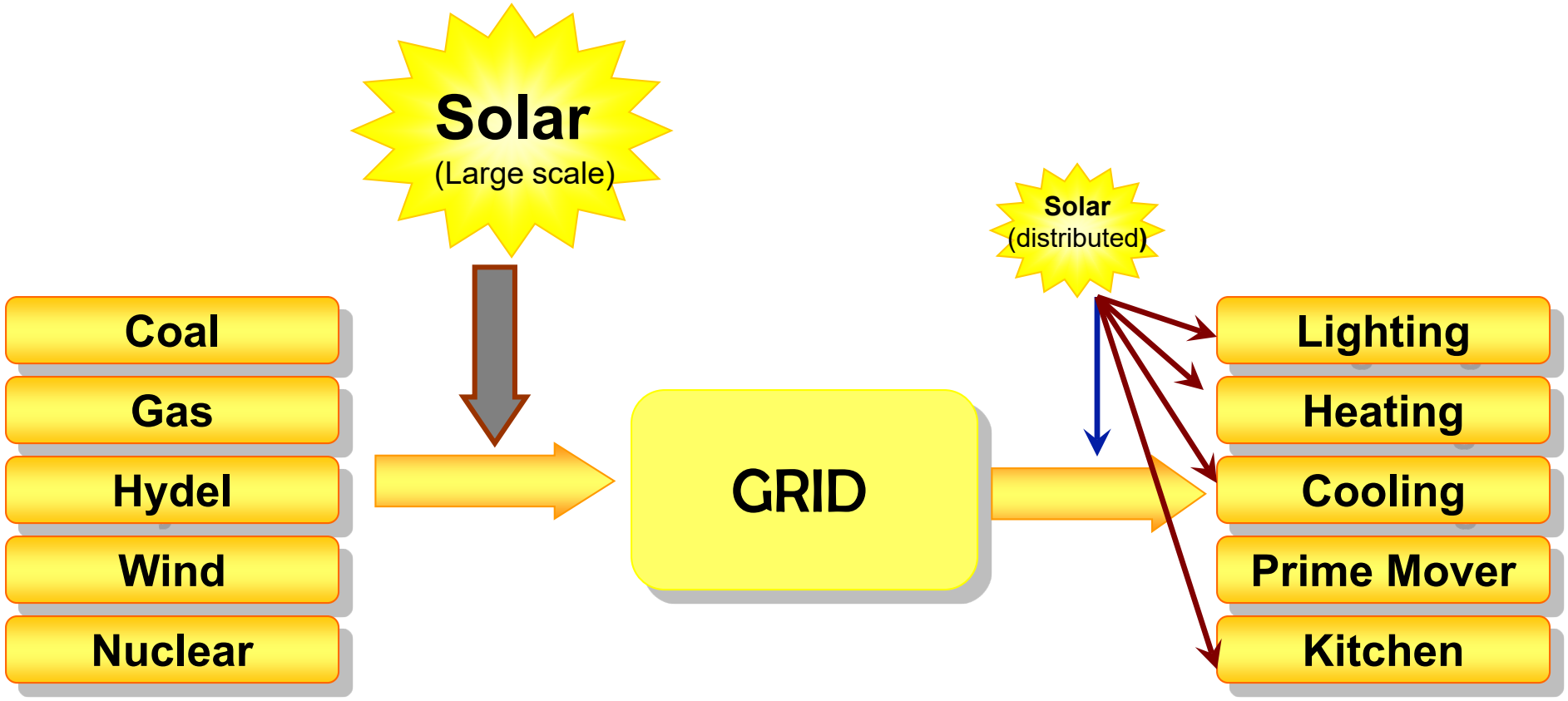
Source: Wikipedia

Target solar development in distributed mode

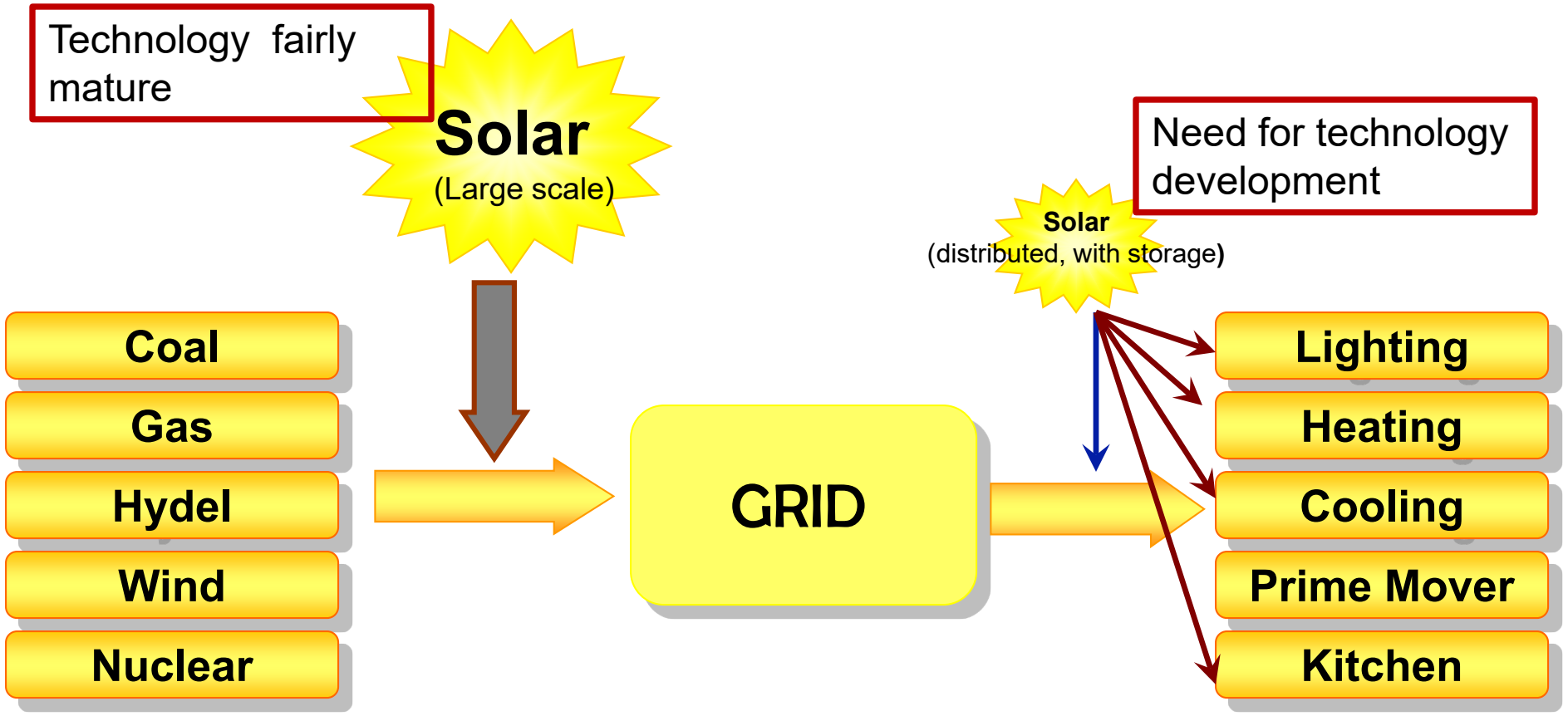
Solar in Central and Distributed mode….



Solar in Central and Distributed mode….



Solar in Central and Distributed mode….



Present thrust on CSP in India:

- High temperature high pressure systems, with thermal storage
- Distributed mode – development of s-CO2 based CSP plant
- Novel heat transfer fluids, storage materials, receiver systems.
- Development of high temperature receivers, heat transfer fluids

THANK YOU

Questions?