



INSTITUT FÜR  
ENERGIETECHNIK UND  
THERMODYNAMIK  
Institute for Energy Systems and Thermodynamics

# Solar Thermal Electricity

Highlights & Trends from SolarPaces2014

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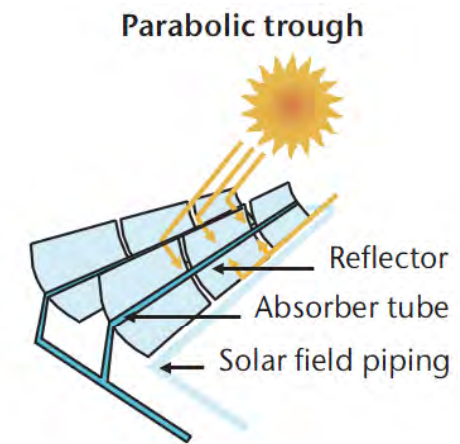
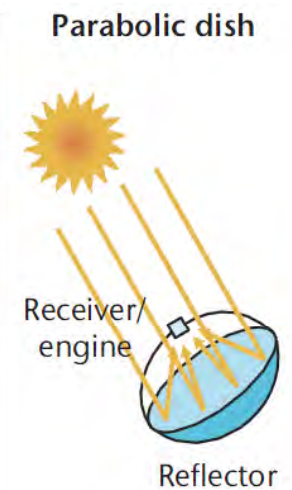
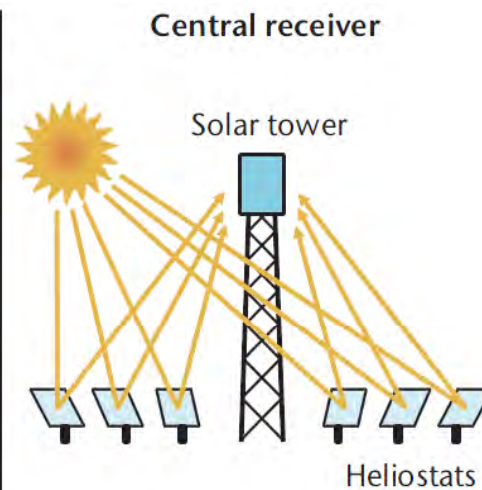
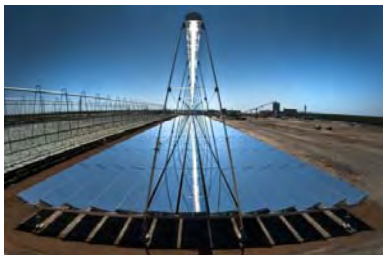
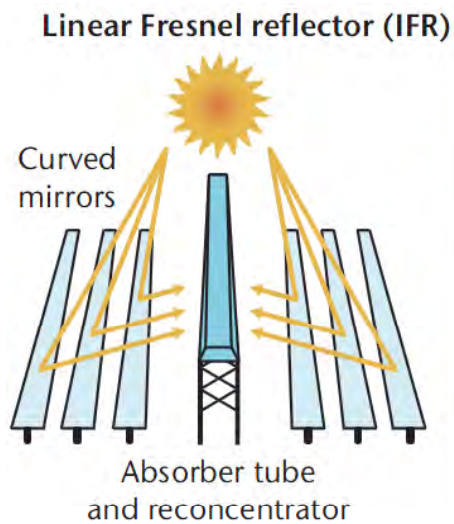


- **Main CSP technologies**
- **Technological road map & trends**
  - Installed capacities
  - Projections
  - Dispatchability
- **Highlights from SolarPaces**
  - Main technological paths
  - Continuous improvements
  - Direct particle cycle

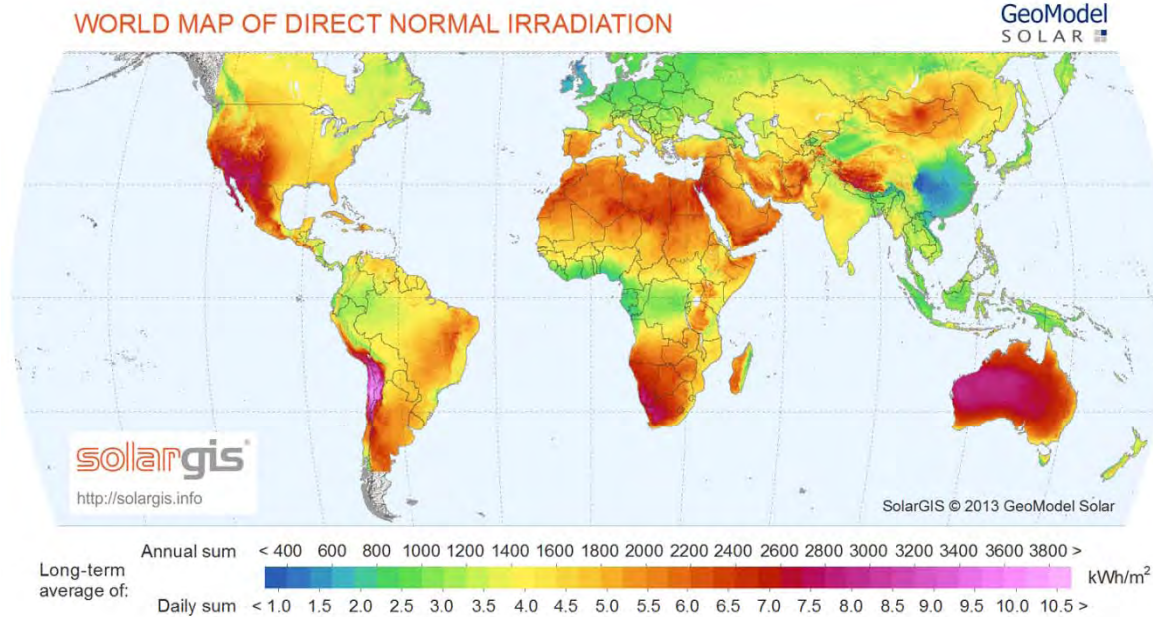


# Main CSP technologies

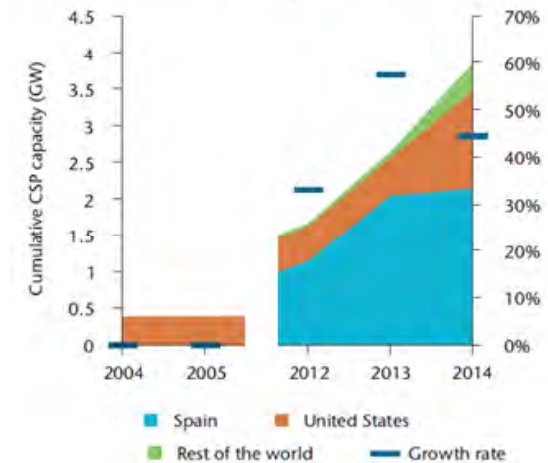
- **Conventional power cycles: Rankine, Brayton...**
  - Fuel replaced via sun light (concentrated solar irradiation)



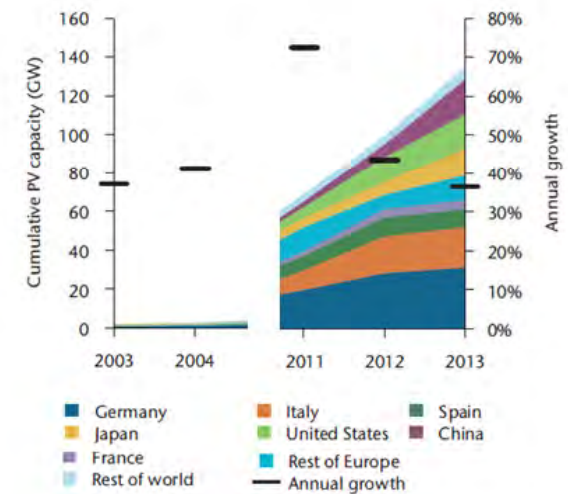
- Disruptive success of PV?



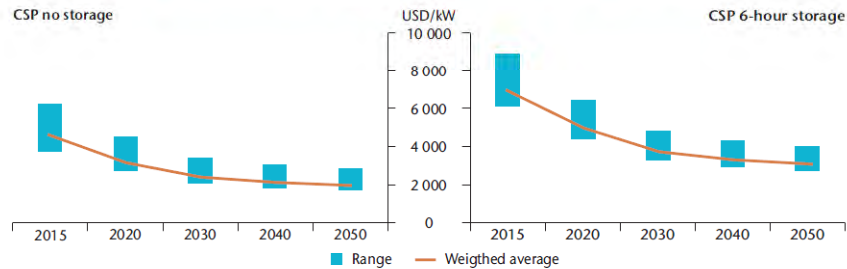
Global cumulative growth of STE capacity



Global cumulative growth of PV capacity

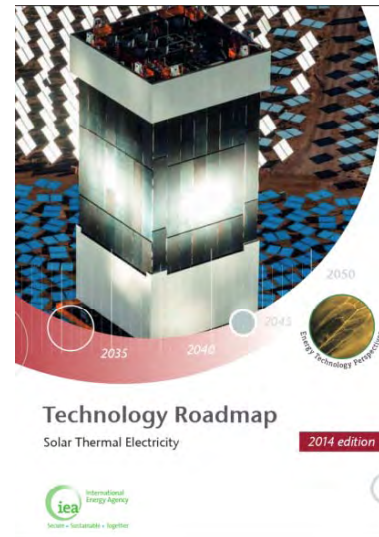


## CSP investment cost projections in the hi-Ren Scenario

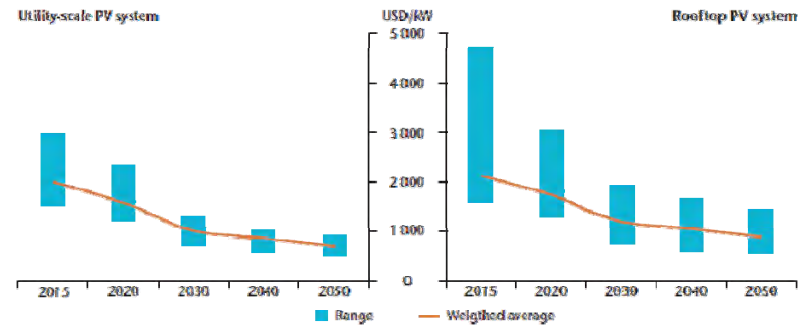


## Projections of LCOE for new-built CSP plants with storage in the hi-Ren Scenario

| USD/MWh | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---------|------|------|------|------|------|------|------|------|
| Minimum | 146  | 116  | 96   | 86   | 72   | 69   | 66   | 64   |
| Average | 168  | 130  | 109  | 98   | 80   | 77   | 72   | 71   |
| Maximum | 213  | 169  | 124  | 112  | 105  | 101  | 96   | 94   |



## PV investments cost projections in the hi-Ren Scenario



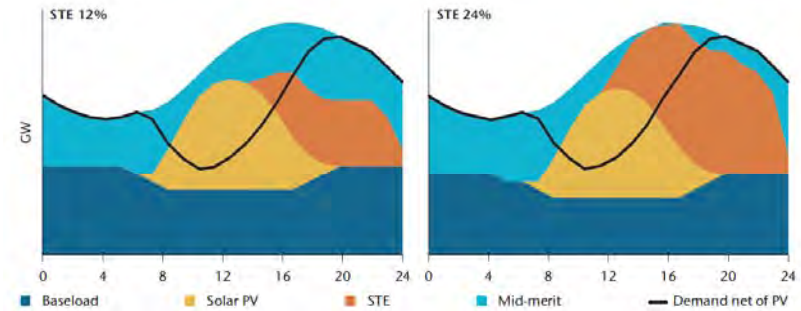
## Projections for LCOE for new-built utility-scale PV plants to 2050 (USD/MWh) in the hi-Ren Scenario

| USD/MWh | 2013 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---------|------|------|------|------|------|------|------|------|
| Minimum | 119  | 96   | 71   | 56   | 48   | 45   | 42   | 40   |
| Average | 177  | 133  | 96   | 81   | 72   | 68   | 59   | 56   |
| Maximum | 318  | 250  | 180  | 139  | 119  | 109  | 104  | 97   |

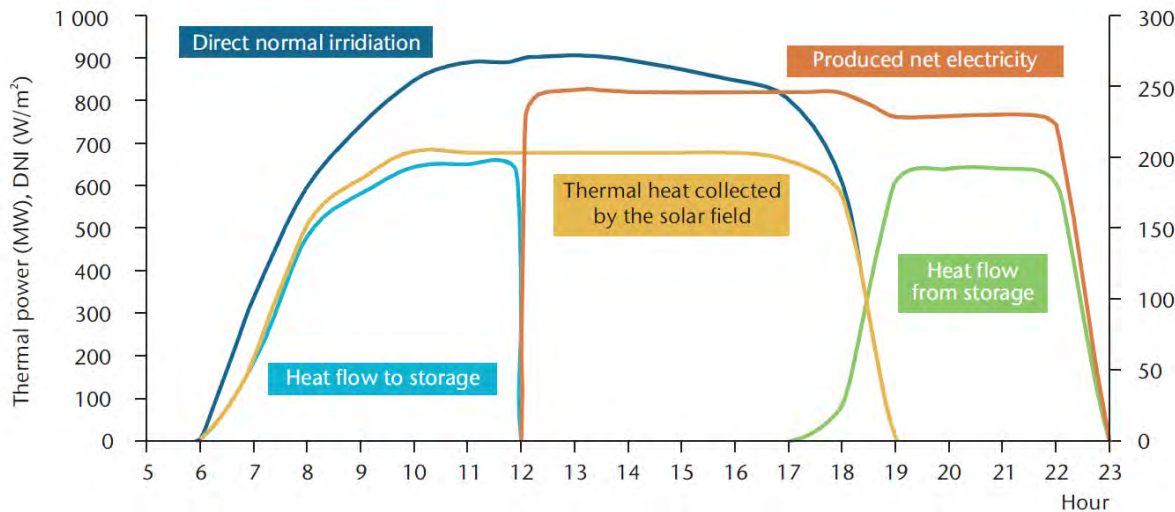


- **Thermal energy storage**

- thermo oil
- molten salt
- particles
- phase change materials

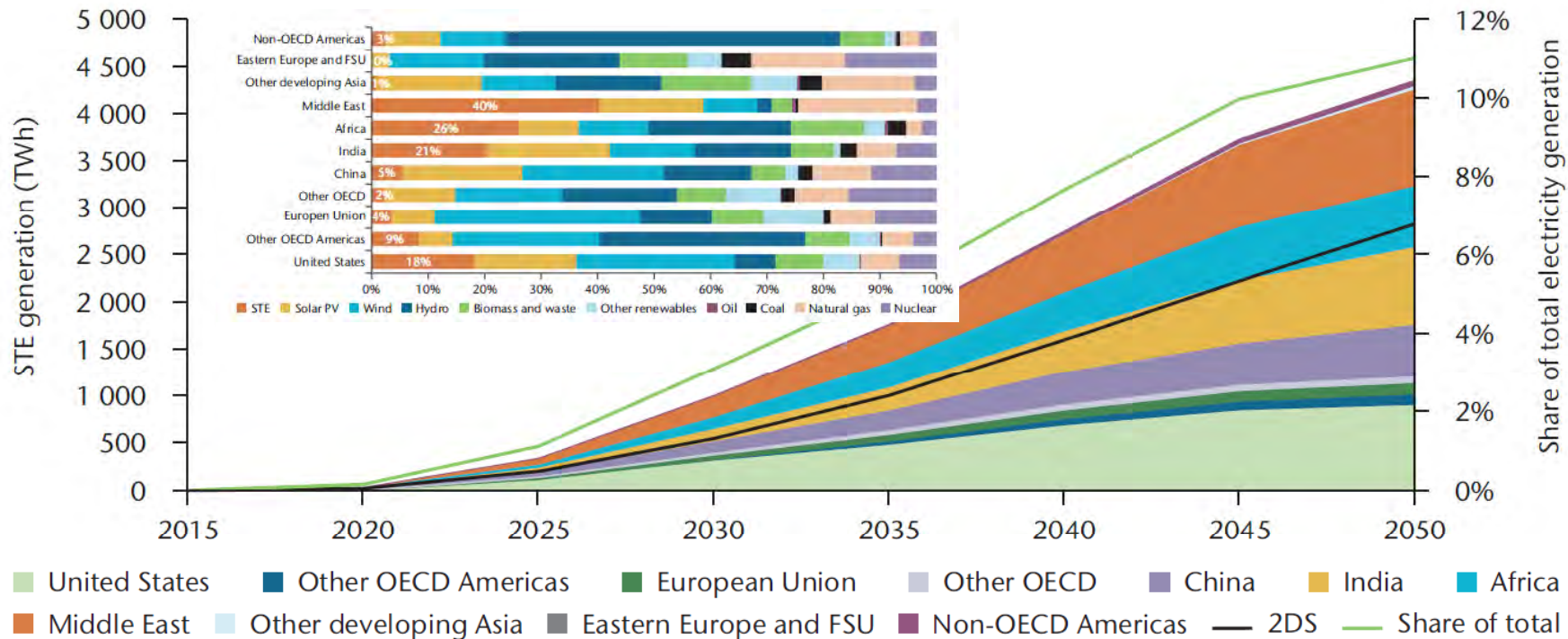


- **Grid needs flexibility – dispatchability creates value!**



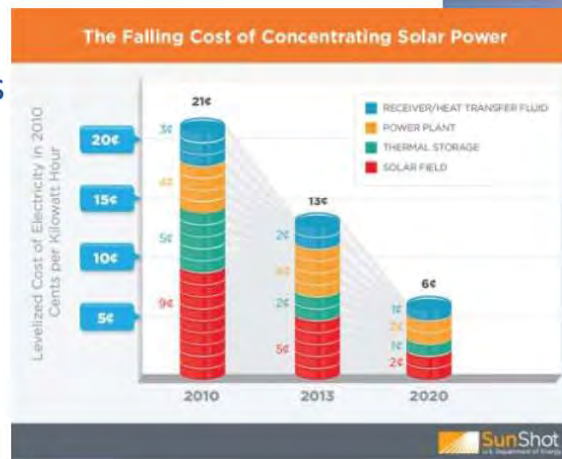
# STE Raodmap until 2050

- **Policy**
  - Difficult financing due to delayed market growth
  - Incentives have to be created
  - South Africa: pays 2.7 times the spot price at peak times



# The Road to SunShot

- Higher performance
- Higher Temperatures
  - Materials
  - Compatibility
- Reduce losses
  - Smaller size
  - Higher flux
  - Modified surfaces

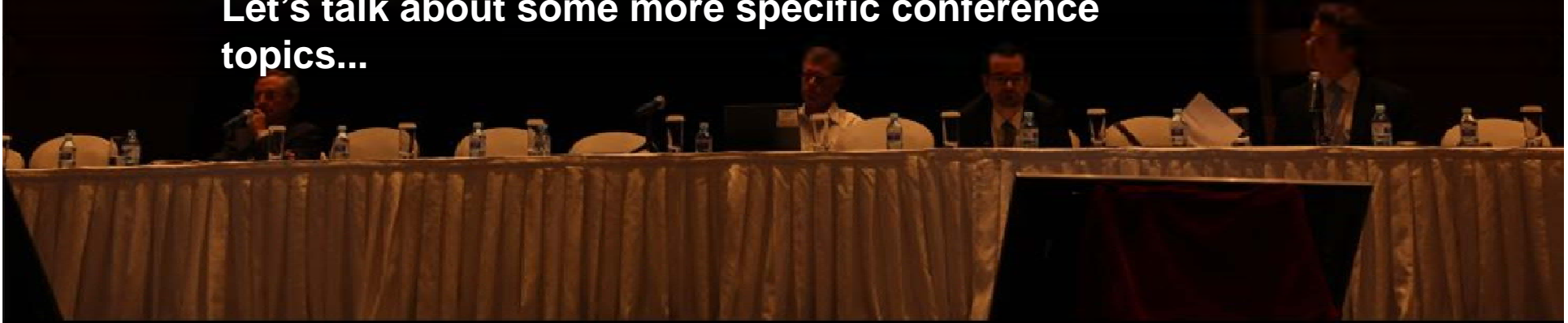


- Alternate working fluids
  - Solids
  - PCM's
  - HTF's
  - SCO<sub>2</sub>
  - Air



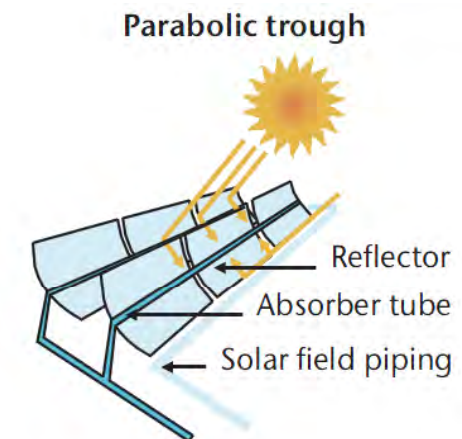
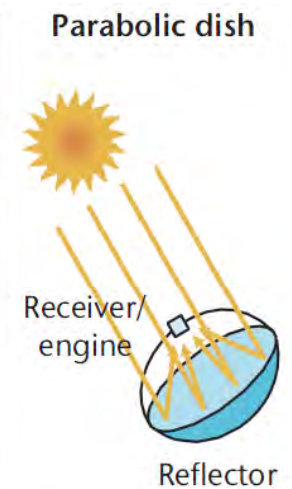
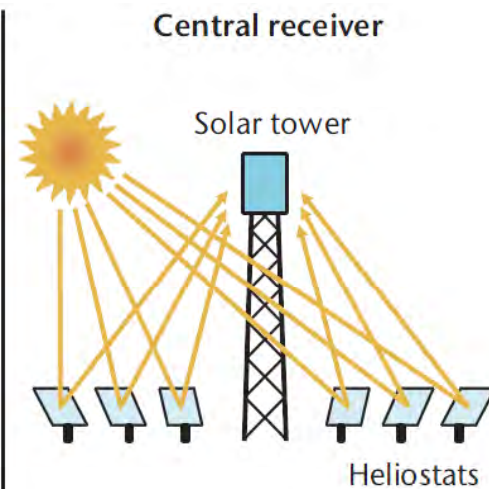
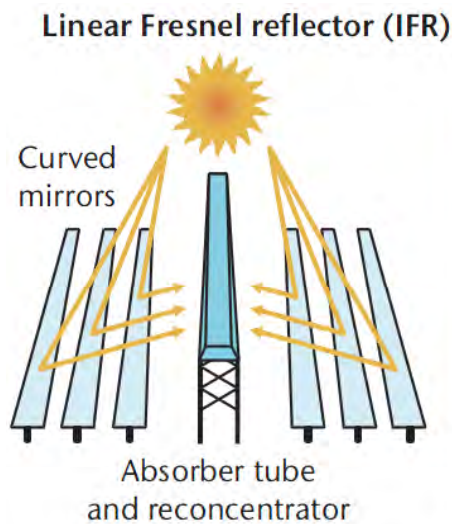
- Heat transfer fluid exit temperature from the receiver > 650°C
- Thermal efficiency > 90%
- Lifetime > 10,000 cycles
- Cost < \$150/kW<sub>th</sub>

Let's talk about some more specific conference topics...





- **Solar Collectors and receivers**
  - Increase aperture area and handle wind loads
  - Non imaging concentration
  - Improve coatings and insulations
  - Optimization of heliostat field design and tracking system
  - Investigation on durability and maintenance

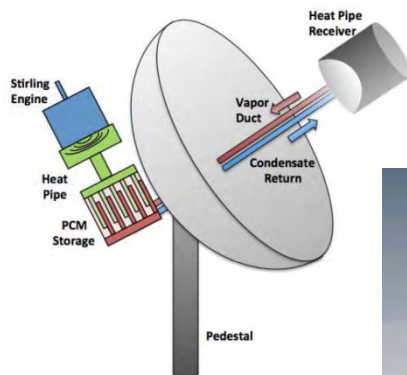


- **Thermal energy storages**
  - Salts at higher temperatures
  - PCMs at higher temperatures with large heat of fusion
    - Metallic eutectics
    - Heat pipes
  - Using solid filler materials as storage media
    - Bulks/stacks

**Fraunhofer ISE**



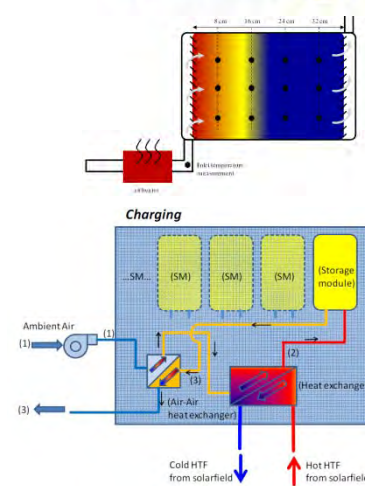
**Sandia National Laboratories**



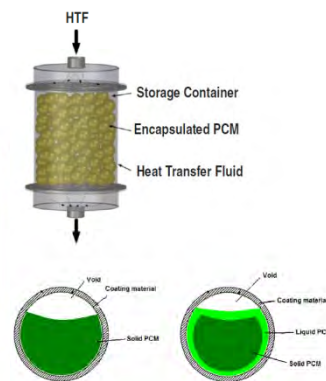
**DLR**



**enolcon**

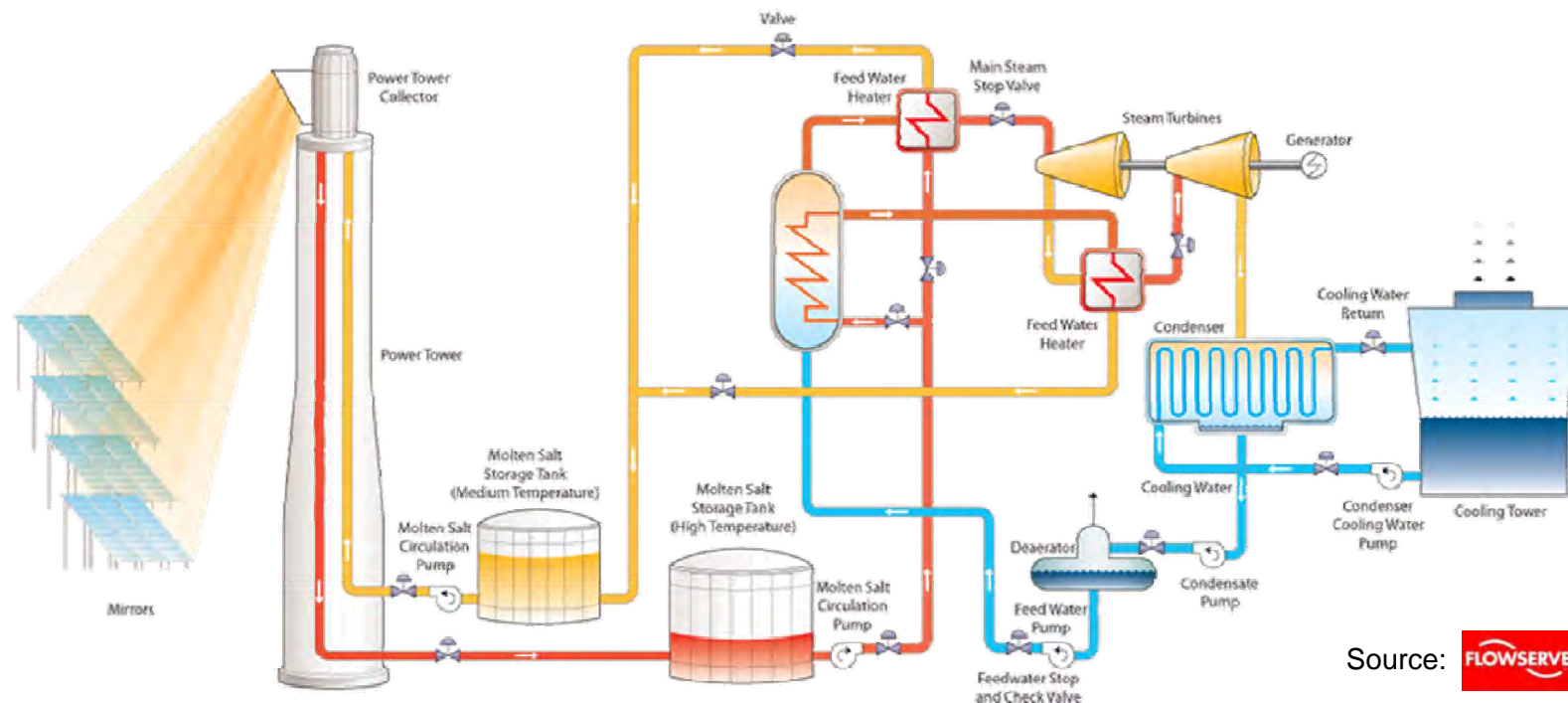


**institute imdea energy**



# Direct Particle Cycle

- **State of the art**
  - Direct storage cycle applying molten salt
- **Replace salt with particles**
  - Higher temperatures and cheaper materials

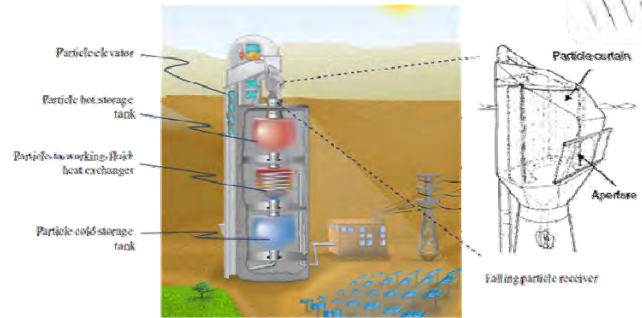
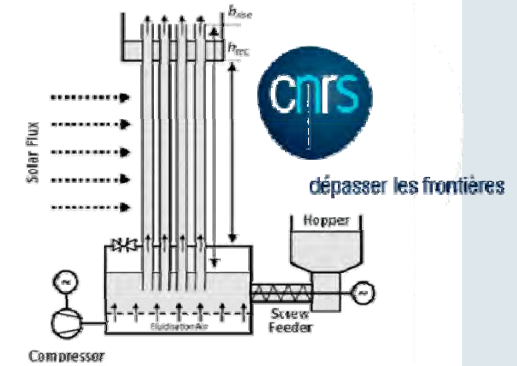
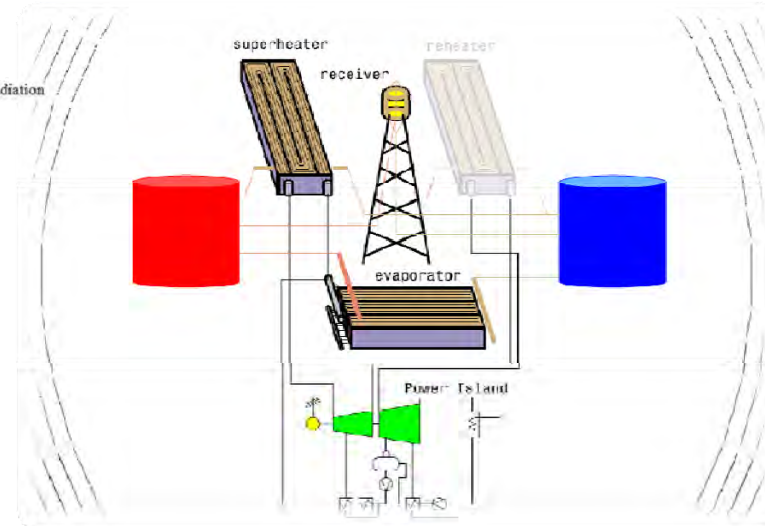
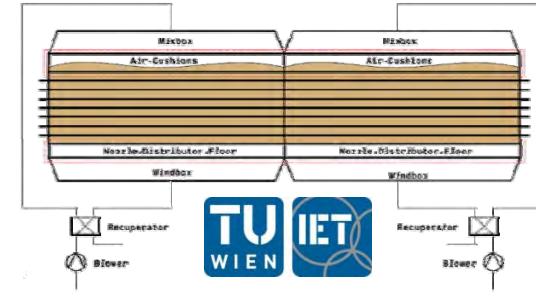
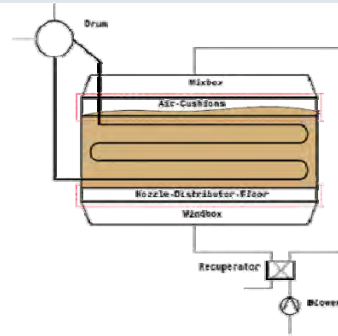
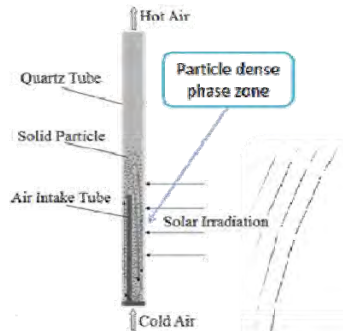


Source: FLOWERVE

# Direct particle cycle



CHINESE ACADEMY OF SCIENCES



**Thank you for your kind attention!**

