



INSTITUT FÜR
ENERGIETECHNIK UND
THERMODYNAMIK
Institute for Energy Systems and Thermodynamics

Solar Thermal Electricity

Highlights & Trends from SolarPaces2014

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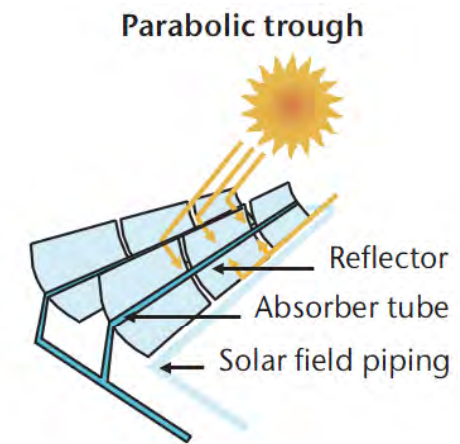
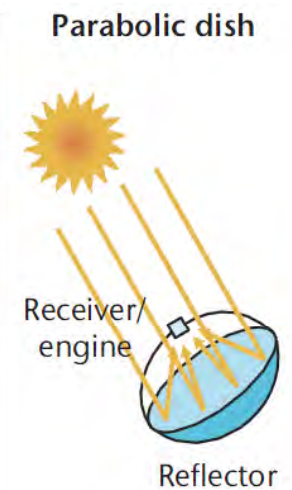
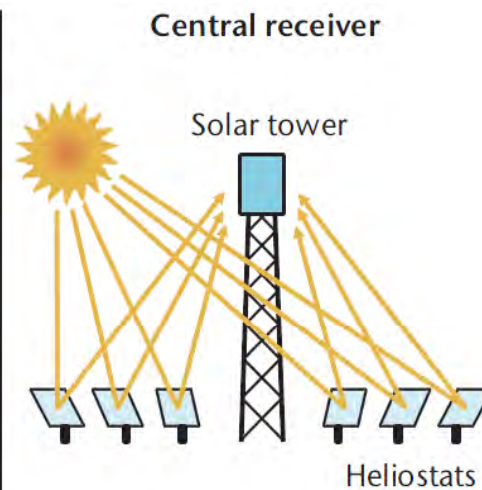
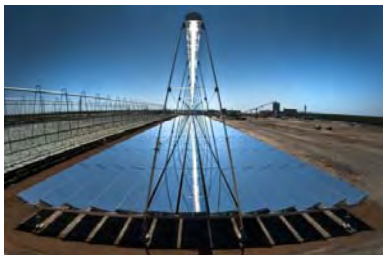
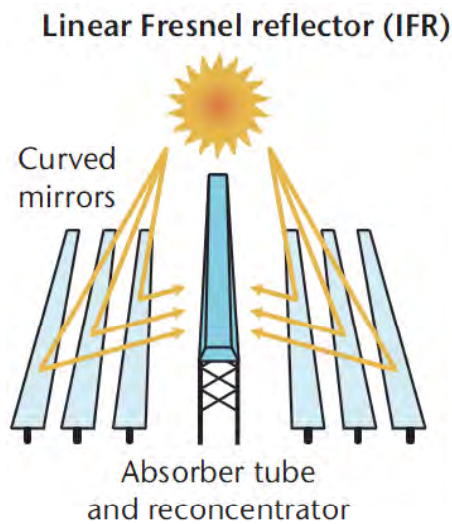


- **Main CSP technologies**
- **Technological road map & trends**
 - Installed capacities
 - Projections
 - Dispatchability
- **Highlights from SolarPaces**
 - Main technological paths
 - Continuous improvements
 - Direct particle cycle

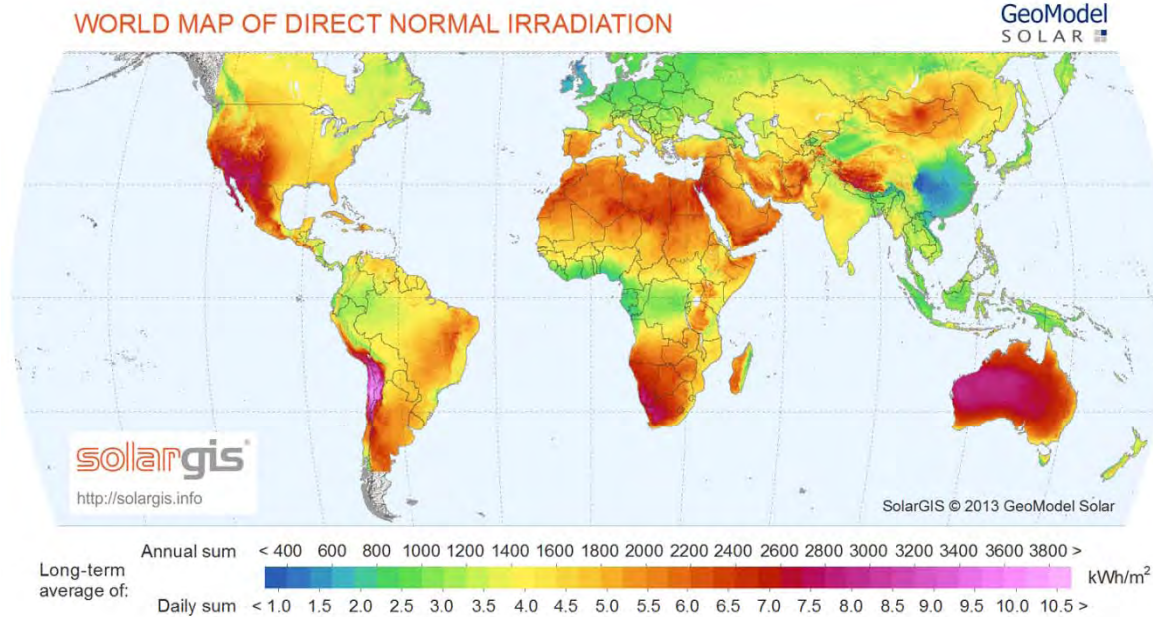


Main CSP technologies

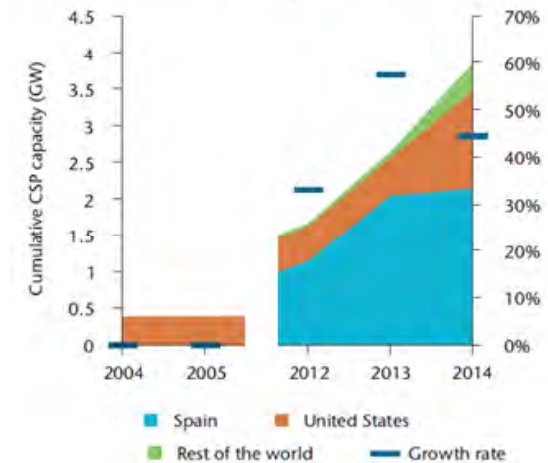
- **Conventional power cycles: Rankine, Brayton...**
 - Fuel replaced via sun light (concentrated solar irradiation)



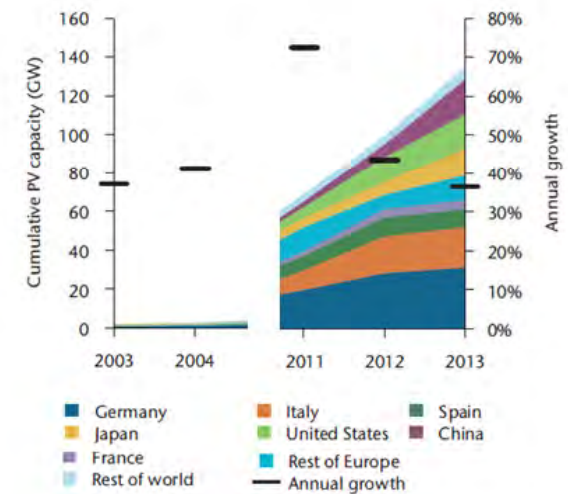
- Disruptive success of PV?



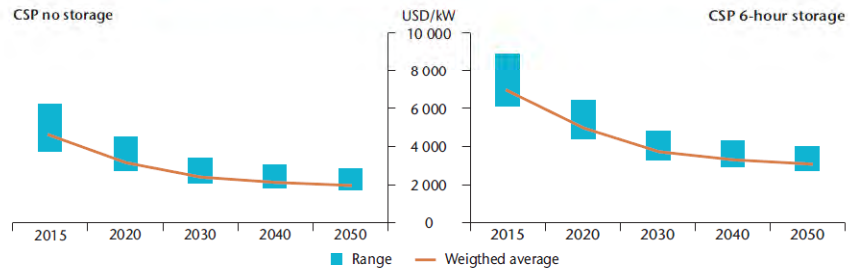
Global cumulative growth of STE capacity



Global cumulative growth of PV capacity

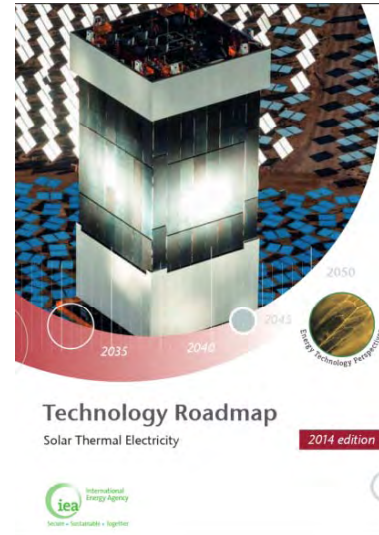


CSP investment cost projections in the hi-Ren Scenario

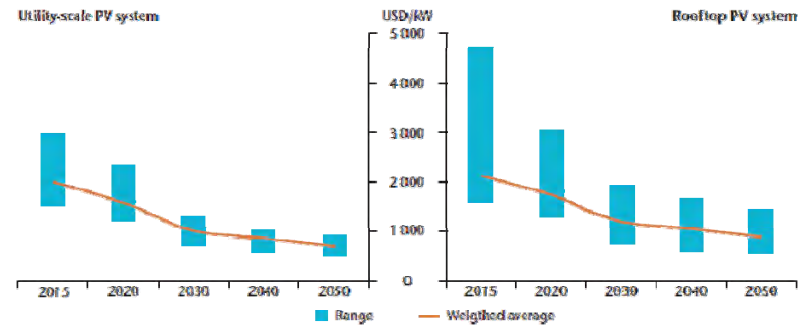


Projections of LCOE for new-built CSP plants with storage in the hi-Ren Scenario

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



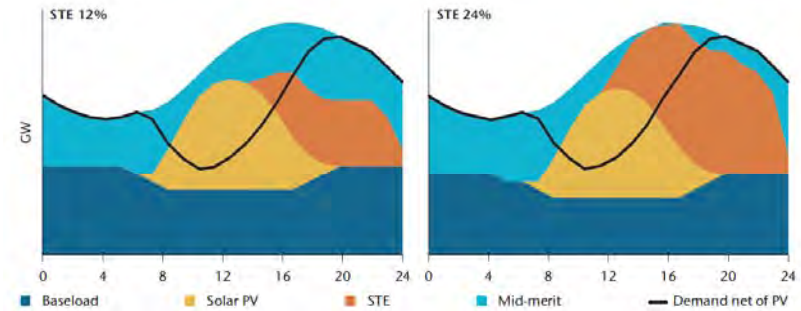
Projections for LCOE for new-built utility-scale PV plants to 2050 (USD/MWh) in the hi-Ren Scenario

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

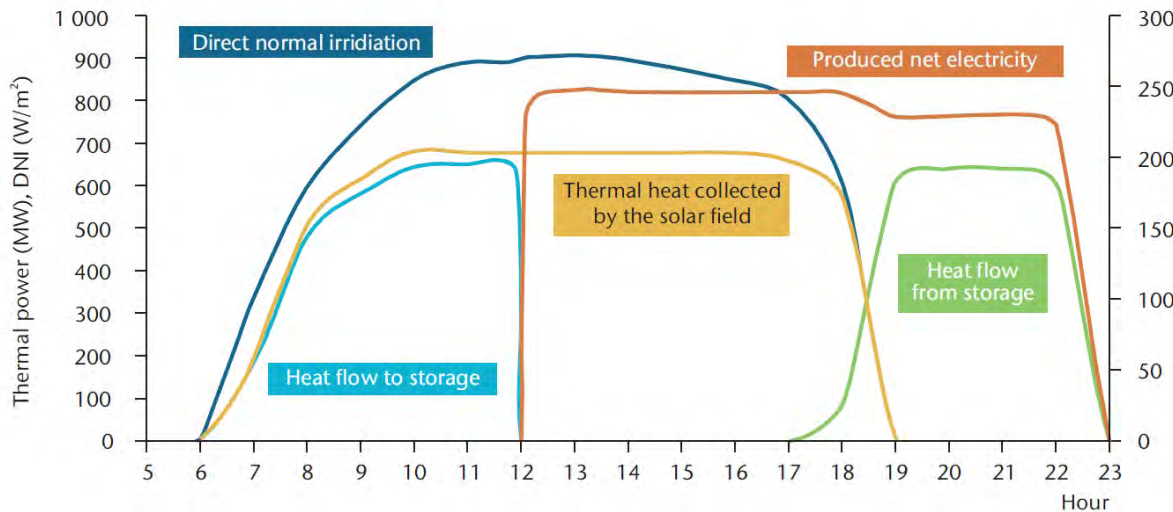


- **Thermal energy storage**

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



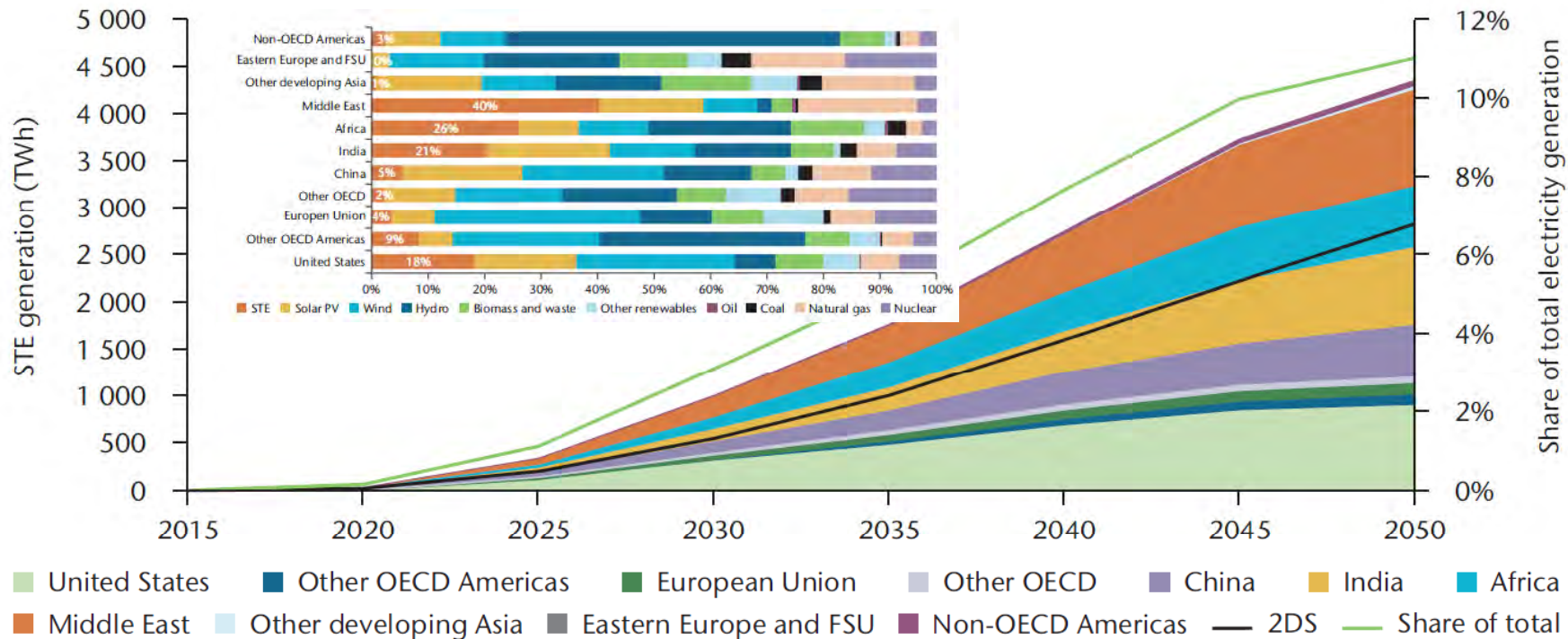
- **Grid needs flexibility – dispatchability creates value!**



STE Raodmap until 2050

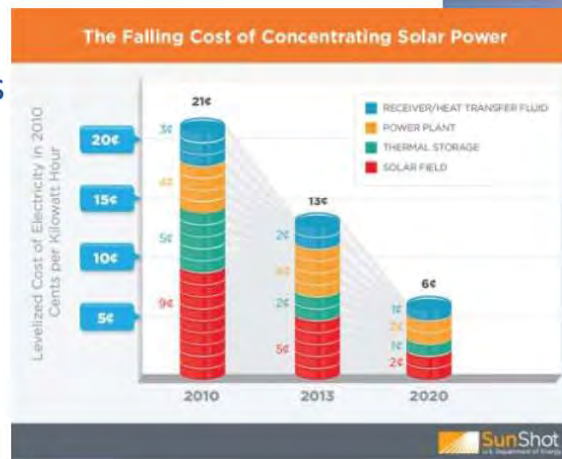
- **Policy**

- 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

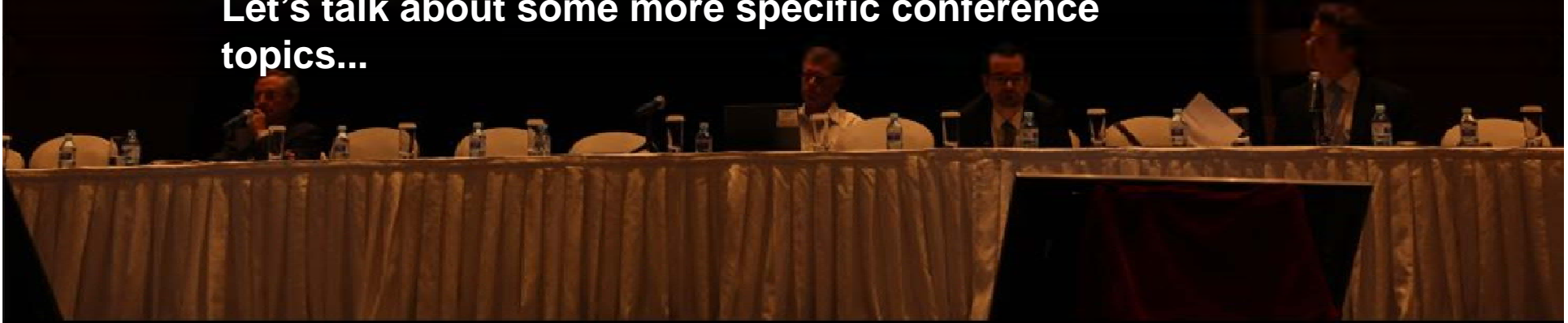


- Alternate working fluids
 - Solids
 - PCM's
 - HTF's
 - SCO₂
 - Air

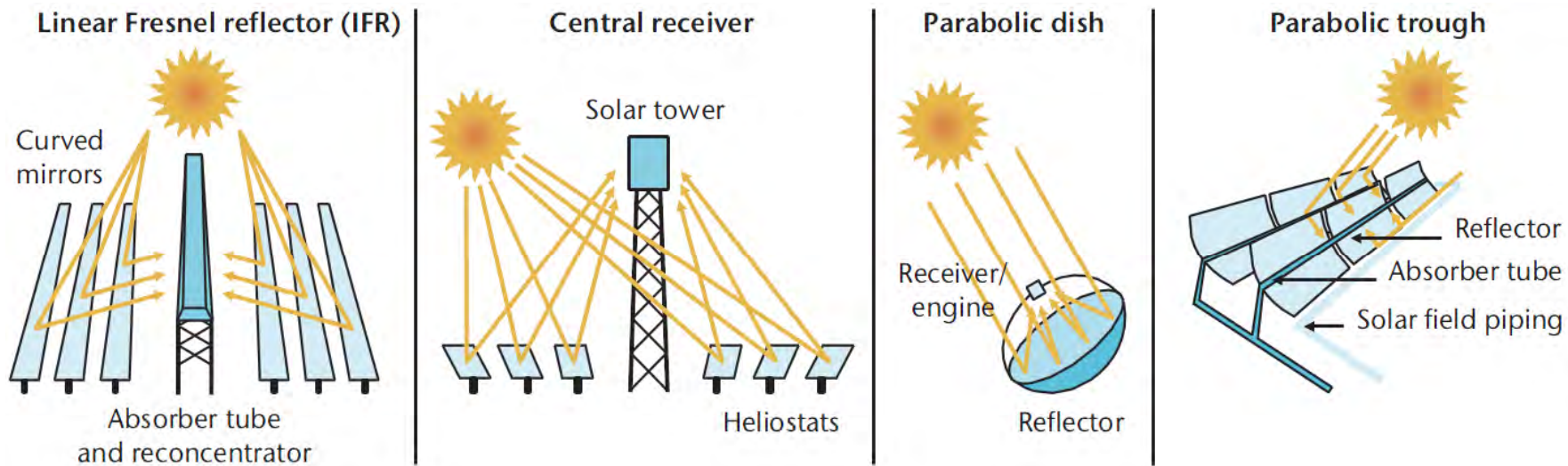


- Heat transfer fluid exit temperature from the receiver > 650°C
- Thermal efficiency > 90%
- Lifetime > 10,000 cycles
- Cost < \$150/kW_{th}

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

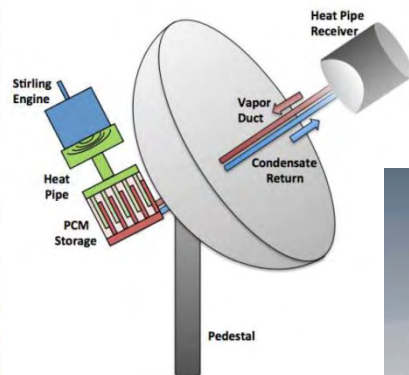


- **Thermal energy storages**
 - Salts at higher temperatures
 - PCMs at higher temperatures with large heat of fusion
 - Metallic eutectics
 - Heat pipes
 - Using solid filler materials as storage media
 - Bulks/stacks

Fraunhofer
ISE



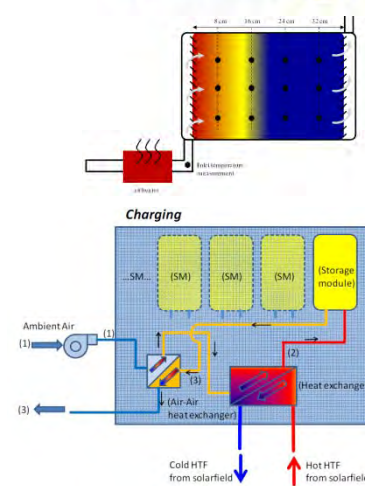
Sandia National Laboratories



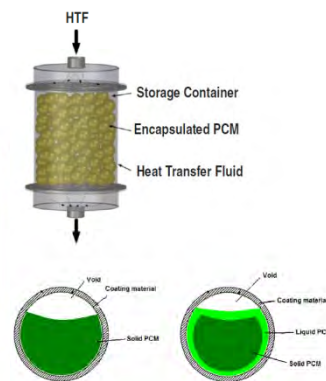
DLR



enolcon

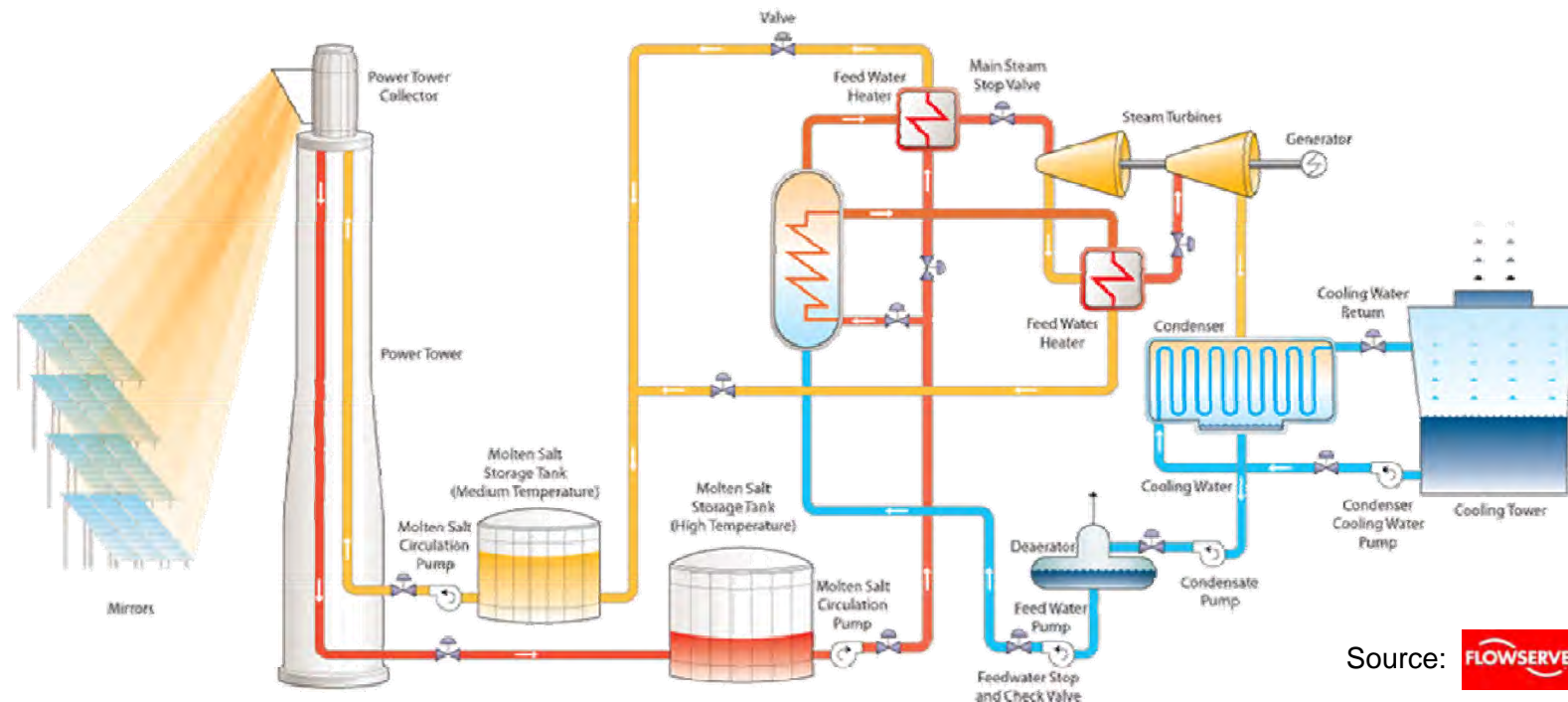


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Direct Particle Cycle

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

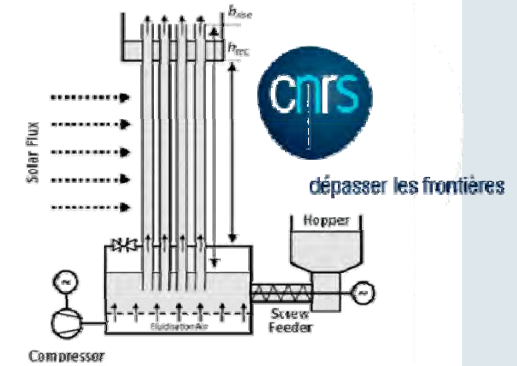
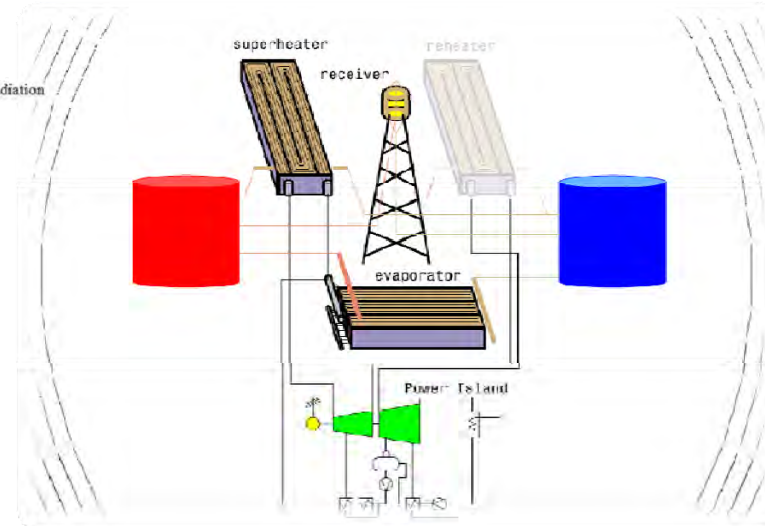
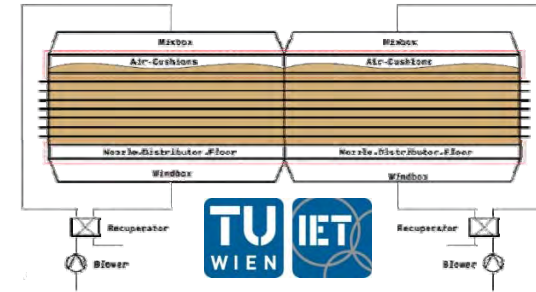
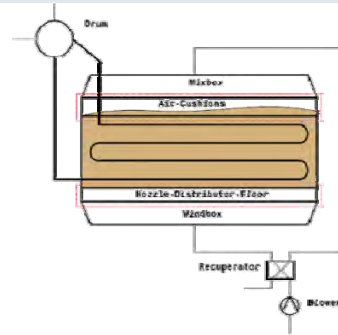
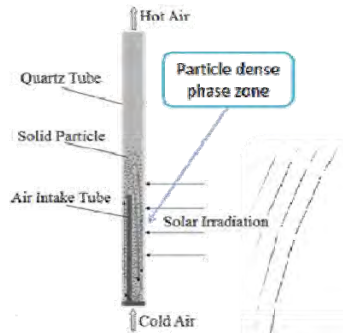


Source: FLOWERVE

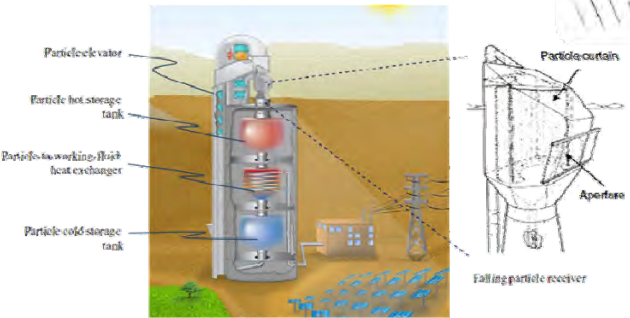
Direct particle cycle



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Thank you for your kind attention!

