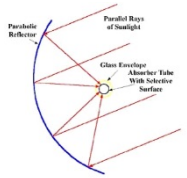
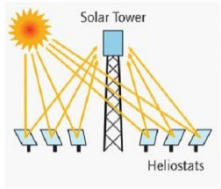
CSP Development at EU level

Experiences and lessons learned from the research perspective

Peter Heller,
CSP Seville 2017
22.-23.11.2017

Deployment of CSP





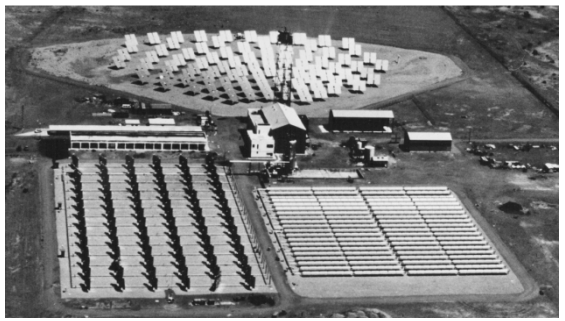
Oil Crisis 1973

Principle

1889 Solar Printing Press

Vision

Uptake



1980 SSPS, Almeria, Spain

Research Facilities

Commercial Projects

Water/Steam Cycles in towers

Storage

0.5h Steam storage

1h Steam storage

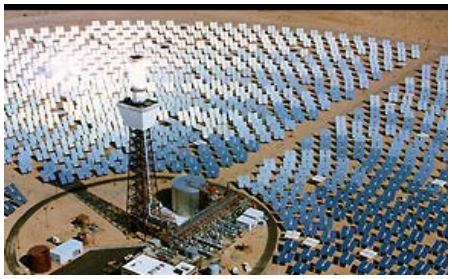
Superheated	Saturated	Superheated	Superheated
			
CESA-1n	PS10	PS20	Ivanpah

Commercial Projects

Molten Salt Cycles in towers

1983	1995	2011	2017
Themis 2 MW	(Solar-Two) 10 MW	Gemasolar 20 MW	Noor-3 150 MW
Storage	3 h Molten Salt storage	15 h Molten Salt	7h Molten Salt

Themis



Solar-Two

Gemasolar

INOOR-3

Commercial Projects

Steam Cycles in parabolic troughs

1984	1985-1990	2008	2013	
SEGS-1	SEGS-II-IX	Andasol-1	Shams-1	Solana
14 MW	30-80 MW	50 MW	100 MW	250 MW
Storage 3 h	0 h	7,5 h	0 h	6 h
Oil	(Nat. Gas)	Molten Salt	(Nat. Gas)	Molten Salt

SEGS-I-IX

Andasol-1

Solana

State of the Art Technology 2017

Solar Tower (Molten Salt)
Molten Salt Storage

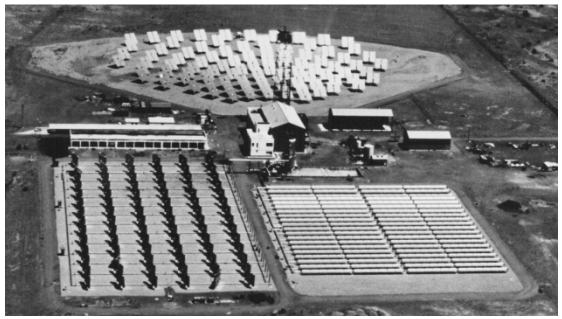
CSP with PV

Parabolic Trough (Thermal Oil)
Molten Salt Storage

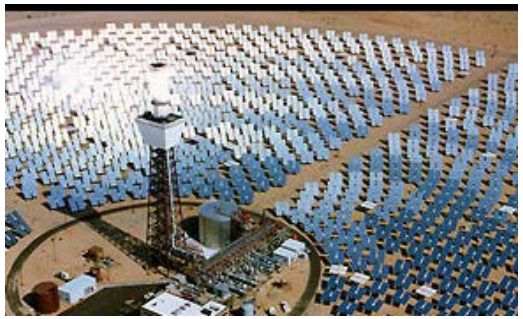
Based on R&D:

1975-1995

>20 years



SSPS, Almeria, Spain

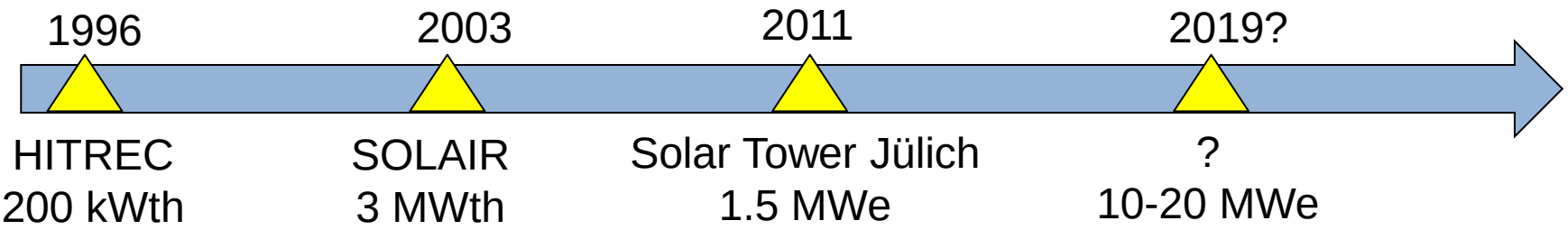


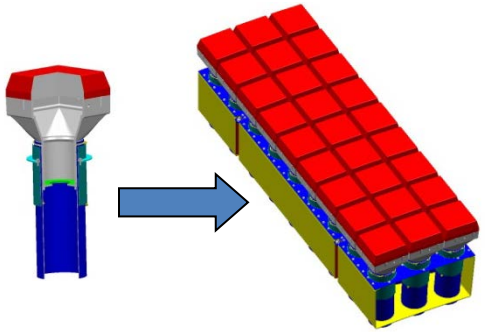
Solar-Two

Cost Reduction

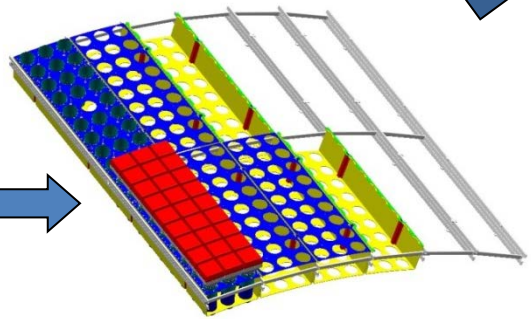
16.09.2017: DEWA awards AED14.2 billion largest CSP project in the world with a record bid of USD 7.3 cents per kW/h to generate 700MW

R&D Projects: Open Volumetric Air Receiver

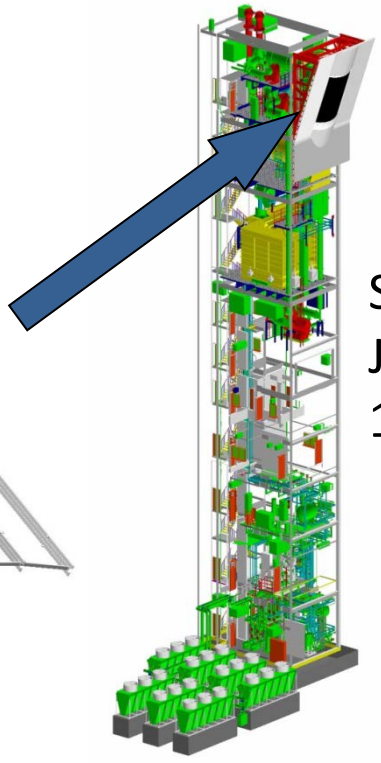




1 Cup



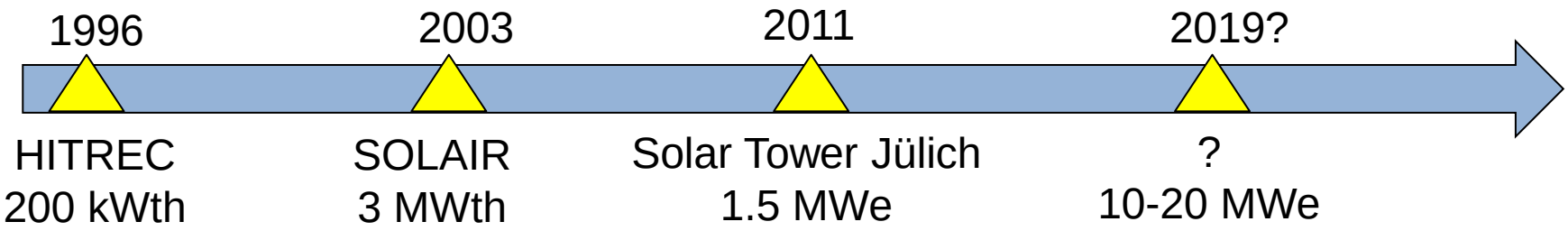
PSA Solair
3 MW_{th}



Solar Tower
Jülich
1.5 MW

……$_{th}$

R&D Projects: Open Volumetric Air Receiver



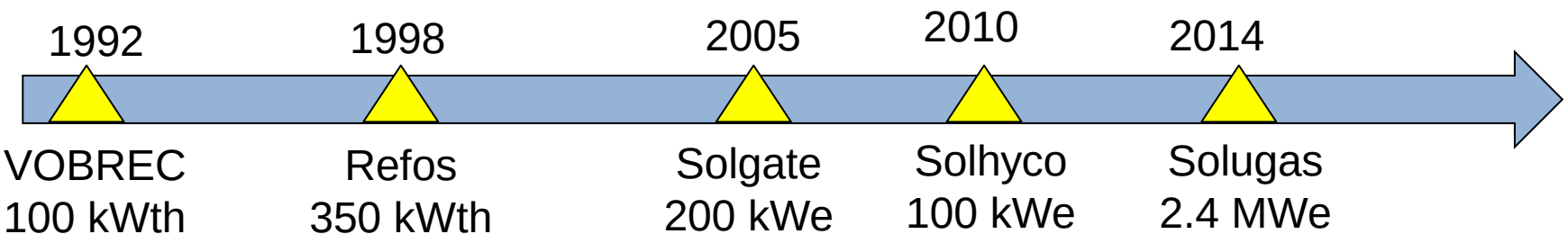
Why such slow advances:

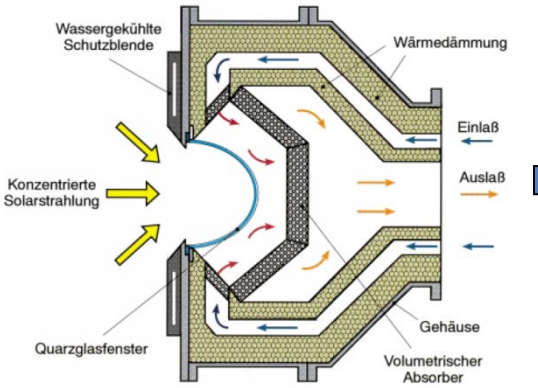
- no industrial interest 1996-2006
- several small R&D projects

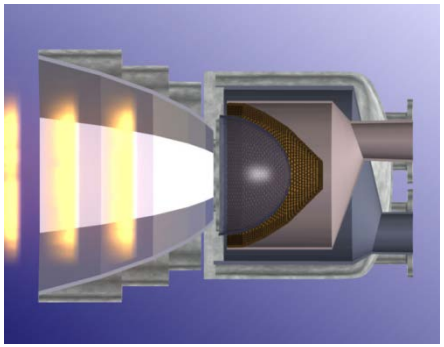
Competitive with Molten Salt Towers?

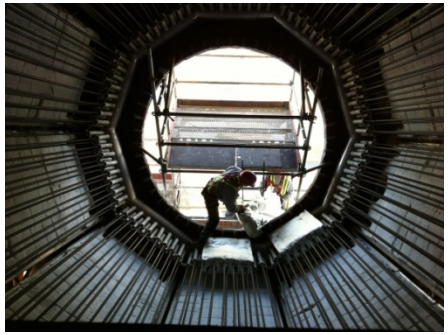
Scalability given?

R&D Projects: Solar-Hybrid Gas Turbine System





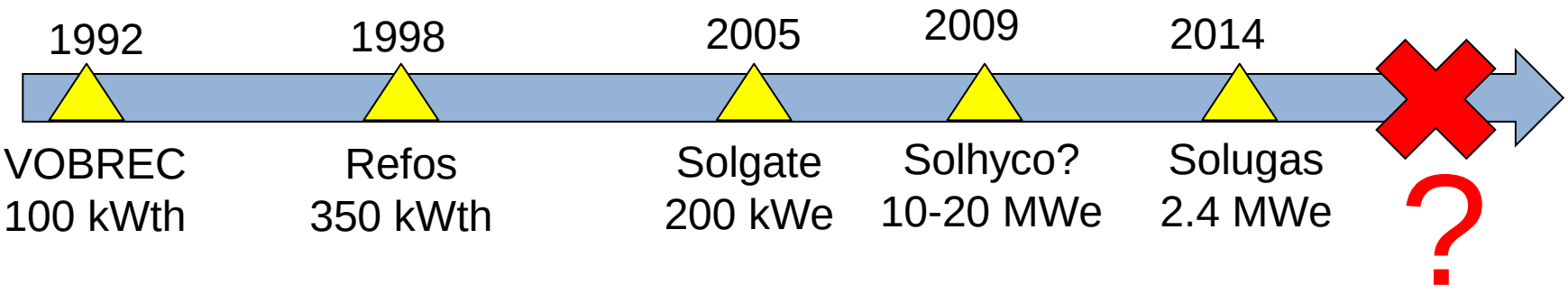




Refos/Solgate, Almeria

Solugas, Seville

R&D Projects: Solar Gas Turbine System



Receiver developments:

- volumetric pressurized ceramic receiver
- metallic tube receiver

Applications:

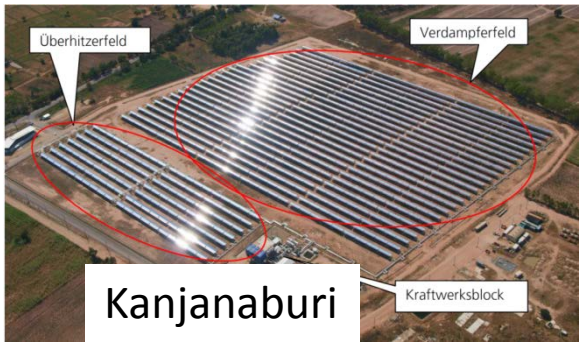
- solar hybrid gas turbine (GT or Combined Cycle)
- solar hybrid cogeneration (micro gas turbine)

Expectations:

- hybrid (fossil-solar) not „en voque“
- competitiveness unclear
- major investment necessary for next steps

Others

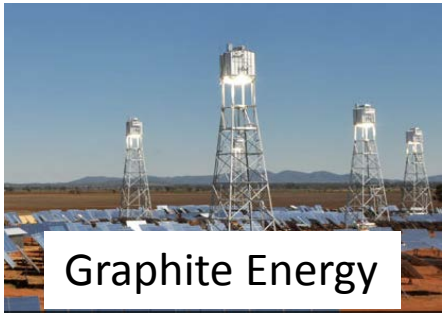
- Direct Steam Generation
- Fresnel Systems
- Dish/Stirling
- Supercritical CO2
- Liquid Metal (Sodium, Lead, …) or Graphite Receivers
- Particle Receiver
- ….

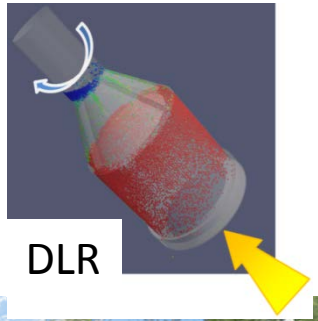


Kanjanaburi


Puerto Errado 2

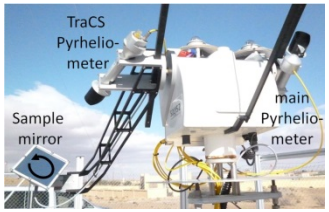

Eurodish

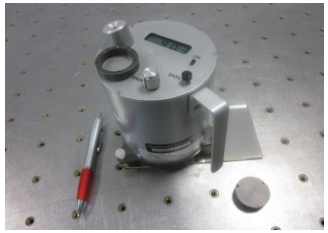

Graphite Energy


DLR

Further R&D and Services

- Project development
  - Meteo analysis: prediction of DNI, soiling, extinction, ….
- Operation:
  - Reduce water consumption
  - Predict DNI with forecast/nowcasting systems
  - Measure soiling rate, optimize cleaning
  - Monitor performance of solar field
  - Durability assessment
- Training and capacity building
  - reference course CSP
  - Training of personnel





Lessons learned

- Innovation speed >20 yrs
- Industry interest/support
- Continuity of development (support from funding agencies)
- Demonstration of new promising technologies
- Operation may be optimized
- Potential for further cost reduction

Thank you for your attention !

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