

Forschungsinfrastruktur des DLR für konzentrierende Solarchemie

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Fachkongress SolarChemieR
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Knowledge for Tomorrow



Vision und Anspruch des DLR-Instituts für Solarforschung

„Weltweit führender Systemkompetenzträger
für konzentrierende Solarsysteme“

Produkt

**Erste Adresse:
für Forschung und
Industrie**

>60% Drittmittelquote
Direktaufträge
auch aus dem Ausland
Hohe Auslastung
aller Großanlagen

2 Ausgründungen
1 xHGF Validierungs-Fond
2 xHGF Enterprise Fond
6 Technologie Lizenzverträge
10 Software Lizenzverträge

**Einzigartige F&E
Infrastruktur**

Solarturm Jülich
Zugang zur PSA
Sonnenofen/ Synlight
Quarz®

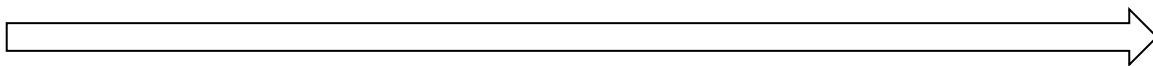
Exzellente Forschung

Bestnoten in Begutachtungen
2 HGF Virtuelle Institute; 1 HGF Allianz
2x DLR Center of Excellence
Descarte Preis der EU (2006)

Idee

Research Facilities for Concentrated Solar Chemistry

Idea



Product

Laboratory Scale

Large-Scale Demonstration

Solar Furnaces (natural light)

Research Platforms etc. (natural light)

High-Flux Solar Simulators (artificial light)

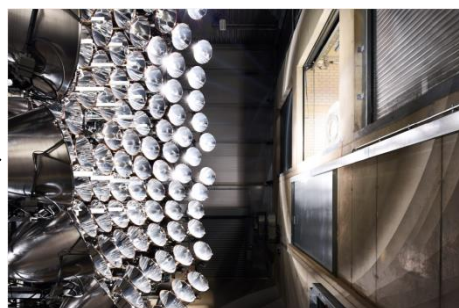
20 - 25 kW_{rad}

300 – 400 kW_{rad}

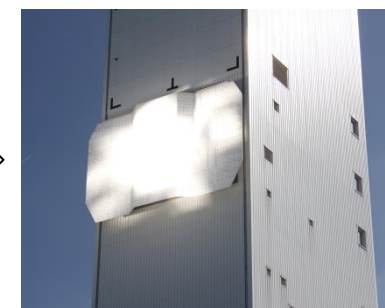
1000 – 2000+ kW_{rad}



Factor ~10



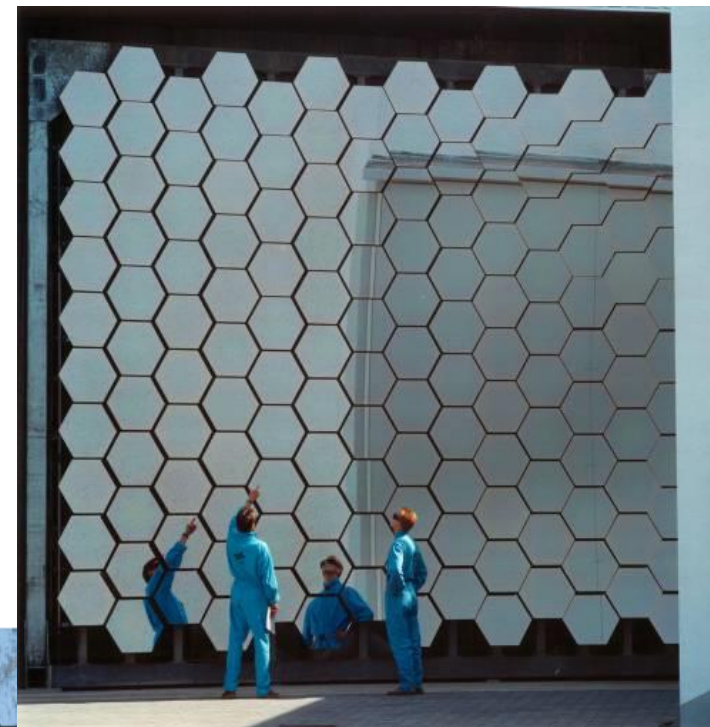
Factor ~10



DLR Research Infrastructure for Solar Chemistry is unique in the world

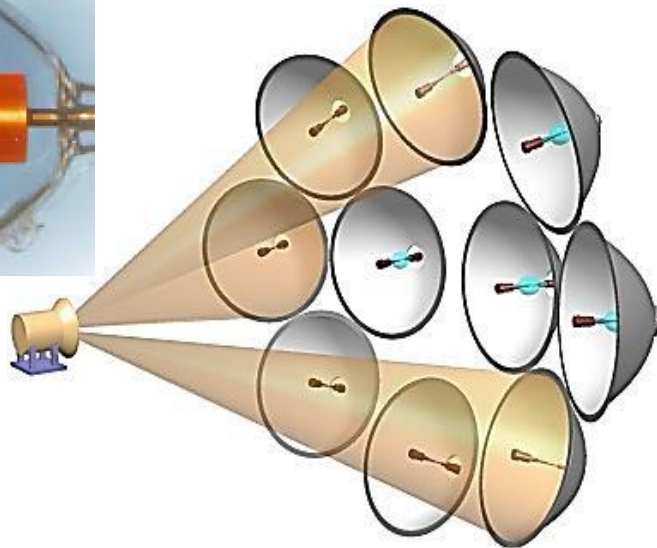
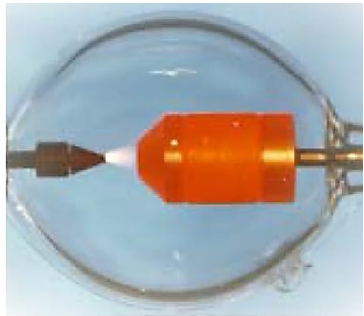


Laboratory Scale: 25 kW High-Flux Solar Furnace (DLR Cologne)

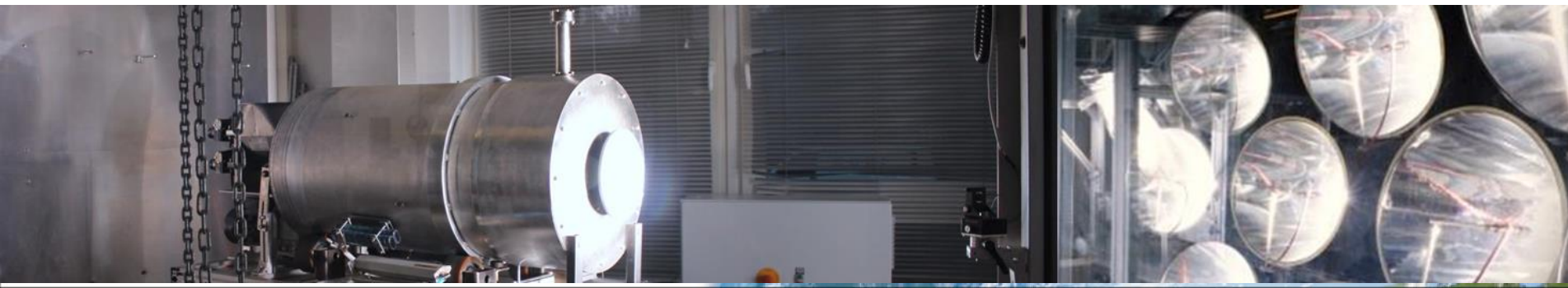
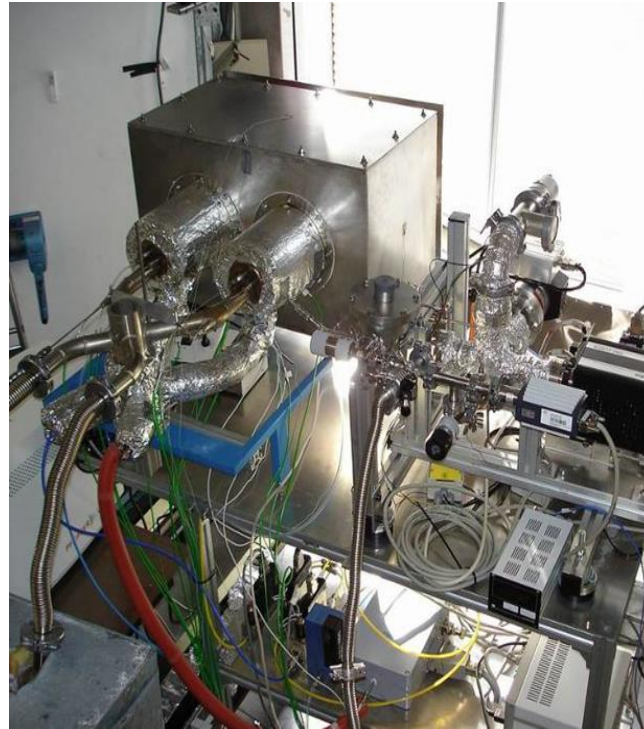
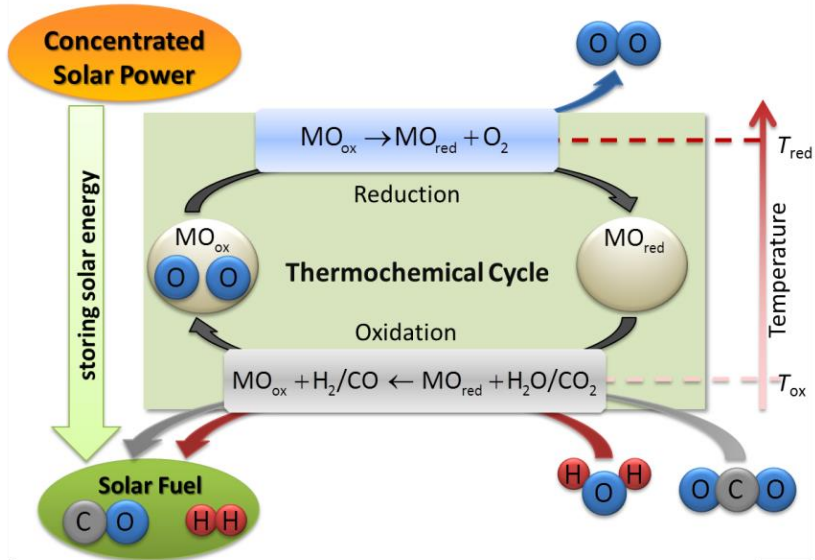


Laboratory Scale: 20 kW Xenon-High-Flux Solar Simulator (DLR Cologne)

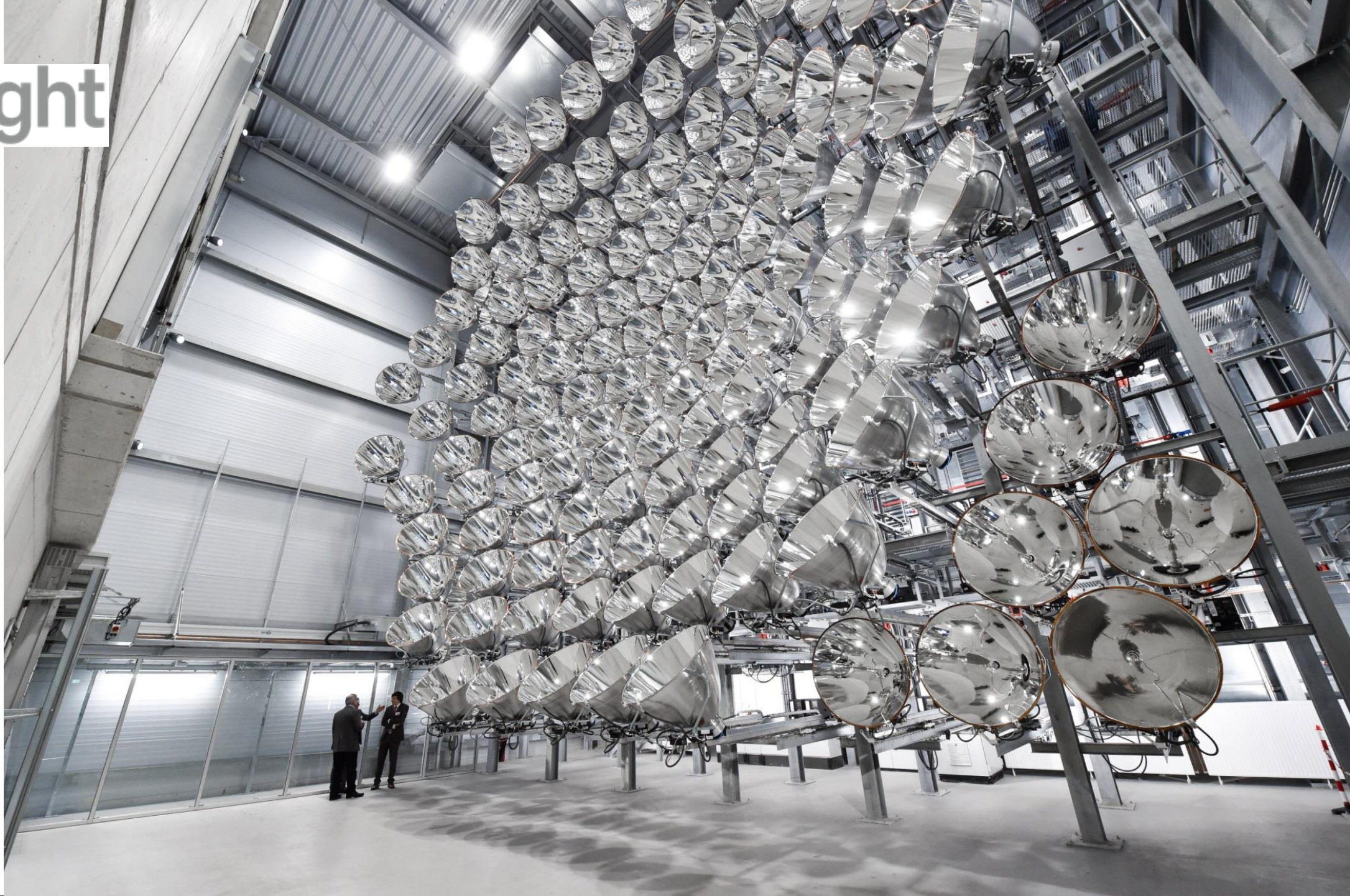
- Artificial light: consistent & unlimited
- 10 x 6 kW_{el} Xenon short-arc lamps
- Commercial cinema lamps:
Light spectrum close to sunlight



Laboratory Scale: Examples of Solar-Chemical Experiments



synlight

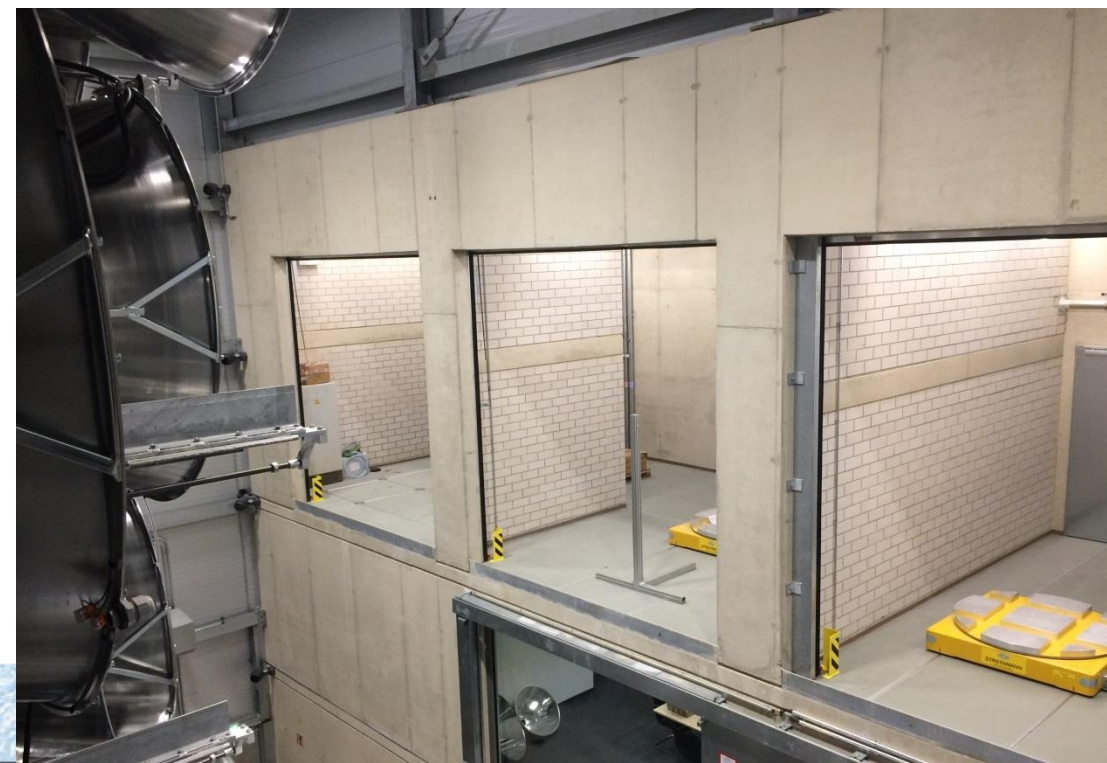
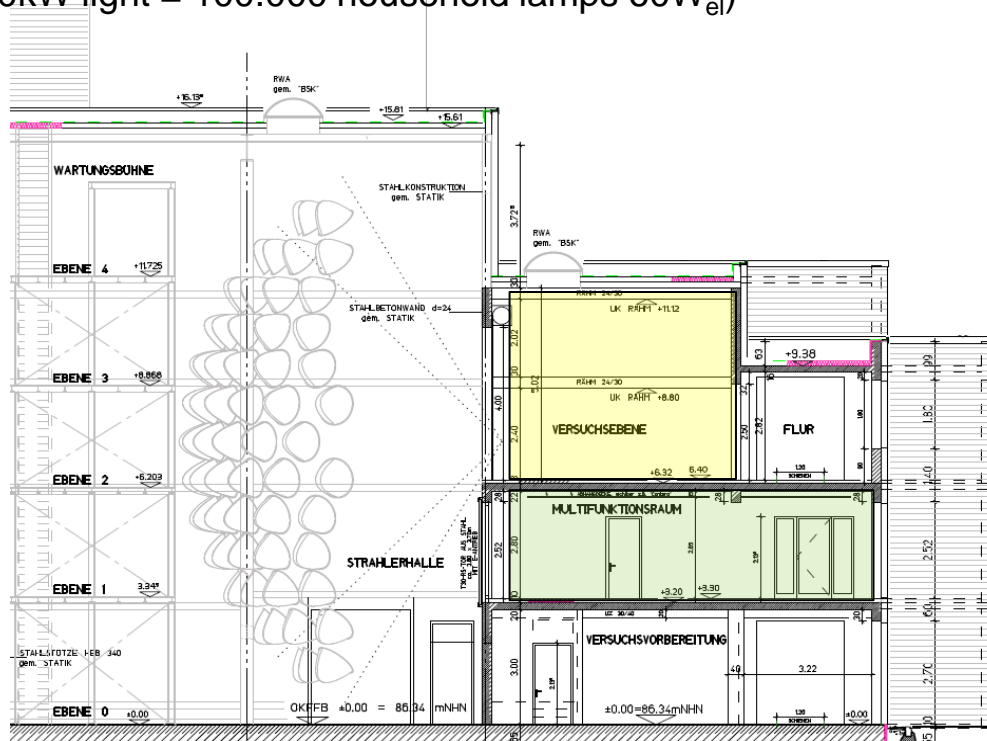
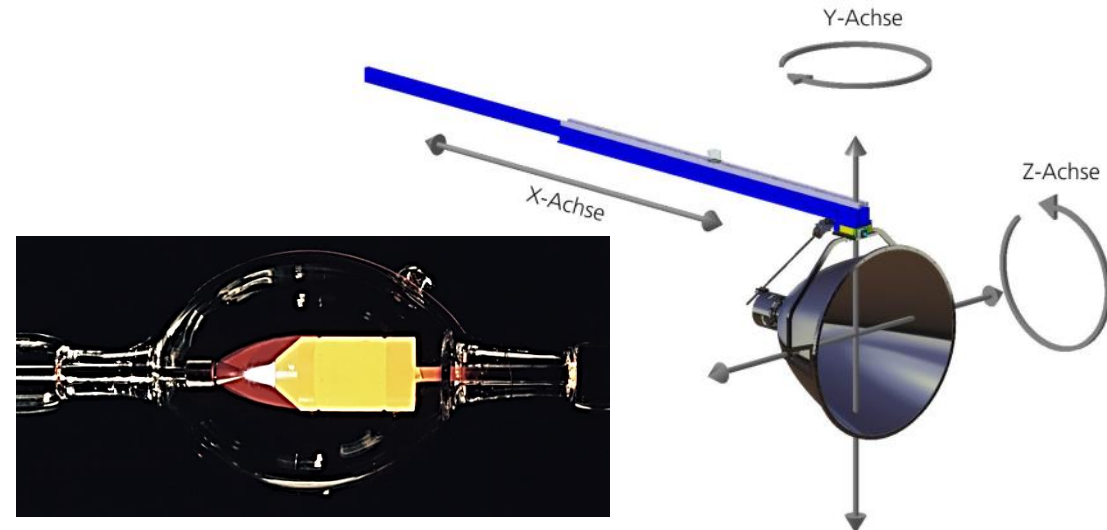


synlight

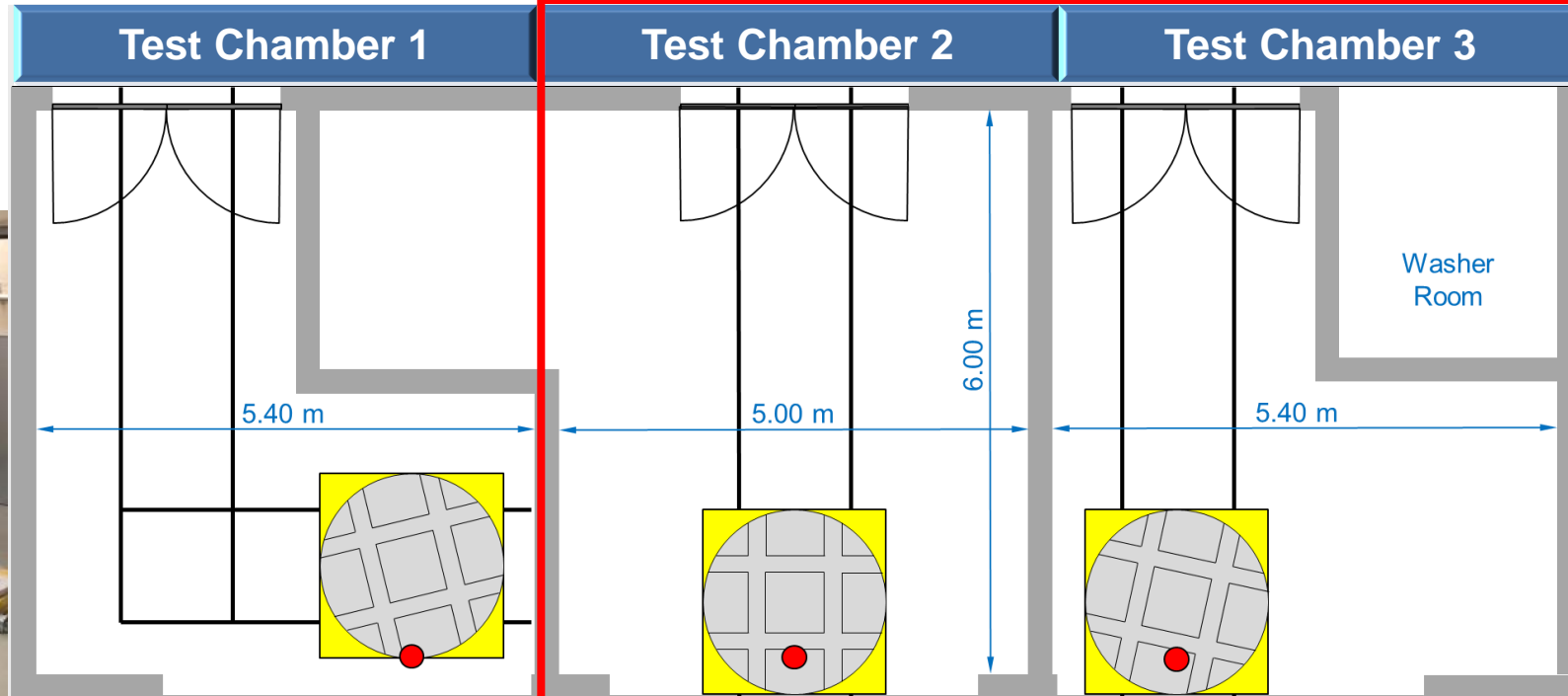




- 149 identical modules, computerized adjustable in 3 axis
- 7kW_{el} - (10kW_{el} -) Xenon cinema lamps as light sources with a light nearly equal to the solar spectrum
- Light concentration up to 12.500 times / $>3000^{\circ}\text{C}$
- Building with 3 test chambers, independent operation, specially equipped
- Validated radiation powers: 240kW / 310kW / 240kW (maximum with 10kW_{el} bulbs: 320kW / 400kW / 320kW)
(Note: 300kW light = 100.000 household lamps 60W_{el})



Synlight: Technical Profile



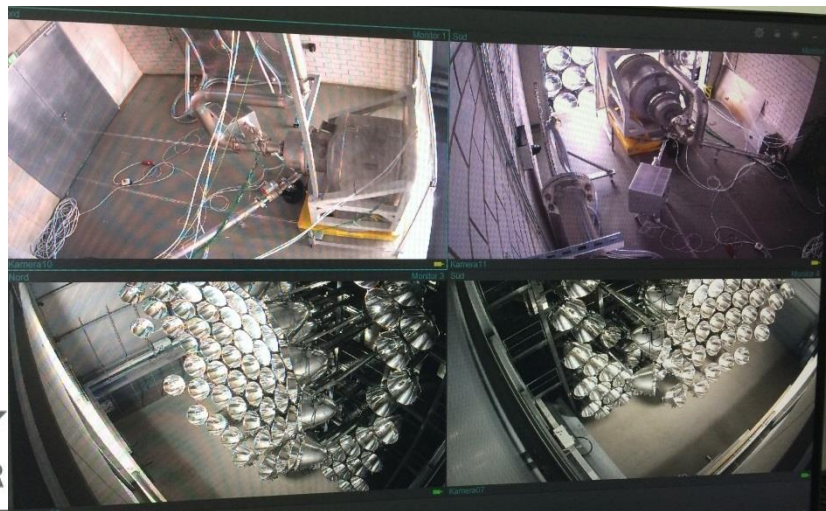
# of Xenon lamps to be focused on reference points	96	121	96
Max. solar radiation power with 7kW_{el} standard lamps	$240\text{ kW}_{\text{rad}}$	$310\text{ kW}_{\text{rad}}$	$240\text{ kW}_{\text{rad}}$
Expected max. radiation power with 10kW_{el} lamps	$320\text{ kW}_{\text{rad}}$	$400\text{ kW}_{\text{rad}}$	$320\text{ kW}_{\text{rad}}$
Peak flux with 7kW_{el} standard lamps	$10.0\text{ MW}/\text{m}^2$	$12.5\text{ MW}/\text{m}^2$	$10.0\text{ MW}/\text{m}^2$
Maximum aperture size of a test object		$4\text{ m} \times 4\text{ m}^*$	
Maximum weight of a test object	$>4\text{ t}^*$	$>6\text{ t}^*$	$>4\text{ t}^*$
Test chamber dimension	$25\text{ m}^2 \times 4.5\text{ m}$	$38\text{ m}^2 \times 4.5\text{ m}$	$26\text{ m}^2 \times 4.5\text{ m}$
Standard equipment in each test chamber	AC power up to 400V/63A, Ethernet 1Gbit/s, ventilation air flow $5\text{ m}^3/\text{s}$, water 100L/min		
Special equipment	Lamps w. high UV proportion	Solar chemical applications w. connection to washer room	

Synlight is a unique Facility

Worldwide existing High-Flux Solar Simulators, Point-focusing $>10\text{kW}_{\text{rad}}$, Data from current publications

High-Flux Solar Simulator	Started	Solar Power [kW]	Electric Power [kW]	Lamps	Peak Flux [MW/m ²]	SB Temp.** [°C]	
DLR, Synlight, Jülich	2017	310 (400)* 240 (320)* 240 (320)*	149 x 7 (149 x 10)	Xe	12.5 10.0 10.0	3580 3370 3370	
Niigata University, Beam-down HFSS	2013	30	19 x 7	Xe	3.2	2470	
KTH Stockholm, Fresnel lens HFSS	2014	20	12 x 7	Xe	6.7	3020	
CERTH, Thessaloniki	2013	20	11 x 6	Xe	4.8	2760	
DLR, HLS, Cologne	2007	20	10 x 6	Xe	4.1	2660	
North China Electric Power University, Beijing	2016	20	7 x 10	Xe	4.0	2630	
EPFL Lausanne, LRESE	Same design	2015	15	18 x 2.5	Xe	21.7	4150
Australian National Univ., Canberra		2015	15	18 x 2.5	Xe	9.5	3320
University of Minnesota, Minneapolis	2010	15	7 x 6.5	Xe	7.3	3100	
University of Florida, Gainesville	Same design	2011	14	7 x 6	Xe	5.0	2790
Georgia Tech, Atlanta		2011	14	7 x 6	Xe	5.0	2790
IMDEA, Móstoles/Madrid	2013	14	7 x 6	Xe	3.6	2550	
Swinburne University, Melbourne	2015	12	7 x 6	MH	0.9	1740	
University of Colorado, Boulder	2016	10	18 x 2.5	Xe	*	*	

First Solar Hydrogen Reactors in Synlight

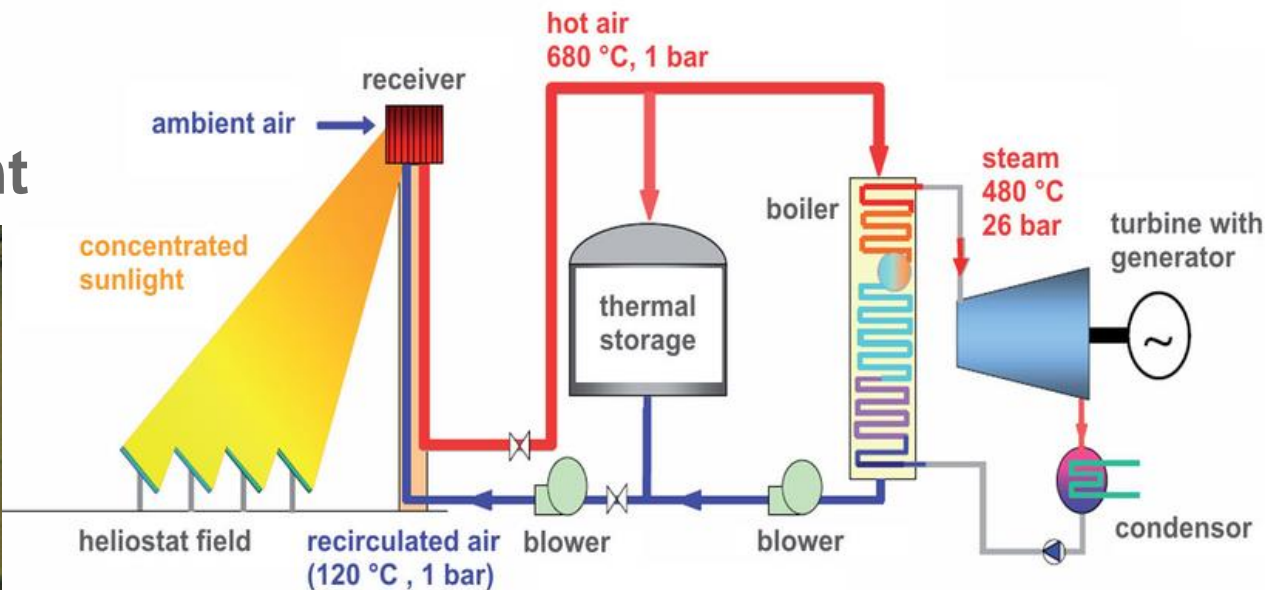


How Powerful is Concentrated Sunlight: Melting of a Steel Plate in Synlight

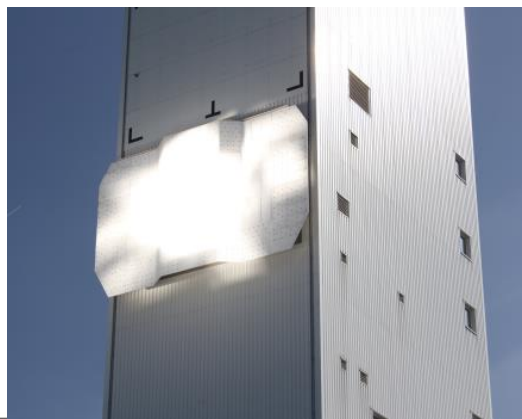
- Melting temperature of carbon steel: $\sim 1500^{\circ}\text{C}$
- Plate thickness: 50 mm
- 120 lamps are focused to the plate
- Their total light power is 300 kW
- 1st drops after 12 s
- Hole occurs after 2 min



Large-Scale Demonstration: Jülich Solar Tower Demonstration Plant

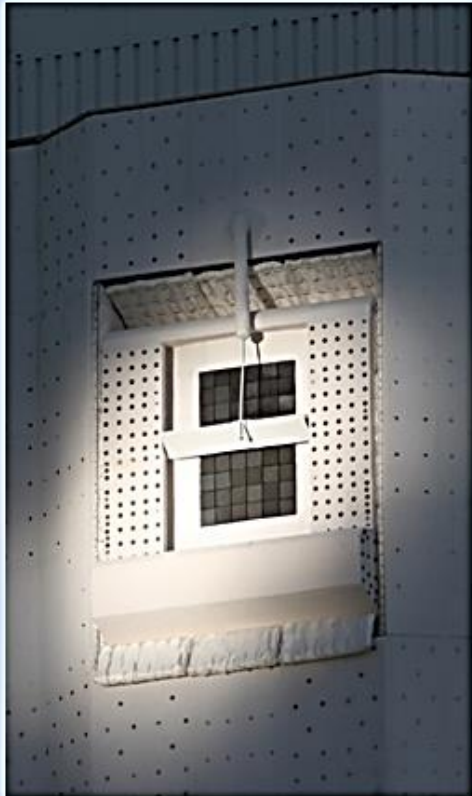


- Commissioned in 2009
- >2000 heliostats / 18.000m²
- 8,2 MW_{th} / 1,5 MW_{el}
- 1 hour thermal storage
- **Research platform**
1 MW_{rad}

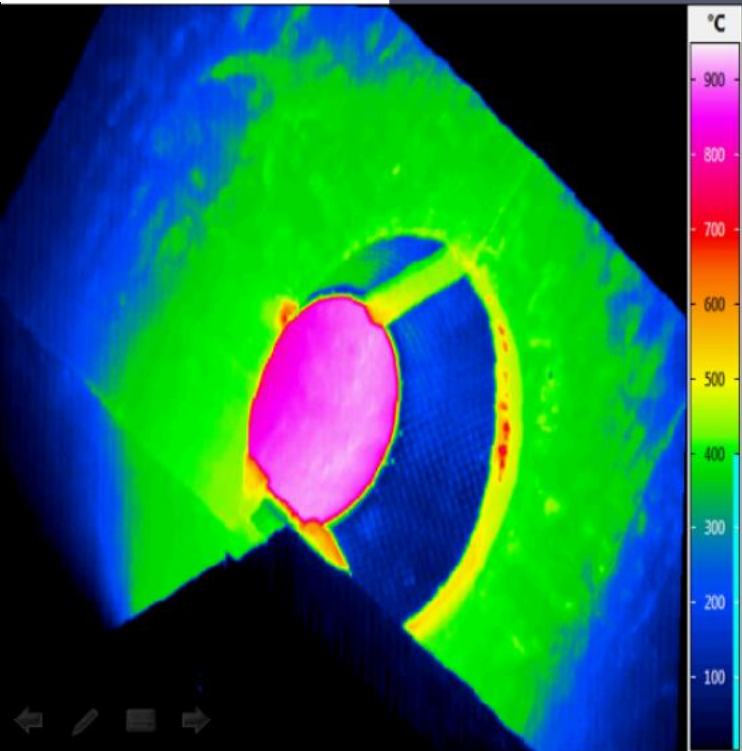
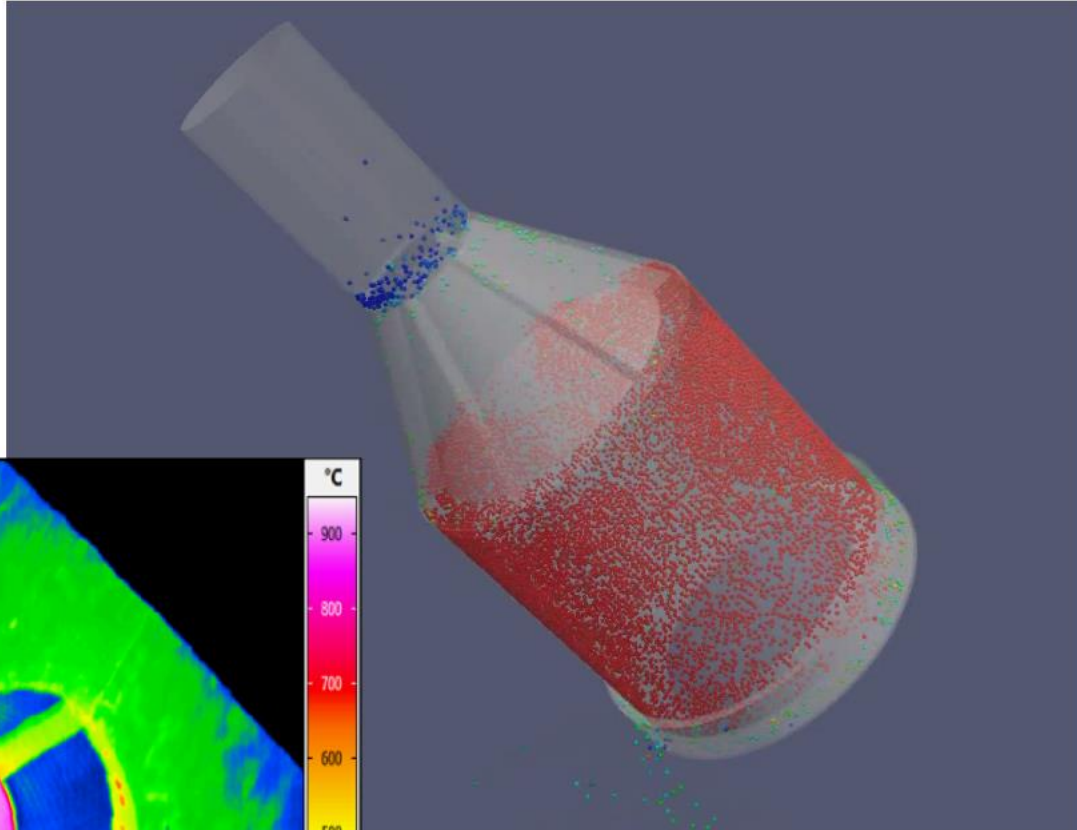


Projects on Jülich Solar Tower Research Platform

Year	2013	2014	2015	2016	2017	2018
Project	INDUSOL/SiBopS		MetRec	Sol2Hy2	CentRec	

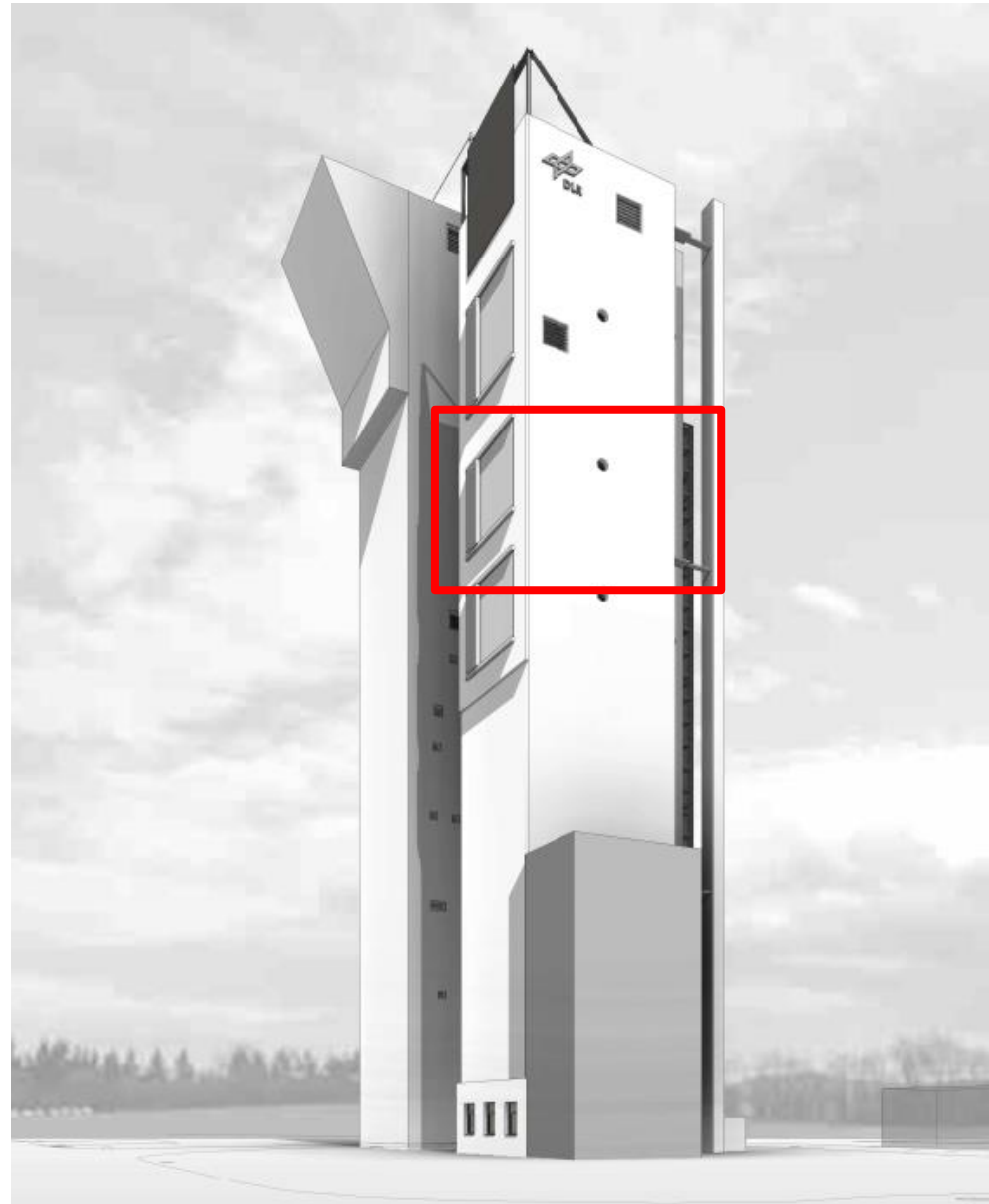


Centrec Particle Receiver Test (2018)



Large-Scale Demonstration: Multi Focal Tower (MFT)

- Additional tower in Jülich, commissioning in 2020
- 3 research platforms, one equipped for solar chemical applications
- >2000 kW radiation power
- For large and heavy experiments (up to 100t)
- Separate control rooms, protected data access
- Various technical gases



Overview: DLR Research Facilities for Concentrated Solar Chemistry

Research facility	High-flux solar simulator HLS	High-flux solar furnace SOF	High-flux solar simulator Synlight		Jülich Solar Power Tower	Multifokus Tower (starting 2020)
			Test chamber 3	Test chamber 2	Research platform	Platform 2
DLR site	Cologne, Germany		Jülich, Germany		Jülich, Germany	
Sunlight / average availability	artificial / unlimited	natural / ~90 d/a	artificial / unlimited		natural / ~90 d/a	
Max. solar power [kW]	20	25*	240 (320)	310 (400)	1000*	2000*
Peak flux density [MW/m ²]	4.1	5	10	12.5	1	1
Max. aperture (width x height) [m x m]	0.5 x 0.5	0.5 x 0.5	2 x 2 (4 x 4)		7 x 3	4 x 4.5
Useable test space (area x height) [m ² x m]	13 x 3.3	29 x 3.3	26 x 4.5	38 x 4.5	90 x 3	64 x 7
Max. weight of test object [t]	0.3	0.3	2.5 (4)	2.5 (6)	10	100
Cooling	heat exchanger up to 60kW		air cooling up to 5m ³ /s, additional water cooling supply		water cooling 2 MW	water cooling 2 MW + air ventilation up to 4m ³ /s
Connections	AC 400V/63A and 230V/10A, water 8L/min, Ethernet 1Gbit		AC 400V/63A and 230V/10A, water 100L/min, CH ₄ , Ethernet 1Gbit		AC, water, CH ₄ , press. air, Ethernet	AC (100kW + 20kW UPS), water 60L/min, techn. gases**, Ethernet
DLR contact	Gerd Dibowski		Dmitrij Laaber		Felix Göhring	

* at 850 W/m² direct normal irradiation** CO₂, CH₄, N₂, H₂, O₂, He, SO₂, press. air

Values in grey are not validated so far.

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