International Overview and IEA STE Roadmap

ASTRI 2015 Annual Workshop

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- The Sun as an energy source
- STE Plant concept
- STE Technologies
- The value proposition of STE technologies
- Commercial STE deployment
- IEA technology roadmap for STE
- Overview of STE and CST research

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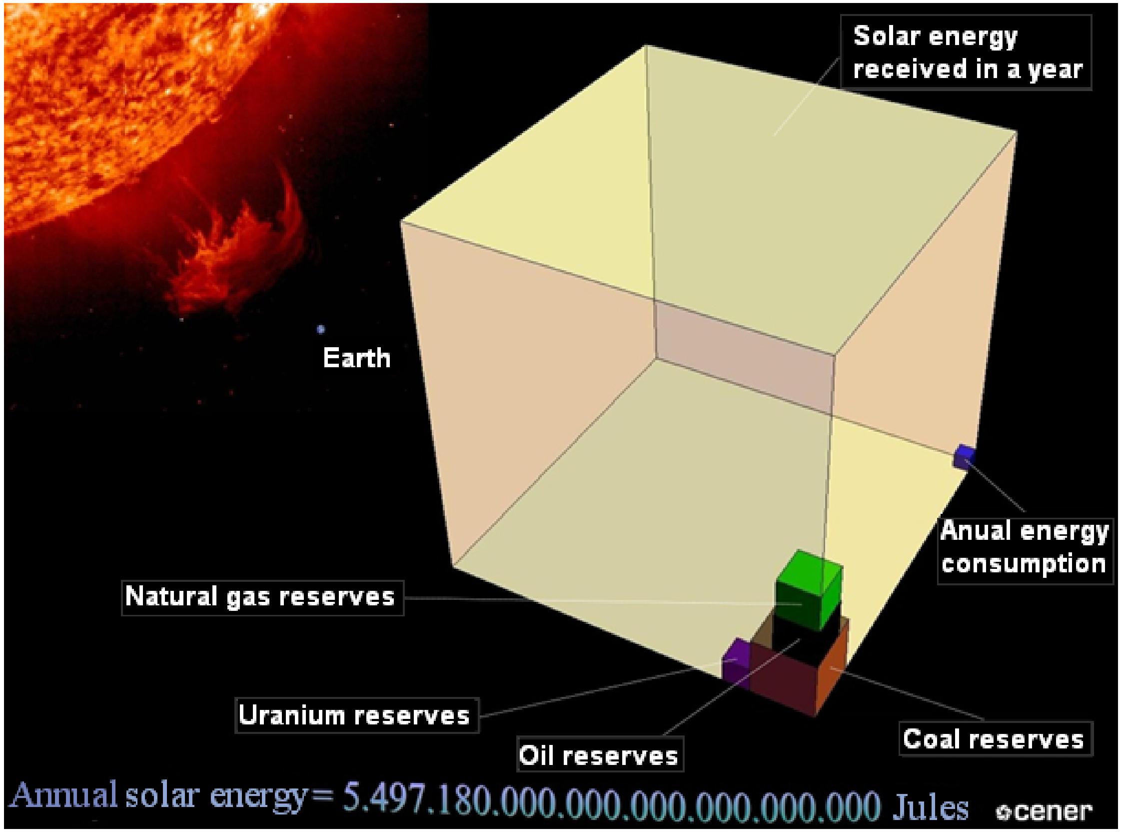
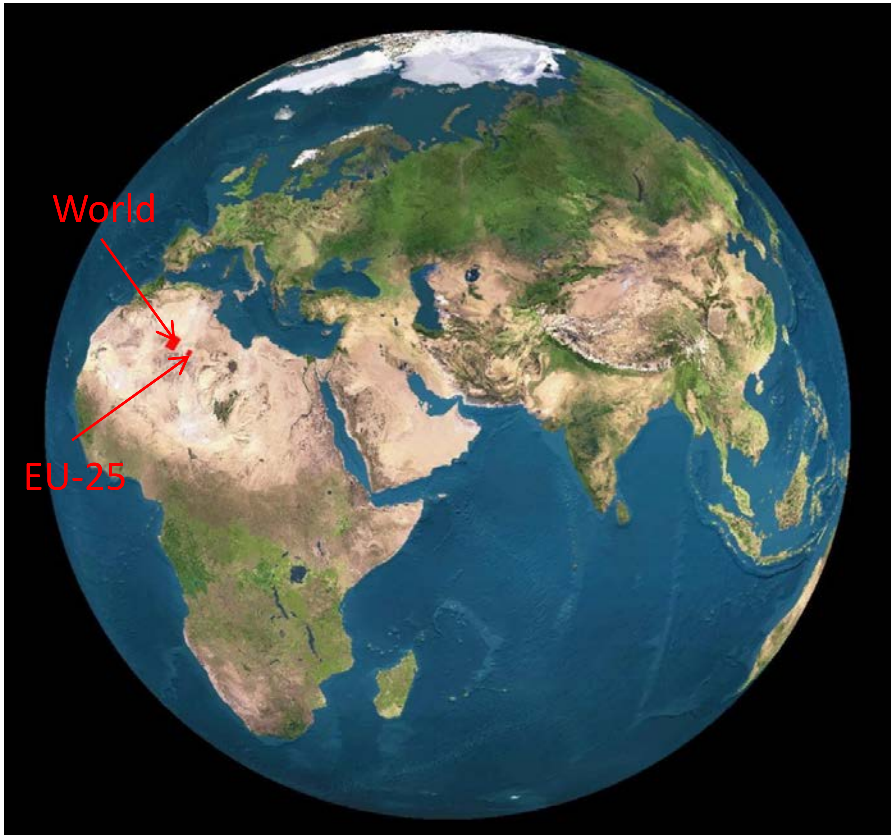
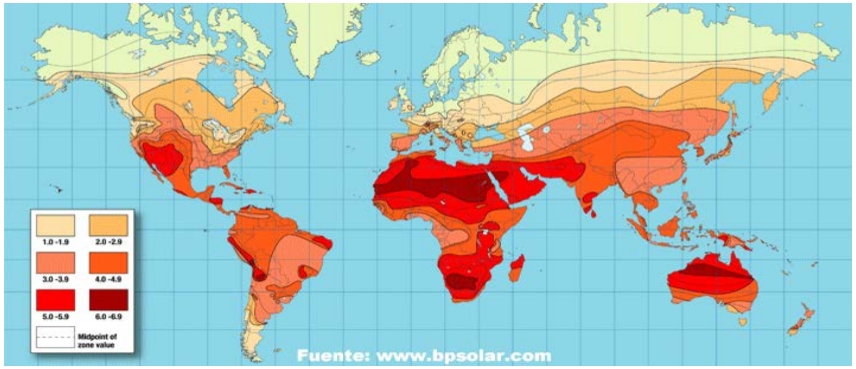
The Sun as an energy source

- Life on Earth is powered and modulated by the Sun.
- The Sun is by far the most important energy source available to us.

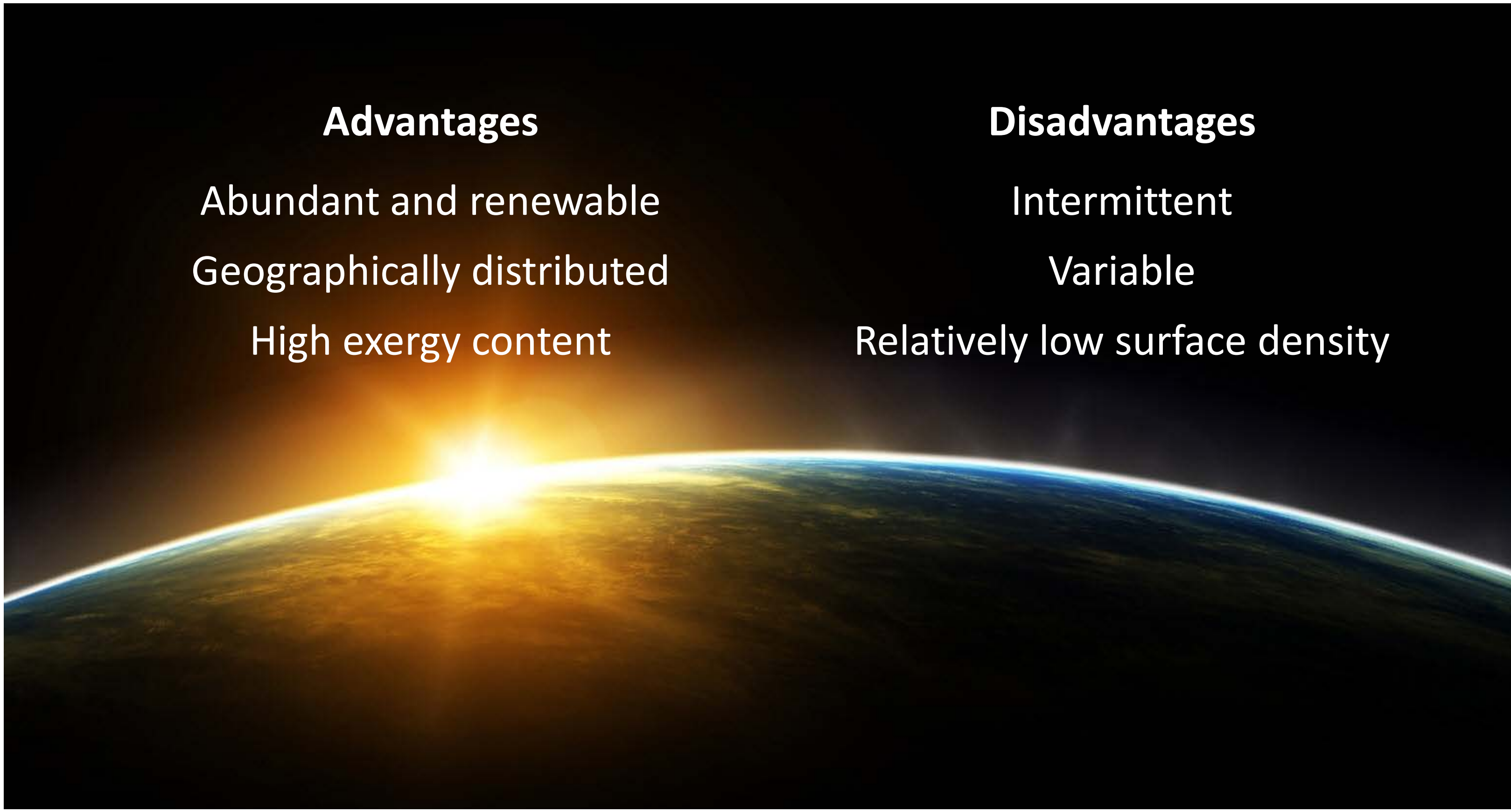


The Sun as an energy source





The Sun as an energy source



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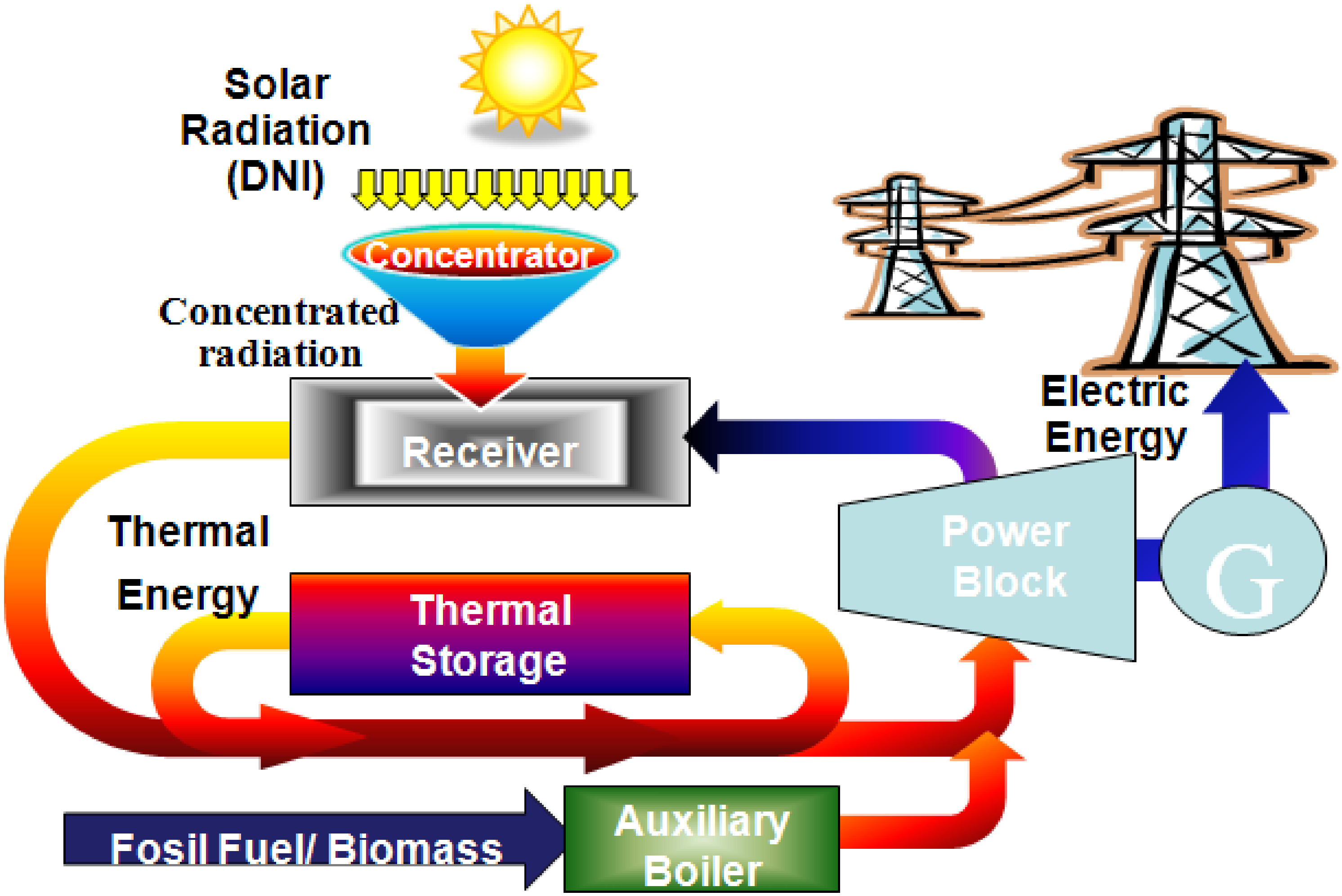
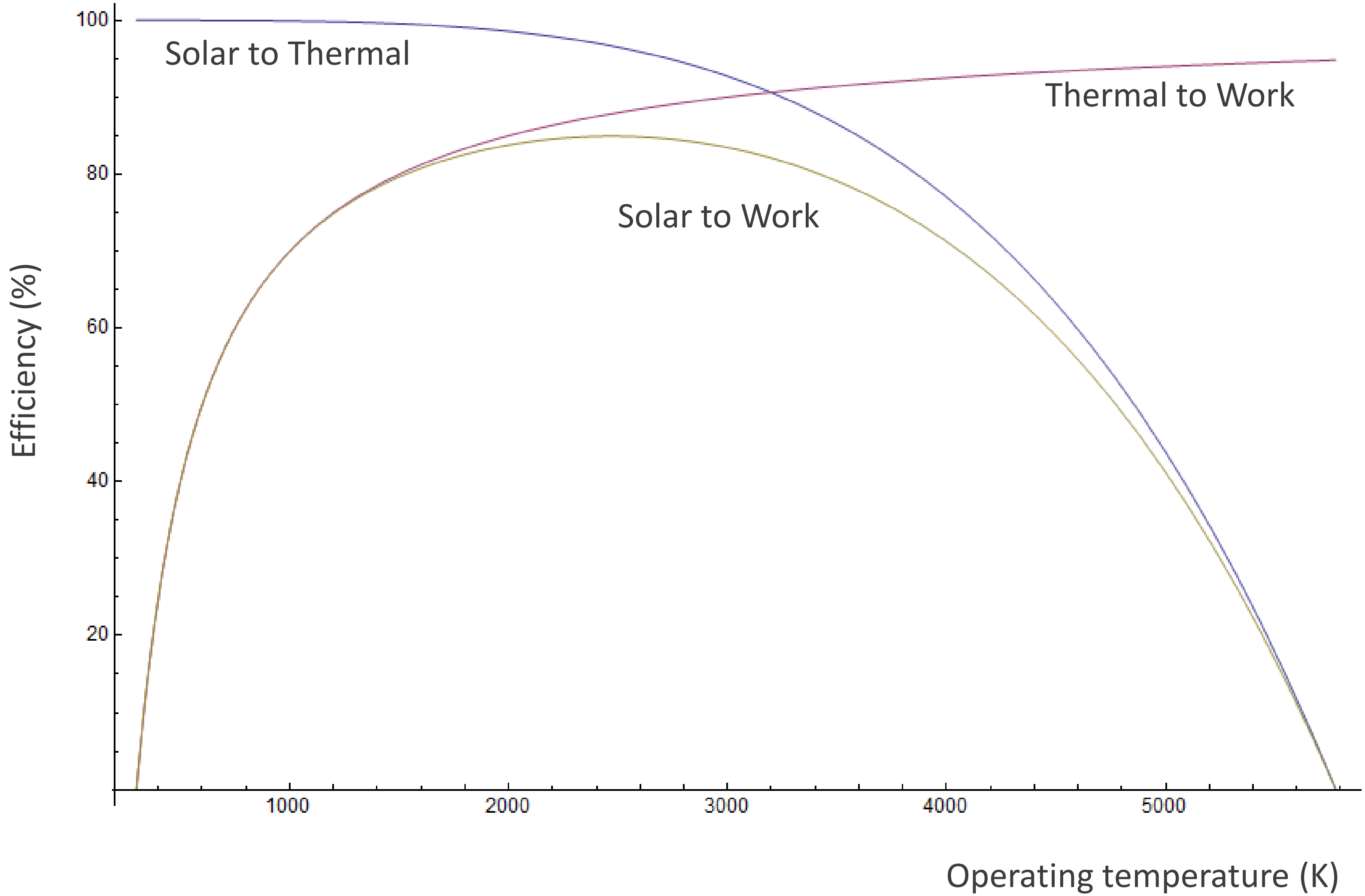
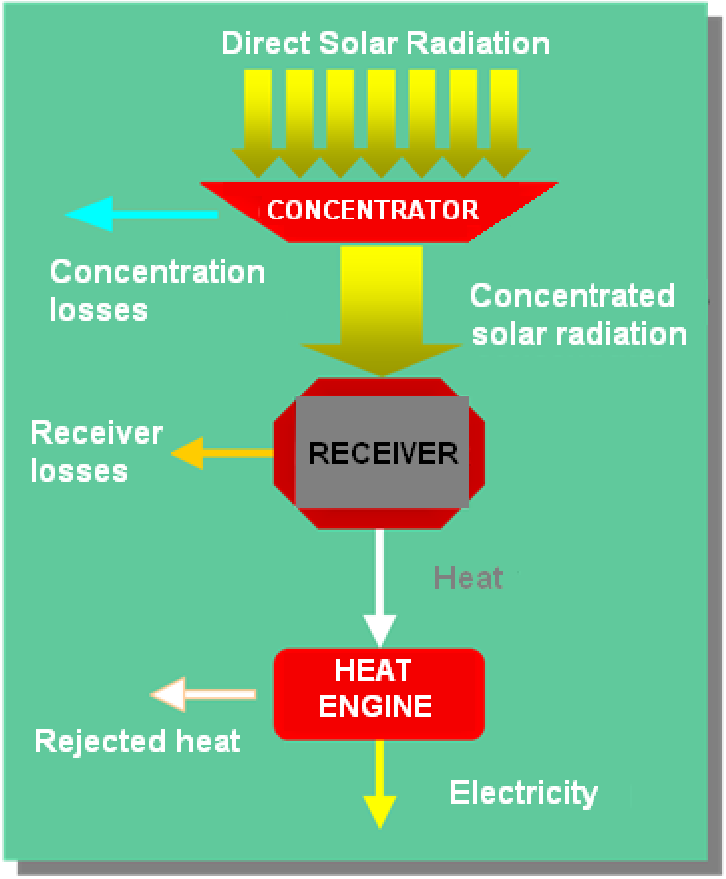
STE plant concept

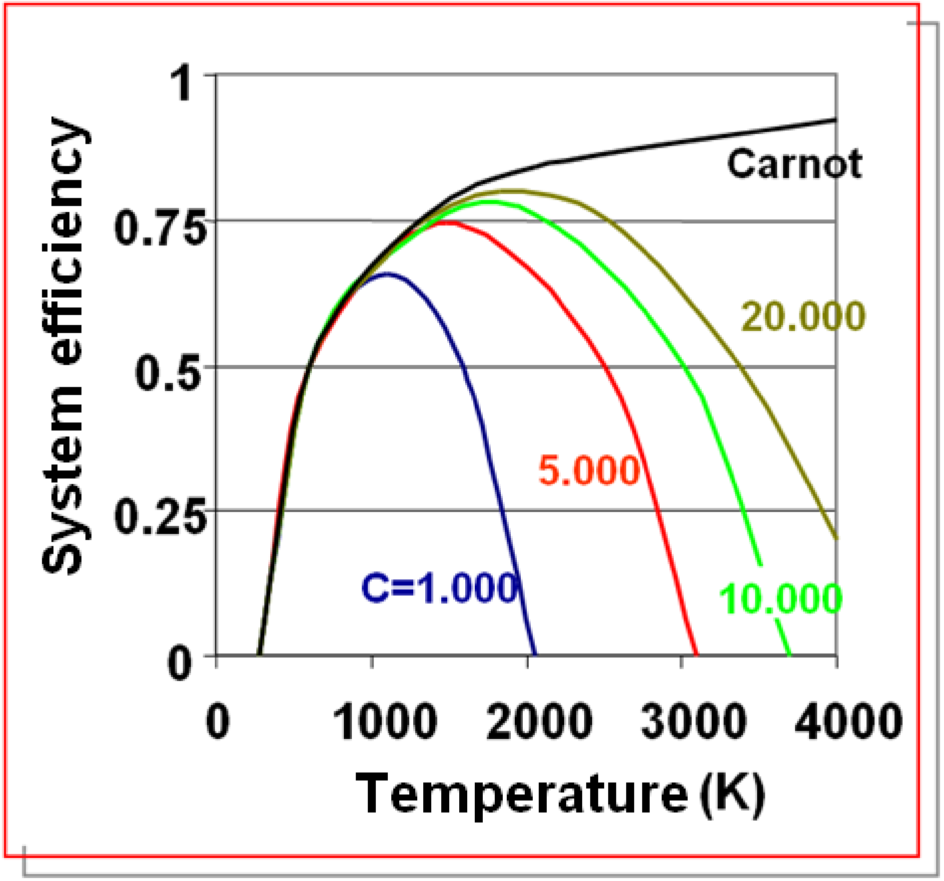


Efficiencies trade-off



The case for the concentration of sunlight





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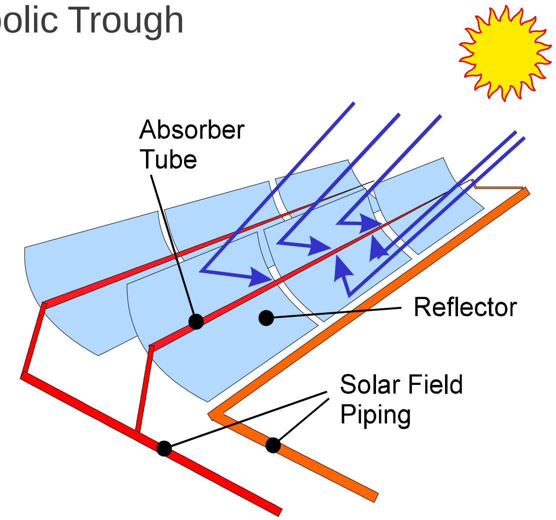
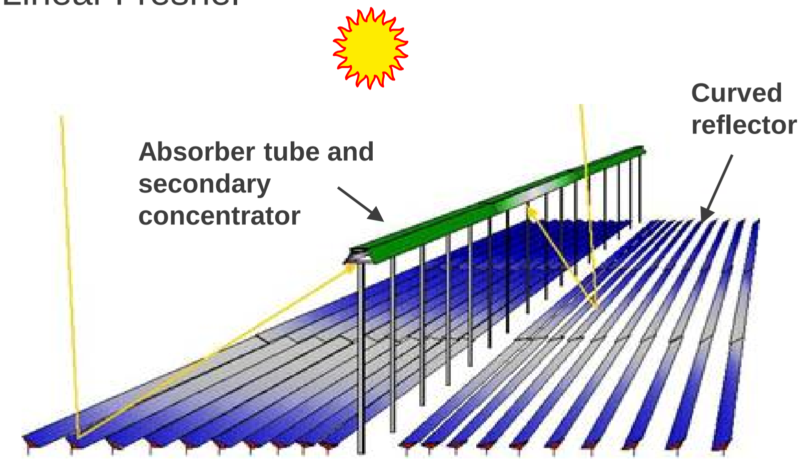
Linear focusing STE technologies

Parabolic Trough

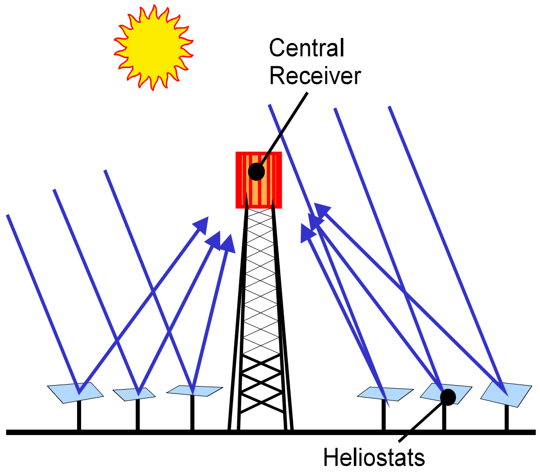


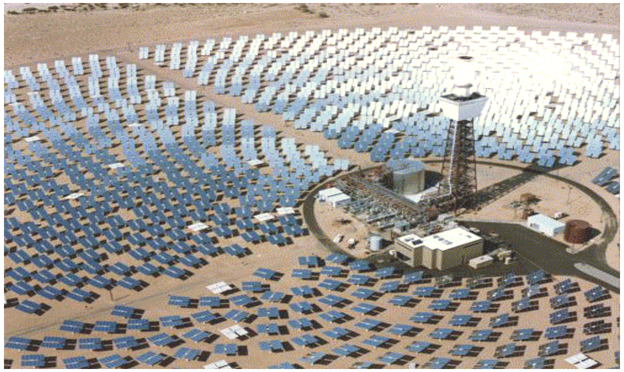
Linear Fresnel



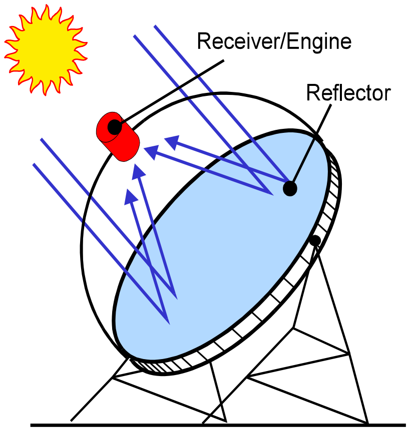
Point focusing STE technologies

Central Receiver (tower) systems





Parabolic Dish

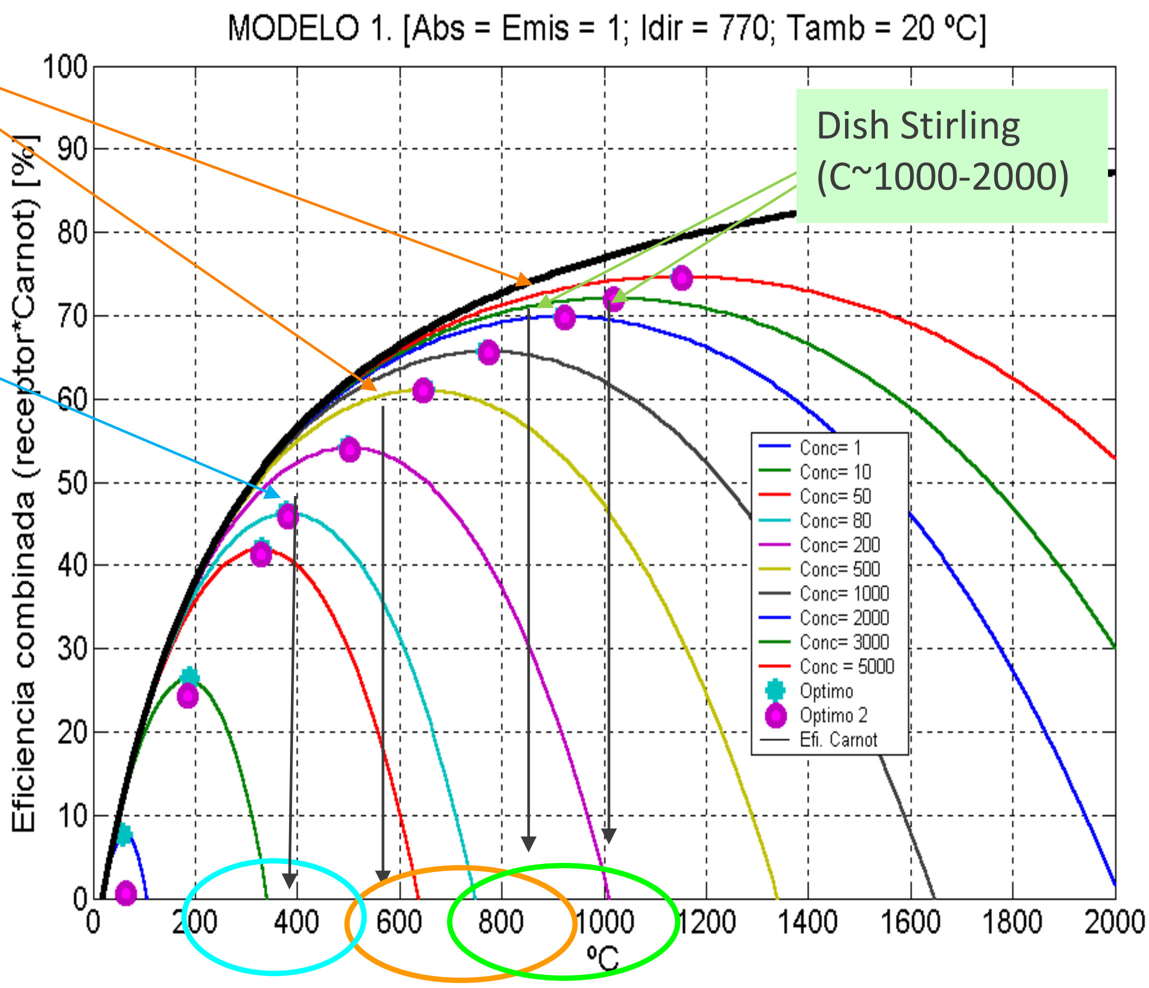


Current sunlight concentration levels

Central receiver
(C~200-1000)

Parabolic-Trough
(C ~50 - 80)

Dish Stirling
(C~1000-2000)



$$C_{3D} \le \frac{1}{\sin^2 \theta_s} \approx 46{,}000$$

$$C_{2D} \le \frac{1}{\sin \theta_s} \approx 215$$

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STE value proposition

- Large potential for cost reduction and technology evolution
- Easy storage integration:
- Increased dispatchability
- Increased capacity factor
- Easy hybridization with conventional and renewable energy sources
- Ability to provide regulation plus reactive current compensation to the grid
- Potential by products (co-generation/water desalination)
- Capacity to foster local and regional industrial development
- Free from geopolitical tensions

Commercial STE plants should play an important role in the future electricity generation mix

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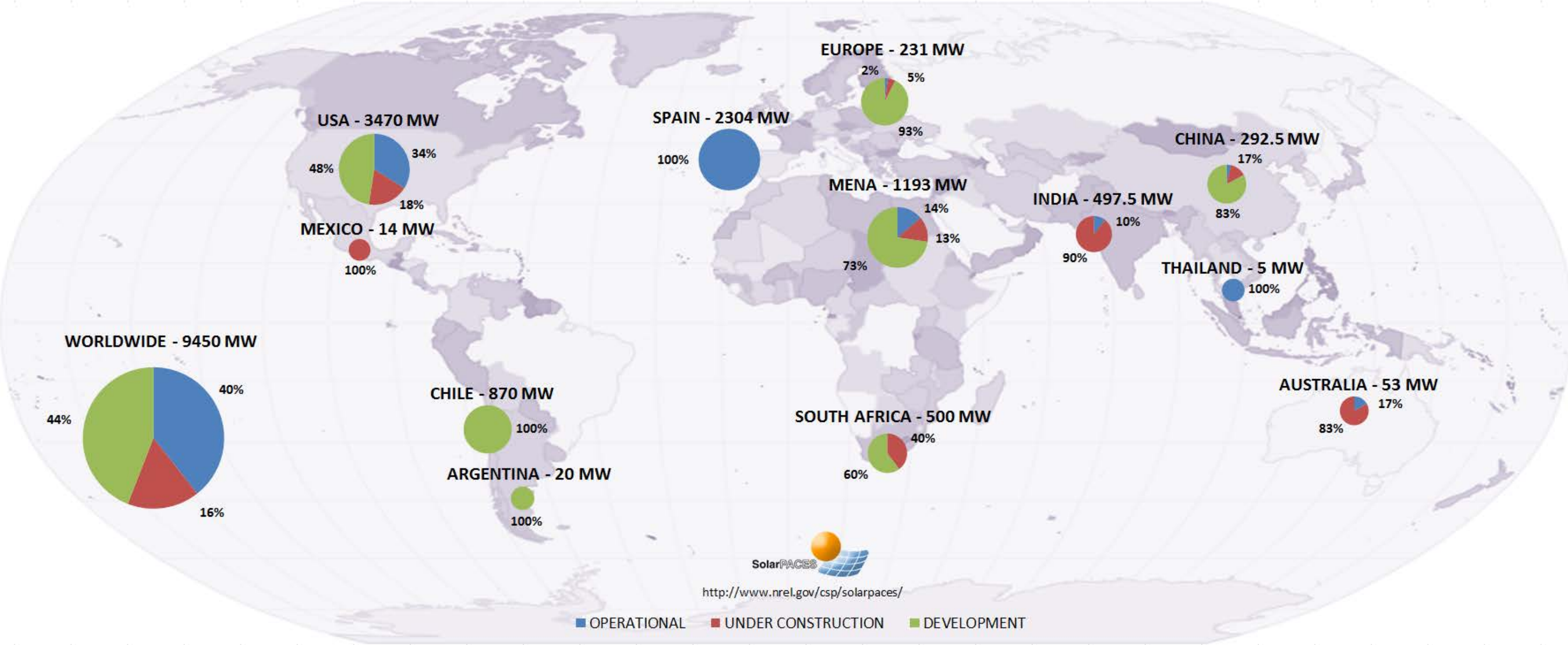
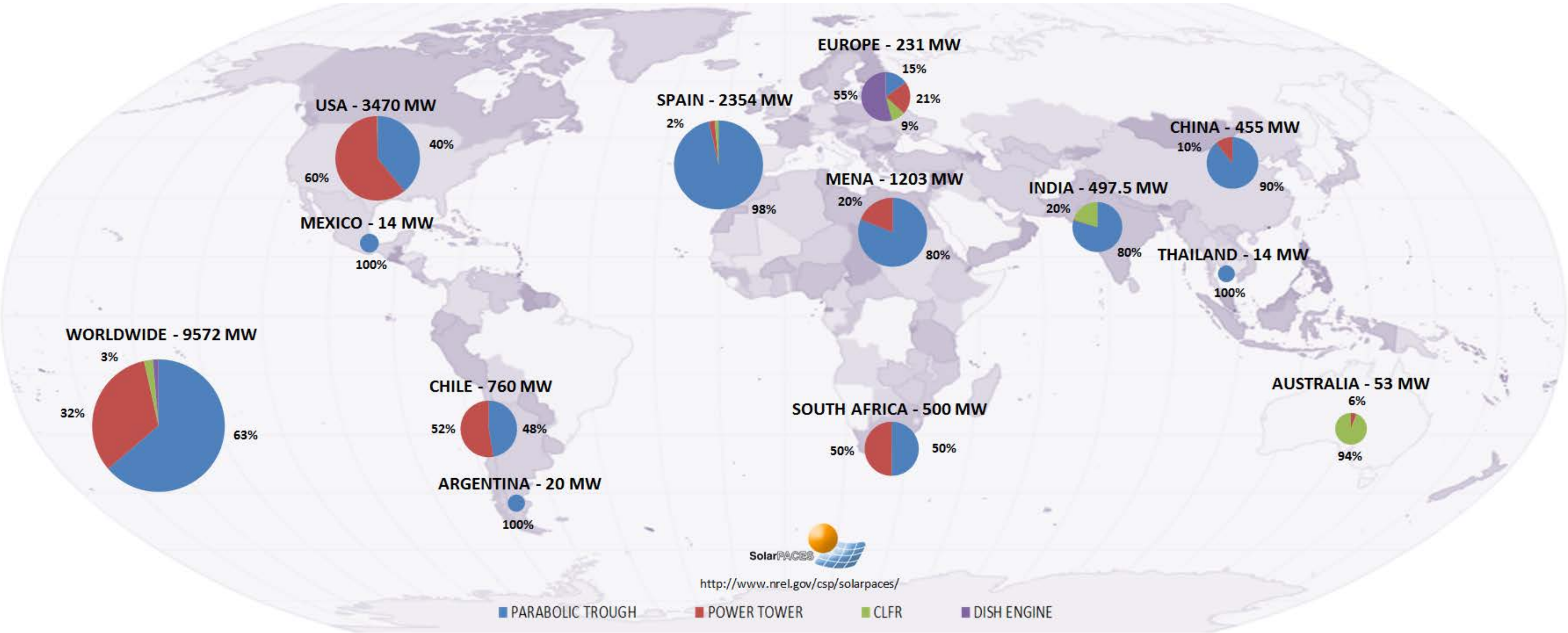
STE Market – Project status



***Source**: SolarPACES / NREL. For additional information, please, visit: http://www.nrel.gov/csp/solarpaces/by_country.cfm*

STE Market – Technology status



Source: *SolarPACES / NREL. For additional information, please, visit: http://www.nrel.gov/csp/solarpaces/by_country.cfm*

STE – Recent projects

Solana - 280 MW,
6 hours storage

Ivanpah, 392 MW

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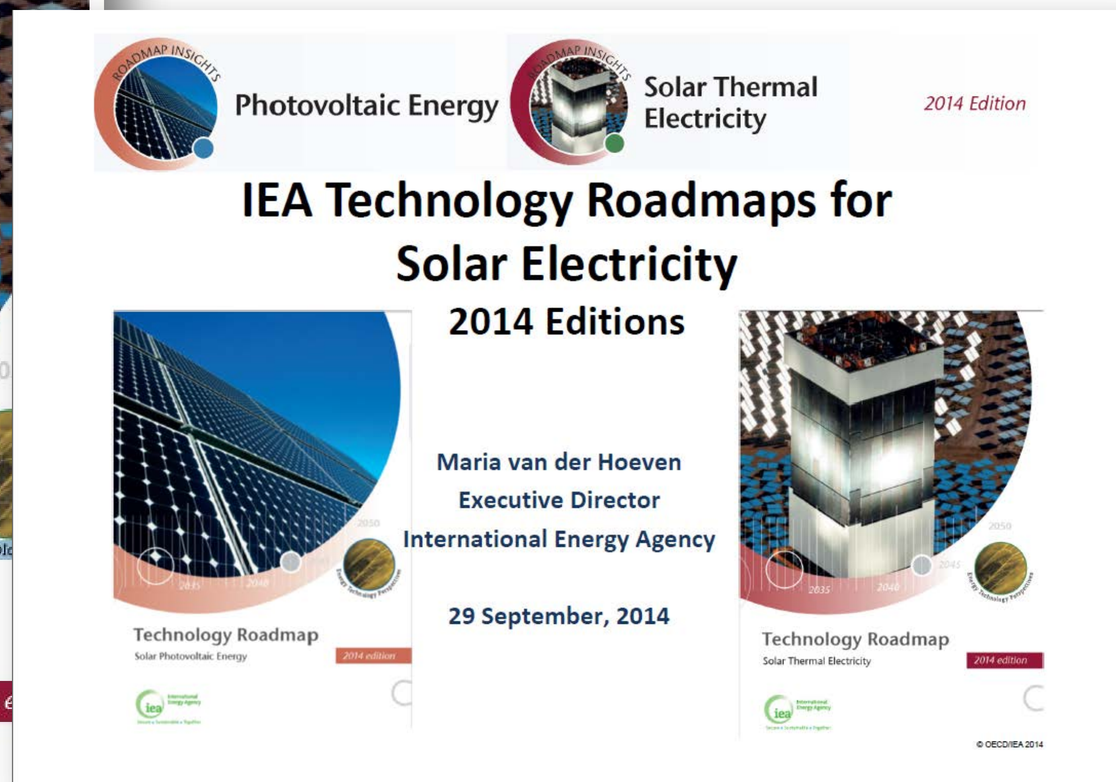
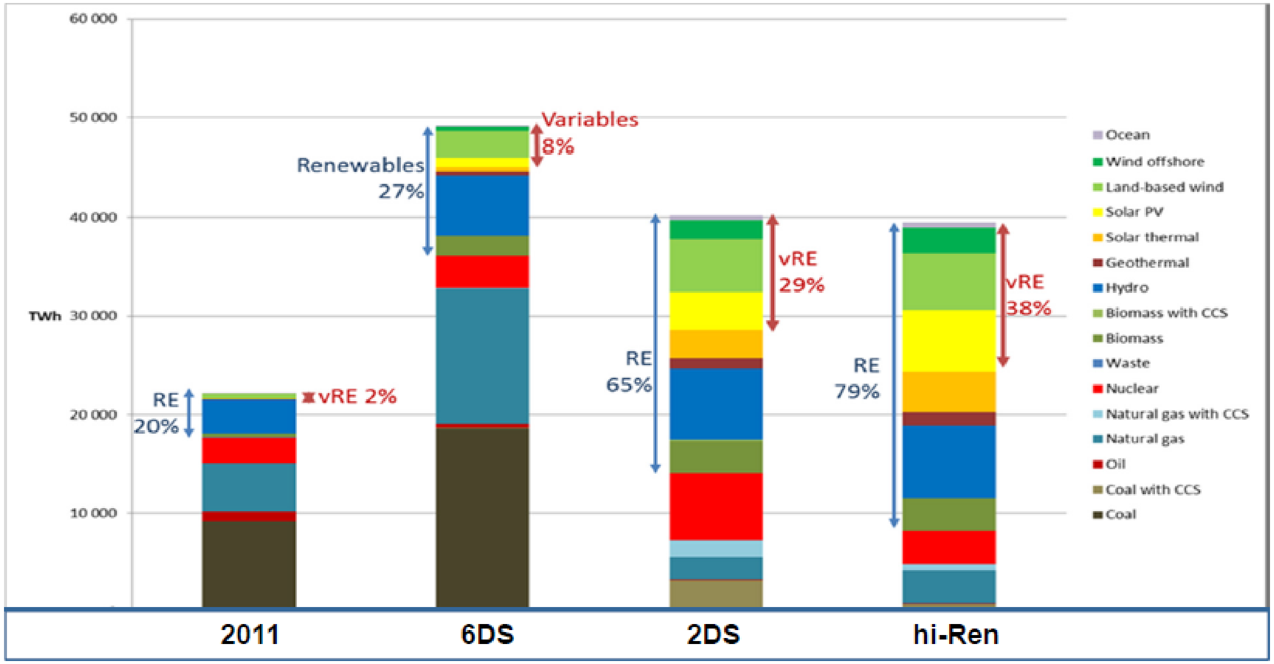
IEA Technology Road Map for STE



IEA Technology Road Map for STE

An Energy Revolution is needed

ETP 2014



- Generation today:
  - Fossil fuels: 68%
  - Renewables: 20%
- Generation 2DS 2050:
  - Renewables: 65 - 79%
  - Fossil fuels: 20 - 12%

iea International Energy Agency

IEA Technology Road Map for STE

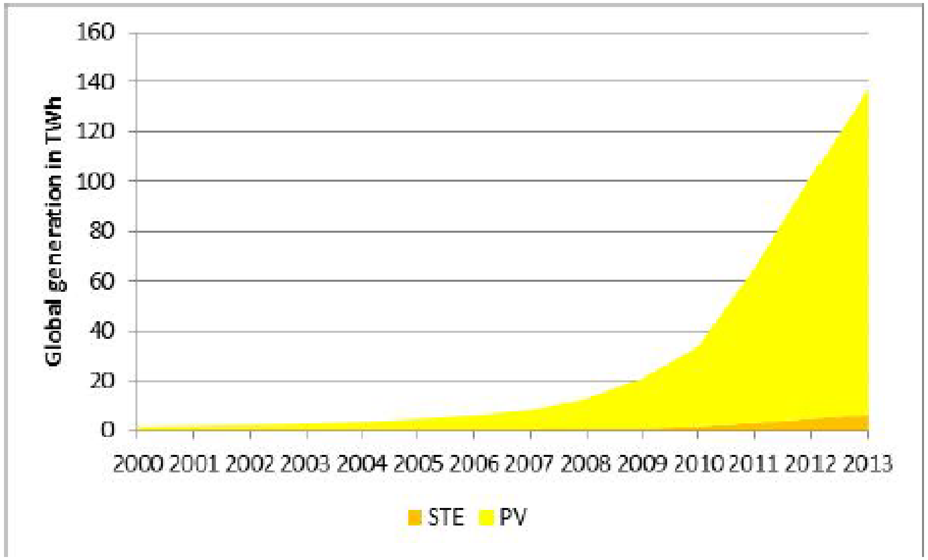
PV ahead, STE (CSP) lagging behind

PV:

- Massive cost reductions
- Also for distributed generation

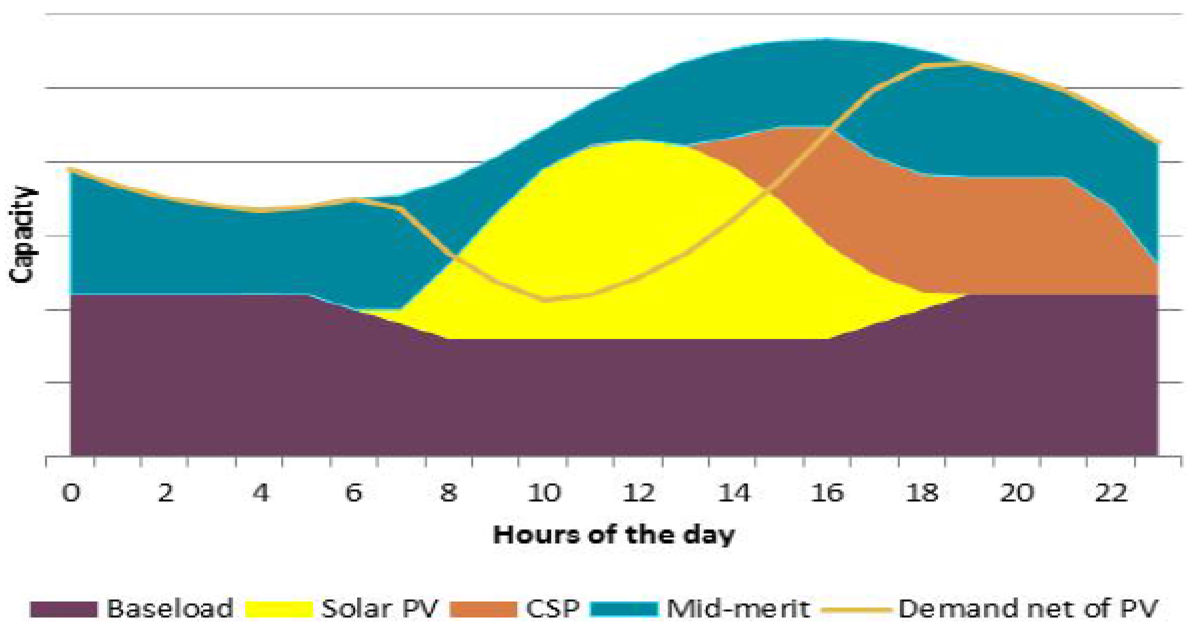
STE:

- Flexible generation not yet fully valued
- Progress in 2013



	Old Roadmap Milestones for 2020 (GW)	To be reached
PV	200	5 years ahead
STE	140	> 7 years later

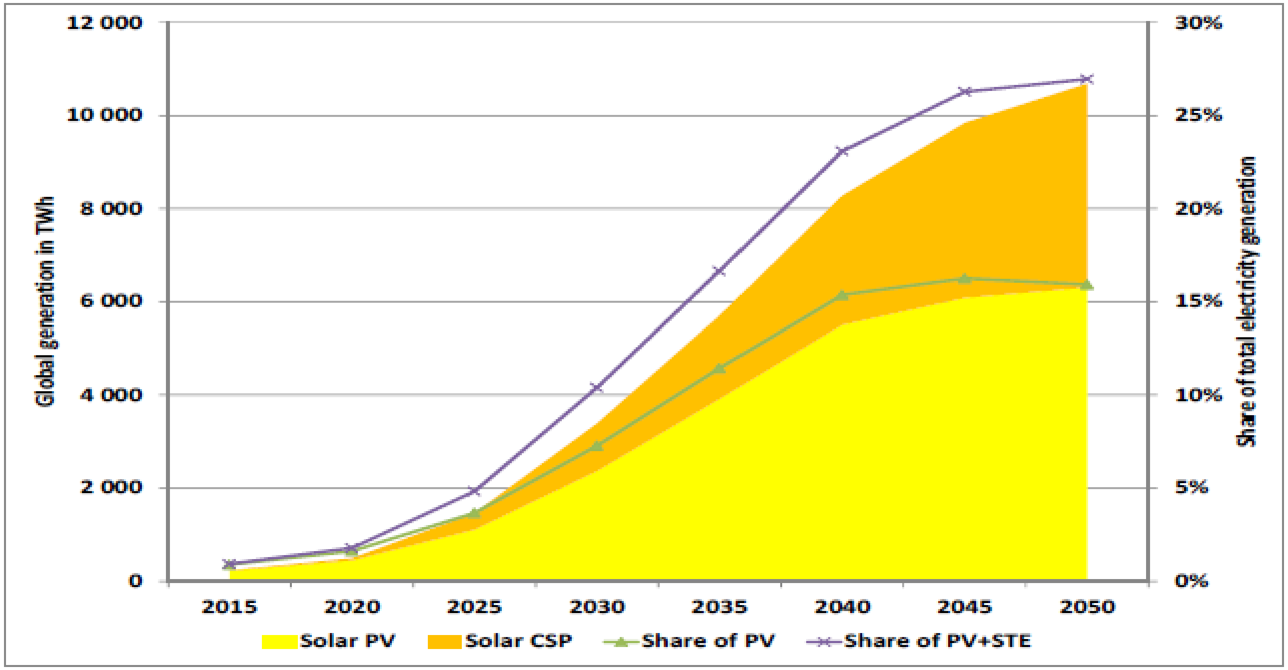
Complementary roles of PV and STE



Thanks to thermal storage, STE is generated on demand when the sun sets while demand often peaks

IEA Technology Road Map for STE

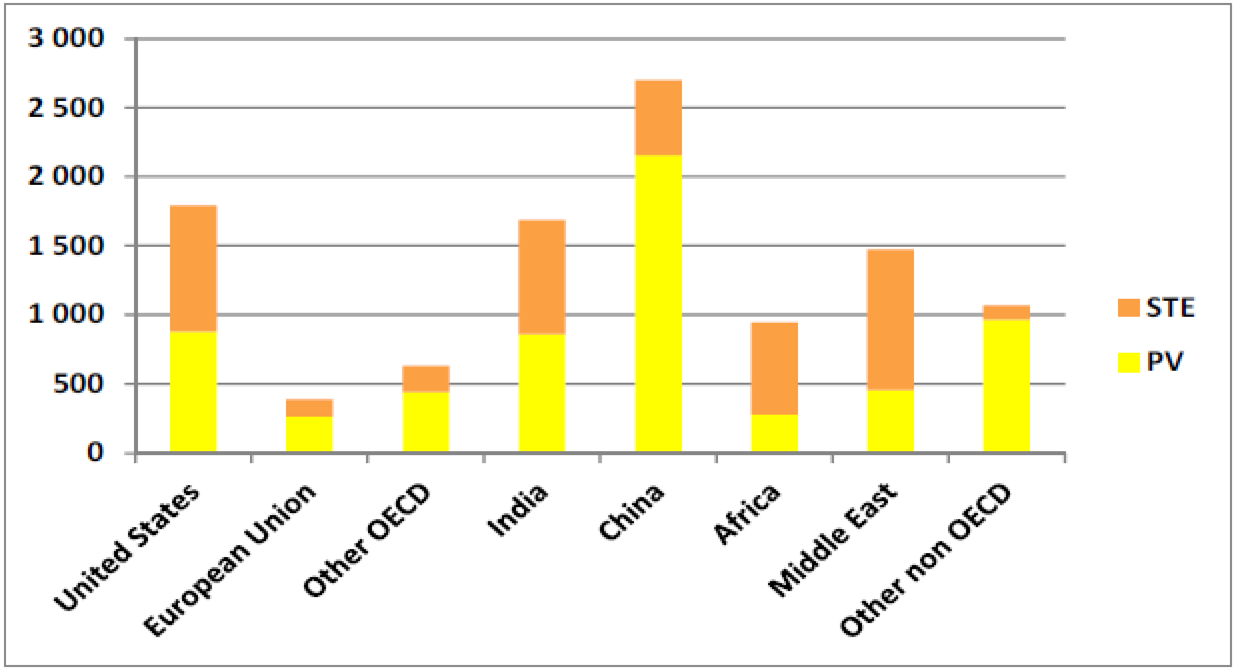
New roadmap vision for solar electricity: PV + STE



Together, PV and STE could become the largest source of electricity worldwide before 2050

IEA Technology Road Map for STE

STE vs. PV generation by region in 2050



China alone accounts for 37% of global PV deployment

STE eventually dominates in Africa and the Middle East; it comes close to PV in India and the United States

Selected messages to policy makers

1. **Set or update long-term targets**
   - Consistent with overall energy strategies
   - Taking into account past and future cost reductions
2. **Develop market designs in a system-approach,** e.g:
   - Fair rules for residential and commercial PV rooftops
   - Time-of-delivery remuneration to take full advantage of dispatchable and flexible generation from STE
3. **De-risk financing with predictable policies**
   - Both capital-intensive technologies
   - Policy predictability most effective and efficient way to reduce risk, thereby improving competitiveness

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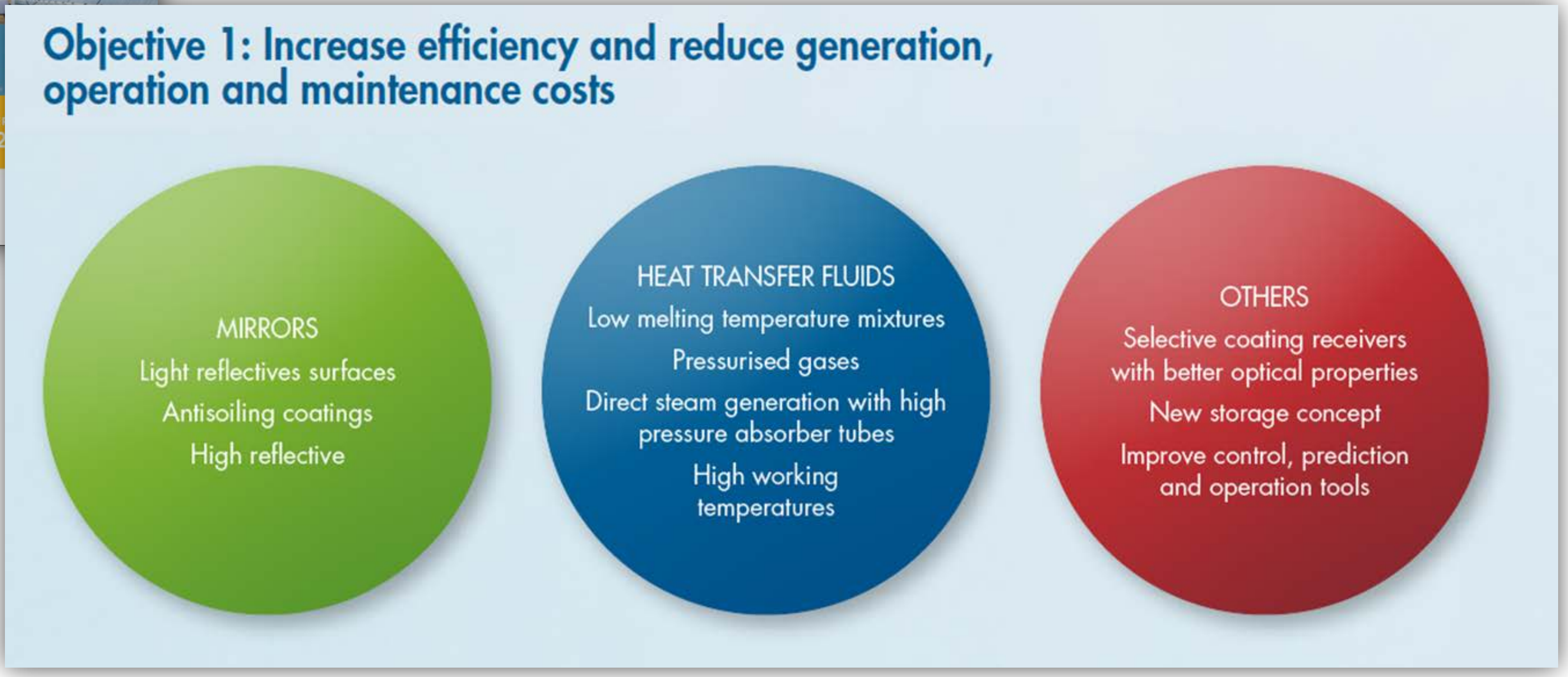
ESTELA – Strategic research agenda



ESTELA – Strategic research agenda

Objective 2: Improve dispatchability

Dispatchability is one of the characteristics that makes STE a favored option among other renewable resources, and "Improving dispatchability" is even more is a most objective for STE development. Indeed, systems with the flexibility to feed the grid on demand are the key for solar thermal electricity to reach its potential. Although many plants are already built with a storage system, more efforts need to be done.

Integration systems:

The integration of solar heat in large steam plants can be achieved through the water preheating line or through the boiler steam/water circuit. In the first case, an appropriate boiler design is required to deal with temperature differences. If the integration is done with the boiler, an improvement of its design and control system is needed.

The integration of solar heat with gas turbine or combined cycle plants is also an option. With a gas turbine, the temperature of the air can be increased in high temperature solar collectors, leading to high conversion efficiencies. The ability to handle transient phases requires an improvement of the design of the control system.

The integration of solar heat with biomass, more appropriate for small sized facilities, is a good combination for an all-renewable fuelled plant. Although the combustion of biomass is not easy, it is possible to use organic fluid thermodynamic cycles (ORC), which simplify operation while increasing the overall efficiency.

ESTELA – Strategic research agenda

Improve forecasting:

Good forecasts are essential for reliable estimates of the costs of a plant in a given site. Many solutions can be envisioned, such as elaborating a very short term forecast for variable sky conditions, developing an electricity forecasting system software to regulate and manage electricity production, improving ground based DNI measurements, using meteorological satellite results, and improving numerical weather prediction models for DNI forecasting, analysing its inter-annual variability and the time and space correlation between solar and wind energy sources.

Objective 3: Improve environmental profile

Heat transfer fluids are of concern because of their potential impact on the environment: the pollution from synthetic oil is one of the most worrying. The environmental and economic parameters of different fluids have been studied.

Desalination is a very interesting application of solar thermal energy. Despite the drawbacks related to the requirements for siting, desalination presents significant technical and economic advantages. There are several technical solutions, such as multi-effect distillation, reverse osmosis, humidification-dehumidification process and membrane distillation. The desalination system can also be the cooler part of the conventional power block. Thus, the optimisation of the integrated or combined cooling process needs to be considered as a research topic.

ESTELA – Strategic research agenda

Storage:

Depending on the HTF (Heat Transfer Fluid), different designs can be set up:

If the HTF is thermal oil, a single storage tank with good temperature stratification instead of a two tank configuration can greatly simplify storage. A single tank can also be optimised by a solid separation between the heat exchanger and the storage material.

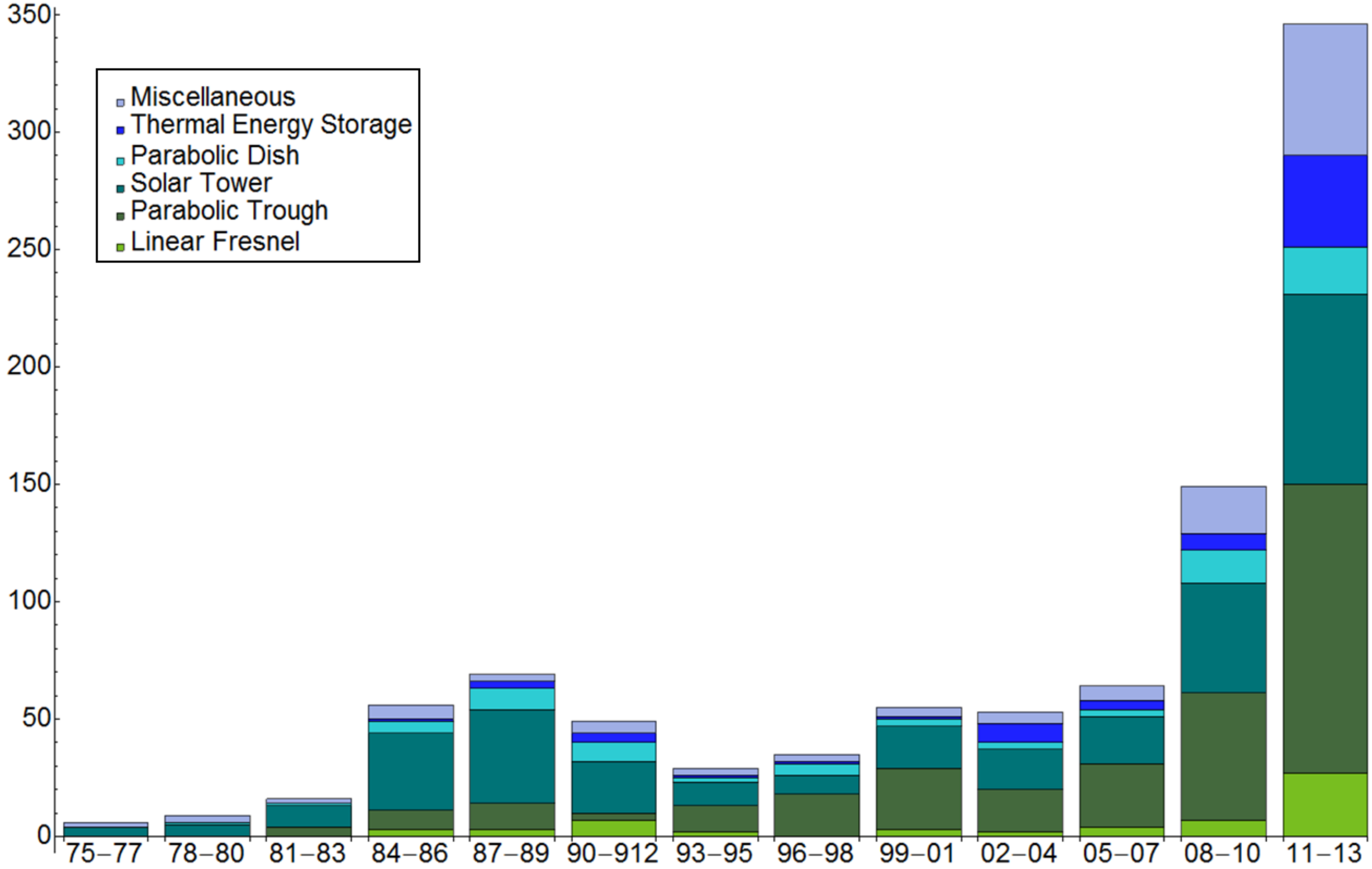
If the HTF is molten salts, no exchanger is needed between the solar field and the storage circuit. New salt mixtures with lower freezing point and which avoid corrosion problems are the research and development goals for this topic.

If the HTF is steam, no exchanger is needed before the power block. Solid/liquid phase change materials applied for saturated steam are to be investigated.

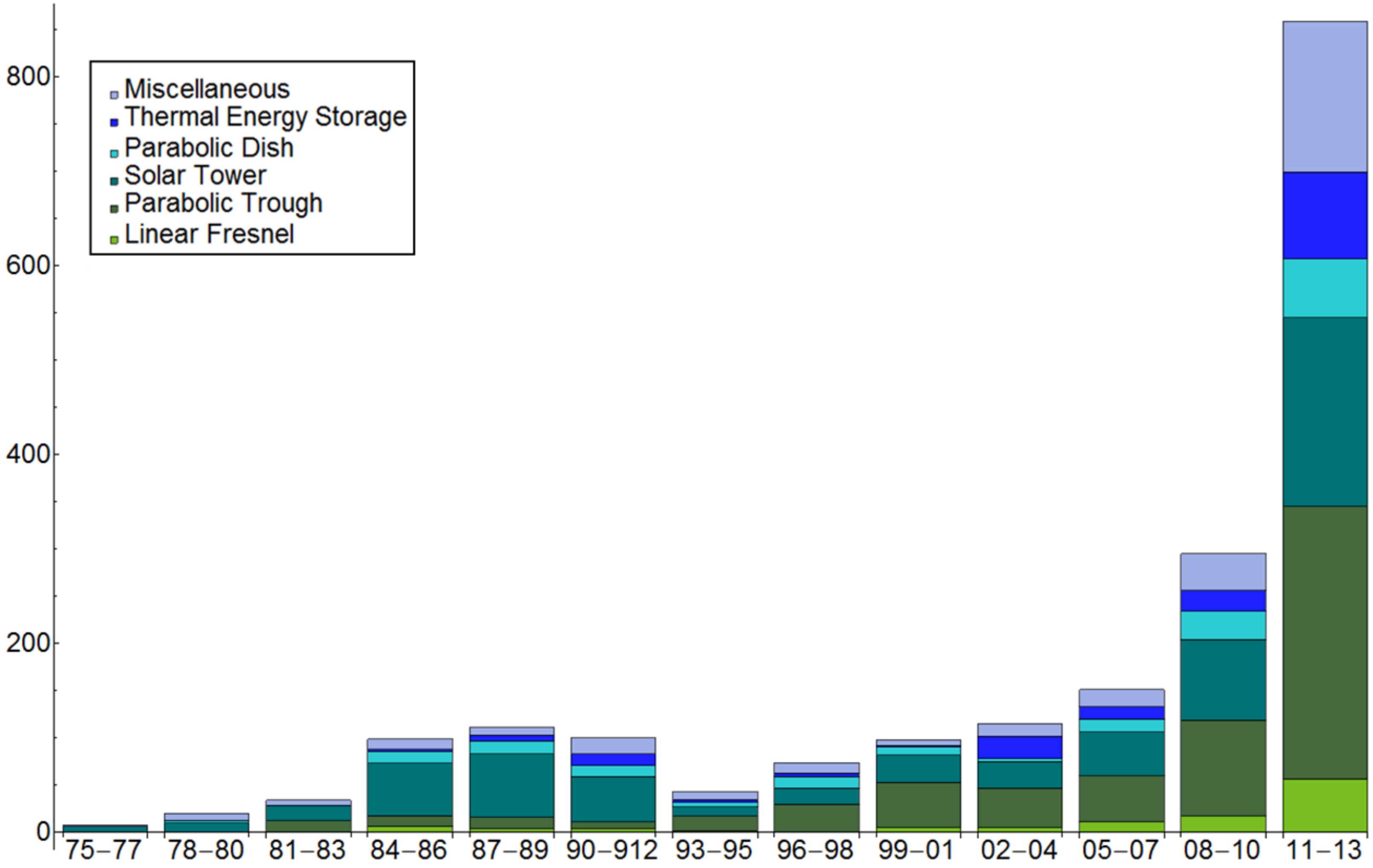
If the HTF is gas, very high temperature applications are feasible. The challenges are how to design effective heat transfer systems and to find suitable storage materials.

In general, improved strategies for charging and discharging thermal heat are necessary to maximise storage capacity. Concepts for thermo-chemical energy storage systems are also to be investigated.

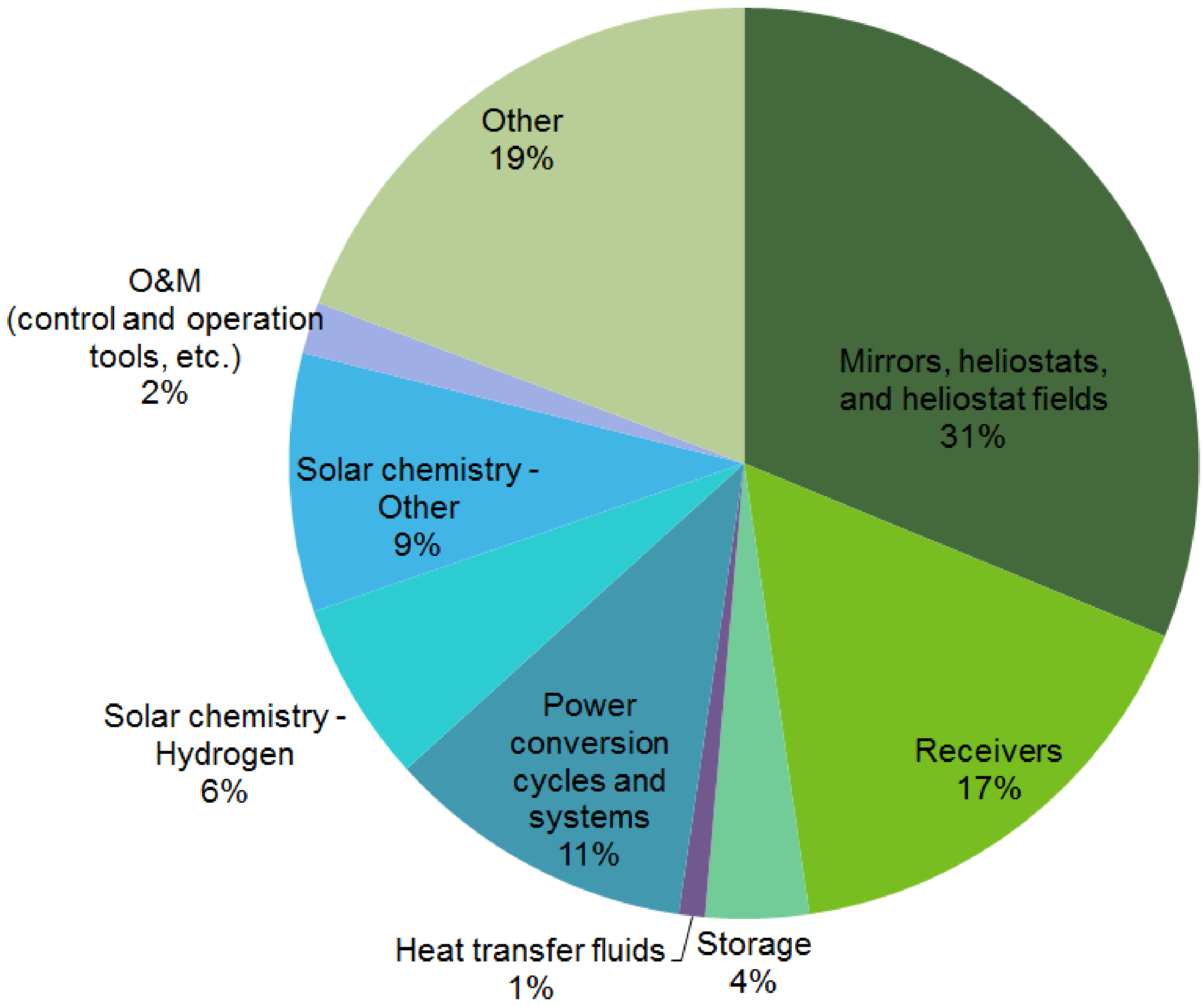
Published articles (1975-2013)



New authors per period (1975-2013)



Research subjects Solar Tower (2010-2013)



2014 SolarPACES Conference Topics

		TU		WE		TH		FR		Total
ID	Topic	A	P	A	P	A	P	A	P	
15	Thermal/Thermochemical Energy Storage			12		12	29	4		**57**
14	Thermal Receiver			6		12	33	5		**56**
3	CSP Systems		29	10		10		5		**54**
11	Solar Collectors			9	34	4		4		**51**
7	Measurement and Control		17	5						**22**
4	General Topics in CSP		9	6		5				**20**
9	Power Cycles			6	9			5		**20**
12	Solar Fuels				6	6		6		**18**
2	Commercial and Demonstration Projects		7	4				5		**16**
6	Heat Transfer Fluids		10			6				**16**
13	Solar Resource Assessment				7	9				**16**
10	Reliability and Service Life Prediction			6	4					**10**
8	Policy and Markets				5			4		**9**
16	Water Desalination ad Detoxification						1			**1**
	TOTAL	**0**	**72**	**64**	**65**	**64**	**63**	**38**	**0**	**366**

Some research initiatives

Acknowledgements

ARENA

Australian Government

Australian Renewable Energy Agency

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CSIRO | Australian National University | The University of Queensland Australia | The University of Adelaide | University of South Australia | QUT | Flinders University

Thank you

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