Prometheus, meaning *forethought*, was the Titan who, in the Greek mythology, stole the fire from Olympus for the benefit of humanity against the will of Zeus and the prevailing Gods

Fire = Solar Power Technology

PROMETHEUS

FET Project
Future Emerging Technologies
Starting TRL = 1/2

COOPERATION

PROMETHEUS

Production Method of Electrical Energy by Enhanced Thermal Electron Emission by the Use of Superior Semiconductors – ProME³ThE²US²

Grant agreement no.: *308975*

DiaC² Lab – Diamond & Carbon Compounds Lab – CNR

TEL AVIV UNIVERSITY אוניברסיטת תל אביב

TECHNION Israel Institute of Technology

National Research Council of Italy

Fraunhofer

IONAC Process

exergy

SOLARIS PHOTONICS

ABENGOA RESEARCH

Basic Research

Applied Research

High-Tech SMEs

Multinational Industry

Duration: May 2013 - Apr 2016

- Total Project Cost: 4.3 M€
- Total EU Funding: 3.0 M€

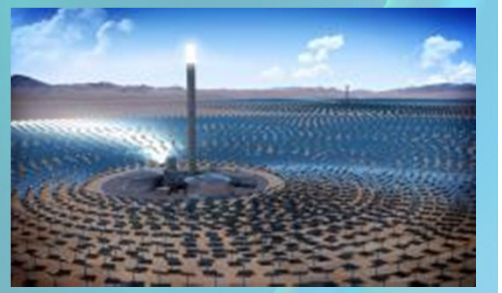
ProME³ThE²US² – High-Temperature Solar Cells

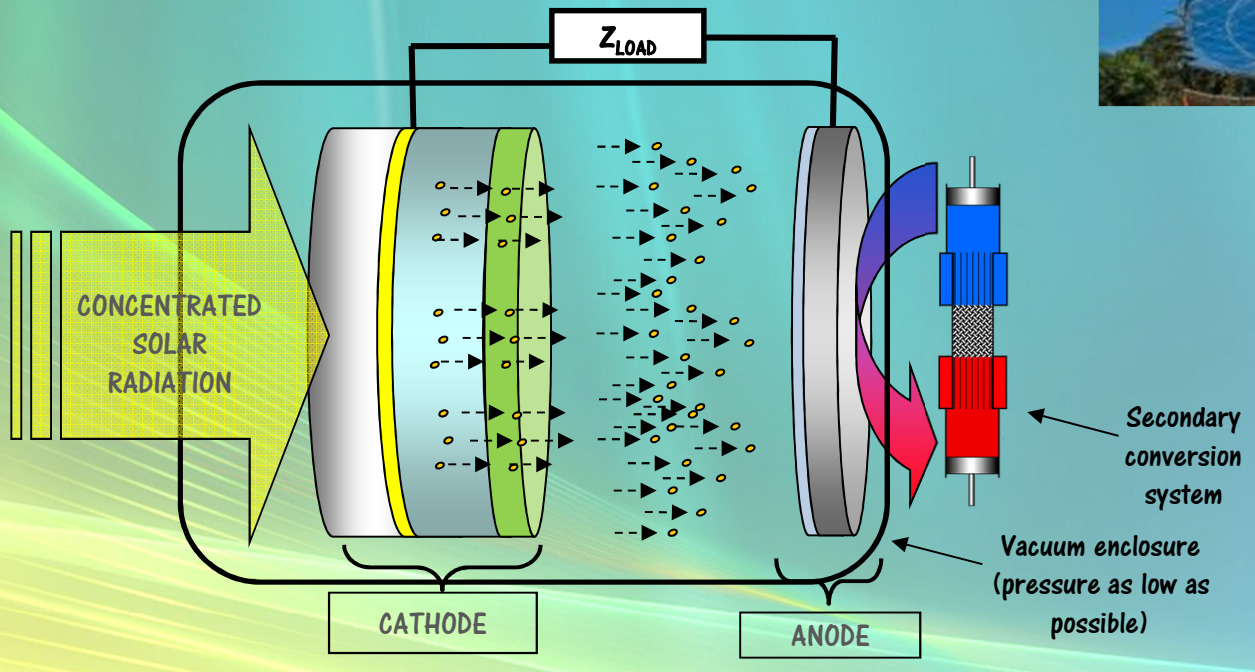
PETE* devices can be defined as high-temperature cells for solar concentrating systems, since they avoid the limitations of junction cells and even benefit from high operating temperatures

*J. Schwede,et al., Nature Materials 9 (2010) 762

Applications:

- Domestic use
- Rural environment use
- Solar Towers



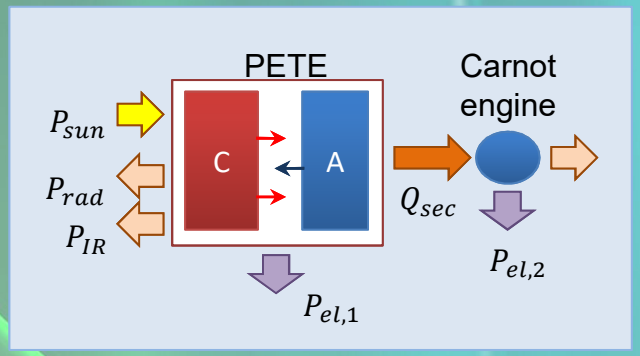


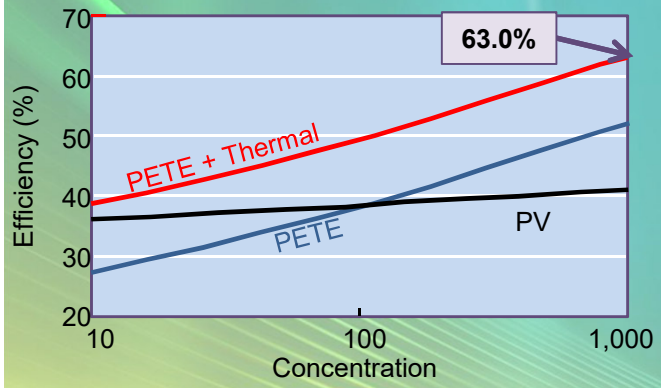
PETE devices utilize both photonic and thermal processes for energy conversion, and are not subject to either the Shockley-Queisser limit or the thermal limit (Carnot): conversion efficiency close to 70% **

**G. Segev, Y. Rosenwaks, A. Kribus, Solar Energy Materials & Solar Cells 140 (2015) 464

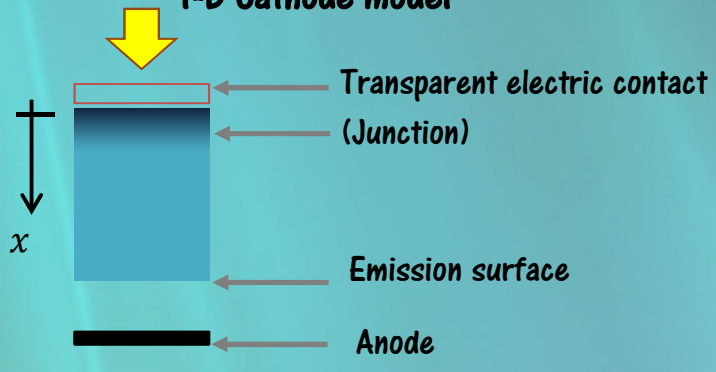
Conversion efficiency

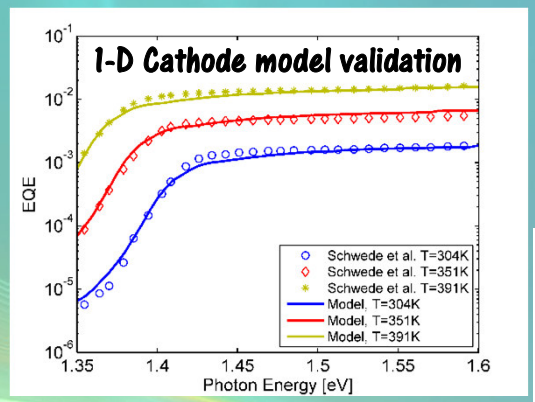
0-D Model: Ideal cathode





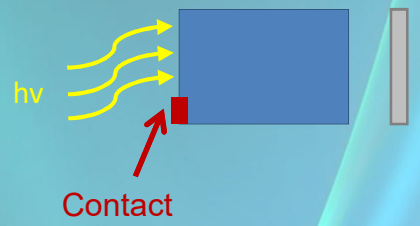
1-D Cathode model

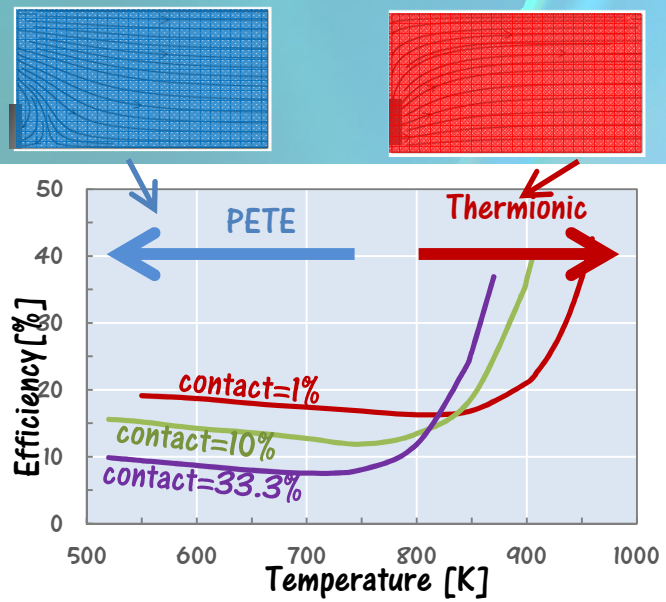




Segev, G., Rosenwaks, Y. Kribus, A.,
J. Appl. Phys. 114 (2013) 044505

2-D Cathode model



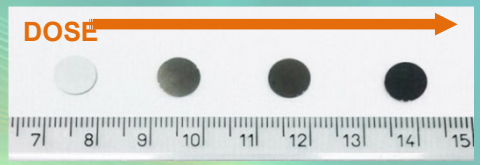


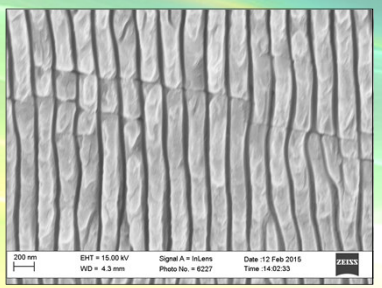
Outputs in brief

PROMETHEUS

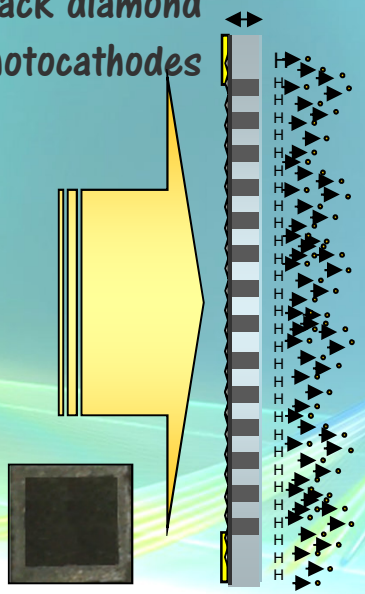
III-V semiconductor photocathodes

Black diamond films

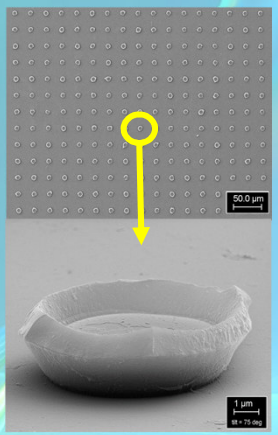




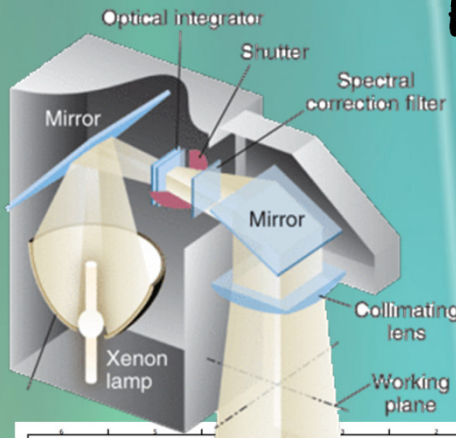
Black diamond photocathodes

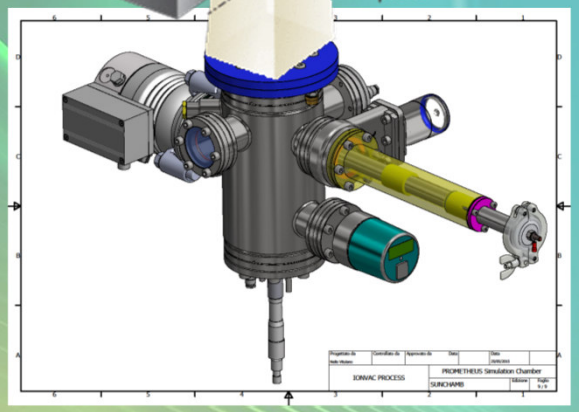


Dielectric microspacer technology

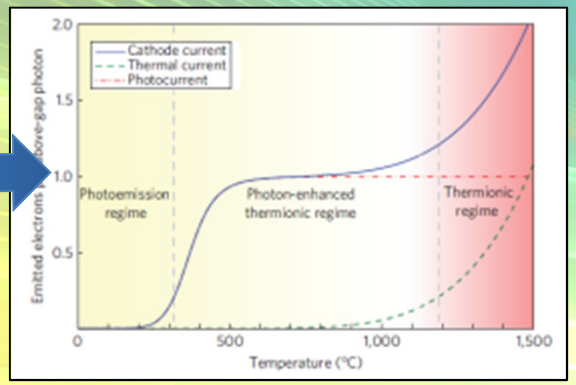


Proof-of-Concept demonstration

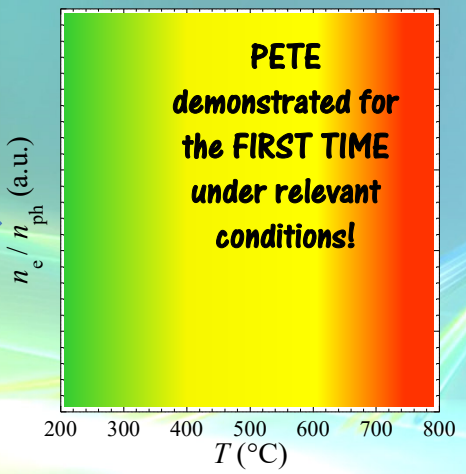




Theory



Experiment

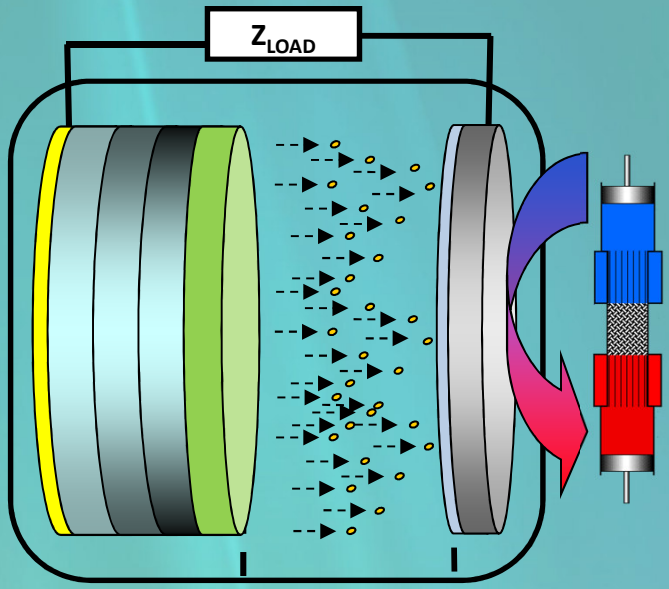


TRL = 3, to be increased to TRL=5 with 3 years development

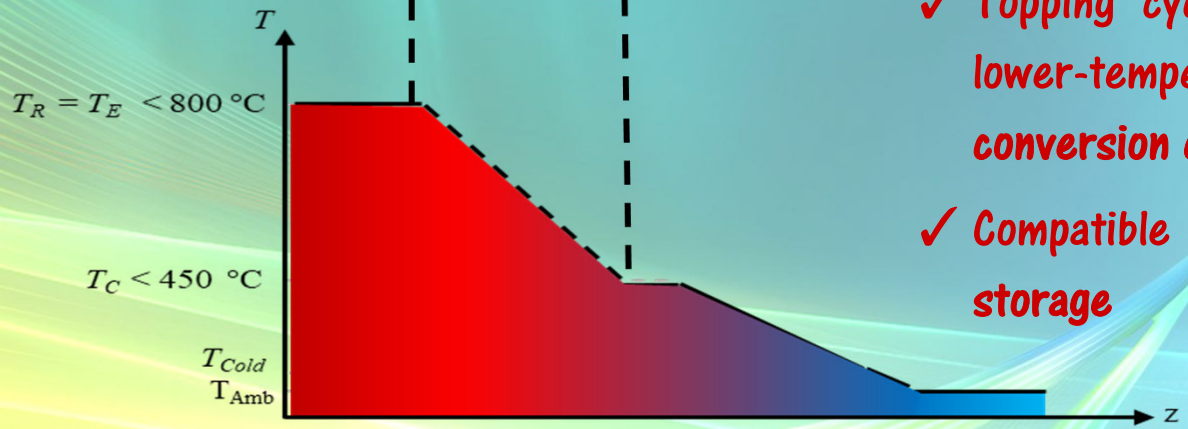
Flexibility

Solid-state device:

- ✓ Compactness
- ✓ No mechanical parts in movement
- ✓ Up- and down-scalable
- ✓ Efficient use of materials



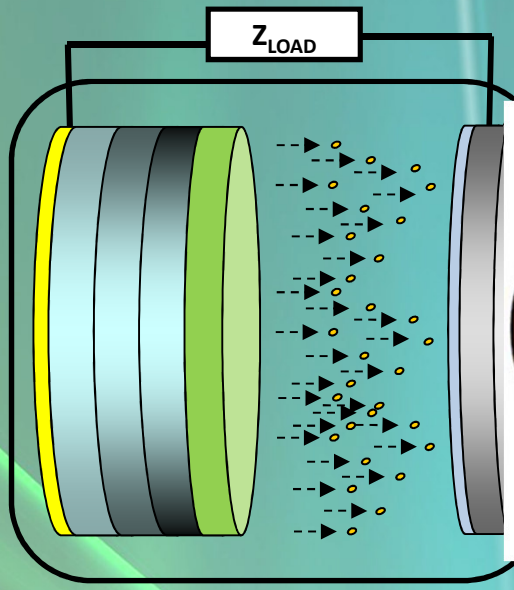
Secondary conversion system
or
Energy storage system

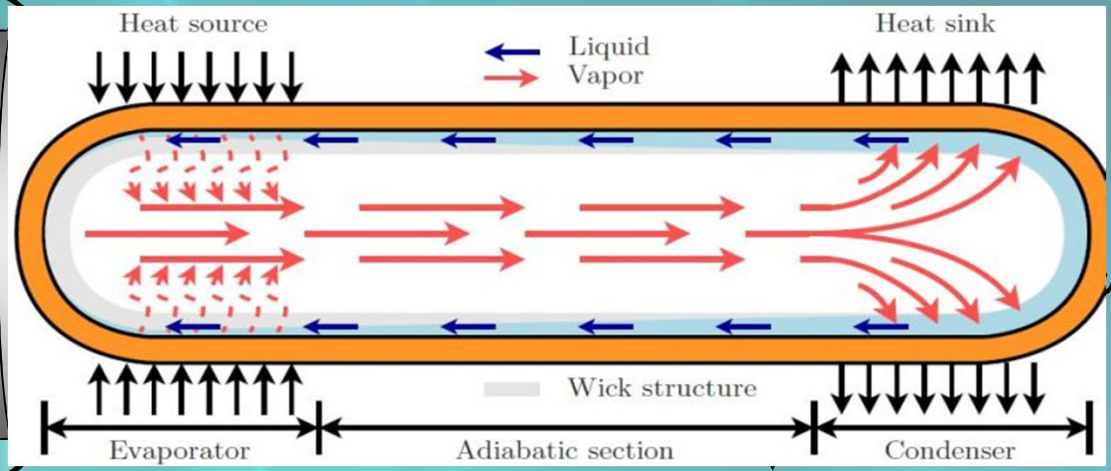


The lowest device operating temperature could be 450 °C:

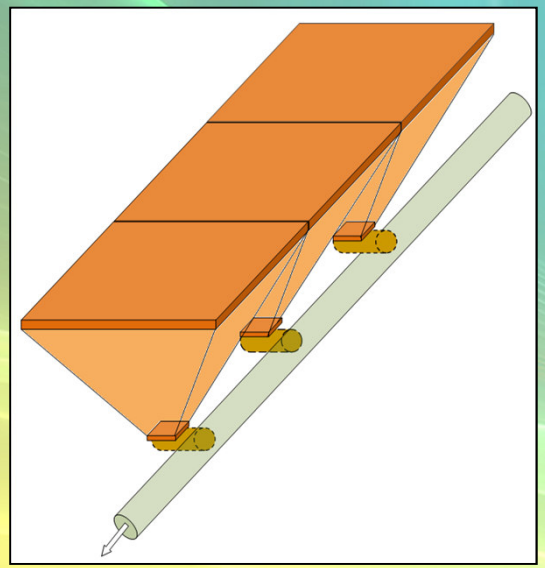
- ✓ Topping cycle of additional lower-temperature conversion cycles
- ✓ Compatible with energy storage

Concept/Cogeneration

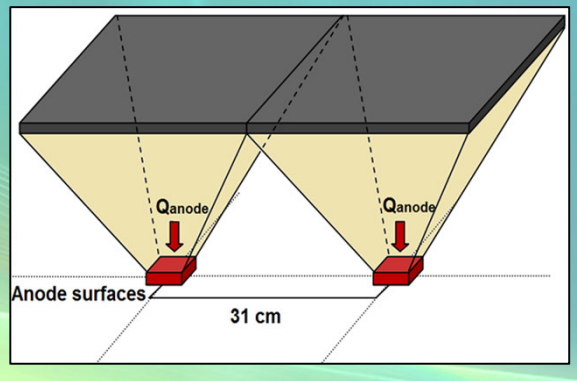




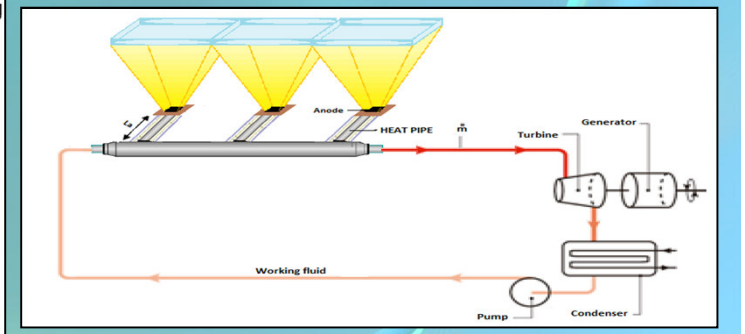
The refrigerant performs an Organic Rankine Cycle (ORC).
The anode heat dissipation is equivalent to a preheating + evaporation stage.



Design of a modular system

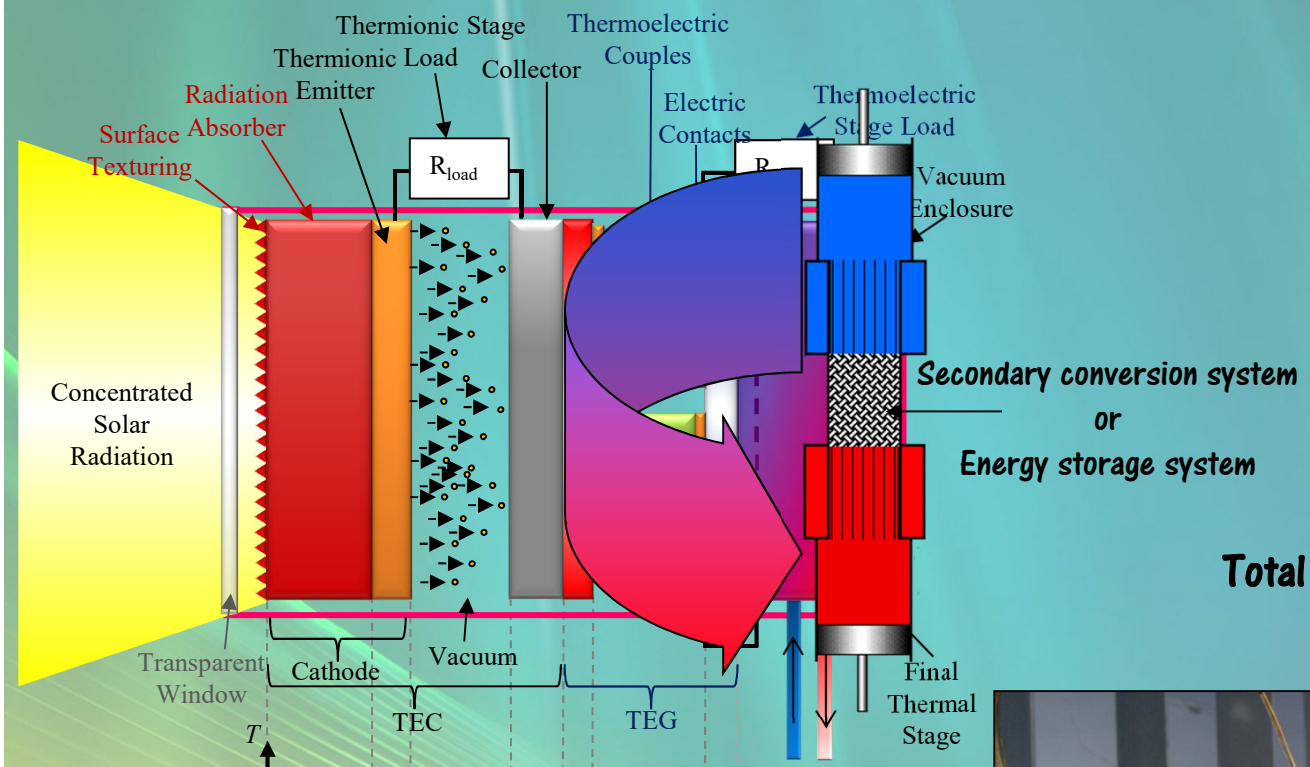


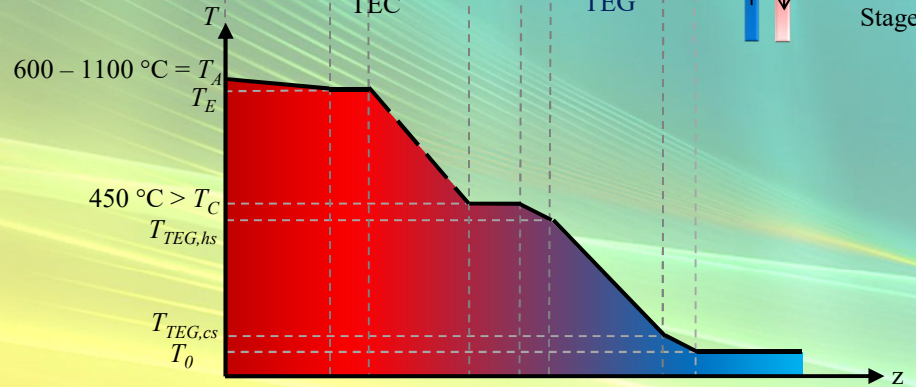
Sizing

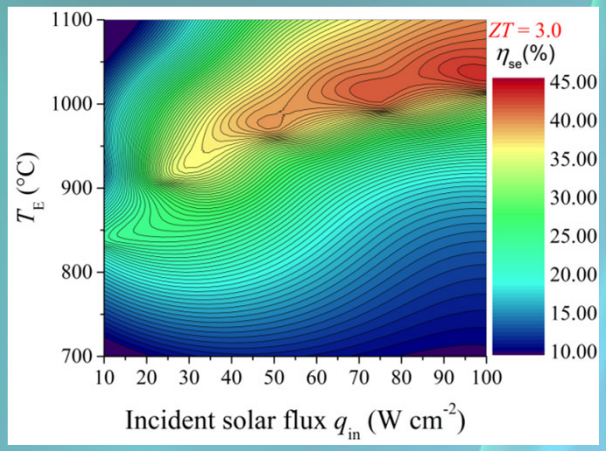


Mathematical model describing the overall system behavior

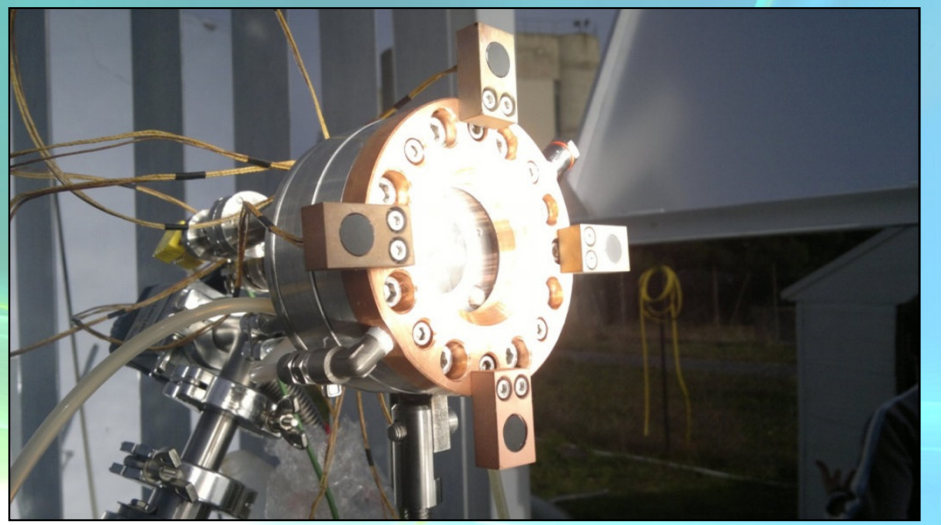
ST²G - Solar Thermionic-Thermoelectric Generator







Total efficiency up to 45% @ 1050 °C

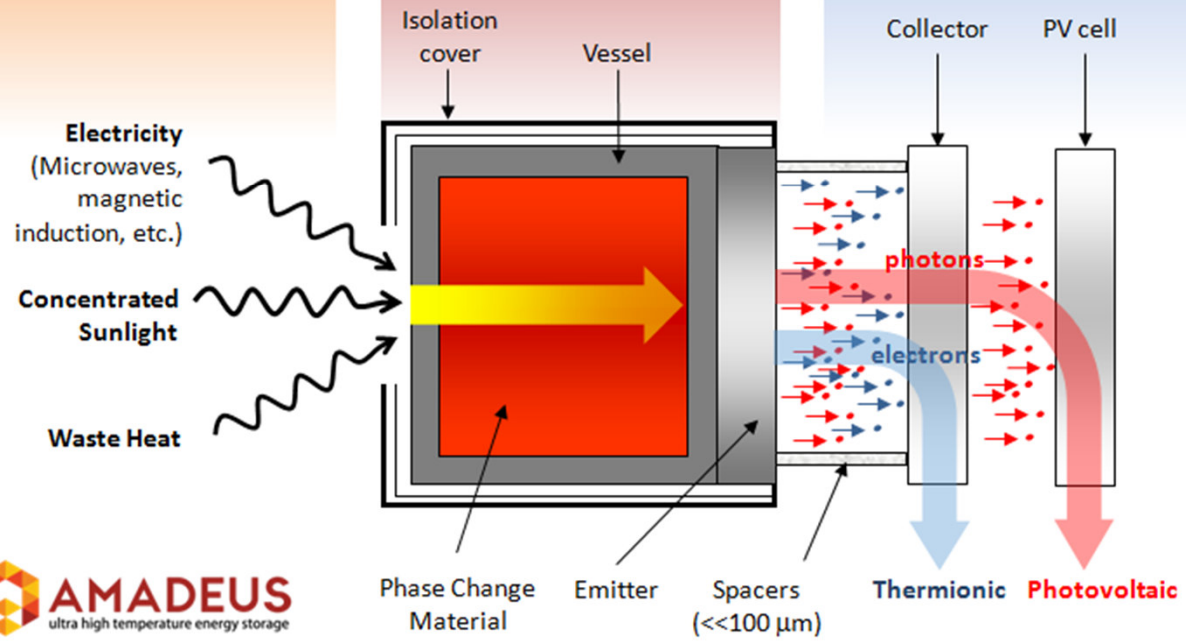


*Pending PCT Patent WO 2014/033690

Inventors: D.M. Trucchi, E. Cappelli, S. Orlando, D. Sciti

Ultra-high-temperature storage with Thermionic-Photovoltaic Generator

Primary Energy	Energy Storage	Energy conversion
Any kind of input energy (solar, electrical, waste heat, …)	Ultra high temperature latent heat storage in molten metals	Solid-state devices (hybrid thermionic & thermophotovoltaic)



AMADEUS
ultra high temperature energy storage

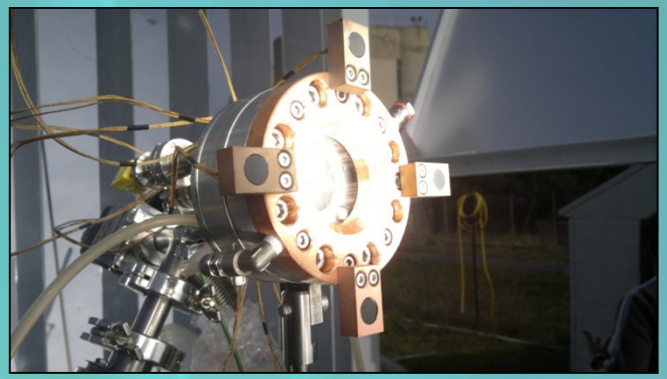
http://www.amadeus-project.eu/
https://youtu.be/D7huVnCnK8s

Future Needs

Photo-thermionics

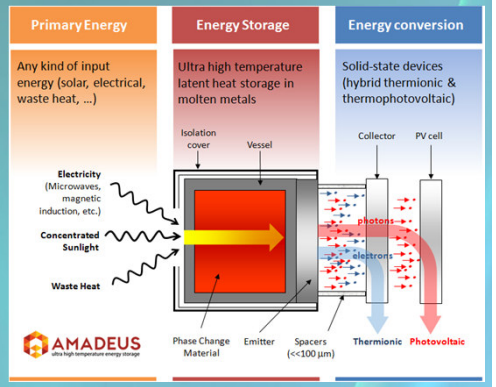
TRL = 3

Thermionics



TRL = 4/5

Thermionic-photovoltaics



TRL = 1/2

For each technology, additional R&D is necessary

Collaborative projects for increasing TRL

In 3 years:

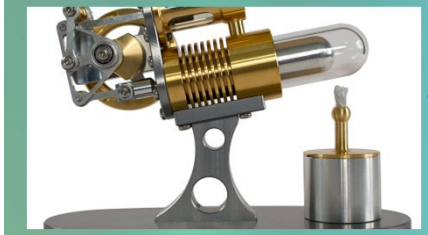
TRL = 5

TRL = 6/7

TRL = 3

Collaboration is welcome!

Future Needs



- Specifically designed thermal cycle (small-scale Stirling engine?)

- Specifically designed storage system (T < 450 °C)

- Indoor irradiation conditions for upscaled prototype

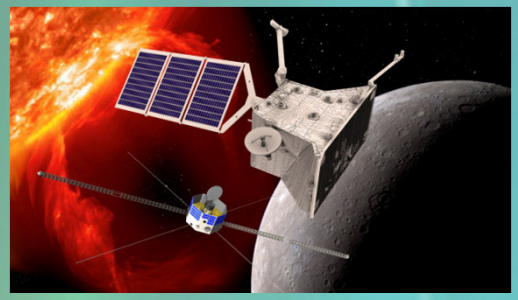
- Outdoor irradiation system for scalability and modularity, and testing under relevant conditions

Why an Inter-Regional Cooperation?

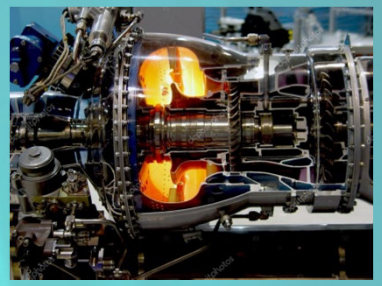
- Highly interdisciplinary know-hows (storage materials, engineering of the thermodynamic engine, optics, etc.)
- The outdoor testing operational site should be located in the Southern Europe
- Other kind of uses: desalination combined to power generation?

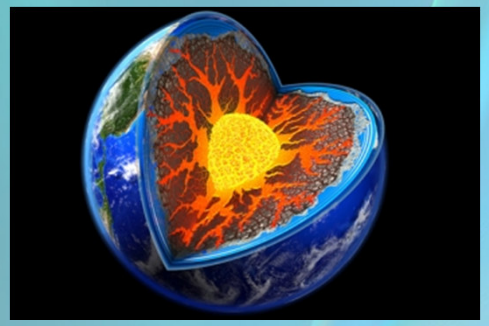
Additional Applications

Energy recovery in Aerospace



Automotive &
Aeronautical Transport





Geothermal energy

Nuclear energy recovery

Industrial furnaces and
metallurgic processes

Impact

Short-term | Medium-term | Long-term

Thank You for the Attention!