U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

SOLAR ENERGY TECHNOLOGIES OFFICE

SETO CSP Program Summit 2019

Integrated heat pump thermal storage and power cycle for CSP

Josh McTigue, NREL

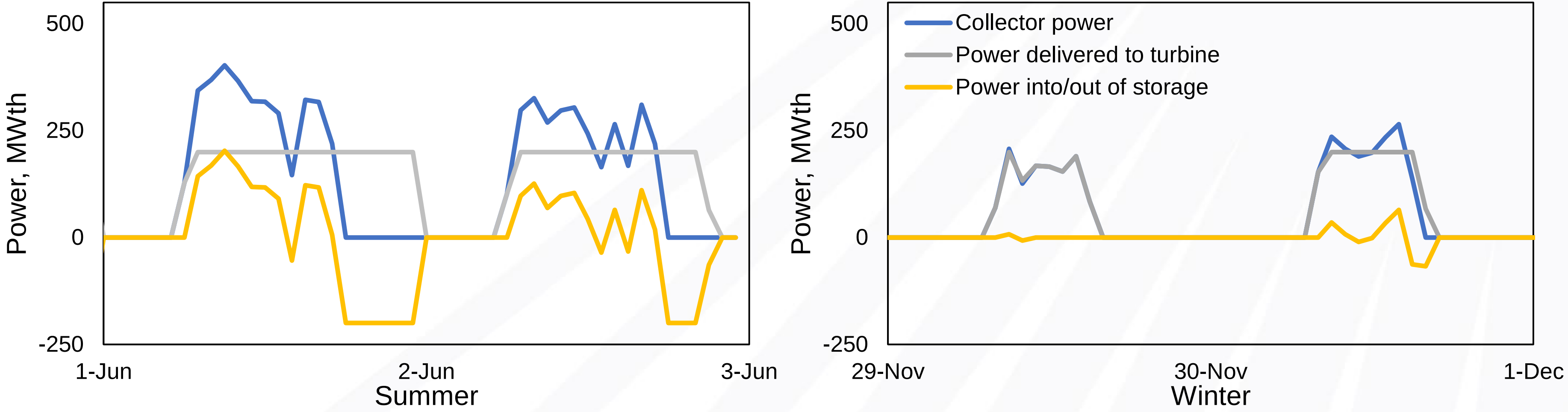
JoshuaDominic.McTigue@nrel.gov

Summary

- Challenges for CSP and Pumped Thermal Electricity Storage (PTES)
- Combining CSP with PTES
- Project tasks and impact
- Project team

Technical Challenges for CSP

Reduced utilization of power cycle and storage in the winter.



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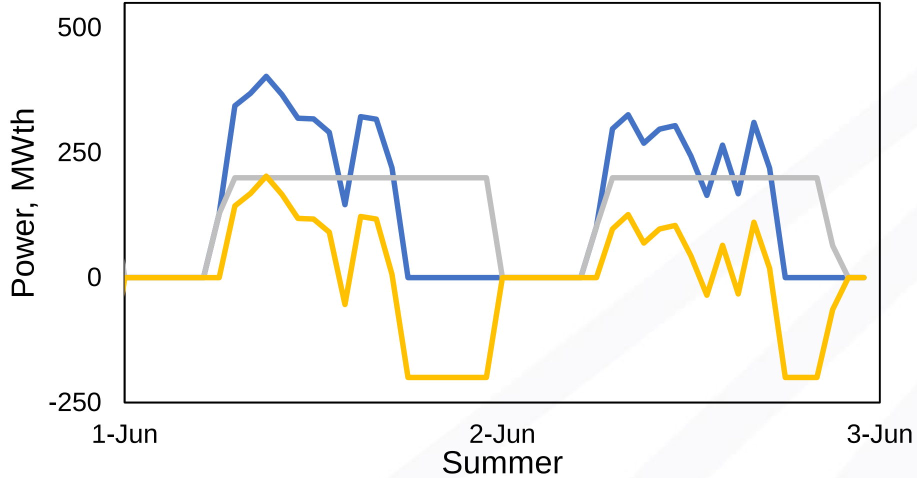
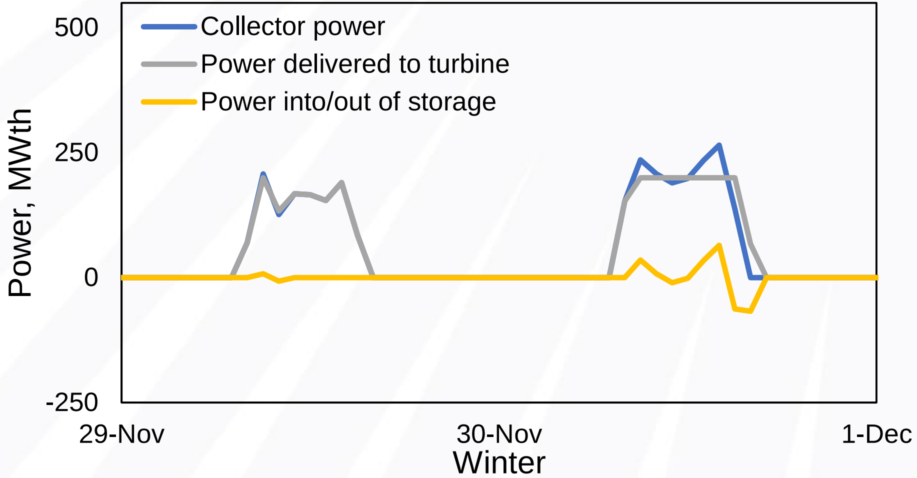
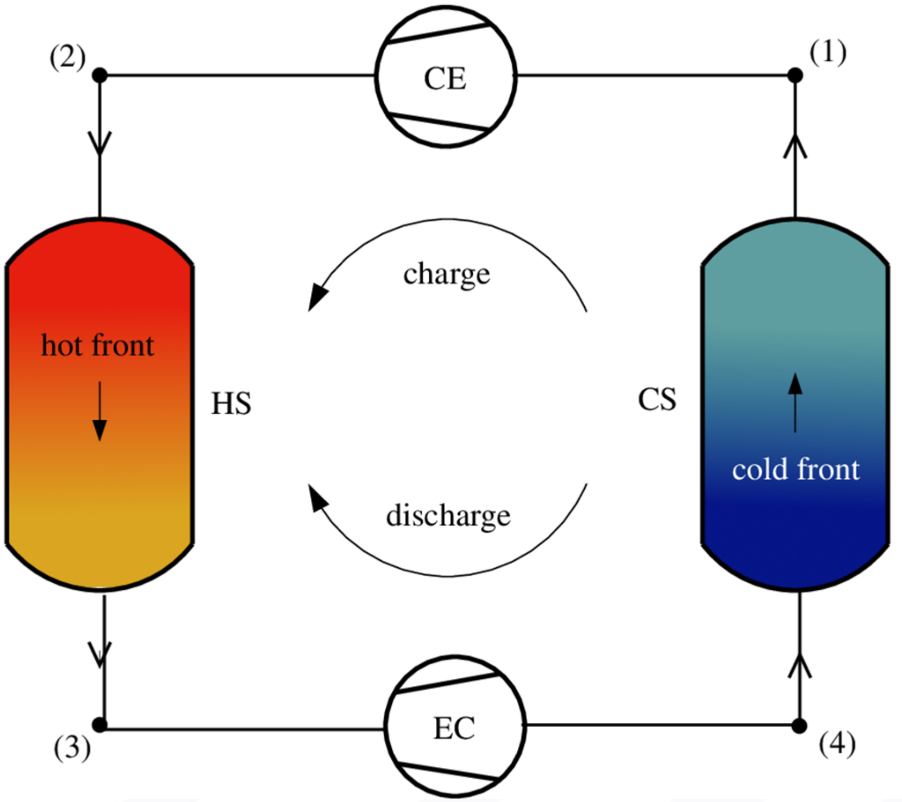




- Solar multiple of 2
- 100 MW_e power plant in central California
- Thermal energy first dispatched to power block, then excess to storage, if available

	Utilization of storage, %		
Storage duration, h	Summer	Winter	Total
6	96.1	7.5	57.2
12	57.6	3.8	31.8

Pumped Thermal Electricity Storage (PTES)



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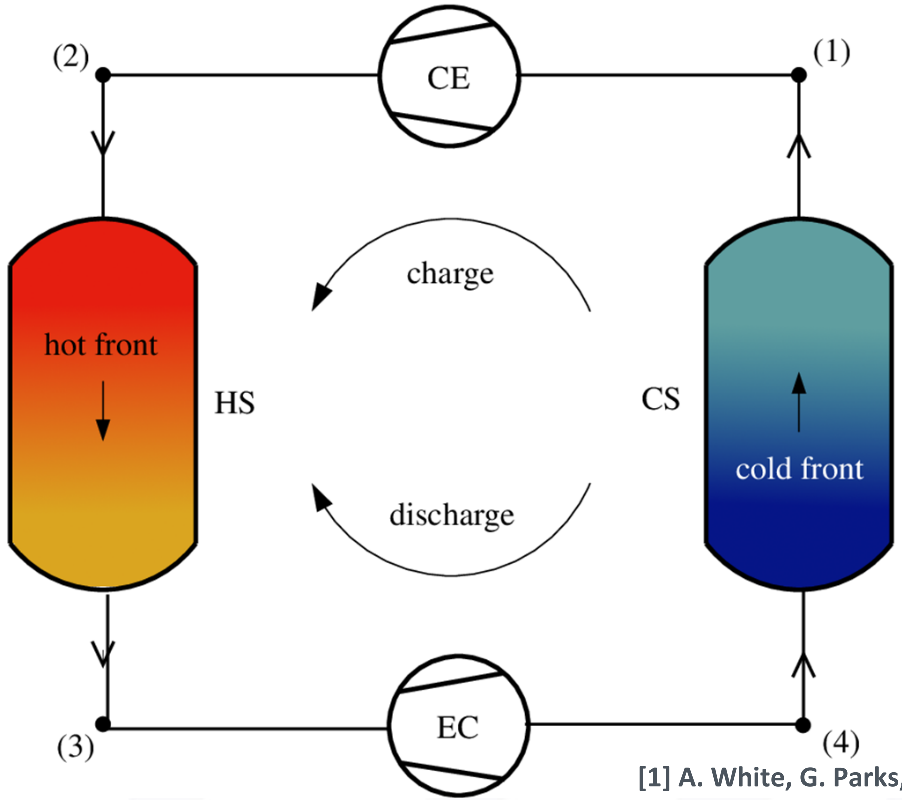


PTES has a hot store and a cold store

Charging:

- Electricity drives a heat pump
- Compression and expansion of a gas creates a hot space and a cold space

Discharging:

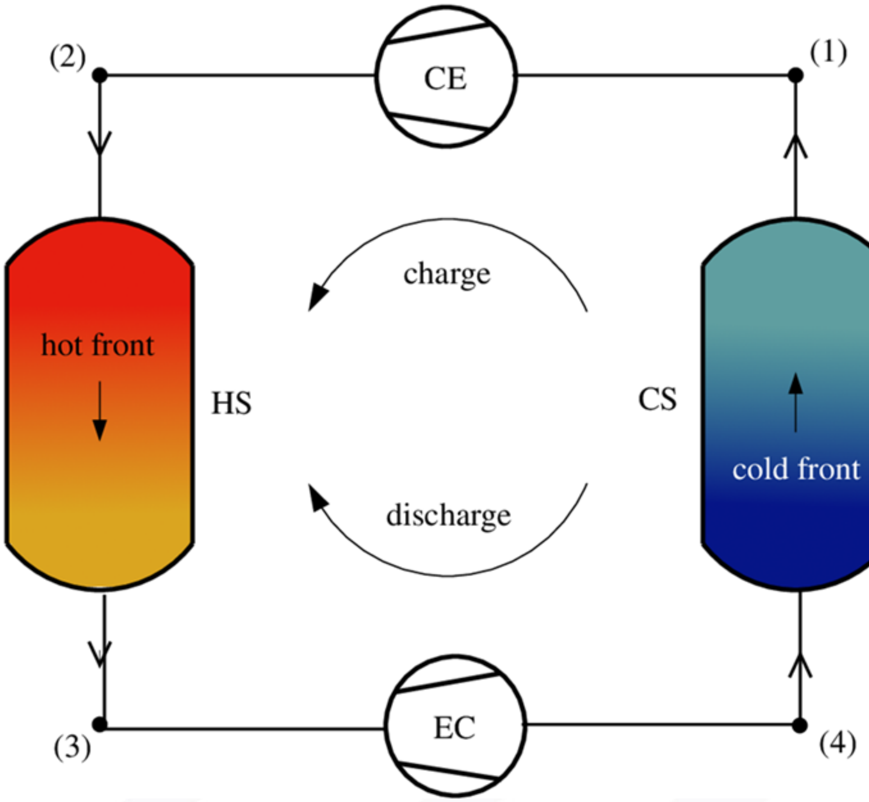
- Reverse cycle: heat engine
- Generate electricity

Upper limit to round-trip efficiency = 100 %

[1] **A. White, G. Parks, and C. N. Markides**, "Thermodynamic analysis of pumped thermal electricity storage," Applied Thermal Engineering, vol. 53, pp. 291–298, May 2013.

[2] **J. D. McTigue, A. J. White, and C. N. Markides**, "Parametric studies and optimisation of pumped thermal electricity storage," Applied Energy, vol. 137, pp. 800–811, Sept. 2015.

Pumped Thermal Electricity Storage (PTES)



Brief history

1924 – first patents to Maguerre

1970s – patents to Cahn, Smith (LAES), Babcock

2000s – concept revived in UK (Isentropic Ltd. + Cambridge) and France (CEA+Saipem) and Switzerland (ABB) simultaneously

2010s – Active research globally. Isentropic Ltd. builds prototype, sells to Newcastle University, UK. Various DOE funding awarded.

Commercial interest: Siemens/Stiesdal Storage Technologies, Malta Inc (Google X), Highview Power, Isentropic Ltd., ABB, WindTP, Echogen, Brayton Energy

Technical Challenges for PTES

- Demonstration of technology
- High temperature compression for heat pump
- Suitable materials for low-temperature storage
- Demonstrate market/value of PTES

Combining PTES with CSP – ‘solar-PTES’

- Leverage CSP expertise in hot thermal storage and power cycles
- Integrating PTES with an existing CSP plant requires the development of the heat pump and cold storage

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New feature	Impact
Heat pump charges hot storage	Decouples storage capacity from solar availability
Heat pump charges cold storage	Reject heat at lower temperatures: • Increases discharging efficiency • Robust to ambient temperature variations
Grid storage capability	Additional value and markets for CSP to operate in

Project tasks and impacts

Task	Impacts
1. Develop system concepts	• Invent new storage systems and power cycles
2. Economic models of components	• Develop low-cost solutions that leverage existing technologies
3. Detailed thermodynamic modelling	• New understanding of interaction between thermal storage and power cycles • Develop open-access models to facilitate research
4. Grid integration modelling	• Assess value solar-PTES provides to grid • Assess commercial viability of solar-PTES

Project team


Josh McTigue
PI


Craig Turchi
Economics


Ty Neises
s-CO_2 power cycles


Guangdong Zhu
CSP analysis


Janna Martinek
Grid analysis


Jennie Jorgenson
Grid analysis


Alex White
Cambridge University


Christos Markides
Imperial College, London

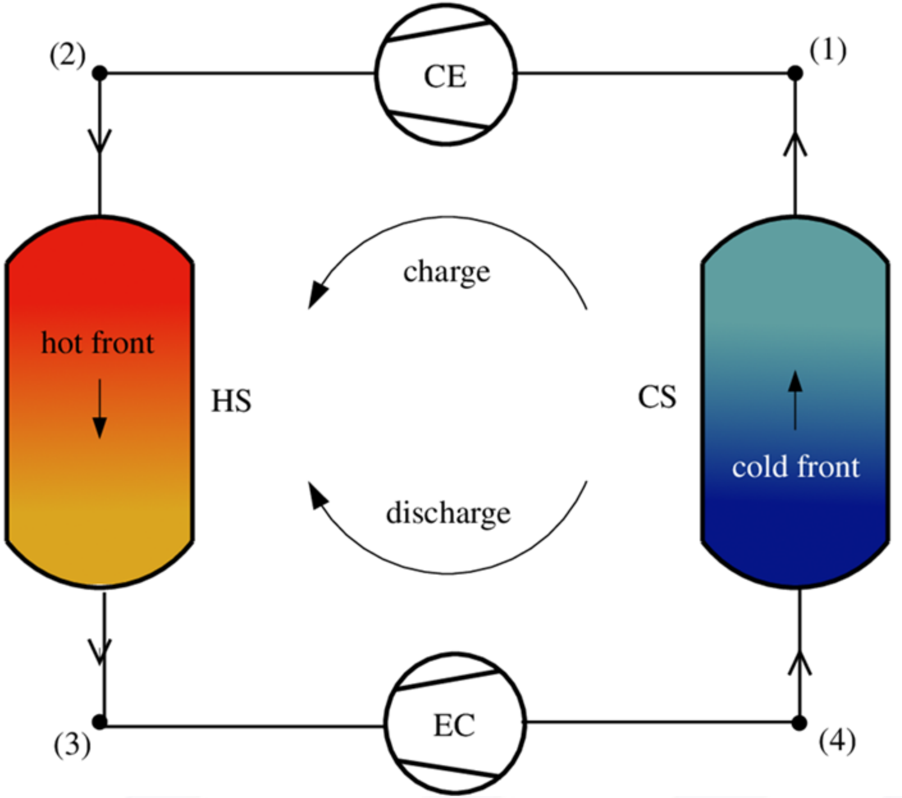

Pau Farres-Antunez
Cambridge University

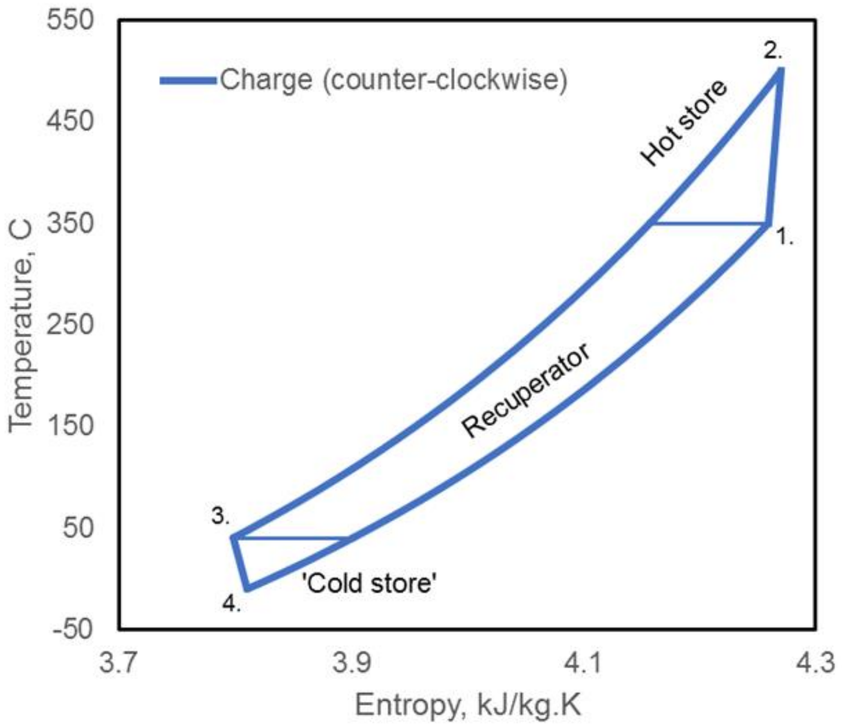
Partners

UNIVERSITY OF CAMBRIDGE

Imperial College London

Questions





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