Technology and Value Assessment Committee

Power-to-Heat-to-Power Storage for Enhancing Photovoltaic Self-Consumption in Heat Electrification

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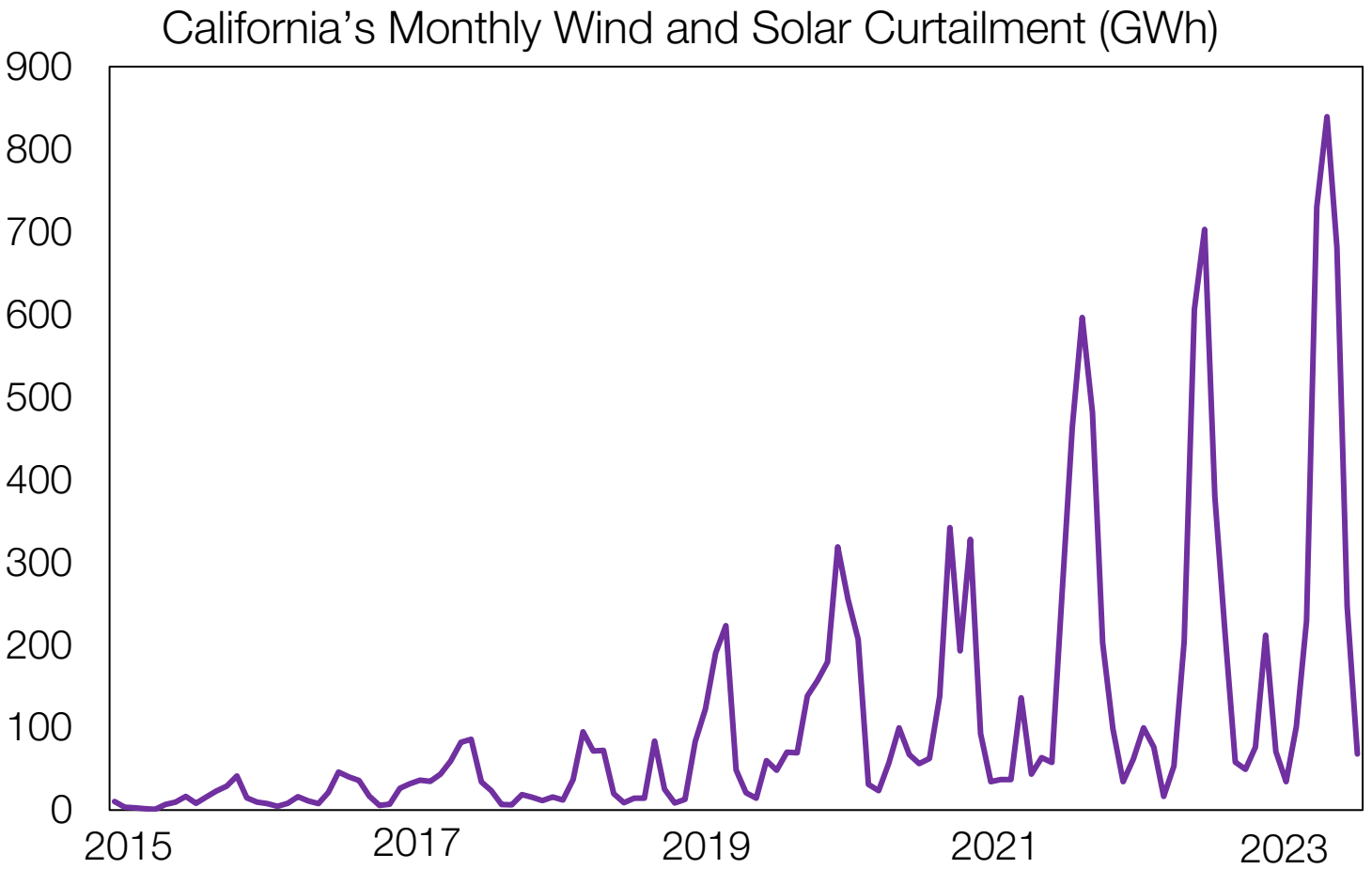
Share of renewables



→ Zero electricity prices

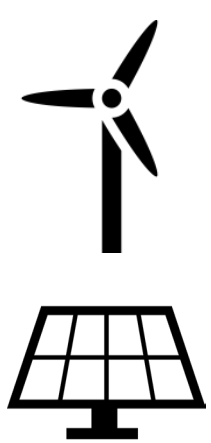
Heat is responsible for 40 % of global CO_2 emissions

→ Electrify heat

→ Cheap energy storage

Source: **California Independent System Operator**, https://www.caiso.com/about/our-business/managing-the-evolving-grid

Store heat through Power-to-Heat (P2H)



Electricity

Power-to-Heat Storage

Power to Heat

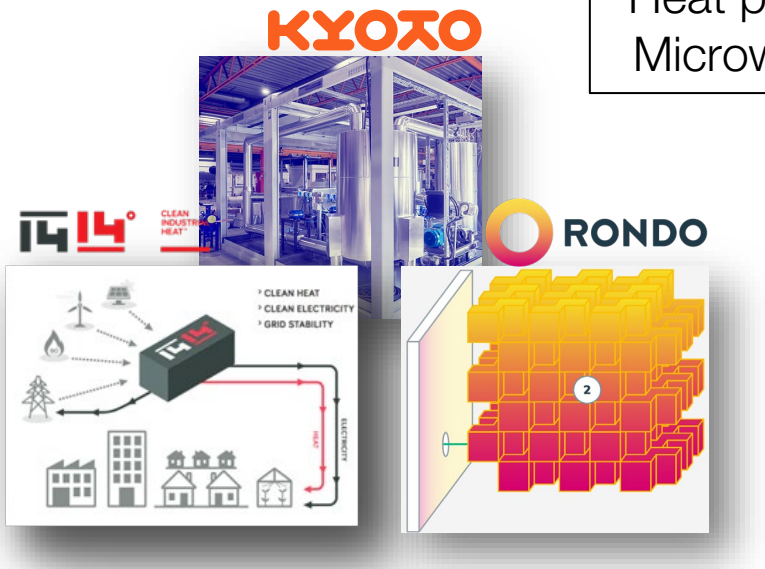
Thermal Storage

Heat

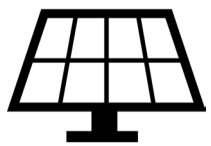
Resistive
Heat pump
Microwave

Latent heat
Sensible heat

What if we add Heat-to-Power (H2P) conversion?



Power-to-Heat-to-Power Storage



Power-to-Heat-to-Power Storage

Electricity → Power to Heat → Thermal Storage → Heat to Power → Electricity

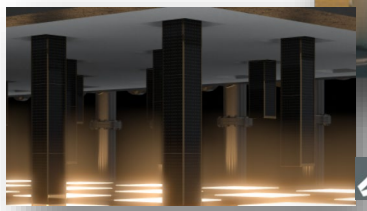
Waste heat

Dynamic: **Stirling, Rankine, Brayton**

Static: **Thermo-PV cell**

MALTA

FOURTH POWER



THERMOPHOTON
POWERING ENERGY STORAGE

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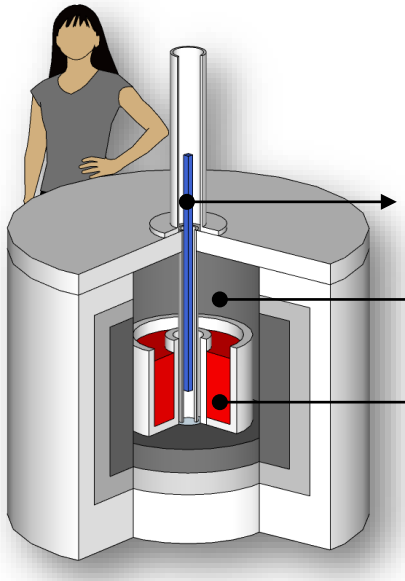
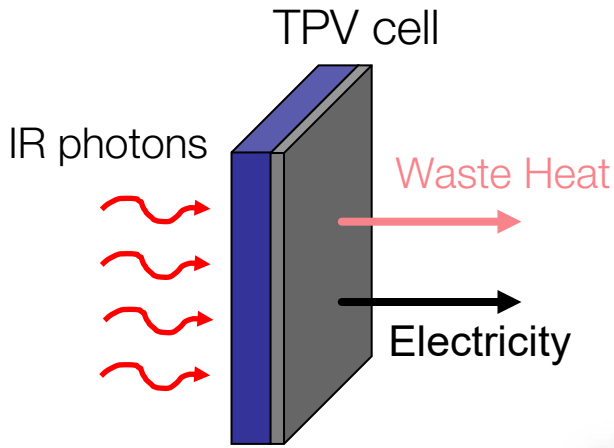
THERMOBAT 2022 2026 THERMOPHOTON POWERING ENERGY STORAGE

LHTPV Demonstrator



100 kWh



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Motivation

- **Buildings** energy consumption accounts for **17 %** of the global CO_2 emissions
- How to reduce the CO_2 emissions in Bulidings?
  - Proposal: **Hybridization** of solar PV, lithium-ion (**Li-ion**) batteries, heat pumps & **PHPS**

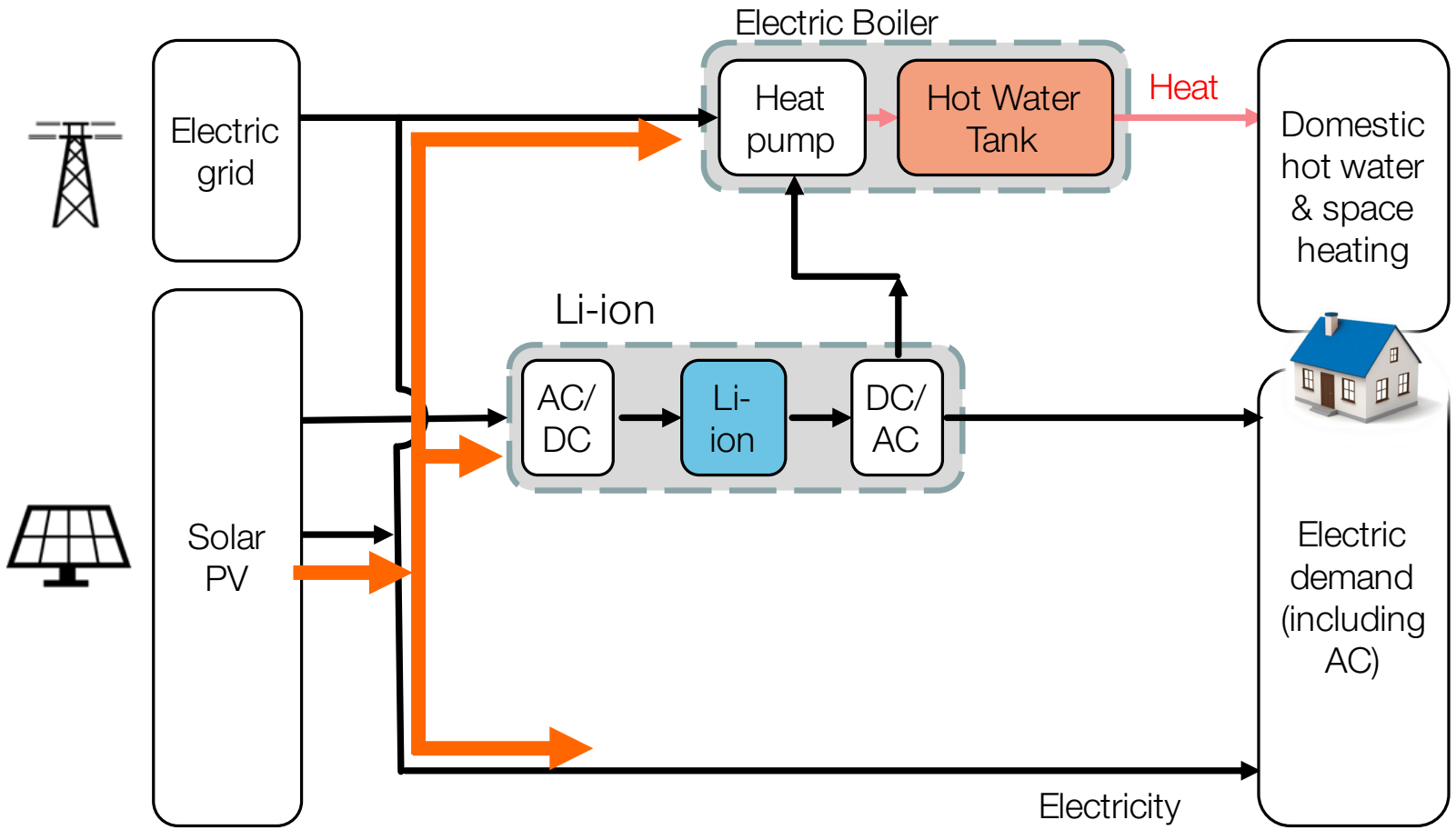
- Research question: Is there a **market** opportunity for **PHPS**?
  - How important is using the **waste heat** in the Heat-to-Power (H2P) conversion?
  - How do some important parameters, such as H2P **efficiency** and the Coefficient of Performance (**COP**) of the Heat Pump, impact on its feasibility?
  - Does the type of **building** affect results?

→ Simulation model to **minimize** the Levelized Cost of Energy (**LCOE**) in €/kWh

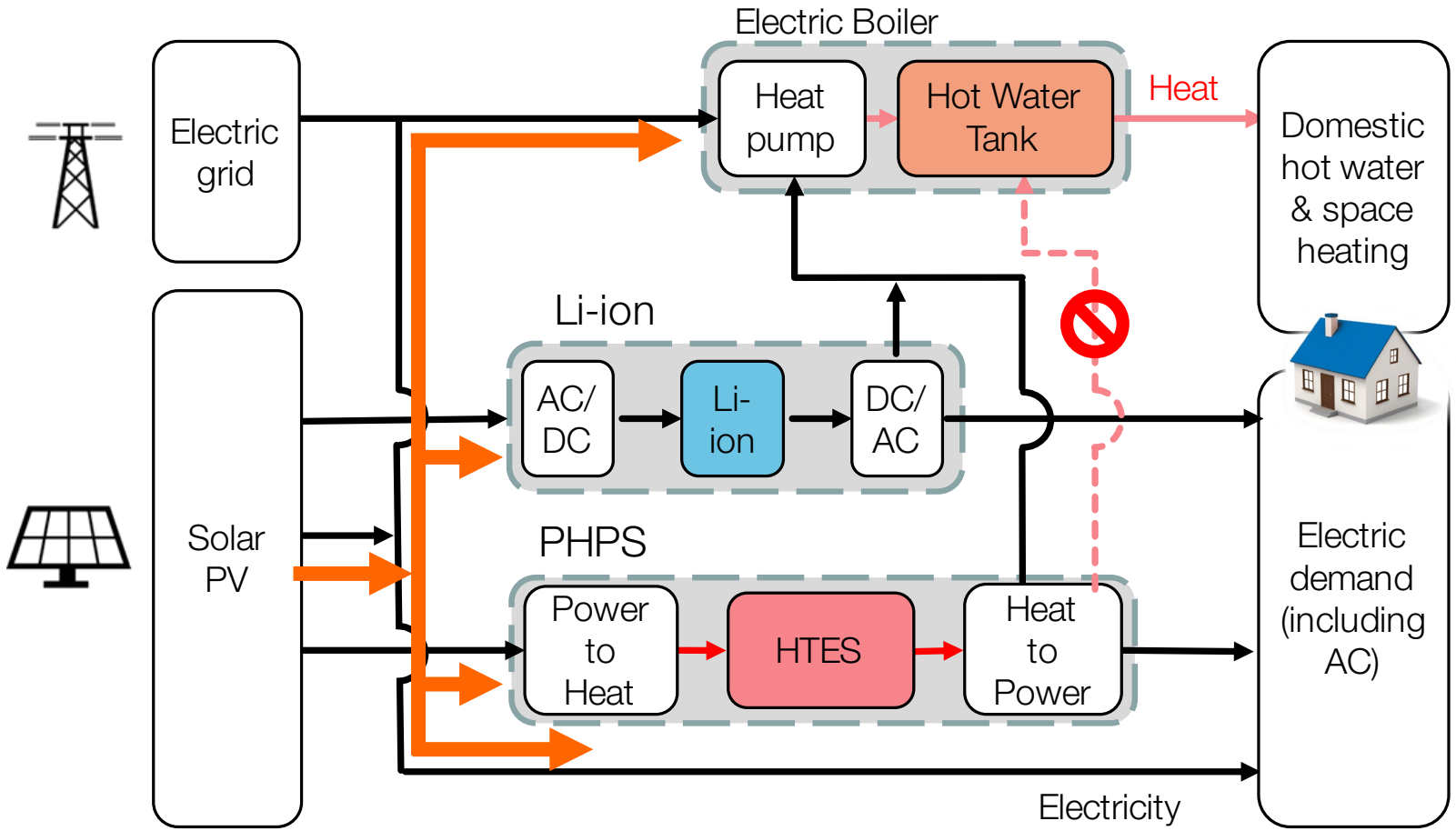
→ Base case: Li-ion

$$LCOE = \frac{CAPEX + \sum_{t=1}^{T} \frac{OPEX(t)}{(1 + WACC_{nom})^t}}{\sum_{t=1}^{T} \frac{E_{electr-year}(t) + E_{heat-year}(t)}{(1 + WACC_{real})^t}}$$

Methodology. Base case



Methodology. Hybrid case



Results

INSTITUTO DE ENERGÍA SOLAR

Hotel

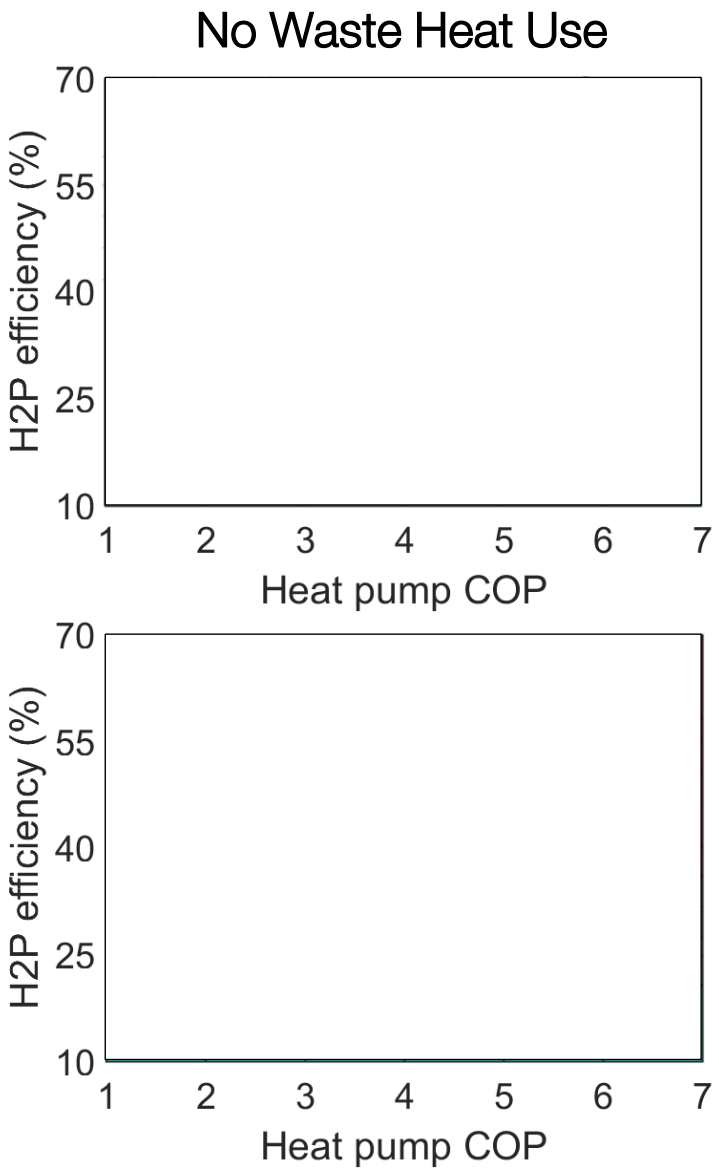
Heat: 0.7 GWh/y
Electricity: 1.4 GWh/y

Heat-electricity ratio: 33 %

Office

Heat: 0.03 GWh/y
Electricity: 0.3 GWh/y

Heat-electricity ratio: 10 %



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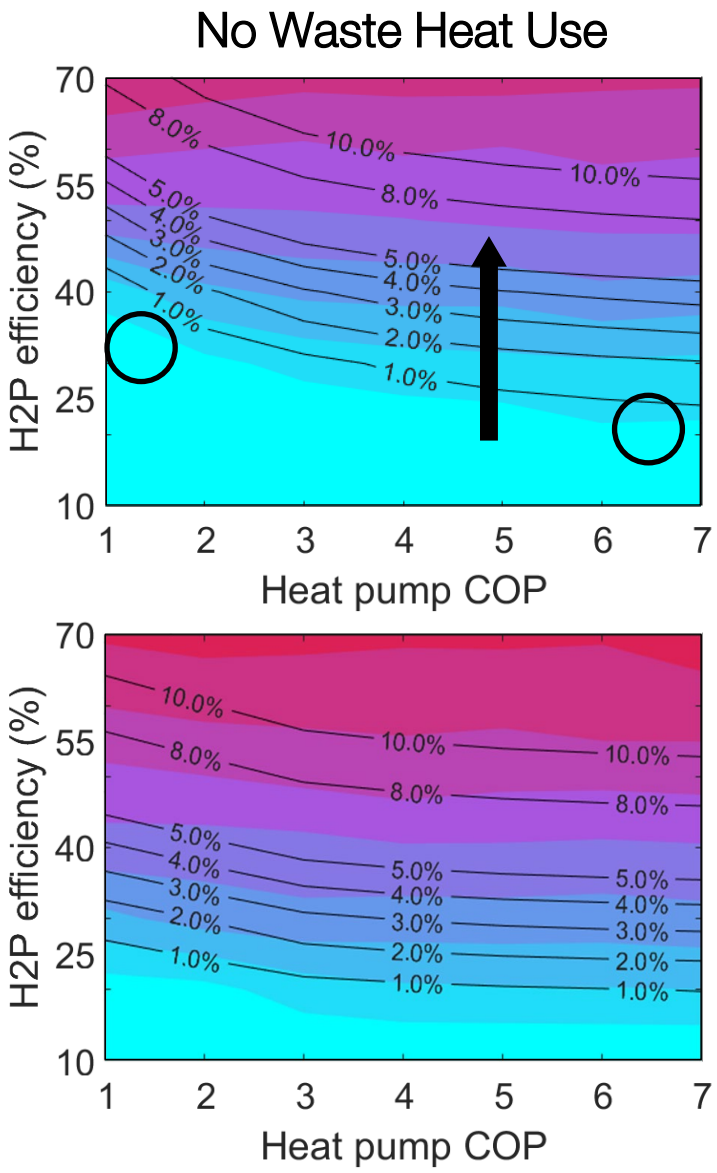
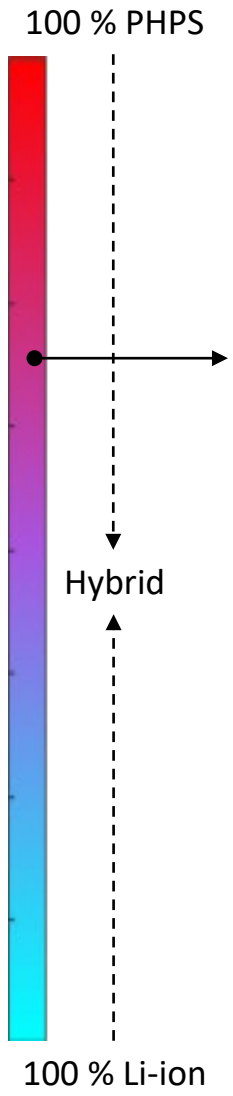
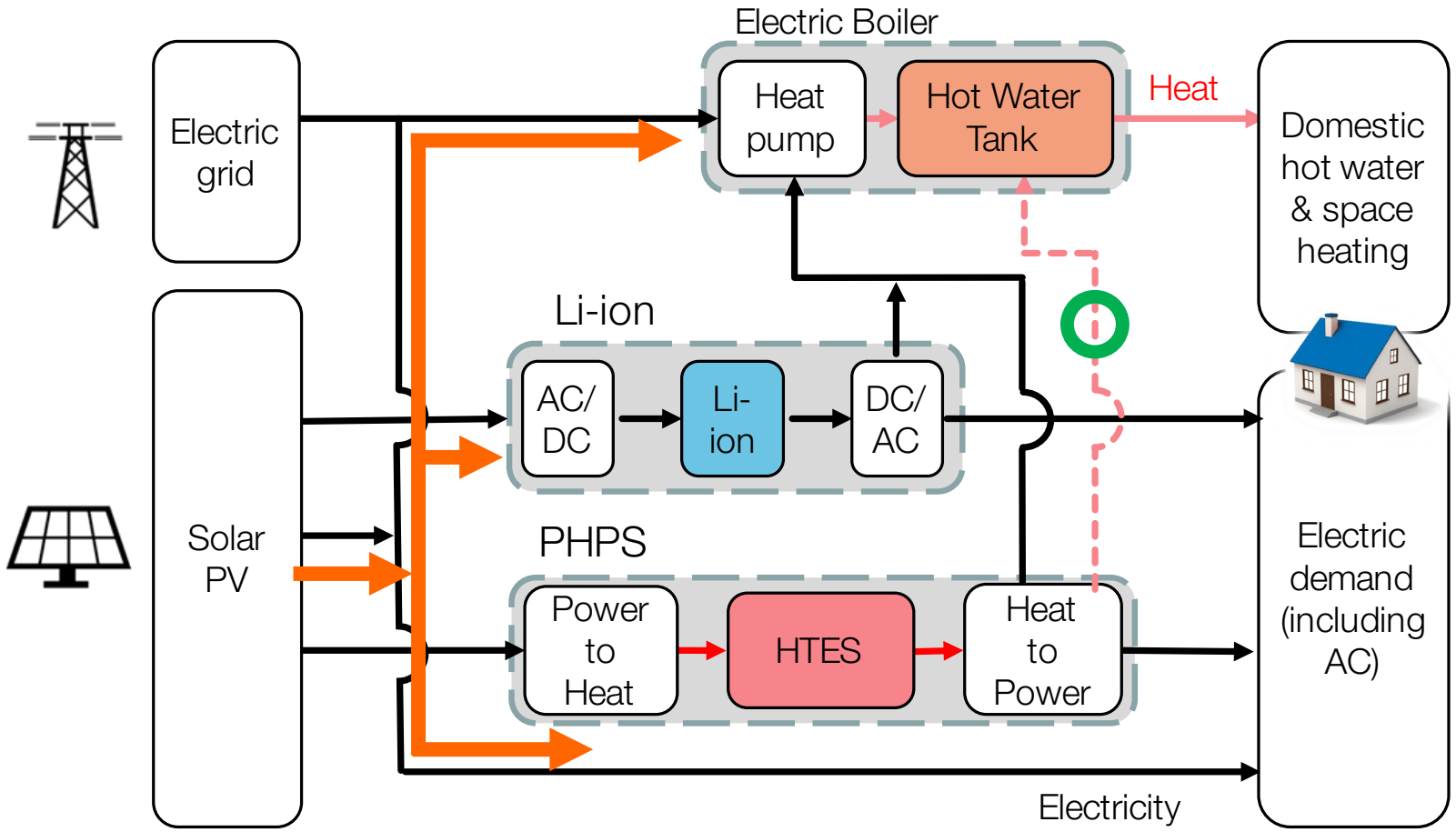




$$\frac{CAPEX_{\mathrm{PHPS}}}{CAPEX_{PHPS}+CAPEX_{\mathrm{Li-ion}}} \cdot 100$$

Methodology. Hybrid case



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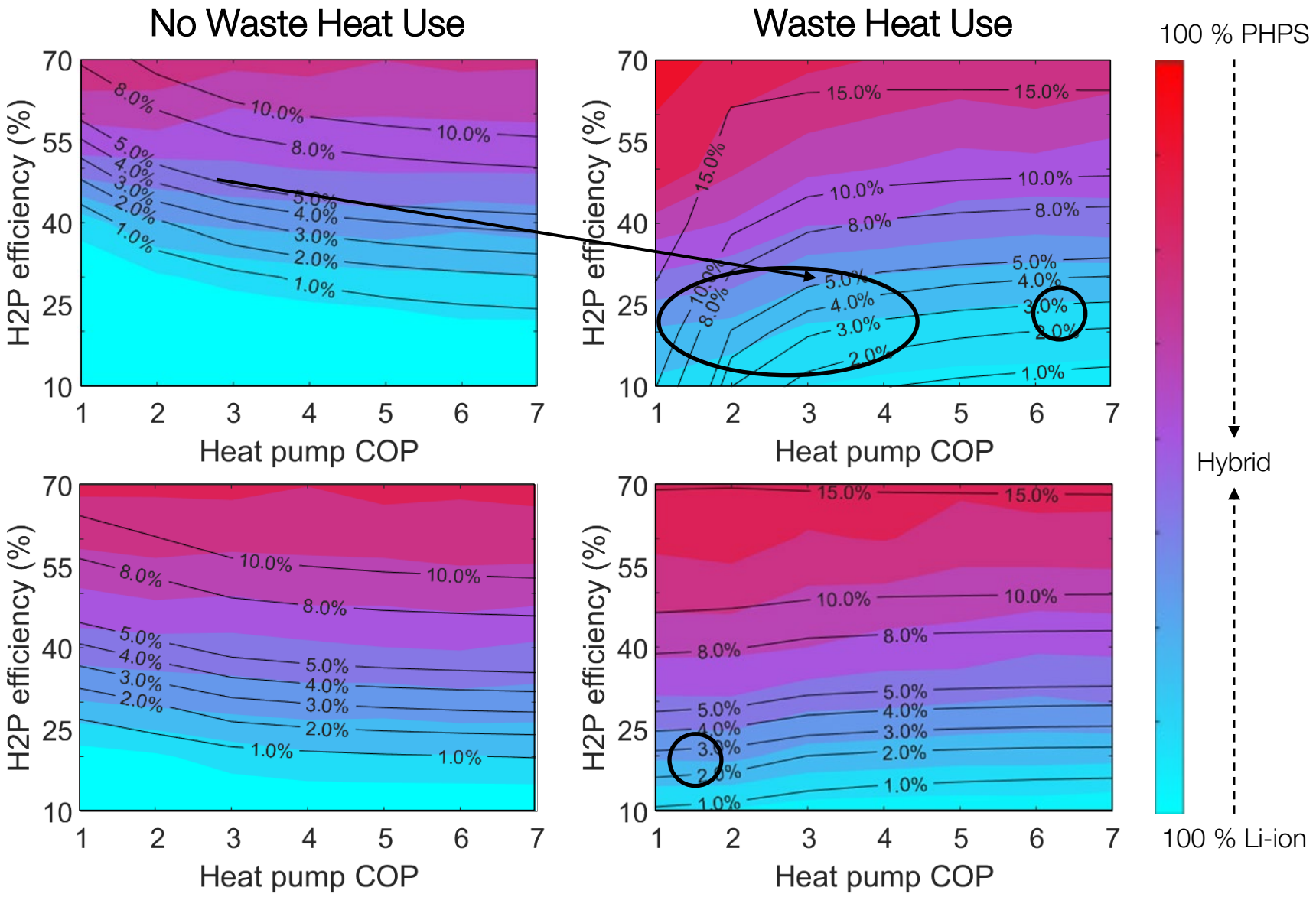

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Results. PV Self-consumption & Optimal Energy Capacity

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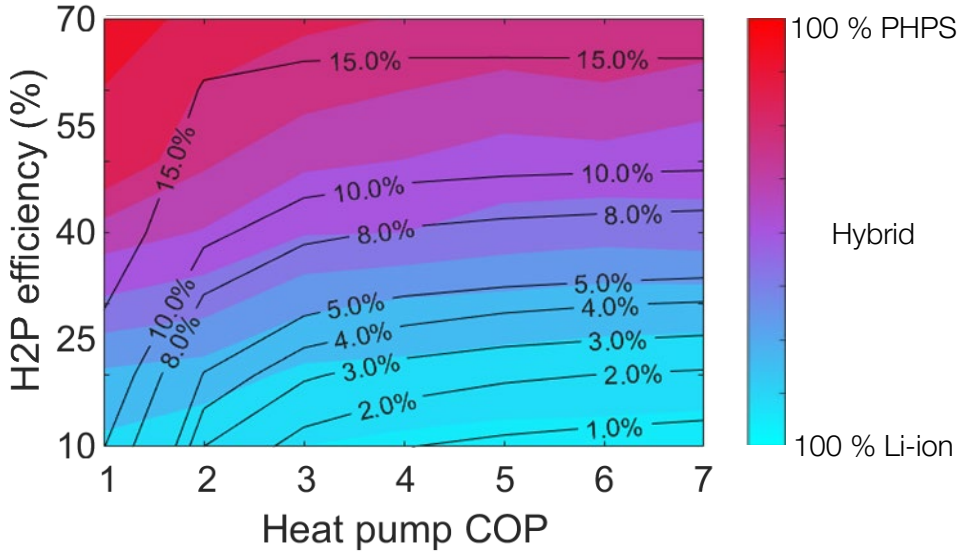
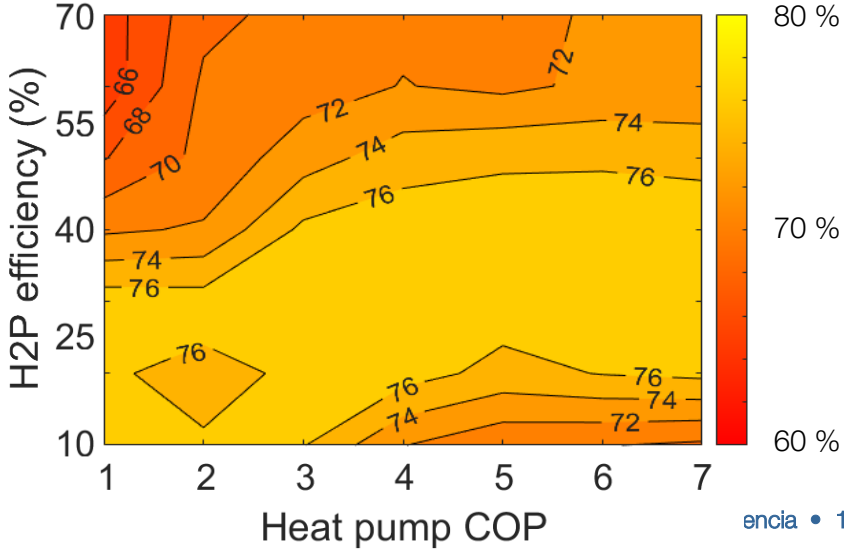
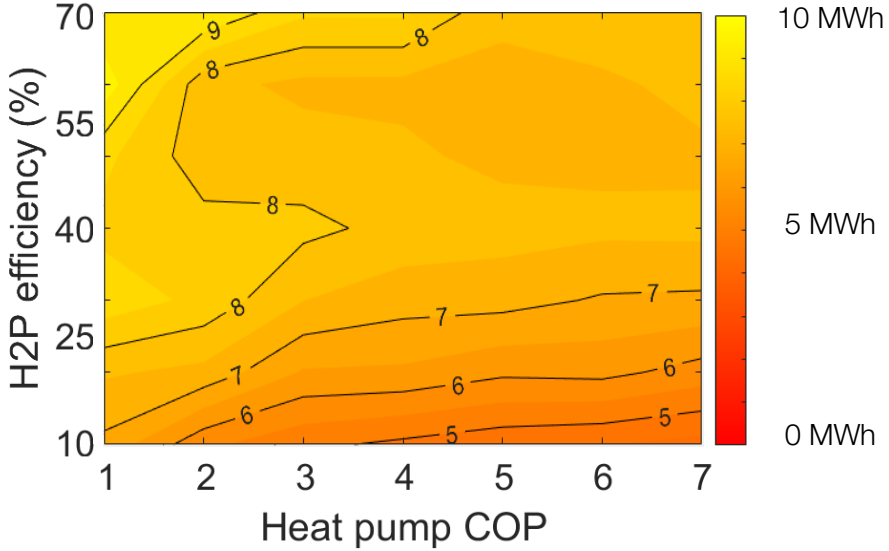
Hotel - Waste Heat Use



PV Self-consumption



Total Energy Storage Capacity (MWh)



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Conclusions

- PHPS is more **suitable** in **using waste heat**
- At **low H2P efficiencies**, using waste heat is the only option for PHPS to be feasible
- Buildings with high **heat to total energy demand ratios** is better for PHPS
- **Hybrid** solution brings highest PV self-consumption ratios
- With highly efficient heat pumps, PHPS feasibility depends only on the H2P efficiency

Thank you for your attention

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Happy to take your questions

We gratefully acknowledge the support of these institutions:


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Innovation in photovoltaics since 1979