



Innovation Type:  
**Methodology**

Development stage:  
**Finished**

Remaining uncertainties at current stage: **Applying the methodology to relevant cases**

TRL: 5-6

Status: **Finished**

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**HighEFF Overall Goals**

	Energy use & emissions	X
	New solutions	
	New methods and tools	X

**Relevant Sectors**

<b>Oil, Gas and Energy</b>	<b>Metal and Material</b>
<b>Food and Chemical</b>	<b>Industry Clusters</b>

# Optimal selection of thermal energy storage technology for fossil-free steam production

*Methodology for identifying the most cost-efficient Thermal Energy Storage (TES) and power-to-heat (P2H) system for load shifting and exploitation of fluctuating renewable energy sources in steam production*

## Challenge

Steam production is still primarily based on the use of fossil fuels, and all the major industrial energy users devote significant proportions of their fossil fuel consumption to steam production. TES combined with P2H technologies such as electric boilers or high-temperature heat pumps (HTHPs) enables the industries to decarbonize their steam production with rather small changes in the infrastructure, and at the same time shift their energy demands to periods with low electricity prices, thus allowing active participation in renewable-based electricity markets.

## Solution

An optimization-based method which helps to select and dimension the cost-optimal TES technology combined with P2H for a given industrial steam process has been developed. The storage technologies considered are latent heat TES, Ruths steam storage, molten salt storage and sensible concrete storage. The method is implemented in Python and uses the steam demand and electricity price profiles as an input to find an optimal TES and P2H combination for the application.

## Potential

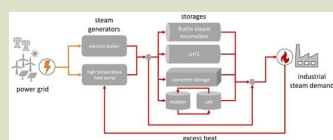
Steam generation systems were estimated to account for 9% of the global final energy consumption in 2005. Assuming that only 1% of steam demand is stored with a cycle duration of one day, roughly 70 000 steam storages of 100 m<sup>3</sup> are required worldwide – and much more, if a shift to renewable-based steam production is desired.

## Further related HighEFF work

- Apply the methodology for identifying an optimal P2H-TES combination to replace fossil-based steam production at the Nidar chocolate factory in Trondheim.

## References

- Beck, A., Sevault, A., Drexler-Schmid, G., Schöny, M., & Kauko, H. (2021). Optimal Selection of Thermal Energy Storage Technology for Fossil-Free Steam Production in the Processing Industry. Applied Sciences, 11(3), 1063.



Simple concept sketch

