Case studies of thermal energy storage in industrial processes

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ECN

Your energy. Our passion.

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ECN at a glance

ECN – Energy research Centre of the Netherlands

Founded in **1955**
5 Commercial licensing deals p/y
500 Employees
+/-20 patents a year
€ 70 M annual turnover

Mission:
…We develop knowledge and technologies for a sustainable energy system…

ECN Focus Areas

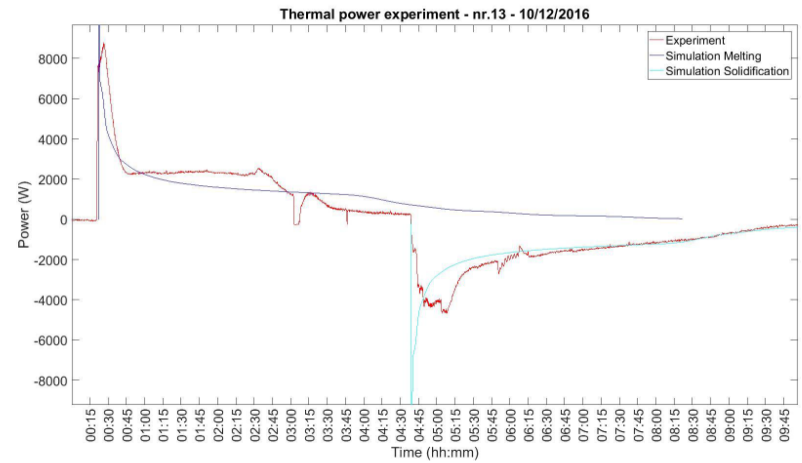
Solar energy | Biomass | Policy studies | Energy efficiency | Wind energy | Environment & Energy engineering

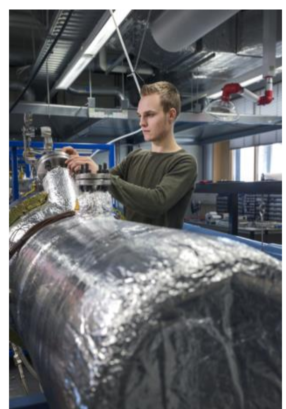
R&D Energy Efficiency in Industry

- Industrial Heat
  - Reuse of waste heat by upgrading or storing heat
  - Sustainable production of heat
- Liquid Separation & conversion
  - Energy efficient separation of liquids (membranes)
  - Recovery of valuable components from liquid streams
- Gas Processing , Treatment & Conversion
  - Gas separation by membranes & sorption
  - Carbon capture and reuse
- Industrial Integration of Renewable Electricity
  - Power2Heat
  - Power2Hydrogen
  - Power2Chemicals/fuels

ECN activities thermal storage

- Industrial case studies
  - Techno-Economic boundary conditions
- Materials screening, selection & testing
  - Phase Change Materials
- System modeling & design
  - Thermal power & stored energy





Industrial case studies

- Chemical sector : pressurized hot water storage for batch reactors
  - PCM and concrete storage as alternatives: PBT > 10 years, high system integration cost in retrofit.
  - Economically feasible and attractive in green field situations.
  - Actually applied in new plant . 30% savings on primary energy.

Het reactieproces bij de productie van ethoxylaten is sterk exotherm. Door nu de mogelijkheid te realiserendaat deze reactiewarmte op een hoog temperatuurniveau kan worden opgeslagen wordt een enorme energiebesparing van primaire energie bereikt. De besparing wordt gehaald doordat deze energie kan worden aangewend voor het opwarmen van grondstoffen.

Rewards
- Een energiebesparing van 30% primaire energie

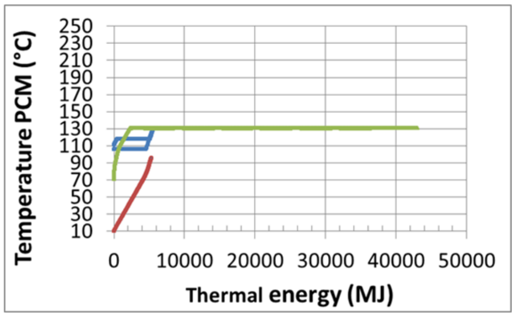
Risks
- Mogelijke besparing kunnen teniet gedaan worden door de ontwikkeling op de energie-markt

Resources
- Extra investering van plm. € 1,5 miljoen t.o.v. het oorspronkelijke (niet duurzame) ontwerp

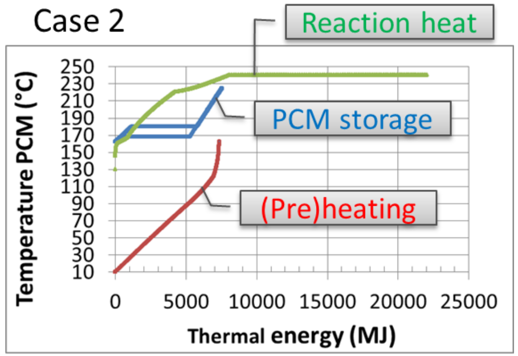
Industrial case studies

- Chemical processes: thermal energy storage in exothermal batch process
  - Case 1) 85% energy saving for the batch process
  - Case 2) 75% energy saving for the batch process

Case 1



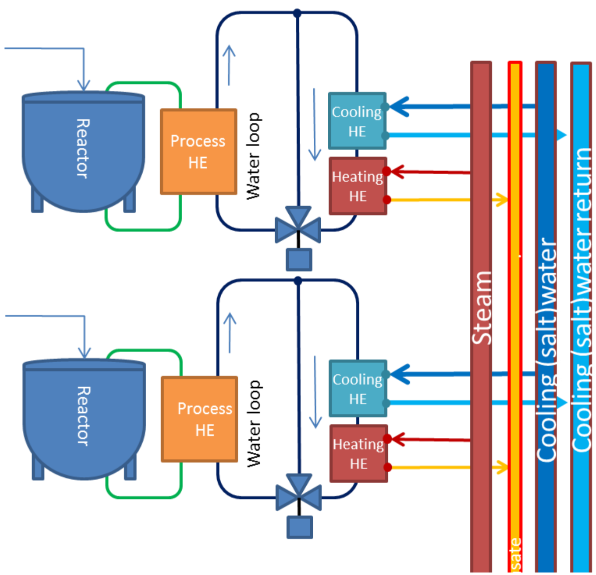
Case 2



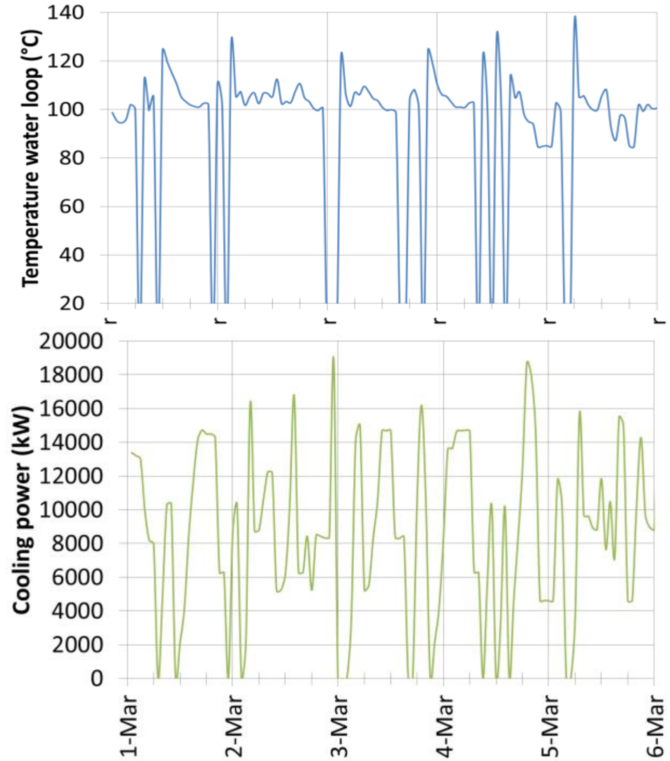
  - More energy saving possible on re-using all of the waste heat.
  - Business cases not attractive for energy (and CO_2) saving alone: additional non energetic benefits needed to justify investments
    - Higher production rates, improved safety, increased product quality, reduced cooling water needs, …..

Thermal storage + heat pump

- Batch process configuration

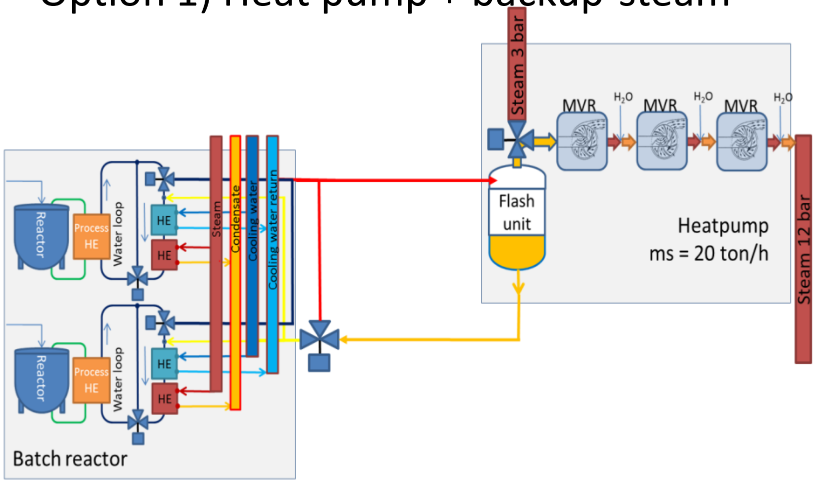


- Heat rejection of water loop

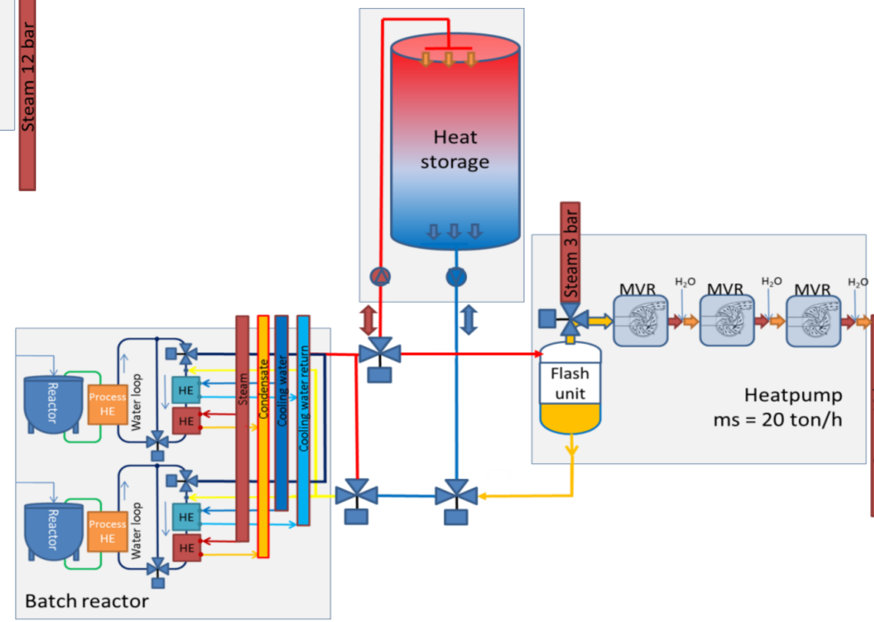


Process modifications

Option 1) Heat pump + backup-steam

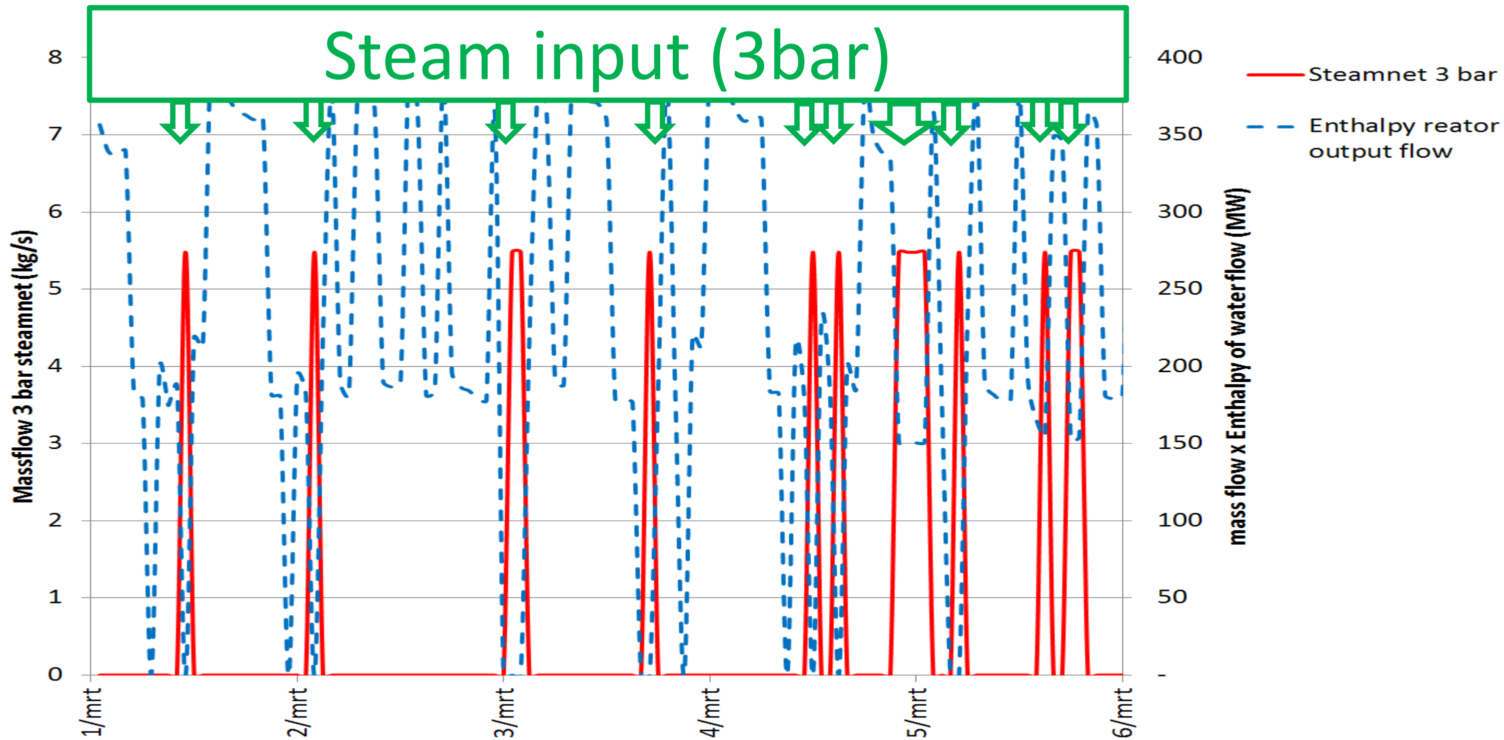


Option 2) Heat pump + thermal storage

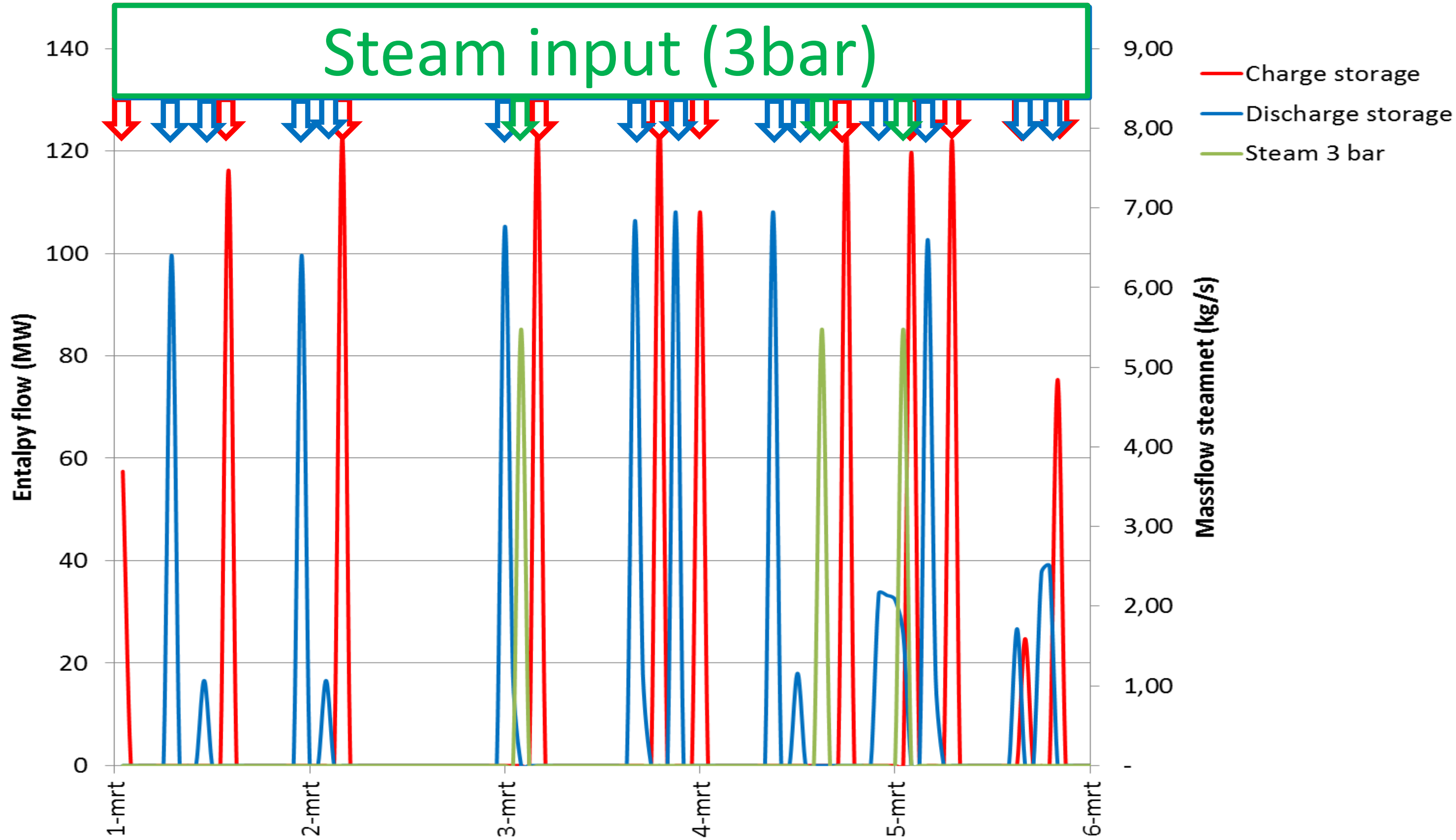


Model results

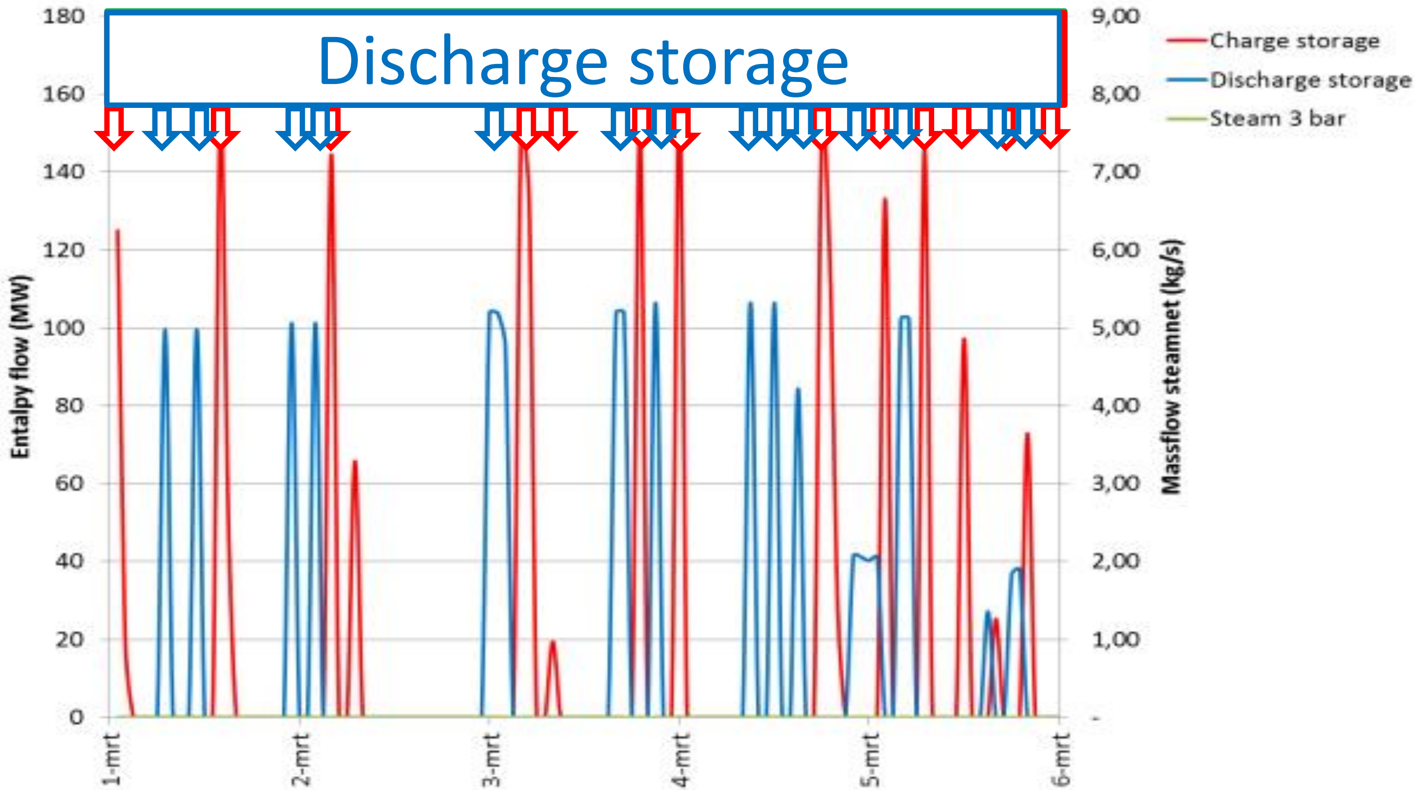
- Input flow of waste heat from the batch reactors (dotted line) and back-up steam supply (red line) for the MVR system, without thermal storage.



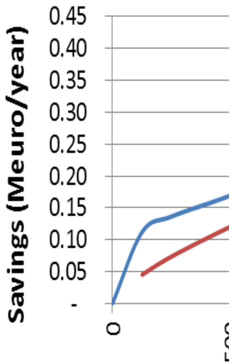
Storage 1000 m³



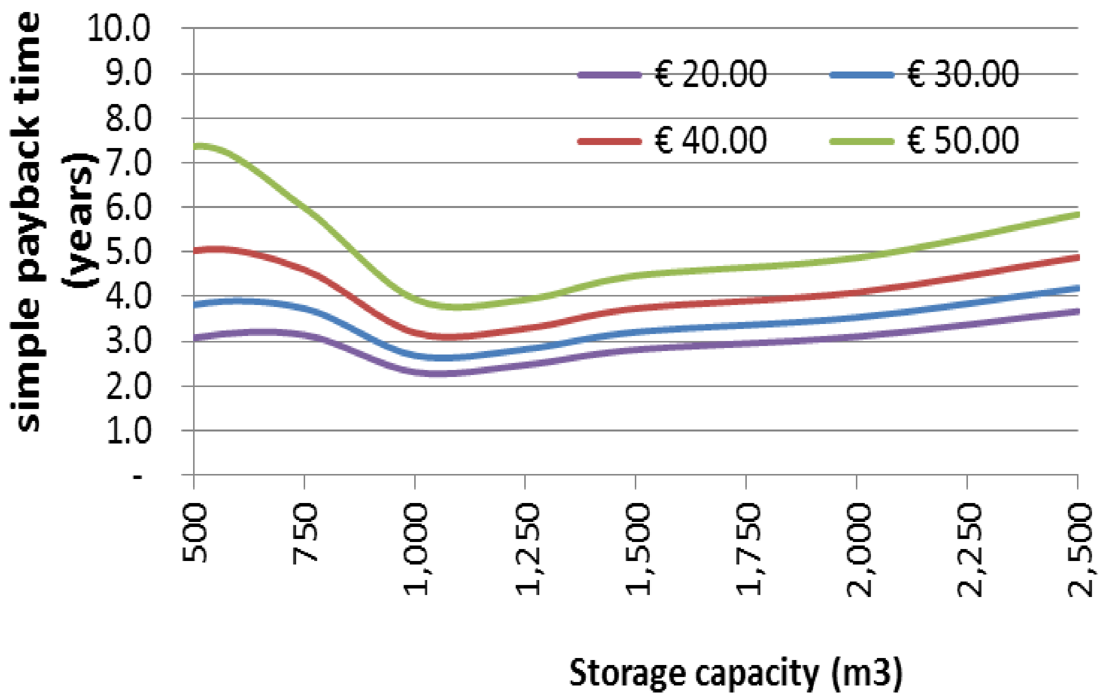
Storage 2500 m³

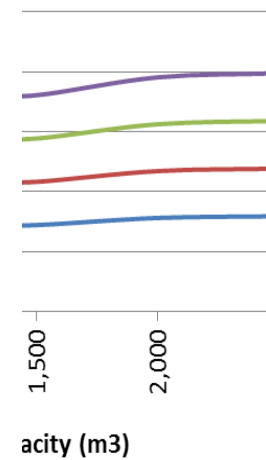


Economic evaluation



Steam cost savi





r the heat pump

Calculated payback times for the thermal storage system, for various electricity prices.

Summary

- Include thermal storage as energy saving measure in green-field situations
- A large amount of waste heat of the batch processes can be re-used by using a mechanical vapour recompression heat pump (MVR)
- A thermal storage system can further increase this amount of waste heat recovery and replace the low pressure steam backup for the heat pump
- The thermal storage capacity is to be balanced between investment costs and energy cost savings
- Pay back times of less than 5 years can be realized for the thermal storage system integration

Thank you for your attention

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