

# Seasonal Storage Solutions

Niels From, PlanEnergi

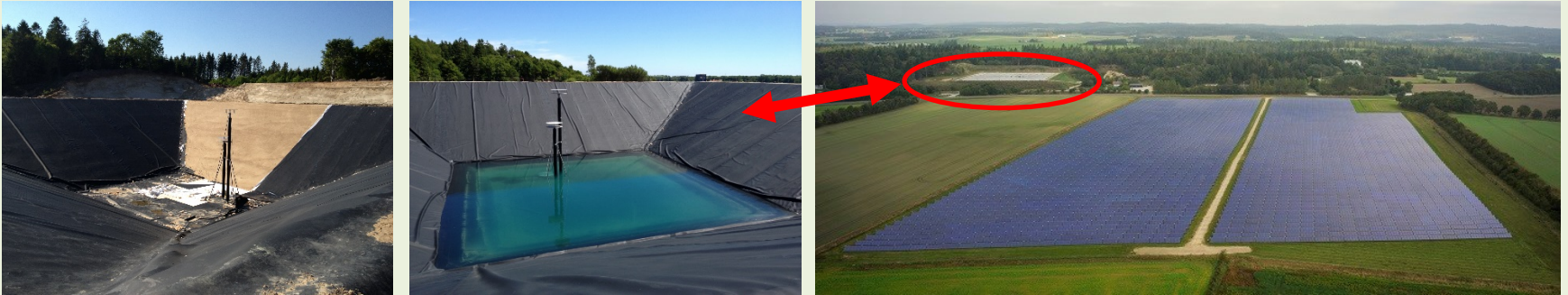


Vojens, DK

# PlanEnergi

- Consultants
  - 30 years with RE
  - 30 employees
  - Offices in
    - Skørping
    - Aarhus
    - Copenhagen
  - [www.planenergi.dk](http://www.planenergi.dk)
- District heating
    - Solar thermal
    - Seasonal storages
    - Heat pumps
    - a.m.
  - Energy planning
  - Biogas
  - Wind turbines

# Seasonal storage references



SUNSTORE 3 in Dronninglund, DK, 2014, 60 000 m<sup>3</sup>



Boreholes in Brædstrup, DK, 2012, pilot



SUNSTORE 4 in Marstal, DK, 2012 , 75 000 m<sup>3</sup>

# Agenda

- Types of Thermal Energy Storages (TES)
- Feasibility of SDH + short term storage
- Feasibility of SDH + long term storage
- Optimal collector area and storage
- Summary

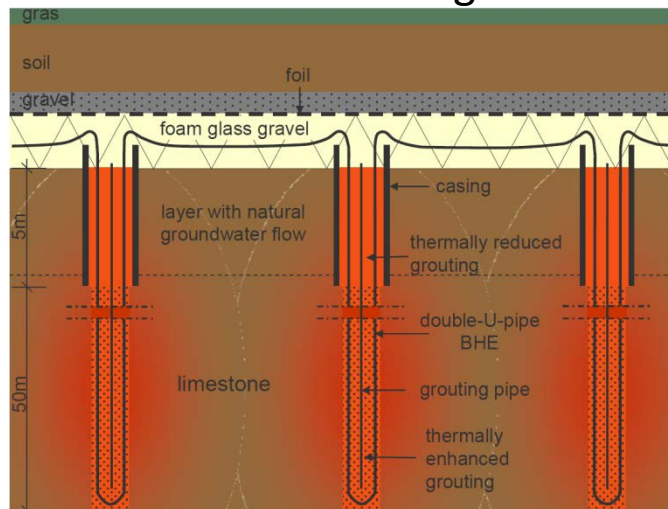


Model of Brædstrup in Legoland

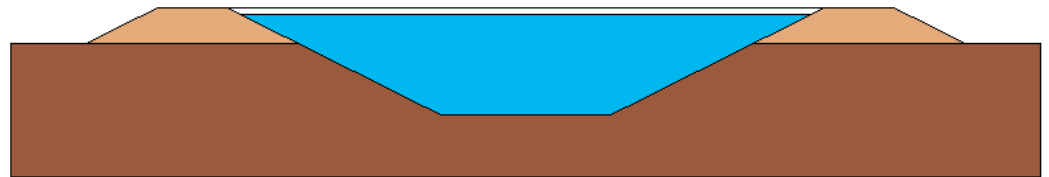


TTES – Steel tank

BTES – Borehole storage

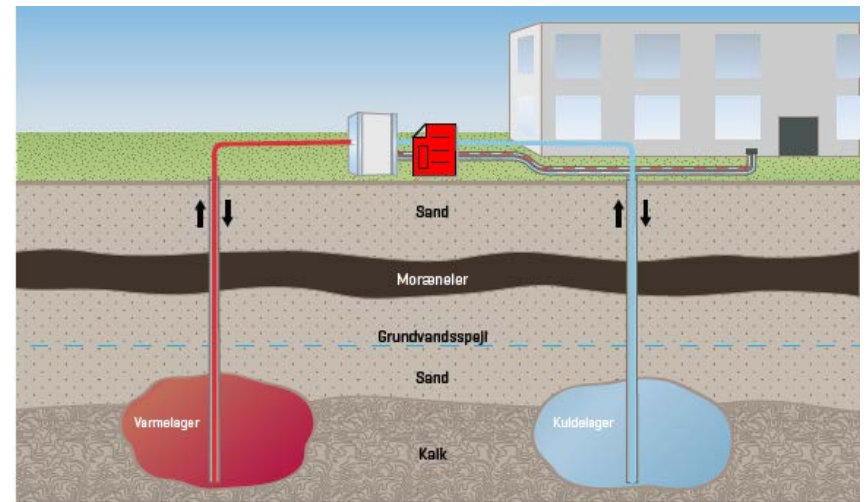


## Types of Thermal Energy Storages

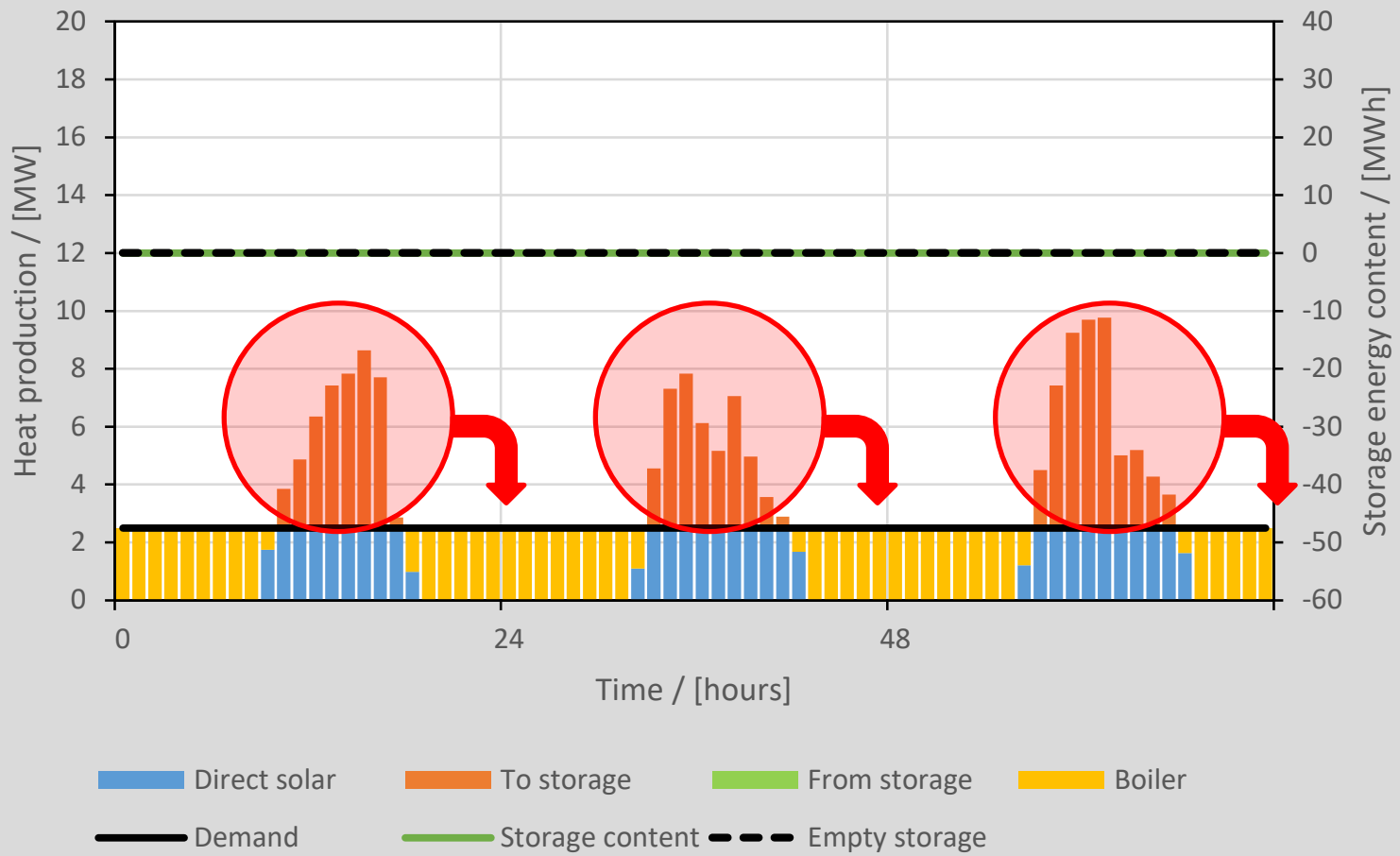


PTES – Pit heat storage

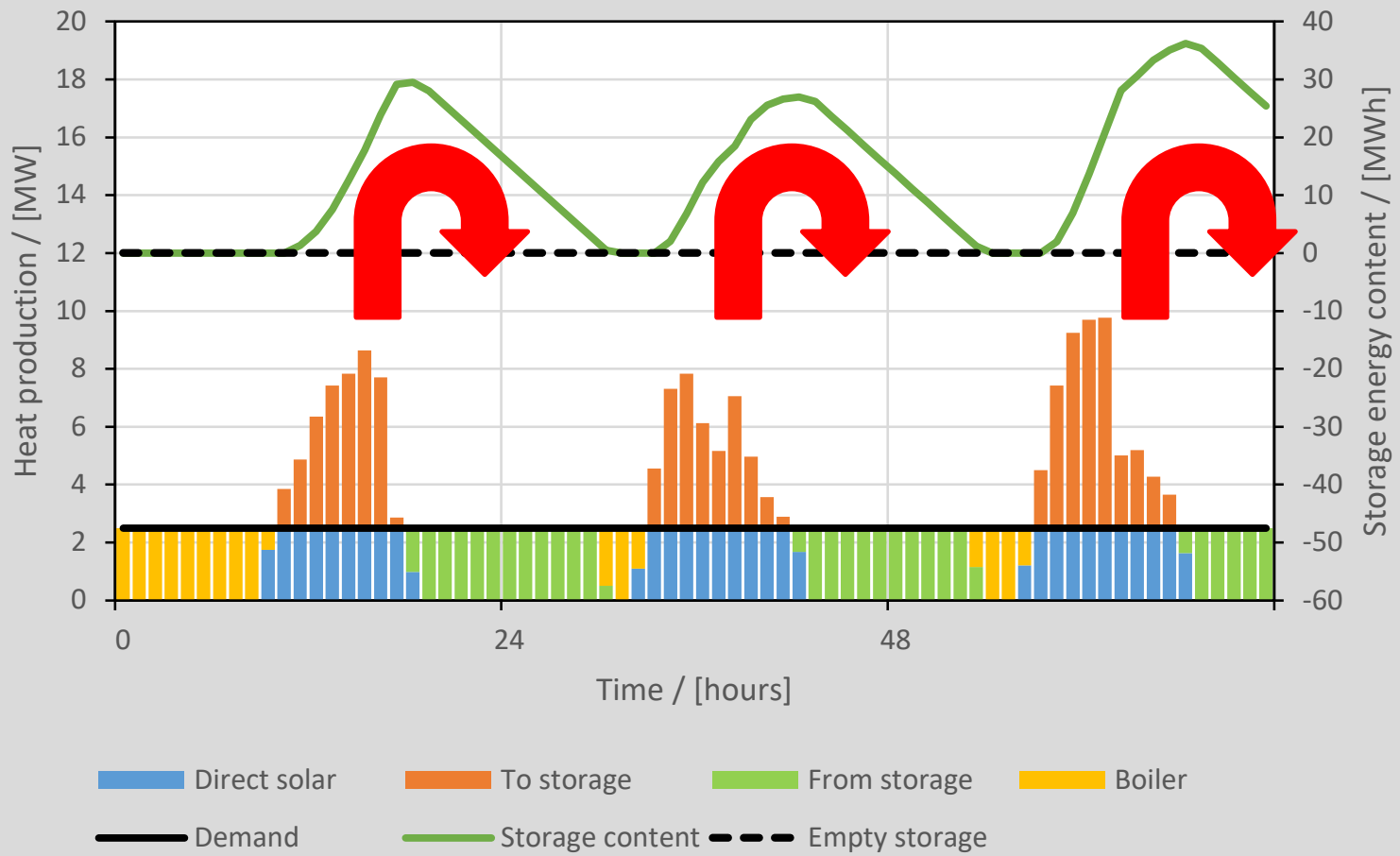
ATES – Aquifer storage



# SDH without storage



# SDH with short term storage

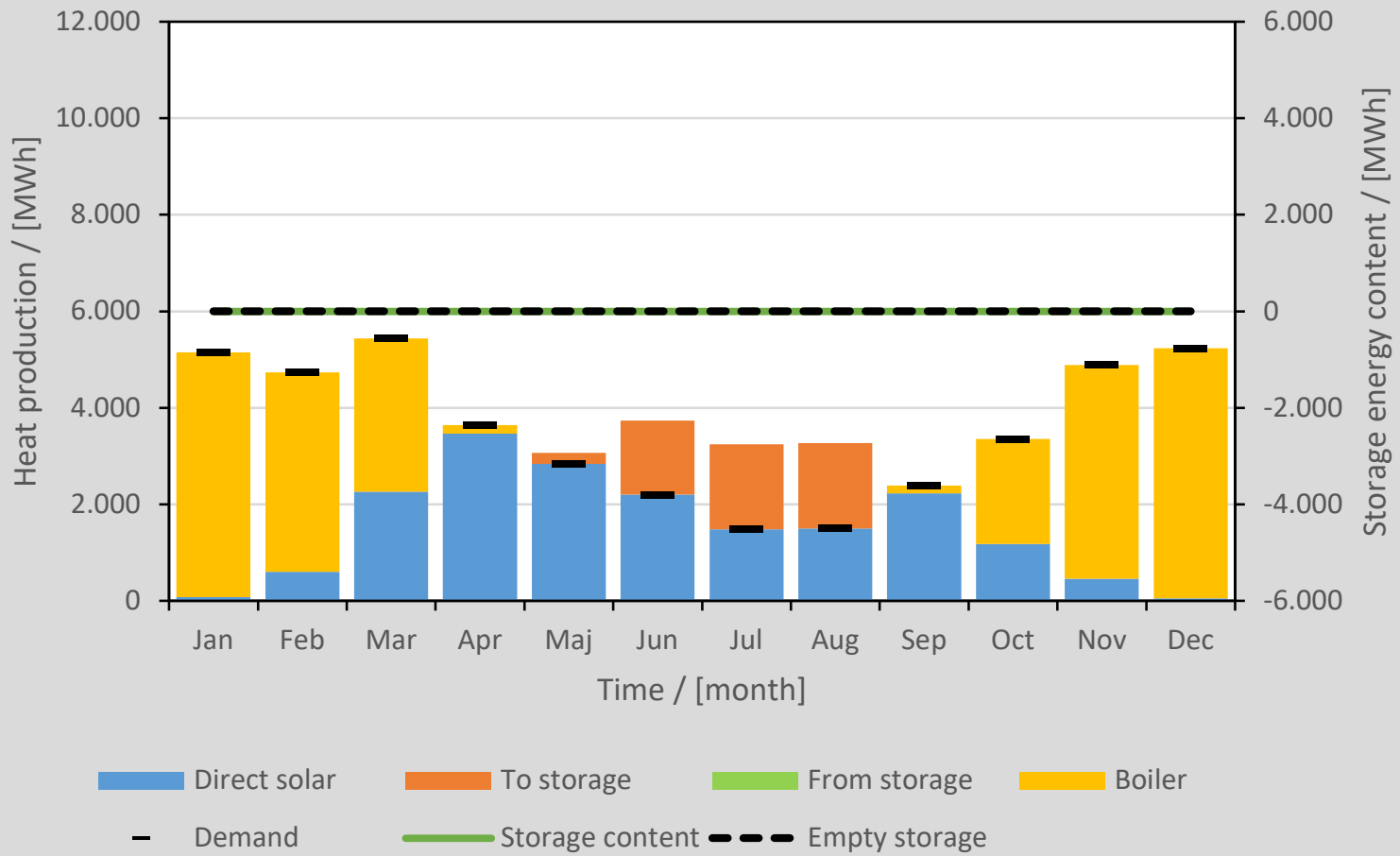


# SDH with short term storage

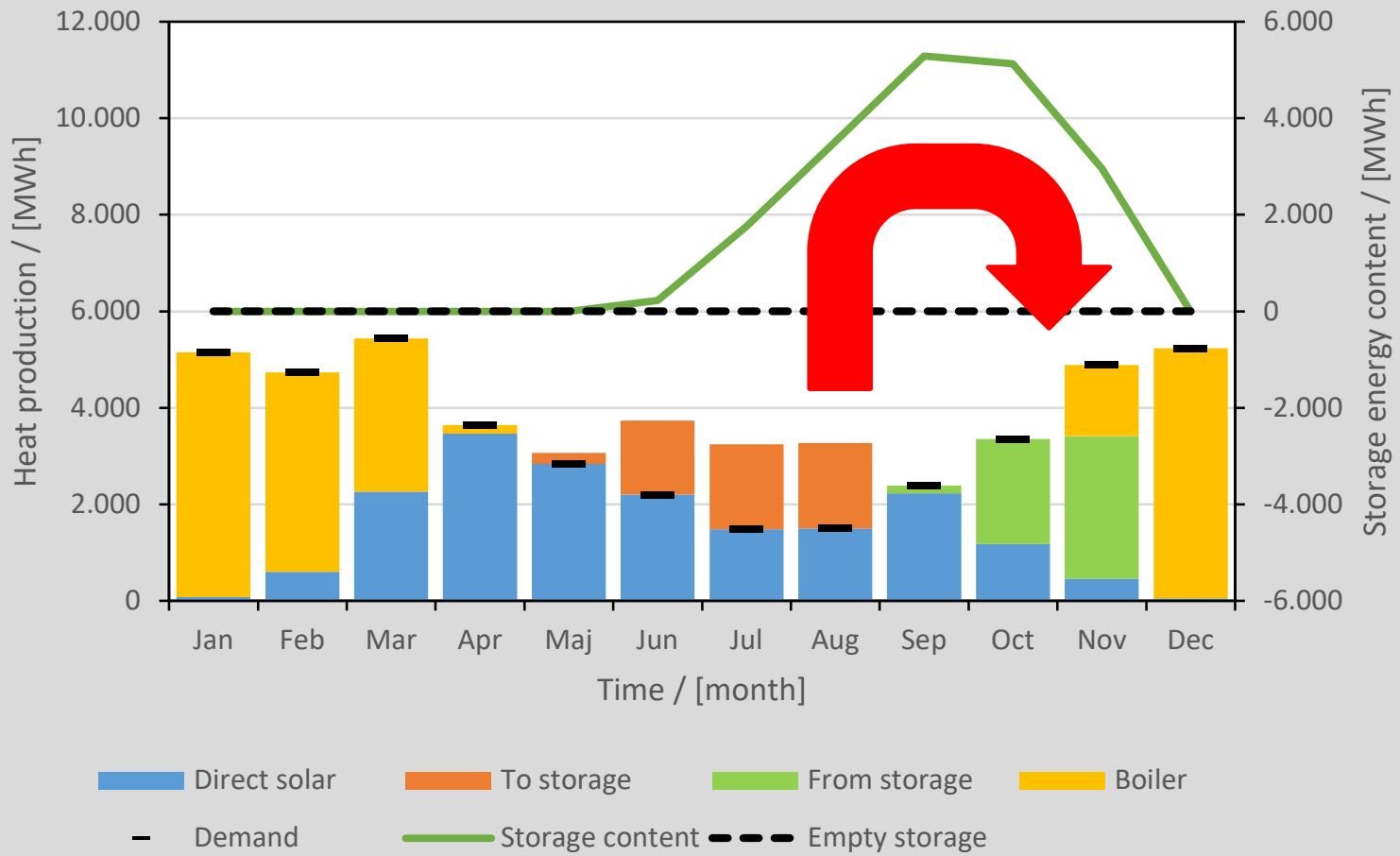
- Technology: Steel tank (TTES)
- $\Delta T \approx 90^\circ\text{C} - 40^\circ\text{C} = 50\text{ K} \rightarrow 1\text{ MWh} \approx 18\text{ m}^3$
- Investment =  $135\text{ €/m}^3$
- **Example** (without heat losses)
  - $5\,000\text{ m}^3 \approx 280\text{ MWh} \approx 675\,000\text{ €}$
  - $280\text{ MWh} * \text{20 cycles/year} * 20\text{ years} = 112\,000\text{ MWh}$
  - Storage costs =  $675\,000\text{ €} / 112\,000\text{ MWh} = \underline{\underline{6\text{ €/MWh}}}$



# SDH with short term storage



# SDH with long term storage



# SDH with long term storage

- Technology: Water pit (PTES)
- $\Delta T \approx 85^\circ\text{C} - 45^\circ\text{C} = 40\text{ K} \rightarrow 1\text{ MWh} \approx 22\text{ m}^3$
- Investment = 1.5 M€ + 15 €/m<sup>3</sup>
- **Example** (without heat losses)
  - 133 000 m<sup>3</sup>  $\approx$  6 000 MWh  $\approx$  3.5 M€<sup>a</sup>
  - 6 000 MWh \* **1 cycle/year** \* 20 years = 120 000 MWh
  - **Storage costs** = 3.5 M€ / 120 000 MWh = **29 €/MWh**<sup>b</sup>
    - a) 5 times cheaper/m<sup>3</sup> compared to tank storages
    - b) 5 times more expensive/MWh compared to short term

# Optimal collector area and storage

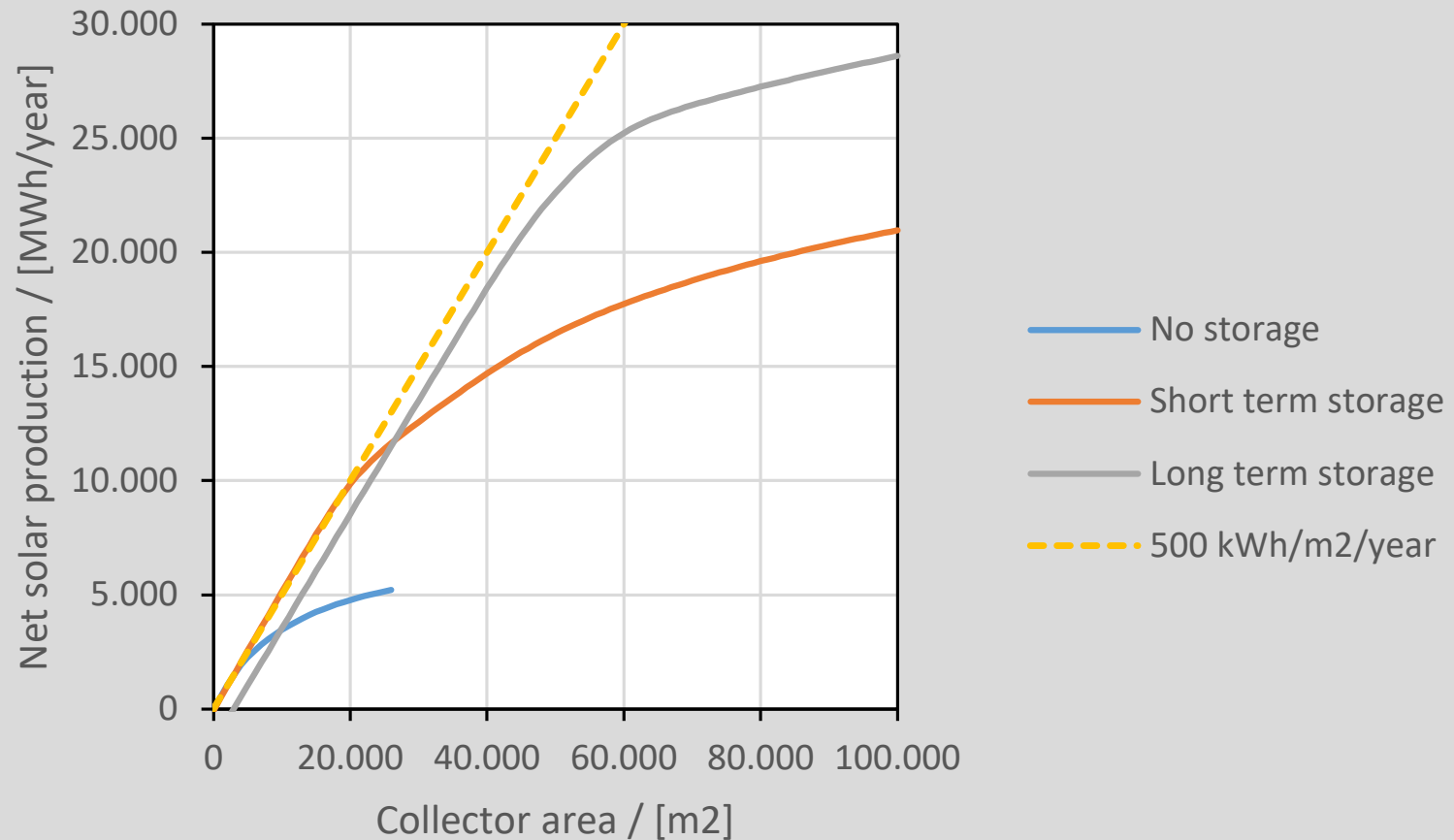


Marstal, DK

# Optimal collector area and storage

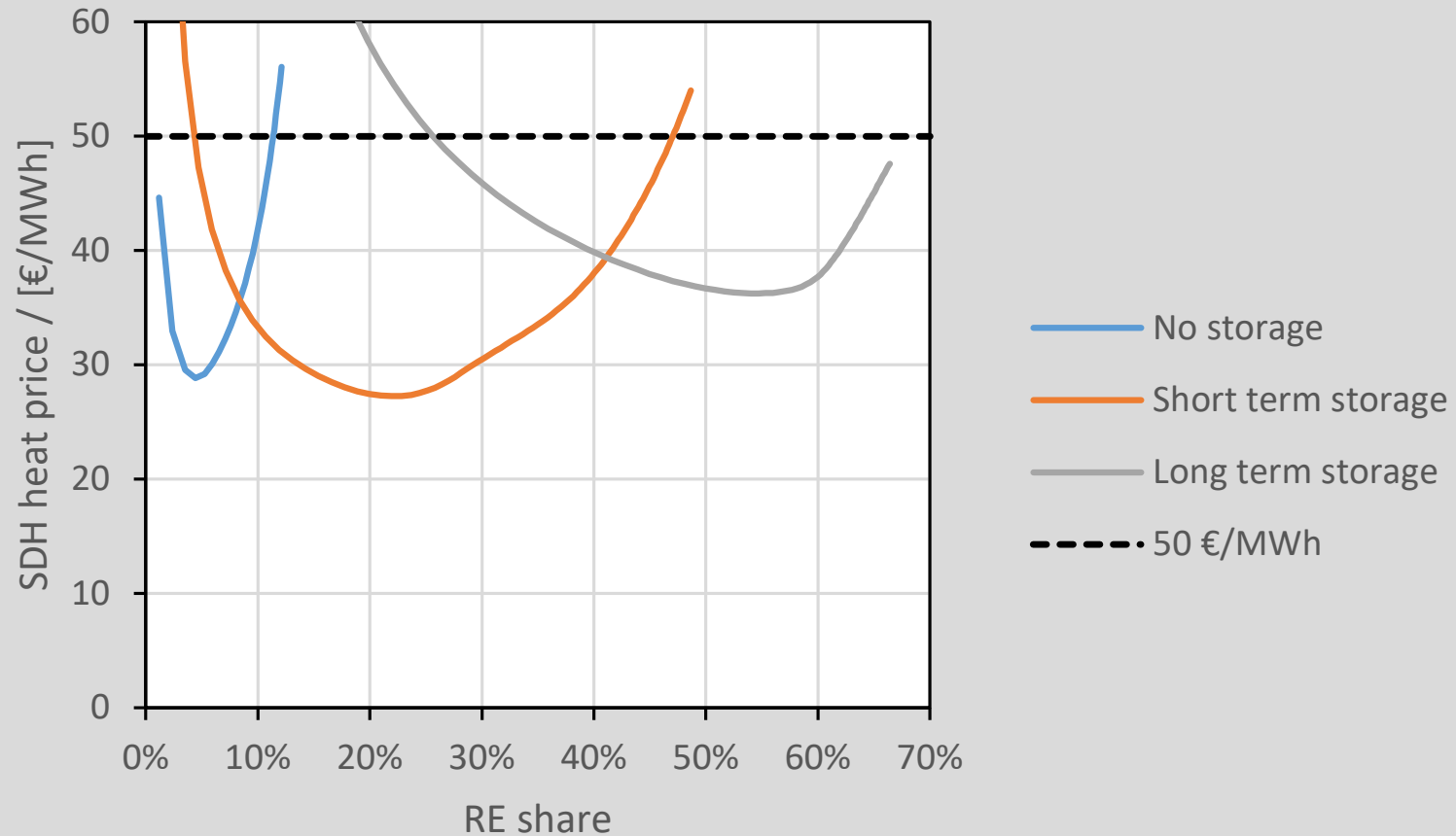
- **Example:** Medium sized Danish DH plant
  - 43 100 MWh/year
- Reference production = Gas boilers (50 €/MWh)
- Supplementary production = SDH
  - Without storage
  - Or with 5 000 m<sup>3</sup> steel tank (0.7 M€)
  - Or with 200 000 m<sup>3</sup> pit heat storage (4.5 M€)
- SDH investment = 0.2 M€ + 180 €/m<sup>2</sup>
- Annual capital costs = 6% of investment

# Net SDH production vs. Collector area

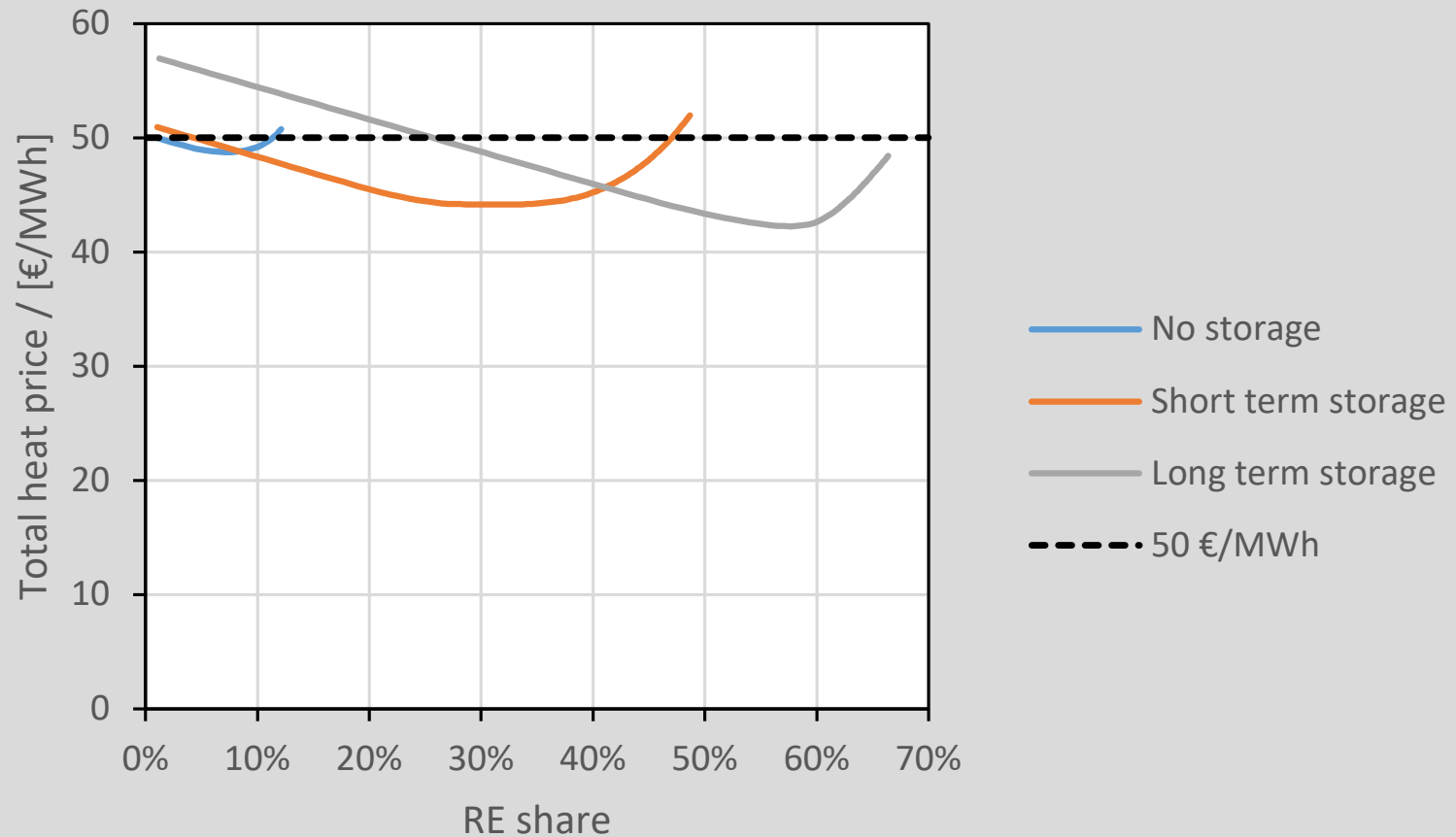




# SDH heat price vs. RE share



# Total heat price vs. RE share



# Summary

- SDH with short term storages is feasible
  - Production price < 30 €/MWh
  - RE share 20-30%
- SDH with seasonal storages can be feasible
  - Production price < 40 €/MWh
  - RE share 40-60%
- Seasonal storages must be cheap (< 30 €/m<sup>3</sup>)



# Thank you for your attention

[nf@planenergi.dk](mailto:nf@planenergi.dk) M +45 2064 6084

[www.planenergi.dk](http://www.planenergi.dk) T +45 9682 0400