Decoupling demands –Thermal stores for CHP

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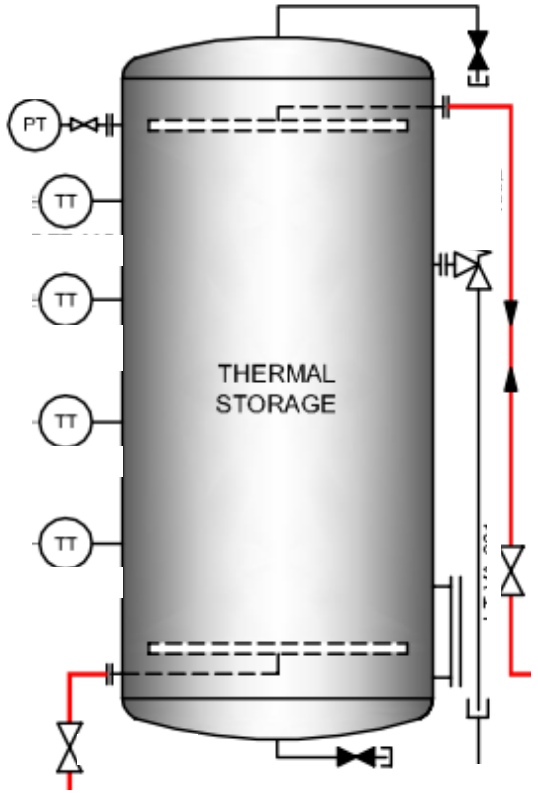
What is a water based thermal store?

- Well insulated hot water accumulator tank designed to receive surplus heat generated by heating production units and supplying heat to the system on demand.
- Usually included in the design of decentralised energy scale CHP plants, but can be integrated with other technologies (i.e. heat pumps, biomass boilers, gas boilers) to prevent cycling during low demand.



What are the benefits of thermal storage in CHP systems?

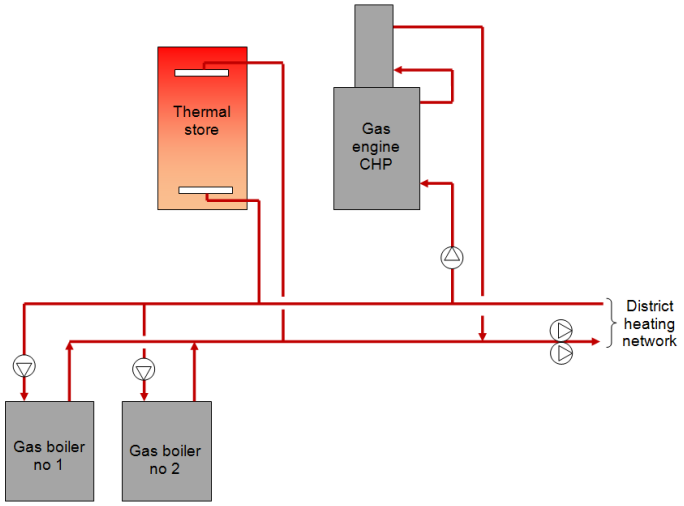
- smoothes plant operation by decoupling operation of heating production units (i.e. gas engine) from heat demand
- economic, extends electricity generation during high tariff hours
- environmental, reduces CO_2 emissions by increasing on-site electricity generation and reduction of boiler use
- improves plant operational flexibility (i.e. buffer to gas or biomass boilers at small heat demands)
- provides short term system resilience
- can pressurise the system

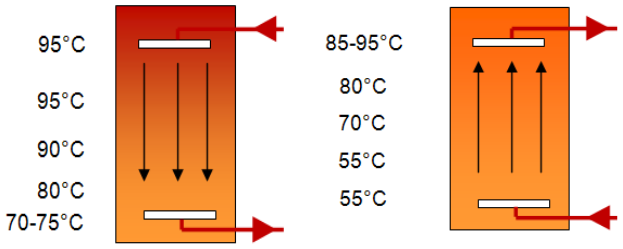
Disadvantages?

- CAPEX
- space requirement
- visual impact for larger units

System integration

- Charging during low heat demands
  - gas boilers are switched off
  - CHP heat output greater than heat demand
- Fully charged
  - return temperature to engine will rise and control engine output before finally switching off
- Discharging during high heat demands
  - CHP heat output less than heat demand
- Fully discharged
  - high level heat in store drops below useable level
  - system calls for supplemental heat from boilers





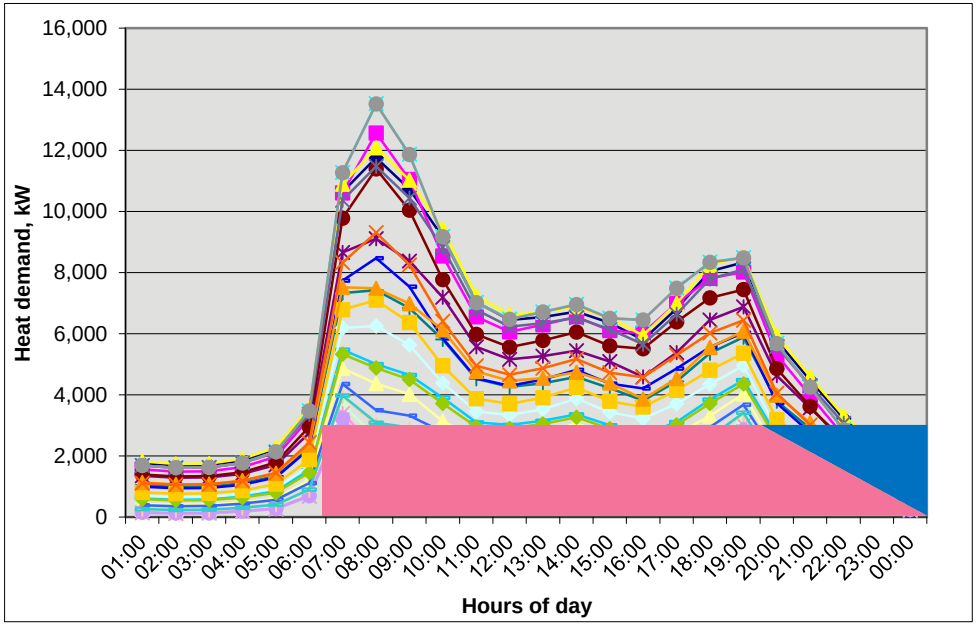
charging discharging

What do they look like?

Sizing

- Things to consider during desing
  - Space constraints, orientation, height to diameter ratio, more than one unit connected in serial or parallel, pressurised on unpressurised tank, design temperature difference
- First pass sizing

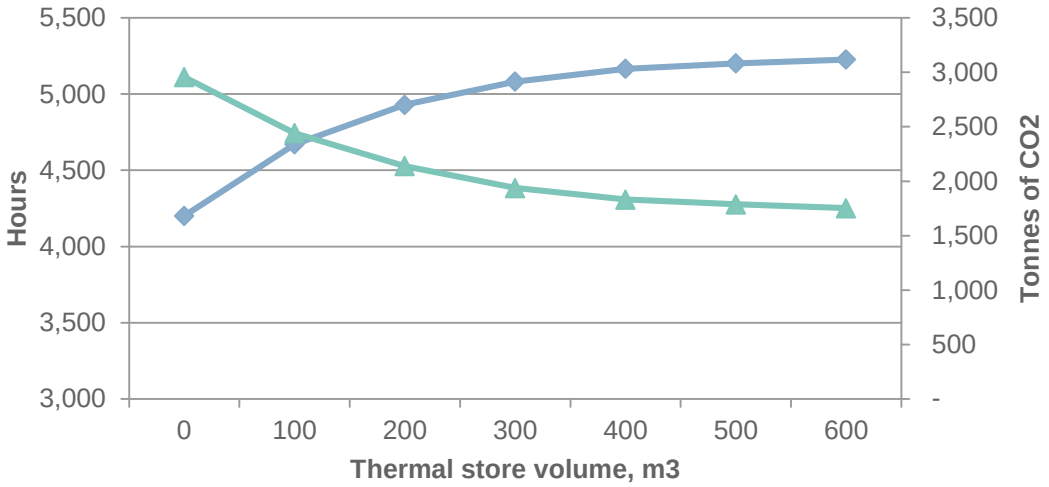
CHP thermal output	**3,195**	**kW**
Charging time	5	h
Percentage of CHP output charging TS	70%	
CHP heat stored in TS	11,183	kWh
or	40,257	MJ
Thermal store design dT	25	C
Required TS active volume	**385**	m3
Active as % of design volume	90%	
TS design volume	**427**	m3
Height to dimeter ratio	2.0	
Estimated diameter	6.5	m
Estimated height	13.0	m

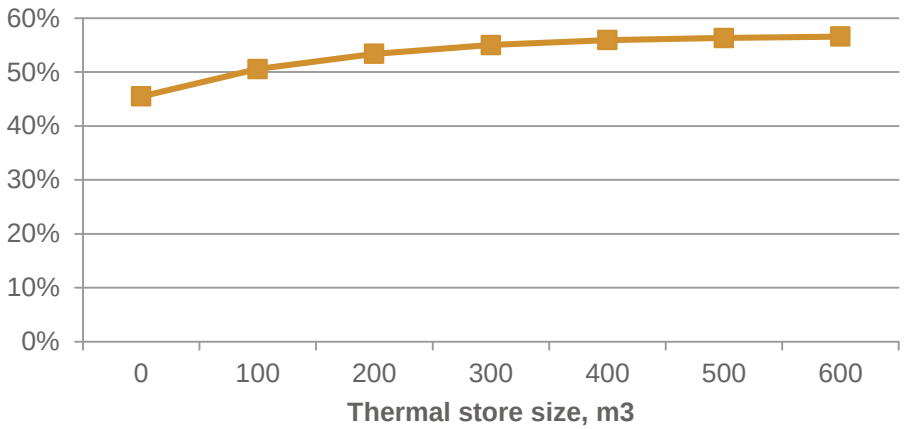


Be realistic about the size!

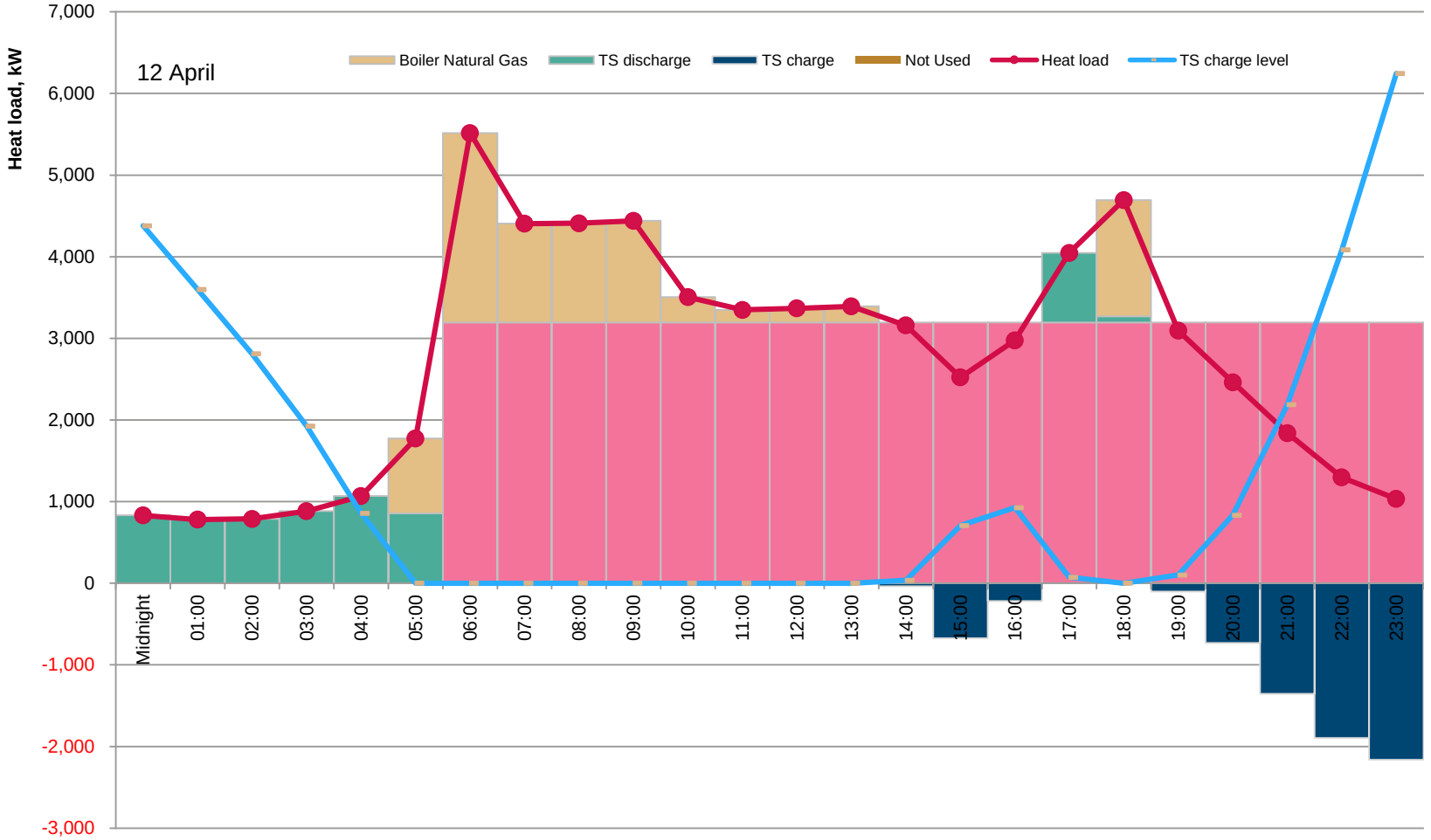
- The actual size can be constrained by
  - Space availability
  - Planning permission
  - Site access to site (maximum diameter and height possible to deliver via road are 4.5m and 16m)
  - Weight constraints

Energy modelling and fine tuning of thermal store size





Daily Operation



Energy modelling and economic results

Energy Balance		
	No TS	**TS 200m3**
CHP electricity generation, MWh	14,130	17,372
CHP heat generation, MWh	13,423	16,503
CHP gas consumption, MWh	35,312	43,415
*Boilers gas consumption, MWh	3,422	-
CO2 emissions, tonnes	2,956	1,832

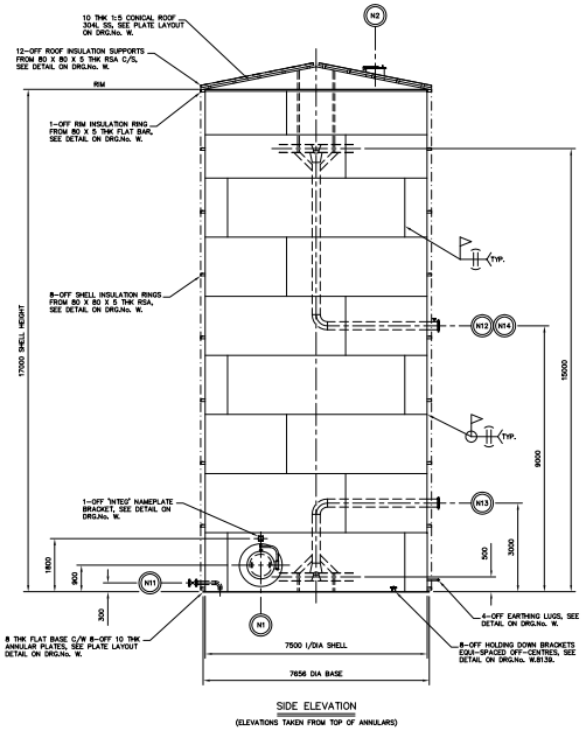
Note: *if heat supplied by CHP were to be supplied by gas boilers instead; based on 90% boiler efficiency

Economic analysis		
Offset of electricity import from the grid, k£	259.4	based on 8p/kWh
CHP gas cost, k£	-162.1	based on 2p/kWh
Offset boiler gas cost, k£	68.4	based on 2p/kWh
CRC, k£	13.5	based on 12£/tonne
Total balance, £k	**179.3**	

Simple payback time	
Thermal store CAPEX, k£	400
Annual revenues, k£	179.3
Simple payback time, years	2.2

Not only a vessel!

- Instrumentation
  - Temperature pressure/level sensors, level switches
  - Nitrogen or steam blanket system (unpressurised tanks)
  - Pressure relief/vacuum valves
- Fittings
  - Drain
  - Pipe connections and diffusers
  - Roof and shell manway
  - Access ladder, walkways, etc



Real world photos

Thank you!

Questions?