Technical optimisation of heat networks

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Project design optimisation – Technical Agenda

- Key factors that lower lifecycle cost
- Lowering heat costs
- Technical optimisation criteria – observations on ‘technical’ criteria used to size CHP
- Thermal storage

Lowering lifecycle heat cost

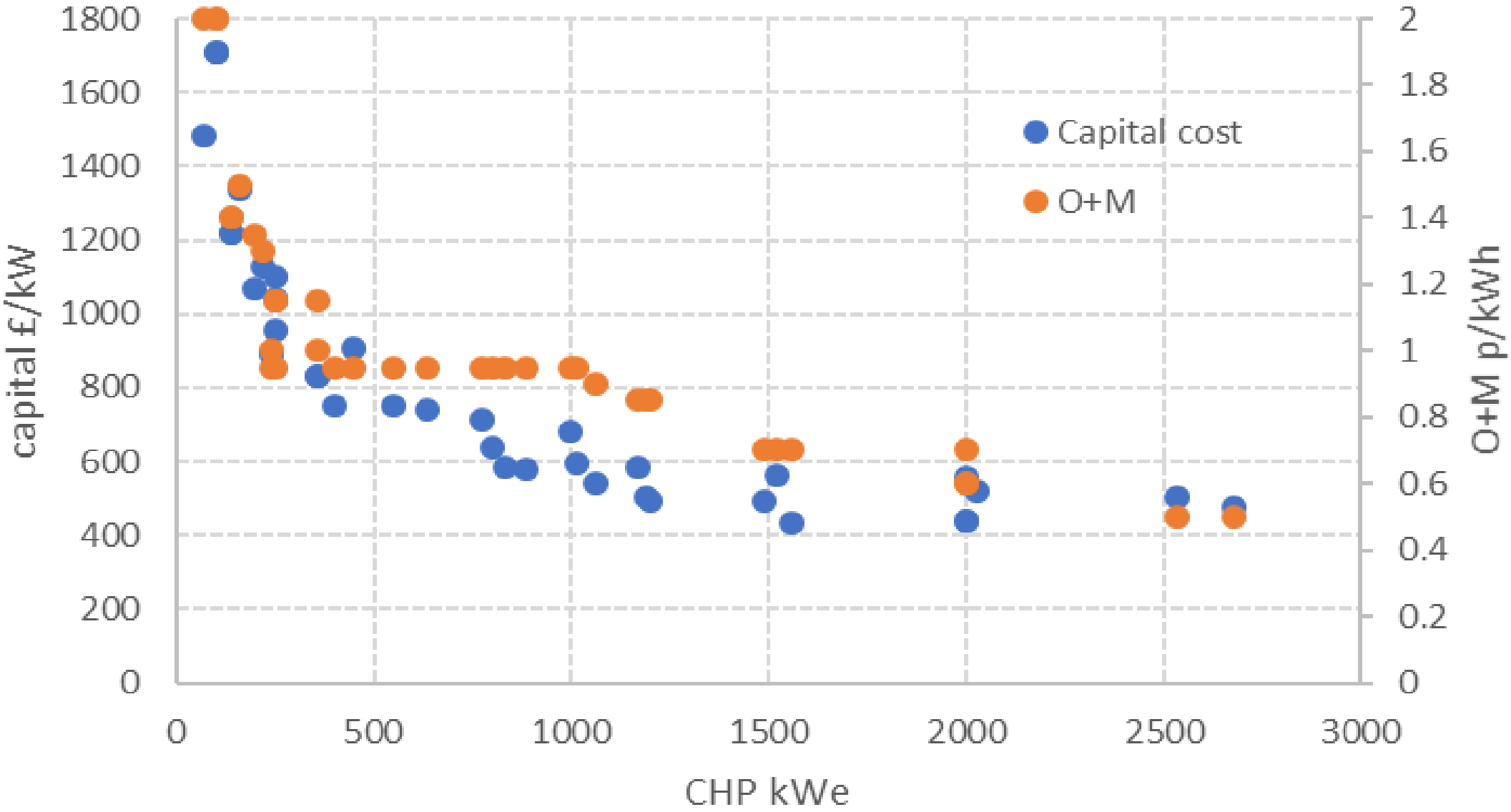
- Accurate annual heat loads = correct revenues and correct CHP size
- Accurate peak loads (and highest dT) = minimal oversizing = lower capex
  - Recommend monitoring of heat loads to assess this e.g. pulse log gas meter, clamp on heat meter, BMS data ?
- Scope to increase DH temperature difference
  - lowers flow rate so smaller DH pipe & lower DH heat losses. Design in new build, survey for options existing buildings.
- Set a tariff structure that reflect the DH capital and operation costs, -
  - e.g. capacity charge and penalty / discount for higher/ lower return temperatures.

Lowering heat costs

Gas CHP is an economic investment.
Selection must be based on economic criteria
Thermal store key part of economics

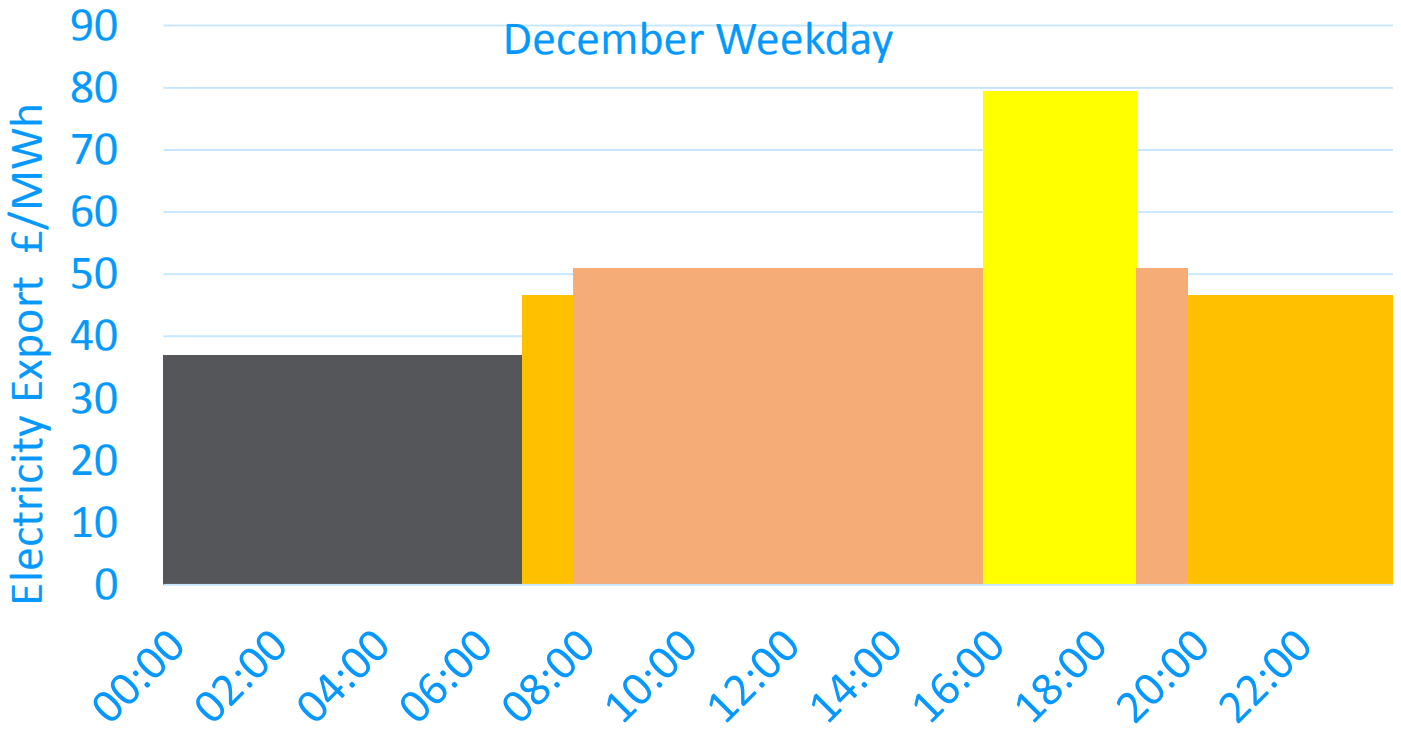
- Make sure the criteria reflect reality eg:
  - Heat demand, gas cost, CHP O+M cost (£/hour CHP operation) max no. CHP starts /day
  - Electricity from CHP will be purchased on a day / night or STOD tariff
  - Part load operation has lower efficiency and high O+M cost
  - Model includes assessment of thermal store
  - Accuracy of the demand profiles, daily and seasonal, will have an impact.

CHP costs


1800
1600
1400
1200
1000
800
600
400
200
0
capital £/kW
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
O+M p/kWh
Capital cost
O+M
0
500
1000
1500
2000
2500
3000
CHP kWe

Electricity prices

Studies tend to use single year round average electricity price. The reality is different :



CHP sizing based on single average electricity price for CHP exported power does not lead economic optimum CHP / thermal store size

Comparison of CHP options

CHP size		2 x 600kWe	2 x 600kWe	2 x 600kWe	1200kWe	1487kWe	1999kWe	2679kWe
Thermal store size	m^3	12	50	50	125	125	175	250
Electricity tariff day	p/kWh	5	5.55	STOD	5.55	5.55	STOD	STOD
Electricity tariff night	p/kWh	5	3.7	3.7	3.7	3.7	3.7	3.7
CHP economic at night		Yes	No	No	No	No	No	Yes
Heat production cost	p/kWh	2.47	2.10	2.07	1.37	1.19	0.70	0.40
CHP and thermal store capital cost	£k	907	943	943	767	872	1335	1523
CO_2 emissions to supply heat load	tonnes /yr	1230	1238	1243	771	614	102	191

For comparison boiler heat costs 2.75p/kWh and the annual CO_2 for boiler only is 2140 tonnes

Common technical sizing metrics – good guidance?

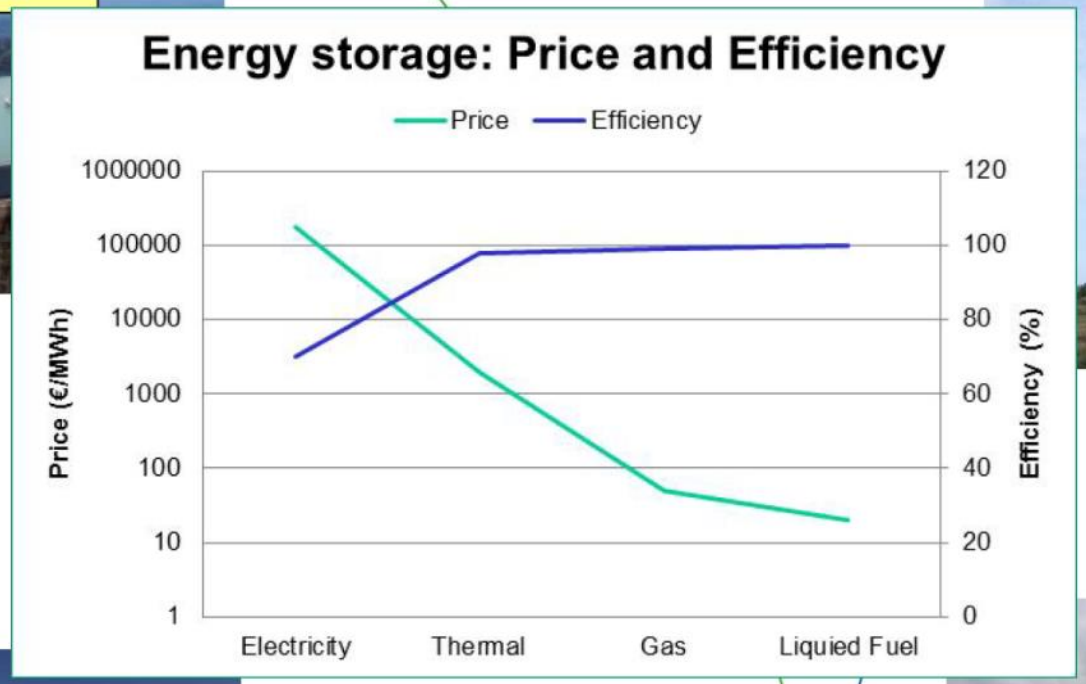
- ‘CHP operates 5-6000 hours per year’
- ‘CHP utilisation over 60%’
- ‘Achieve HNIP requirement of 75% heat from CHP’

CHP size		2 x 600kWe	2 x 600kWe	2 x 600kWe	1200kWe	1487kWe	1999kWe	2679kWe
CHP utilisation		52%	52%	51%	56%	51%	46%	32%
CHP hours run		4554	4516	4489	4916	4449	4016	2783
Proportion of heat from CHP		75%	75%	74%	77%	82%	94%	91%

- Much more complex with private wire

Energy Storage

Pump Hydro Storage
175 €/kWh
(Source: Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits. Electric Power Research Institute, 2010)

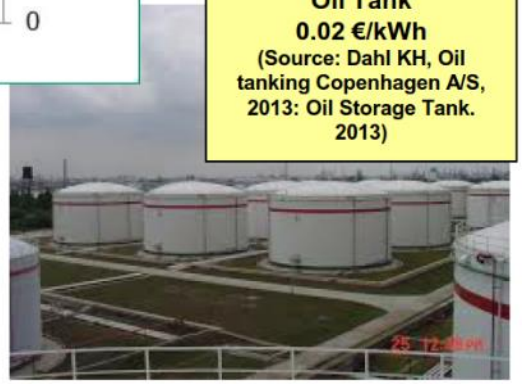


Thermal Storage
1-4 €/kWh
(Source: Danish Technology Catalogue, 2012)

Tesla PowerWall
800 €/kWh
(Source: http://solarlove.org/solarcity-tesla-battery-create-turnkey-systems-depth/

200,000 m3 Thermal Storage
500 €/MWh
(Vojens: 200,000 m3 for 30 mio. DKK)

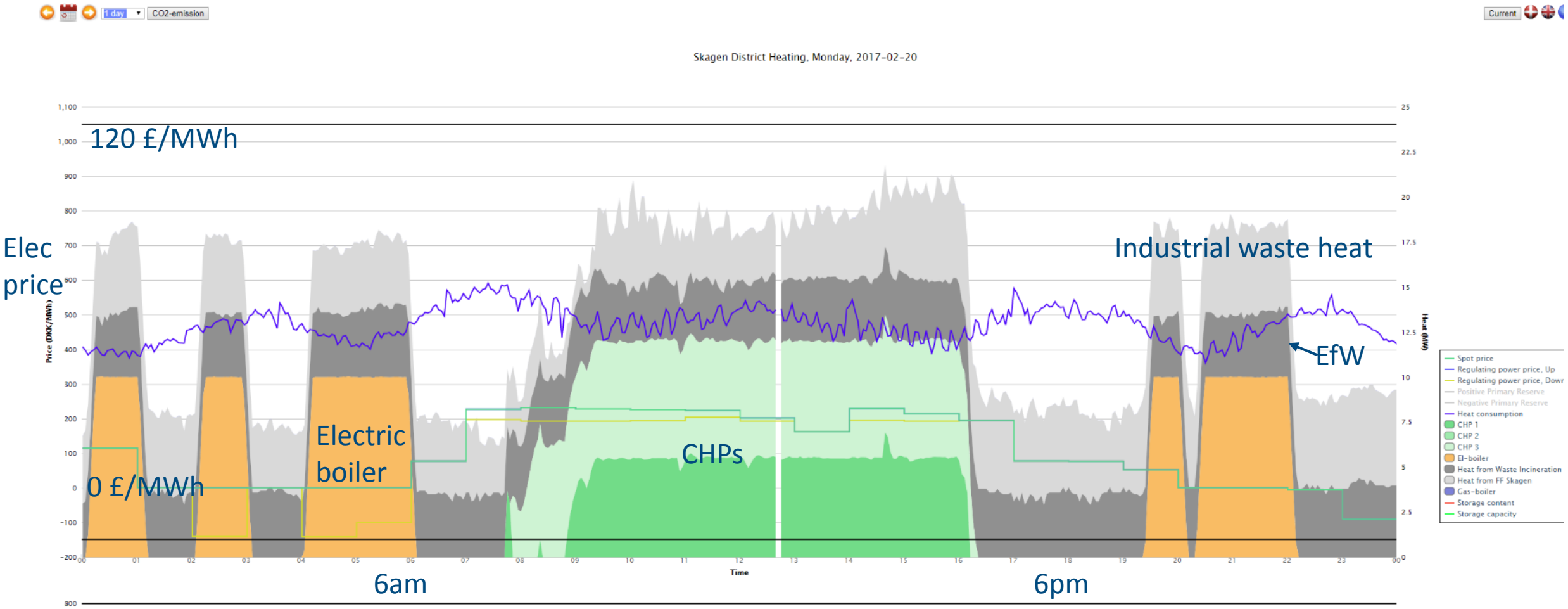
Natural Gas Underground Storage
0.05 €/kWh
(Source: Current State Of and Issues Concerning Underground Natural Gas Storage. Federal Energy Regulatory Commission, 2004)



Oil Tank
0.02 €/kWh
(Source: Dahl KH, Oil tanking Copenhagen A/S, 2013: Oil Storage Tank. 2013)

Ref Prof Henrik Lund
www.4dh.eu

CHP / DH responding to electricity price



Summary

- Size the CHP based on:
  - a day / night or STOD tariff
  - the greatest economic return - to your investment criteria
  - Avoid part load operation
- Private wire – economics complex, do need to be accurate with all the electricity prices, hourly electricity demands and modelling
- Speicifations need to incude measureable commissioning requirments eg DH return temperature when no / very little load.
- Futureproofing
  - Lower return temperatures will help all technologies aim over time for below 40C
  - Variable flow temperature beneficial – design plant / DH connections to operate at lowest possible temperatures, and work towards achieving this out of heating

Sæby District Heating - 17-10-2017 12:21:00

Solar Radiation: 128 W/m²

Outdoor Temperature: 15°C

Sold Electricity: 5.0 MW

Solar Collector

31 °C | 31 °C | 0.0 MW

Gas Engine 1

0 m3/h | 0.0 MW | 0.0 MW

Absorption

0.0 MW | 3.3 MW | 3.8 MW

COP: 1.15

Gas Engine 2

0 m3/h | 5.0 MW | 3.9 MW

0.2 MW

Storage 1

6.8 MWh

Storage 2

13.7 MWh

Gas-boilers

0.0 MW | 0 m3/h

El-boiler

0.0 MW | 0.0 MW

Forward temperature: 65 °C

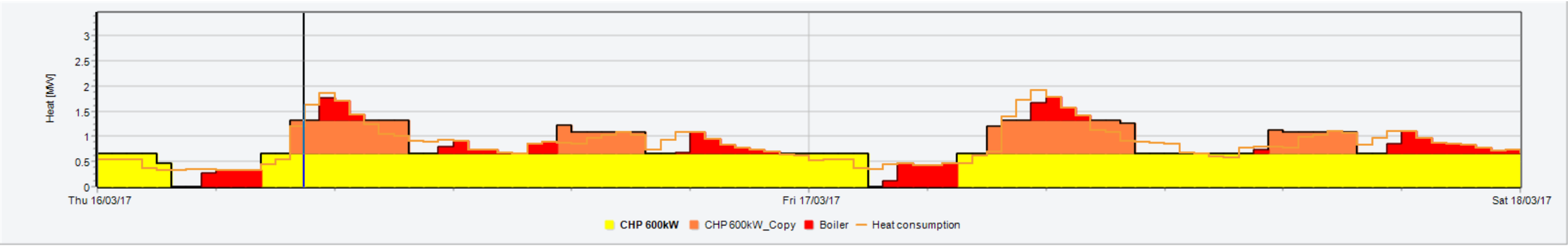
District Heating: 7.5 MW

Return temperature: 35 °C

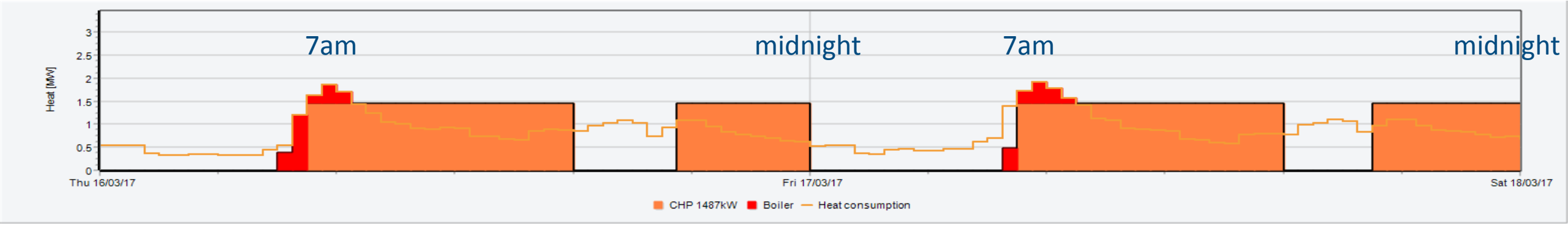
Sæby Varmeværk a.m.b.a.

CHP operation economic optimisation

Part load operation 2 x 600kWe CHP single electricity price small thermal store,



RED is Boiler ORANGE is CHP YELLOW is CHP 2



Single larger CHP operation day / night tariff large thermal store-