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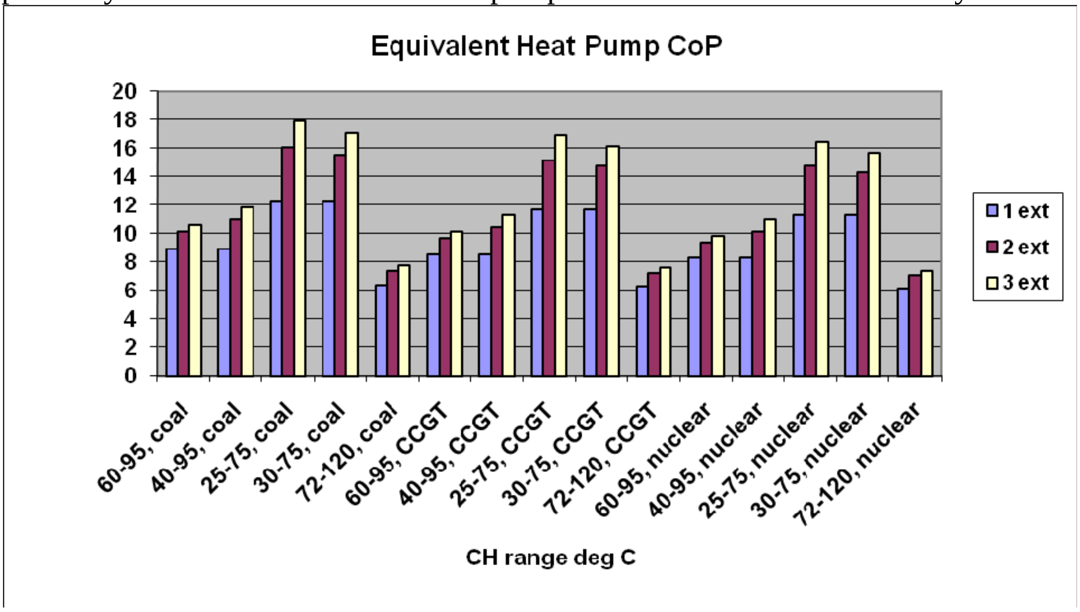
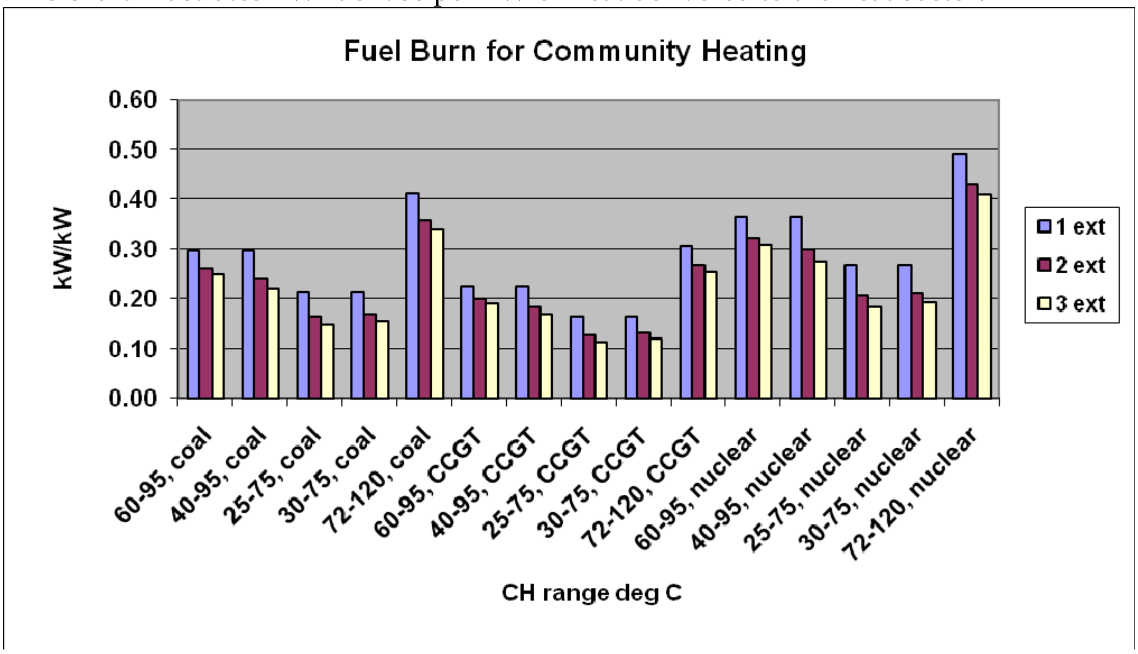
CHP how the Coefficient of Performance for its Heat, units of heat per unit of electricity foregone is a function of heat network flow and return temperatures.

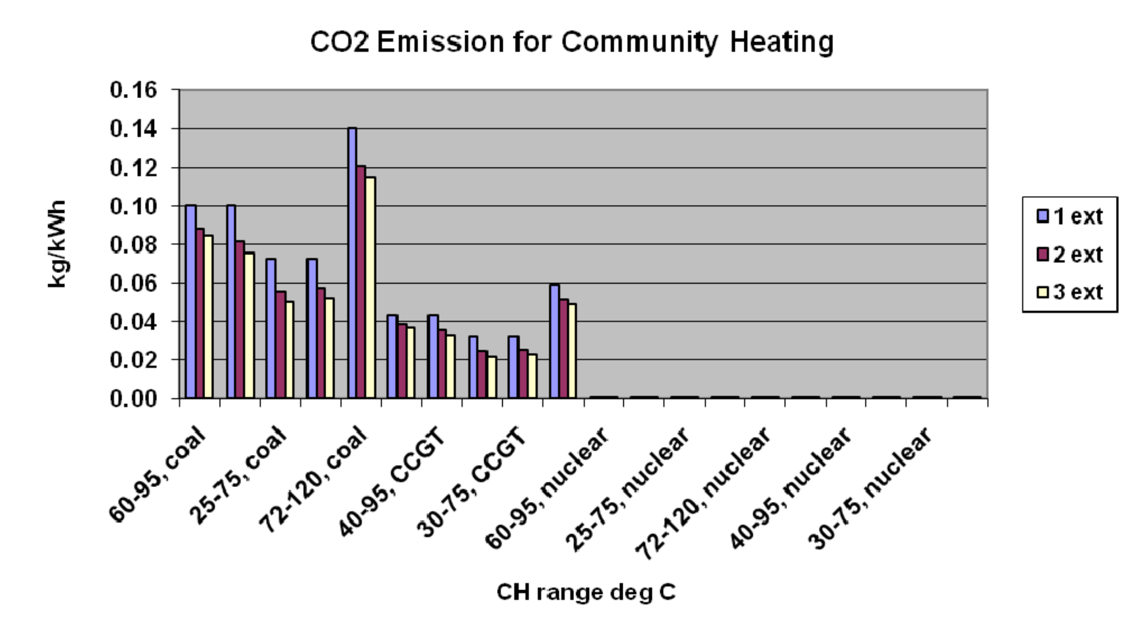
This chart illustrates how the COP of heat from CHP varies with the number of stages of extraction and the temperature of the heat network and for different steam turbine power cycles. COP Electric Heat Pump in practice 2-4. CHP COP in theory 6-18



This chart illustrates kW fuel use per kW of heat delivered to the heat sector.



This chart illustrates the CO_2 emissions per unit of heat delivered to the heat sector.



One can estimate the decarbonising effect of the heat by comparing figures in this chart to the CO_2 emissions from a new condensing gas boiler at 0.222kg CO_2 per kWh.

Note calculations for the COPs come from steam table information. The COPs in practice will be lower due to inefficiencies in the steam cycle.

The relative COPs are valid signalling benefits from low temperature district heating networks compared to higher temperature district heating.

Orchard Partners London Ltd work under an EU project Ecostiler indicates that it may be practical to retrofit UK domestic sector housing heated by gas boilers and radiators to a district heating network designed to operate normally at 75C flow 30C return but on the coldest day with the supply temperature rising to 90C.

The 30C return comes from an “Exergenius” way to heat domestic hot water.
Over sizing of existing heat emitters, reduction in fabric heat load from the cost effective fabric insulation measures such as roof insulation and cavity fill and improved controls reduce demand and return water temperatures. By raising the temperature to radiators on the coldest days we increase their output.

Principal Assumptions

1. Comparisons are made between the electricity output and the heat returned from the condenser for (1) a simplified fully condensing steam cycle and (2) a similar simplified cycle fully exhausting to a back pressure determined by the district heating flow temperature.

2. The net fuel burn is then determined by taking the fuel burn needed to recover the lost electrical output (using data for typical plant efficiency) and subtracting the additional heat recovered from the district heating condenser drains.

3. The fuel burn per unit of heat output is then obtained by simple division.

4. For multiple levels of extraction, the calculation is made for intermediate extraction temperatures interpolated linearly. The figures are then averaged.

5. Steam turbine LP cylinder efficiencies taken to be 0.85 isentropic, 0.985 electrical and 0.985 mechanical.

6. The condensing pressure for the fully condensing cycle is taken to be 0.04 bar.

7. Typical plant efficiencies are taken as shown in the following table.

	efficiency	reference
Coal fired generation	0.38	notional
Coal fired utility boiler	0.9	notional
CCGT generation	0.519	DUKES 2008
CCGT steam turbine	0.36	calculated
Nuclear generation	0.33	typical new PWR

8. These figures are assumed to represent the performance of an extraction-condensing steam turbine operating at its design point. There is therefore no allowance for the inefficiencies introduced by part load or off-design operation, either for controlled or uncontrolled extraction. Equally there is no allowance for increased efficiency when the district heating flow temperature is reduced under part-load or off-design conditions.

9. This methodology provides a comparison between the various generation technologies at the design point. A comparison across a range of operational conditions requires further assumptions to be made regarding design and results to be expressed in a more complex format.

OP Reference COP-CHP-DifferentFlow&ReturnTemperaturesDH.xls

W R H Orchard. April 2014.