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WHY HEAT FROM COMBINED HEAT AND POWER (CHP), VILNIUS THREE, IS AS RENEWABLE AS HEAT FROM ELECTRIC HEAT PUMPS. A MARGINAL ANALYSIS FOR FUEL ALLOCATION TO ELECTRICITY AND HEAT

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OVERVIEW

The paper illustrates how a marginal analysis allocates fuel to the primary product electricity, and the waste product heat, in thermal power generation. Where the heat performs a useful function on its way to the environment, in accordance with thermodynamic laws, the process is called CHP.

The marginal analysis method is simple.

1. What is the marginal fuel use when electricity output is increased or decreased by one unit, when there is no change in demand for heat?
2. What is the marginal fuel use when heat output is increased or decreased by one unit, when there is no change in demand for electricity?

The method is thought to be a robust procedure, as it mirrors the marginal fuel burn and thus cost for the two products. Price is a different matter, due to lack of competition between CHP's, operators can price just below the cost of heat from boilers.

Information on marginal fuel use for Vilnius 3 analysed during energy policy work is presented.

This type of power plant is termed a "Virtual Heat Pump" by Professor Robert Lowe of University College London.

The EU defines heat from electric heat pumps, as renewable if the COP of the heat is equal to or greater than 2.9. Heat from large scale CHP has a COP of infinity for heat for horticulture at 28C and a COP in excess of eight for city heating from CHP.[i].

This paper analyses electric heat pumps and CHP by comparing their coefficients of performance (COP), a measure of the amount of useful heat per unit of electricity.

The analysis evaluates the effect of average and marginal losses in electrical and heat networks on EHP's and CHP's for three locations in UK's electrical infrastructure.

First large scale CHP's such as Vilnius 3. Second 500kW local gas engine CHP at UK's 11kV to 415V local area transformers. Third electric heat pumps and micro CHP in domestic consumer's premises. The model, in spreadsheet form, will be available to delegates.

Professor David JC Mackay's book Sustainable Energy without Hot Air [ii] has stimulated discussion in the UK about the relative merits of electric heat pumps or CHP to decarbonise the UK heat sector. His conclusions differ from Energy Paper 20 (1977) [iii] that recommended conversion of cities to large scale CHP on the Odense model as offering greater primary energy savings than electric heat pumps. The paper reviews Mackay's work.

Long term UK thermal electricity generation can be large scale CHP burning bio fuels or nuclear CHP, demonstrated in the UK at Calder Hall, and in Lithuania at Ignalina, as use of gas and other fossil fuels is reduced.

The EU [iv] propose a new "Carnot Efficiency" allocation method which we compare to an analysis of Vilnius 3 [v]. The author questions why 28C heat normally rejected to the environment in power generation and used for horticulture in Holland, incurs a fuel burn and the fuel burn for electricity reduces. How does use of this reject heat, increase electrical efficiency?
The paper discusses the effect of subsidising electricity or heat to encourage use of waste heat. We analyse the difference in "savings signals" when the heat and electricity from CHP feed their respective sectors or feed a combined heat and electricity sector.
The author reasons that use of heat from CHP can only result in significant savings in the heat sector. If it could give savings in the heat sector, encouraging motorists to run their car heaters summer and winter it would save significant fuel savings for the transport sector.

METHODS

The fundamental methodology for analysis is set out in "the Orchard Convention". [vi] and in the paper.

RESULTS

The analysis signals cross over points for CHP and electric heat pumps. Typically, the COP for heat from large scale CCGTT CHP or CHP fuelled by coal, biomass or nuclear delivers heat to consumers, after network losses are evaluated, with higher COPs than local air source heat pumps. CHP's with low electrical efficiencies such as micro stirling engine gas fired CHP's appear inferior to electric heat pumps where their electricity source is large gas fired CCGT.

CONCLUSIONS

The paper concludes that securing heat and electricity supplies in UK cities as recommended in Energy Paper's 20, 35and 53 will result in greater CO2 displacements and more secure heat and electricity supplies for consumers, due to vulnerability of electrical transmission systems. We propose the installation of a 75C flow and 30C return district heating compatible with heat from solar, EHP's, geothermal and CHP, and 10GW of dual fuel oil and gas fired condensing 500kWel CHPs at most local 11kV to 415 V transformers. These act as emergency generators and back up wind.
The author suggests the EU classifies heat from CHP as renewable where its COP is greater than 2.9. He sees no difference between heat from CHP and EHP's. Both have a fossil fuel overhead and share common analytical principles.

REFERENCES

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