Edge Debate 41 - The cases for and against combined heat & power and community heating.

22nd September 2010 – University of Southampton.

Chair: Mike Murray
Speakers: Councillor Matthew Dean, Bill Watts, Phil Jones

Andy Ford, CIBSE President Elect, welcomed the speakers and a large audience to this first combined CIBSE & Edge Debate.

Presentations

Councillor Matthew Dean – Southampton City Council

Councillor Dean explained that he was not an engineer and therefore would not address the technicalities of Combined Heat & Power (CHP) but rather focus on his long experience of Southampton's CHP system - one of the largest in UK.

The system was conceived in response to concerns flowing from the 1970s oil crisis. Because of its fairly accessible 'hot rocks', Southampton was chosen by the Department of Energy to trial geothermal district heating. When these trials were abandoned, Southampton District Council took up the network and moved it forward. By 1986 it was serving the whole Civil Office complex.

The system had since been improved and expanded with a CHP plant replacing the geothermal heat source. It came to include an absorption cooling circuit (to an hotel) and a private wire system to the port – with the further air quality benefit of enabling diesel powered cranes to be replaced by 'clean' electric ones.

Currently the CHP system served 35 large commercial clients including IKEA, M&S, leisure centres, pools and private and social housing. Reluctant developers were not compelled to join the system. Indeed, Hammerson UK were currently tendering West Quay to other energy providers.

The CHP system was reckoned to reduce emissions by 11,000tonnes/year.

There have been no unplanned outages since 1986.

The distribution network did occasionally involve significant, but manageable, disruption to roads.

The system was operated by Utilicom acting as a statutory authority.

The core strategy had been endorsed as sound by planning inspectors and the City Council's experience with the system over the years had been positive.

Councillor Dean pleaded for rigorous 'science' in the CHP debate since we could not afford to get things wrong - the novel scenario of politicians blaming engineers, when society better understood the obverse!

Mike Murray – i-to-i Solutions & Conference Chair.

Mike Murray said that the pros and cons of CHP have been argued for a long time. The recent Max Fordham & Partners (MFP) Report rekindled this debate and had raised it with policy- makers.

It now created a chance for the industry to bridge and, perhaps finally, to resolve differences – with issues often so complex as to sideline all but the most adept from the discussion.

Bill Watts - Max Fordham & Partners

Bill Watts explained the MFP Report originated from his puzzlement as a building services engineer with the flawed logic of promoting the CHP agenda a panacea for energy use in UK. The debate was not just about engineering. It was about business practice, regulation and taxation, future sources of energy, security, global markets, land use, food and waste management. CHP's expensive district heating infrastructure affected these issues.

His main concern was that the economic imperative to pay for the infrastructure to deliver heat mitigated against the overarching imperative to **save** it.

CHP's thesis was that by-product heat in generation can be captured and distributed for use via pipes in the ground. Any analysis must take into account the losses inherent in this arrangement and his analysis found that these, together with mismatches of the heat supply and demand, largely negated the benefits promoted by CHP's proponents.

He reflected on a main argument for gas fired CHP was its ability to reduce CO2 emissions compared to the emissions of grid electricity. He reasoned that, as grid electricity currently contains 30% coal generation, which was a very carbon intensive fuel, it was unsurprising that CHP electricity produced less CO_2.

But this thesis only held true today. At some point in UK's progress to the objective of "decarbonising" its electricity grid, gas-fired CHP would become the more CO_2 intensive solution.

However, the analysis for his paper assumed gas as the generating fuel in exploring whether CHP made best use of it – parking the question of what future decarbonised energy sources might be.

In examining whether CHP was an efficient use of gas, his analysis contrasted its performance with a combination of:

- Gas heating, by local condensing boilers.
- Grid electricity generated by a combined cycle gas turbine or CCGT.

Theoretical data in the Digest of UK Energy Statistics (DUKES) showed CHP might produce electricity and heat more efficiently than combining CCGT electricity and gas boiler heat.

But DUKES's measured data showed CHP to offer no efficiency advantage. With distribution losses accounted, it became the less energy and CO_2 efficient option.

Even then, the efficiency of CHP depended on a continuous demand for all of its exported heat. This was rarely the case with heat networks.

Bill Watts' then presented his energy model based on a community with a heat density of 3000kW/km^2 (e.g., Enfield) – which he'd selected because it was the 'entry level' for CHP in DeFRA's guidance. But since only 20% of UK's population lived in areas of higher heat density, he regarded it as a fair test.

The model indicated CHP was unable to cope with the wide range of seasonal heat demands – a mismatch that produced a deficit for 9 months, needing to be in-filled by other means, and 3 summer months when unusable surplus heat would be wasted.

The effect was that while CHP outperformed a combination of 'existing grid' electricity' and local gas boiler heating, CCGT with local gas boilers proved the lower CO_2 option and, in a like-for-like, 'all gas' comparison, a better policy choice than CHP.

His sensitivity analyses showed that

- improving household insulation to reduce and stabilise heat demands had no effect on the ranking.
- Seasonal heat storage (to capture and reuse surplus CHP heat from summer), even if feasible and affordable, was unhelpful – except at higher household insulation standards.

Only at higher heat load densities did a case for CHP begin to emerge – but it would require CHP's electrical efficiency to be improved from 29% used in his model to 38%, (current 'best of class') and the demand heat density to increase to >5000kW/km^2 (a city centre scenario) before CHP began to overtake CCTG + local boiler as the lower CO_2 emission option.

The sensitivity analysis showed that improving insulation standards in the building stock produced better outcomes than even the most efficient CHP option examined.

Bill Watts then considered how CHP might fit with upcoming low & zero carbon energy options:

- It was not an ideal accompaniment to unpredictable wind and wave power - since its economics determined it as a base load rather than a 'peak lopping' system.
- The opportunity to produce gas from waste had the potential to meet 50% of UK's needs at a fraction of the cost of CHP
- Biomass fuelled power stations were already a reality and one stepping stone to a decarbonised grid
- And, of course, geothermal remained an option in some instances

He concluded that CHP did not well fit with upcoming electricity generation and wider energy options.

Bill Watts then considered heating, where the choices were typically presented as either to reduce the heating needs of building stock or to provide "low carbon" heat from a district heating pipe.

He acknowledged that reducing the demand for heat would not be easy, but could be done incrementally as knowhow improved. Once achieved, its benefits of financial return and fuel security would endure.

The alternative siren call from the CHP lobby was that if heat is free or practically free, there was no point in reducing heat demands. But as his analysis demonstrated, Bill Watts saw few opportunities for CHP to use less energy than the current best practice alternative and that CHP heat was far from free. It involved running costs, capital costs and lost-opportunity costs from not funding something better - such as harnessing biomass and waste.

He was concerned that the attraction of so called "cheap heat" merely shifted a reliance problem - like moving from heroin to methadone. The high cost of district heating installations, needing to be repaid through heat sales, produced a corrosive incentive to do nothing to reduce standing heat demand - leaving UK with an inefficient stock rather than solving the problem.

His experience, and he surmised other consultants', was that the drive for CHP and district heating often had more to do with its bureaucratic acceptability, as in planning approvals, than with really saving energy.

In conclusion, Bill Watts said putting effort and money into insulating buildings and decarbonising the grid was far more valuable than funding district heating and its uncertain returns.

Phil Jones – Chair CIBSE CHP Group; Visiting Research Fellow London Southbank University

Phil Jones said he had worked as an engineer on CHP and energy efficiency issues for 30 years.

He agreed with many of Bill Watt's points and accepted CHP will not be effective in all scenarios. Its proponents had not purported it as the panacea that Bill Watts railed against. Its applications were actually quite narrow, but aggregated, of such untapped potential nationally as to merit good policy and practice.

So he was disturbed that the MFP Report was based on the fallacy of CHP being a panacea - enabling Bill Watts to model and duly rubbish it by referencing a poorly constructed marginal application.

Phil Jones said the MFP report misrepresented CHP and undermined the work of policy makers and practitioners in the field. It was a tenuous and sometimes ignorant thesis. It was an unhelpful contribution to energy policy.

His experience was that where people were looking to save money and good CHP enabled it, CO_2 merits also came into play. CHP was an energy saving measure where there was a base load of heat demand – as in the case of Southampton where the mix of customers produced the demand stability needed.

Good practice was to size CHP just above base load heat demand as with any base-load boiler. Bill Watts' exemplar analysis oversized the CHP plant - presumably based on the misconception of balancing electrical supply.

Thus at seasonal low heat demand it ended up throwing a lot of heat away - compounding the shortcomings of an already difficult exemplar.

He urged that CHP modelling must be robust – based on hour by hour heat demands – and certainly not monthly kWh/m^2 averages as used in the MFP Report.

He explained that good CHP applications benefitted from asynchronous diurnal and seasonal heat demands for base-load stabilisation and, crucially, on establishing anchor loads with hourly demand profiles – which can then be build off.

Phil Jones summarised the Waterloo (Southbank) study as a good example of CHP design practice.

His other concern with the MFP Report was that it flew in the face of compelling evidence that supported CHP:

- Its widening uptake on new and retrofit buildings
- The roll-out of retrofitted district heating
- Levels of investment by intelligent clients, like LDA, in the technology
- The levels of private investment by the growing numbers of Energy Supply Company (ESCo)
- The 5 – 10 year returns CHP projects typically yield
- That district heating networks, once established, invariably grew - as new customers learnt of their benefits.

All as evidence by major schemes in places as far apart as Pimlico and Aberdeen.

Phil Jones said CHP was not a panacea. It was a part of a mix of solutions to UK's energy needs.

At national level, using gas to drive CHP may only be a transitional technology, but valuable as a means of reducing pressure on the grid and inefficient 'spinning' capacity. It enabled communities directly to improve their lot now - rather than as hostages to the machinations of the grid generators.

Establishing local heat networks derived from gas-fired CHP helped future-proof UK's energy strategy options - by enabling low and zero carbon technologies to be tapped at 'district scale'; as with biofuel-from-waste, fuel cells and the like. In the interim and beyond, CHP married well with a 'smart grid' development.

In conclusion Phil Jones challenged Bill Watts to stop peddling the MFP Report as 'gospel' until it had been scrutinised and evaluated by peer-review.

Discussion.

The Chair, Mike Murray, invited wider discussion – explaining Chatham House Rules applied to speakers from the floor.

1. BW had presented a lot of figures but, simplistically, burning gas to generate electricity and not throwing away half of the energy produced in the form of heat has got to be a sound idea.

2. The ongoing security of gas supplies is so worryingly outside our control nationally, that insulation has got to be the better way forward.

3. In UK's journey to a low carbon economy, gas-fired CHP may lie on the path but it is not a long term solution. Switching to bio-gas is probably not an answer since limited bio-fuels are likely to be reserved for high order energy uses like transportation.

PJ – *Bio-fuels will be imported – as with oil! Is decarbonising the grid a silver bullet or pie in the sky? What does a decarbonised grid look like? Is it right to try to anticipate an energy future much beyond the next 20 years?*

The imminent need to replace primary power stations over the next 10 – 20 years must inevitably produce greener grid electricity than at present – leaving CHP as a dirty legacy technology.

PJ – *CHP is not going to be a stranded asset.*

4. As PJ said, biomass will be imported. UK's current 47% target for biomass anticipates that half will be imported.

MD – *The last speaker's comments were supported by the massive part anticipated for bio-fuels in the Port of Southampton's business plan.*

5. It is vital that UK government resolves the energy debate and national policy - yet at the moment DECC aligns with BW's views and DCLG follows PJ's. We desperately need to sort ourselves out.

Real operational data from the Malmo CHP system showed it achieved CoPs of >5 – far better than the heat pumps espoused by DECC. The evidence was that scale is important in achieving high efficiencies – with a minimum 'entry level' of 15MW, roughly equating to 15000 homes.

BW - *Malmo's CHP appeared to' work' because its heat output was rated at the seasonal minimum – meaning that the majority of the heat demand had to be met from other sources, like local boilers.*

6. How can CO_2 intensities that underlay the debate be validated when they have been 'bouncing around' - according to whose view of the world prevails?

7. Does BW owe an apology for creating an exemplar model to attack CHP that involves excessive dumping of heat in summer?

MD – *For clarity, the Southampton CHP system was not subsidised by the Council in any way.*

8. This is not an either/or policy question. Are we trying to rule out too many options too soon?

PJ – *Yes, it seems so.*

9. Has BW and MFP got the hump because of misdirection by some planner or other enforcing agency to use CHP?

10 CHP has an important public perception role. It works as a given of direct local participation with the growing demand for it well evidenced by the ways that cities are competing to involve.

11. As an ESCo, we are in the world to make money. CHP is one of our offerings.

12 ` Has BW considered the implications of tabling a report based on an incorrect analysis?

13 If there is a case to be made for CHP, why don't good quality CHP systems in the UK save any carbon at all?

14. The efficiencies used in the MFP report all comply with CHPQA.