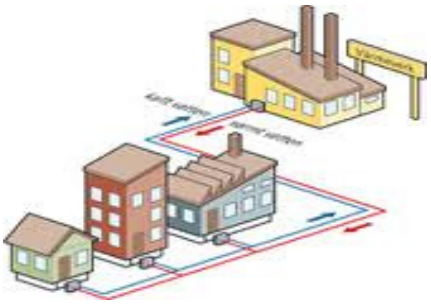
INITIATING DOCUMENT

Promoting the case for a pre-feasibility study for Brighton & Hove CHP and district heating from Shoreham power station

December 22nd 2011



Promoting the case for a pre-feasibility study for Brighton & Hove

CHP and district heating from Shoreham power station

22nd December 2011, document by RIG[1] and TBH[2]

FOREWORD

Combined heat and power (CHP) and *district heating* (DH) provide an efficient and cost-effective use of energy in many European cities.

In February 2011 we called for a pre-feasibility study for a Brighton & Hove CHP and DH scheme from Shoreham power station in our evidence to the Council's scrutiny committee on the potential for renewable energy in the city.

This *initiating document* aims to delineate tasks and produce a preliminary outline for a *scoping document*, to promote the case for a pre-feasibility study.

Terms of reference for a scoping study.

(a) The purpose of the scoping study should be to outline how the CHP/DH scheme will develop over the years and what this does to the cash flow and energy balance.

(b) The study will determine the price of oil in $ per barrel of crude, or the domestic gas price now 4p/kWh, at which the CHP/DH scheme would become economically viable[3]. An estimate is that the project will make a 5% real return on capital of the order of £2.1 billion invested (scenario A) or £2.6 billion (scenario B), at a crude price of $150, which may apply from 2013. We should be prepared for this so that we can implement the scheme as soon as it becomes economic to do so.

(c) The scheme will have a rationale for an extended interim period up to the implementation of an electric economy. The costs of construction must be amortised over this period, and the study must calculate that the financial and infrastructural extent of the scheme is in accordance with plans for this outcome.

(d) The study will aim to determine the scope, size and timing of the project(s). Indications are that DECC[5] is in favour of small CHP/DH schemes, say linked to hospitals and locally connected to external properties. These are directly viable. We will consider how such small schemes can link to a scheme utilising a large amount of waste heat from Shoreham power station, which is the main objective of the study. For this principal objective, the scope may be from Worthing to Brighton, a radius of about 10 km from the power station, Brighton & Hove alone, or if the Working Group decides, a reduced, phased scheme. Scenarios vary, depending largely on the practical extent of the proposed pipe network. In scenario A, the size should be to utilise on average 70% of the waste heat in the cooling water, about 1.8 TWh[4] per year, by connecting about 70,000 buildings, 30% of the Worthing/Brighton total, at about 400MW peak, an average of 4kW per building, or 20 MWh per year per building. In scenario B, 100% of the waste heat is utilised, at 2.6 TWh per year, by connecting 100,000 buildings. The timing should be able to identify the issues so that the project could be implemented as soon as it is economic to do so. Considerations will be given

to more than one CHP power source in order to maintain continuity of supply under maintenance.

(e) Further objectives should be to identify the job creation potential, the best routes for the bus mains, the cost of the project, the prospective sources of finance, the tariff for hot water, the legal issues and the public reaction to road construction upheaval over a long period of time.

(f) Changes necessary or conducive to the regulatory regime will be itemised.

What follows are our initial thoughts on how to proceed with the scoping study. Some contributors from RIG and TBH are given at the end of the document.

We invite comments from all of you on how we need to modify this sketch and extend it.

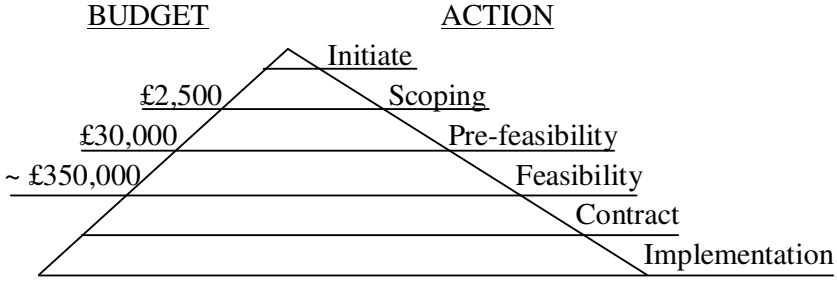
CHAPTER I

TASKS

1.1 The audience of the scoping document is officers of Brighton & Hove City Council including its sustainability team, members of whom are Thurstan Crockett and Francesca Iliffe, councillors across the political spectrum, the leader of the Council, Bill Randall, and officers of DECC, in particular Patrick Allcorn, with whom we have been in contact and held a recent meeting, its chief scientific advisor, David MacKay, and ministerial contacts whose assent is necessary to authorise changes to the regulatory framework.

1.2 The rationale for the study is that discussion with Scottish Power, given its concentration on operational and other issues, is not progressing, that large amounts of waste heat are being lost is irrefutable, and that in order to regain interest and promote action, more detailed and fully scrutinised proposals need to be fleshed out.

1.3 The scoping study is allocated £2,500 from various sources in RIG and TBH. Its funding is intermediate between what we have spent currently, which is minimal, but with technical expertise and much interest from members of the associations, and the costs of a pre-feasibility study. We are advised that £20,000 to £30,000 should be sufficient for a pre-feasibility study and £40,000 to £50,000 is a reasonable price for a full feasibility study. An estimate from another source is £40,000 for pre-feasibility and £4 million for feasibility.



1.4 We are seeking grants so that the scoping study can be reimbursed and the pre-feasibility study can take place. Michael King, chairman of Aberdeen Heat & Power Co. who has been responsible for the construction of CHP developments in Aberdeen, now comprising over 1,000 domestic connections, will be contacted with a view to providing advice on this.

1.5 The facilitator would like a document put together under 'Chatham House rules' – as was done with the Renewables Consultation document several years ago. This means everyone has their say, and cannot modify what anyone else says without their agreement. If there is a disagreement, the document can reflect that, without naming individuals, whose contributions are anonymous, except that the list of contributors, with profiles, is at the end of the document. The purpose of the facilitator (more usually called the editor) is to give the document a common look and feel.

1.6 A separate task is facilitating contributors to put forward material. We will both initiate this process in preliminary selection of names, and ask more generally for members of the associations to put forward names of people that we can involve in this study.

1.7 The facilitator's contribution will span 3 months – November 2011 to January 2012.

1.8 An objective of the study is to transfer knowledge of other schemes to Brighton & Hove. It will be necessary to document the contribution of the CHP expert from Munich.

1.9 For our own part, we intend on the engineering side, to put out feelers on participation, if not already sent out, to the following engineers:

John Kapp
Nick Rouse
Prof. Alan Turner
Lara Lewington
engineers suggested by Chris Tomlinson of Eon
Bob Ashley and Andy French of Mott MacDonald.

In terms of the regulatory framework, we hope an advisor will be Patrick Allcorn, heading the Decentralised Energy and Heat team at DECC.

We expect to maintain contacts with all political groups on the Council, including especially Bill Randall, leader of the Council, and with the local government administration including its sustainability team, members of whom are Thurstan Crockett and Francesca Iliffe.

1.10 For the Power Point presentation of the document and the document itself, we suggest Mike Foxcroft – who has given his assent and did the EDRAP facing page. We would be prepared to pay £250 and a photographer £90 to get the presentation looking professional.

1.11 For the financial evaluation, we invite your suggestions. We will obtain someone with an engineering and accountancy background to do a financial audit of the proposals.

1.12 Risk evaluation is a feature of all project methodologies. We will exclude evaluation of certain risks which could be statistically quantified – for instance war, economic recession, epidemic or a tsunami, and restrict ourselves to a narrow evaluation of risk based on error resulting from imperfect information in the area investigated. Such an evaluation can be improved, but not eliminated, by further and deeper study, and there may be an optimum use of resource in which accuracy is paid off against time and the expense of investigation. We will not go into second order considerations – the errors inherent in evaluating errors, but use intuitive methods to classify major deviations, and consider strategies which may reduce adverse risk, or balance this against risks where the outcome is especially advantageous.

1.13 The basis of calculations will be itemised in the scoping report. All figures given in this initiating document should be subject to independent scrutiny, if included in the scoping report.

1.14 The report will have a set of references.

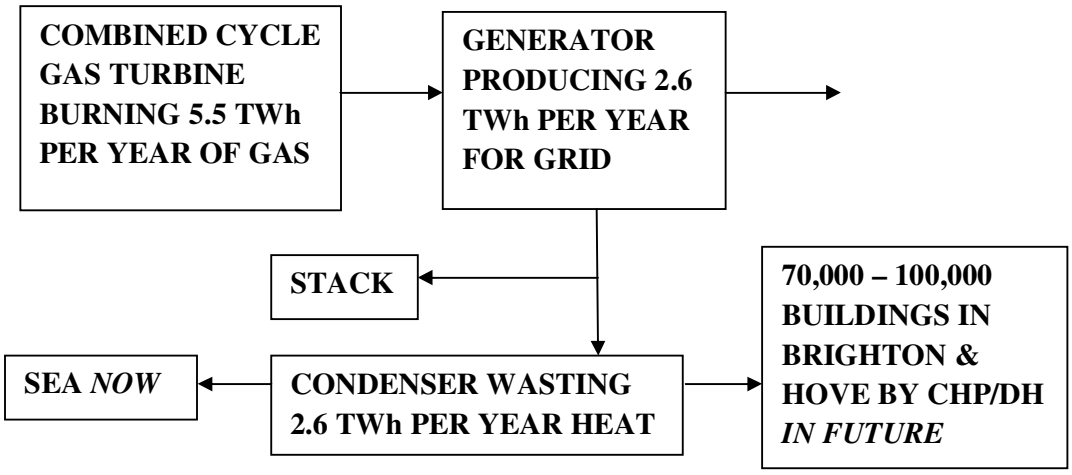
CHAPTER II

PROPOSALS

2.1 Using heat from Shoreham power station.

Shoreham power station is owned by Scottish Power/Iberdrola, and is located half a mile from Hove's western boundary. In 2010 this had a nameplate rating of 420 MW, amounting to 2.6 TWh per year for the National Grid, the same amount that is consumed in the coastal towns from Worthing to Brighton.

The power station is about 50% efficient, and so wastes as much energy as it generates, most of which goes into the sea. The amount of this wastage in 2010 was 2.6 TWh per year, which is more than the proposed 650 MW Rampion offshore windfarm, which will generate 2 TWh from 2017. We estimate this is enough energy to heat under variable load in scenario A, 30% of the number of buildings, 70,000, from Worthing to Brighton or 70% in Brighton & Hove, with a CHP and DH scheme, or in scenario B, 100% of the buildings in Brighton & Hove, as shown in the diagram.



2.2 Initial estimates are the scheme under scenario A would cost about £2.1 billion, less than Rampion, and create 500 local jobs to a maximum of 700 for sixteen years[6]. It would save 1.8 TWh of gas that is presently burned to heat those buildings, and over 370 million tonnes per year of CO_2. The assumptions are documented in reference [6]. Neither scenario A nor scenario B assumptions aggregate the total expenditure from its components – we are not yet in a position to do that in this initiating document – but we break down expenditure based on estimates from analysis of other engineering projects.

2.3 For scenario B the scheme would cost about £2.6 billion, comparable with Rampion. The scheme would employ 10,000 people locally for each year over 3 years[7]. The assumptions are documented in reference [7]. It would save 2.6 TWh of gas that is presently burnt to heat these buildings, and 550 million tonnes per year of CO_2.

2.4 Small scale CHP/DH schemes will be investigated in the study. CHP generators could be located in unoccupied buildings (which includes some unused churches). Hospitals are a

good source of near-constant heat requirements over a day. A change to the regulatory regime, or the subcontracting of power supply to a CHP/DH provider for a hospital, so that local domestic properties and businesses can also connect, will be considered. Connection to a Shoreham CHP/DH scheme would provide resilience under maintenance for such relatively small scale schemes.

2.5 The fact that DH is so widespread in some countries and expanding makes one believe it must be possible in the UK. In Finland 40% of building heating comes from CHP and another 10% from DH plants that provide just heat but no electricity. In Denmark, the figures are 48% and 14% heat only. CHP has proved possible in big cities like Stokholm or Flensburg.

We have been advised that continental district heating schemes were originally developed as an economic and environmental answer to the replacement of domestic coal to a more efficient form of centralised coal power generation, and that economies are unequivocal in cold climates such as Scandinavia, but must be properly evaluated elsewhere.

2.6 To the question of using 2.6 TWh of waste heat productively, there may be ways of using sizable amounts of heat in a district heating scheme, but the 2.6TWh figure requires the station running at a 70% capacity factor[8]. There is no feasible heat load that is close enough to constant throughout the year to provide such a capacity factor even when we add in hotels, swimming pools and greenhouses.

2.7 We envisage 8 parts to the scoping study.

(a) Description of the characteristics of Shoreham power station. This is a 420 MW Combined Cycle Gas Turbine (CCGT) which started generating in 2000, and generated 2.6 TWh of electricity in 2010. It has two generators – a gas turbine and a steam generator connected on one shaft, although the steam generator can be turned off, in which case the gas goes up the stack.

(b) An identification of the current energy costs and efficiencies of the Shoreham power station, and a similar evaluation of corresponding profitability. It discharges about the same amount of energy, 2.6 TWh, into the sea as cooking water.

(c) An identification and subdivision of proposed schemes using waste heat from Shoreham power station, both

(i) The engineering aspects, technical characteristics and technical feasibility of CHP/district heating schemes using or linking to waste heat from Shoreham power station.

(ii) The financial aspects of the various schemes suggested.

(d) An identification of eventual energy costs and efficiencies, after build, for any proposed schemes, and in terms of financial profitability.

(e) An identification of transfer costs from the current state to the proposed configurations, including network build and power station down-time, both under an energy and a financial evaluation. £50 million costs in power station reconfiguration down-time have been suggested.

(f) The intermittency arising from maintenance has to be addressed. The public would not accept the intermittency ensuing from only one power station; a claim is that the

system could not be shut down for a week for maintenance. Another aspect is that planned down time can be accommodated by householders turning on internal boiler systems, where these exist. The planned development of 700 new homes at Toad Hole Valley, to be linked to a DH scheme, may not have their own boilers, so for this scheme it is desirable to have more than one DH energy source. Large district heating systems tend to have several generators. A 30 MW palm oil burning plant by Edgely Green Power which has obtained planning permission for Shoreham could satisfy this. Stokholm has four generators, including huge 250 MW heat pumps, which would operate at somewhat less efficiency in Brighton & Hove, because the temperature difference for their use in Stokholm is obtained by tapping deep very cold water.

(g) An investigation of the regulatory regime, and changes that could be made to it, in accordance with energy and financial costs and efficiencies, and the incentives, both as an accumulated sum and in terms of detailed proposals, that would be necessary to make selected energy efficient schemes viable.

(h) We will produce a well-presented and professional-looking document, with a power-point presentation to accompany it.

2.8 In terms of the engineering part of the project, this can be divided (this list can be extended) into the following parts.

(a) Connection of Shoreham Power Station to a housing development, mooted to be 2,000 homes, in Shoreham itself.

(b) A main pipe along and under the pebbles on the seafront to the centre of Brighton and beyond has been suggested, both

(i) connecting to large seafront hotels

(ii) extended to feed-off points

and objections raised that bedrock would have to be reached under sea level, otherwise the pipe would be subject to subsidence and would leak. The reply has been that hardpan is above sea level, allowing the main pipe to be laid. We would like to know precisely the geology of the seafront (the claim is that it is even), since the cost implications are significant, and sources of information have been suggested.

(c) The difficulties in retro-fitting current domestic housing stock have to be evaluated [8]. This is why we are including (e) on a reduced scheme.

(d) A large scheme, covering the whole of Brighton & Hove, extended to Worthing, alternatively just Brighton & Hove, with a pipe network infrastructure to match.

(e) A reduced extendable scheme, serving large seafront hotels, King Alfred and Prince Regent swimming pools, Grand Avenue Council offices, Hove and Brighton Town Halls, possibly Royal Sussex County Hospital, and a new housing development in Shoreham.

(f) Thermodynamic efficiency of the power station in the new configuration and the balance between electricity power output and heat output.

(g) The network will need to be configured around existing networks of water supply, sewerage, electricity and gas under roads, and cable under pavements. Councils in the UK initiated water supply, sewerage, gas and electricity networks around the beginning of the 19th century. This type of integrated Council infrastructure still exists

in other European countries, and it has allowed the integrated planning of CHP/DH networks elsewhere in Europe. The public sector ability to direct this type of activity no longer exists in the UK, where these networks have not been designed with a DH system in mind, which may result in limitations in the contours of the network. Digitised Ordnance Survey maps of utility distribution networks were developed in the 1990's. These information sources will have to be accessed to determine the network configuration.

(h) Evaluation of network heat loss, pipe diameters and flow through. The piping network will be a closed-cycle fresh water network. We have been advised of the existence of a district heating scheme with a pipe length of 24 km.

(i) Complementary schemes and technologies to go with (a), (b) and (d)/(e). More than one CHP power source will be required in order to maintain continuity of supply under maintenance. In order to get a reasonable capacity factor, this includes the need to build a large heat store (a large insulated tank) to level out the daily variation in the heat load.

2.9 In terms of the financial aspect we would need advice on the full set of priorities. This includes:

(a) Pipe-laying costs. A very rough figure for the cost of pipe laying for CHP is £1,000/metre.

(b) We have been advised that the cost of the network is *the* factor. For scenario A, 70,000 houses at 10 metres average distance between them equates to £700 million. £2,000 to fit a heat exchanger and heat meter in each house amounts to £140 million. For scenario B, 100,000 houses in the network equates to £1 billion. To fit a heat exchanger and heat meter in each house is £200 million.

(c) A contributor to the document has seen the construction of a DH pipe along a European road using equipment that performed the digging of the trench, laying of the pipe and resurfacing of the road that took place in a day.

(d) Another contributor writes here and in (e): This scheme can only be built up over many years. These pipes are big and take up a lot of room. The main ones leaving the power station would probably be 1 metre in diameter. This means a large fraction of the roads in the city being blocked or very heavily restricted throughout the time of construction.

(e) This slow build up over many years creates a chicken and egg problem. If we completely redesign the condenser so that we are producing fresh water not sea water at 85 ºC we have to be able to get rid of most of that heat as, at start, we will only have a few customers. Or else we run the station at very low output. If we do cut the station output to very low levels then initially we have the double problem of very low electricity production and low income from paying customers. If we leave the power station running at near full level we will have to build some large but temporary cooling towers.

(f) Likely scenarios of increases in gas prices, correlating prices with the time factor, and the economic payoff in terms of gas price escalation.

(g) Identification of financial regimes – incentives and legislative changes – that would make such schemes economic. This appears to be essentially to find a method of financing the network build.

(h) The marginal payoff of the non-local effect on gas prices. If gas consumption goes down, the price of gas goes down, and other users of gas benefit financially. This may be a consideration in designing the regulatory framework involving cost incentives.

(i) We claim the legislative framework is politically driven. Our objective is to properly evaluate the economic and linked energy saving benefits, and having done so if the answer is positive, to lobby effectively to implement the changes required.

(j) Change-over costs for the power station and the network build. Shutting down the power station while the work is done will lose about £100 million a year of electricity.

(k) Identification of sources of large-scale finance.

(l) Billing the system.

(m) Interaction with other schemes.

(n) Effect on jobs. Estimates for scenario A, of 500 local jobs in network construction (the pipes themselves would probably come from Scandinavia) with up to 700 employed at peak have been suggested, amounting to ~10,000 job years. For scenario B the estimate is 10,000 jobs locally per year, amounting to ~30,000 job years.

2.10 Other considerations are

(a) We will relate this to the government targets for energy, to reduce carbon emissions from burning fossil fuels by 80%, one fifth of present, by 2050. The target for the UK is to generate 30% of our electricity from renewable resources by 2020[10],[11].

(b) The EU's Cogeneration Directive 2004/08/EU requires us to support such schemes.

(c) Energy saved by CHP/DH is considered in combination a renewable resource by DECC.

(d) Some 20 GW of old power station plant is due to be decommissioned by 2017. About 4 GW of new CCGT power stations have been given planning licences by DECC in 2011. This includes one near Port Talbot of 900 MW, one in rural Derbyshire of 1.3 GW, and one at Croyton in Thames mouth of over 1 GW. The latter is the only one that plans to utilise a token amount of its waste heat by CHP.

(e) The projected economic life of a CCGT station is 40 years. If so, Shoreham will run until 2040, and the new CCGT stations will be run until about 2055.

(f) The price of crude oil peaked in 2008, tripling to $148 for a few weeks before falling back to about $50. It is now about $110. It is forecast to rise in real terms, as world oil production peaked in 2008, and perceived demand now exceeds physical supply.

Notes

The reader is cautioned that estimates in this document are just that. It is our aim that more precise calculations based wherever possible on verifiable cross-checked assumptions will be presented in the scoping report.

[1] RIG is the Renewables Infrastructure Group of Hove Civic Society.
[2] TBH is Transition Brighton & Hove.
[3] Oil prices and natural gas prices cannot diverge by too much. It is perfectly possible to turn natural gas into liquid transport fuel using the Fischer Tropsch process. Only the relative price of oil and natural gas prevent its widespread use.
[4] A TWh is a tera watt hour, and equals 1 billion kWhs.
[5] DECC is the Department of Energy and Climate Change.
[6] We indicate some of the assumptions of scenario A. To install DH, Stokholm has dug up every road with a trench 4 metres wide over 40 years. The construction period for Brighton & Hove is estimated as 40 years times the relative populations of the two cities (250,000 divided by 810,000), roughly 12 years. This assumes the same number of people employed in Stokholm to do this are employed in Brighton & Hove. We have added a factor of 4 years to account for the denser activity for Brighton & Hove that 12 years implies would have to be spent over a longer period to reduce the upheaval otherwise generated in economic and social activity. The estimate of the number of jobs is derived in comparison with 500 locally for Rampion, but is expected to be more labour intensive.
[7] For scenario B, the number of local jobs per year is calculated as an estimate of the overall cost of the project to be spread over 3 years, £2.6 billion, divided by an estimate of £24,000 per job, giving 40,000 jobs per year or 20,000 jobs per year in the city. An objection raised is that not all capital is held by individuals, but represents also material assets on which trade between corporations takes place. The amount of payment to individuals therefore works out lower for a standard project, especially where material assets rank high. The figure derived for the number of local jobs seems to be half the 20,000 quoted. The reply has been that the computation given works out in practice.
[8] Capacity factor is just a more correct term for load factor. It is the annual generation that was achieved (2.6 TWh) as a fraction of the theoretical output it could achieve if it ran flat out at its rated capacity all year (430 MW × 8760h = 3.77 TWh), 2.6 = 70% of 3.77.
[9] Link http://www.scotland.gov.uk/Resource/Doc/362183/0122534.pdf is a 133 page report published in Sept 2011 on utilising the waste heat from 4 power stations to heat urban conurbations in Scotland.
[10] Link
www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/renewable_ener.aspx.
[11] DECC Heat and Energy Saving Strategy Consultation – Chapter 6 – District Heating.
Link hes.decc.gov.uk/consultation/download/index-28051.pdf.

Contributors

Jim Adams was appointed a facilitator of this process, as agreed at the TBH meeting on 26th October. He is a mathematician and not an engineer, and a former coordinator of Brighton & Hove Eco Energy.

Ahlem Boujanah assists in the organisation of RIG.

Graham Ennis is a political and environmental polymath, Brighton & Hove Eco Energy.

John Kapp is a former engineer, a leading spirit in CHP/DH schemes and is secretary of RIG.

Patrick Lowe is the facilitator for TBH.

Helmut Lusser is a former Town Planner and is chairman of Hove Civic Society.

Terry Rixon is the webmaster of TBH.

Nick Rouse is an engineer and director of OVESCo.

David Porter is a businessman with a company Efficient Refurbs.

Clare Tickly represents the Conservation Advisory Group (CAG).