

Built Environment Services

M5X01836



Assignment 2: Renewable
Energy Sources For Building
Services

P152115

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Introduction

The reasoning behind this paper is to determine the best energy efficient systems and Methods currently available in construction technology. Furthermore, to ascertain which 2 services, can be managed effectively and complement each other respectively. Focusing to the power and cost demands of a proposed second stage development of an SA1 University Sports Complex Development. Emphasis on the features of Heat and Power (CHP) for the development.

Built Environment Services: Assignment 2**Renewable Energy Solutions in Building Services****CHP - Combined Heat and Power**

Francis et al (2014) Avers, that Energy Consumption calculations are detrimental to the success of any non-domestic development. Reiterating that it is crucial to consider all aspects at the earliest stage of concept and design. Also, stating that Swimming pools whether unaccompanied or as part of a Leisure complex require even further precision in calculating lifecycle requirements. Meeting these needs through careful selection of current technologies also using innovative new technologies available. This will allow new construction to at a minimum, meet the standards for building regulations but also with the aim to achieve Sustainable Construction recognition through schemes such as BREEAM.

Npower (2018) agree, insisting that up to 65% of the total energy usage each year in these types of development is owed to the pool heating. Additionally, that the Ventilation and heat management systems are inclusively energy dependant too (Fig 1.0).

CIBSE (2017) proffer, that multi use building complexes with integrated swimming pool and Gymnasiums represent the qualities linked to a Type 4 Combined centre (Fig 1.1) By using the pre-determined parameters set in this guide, it is possible to predict the annual usage associated with the centre.

Estimated Costs Per Annum (PA)

A floor area of 6000m² is specified in the assignment brief. This is in relation to the centre being utilised for combined services.

CIBSE (2017) state, that prerequisite amounts are used to produce the estimated annual outlay for running a Type 4 Non-Domestic Building (Fig 1.3). By calculation involving these figures, it is possible to give an estimation of running costs:

£14.33 + VAT - Type 4 Typical Cost per M²

6000M² x 14.33 = £85,980 + VAT (20%)

= £103,176 PA

These calculations assume that the development is of typical construction and not of higher values associated with a good standard described by the ECON 78 Best Practice Guide. Further implying that the centre is standardised to meet minimum building regulations. With no further energy saving methods or systems installed to achieve a Good standard of energy reduction associated with Sustainable Building Schemes.

The “Good” Rating estimate within the Econ Guide (Fig 1.2) states that it is possible to produce a centre that can operate at 45% reduction in fuel costs and higher efficiency. In theory, it indicates that it would be possible to reduce annual costs to £7.91m² in comparison to the typical values shown above.

Although, these estimated figures do not show any comprehensive data which has applied the use of combined sustainable methods in a singular project. The use of multiple systems will lower the operating costs over the lifecycle of each element once initial costs have been recovered through savings in fuel.

Possible solutions

The most suitable solutions available within current technologies that can help alleviate costs associated with maximising a combined centres energy savings. Can be listed in 3 main categories:

Electrical (Power) Producing: e.g. Wind Turbines, Wind Power or Photovoltaics etc

Heat Production: e.g. Biomass & Biofuel Boiler, Ground Source Heat Pump, Air Source Heat recovery, Solar Thermal or District Heating and Cooling.

Dual Usage / Combined – e.g. (CHP) Combined Heat and Power, Gas CHP, Biomass CHP

(ECG78) The Energy Consumption Guide 78 (2017) proffers, that in any circumstance where “energy saving criteria” is to be exploited to improve performance, that the first evaluation to be carried out should include extensive reporting on existing U-value’s or for planned installation. Additionally, suggesting that the supply chain and fixed pricing must be secured pre-construction. Owing to the fluctuation of supplier costs for high demand products such as graded u-value insulation. Avoiding the risk of settling for an inferior product to keep with the critical path of construction. Avoiding the possibility of thermal bridging in untested materials.

Williams (2013) agrees, claiming that setting fixed prices before-hand for materials that meet higher sustainability values will undoubtedly incur higher initial costs. But the extra money will be recouped by the client over the lifecycle of the building.

Additionally, stating that higher performing materials are subject to vast changes in a

short period “The cost of insulation rose 260% but dropped again in 2007, once more suppliers entered the market “.

CIBSE (2018) Insist, that 18% of the UK's total Co2 emissions are emanated through the requirements of space heating and hot water production. Moreover, claiming that CHP is the most advanced technological solution available to enable a lower carbon output in non-domestic properties with high power demands. “Combined heat and power (CHP) have been recognised as the technology that can reduce CO2 emissions”.

Wood (2014) agrees with this argument and avers that there are many options which can be applied in leisure centre design, but CHP meets higher performance Values. Furthermore, that these can be detrimental to pacifying the Government Scheme of 10GW. An abundance of Experts within the industry state that this focuses to highly on the production of electrical generation through alternative technologies. E.g. Wind Farms (offshore) which still use the national grid. Though, sustaining that CHP is still the most affective in electrical production when a need for a heavy heat supply is apparent.

Carbon Trust (2018) endorses, that CHP offers Larger developments the prospect of numerous benefits “lower Co2 Environmental Performance, cut costs and provide a more reliable and secure energy supply”. Although, additionally stating that for it to become a viable economical solution, that the development must have a minimum annual operating period of 4500 Hours to be most affective in recovering initial outlay costs of installation.

The hours of operation with heaviest energy usage are stated as between 7am and 10pm for 6 days a week:

Per Day: 15hrs

365 days a year – 52 days (closed) = 313 open days

Working on the assumption that the centre will be closed at a minimum of Christmas and New Year's Day, the per annum operational hours can be calculated to:

311 days x 15 operating hours per day.

= **4665 Hours (PA)** (Including the centre being open at bank, national and school holidays)

This figure is calculated by multiplying the opening hours of the centre only. Further consideration towards the cost of maintaining the optimum temperature of the pool which will require fuel exertion. Energy.gov (2018) assert, that swimming pools are more cost-effective when they are kept at a controlled level, close to operating level. Additionally, maintaining that by allowing the water to cool in in-operational times will cost more by means of fuel energy to recover the heat lost during lower temperature maintenance "The energy consumption for each degree rise in temperature will cost 10%–30% more in energy costs". This indicates that the optimal operational phase necessary to preserve heat loss is 17 hours per day, for 7 days per week:

365 days x 17hrs

= **6205 operating hours PA**

Troup Bye waters (2016) proffer, that the proposed SA1 site location would not be affected directly by any site or planning limitations for the purposes of a CHP Engines installation or use.

The SA1 Preliminary Low / Zero Carbon Report (LZC) (2016) insists that a CHP Engine will be the superlative choice for the site for existing buildings and proposed developments (Fig 1.3). Furthermore, stating within the report that CHP is suitable for buildings with multi-use design. Owing to the potential to share heat between different properties within a controlled radius of existing buildings with CHP as a primary source of fuel conversion. E.g. a CHP Engine housed at a leisure centre may over produce electricity as its primary focus is heat. The excess electricity can be shared to an alternative building such as the Face South or Library building or sold back to the national grid via an outbound tariff. The same is viable to surplus heat to be used by the sports centre.

Cambridge City Council (2012) confirms this, although warn that multiple CHP engines within near propinquity has the potential to jeopardise air quality at the site.

Also, stating that a solution to this problem is the use of shared gas steam powered turbines (Fig 1.4).

Co2 Reduction

EnerG (2017) states, that Sunderland Aquatics centre has accomplished “a carbon saving to date of 539 tonnes of CO₂, which is equivalent to planting 82,923 trees”.

This projected saving is highly significant to operational lifecycle expenditure because of the rate of Carbon Tax (CT) per annum. H M Revenue & Customs (2017) have set CT at £18 per Tonne, this equates to the project in Sunderland achieving a saving of £9,702 at the time of report.

Troup Bye waters (2017) also agree with the benefits available through this method of construction. Stating that similar CT reductions will be achievable at a development on the proposed SA1 Site. Estimating this saving at 13% per annum, for domestic hot water supply alone (Fig 1.5). Also, stating that this saving can be improved on by the use of Photovoltaic systems (Fig 1.6) but would not provide the energy requirements that a project of this size would need alone. CHP will improve CT benefits by functioning at optimal efficiency or 6205 hrs PA as previously calculated. Wimbush (2017) insist that CHP routinely saves around 8 and 20%. Moreover, that this reduction of CT will lower Return on investment (ROI) intervals from the primary outlay to operate at a profit per annum (Fig 1.7)

ECON 78 (2017) expresses, that electricity and gas are subjected to individual taxation via HMRC. By exploiting CHP as the foundational resource for both requirements, this allows supplementary benefits to be attained by lowering the threshold governed under the Climate Change Levy (CCL) (Fig 1.2).

By employing gas as a solitary fuel source, it is possible to make added savings on inbound fuel Tariffs (GBP):

Gas – 1p per KW

Electricity – 5.5p per KW

This shows a discount of 4.5p/kw or 82% are achievable.

Carbon Trust (2018) concur, expressing that most CHP are free of the restrictions within CCL regulation. Although, not all systems are exempt to benefit from a reduction or exemption. Government Legislation is not always set in stone and it is subject to possible changes in the future, e.g. The code for sustainable homes (RIP).

Proven case studies show alterable results from CHP with ranges from 10 – 22%

Per annum with regards to inbound fuel expenditure:

“Haverhill Leisure Centre – Suffolk 10% (Abbey Croft Leisure, 2011)

Aquatics Centre – Sunderland 22% (EnerG, 2017)

Shipley Pool – Bradford 18% (Bosch, 2018)”

The average savings of the above centres is 17%. Using this figure, it is possible to approximate savings at the SA1 development:

Fuel (Gas) Costs: £103,248 PA

Reduction (17%): £17,552.16

Estimated Total Cost: £85,695.84 (Exclusive of CCL if non-exempt or reduction entitlement).

Repayment & Lifecycle

Troup Bye Water (2017) aver that, it is possible to purchase CHP via different methods dependant on the development’s financials: Lump Sum, Lease to Purchase or Capital Investment. However, additional maintenance costs must be factored into any design (Fig 1.8)

Supplementation & Conclusion

A Plethora of resources list CHP as the most suitable technology for the development as a sole supply of heat and electricity. However, Supplementation by means of an electrical bias technology such as Wind Turbines due to the geography of the site or alternatively Solar PV which surpasses the emission production of a CHP turbine is not suitable as a sole supply.

It is Clear that materials with superlative thermal values within the buildings construction will be detrimental to the success of any low emission technologies success during its lifecycle. Additionally, the estimations and data accessible to developers when considering CHP is vast and no doubt are projected to show the pros in a much more positive light. A key factor which will appeal to clients will be the reduction in CT and Possible exclusion from the CCL.

The SA1 Face South and Library buildings employ CHP and via connecting system enhancement rather than an additional turbine, it will be exceptionally advantageous.

This can be realised by commissioning an alteration to the existing Building Management Systems (BMS). Lastly, this will lower maintenance costs involved with multiple plant by centralising the system to supply all 3 building. Shared heat and electrical reserves have the ability to be stored or profited by means of the feed out tariffs available.

References

Bosch. (2018). *Case Study Shiply Pool*. Available: <https://www.bosch-thermotechnology.com/gb/en/commercial-industrial/solutions/commercial-buildings-and-public-sector/sports-and-leisure/>. Last accessed 02/05/2018.

Cambridge City Council (2012). *Gas Fired Combined Heat and Power (CHP) Advice Note for Developers on reducing the impact on Air Quality*. Cambridge: CCC . 1-4.

Carbon Trust. (2017). *Sports and leisure Introducing energy saving opportunities for business*. Available: https://www.carbontrust.com/media/39352/ctv006_sports_and_leisure_sector_overview.pdf. Last accessed 29/04/2018.

CHP as a carbon reduction tool - what to consider. (2018). 1st ed. [ebook] London: 2degrees, pp.1-18. Available at: http://file:///C:/Users/asus/Downloads/Slides%20from%20webinar_%20CHP%20as%20a%20carbon%20reduction%20tool.pdf [Accessed 3 May 2018]. UK Government: Parliment (2008). *Making Government Operations More Sustainable: A Progress Report; Seventh Report of Session 2007-08; Report, Together with Formal Minutes, Oral and Written Evidence*. London: Parliment. 42-45.

CIBSE AM12: Addendum. (2018). 1st ed. [ebook] London: CIBSE, p.1. Available at: <https://www.cibse.org/getmedia/d37407fc-3327-47a5-88bb-56c1f0201124/AM12-addendum.pdf.aspx> [Accessed 21 Apr. 2018].

CIBSE. (2018). *CHP Overview*. Available: <https://www.cibse.org/networks/groups/chp-district-heating/chp-overview>. Last accessed 22/04/2018.

Energy Consumption Guide 78: Best Practice Program. (2017). 1st ed. [ebook]
London: CIBSE, pp.9-36. Available at: <https://www.cibse.org/getmedia/34def23a-c65b-405e-9dff-ce181c0b1e0d/ECG78-Energy-Use-in-Sports-and-Recreation-Buildings.pdf.aspx> [Accessed 1 Apr. 2018].

Energy.gov. (2017). *Managing Swimming Pool Temperature for Energy Efficiency*. Available: <https://www.energy.gov/energysaver/managing-swimming-pool-temperature-energy-efficiency>. Last accessed 20/04/2018.

Francis et al (2014). *European Building Construction Illustrated*. London: John Wiley & Sons.

HM Revenue & Customs. (2017). *Carbon price floor: reform*. Available: carbon-price-floor-reform. Last accessed 26/04/2018.

Introducing combined heat and power. (2018). 1st ed. [ebook] London: The Carbon Trust, p.1. Available at:
https://www.carbontrust.com/media/19529/ctv044_introducing_combined_heat_and_power.pdf [Accessed 15 Apr. 2018].

LEISURE SECTOR Haverhill Leisure Centre, Suffolk. (2011). 1st ed. [ebook]
London: Abbey Croft Leisure, pp.1-2. Available at:
https://www.theade.co.uk/assets/docs/case-studies/EuroSitePower-Haverhill_CaseStudy_leisurecentre.pdf [Accessed 1 May 2018].

NPower Ltd. (2018). *Eco Town: Leisure Centre*. Available:
https://www.npower.com/business/save-energy/eco-town/leisure-centre/#point_4.
Last accessed 20/04/2018.

UWTSD Phase 1 Low & Zero Carbon Feasibility Study. (2018). 1st ed. [ebook]

Swansea: Troup Byewaters + Anders, pp.3-31. Available at: <http://Moodle> [Accessed 20 Apr. 2018].

Wells, J (2003). *Solutions for Energy Security & Facility Management Challenges*.

London: The Fairmont Press, Inc. 69-72.

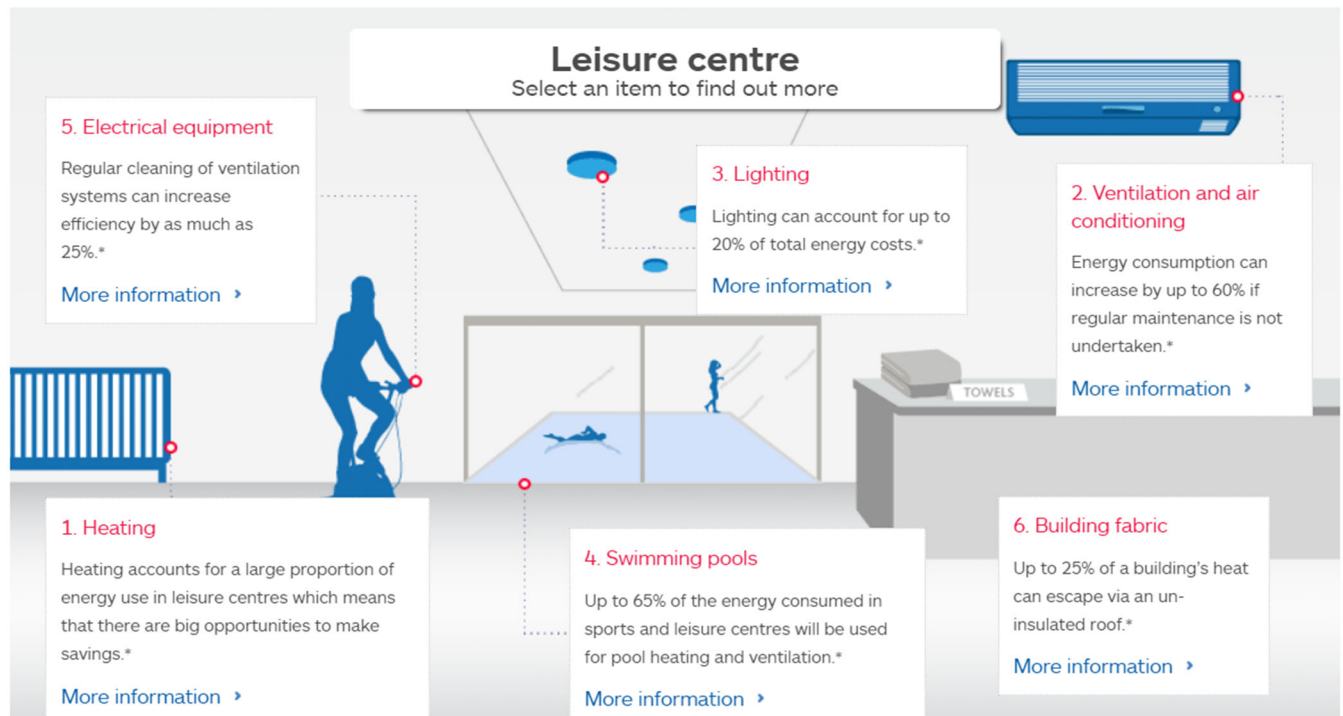
Williams, J (2013). *Zero-carbon Homes: A Road Map*. London: Routledge. 36 - 62

Wood, J (2014). *Local Energy: Distributed Generation of Heat and Power*. 3rd ed.

London: IET. 31-34.

Appendix

FIG 1.0



NPOWER LTD (2018). Eco Town Liesure Centre. (image) available at:

https://www.Npower.com/business/save-energy/eco-town/leisurecentre/#point_4

Fig 1.1

Type 4 – combined centre

This includes a 25 m five-lane pool and a learning pool, plus a six-court sports hall and a six-lane indoor bowls hall. There is a licensed bar and snack bar, fitness room and health suite with jacuzzi, sauna and solarium.

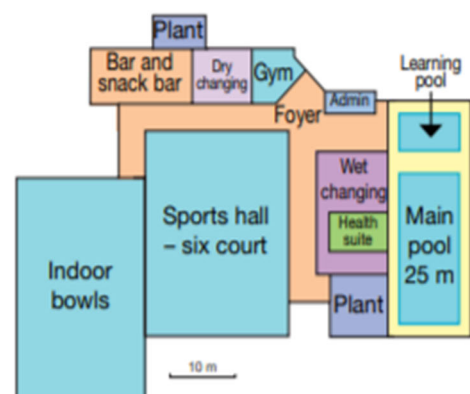


Fig 1.2

Description	Cost (£/m ²) <i>Good practice</i>	Cost (£/m ²) <i>Typical</i>
1 Local dry sports centre	5.09	9.21
2 25 m swimming pool centre	14.08	26.40
3 Leisure pool centre	14.74	27.40
4 Combined centre	7.91	14.34
5 Fitness centre	8.99	15.16
6 Sports ground changing facility	6.52	11.18
7 Ice rink	10.18	16.20

Note: The cost benchmarks are based on average unit rates (including standing and demand charges, but excluding the Climate Change Levy and VAT) of 5.5p/kWh for electricity and 1p/kWh for gas. Energy prices vary with the size of supply and are changing rapidly – if yours are significantly different you will need to adjust the cost benchmarks.

Energy Consumption Guide 78: Best Practice Program. (2017). 1st ed. [ebook]

London: CIBSE, pp.9-36. Available at: [https://www.cibse.org/getmedia/34def23a-](https://www.cibse.org/getmedia/34def23a-c65b-405e-9dff-ce181c0b1e0d/ECG78-Energy-Use-in-Sports-and-Recreation-Buildings.pdf.aspx)

[c65b-405e-9dff-ce181c0b1e0d/ECG78-Energy-Use-in-Sports-and-Recreation-](https://www.cibse.org/getmedia/34def23a-c65b-405e-9dff-ce181c0b1e0d/ECG78-Energy-Use-in-Sports-and-Recreation-Buildings.pdf.aspx)

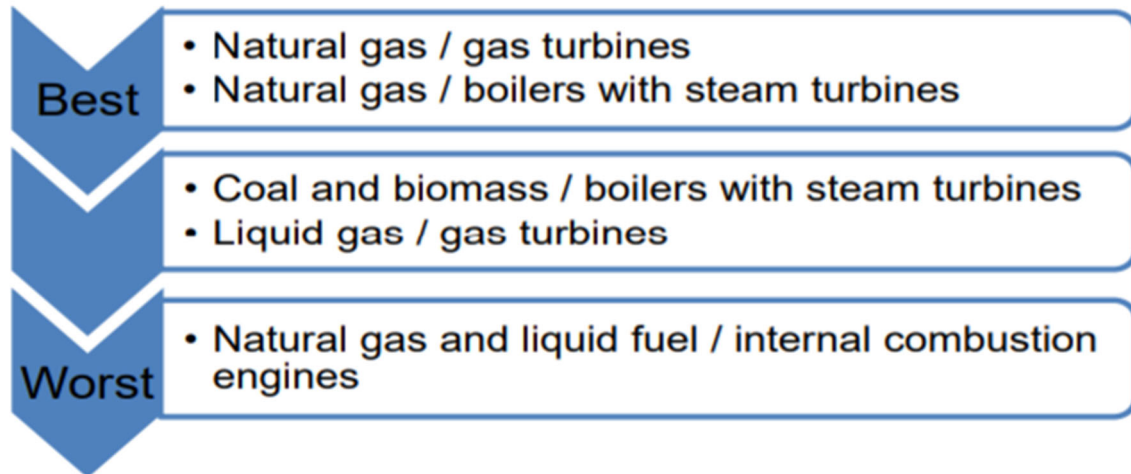
[Buildings.pdf.aspx](https://www.cibse.org/getmedia/34def23a-c65b-405e-9dff-ce181c0b1e0d/ECG78-Energy-Use-in-Sports-and-Recreation-Buildings.pdf.aspx)

Fig 1.3

COMPANYNAME	PRIMEMOVER	SECTOR	CHPTPC (kWe)	TOWN	COUNTY	POSTCODE	CHPREGION
BAMC	Reciprocating engine	Transport, commerce and administration etc	168	CARDIFF	GLAMORGAN	CF62 3YA	WALES
BETSI CADWALADR UNIVERSITY HEALTH BOARD	Reciprocating engine	Transport, commerce and administration etc	330	BANGOR	GWYNEDD	LL57 2PW	WALES
DWR CYMRU WELSH WATER	Reciprocating engine	Other industrial branches	1,200	ADENBURY	WREXHAM	LL13 0PA	WALES
DWR CYMRU WELSH WATER	Reciprocating engine	Other industrial branches	3,120	PORT TALBOT	WEST GLAMORGAN	SA13 1RA	WALES
DWR CYMRU WELSH WATER	Reciprocating engine	Other industrial branches	4,680	CARDIFF		CF24 2RX	WALES
ENERG COMBINED POWER LIMITED	Reciprocating engine	Other	70	HOLYWELL	FLINTSHIRE	CH8 7UZ	WALES
ENGIE	Combined cycle gas turbine	Chemicals	27,200	BARRY	VALE OF GLAMORGAN	CF63 3DH	WALES
GWYNEDD COUNCIL	Reciprocating engine	Other	40	BANGOR		LL57 2SD	WALES
GWYNEDD COUNCIL	Reciprocating engine	Other	76	PWLLHELI	GWYNEDD	LL53 5PF	WALES
GWYNEDD COUNCIL	Reciprocating engine	Other	76	CAERNARFON	GWYNEDD	LL55 1DU	WALES
GWYNEDD COUNCIL	Reciprocating engine	Other	90	PORTHMADOG		LL49 9HW	WALES
HYWEL DDA HEALTH BOARD	Reciprocating engine	Transport, commerce and administration etc	210	ABERYSTWYTH	CEREDIGION	SY23 1ER	WALES
INBEV UK LTD	Reciprocating engine	Food drink & tobacco	6,722	MAGOR	MONMOUTHSHIRE	NP26 3RA	WALES
NORTHWOOD & WEPA LTD	Simple Cycle Gas turbine	Paper, publishing and printing	9,000	BRIDGEND	MID GLAMORGAN	CF34 9RS	WALES
SWANSEA UNIVERSITY	Reciprocating engine	Transport, commerce and administration etc	1,760	SWANSEA	SOUTH GLAMORGAN	SA2 8PP	WALES
UPM-KYMMENE (UK)	Pass-out condensing steam turbine	Paper, publishing and printing	24,839	DEESIDE	FLINTSHIRE	CH5 2LL	WALES

Fig 1.4

Figure 1: Indicative Relative NOx Emissions Performance of Common CHP Prime Mover Technology/ Fuel Combinations⁴



Cambridge City Council (2012). *Gas Fired Combined Heat and Power (CHP) Advice Note for Developers on reducing the impact on Air Quality*. Cambridge: CCC . 1-4.

Fig 1.5

WA0155 UWTSD Phase 1
LZC Study

Troup Bywaters + Anders

	CO ₂ Emissions [kgCO ₂ /annum]
Baseline Scenario	262,147
CHP engines	228,126
Percentage Reduction	13%

Table 15 CO₂ emissions with wind compared with the baseline scenario

UWTSD Phase 1 Low & Zero Carbon Feasibility Study. (2018). 1st ed. [ebook]

Swansea: Troup Bywaters + Anders, pp.3-31. Available at: <http://Moodle> [Accessed 20 Apr. 2018].

Fig 1.6

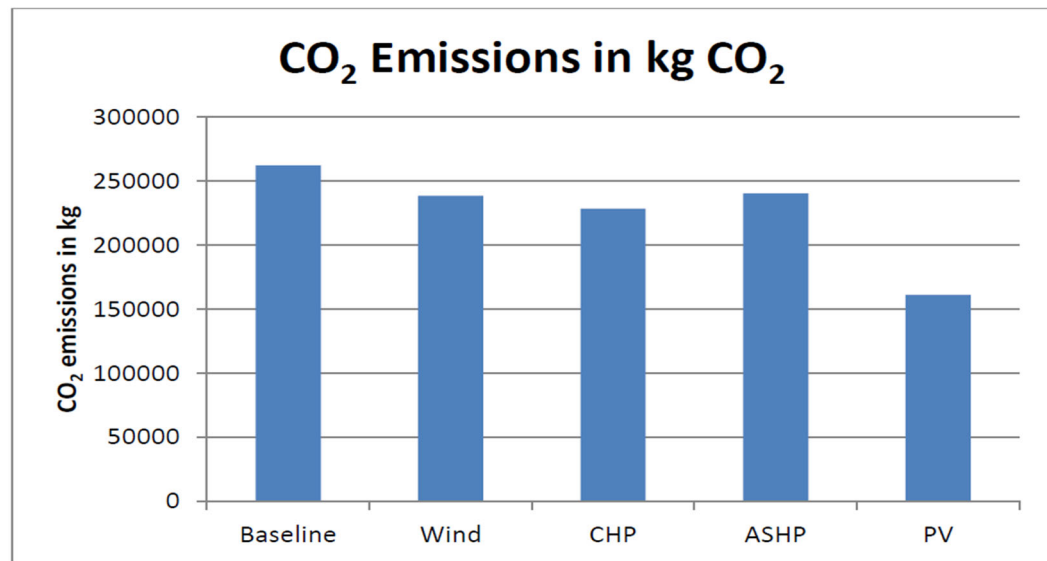
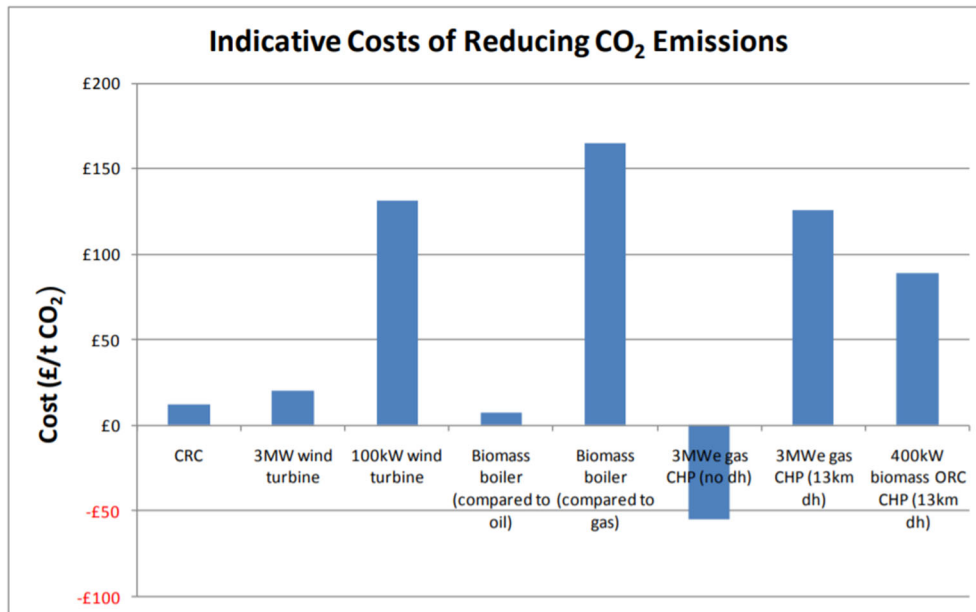


Figure 6. Bar chart showing total regulated building CO₂ emissions association with each LZC scenario

UWTSD Phase 1 Low & Zero Carbon Feasibility Study. (2018). 1st ed. [ebook]

Swansea: Troup Byewaters + Anders, pp.3-31. Available at: <http://Moodle> [Accessed 20 Apr. 2018].

Fig 1.7

Cost of Reducing CO₂

* no allowance made for ROCs, FiTs or RHI revenue

CHP as a carbon reduction tool - what to consider. (2018). 1st ed. [ebook] London: 2degrees, pp.1-18. Available at: http://file:///C:/Users/asus/Downloads/Slides%20from%20webinar_%20CHP%20as%20a%20carbon%20reduction%20tool.pdf [Accessed 3 May 2018].

Fig 1.8

	CHP
Installation Cost	£17,490
Total Annual Maintenance Cost Over Life Span	£7,000
Total Cost Over Life Span [Inc FiT]	£-135,450
Total CO ₂ Savings Over Life Span [TonnesCO ₂]	680
Life Span	20 years
£ per Tonne of CO₂	-£199

UWTSD Phase 1 Low & Zero Carbon Feasibility Study. (2018). 1st ed. [ebook]

Swansea: Troup Byewaters + Anders, pp.3-31. Available at: <http://Moodle> [Accessed 20 Apr. 2018].

