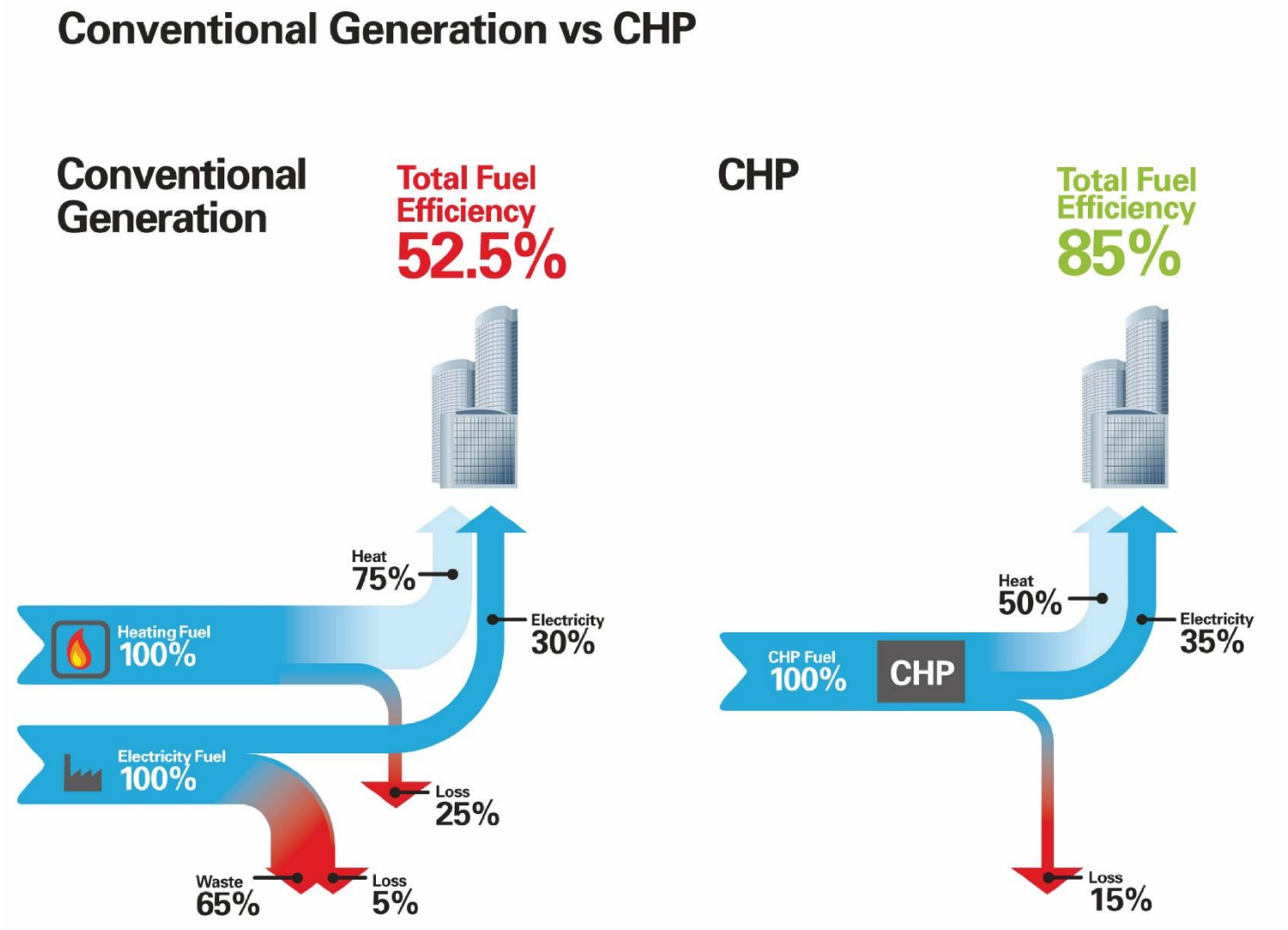
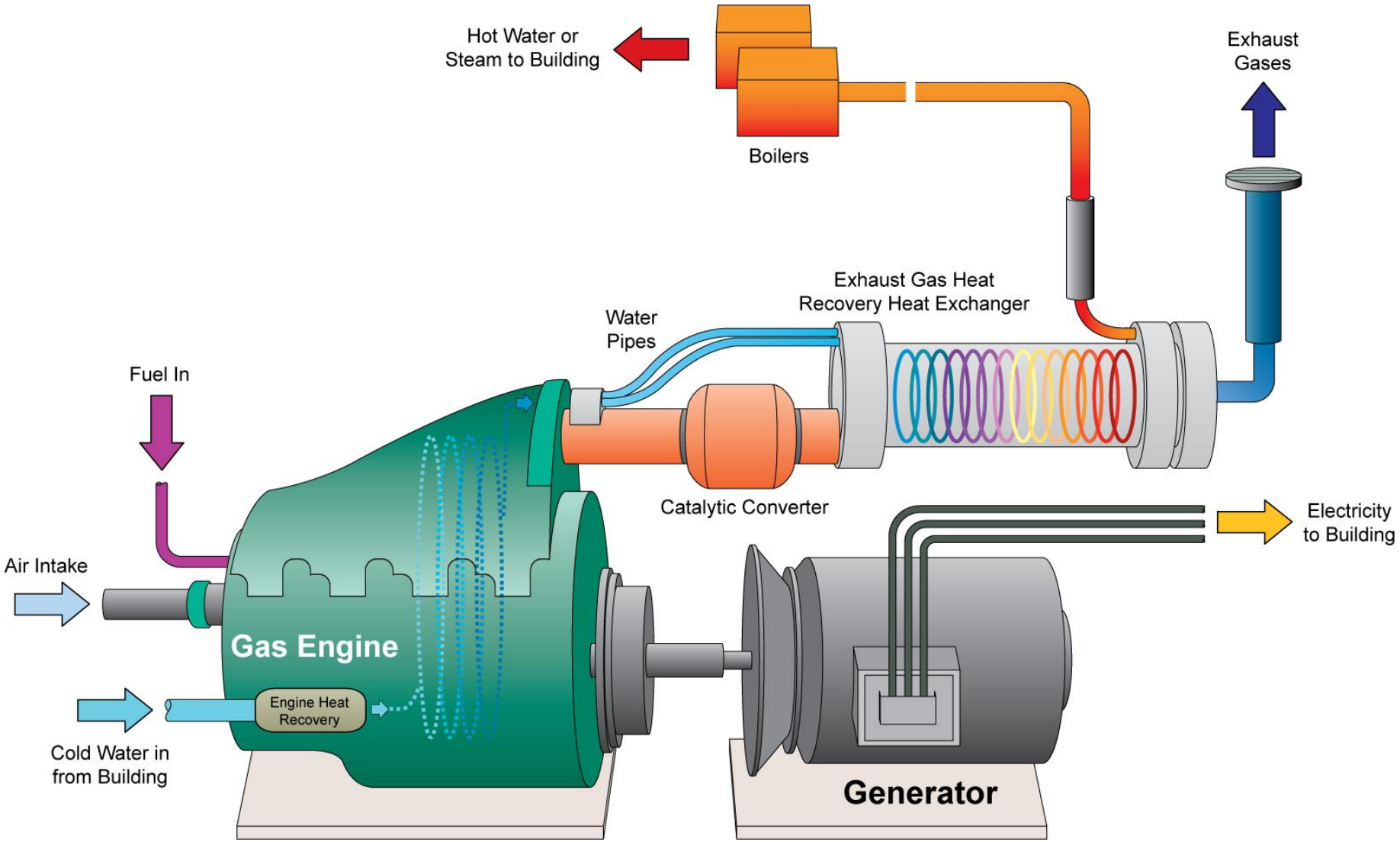
# What is Combined Heat & Power (CHP)?

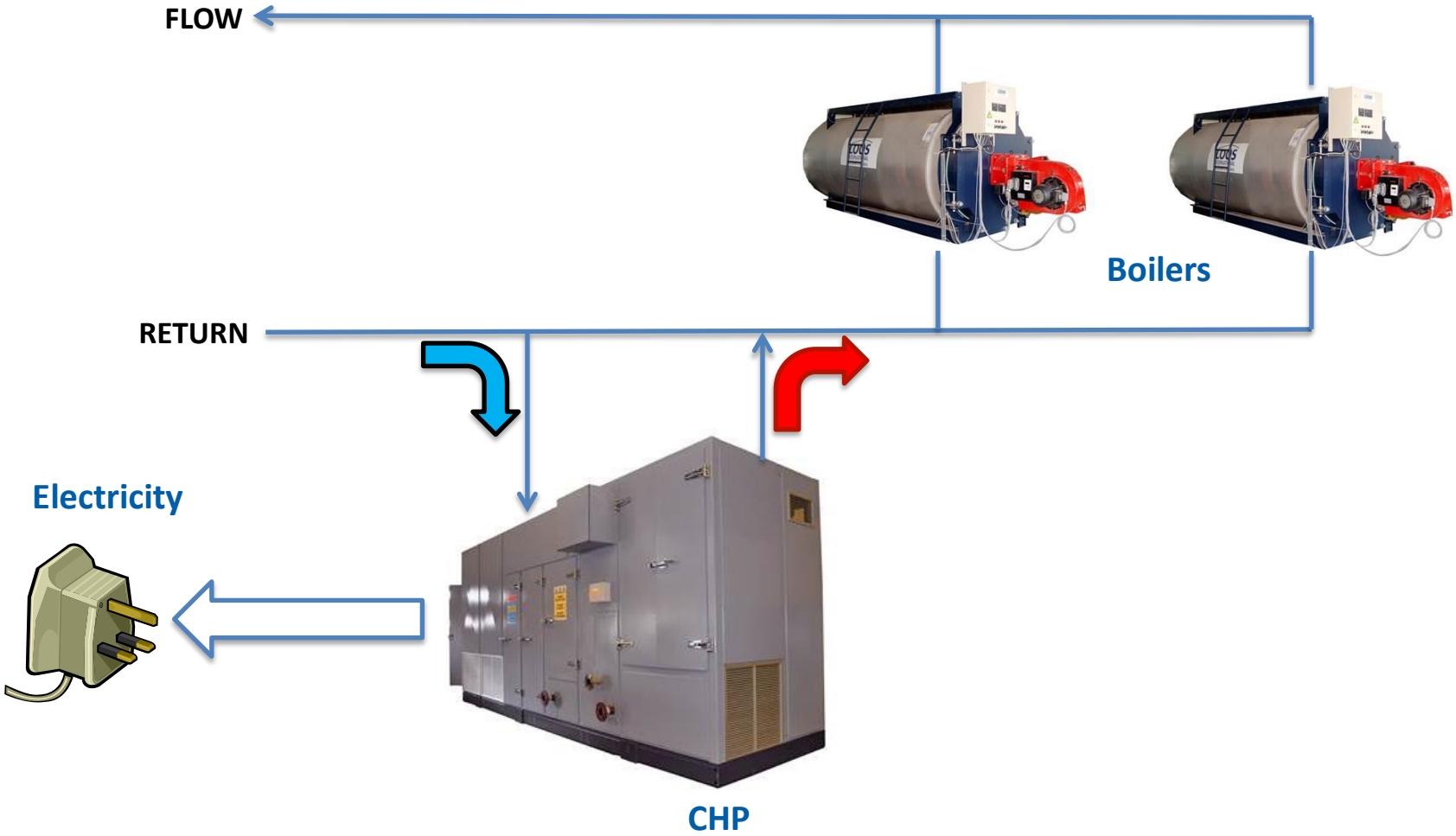
# Energy Savings



# How CHP works



# Simple Boiler Interface



# CHP Key Design Issues

How does your host site work?

- How many hours does the site operate?
- What does the electrical load profile look like?
- How and when is the thermal loading used?

Heat demand is critical

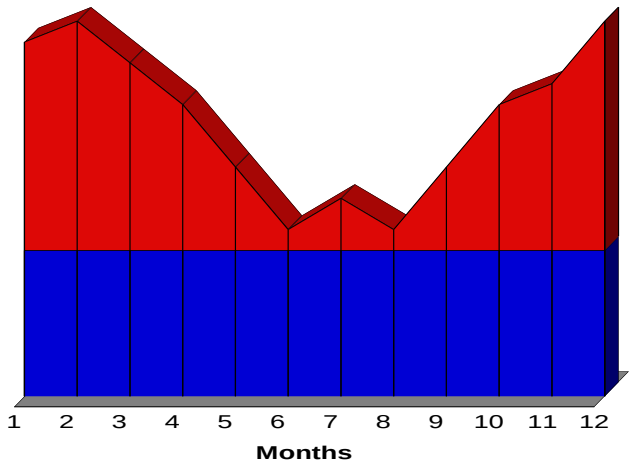
- CHP heat output must be maximised to achieve savings
- CHP sizing is based on heat demand for most sites
- CHP must be able to supply the grade of heat required, eg. steam, medium pressure hot water

Electric loads need to be determined

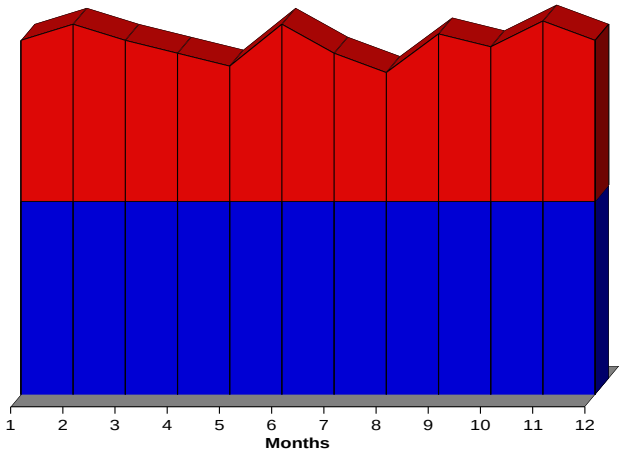
- Best connection interface is at the meter supply point
- Can connect at sub-distribution boards providing there is capacity in the cable

# Demand Profile Requirements

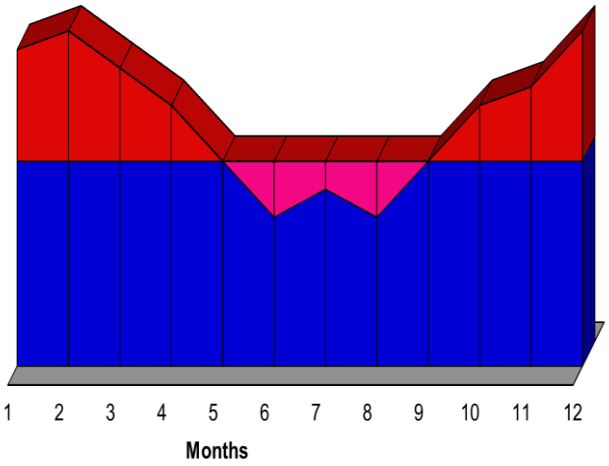
Thermal Profile - Base Load



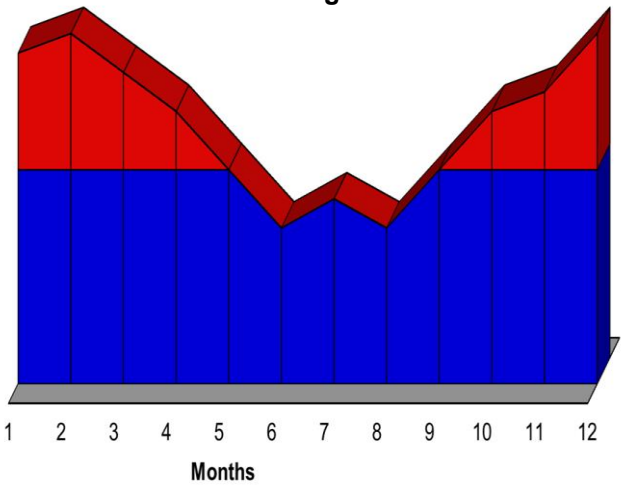

Electrical Profile - Base Load



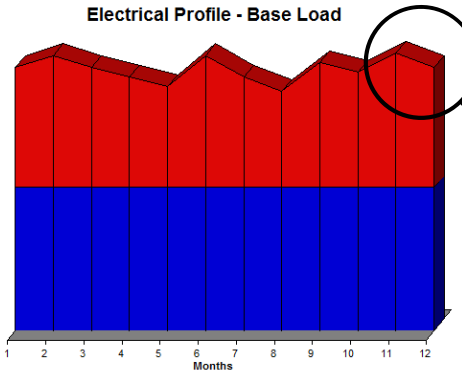

CHP now generates excess heat in summer

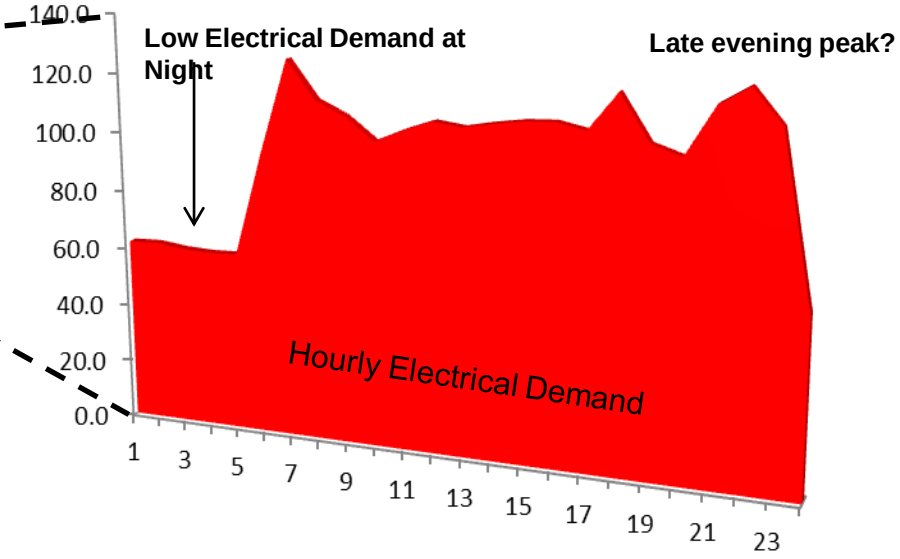


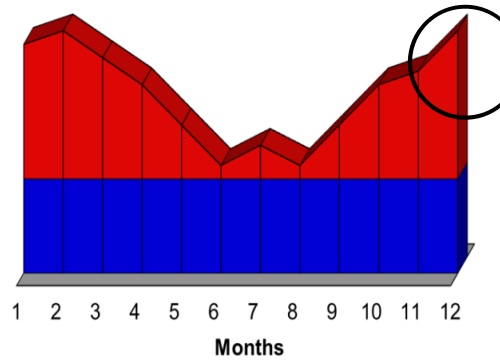

CHP “load tracking” in summer

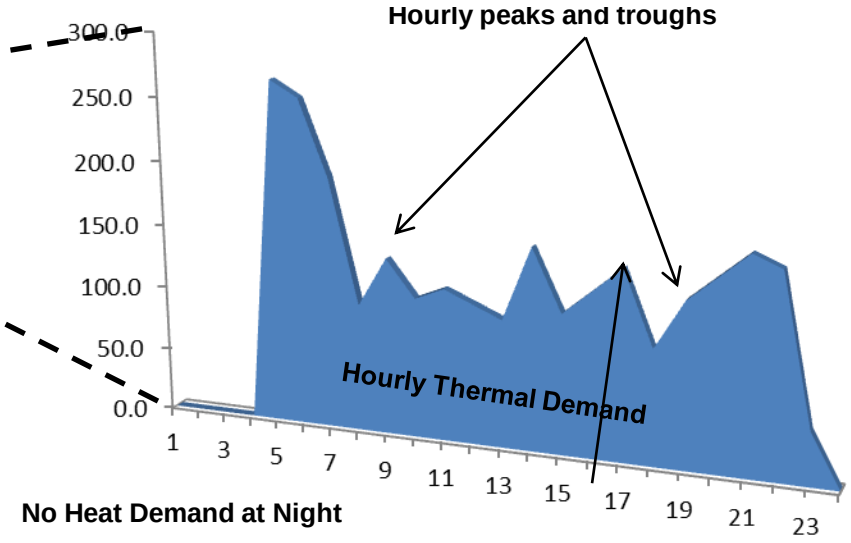


# CHP Sizing – The Devil is in the Detail!



# Other Factors to Consider

- Low cost energy saving measures first
- A detailed feasibility study is essential
- Don’t overestimate heat & power demands
- Best sites have year round heat demand
- Usually running 5,000 hrs/yr for economic viability
- CHP should always be the lead ‘boiler’
- Gas availability
- Noise issues
- Analyze a range of CHP types and sizes
- Consider all the practical issues carefully
- Assess all the environmental benefits/issues
- Use guidance from CIBSE AM12

# CHP Positioning

| PLANT LOCATION (Normally in boiler house) | GENERAL ACCESS FOR SERVICING | AIRBORNE NOISE | VIBRATION ISSUES | FLOOR LOADING | EXHAUST | PLANNING |
|---|---|---|---|---|---|---|
| **Ground Floor** | Good | Easy to deal with | Easy to deal with | Not an Issue | Careful consideration | No (maybe flue) |
| **Mid Level** | Careful consideration | Easy to deal with | Careful consideration | Careful consideration | Average | No (maybe flue) |
| **Roof** | Very Careful Consideration | Easy to deal with | Careful consideration | Careful consideration | Short exhaust | Yes |
| **External Location** | Good | Careful consideration | Not an Issue | Not an Issue | Careful consideration | Yes |

# Summary

There is a lot to think about……

There are several excellent CHP suppliers out there who will all give you a free feasibility study using sophisticated models which will take all this into account

## CHP Key Design Issues

How does your host site work?

- How many hours does the site operate?
- What does the electrical load profile look like?
- How and when is the thermal loading used?

Heat demand is critical

- CHP heat output must be maximised to achieve savings
- CHP sizing is based on heat demand for most sites
- CHP must be able to supply pressure hot water

Electric loads need to be de

- Best connection interface is
- Can connect at sub-distribut

## Other Factors to Consider

- Low cost energy saving measures first
- A detailed feasibility study is essential
- Don't overestimate heat & power demands
- Best sites have year round heat demand
- Usually running 5,000 hrs/yr for economic viability
- CHP should always be the lead 'boiler'
- Gas availability
- Noise issues
- Analyze a range of CHP types and sizes
- Consider all the practical issues carefully
- Assess all the environmental benefits/issues

## Unit Positioning

| PLANT LOCATION (Normally in boiler house) | GENERAL ACCESS FOR SERVICING | AIRBORNE NOISE | VIBRATION ISSUES | FLOOR LOADING | EXHAUST | PLANNING |
|---|---|---|---|---|---|---|
| Ground Floor | Good | Easy to deal with | Easy to deal with | Not an Issue | Careful consideration | No (maybe flue) |
| Mid Level | Careful consideration | Easy to deal with | Careful consideration | Careful consideration | Average | No (maybe flue) |
| Roof | Very Careful Consideration | Easy to deal with | Careful consideration | Careful consideration | Short exhaust | Yes |
| External Location | Good | Careful consideration | Not an Issue | Not an Issue | Careful consideration | Yes |

# CHP Equipment Options

# CHP Options - Internal packages

- Fully contained packages <500kWe
- Modular blocks >500kWe
- Least expensive option
- Limited flexibility
- Greater level of site integration
- Lower unit build cost

Image © ENER-G

# CHP Options - External packages

- Contained packages up to 2 MWe or more
- Special acoustic housings
- Good flexibility
- Simpler site integration
- Lower noise options
- Planning issues

Image © ENER-G

# CHP Operation, Financial & Carbon Savings Explained

UNDERSTANDING THE SAVINGS CHP OPERATORS CAN MAKE

# Who we are

With over 25 years experience. We work with clients in supermarkets & retail, hotels, leisure centres, petrol station forecourts, hospitals, schools, research centres and other private and public sectors organisations.

2EA have been in CHP industry for over 20 years and providing CCL consultancy for 18 years.

Specialise in specific UK & EU legislation:

- Climate Change Levy Taxation
- CHP & CHPQA Management
- Energy Saving Opportunity Scheme (ESOS)
- Streamlined Energy & Carbon Reporting (SECR)
- Medium Combustion Plant Directive (MCPD)
- Display Energy Certificates (DEC)

# What we will be covering

- A look at Climate Change Levy (CCL)
- A look at the CHPQA Programme
- Understanding and calculating CHP Financial Savings
- Understanding and calculating CHP Carbon Savings

# Climate Change Levy (CCL)

A BRIEF OVERVIEW

Climate Change Levy (CCL) was introduced in 2001 under the Finance Act 2000 for non-domestic organisations.

CCL is applied to electricity, gas, liquid petroleum gas (LPG) and solid fuels. However, exemptions for supplies from certain renewable sources and Combined Heat and Power (CHP) may be applicable.

CCL appears on non-domestic electricity and gas bills as CCL. It is applied at the time of supply and is charged on the energy used.

CCL is calculated based on the amount of energy being supplied and is charged by the supplier of the taxable commodity. Suppliers then pay the collected tax to HM Revenue and Customs.

CCL is often shown as a separate line item on energy bills (usually above the VAT line) and is also VAT chargeable. It is charged at a flat rate on every kilowatt-hour (kWh) of energy used.

| Taxable Commodity | Rate from 1st April 2018 | Rate from 1st April 2019 | Rate from 1st April 2020 |
|---|---|---|---|
| Electricity (£/kWh) | £0.00583 | £0.00847 | £0.00811 |
| Gas (£/kWh) | £0.00203 | £0.00339 | £0.00406 |
| LPG (£/kWh) | £0.01304 | £0.02175 | £0.02175 |

| Taxable Commodity | Rate from 1st April 2021 | Rate from 1st April 2022 | Rate from 1st April 2023 |
|---|---|---|---|
| Electricity (£/kWh) | £0.00775 | £0.00775 | £0.00775 |
| Gas (£/kWh) | £0.00465 | £0.00568 | £0.00672 |
| LPG (£/kWh) | £0.02175 | £0.002175 | £0.002175 |

| Sector | Total CCL Payable (2018/2019) | Total CCL Payable (2019/2020) | Difference | Percentage Increase |
|---|---|---|---|---|
| **Hotels** | £33,349.08 | £52,268.43 | £18,919.35 | 57% |
| **Supermarkets** | £24,026.60 | £35,324.32 | £11,297.72 | 47% |
| **Leisure Centres** | £8,781.24 | £13,499.74 | £4,718.50 | 54% |
| **Hospitals** | £81,853.23 | £122,013.06 | £40,159.83 | 49% |
| **Office Blocks** | £3,280.22 | £4,975.64 | £1,695.42 | 52% |
| **Schools** | £2,396.50 | £3,720.86 | £1,324.36 | 55% |
| **GP Practices** | £435.41 | £656.28 | £220.87 | 51% |

By installing and operating a CHP unit, a business can apply for CCL relief on the gas used by the CHP unit by being registered with the Department of Business, Energy & Industrial Strategy (BEIS) CHP Quality Assurance (CHPQA) Programme

# CHPQA Programme

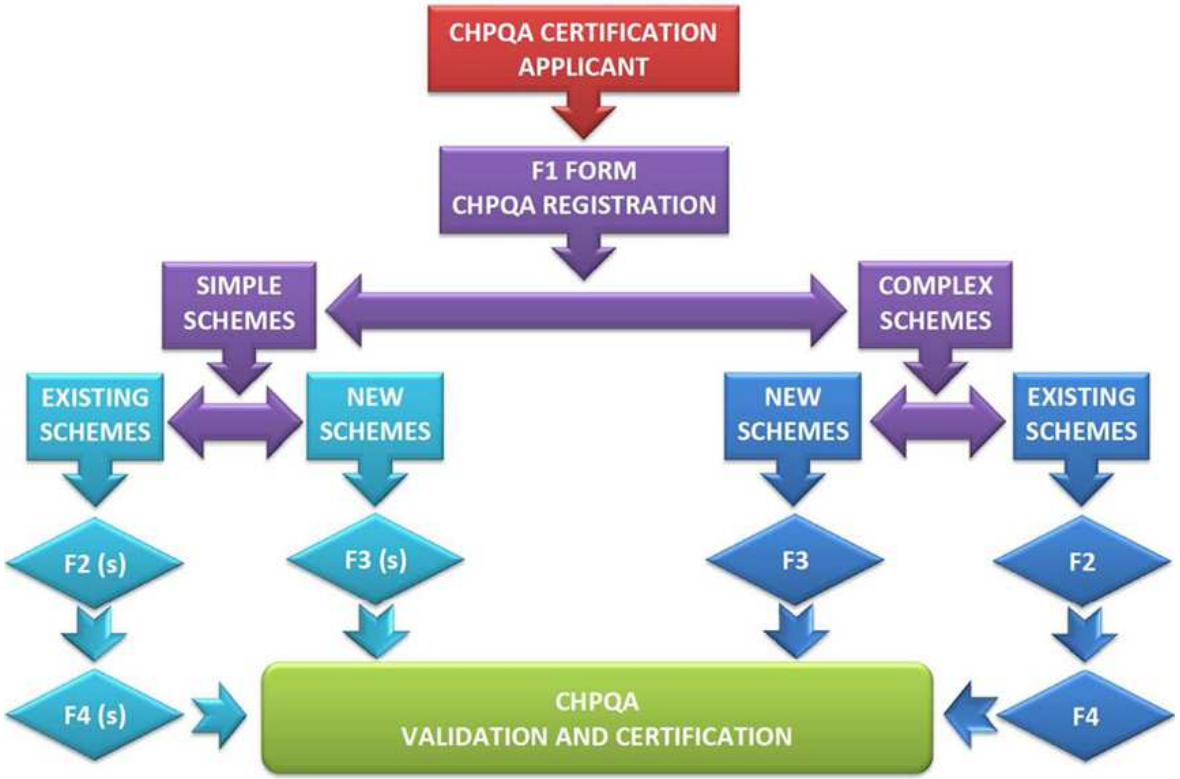
# What is the CHPQA?

The CHPQA Programme was introduced at the same time as CCL in 2001 and, like most government programmes, has developed tighter rules to ensure the programme works to its best abilities.

The CHP Quality Assurance programme (CHPQA) is a government initiative that aims to provide a method for assessing all types and sizes of Combined Heat & Power (CHP) schemes throughout the UK.

Participation in the scheme is voluntary, however, successful CHPQA certification grants eligibility to a range of benefits, including; Renewable Obligation Certificates, Renewable Heat Incentive, Enhanced Capital Allowances and preferential Business Rates.

CHP schemes that are fully certified as “Good Quality CHP” under the Combined Heat and Power Quality Assurance (CHPQA) programme, and have obtained a Secretary of State (CHP) Exemption Certificate are exempt from the rates of CCL on the fuel they use.



# CHP Savings

ELECTRICITY & HEAT

# Is your CHP Unit making you savings?

When you ask CHP owners why they are operating a CHP unit, they will most often answer ‘because it saves us money’. But does it? How do you know it’s making the savings you expect?

Unless you know how to calculate your CHP savings, you will not be able to answer the question. In this section we will look at the common methodology to calculate CHP savings.

# What do you need to know?

Before we can calculate CHP savings there are two (2) major requirements, they are:

1. Utility Prices

2. CHP Operational Data

Dealing with each of these in turn:

# Utility Prices

To calculate your CHP savings you will need the following utility data:

- Electricity Day Rate Price (£/kWh)
- Electricity Night Rate Price (£/kWh)
- Gas Price (£/kWh)
- Maintenance Cost (£/kWh)*

** This is normally a rate charged by the CHP maintainer based on the electricity generated by the CHP unit. This is also known as the CHP electricity price and in most cases does not vary if the CHP operates during the day or the night.*

Climate Change Levy – Gas (£/kWh)

Climate Change Levy – Electricity (£/kWh)

# CHP Operational Data

To calculate your CHP savings you will need the following CHP operational data:

- CHP hours run in period
- CHP Gas used (kWh) in period
- CHP Electricity generated (kWh) in period
- CHP Heat supplied (kWh) in period

You will also require details of the heat efficiency of the gas fired back-up boiler(s) to the CHP unit.

Once we have the above data for a specific period that we wish to look at, normally monthly, then we can start to calculate the CHP savings.

# CHP Operation

Simply put, a CHP unit consumes gas to generate electricity and supply heat to the site it is installed at.

For these calculations we are going to make the following assumptions with regards to the CHP operation and the utility prices:

The CHP unit has the following specification:

| | |
|---|---|
| Electrical Output: | 100 kW |
| Heat Output: | 150 kW |
| Gas Input: | 300 kW |

Daily Run Hours: 17 – The CHP unit does not run during the ‘night’ period

Taking the month of January 2020 as an example, the CHP unit would have operated for 527 hours and generated/consumed the following:

| | |
|---|---|
| Electricity Generated in period: | 52,700 kWh |
| Heat Supplied in period: | 79,050 kWh |
| Gas Consumed in period: | 158,100 kWh |

Finally, before we can start calculating the CHP savings, we must know if the CHP unit is registered under the CHPQA Programme.

If the CHP unit is registered under the Programme and meets the criteria for good quality CHP, then all the gas used and all the electricity generated by the CHP is exempt from climate change levy (CCL). We will for this example assume that the CHP unit is registered and certified as good quality.

For the following example, we will assume the utility prices are:

| | |
|---|---|
| Electricity Day Rate Price: | £0.08000/kWh |
| Electricity Night Rate Price: | £0.04000/kWh |
| Gas Price: | £0.02000/kWh |
| Maintenance Cost: | £0.03000/kWh |

The Climate Change Levy rates for January 2020 were:

| | |
|---|---|
| Climate Change Levy – Gas: | £0.00339/kWh |
| Climate Change Levy – Electricity: | £0.00847/kWh |

We will also assume that the gas fired back-up boiler heat efficiency is 85%.

We now have all the data we need to calculate the CHP savings. The first step is to calculate the CHP costs.

# CHP Costs

Effectively the total cost to operate the CHP, is the cost of the gas consumed and the cost of the maintenance to operate it; so we have:

| | | |
|---|---|---|
| Cost of CHP Gas: | 158,100 kWh x £0.02/kWh | = £3,162.00 |
| Cost of CHP Maintenance: | 52,700 kWh x £0.03/kWh | = £1,581.00 |
| **Total CHP Operational Cost:** | | **= £4,743.00** |

# CHP Savings

We will now look at the CHP savings.

These can be separated into two (2) parts:

1. The electricity savings
2. The heat savings

# The Electricity Savings

If there was no CHP unit operating on site, then the electricity generated by the CHP unit would have to be imported from the grid and would include the cost of CCL. So the cost of importing the equivalent electricity from the grid would be:

| | |
|---|---|
| Electricity Day Rate Price: | £0.08000/kWh |
| Climate Change Levy – Electricity: | £0.00847/kWh |
| Total Electricity Price (Day): | £0.08847/kWh |

Therefore the total cost to import the equivalent electricity from the grid would be:

**Total Cost Equivalent Grid: 52,700 kWh x £0.08847/kWh = £4,662.37**

# The Heat Savings

We must also take into account the heat supplied by the CHP unit; for if this was not available then, this heat would have to be supplied the site boiler(s), which would use gas to generate it.

Assuming that the boiler has a heat efficiency of 85%, then the quantity of gas used to generate the equivalent heat would be:

| | | |
|---|---|---|
| Equivalent Boiler Gas: | 79,050 kWh / 0.85 | = 93,000 kWh |

As the gas used in the boiler is not subject to a CCL exemption, then the CCL rate for gas needs to be included in the price of the gas.

So the price of the boiler gas would be:

| | |
|---|---|
| Gas Price: | £0.02000/kWh |
| Climate Change Levy – Gas: | £0.00339/kWh |
| Total Gas Price: | £0.02339/kWh |

Therefore the total cost of the boiler gas used to replace the equivalent heat from the CHP would be:

**Total Boiler Gas Cost:** **93,000 kWh x £0.02339/kWh = £2,175.27**

So this an effective saving, as this gas does not have to be purchased to generate the heat that is being supplied by the CHP unit.

# Total Savings

Therefore the total savings by operating the CHP unit are as follows:

| | |
|---|---|
| Total Electricity Saving: | £4,662.37 |
| Total Heat Saving: | £2,175.27 |
| Total Energy Cost Saving: | £6,837.64 |

From this we must deduct the Total CHP Operational Cost

| | |
|---|---|
| Total CHP Operational Cost: | £4,743.00 |
| This gives us then a total nett monthly saving of: | **£2,094.64** |

The above example is based on the optimum performance of the CHP, to calculate your actual CHP savings, then metered values for CHP electricity generated, heat supplied and gas consumed must be used.

# CHP Savings

THE CARBON

# Is Your CHP Unit Making Carbon Savings?

If operating correctly; your CHP unit will also give you carbon savings, which under the current climate can be just as important as financial savings.

In this section we will look at the most common methodology to calculate your CHP carbon savings.

# What do you need to know?

Before we can calculate CHP carbon savings there are two (2) major requirements, they are:

1. Emissions Factors

2. CHP Operational Data

Dealing with each of these in turn:

# Emissions Factors

For the example shown we will use the following emissions factors:

| | |
|---|---|
| CO2 Released for every kW of natural gas burnt (kg): | 0.184557 |
| CO2 Released for every kW of grid electricity used (kg): | 0.490230 |

# CHP Operational Data

To calculate your CHP carbon savings you will need the following CHP operational data:

CHP Gas used (kWh) in period

CHP Electricity generated (kWh) in period

CHP Heat supplied (kWh) in period

You will also require details of the heat efficiency of the gas fired back-up boiler(s) to the CHP unit.

Once we have the above data for a specific period that we wish to look at, normally annually, then we can start to calculate the CHP carbon savings.

Using a sample year, the CHP unit generated and consumed the following:

| | |
|---|---|
| Electricity Generated in period: | 286,818 kWh |
| Heat Supplied in period: | 572,330 kWh |
| Gas Consumed in period: | 1,194,399 kWh |

We will also assume for the following example that the gas fired back-up boiler heat efficiency is 80%.

We now have all the data we need to calculate the CHP carbon savings. The first step is to calculate the carbon emissions from the CHP unit.

# CHP Carbon Emissions

Effectively the total carbon emissions from the CHP is total gas consumed multiplied by the emissions factor for natural gas; so we have:

| | | |
|---|---|---|
| CHP Carbon Emissions: | 1,194,399 kWh x 0.184557 | = 220,435 kg |

# The CHP Carbon Savings - Electricity

If there was no CHP unit operating on site, then the electricity generated by the CHP unit would have to be imported from the grid and would include carbon emissions.

So the carbon emissions from importing the equivalent electricity from the grid would be:

| | | |
|---|---|---|
| Grid Electricity Carbon Emissions: | 286,818 kWh x 0.490230 | = 140,607 kg |

# The CHP Carbon Savings - Heat

We must also take into account the heat supplied by the CHP unit; for if this was not available then, this heat would have to be supplied the site boiler(s), which would use gas to generate it.

Assuming that the boiler has a heat efficiency of 80%, then the quantity of gas used to generate the equivalent heat would be:

| | | |
|---|---|---|
| Equivalent Boiler Gas: | 572,330 kWh / 0.80 | = 715,413 kWh |

As the gas used in the boiler also creates carbon emissions, then this must also be taken into consideration when calculating the CHP carbon savings. So the carbon emissions from the equivalent boiler gas would be:

| | | |
|---|---|---|
| Boiler Gas Carbon Emissions: | 715,413 kWh x 0.184557 | = 132,035 kg |

So this an effective carbon saving, as this gas does not have to be consumed by the boiler to generate the heat that is being supplied by the CHP unit.

# Total Carbon Savings

Therefore the total carbon savings by operating the CHP unit are as follows:

| | |
|---|---|
| CHP Carbon Savings - Electricity: | 140,607 kg |
| CHP Carbon Savings – Heat: | 132,035 kg |
| Total CHP Carbon Savings: | 272,642 kg |
| From this we must deduct the CHP Carbon Emissions: | |
| Total CHP Carbon Emissions: | 220,435 kg |
| | |
| This gives us then a total CHP Carbon Saving of: | **52,207 kg** |

This equates to a percentage saving of 19% against the equivalent consumption from grid supplies.

# Total Savings

This gives us then a total nett monthly CHP Saving of: **£2,094.64**

This gives us then a total annual CHP Carbon Saving of: **52,207 kg**

# Key take aways

1. Ensure that your CHP unit is correctly sized for the site it is to operate on.

2. For maximum efficiency, the CHP scheme should be heat led.

3. Register you CHP unit with the CHPQA Programme.

4. Complete HMRC forms PP10 and PP11 to obtain your CCL exemption.

5. Carry out annual CCL reconciliation.

Our online CCL calculator:

https://www.2ea.co.uk/CCL-Calculator.html

Our CCL Paper

https://www.2ea.co.uk/Media/Library/2ea-climate-change-levy-paper-v5.4.pdf

*Topic: A multi-sector analysis of the cost difference of CCL rates 2018 – 2022*

# Questions?

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2EA®

Think Energy,
Let's Save It Together.