Combined Heat & Power

09/02/2018

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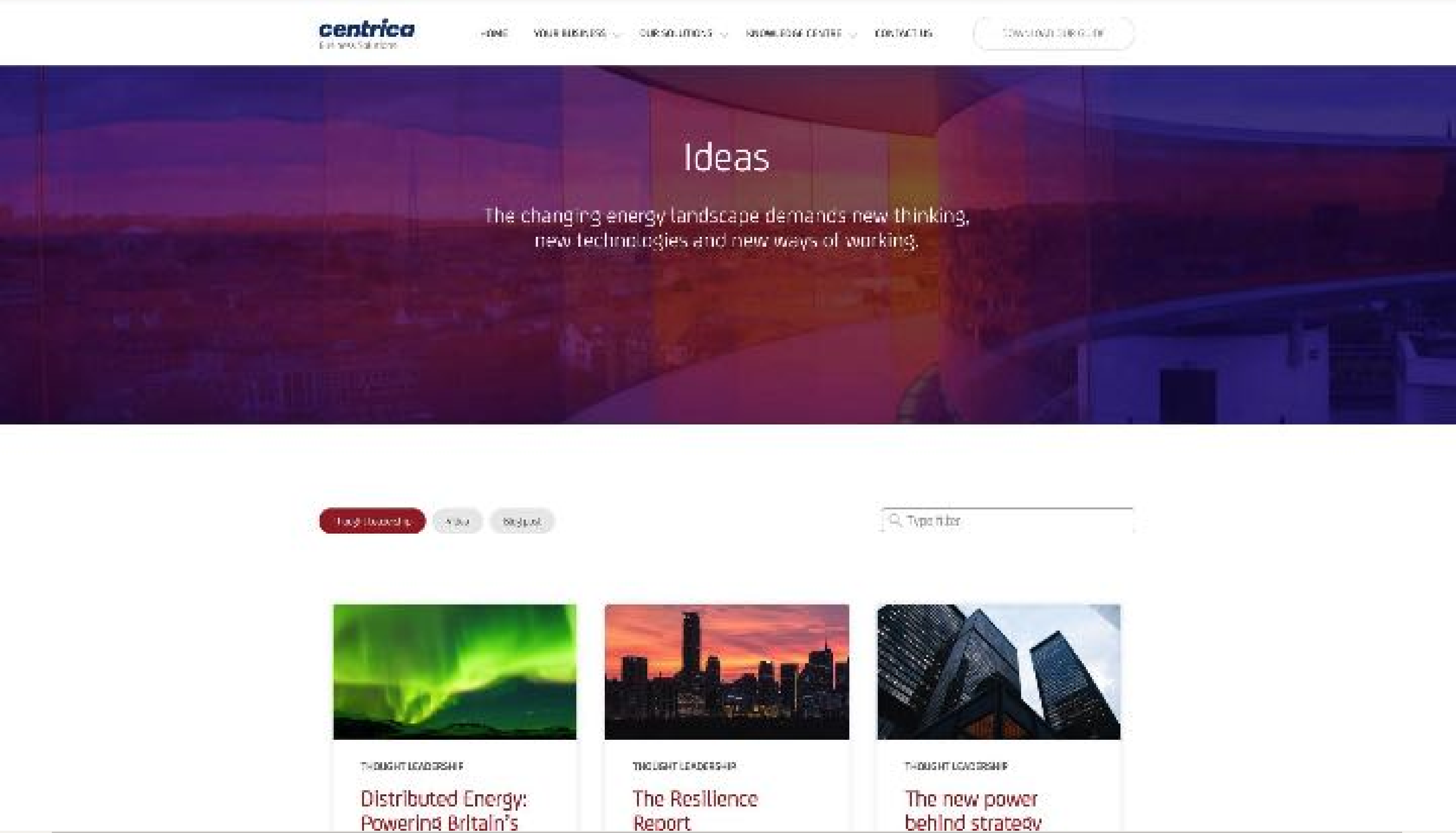


Videos

Power in your hands

Demand Side Response

C.H.P.

Panoramic Power

Contents

Introduction to Centrica Business Solutions

Introduction

MADE IN BRITAIN

Estimated that our CHP technology has helped to reduce UK CO_2 emissions by over **1,700,000 tonnes**

Centrica Business Solutions

Providing global sustainable energy & resilience solutions

Centrica Business Solutions

Providing global sustainable energy & resilience solutions

Temp Technology

Providing global sustainable energy & resilience solutions

- ✓ Irish Owned
- ✓ 25+ years lead supplier of Irish CHP
- ✓ Partner since 1991
- ✓ 200+ Irish installations to date

Temp Technology

TEMP TECH

Providing global sustainable energy & resilience solutions

- ✓ Kerry GTIC
- ✓ Coombe Women's Hospital
- ✓ St. Vincent's
- ✓ O.L.H.S.C.
- ✓ Aura, Coral & Kingfisher Leisure Clubs
- ✓ Radisson, O’Callaghan & Dalata Hotels
- ✓ Maltings Company
- ✓ Midlands Prison

Centrica & Temp Tech Clients

Providing global sustainable energy & resilience solutions

Why CHP?

What is CHP?

Generator?

or

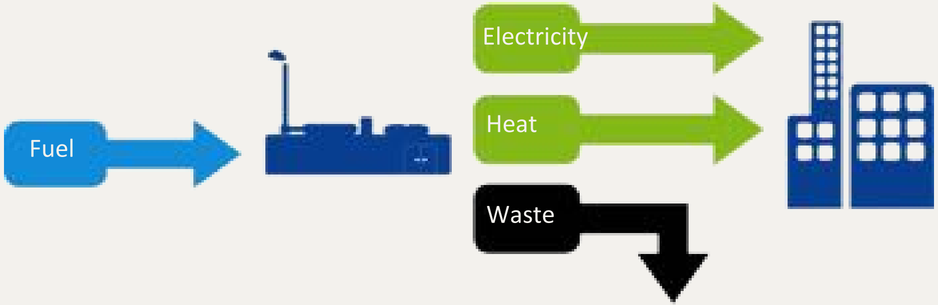
Boiler?

What is CHP?

Single unit **fuel** converted into **Electricity** & **Heat**

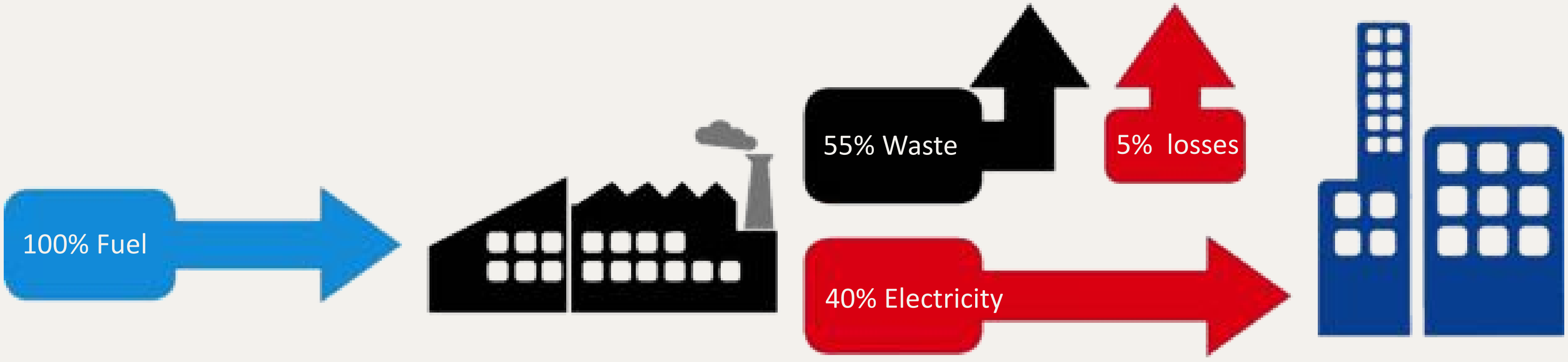
1. **Electricity** produced by engine-powered alternator

2. **Heat** is a **by-product** captured from:
   a) Engine jacket water and lubrication oil
   b) Engine exhaust gases



Centralised Generation

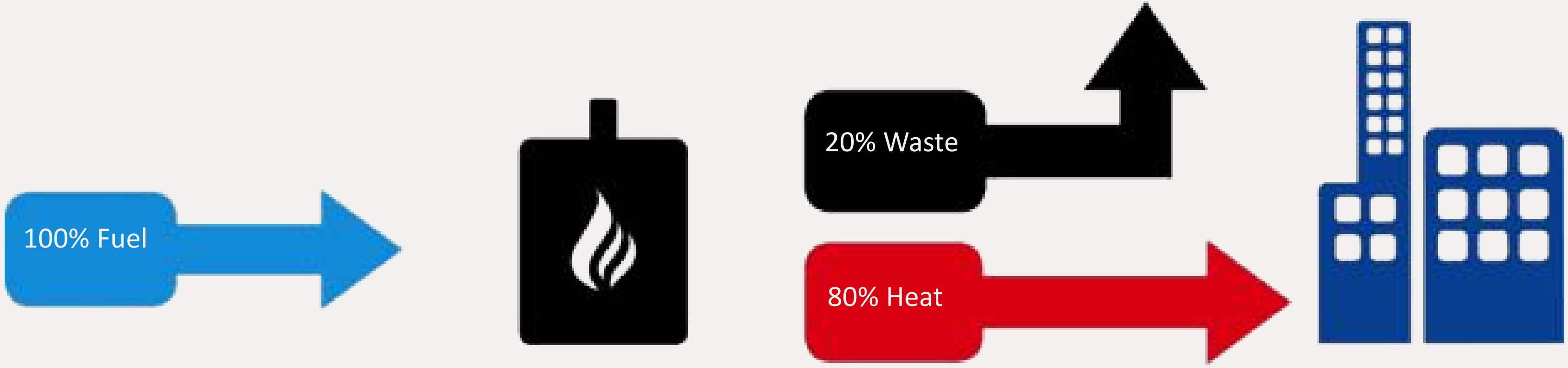
(Conventional Electricity Generation)



* *Energy efficiency figures reproduced from GPG388 (Carbon Trust, 2004)*

Conventional Heating

(Boilers)



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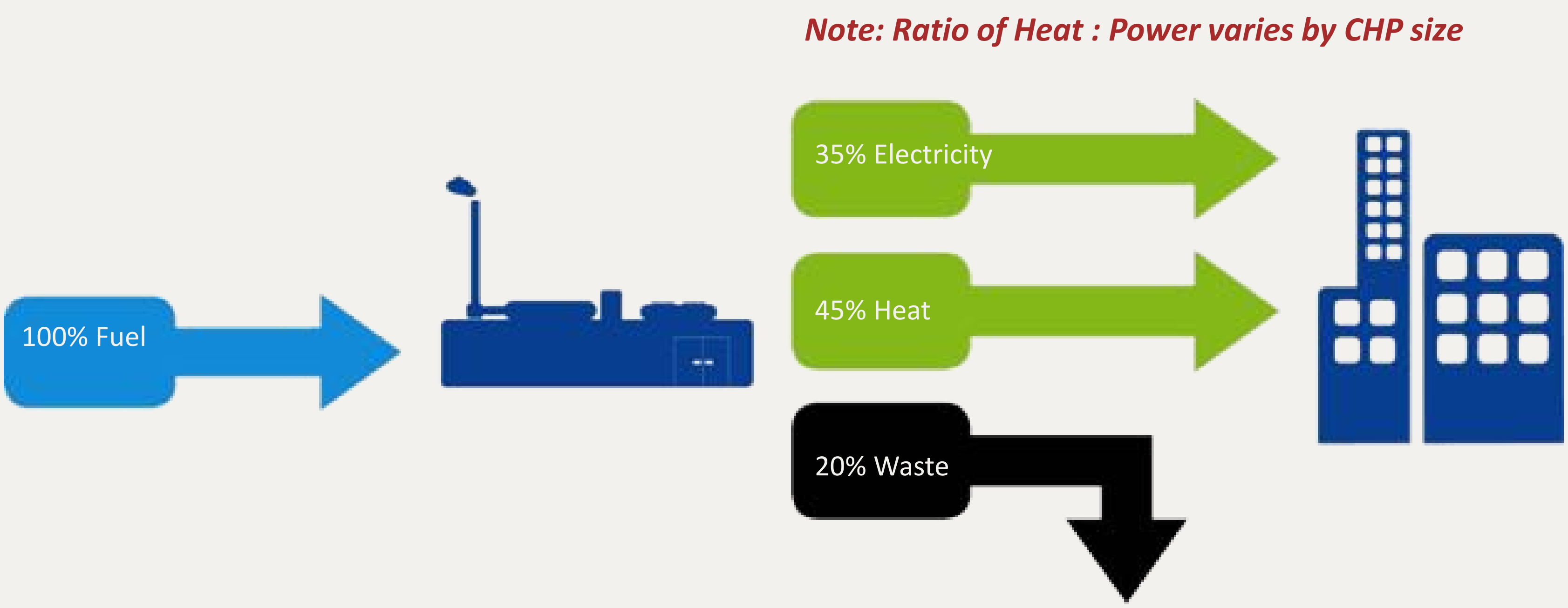
Combined Heat and Power (CHP) Plant



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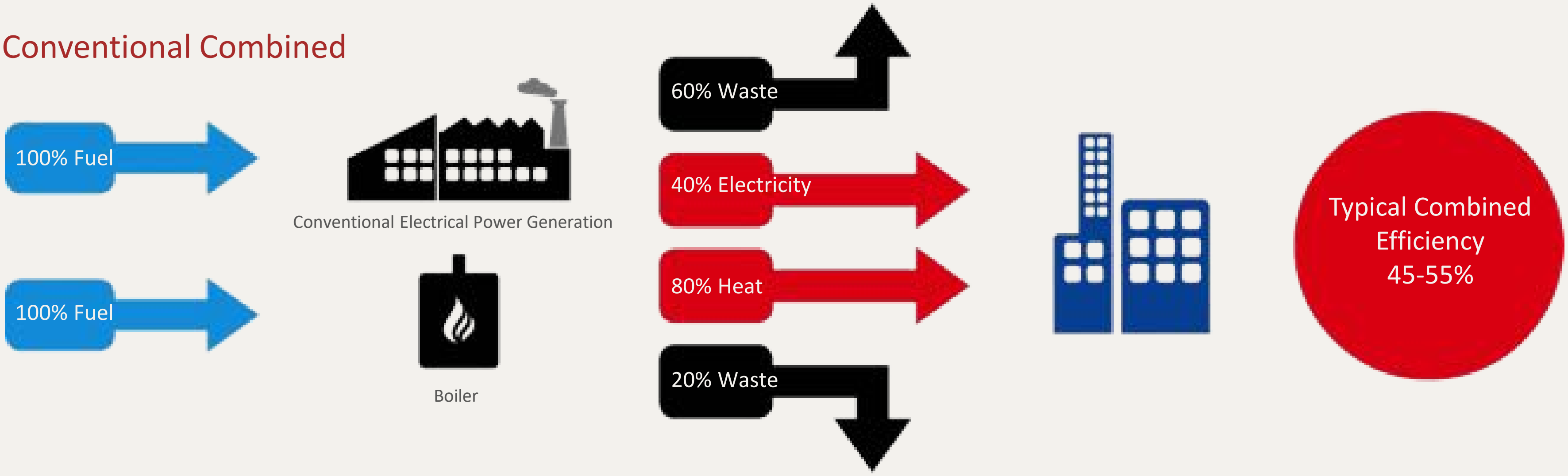
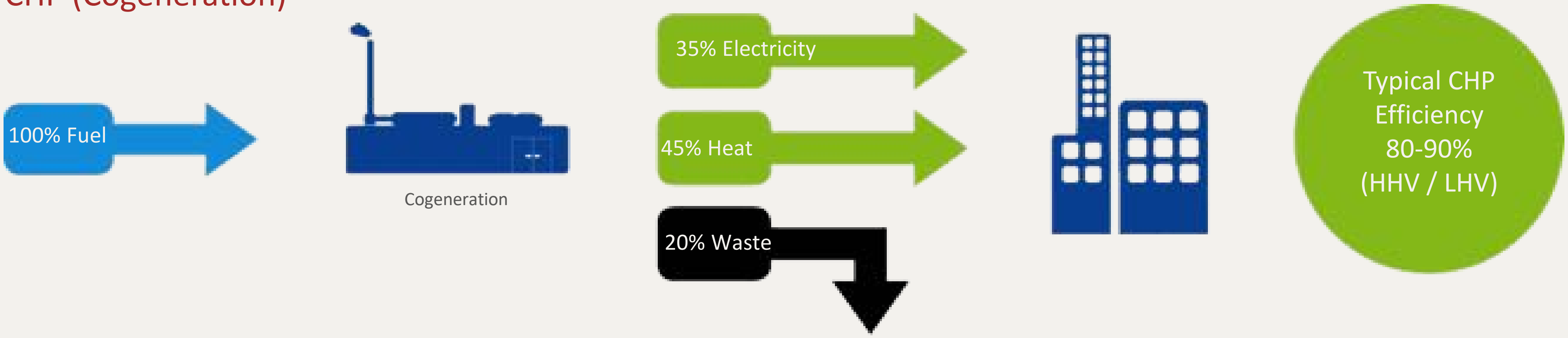
Comparison of Combined Efficiencies

Conventional Combined



CHP (Cogeneration)



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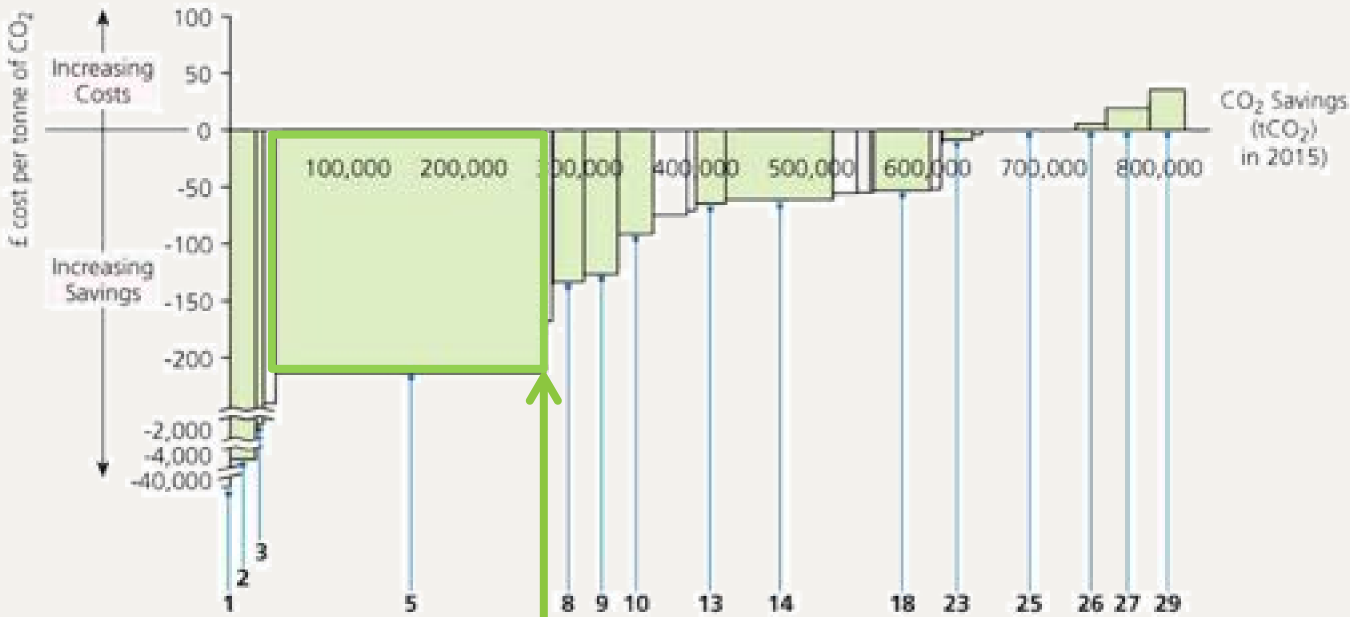
Health Sector: NHS – Marginal Abatement Cost (MAC)



This table illustrates just some of the carbon saving measures that the NHS could implement. Not all are numbered above. Some CO2 savings are too small to depict on this scale of graph.	(£ / Tco2) -savings +costs	CO2 Savings (Tco2/Yr.)	£,000 Savings (£000/Yr.)
1 Packaging of Medical equipment	-40,299	2	+ 81
2 Reduce Drug Wastage	-3,987	22,430	+89,428
3 Teleconferencing to replace 5% of business miles	-2,038	6,827	+13,913
4 Decentralisation of hot water boilers in non-acute/PCT	-240	10,612	+2,547
5 Combined Heat and Power installed in acute trusts	-213	232,331	+49,487
6 Variable Speed Drives	-168	5,508	+925
7 Introduce hibernation system for ambulance stations	-135	1,096	+148

"Decision Making in the NHS using Marginal Abatement Cost Curves"

NHS Sustainable Development Unit, 2017

In Conclusion

1. Neither generator nor oiler: Combined Heat & Power
2. Single unit fuel converted into Electricity & Heat
3. Using natural resources more efficiently
4. Overall efficiency increase compared to traditional
5. The most cost effective method to save carbon

Where does CHP work best?

CHP Market Sectors

Small CHP Range (4 kWe – 530kWe)

Product Reference	Electrical Output kWe	Engine Manufacturer	Engine Type	Aspiration Type	Output Brake kWb	Output Jacket Water kWt	Output Exhaust Gas kWt	Total Heat Output kWt
CBS 4	4	Yanmar	3GPF68-C	Natural	TBC	TBC	TBC	8
CBS 10	10	Yanmar	3GPF88-C	Natural	TBC	TBC	TBC	17
CBS 25	25	Yanmar	4GPF98-C1	Natural	TBC	TBC	TBC	38
CBS 35M	35	MAN	E 0834 E 302	Natural	38	40	22	62
CBS 50M	50	MAN	E 0834 E 302	Natural	54	46	33	79
CBS 70M	71	MAN	E 0836 E 302	Natural	75	63	46	109
CBS 90	90	CBS	EGE-06L	Natural	95	109	54	163
CBS 100	100	CBS	EGE-06L	Natural	105	116	59	175
CBS 110	110	CBS	EGE-06L	Natural	116	123	63	186
CBS 125	123	CBS	EGE-06L	Natural	130	131	69	200
CBS 135	135	CBS	EGE-08V	Natural	143	147	72	218
CBS 150	152	CBS	EGE-08V	Natural	160	156	80	236
CBS 165	165	CBS	EGE-12V	Natural	173	196	89	284
CBS 185	185	CBS	EGE-12V	Natural	194	210	98	309
CBS 210	210	CBS	EGE-12V	Natural	220	226	111	337
CBS 200M	201	MAN	E 2876 LE 302	Turbocharged	210	120	143	263
CBS 230	229	ENER-G	EGE-12V	Natural	240	237	121	358
CBS 250M	255	MAN	E 2848 LE 322	Turbocharged	265	176	145	321
CBS 310	310	Perkins	4006-23 TRS1	Turbocharged	322	152	205	357
CBS 375	378	Perkins	4006-23 TRS2	Turbocharged	393	162	239	401
CBS 400M	404	MAN	E 2842 LE 322	Turbocharged	420	291	222	513
CBS 425	430	Perkins	4008-30 TRS1	Turbocharged	447	189	279	468
CBS 500	506	Perkins	4008-30 TRS2	Turbocharged	526	211	316	527
CBS 530M	529	MAN	E 3262 LE 202	Turbocharged	550	336	312	648

CHP Sizes

Internal Packages – Small Scale CHP

Typical Large CHP Range

(400V 3ph(1) & 500NOx/Nm3(2,3))

Designation	Minimum Methane No	kW_e (4,7)	kW_{lthw} (8,9)	kW_{ex} (9,10)	kg/h Steam(9,10,11)	kW_{gas} - LHV(12)	kW_{gas} - HHV(13)	Elec Eff.(14)	Thermal Eff.(14)	Total Eff.(14)
CBS 770	≥70(6)	776	401	422	534	1,832	2,026	42.4%	44.9%	87.3%
CBS 850	≥80	854	443	448	564	1,993	2,204	42.8%	44.7%	87.6%
CBS 1010	≥80	1,012	475	461	569	2,298	2,542	44.0%	40.7%	84.8%
CBS 1160	≥70(6)	1,169	600	628	795	2,731	3,020	42.8%	45.0%	87.8%
CBS 1280	≥80	1,287	664	659	828	2,974	3,289	43.3%	44.5%	87.8%
CBS 1520	≥80	1,523	712	691	852	3,438	3,802	44.3%	40.8%	85.1%
CBS 1560	≥70(6)	1,560	885	777	976	3,649	4,036	42.8%	45.5%	88.3%
CBS 1710	≥80	1,718	974	821	1,023	3,991	4,414	43.0%	45.0%	88.0%
CBS 1950	≥70(6)	1,948	1,048	1,016	1,285	4,555	5,038	42.8%	45.3%	88.1%
CBS 2025	≥80	2,028	965	936	1,159	4,573	5,058	44.3%	41.6%	85.9%
CBS 2150	≥80	2,145	1,161	1,078	1,356	4,990	5,519	43.0%	44.9%	87.9%
CBS 2530	≥80	2,530	1,200	1,147	1,426	5,748	6,357	44.0%	40.8%	84.8%

1) 415V is available for all units. Information for the 11kV units are on Pages 3 & 4;
2) NO_x number at 5% O_2. Please see Pages 2 and 4 for ≤250mgNO_x/Nm^3 configurations;
3) Normal cubic meter is 1013.25mbar and 273.15°K;
4) Based on standard reference conditions according to ISO 3046-1: P_{atm} = 1000mbar, T_{air} = 25°C & RH_{air} = 30%;
6) Variant available for high ambient temperatures with second stage aftercooler at 53°C. Variant requires MN≥80 for same mechanical & electrical output;
7) Gross power as measured at the generator terminals at nominal voltage and frequency & PF = 1.00;
8) Inclusive of recovered heat from engine block, lube oil and first stage aftercooler only (ie second stage aftercooler at 42°C omitted);
9) Subject to ISO 3046 tolerances (+/- 8%); 10) Exhaust heat recovered to 120°C;
11) Estimated values based on 7bar_g dry saturated steam (T_{sat} = 170.43°C), boiler feedwater at 85°C & no economiser on boiler.
13) Derived from LHV figure with additional 10.6% to allow for latent heat of vaporisation - this figure to be used for economic calculations.

Large CHP Range (400kWe – 4.0MWe)

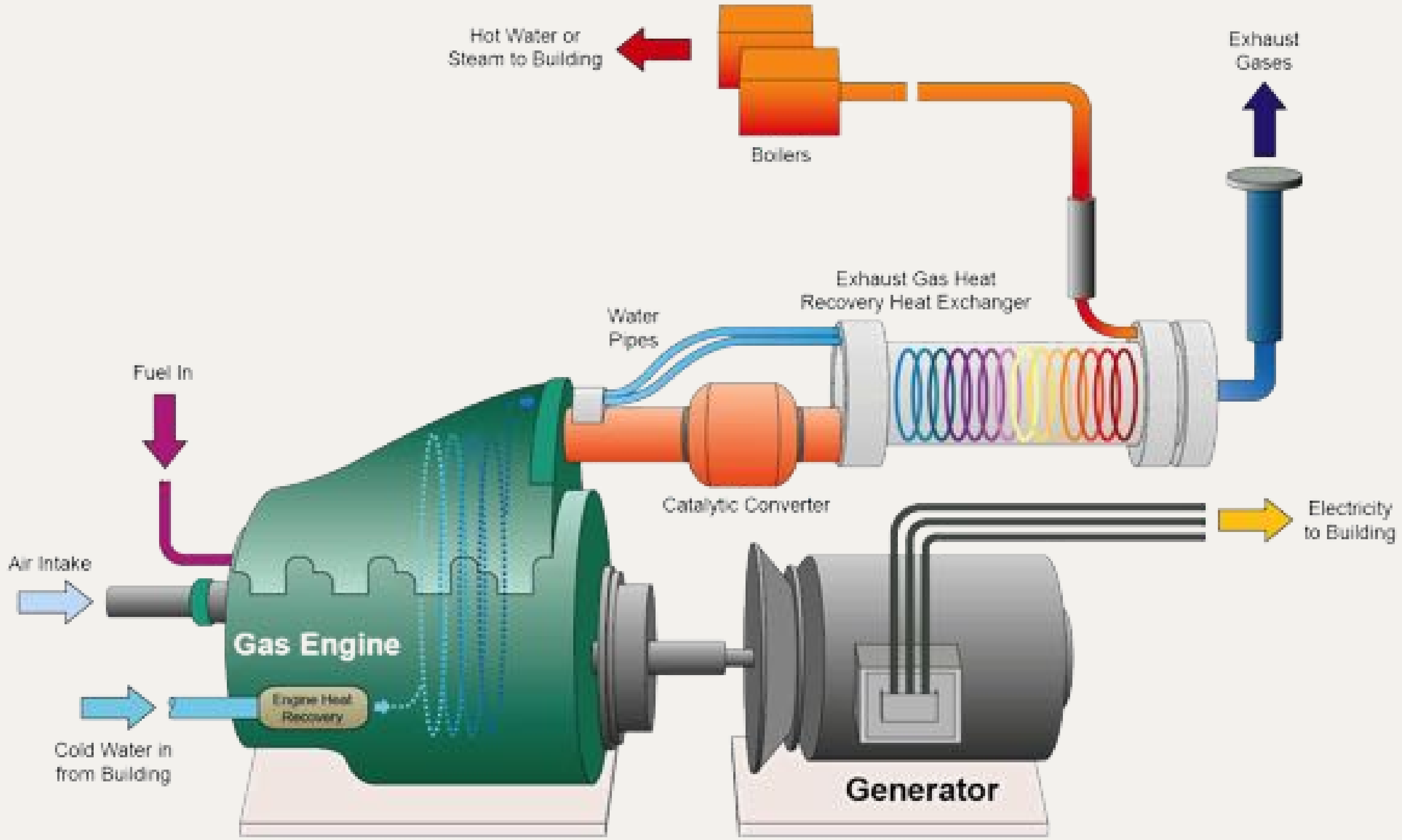
Typical Features

- Contained package
- Special acoustic package
- Options for site integration
- Lower noise options
- Plug & Play
- Portable Asset

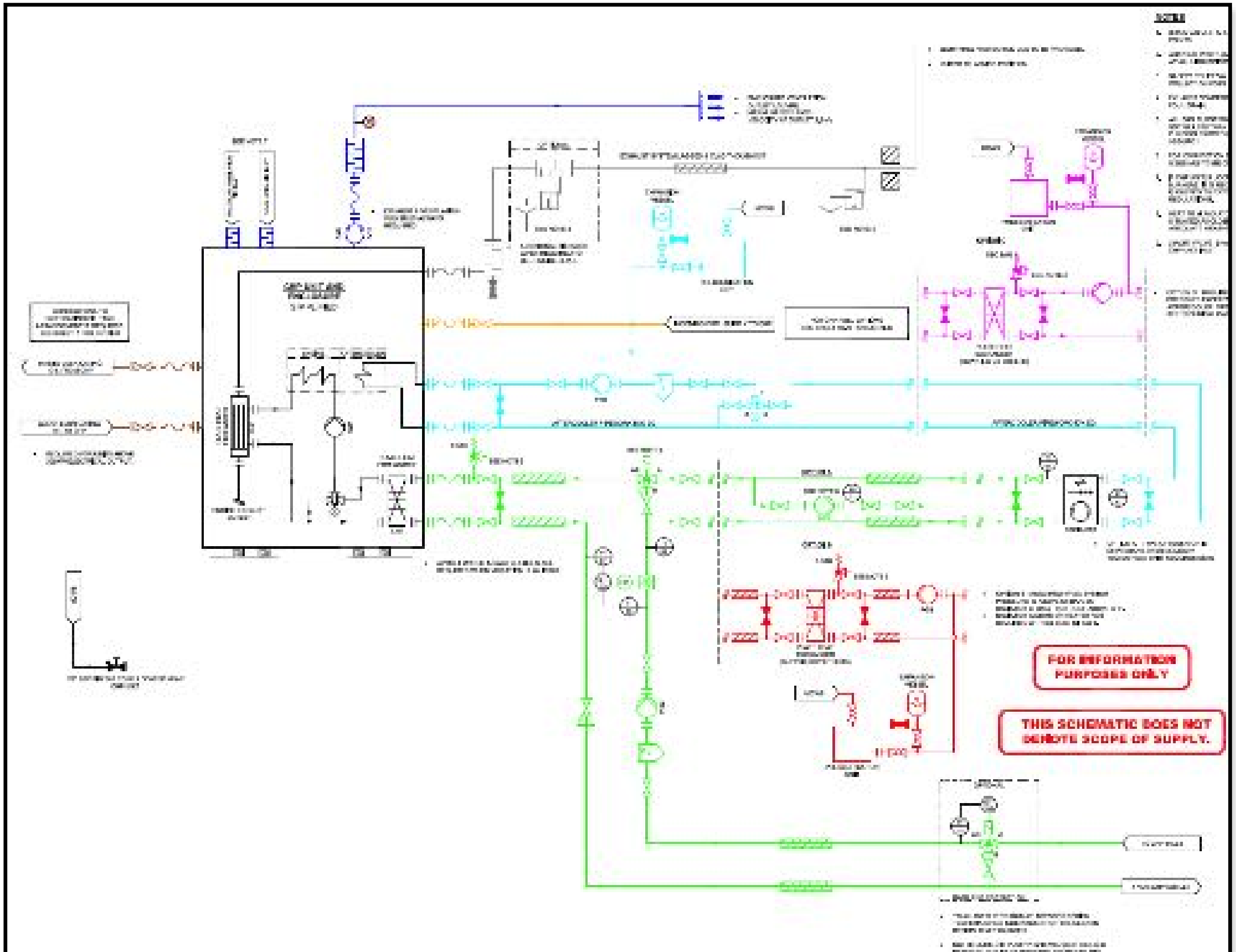
Large CHP Range – External Packages

What makes up a CHP unit?

What makes up a CHP unit?



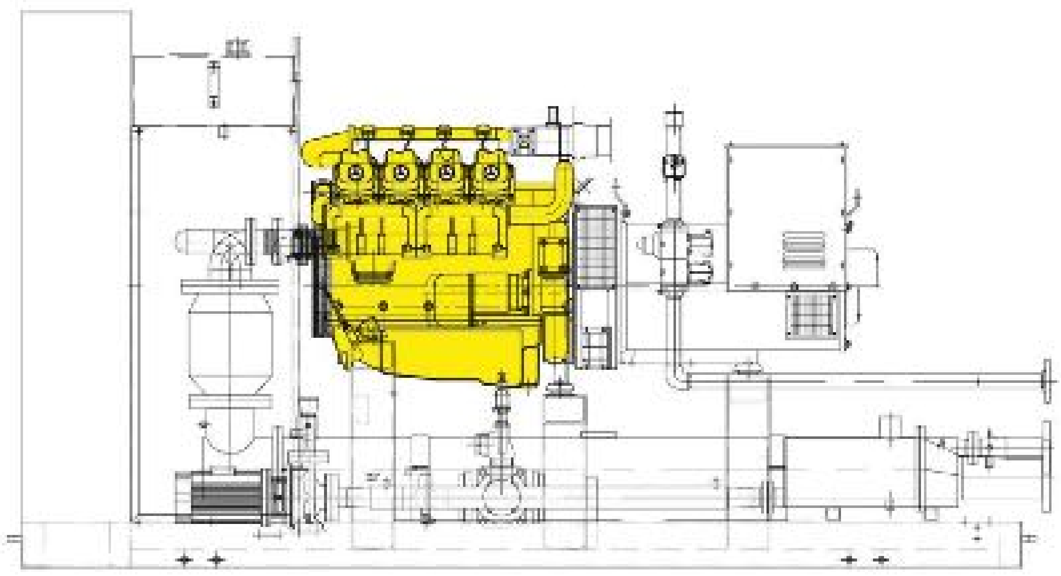
Component Parts: P&ID’s



Component Parts

Prime Mover

- Gas reciprocating engine (*typically*)
- Commercially proven diesel engines
- Very little modifications: only fuel ignition & cylinder compression ratio reduction
- Incredibly strong, reliable & designed to cope with the stress of diesel (> Gas)



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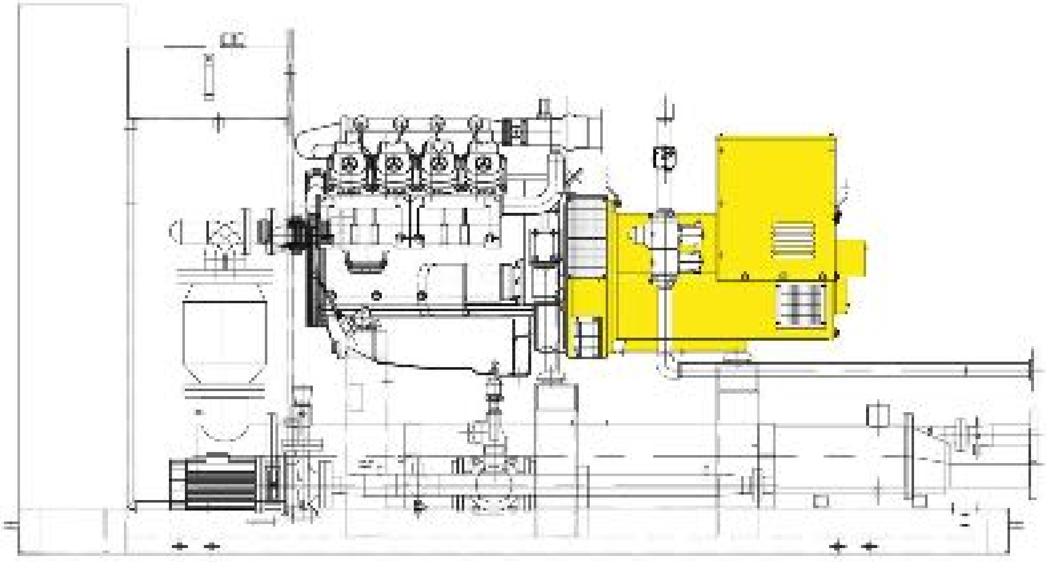
Component Parts

Generator

- Windings Designed to reduce certain harmonics
- Optional power factor correction equipment available
- Ensures generation is at optimum power factor for site
- Meets the requirements of BS EN 60034, Quality Assured to ISO9001



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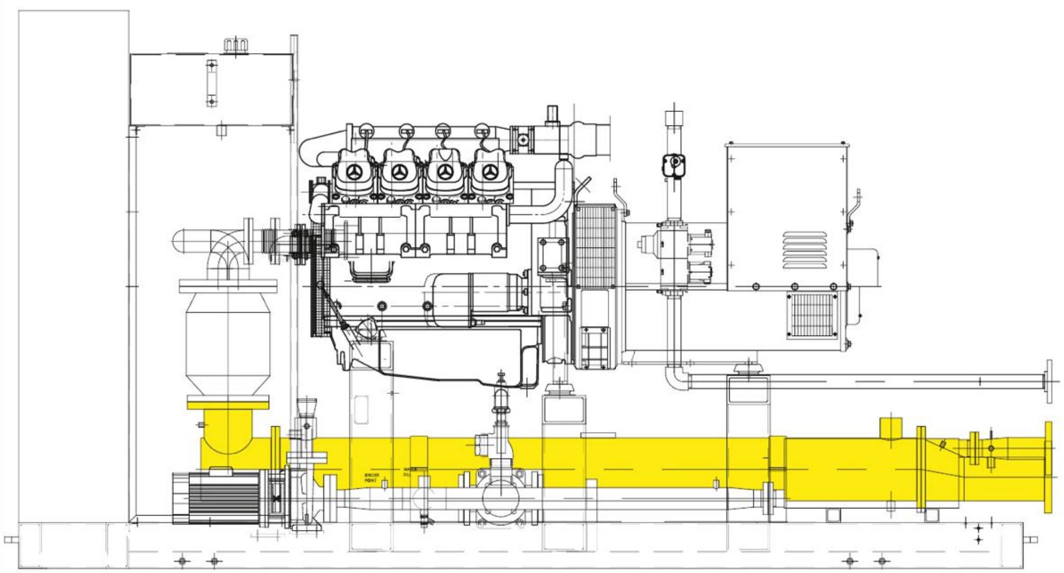
Component Parts

Heat Recovery System

- Heat Recovery System varies with CHP model
- Takes “waste heat” from the engine exhaust gas – *Similar to a cars interior heater*
- The Heat Recovery System also takes 'waste heat' from the exhaust gas
- Cooling it from 600°C down to 120°C in the process



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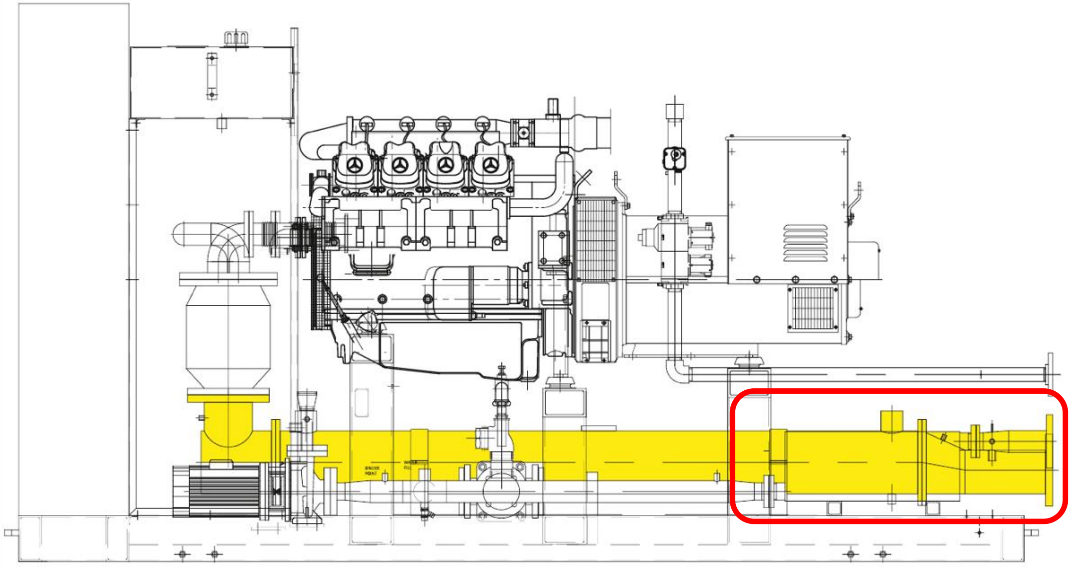
Component Parts

Plate Heat Exchanger (Primary Isolation)

- High efficiency plate heat exchanger isolates from client side heat system
- Advantages of this are: Ease of maintenance & Security of heat supply
- Most CHP units provide heat to site at approximately 90°C



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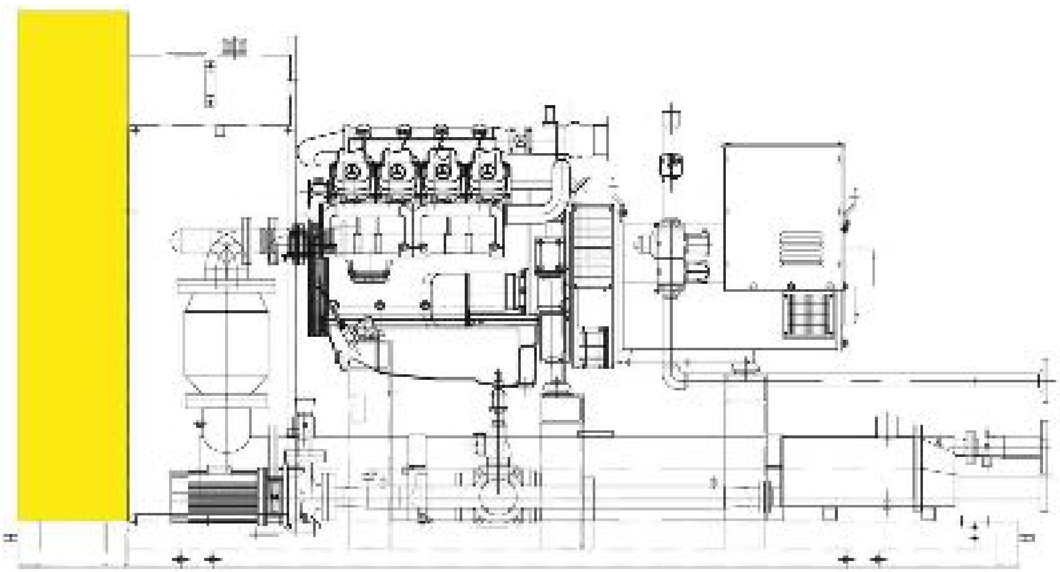
Component Parts

E-POWER, Electrical Control & Monitoring

- E-POWER control system for CHP and plant room boilers
- Sophisticated Cloud based control and monitoring system
- Responsible for the energy flow to the clients’ site
- Real time monitor and control of the prime mover, generator & heat recovery systems



Note: Broadband connection required at CHP site

Component Parts

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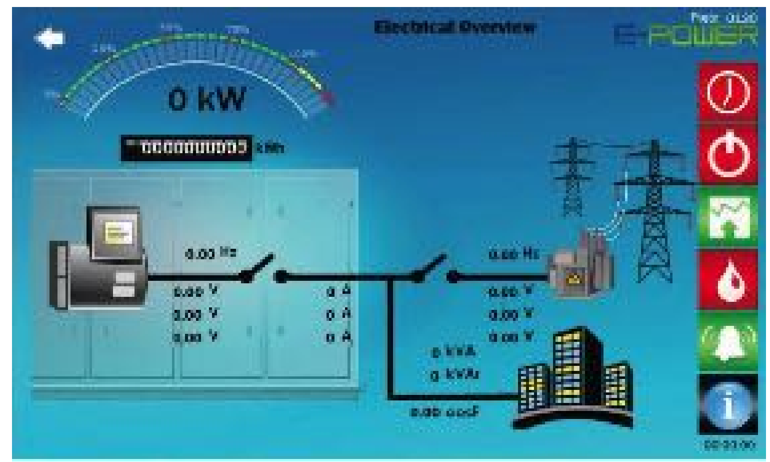
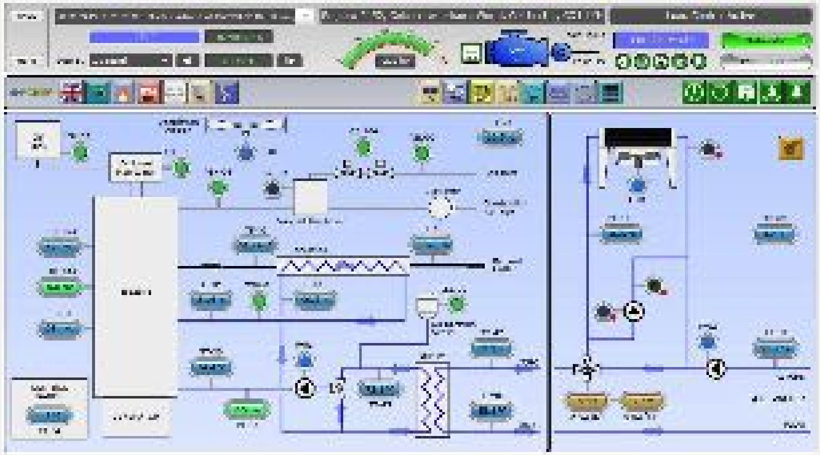


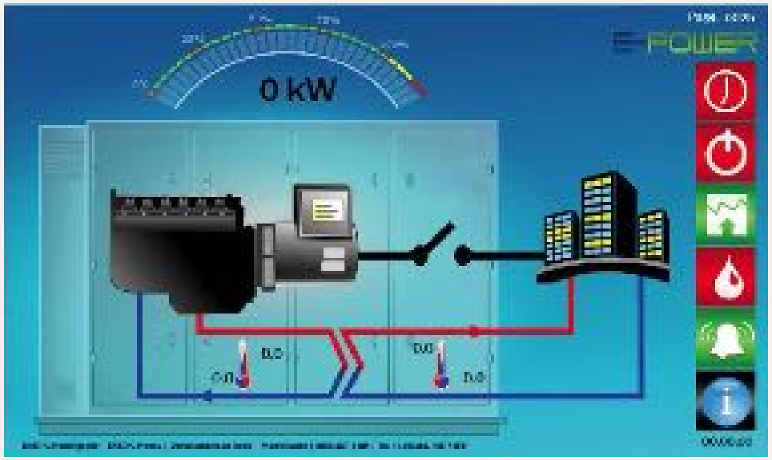
Note: Broadband connection required at CHP site

Component Parts

E-POWER, Electrical Control & Monitoring

- E-POWER monitors 200+ parameters ensuring safe operation of multiple site plant and equipment
- 24/7 bureau allows immediate diagnosis
- Satellite tracking system routes the nearest engineer
- Local client interface via 7" colour touchscreen
- Live Remote information via Cloud
- Log in via web page for retrieval anywhere worldwide

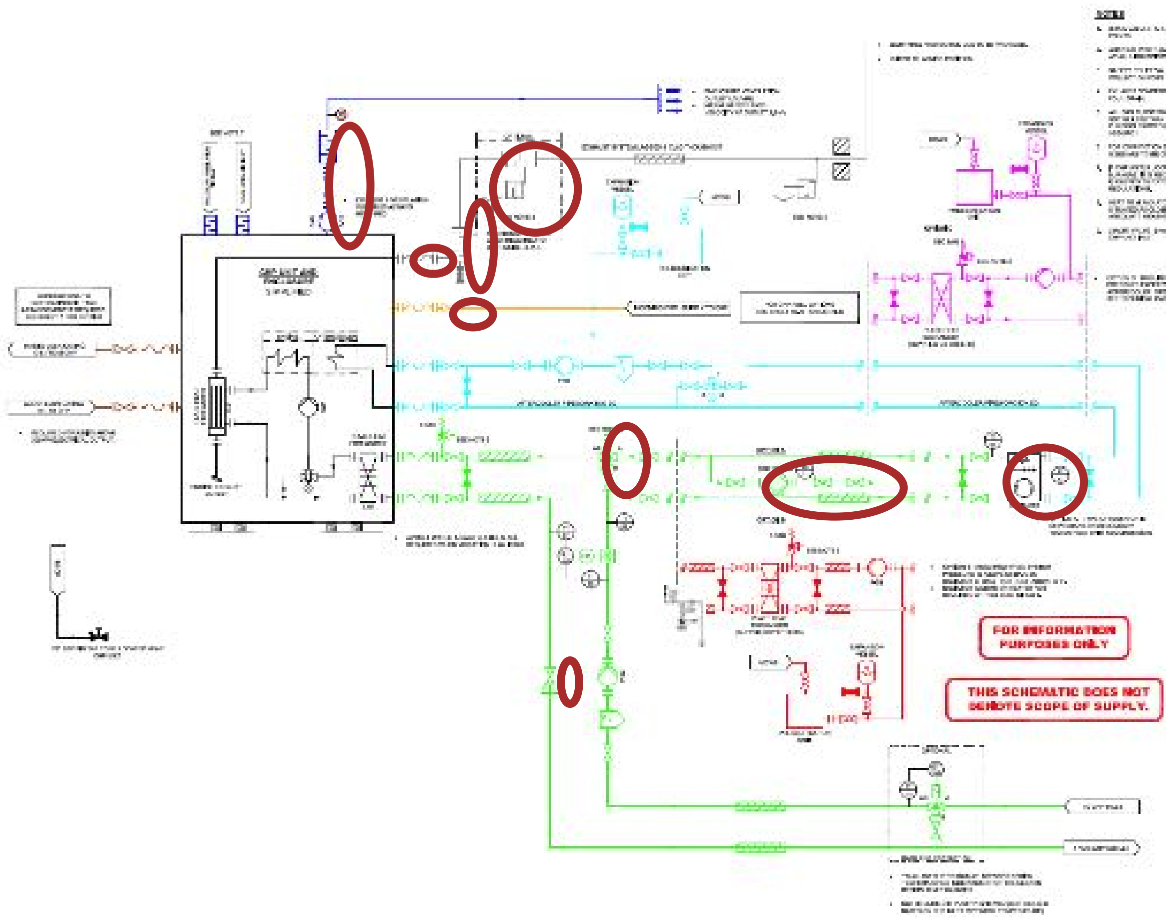




Note: Broadband connection required at CHP site

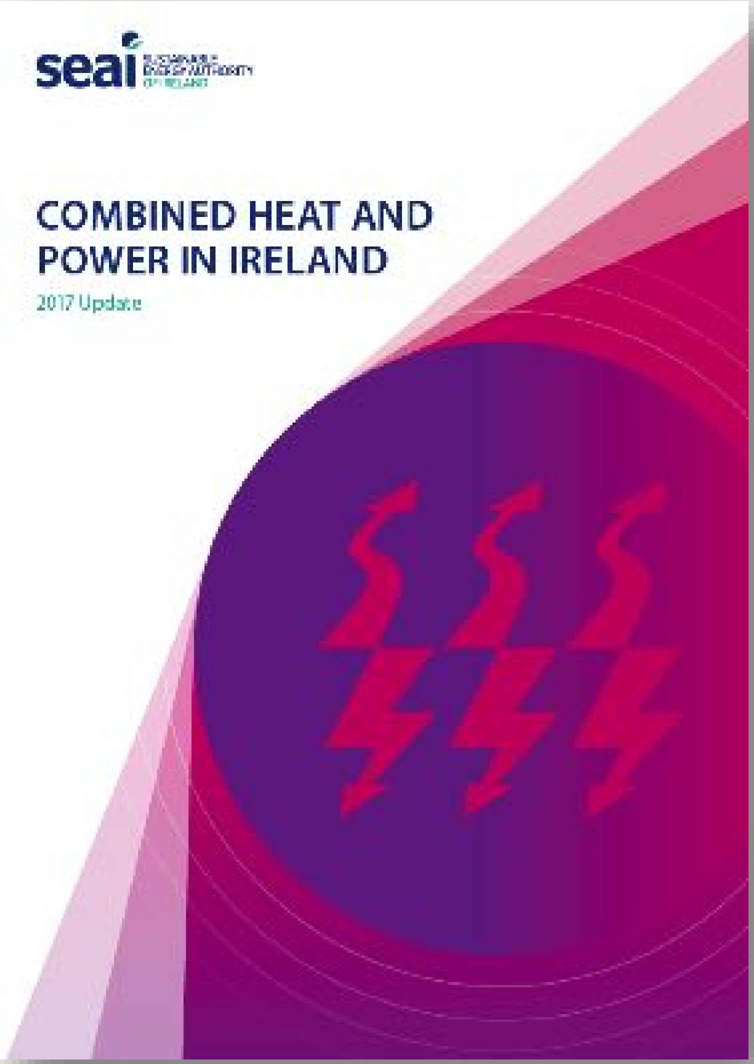
CHP & Heat Trim Radiator & Aftercooler:

Application Components (Optional)



Which fuels are best for CHP?

Which Fuels are best for CHP?



Which Fuels are best for CHP?

Overview

Capacity

- The installed capacity of CHP in Ireland at the end of 2016 was 343 MWe (404 units), of which 312 MWe (284 units) was operational, a decrease of 0.4 MWe (0.1%) in operating capacity from 2015.

CHP by Fuel

- Natural gas was the fuel of choice for 245 operational CHP units in 2016. Oil products made up the next most significant share with 20 units while biogas accounted for 15 units. The remainder was biomass and solid fuel with 2 units each.
- Natural gas fuelled 286 MWe (91%) of the operational capacity in 2016. Biogas fuelled 8.4 MWe (2.7%), oil products 7.5 MWe (2.4%), biomass 5.4 MWe (1.7%) and solid fuel was used by the remaining 5.2 MWe (1.7%).
- Biomass and bioenergy CHP, as renewable energy sources are counted towards Ireland's renewable energy targets. Renewable CHP contributed 0.2 percentage points to both RES-E and RES-H in 2016.

CHP by Sector and Sub-Sectors

- There are a large number of relatively small units in the services sector. The services sector accounted for 81% of the units and 12% of the operational capacity.
- Within the services sector, hotels account for the majority (27%) of units while the leisure sub-sector (which includes swimming pools, leisure centres, gyms, etc.) is the second largest at 17%.
- The industry sector accounted for 17% of the units and 88% of the operational capacity.
- The food sub-sector of industry contains the largest number of units with 47% of units and 23% of industrial operational capacity.

CHP Electricity Generation

- In 2016, 7.1% of Ireland's electricity was from CHP installations, compared with 7.5% in 2015.

Primary Energy Savings

- There was a primary energy saving of 24% or 2,071 GWh from CHP plants in 2016 compared to separate heat and electricity production.

CHP by Fuel

CHP Fuel Input and Thermal/Electrical Outputs

- In 2016, fuel input decreased by 1.3%, estimated useful heat output decreased by 6.1% while electricity output increased by 2.1%.
- The overall stock of CHP installations has become more efficient, increasing from 76% in 2001 to an efficiency of 82% in 2016.

Which Fuels are best for CHP?

Table 1: Number of Units and Operational Capacity by Fuel in 2016

	No. of Units	Operational Capacity MWe	No. of Units %	Operational Capacity %
Natural Gas	245	285.5	86.3%	91.5%
Solid Fuels	2	5.2	0.7%	1.7%
Biomass	2	5.4	0.7%	1.7%
Oil Fuels	20	7.5	7.0%	2.4%
Biogas	15	8.4	5.3%	2.7%
Total	**284**	**312.1**	**100%**	**100%**

Source: SEAI

Table 1 illustrates the operational capacity and number of units by fuel in 2016. Oil fuels used are liquefied petroleum gas (LPG), heavy fuel oil, refinery gas and biodiesel. Natural gas was the fuel of choice for 285.5 MWe (245 units) in 2016. It is worth noting that there is a single 160 MWe gas plant which dominates. Biogas made up the next most significant share with 8.4 MWe (15 units) followed by oil fuels with 7.5 MWe (20 units) and biomass accounted for 5.4 MWe (2 units). The remainder was solid fuels at 5.2 MWe (2 units).

Fuel Heating Values & Efficiency

Beware of Lower Heating Value (LHV)

Lower Heating Value (LHV)

"The usable energy content of Gas when the water vapour is produced during fuel combustion and remains gaseous"

Vapour is not condensed to water

Latent heat of vaporisation of water is not usable

"Lower Heating Value"

Lower Heating Value (LHV)

Condensing Boiler or CHP with Condensing circuit:

Efficiencies in excess of 100% !

LHV assumes all water is in vapour state after combustion

Lower HV gives Unrealistic Efficiencies

Also known as:
Net Calorific Value (NCV)
Lower Calorific Value (LCV)

Higher Heating Value (HHV)

H.H.V. = latent heat of vaporization of water is usable

Cannot exceed 100% Thermodynamic Heating Efficiency

HHV assumes water is in liquid state after combustion

"Higher Heating Value"

Higher Heating Value (HHV)

Thermodynamic Heat of Combustion:

"Enthalpy change for the reaction assumes a common temperature of the compounds before and after combustion…"

* Remember: **"Higher HV gives Lower Efficiencies"**

(*Realistic*)

11% approx. difference (natural gas)

Also known as:
Gross Energy
Gross Calorific Value (GCV)
Higher Calorific Value (HCV)

LHV vs HHV (So What?)

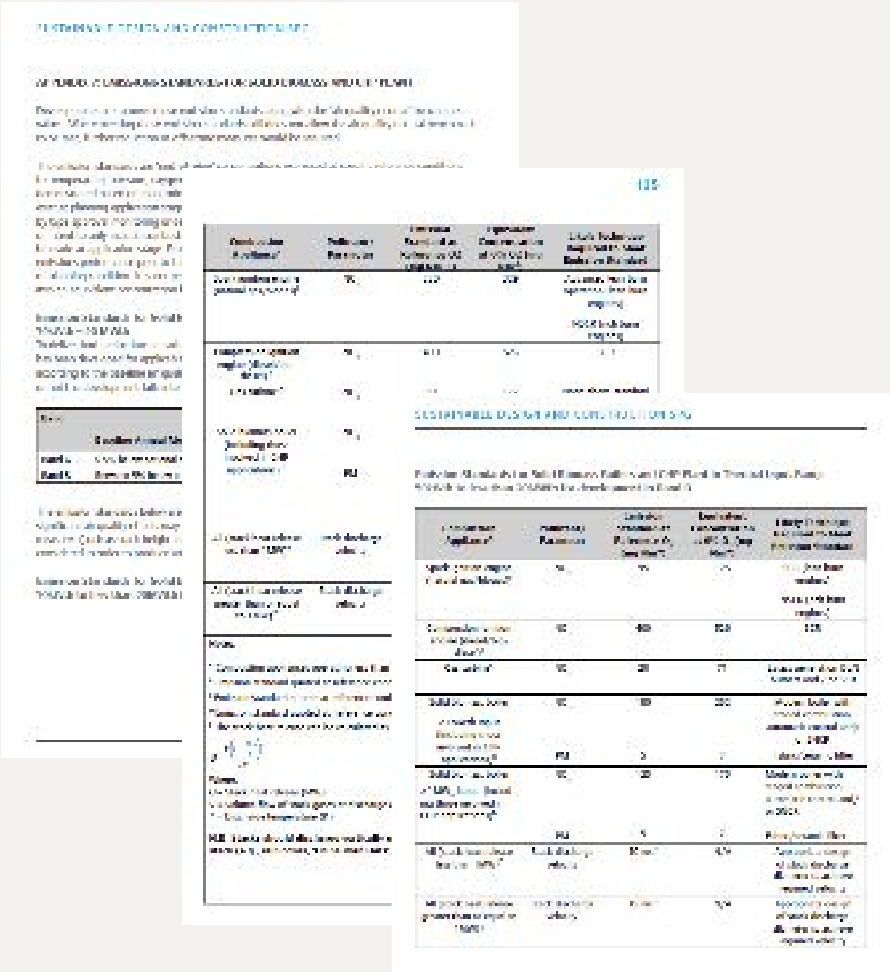
Fuel (Gas) is purchased with HHV energy content

Therefore assuming a CHP will only consume the LHV amount

11% underestimate of fuel spend!

A look at emissions in the UK

Exhaust - Emissions in London

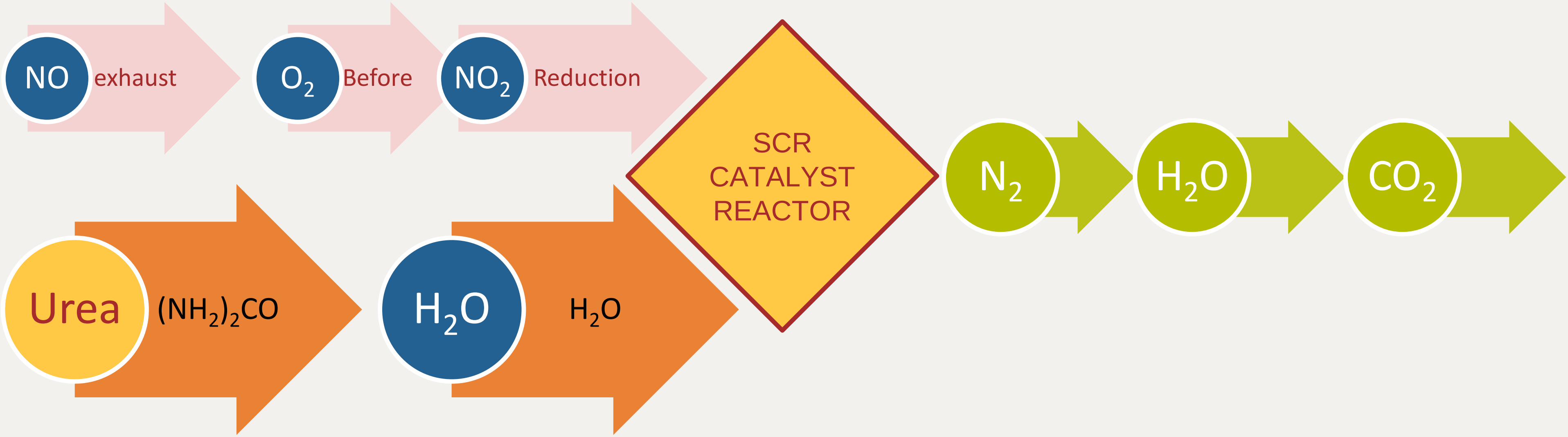


Exhaust – NOx Emissions

NOx Levels	Emissions @ 5% O_2
Standard CHP	500mg/Nm^3
CHP + Integrated Catalyst	250mg/Nm^3
CHP + Integrated Low NOx Catalyst	50mg/Nm^3
**Selective Catalyst Reduction (SCR)*	*?*

Exhaust – Selective Catalytic Reduction

NOx Levels	Emissions @ 5% O_2
Selective Catalyst Reduction (SCR) + External Plant to CHP	10 – 50mg/Nm^3



Exhaust – Selective Catalytic Reduction

NOx Levels	Emissions @ 5% O_2
Selective Catalyst Reduction (SCR) + External Plant to CHP	$10mg/Nm^3$
Increased Cost of SCR Plant	
Increased Cost of Installation	
Delivery of consumable + Emissions from delivery vehicle	
Cost of consumable	
Cost of Maintenance of SCR	

CHP Economics

What is the value proposition?

Reduced:
Energy Costs
&
Carbon
Footprint

CHP Economics

Dependent on:

- Energy Demand Profiles
- Spark Spread
- Operational Hours
  (Approx. > 4,000hrs P.A.)

Now, let's look at an example…..

Product selection: 230kWe (Economic Example)

Product Reference	Electrical Output kWe	Engine Manufacturer	Engine Type	Aspiration Type	Output Brake kWb	Output Jacket Water kWth	Output Exhaust Gas kWth	Total Heat Output kWth	Fuel Input (LHV) kW	Fuel Input (HHV) kW	Max Return Operating Temp °C	Generator Type	Generator Efficiency %	Overall Unit Efficiency (LHV) %
CBS 4	4	Yanmar	3GPF68-C	Natural	TBC	TBC	TBC	8	15	16	55	-	TBC	84.8
CBS 10	10	Yanmar	3GPF88-C	Natural	TBC	TBC	TBC	17	32	36	68	-	TBC	84.5
CBS 25	25	Yanmar	4GPF98-C1	Natural	TBC	TBC	TBC	38	75	82	75	-	TBC	85.2
CBS 35M Mk1	35	MAN	E 0834 E 302	Natural	38	40	22	62	113	125	80	UCI224G-311	92.8	85.9
CBS 35M Mk1 (Low NOx)	35	MAN	E 0834 E 302	Natural	38	40	22	62	113	125	80	UCI224G-311	92.8	85.9
CBS 50M Mk1	50	MAN	E 0834 E 302	Natural	54	46	33	79	148	164	80	UCI224G-311	92.9	87.5
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CBS 70M	71	MAN	E 0836 E 302	Natural	75	63	46	109	204	226	80	UCI274E-311	94.1	88.2
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CBS 90	90	CBS	EGE-06L	Natural	95	109	54	163	280	309	80	UCI274H-311	94.9	90.4
CBS 90 (Low NOx)	90	CBS	EGE-06L	Natural	95	109	54	163	280	309	80	UCI274H-311	94.9	90.4
CBS 100	100	CBS	EGE-06L	Natural	105	116	59	175	304	336	80	UCI274H-311	95.0	90.3
CBS 100 (Low NOx)	100	CBS	EGE-06L	Natural	105	116	59	175	304	336	80	UCI274H-311	95.0	90.3
CBS 110	110	CBS	EGE-06L	Natural	116	123	63	186	328	363	80	UCI274H-311	95.0	90.1
CBS 110 (Low NOx)	110	CBS	EGE-06L	Natural	116	123	63	186	328	363	80	UCI274H-311	95.0	90.1
CBS 125	123	CBS	EGE-06L	Natural	129	130	69	199	359	397	80	UCI274H-311	95.0	89.8
CBS 125 (Low NOx)	123	CBS	EGE-06L	Natural	129	130	69	199	359	397	80	UCI274H-311	95.0	89.8
CBS 135	135	CBS	EGE-08V	Natural	143	147	72	218	395	437	80	UCDI274K-311	94.7	89.4
CBS 135 (Low NOx)	135	CBS	EGE-08V	Natural	143	147	72	218	395	437	80	UCDI274K-311	94.7	89.4
CBS 150	150	CBS	EGE-08V	Natural	159	155	79	235	429	475	80	UCDI274K-311	94.7	89.8
CBS 150 (Low NOx)	150	CBS	EGE-08V	Natural	159	155	79	235	429	475	80	UCDI274K-311	94.7	89.8
CBS 165	165	CBS	EGE-12V	Natural	173	196	89	284	504	558	80	HCI444E-311	95.5	89.2
CBS 165 (Low NOx)	165	CBS	EGE-12V	Natural	173	196	89	284	504	558	80	HCI444E-311	95.5	89.2
CBS 185	185	CBS	EGE-12V	Natural	194	210	98	309	550	608	80	HCI444E-311	95.5	89.8
CBS 185 (Low NOx)	185	CBS	EGE-12V	Natural	194	210	98	309	550	608	80	HCI444E-311	95.5	89.8
CBS 210	210	CBS	EGE-12V	Natural	220	226	111	337	606	671	80	HCI444E-311	95.5	90.3
CBS 210 (Low NOx)	210	CBS	EGE-12V	Natural	220	226	111	337	606	671	80	HCI444E-311	95.5	90.3
CBS 200M	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC
CBS 230	228	CBS	EGE-12V	Natural	239	237	121	357	648	716	80	HCI444E-311	95.4	90.6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CBS 250M	254	MAN	E 2848 LE 322	Turbocharged	265	150	145	321	680	752	80	HCI534C-311	95.9	84.7
CBS 310	310	Perkins	4006-23 TRS1	Turbocharged	322	152	205	357	820	907	80	HCI544E-311	96.2	81.4
CBS 310 250NOx	310	Perkins	4006-23 TRS1	Turbocharged	322	150	212	362	861	952	80	HCI544E-311	96.2	78.1
CBS 375	375	Perkins	4006-23 TRS2	Turbocharged	390	162	237	399	971	1074	80	HCI544E-311	96.3	79.8
CBS 375 250NOx	375	Perkins	4006-23 TRS2	Turbocharged	390	165	253	418	1026	1135	80	HCI544E-311	96.3	77.4
CBS 400M	404	MAN	E 2842 LE 322	Turbocharged	420	236	222	513	1045	1156	80	HCI544E-311	96.3	87.9
CBS 425	425	Perkins	4008-30 TRS1	Turbocharged	442	188	277	465	1107	1224	80	HCI544E-311	96.3	80.5
CBS 425 250NOx	425	Perkins	4008-30 TRS1	Turbocharged	442	200	296	496	1159	1282	80	HCI544E-311	96.3	79.6
CBS 500	500	Perkins	4008-30 TRS2	Turbocharged	521	210	314	524	1286	1422	80	HCI634G-311	96.1	79.8
CBS 500 250NOx	500	Perkins	4008-30 TRS2	Turbocharged	521	218	336	554	1336	1478	78	HCI634G-311	96.1	79.4
CBS 530M	531	MAN	E 3262 LE 202	Turbocharged	550	257	312	648	1341	1483	80	HCI634H-311	96.5	88.0
CBS 530M 250NOx	520	MAN	E 3262 LE 202	Turbocharged	539	270	329	688	1368	1514	78	HCI634H-311	96.5	88.2

Technical Datasheet Extract

E230 (Low NOx) Natural Gas CHP Unit

Energy Balance and Load Data at Power Factor 1		Units	100%	75%	50%
Electrical Output	(+/-3%)	kW	229	171	114
Electrical Efficiency (Net)	(+/-5%)	%	35.3%	33.1%	29.6%
Heat Output	(+/-10%)	kW	357	292	217
Thermal Efficiency (Net)	(+/-8%)	%	55.1%	56.3%	56.3%
Fuel Input (Net / Gross)*	(+/-5%)	kW	648 / 716	519 / 574	386 / 427
Total Efficiency (Net)	(+/-8%)	%	90.5%	89.5%	86.0%
Heat Output from Jacket Water	(+/-8%)	kW	236	200	151
Heat Output from Exhaust Gas @ Outlet Temp.	(+/-8%)	kW	120	91	66
Aftercooler Heat Output	(+/-8%)	kW	N/A	N/A	N/A
Radiated Heat Output	(+/-8%)	kW	23	16	10
Combustion Air Flow (30 C, 100 kPa, 30% RH)	(+/-5%)	m^3/h	680	545	406
Fuel Mass Flow (ρ = 0.75kg/Nm^3)	(+/-5%)	kg/h	48.6	38.9	28.9
Fuel Volume Flow (LHV = 10kWh/Nm^3)	(+/-5%)	Nm3/h	64.8	51.9	38.6
Exhaust Mass Flow (Wet)	(+/-5%)	kg/h	849	680	505
Exhaust Volume Flow @ Outlet Temp.	(+/-5%)	m^3/h	946	758	563

*Natural gas Net and Gross fuel input figures are based on 36MJ/Nm3 and 39.8MJ/Nm3 respectively. The Gross figure is used when establishing UK fuel costs. Net figures are provided for ease of performance comparison with other technologies.

Simple CHP Savings Calculations – 230kWe CHP

CHP Hourly Running Costs =

+	Fuel 716kW x 2.5c / kWh	= €17.90
+	Premier Plus O&M	= € 3.00
	Hourly Operational Costs	= **€20.90**

Simple CHP Savings Calculations – 230kWe CHP

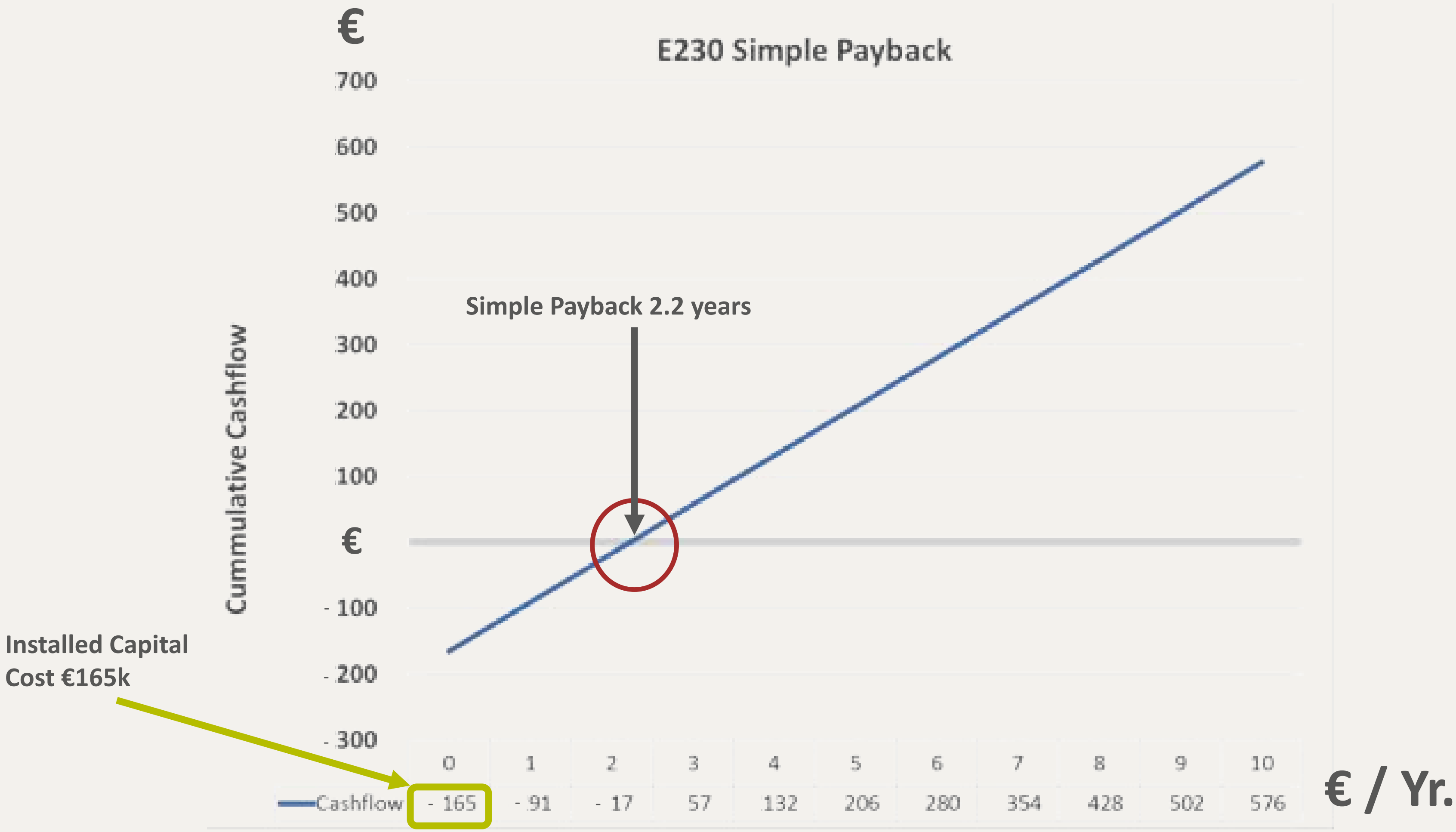
CHP Hourly Energy Savings =

+	229kWe x 10c/kWh	= €22.90
+	357kWth / 80% x 2.5c/kWh	= €11.19
	Hourly Energy Saving	= **€34.09**

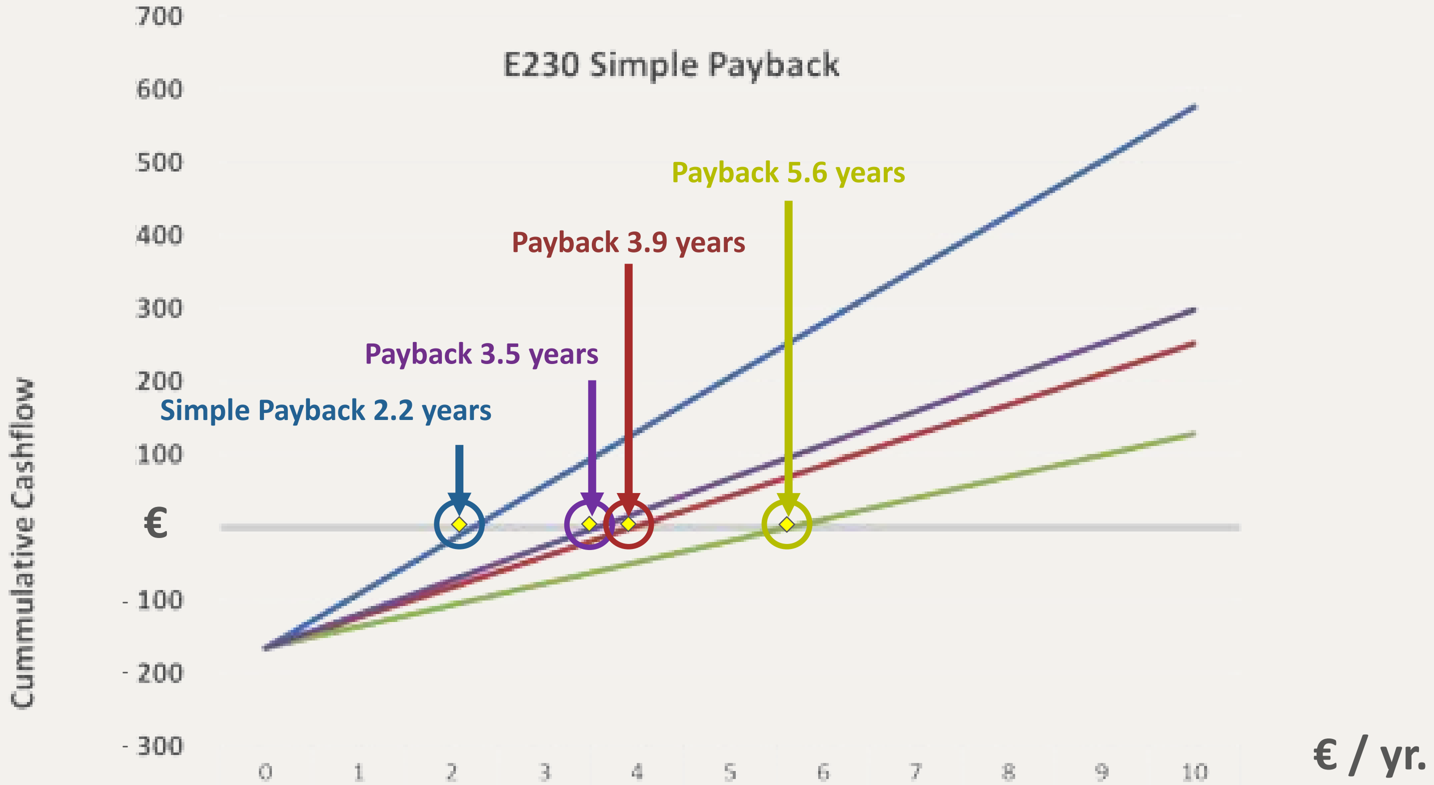
Simple CHP Savings Calculations – 230kWe CHP

Hourly Energy Savings =	**+ £ 34.09**
Hourly Running Costs =	**- £ 20.90**
Net Saving =	**£13.19** per hour
£103,989 per annum	(7,884hrs.)

Simple CHP Savings Calculations



Sensitivities Analysis



	0	1	2	3	4	5	6	7	8	9	10
Cashflow	- 165	- 91	- 17	- 57	- 132	206	280	354	428	502	576
Gas at 4p/kWh	- 165	- 123	- 82	- 40	- 2	43	85	127	168	210	252
50% Heat use	- 165	- 136	- 106	- 77	- 47	- 18	11	41	£70	100	129
5000 hours	- 165	- 119	- 72	- 26	- 20	67	113	159	206	252	298

In Conclusion

1. Desktop calculations for CHP economics are relatively “simple”

2. Complications arise in defining:
   A. Inputs :   e.g. *Spark Spread*
   B. Operating parameters: e.g. *Size of CHP v’s load*

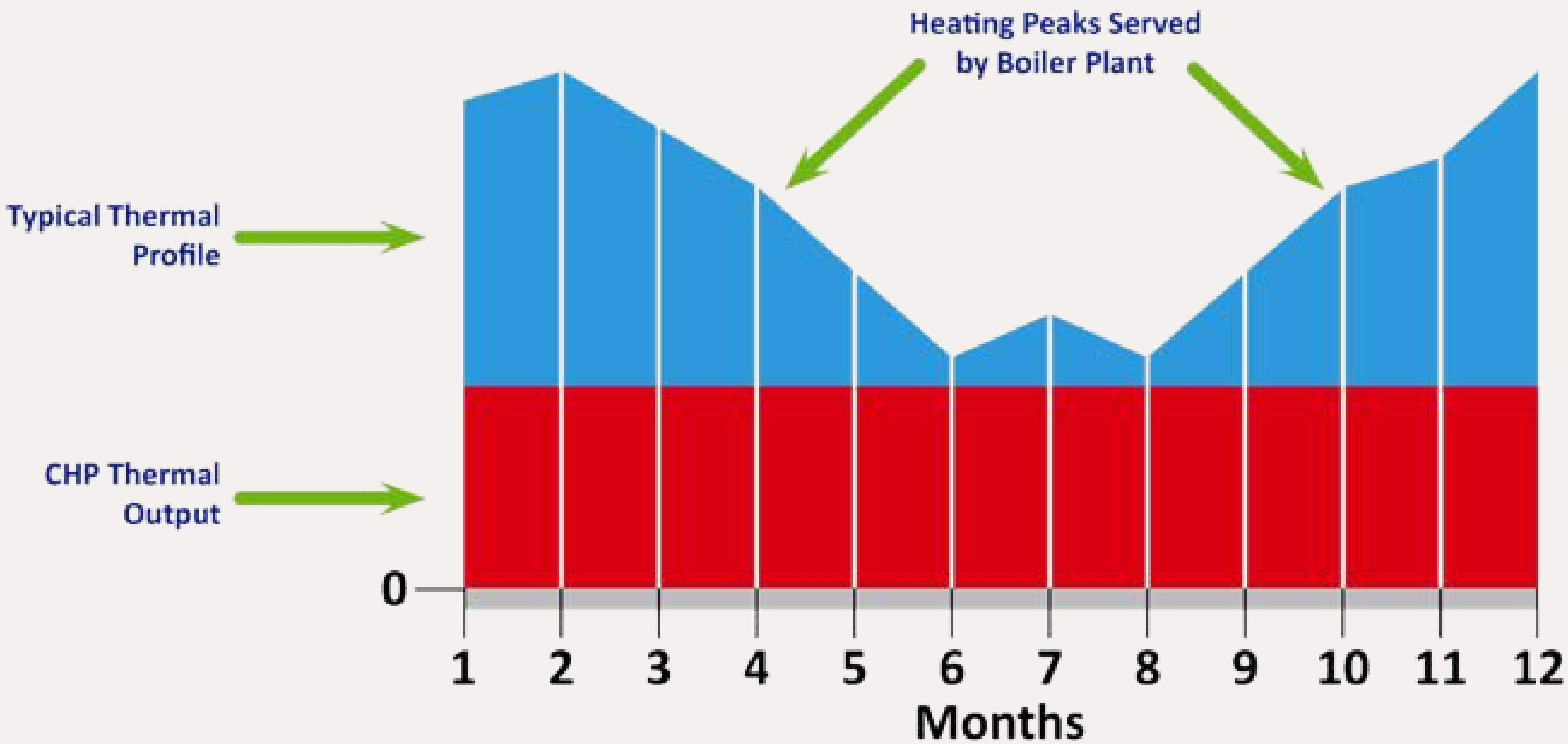
3. Change of inputs has significant Economic impact (as illustrated)

4. The devil is in the detail (*as we will later see*)

Load Profiling: Impact on CHP

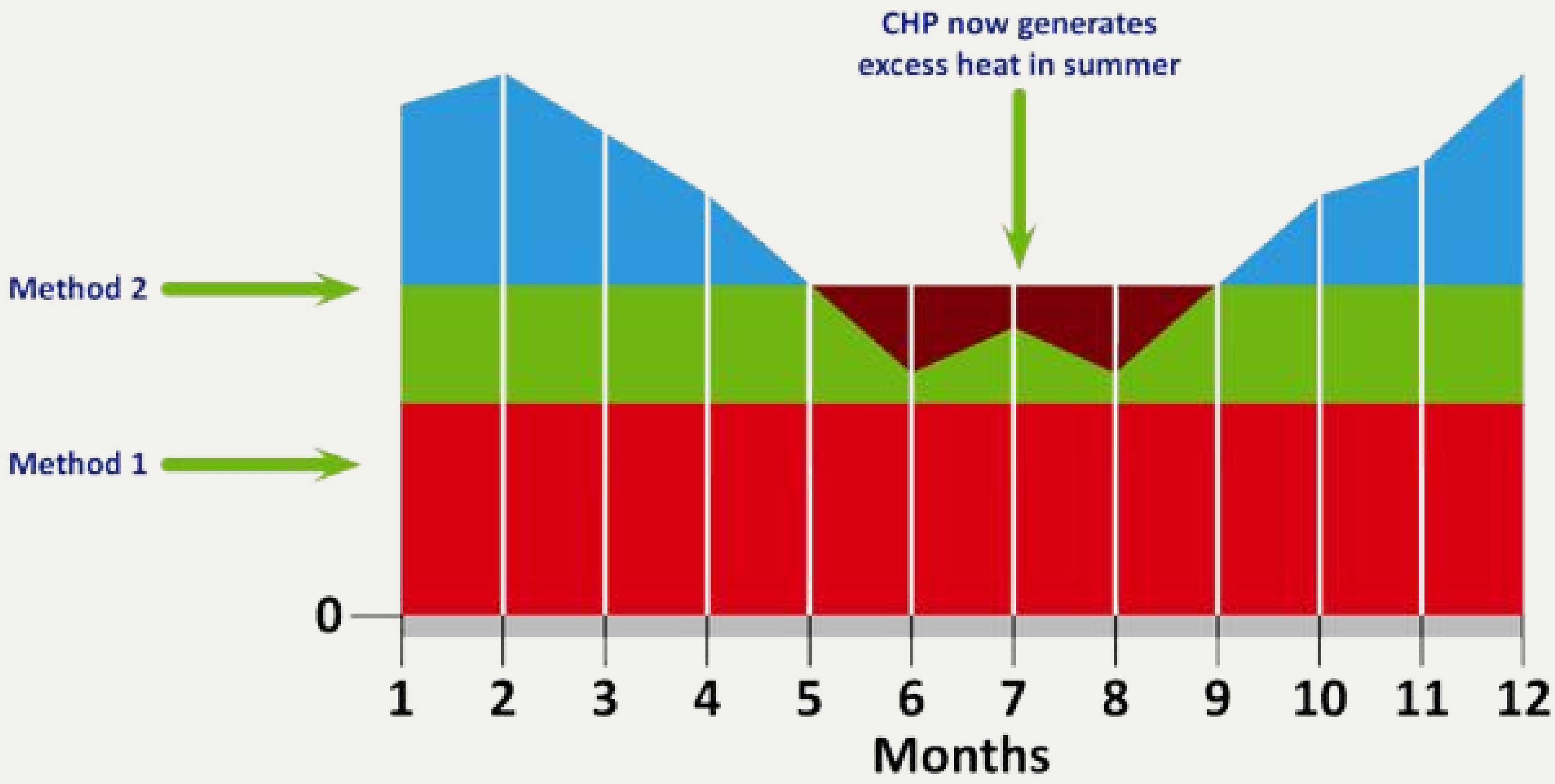
CHP Sizing

Baseload Thermal (Method 1)



CHP Sizing

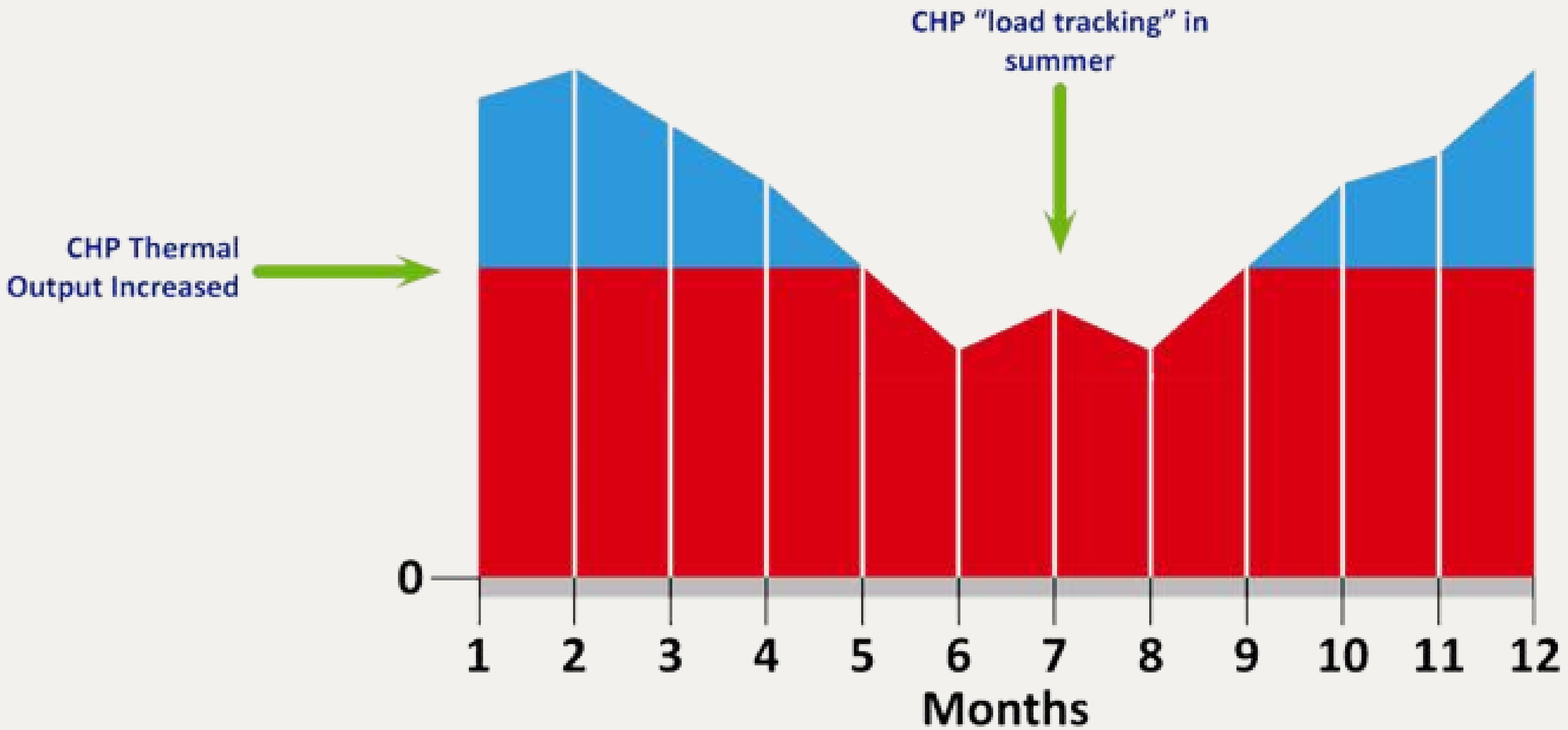
Heat Trim (Method 2)



*Allowance within CHP Quality Assurance (CHPQA) to trim up-to 30% of excess heat, while still meeting Quality Index of >105

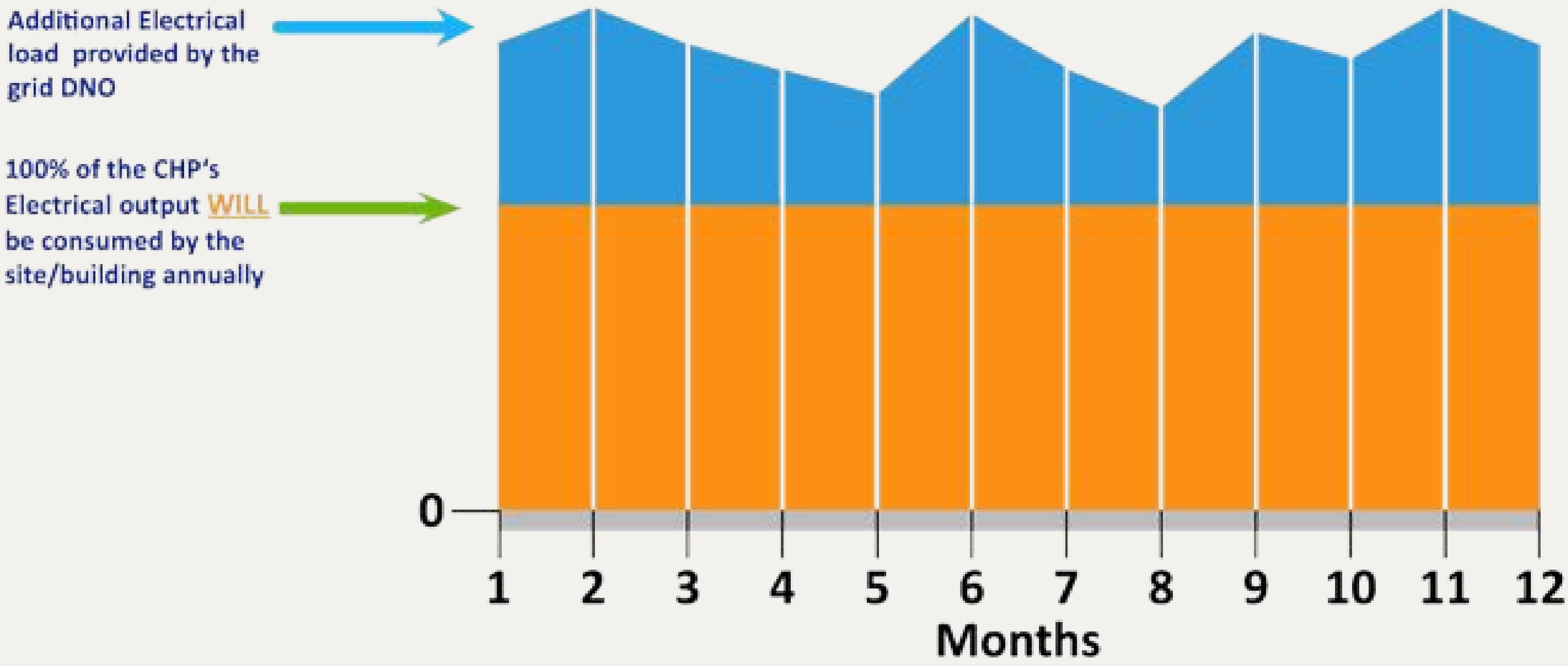
CHP Sizing

Thermal Modulation (Method 3)



CHP Sizing

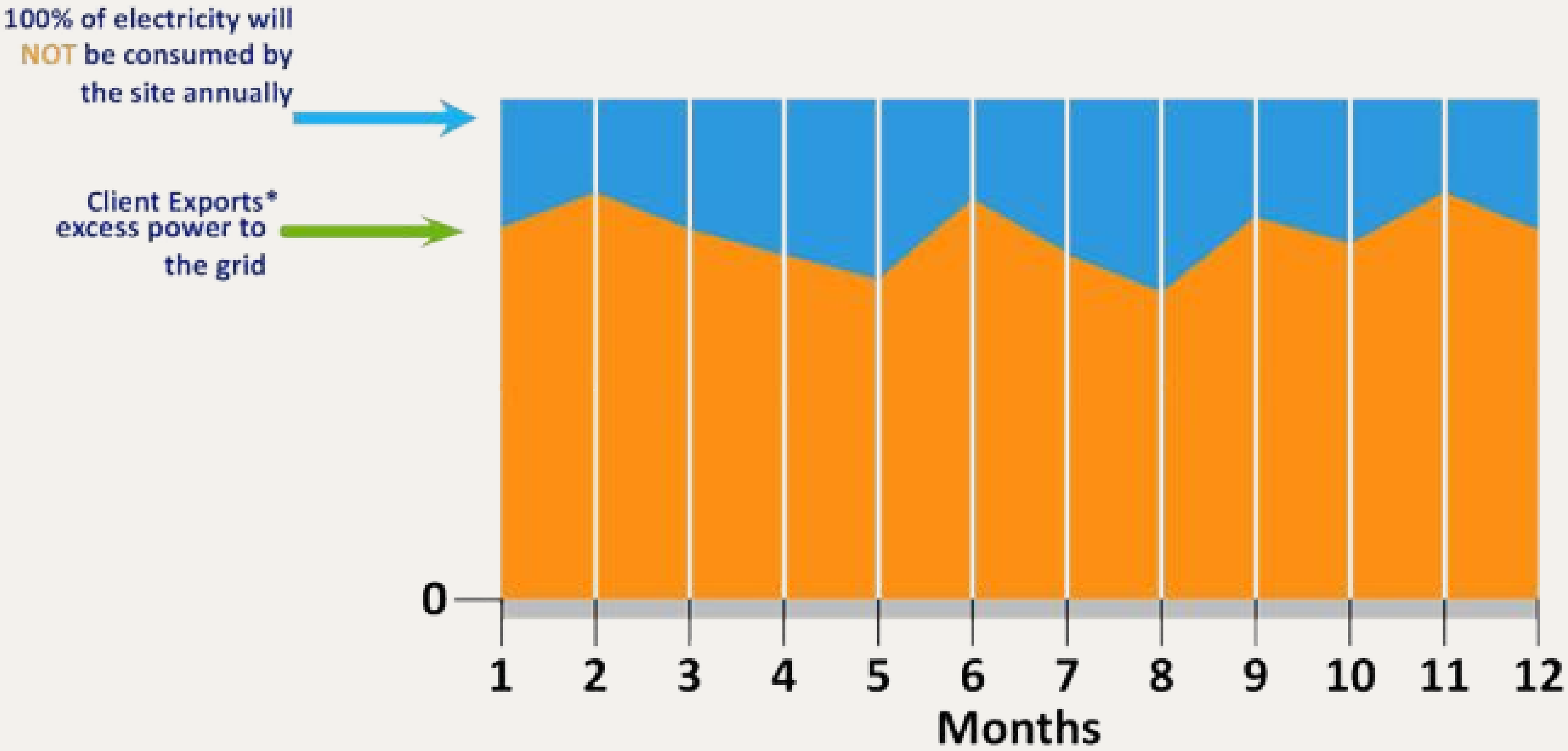
Electrical Baseload



** G59 + DNO permission required for Operation*

CHP Sizing

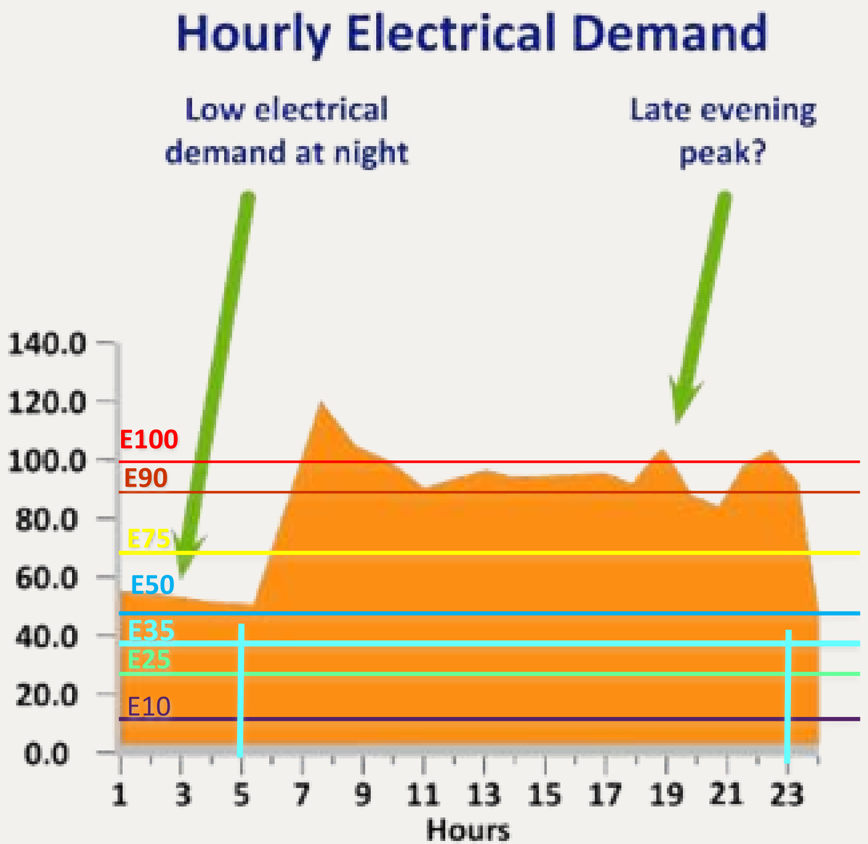
Electrical Export (Method 4) "Spill"

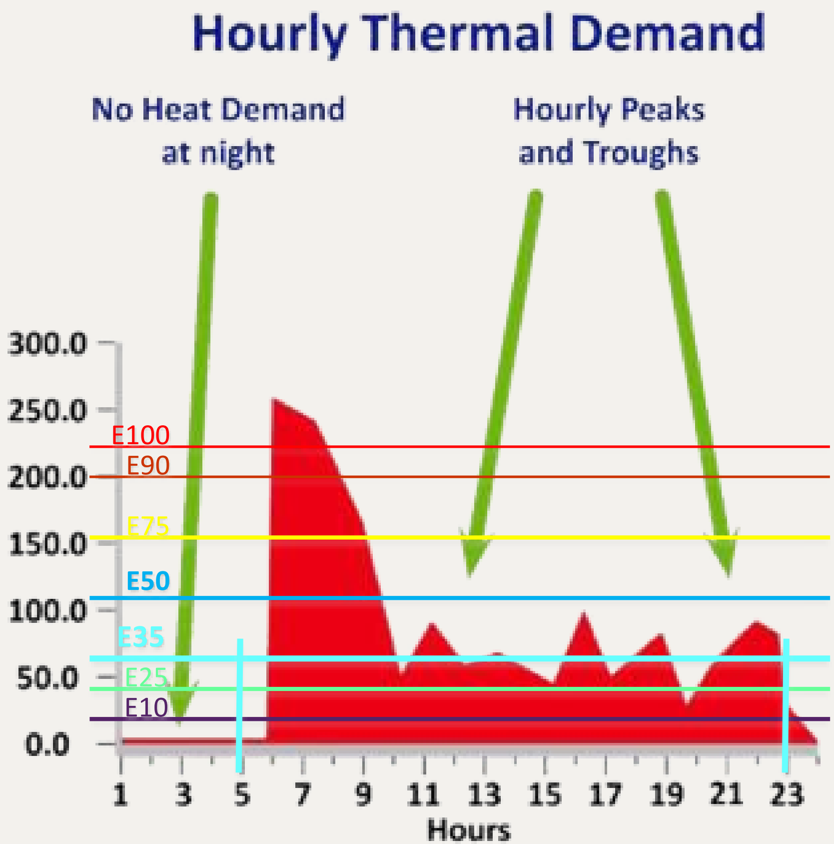


***** G59 + DNO permission required for Operation*

CHP Sizing

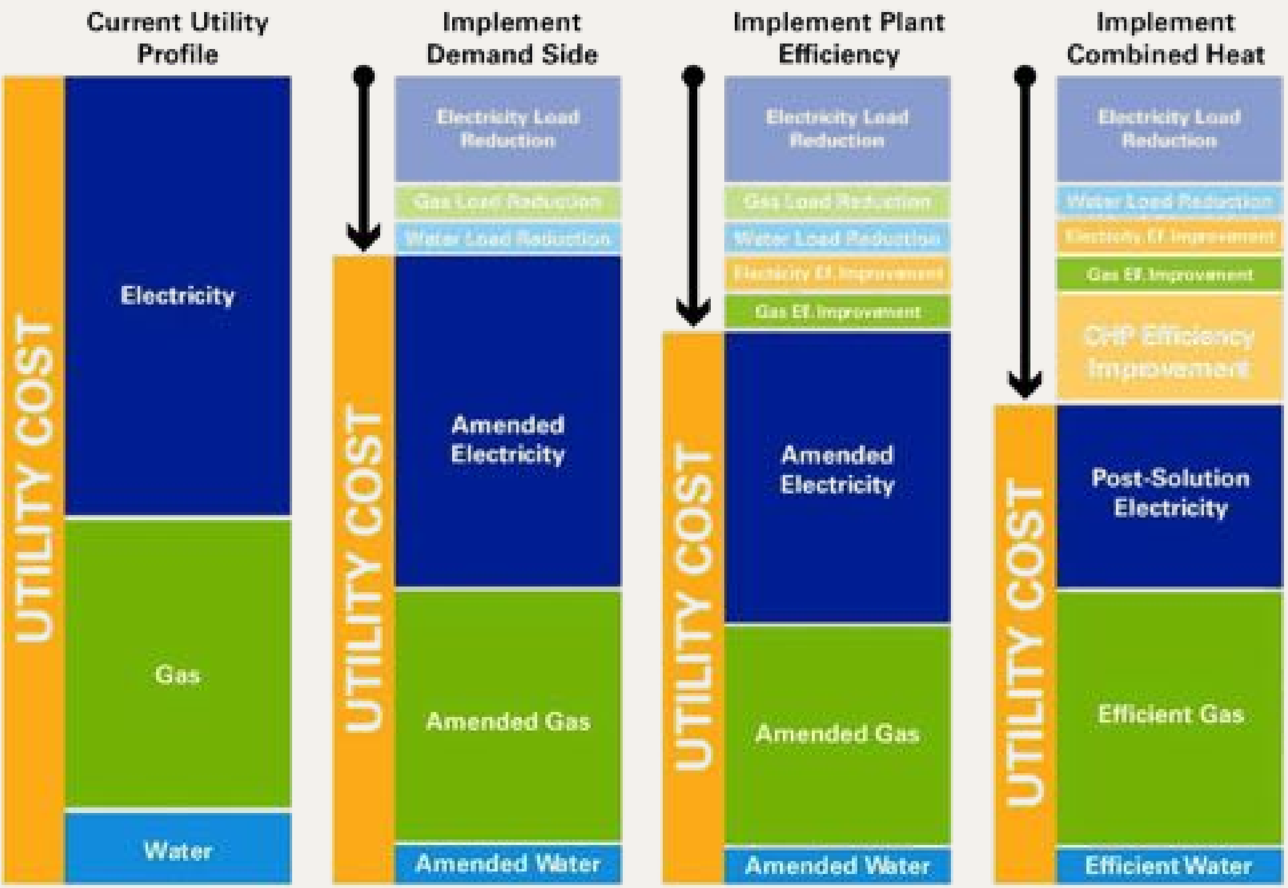
Devil is in the Detail





CHP Sizing

Demand Measures & Efficiency Measures 1st



Conclusions: Load Profiling & Best Practice

A. **No substitute** for good quality metering data

B. Simple load averages are **seldom representative** of site behaviour

C. Monthly totals: Ensure a typical "*shape*" for the application is applied

D. Establish realistic programs ***before defining suitable CHP size*** for both:

   a) Demand measures
   b) Efficiency measures
   c) Sizing CHP for **Tomorrows** demands

Trigeneration

Tri-Generation – Summary

A. Specialised applications only
B. Works best with high loads – output of 6°C Minimum with low COP
C. Additional Hardware increases CHP cost by 100%
D. Absorption Chiller footprint to be considered
E. Mandatory feasibility modelling

Trigeneration Case Study

Tri-Generation Example sites

Project	Size of Absorption Chiller	CHP	CHP kWe	CHP kWt
Tangerine Sites	4 x 247kW	4x E 230	4x229	4x 358
Nottingham Combined Court	138kW	E 125U	124	200
Royal Mail Gateshead	200kW	E 185	185	309
CISCO Systems	322kW	E 425	430	468
Glenfields Hospital	71kW	E 70	70	104
Granada Studios	500kW	E 1020	1027	1317
Isle of Wright Hospital	325 kW	2X E 150	2x 152	2x 236
Nottingham Magistrates	160kW	E 150	150	231
Birmingham Heartlands	300kW	E 1166	1150	1428
Shrewsbury Hospital	500kW	E 1.150	1150	1428
Solihull Hospital	340kW	E 770	770	834
Liverpool Museum	1 MWc	2x E770	770 x2	834
Project 371	261kW	E 185	185	280
Redcar and Cleveland College	160kW	E 150	150	231
MTC Ansty	160kW	E 150	150	231
Pharma site	1200kW	2x E 2000	2000 x2	2176 x2
Coventry University	250kW	E 205	210	345
Wand Royal Mail	2 x 500kW	4x E 1020	1027 x4	1317 x4
Network Rail. York	150kW	E 135	135	217
Tremough ESI	170kW	E 210	210	337
Manchester City Football Academy	500kW	2x E310	310	357
Buckingham Gate	360kW	E500	500	527
BAE Systems	100kW	E90	90	152

Conclusions

CHP is…

- A reliable and efficient technology
- A key part of decentralized energy strategy

Well designed CHP will…

- Run smoothly & efficiently
- Generate Heat, Power and a Return on Investment

Thank you

Centrica Business Solutions
www.centricabusinesssolutions.co.uk

If you have any questions please contact:
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