

**Energy Solutions (UK) Ltd**

**VariPower 19kW**



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## INTRODUCTION

### VariPower

VariPower is a variable speed generator with integrated energy storage. Unlike traditional generators which only run at one speed whatever the load demands, the variable speed generator combines the latest control technology and PMG alternator and will run at the most efficient RPM (between 900 – 2000) dependent on the energy requirement; providing just enough power for the load and to charge/top up the batteries without any waste.

When demands are low the generator will run at just 900 RPM, producing very low noise, using less fuel, and producing less CO2 and NOX. For times when a higher load is demanded the generator can move up in speed to anything up to 2000RPM; delivering higher amounts of power, quickly and efficiently.

The batteries within each unit act as an energy store; so at times of very low demand, or when completely silent power is required, the batteries alone can run the load, the generator will not need to start at all. At this point no fuel is used and emissions are at zero.

The built in intelligence of the system means the VariPower provides power in the most efficient way possible without the need for user intervention.

Through our examples in this paper we will outline the potential savings in terms of lowering operating costs, emissions and noise by using the VariPower in place of a standard diesel generator. The statistics are based on tests undertaken by Energy Solutions engineering team.



VariPower 19k

**FIXED SPEED GENERATORS – WHAT THEY TELL US**

Manufacturers of diesel generator sets publish fuel consumption figures for their machines. The data below is from FG Wilson on a generator using a variant of the same base engine as we use in the VariPower:

**FG Wilson P26-6S (24kVA)**

<b>Fuel System</b>				
<b>Fuel Filter Type:</b>	Replaceable Element			
<b>Recommended Fuel:</b>	Class A2 Diesel or BSEN590			
<b>Fuel Consumption: l/hr (US gal/hr)</b>				
	<b>110%</b>	<b>100%</b>	<b>75%</b>	<b>50%</b>
<b>Prime</b>	<b>Load</b>	<b>Load</b>	<b>Load</b>	<b>Load</b>
<b>50 Hz</b>	7.9 (2.1)	7.4 (2.0)	5.7 (1.5)	4.0 (1.1)
<b>60 Hz</b>	-	-	-	-

**FUEL CONSUMPTION/KWH**

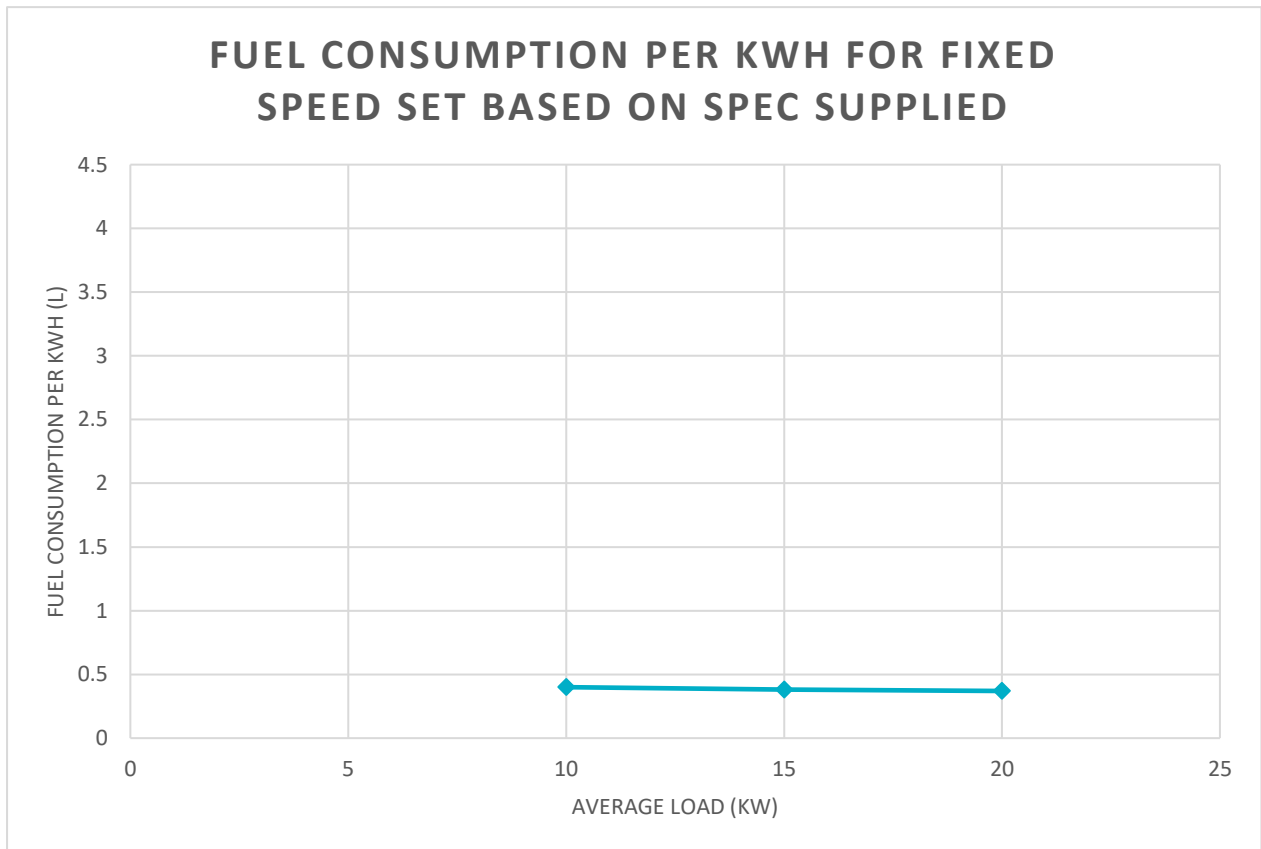
Expressing fuel consumption in litres per hour is the equivalent of giving fuel consumption for a car as litres per hour at different speeds – not very informative data!

When it comes to a car, the miles per gallon consumption is useful, likewise for generators, we really want to understand how much fuel we are using per kWh of electricity produced.

This table takes the data from the generator spec sheet and shows it as litres per hour AND litres per kWh.

<b>Load Level</b>	<b>Fuel Consumption/Hour</b>	<b>Fuel Consumption/kWh</b>
100% (20kW)	7.4L	0.37L
75% (15kW)	5.7L	0.38L
50% (10kW)	4.0L	0.4L

**FIXED SPEED GENERATOR FUEL CONSUMPTION PER KWH – WHAT THEY TELL US**

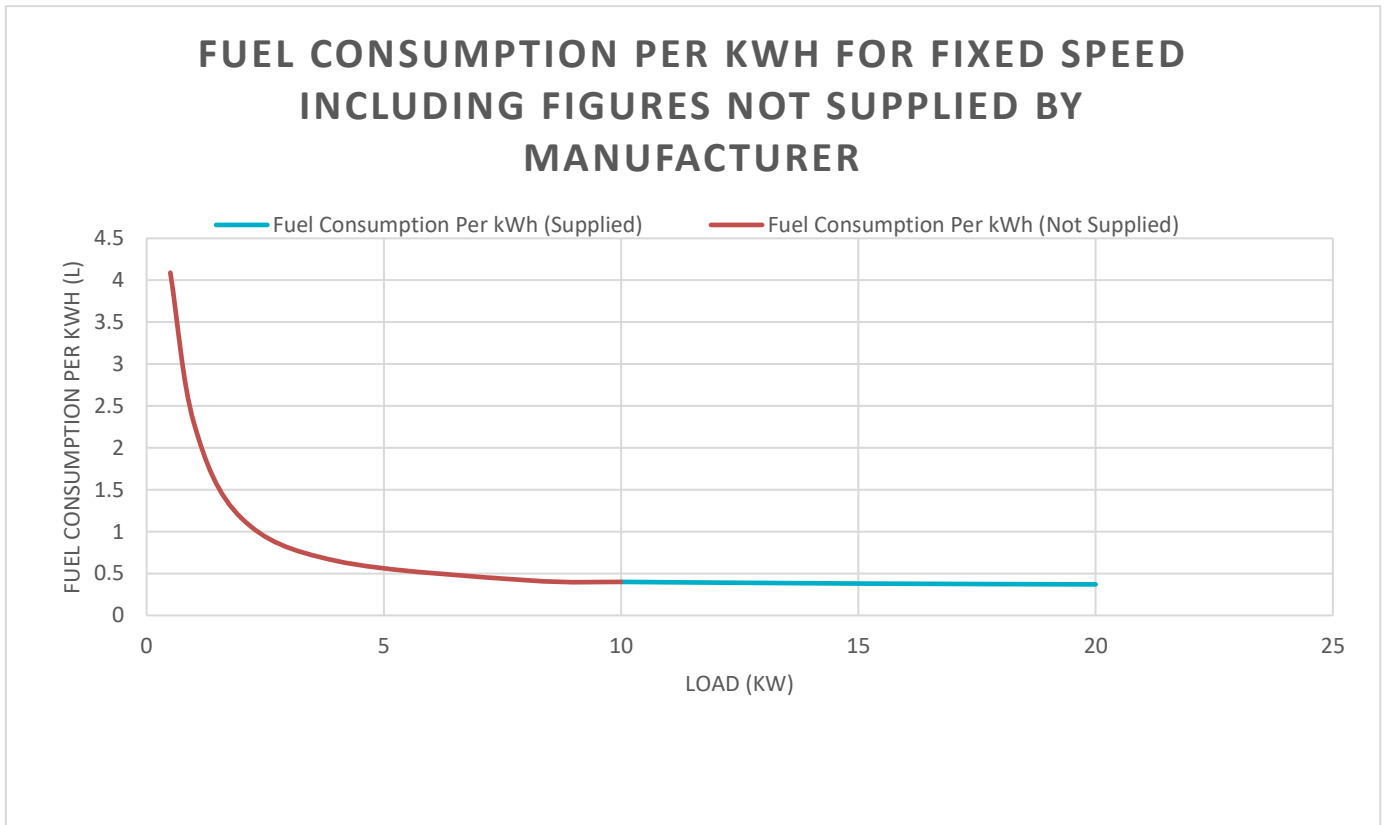


It is very rare that generator manufacturers publish fuel consumption data below 50% load. The chart above is based on what FG Wilson publish.

However, we have tested generators in 5% load increments from 0-100% go understand what happens across the range. The results below 50% load show a dramatic increase in fuel consumption per kWh as shown on the next page.

**FIXED SPEED GENERATOR FUEL CONSUMPTION PER KWH – WHAT THEY DON'T TELL US**

You can see why this information is not published – and certainly never at litres per kWh:

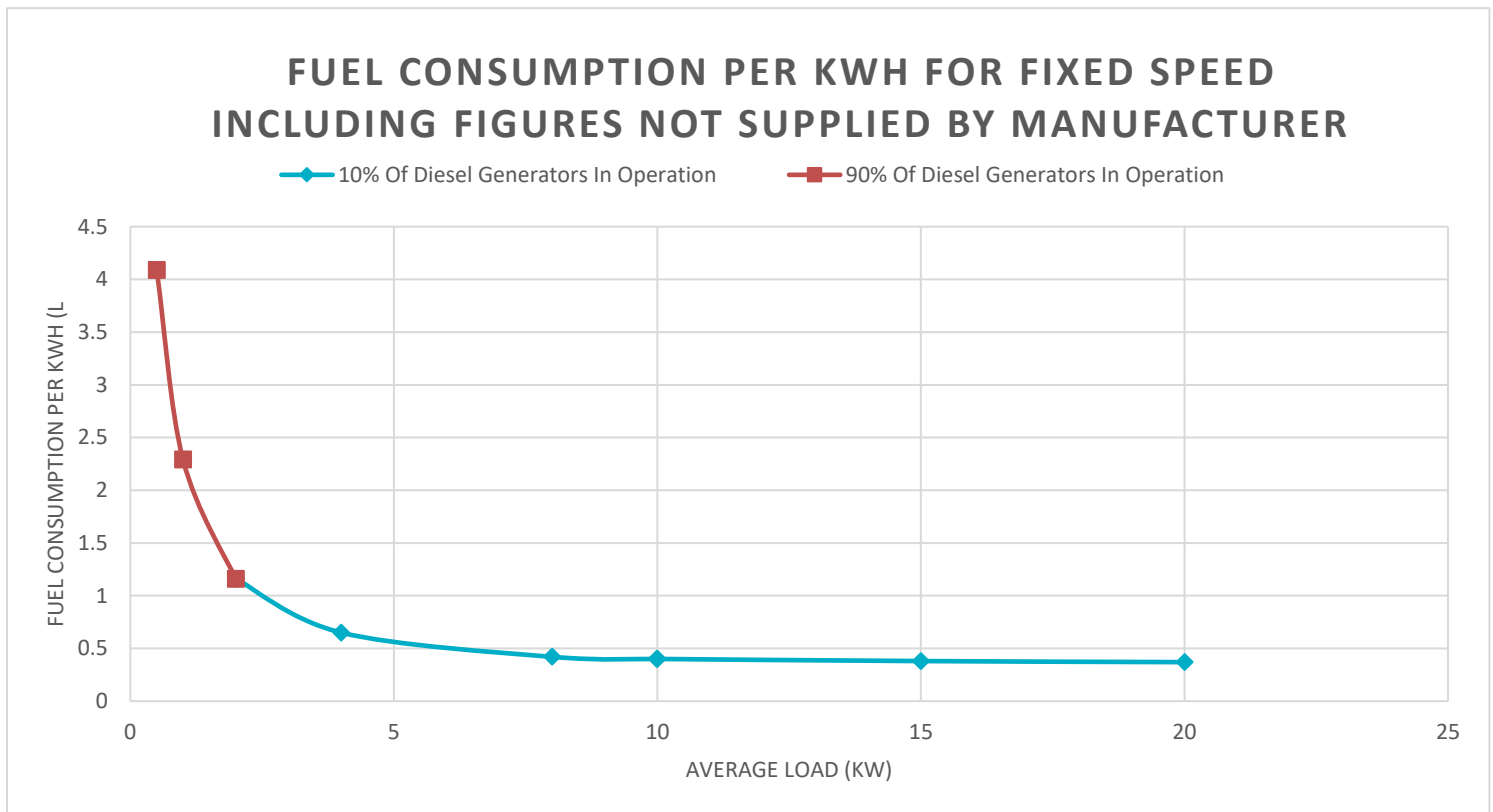


**AVERAGE LOAD OF A FIXED SPEED GENERATOR**

90% of diesel generators operate at an average load of under 10% capacity. The capacity where most machines operate is shown as the red section of the graph below.

The industry average is 5-8% load – midway in the red section.

At 5% load, the fuel consumption is 570% higher, per kWh, than at 50% load - a massive 82% drop in efficiency.



## HOW VARIPOWER COMPARES TO A FIXED SPEED GENERATOR

This is where the VariPower offers unrivalled performance. Because it operates at a variable engine speed – or from stored battery power at very low loads, it has an almost flat fuel consumption per kWh.

Furthermore, because the engine does not run all the time, the service intervals are extended.

The payback from the fuel and service costs versus a standard 'cheaper' fixed speed generator can be dramatic – as little as 18 months.

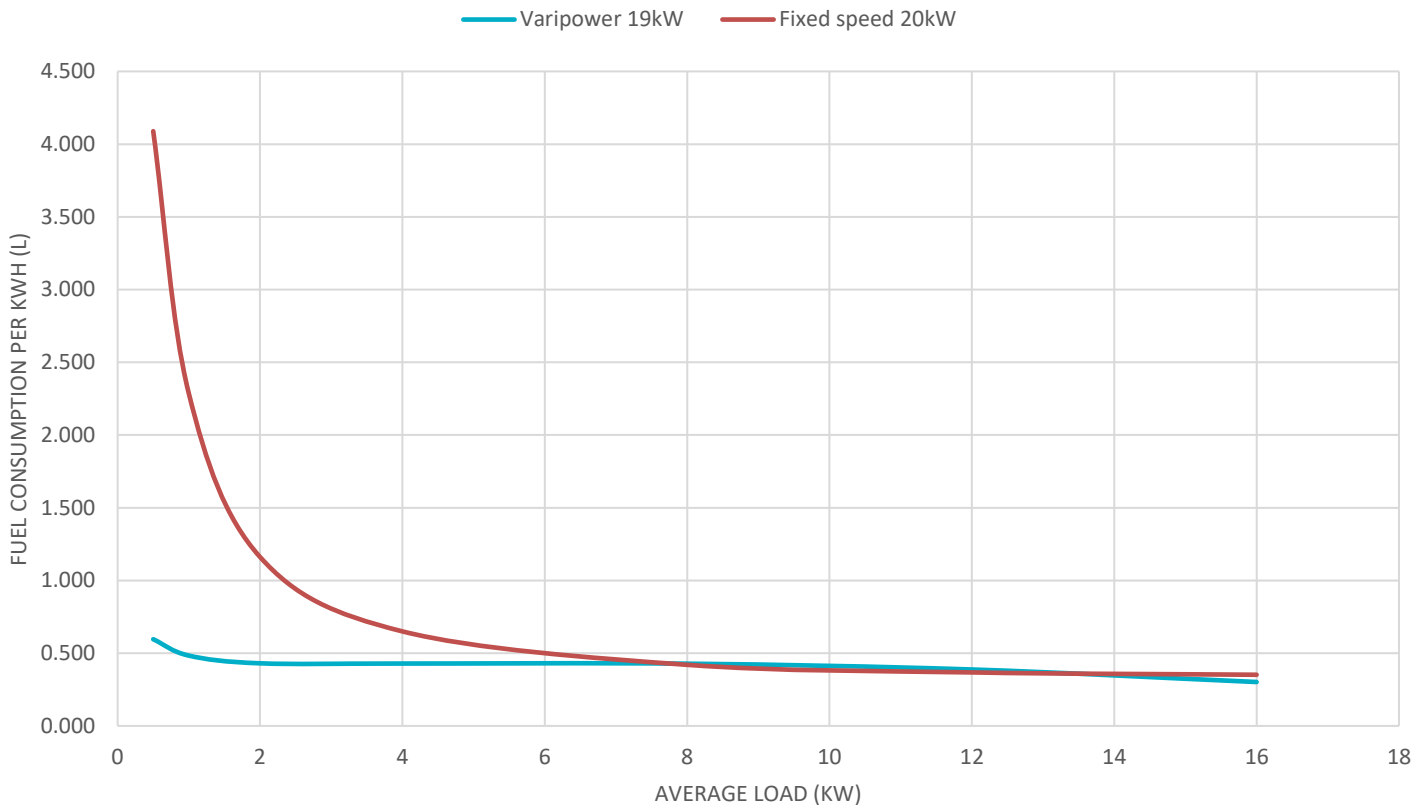
In addition, every litre of fuel saved equates to 2.6kg of CO<sub>2</sub> saved. Engines running correctly loaded, burn more cleanly - reducing harmful particulates (formed from partially combusted fuel).

If you have data for your application, we can very quickly model the savings. This allows you to see how soon you can be saving money, emissions and offering periods of silent operation.



## FUEL USAGE

### LITRES OF FUEL BURNED PER KWH AT VARIOUS LOADS FOR FIXED SPEED GENSET VS VARIPOWER



The graph illustrates how much fuel is burnt, by both a fixed speed 20kW generator and a 19kW VariPower, to supply power for different average loads.

At an average load of 0.5kW (2.5%), a VariPower unit would be able to deliver the power using just 7 litres of diesel per day, whereas a standard diesel generator would require 49 litres per day. In addition, there would be a substantial difference in emissions with the VariPower emitting only 19kg CO<sub>2</sub> per day, whilst the standard generator emits 131kg CO<sub>2</sub> for the same load.

One of the major benefits for this level of power demand, is the reduction in noise that a VariPower offers over a standard diesel generator. To deliver power a standard generator will need to run 24/7. The VariPower engine runtime is reduced by 92.5% - under 2 hours of run time in 24 hours.

**EXAMPLE 1. DOMESTIC HOUSE 500W AVERAGE LOAD**

**FUEL, EMISSIONS & NOISE REDUCTIONS**

The table below shows the volume and value of fuel used to supply the loads in an average domestic property over a 30 day period. In order to supply all loads, the fixed speed generator will have to run 24/7 whereas the VariPower engine runtime will be reduced by 92.5% as loads can be supplied via the VariPower battery bank.

The figures below show a reduction of 87% in the running costs for the VariPower vs a standard generator running for 30 days. The VariPower reduces CO2 emissions by 85% compared to the standard generator and deliver power 92% of the time with no noise.

<b>DOMESTIC HOUSE - 14kWh/Day = Approx 500W Average Load</b>		
	<b>Fixed Speed 20kW Genset</b>	<b>VariPower</b>
<b>Average Load</b>	500W	500W
<b>Total Power Consumption Per 30 Days</b>	360kWh	360kWh
<b>Fuel Consumption Per kWh</b>	4.089L	0.596L
<b>Total Fuel Consumption Per 30 Days</b>	1472.04L	214.56L
<b>Cost Of Fuel</b>	60p	60p
<b>Total Engine Runtime Per 30 Days</b>	720 Hours	54 Hours
<b>Servicing Cost Per Hour Of Runtime</b>	40p	40p
<b>Fuel Cost Per 30 Days</b>	£883.22	£128.74
<b>Servicing Cost Per 30 Days</b>	£288.00	£21.60
<b>Total Running Cost Per 30 Days</b>	£1,171.00	£150.34
<b>Silent Hours Per 30 Days (720 Hours)</b>	0 Hours	666 Hours
<b>CO2 Emissions Per 30 Days</b>	4.0 Tonnes	0.6 Tonnes

<b>Total Savings Per 30 Days</b>
Running Costs - £1020.66
Silent Running Hours - 666 Hours
CO2 Emissions - 3.4 Tonnes

**TOTAL COST OF OWNERSHIP**

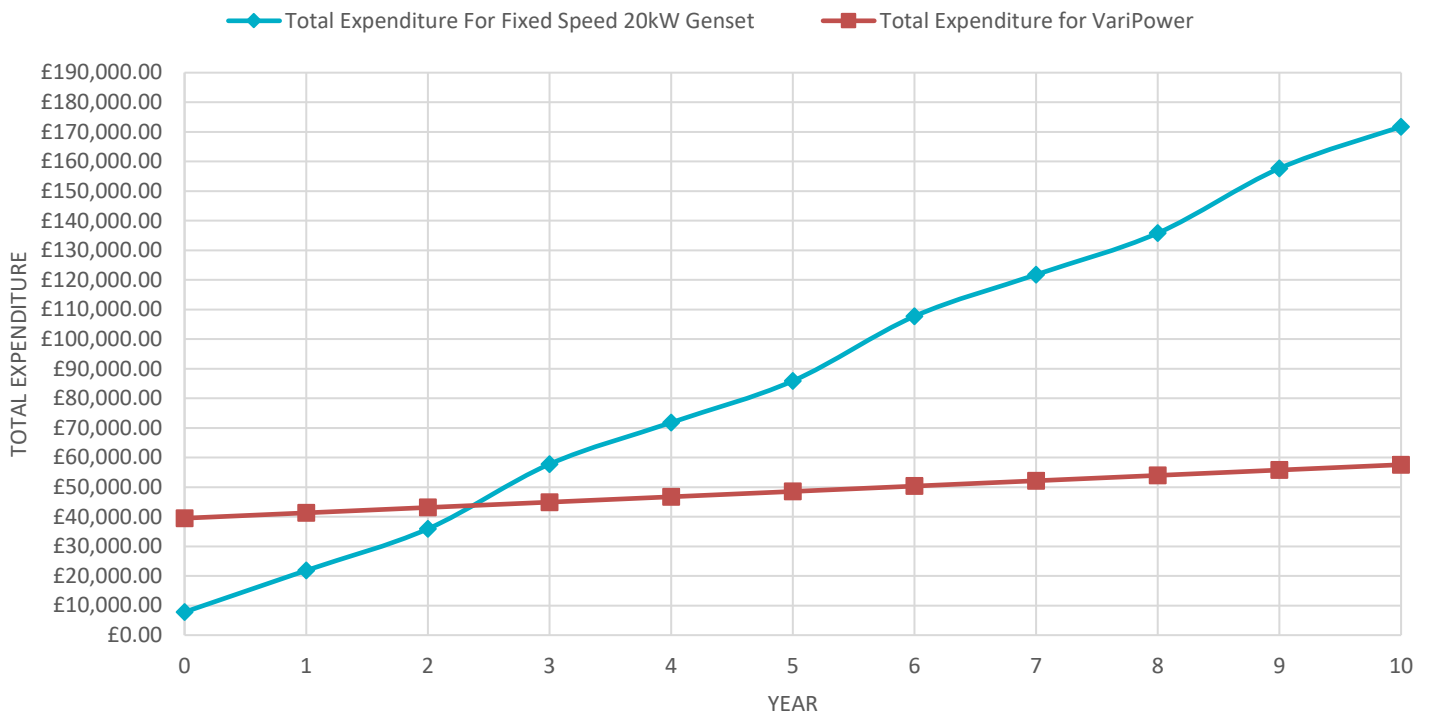
The capital cost of a VariPower is higher than that of a fixed speed generator. However, running costs of generators are the biggest cost over time. This can be seen by the figures in Year 0 on the following table.

Based on a 500W average load for the duration of its use a VariPower unit would start to deliver savings in terms of fuel, emissions and noise from Day 1 and the capital expenditure is repaid within two years and five months by the reduction in fuel and servicing costs. The expenditure figures also include replacement of the fixed speed generator every 3 years based on a lifespan of 20,000 hours of runtime. Over a 10 year period of use, the overall total savings for the VariPower are £114,206.56 compared to running a fixed speed generator for the same load requirements.

Year	Total Expenditure For Fixed Speed 20kW Genset	Total Expenditure for VariPower
0	£7,800.00	£39,500.00
1	£21,854.69	£41,304.03
2	£35,909.38	£43,108.06
3	£57,764.06	£44,912.10
4	£71,818.75	£46,716.13
5	£85,873.44	£48,520.16
6	£107,728.13	£50,324.19
7	£121,782.82	£52,128.22
8	£135,837.50	£53,932.26
9	£157,692.19	£55,736.29
10	£171,746.88	£57,540.32
Cost per kWh Over 10 Years	£3.92	£1.31

Purchase Cost Of VariPower = £39,500 Purchase Cost of Fixed Speed 20kW Genset = £7,800 Investment (Difference in Capital Cost) = £31,700
Return on Investment = 2 YEARS 5 MONTHS

## TOTAL EXPENDITURE (CAPEX + OPEX) - FIXED SPEED GENSET VS VARIPOWER - DOMESTIC HOUSE



**EXAMPLE 2. LARGE CONSTRUCTION SITE 1 KW AVERAGE LOAD**

**FUEL, EMISSIONS & NOISE REDUCTIONS**

The table below shows the volume and value of fuel used to supply the loads on a construction site over a 30 day period. In order to supply all loads, the fixed speed generator will have to run 24/7 whereas the VariPower will reduce engine runtime by 81% as loads can be supplied via the VariPower battery bank.

The figures show a reduction in running costs for the VariPower at 78% against the cost of a standard generator running for 30 days. It will reduce CO2 emissions by 80% in comparison to the standard generator and deliver power 73% of the time with no noise.

<b>LARGE SITE - 24kWh/Day = 1kW AVERAGE LOAD</b>		
	<b>Fixed Speed 20kW Genset</b>	<b>VariPower</b>
<b>Average Load</b>	1kW	1kW
<b>Total Power Consumption Per 30 Days</b>	720kWh	720kWh
<b>Fuel Consumption Per kWh</b>	2.286L	0.483L
<b>Total Fuel Consumption Per 30 Days</b>	1645.92L	347.76L
<b>Cost Of Fuel</b>	60p	60p
<b>Total Engine Runtime Per 30 Days</b>	720 Hours	137 Hours
<b>Servicing Cost Per Hour Of Runtime</b>	40p	40p
<b>Fuel Cost Per 30 Days</b>	£988	£209
<b>Servicing Cost Per 30 Days</b>	£288.00	£54.80
<b>Total Running Cost Per 30 Days</b>	£1,275.55	£263.46
<b>Silent Hours Per 30 Days (720 Hours)</b>	0 Hours	583 Hours
<b>CO2 Emissions Per 30 Days</b>	4.5 Tonnes	0.9 Tonnes

<b>Total Savings Per 30 Days</b>
Running Costs - £1012.09
Silent Running Hours - 583 Hours
CO2 Emissions - 3.6 Tonnes

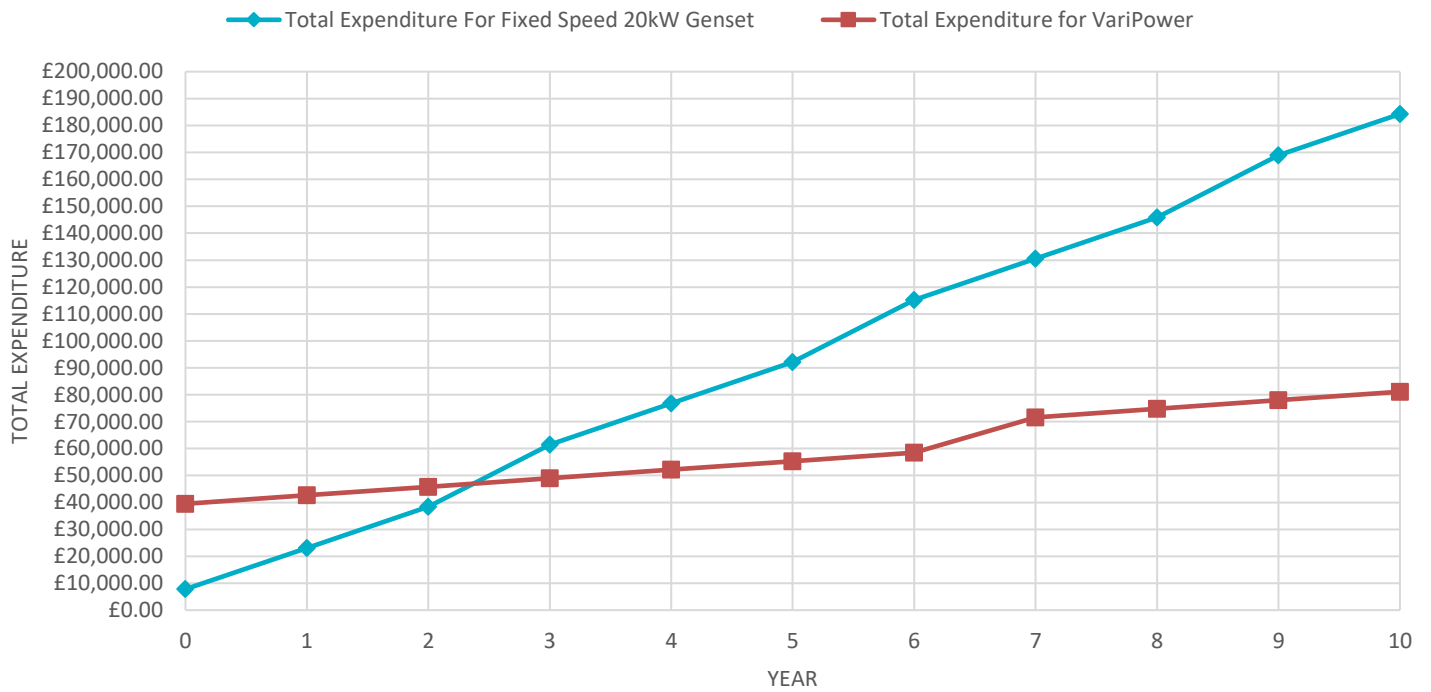
## TOTAL COST OF OWNERSHIP

Based on a 1kW average load for the duration of its use, a VariPower unit would start to deliver savings in terms of fuel, emissions and noise from Day 1, however the capital expenditure is repaid within two and half years by the reduction in fuel and servicing costs. The expenditure figures also include replacement of the fixed speed generator every 3 years based on a lifespan of 20,000 hours of runtime along with replacement of the lithium batteries in the VariPower in the 7<sup>th</sup> year as they reach the end of their cyclic life. Over a 10 year period of use, the overall total savings for the VariPower are £103,151.52 compared to running a fixed speed generator for the same load requirements.

Year	Total Expenditure For Fixed Speed 20kW Genset	Total Expenditure for VariPower
0	£7,800.00	£39,500.00
1	£23,106.62	£42,661.47
2	£38,413.25	£45,822.94
3	£61,519.87	£48,984.42
4	£76,826.50	£52,145.89
5	£92,133.12	£55,307.36
6	£115,239.74	£58,468.83
7	£130,546.37	£71,630.30
8	£145,852.99	£74,791.78
9	£168,959.62	£77,953.25
10	£184,266.24	£81,114.72
Cost per kWh Over 10 Years	£2.10	£0.93

Purchase Cost Of VariPower = £39,500
Purchase Cost of Fixed Speed 20kW Genset = £7,800
Investment (Difference in Capital Cost) = £31,700
<b>Return on Investment = 2 YEARS 6 MONTHS</b>

## TOTAL EXPENDITURE (CAPEX + OPEX) - FIXED SPEED GENSET VS VARIPOWER - LARGE CONSTRUCTION SITE



**EXAMPLE 3. TELECOMS SITE 2KW AVERAGE LOAD**

**FUEL, EMISSIONS & NOISE REDUCTIONS**

The table below shows the volume and value of fuel used to supply the loads on a telecoms site over a 30 day period. In order to supply all loads, the fixed speed generator will have to run 24/7 whereas the VariPower will reduce the engine runtime by 77% as loads can be supplied via the VariPower battery bank.

The figures show a reduction in running costs for the VariPower at 63% against the cost of a standard generator running for 30 days. It will reduce CO2 emissions by 62% in comparison to the standard generator and deliver power 73% of the time with no noise.

<b>TELECOMS SITE - 48kWh/Day = 2kW AVERAGE LOAD</b>		
	<b>Fixed Speed 20kW Genset</b>	<b>VariPower</b>
<b>Average Load</b>	2kW	2kW
<b>Total Power Consumption Per 30 Days</b>	1440kWh	1440kWh
<b>Fuel Consumption Per kWh</b>	1.162L	0.430L
<b>Total Fuel Consumption Per 30 Days</b>	1673.28L	619.20L
<b>Cost Of Fuel</b>	60p	60p
<b>Total Engine Runtime Per 30 Days</b>	720 Hours	166 Hours
<b>Servicing Cost Per Hour Of Runtime</b>	40p	40p
<b>Fuel Cost Per 30 Days</b>	£1,004	£372
<b>Servicing Cost Per 30 Days</b>	£288.00	£66.40
<b>Total Running Cost Per 30 Days</b>	£1,291.97	£437.92
<b>Silent Hours Per 30 Days (720 Hours)</b>	0 Hours	554 Hours
<b>CO2 Emissions Per 30 Days</b>	4.5 Tonnes	1.7 Tonnes

<b>Total Savings Per 30 Days</b>
Running Costs - £854.05
Silent Running Hours - 554 Hours
CO2 Emissions - 2.8 Tonnes



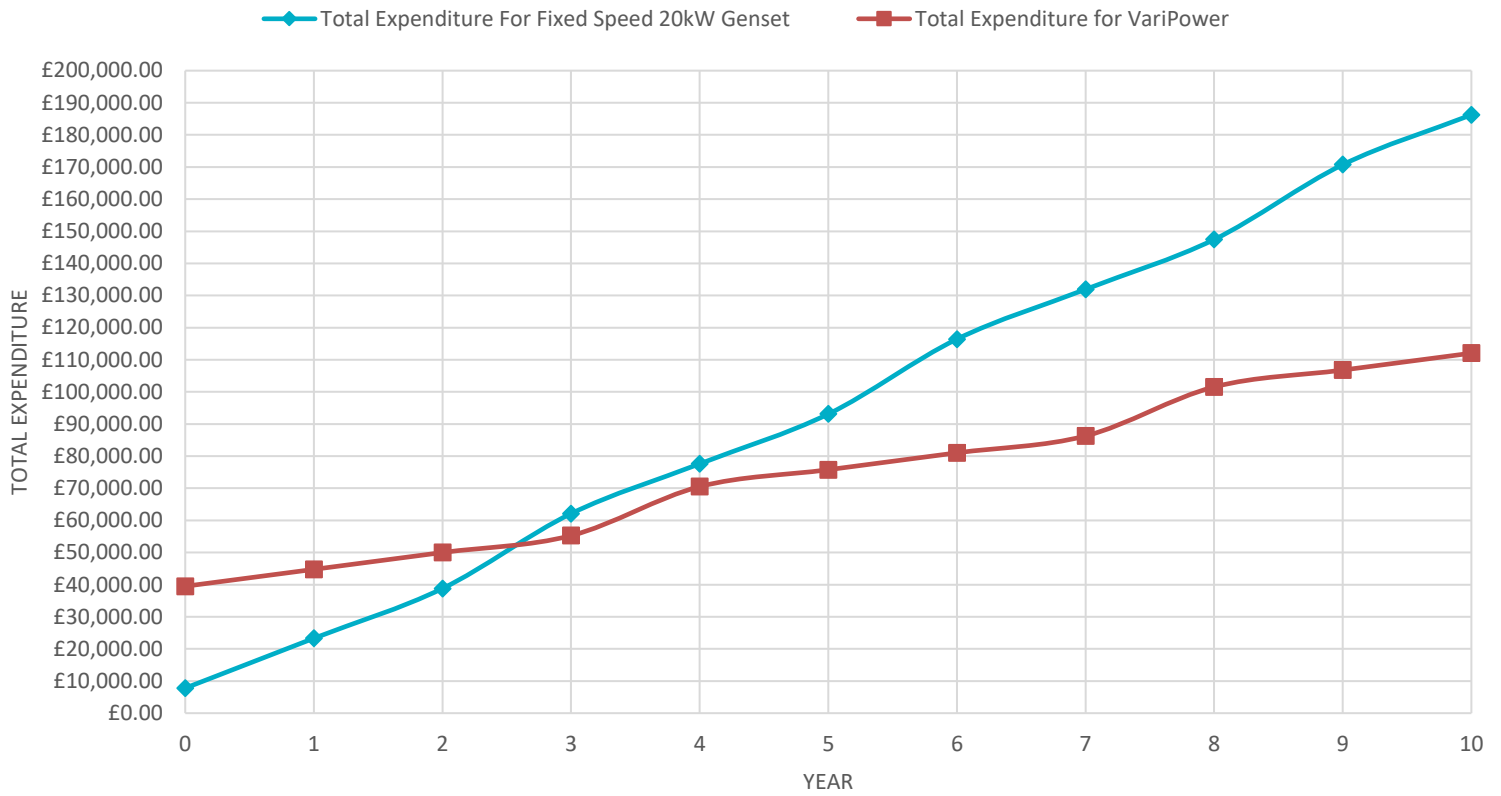
## TOTAL COST OF OWNERSHIP

Based on a 2kW average load for the duration of its use, a VariPower unit would start to deliver savings in terms of fuel, emissions and noise from Day 1, and the capital expenditure is repaid within two years and ten months by the reduction in fuel and servicing costs. The expenditure figures also include replacement of the fixed speed generator every 3 years based on a lifespan of 20,000 hours of runtime along with replacement of the lithium batteries in the VariPower every 4 years as they reach the end of their cyclic life. Over a 10 year period of use, the overall total savings for the VariPower are £74,185.76 compared to running a fixed speed generator for the same load requirements.

Year	Total Expenditure For Fixed Speed 20kW Genset	Total Expenditure for VariPower
0	£7,800.00	£39,500.00
1	£23,303.62	£44,755.04
2	£38,807.23	£50,010.08
3	£62,110.85	£55,265.12
4	£77,614.46	£70,520.16
5	£93,118.08	£75,775.20
6	£116,421.70	£81,030.24
7	£131,925.31	£86,285.28
8	£147,428.93	£101,540.32
9	£170,732.54	£106,795.36
10	£186,236.16	£112,050.40
Cost per kWh Over 10 Years	£1.06	£0.64

Purchase Cost Of VariPower = £39,500
Purchase Cost of Fixed Speed 20kW Genset = £7,800
Investment (Difference in Capital Cost) = £31,700
<b>Return on Investment = 2 YEARS 10 MONTHS</b>

## TOTAL EXPENDITURE (CAPEX + OPEX) - FIXED SPEED GENSET VS VARIPOWER - TELECOMS SITE



**EXAMPLE 4. REMOTE TELECOMS SITE – 2KW AVERAGE LOAD**

**FUEL, EMISSIONS & NOISE REDUCTIONS**

The table below shows the volume and value of fuel used to supply the loads on a **remote** telecoms site over a 30 day period. The remoteness of these sites means that the cost of fuel and servicing is more expensive compared to the non-remote telecoms site. In order to supply all loads, the fixed speed generator will have to run 24/7 whereas the VariPower will only run 23% of the time - the remaining time, loads can be supplied via the VariPower battery bank.

The figures show a reduction of 63% in running costs for the VariPower vs the cost of a standard generator running for 30 days. It will reduce CO2 emissions by 62% compared to the emissions of the standard generator and deliver power 77% of the time with no noise.

<b>REMOTE TELECOMS SITE - 48kWh/Day = 2kW AVERAGE LOAD</b>		
	<b>Fixed Speed 20kW Genset</b>	<b>VariPower</b>
<b>Average Load</b>	2kW	2kW
<b>Total Power Consumption Per 30 Days</b>	1440kWh	1440kWh
<b>Fuel Consumption Per kWh</b>	1.162L	0.430L
<b>Total Fuel Consumption Per 30 Days</b>	1673.28L	619.20L
<b>Cost Of Fuel</b>	£1.20	£1.20
<b>Total Engine Runtime Per 30 Days</b>	720 Hours	166 Hours
<b>Servicing Cost Per Hour Of Runtime</b>	£1.00	£1.00
<b>Fuel Cost Per 30 Days</b>	£2,008	£743
<b>Servicing Cost Per 30 Days</b>	£720.00	£166.00
<b>Total Running Cost Per 30 Days</b>	£2,727.94	£909.04
<b>Silent Hours Per 30 Days (720 Hours)</b>	0 Hours	554 Hours
<b>CO2 Emissions Per 30 Days</b>	4.5 Tonnes	1.7 Tonnes

<b>Total Savings Per 30 Days</b>
Running Costs - £1819.90
Silent Running Hours - 554 Hours
CO2 Emissions - 2.8 Tonnes

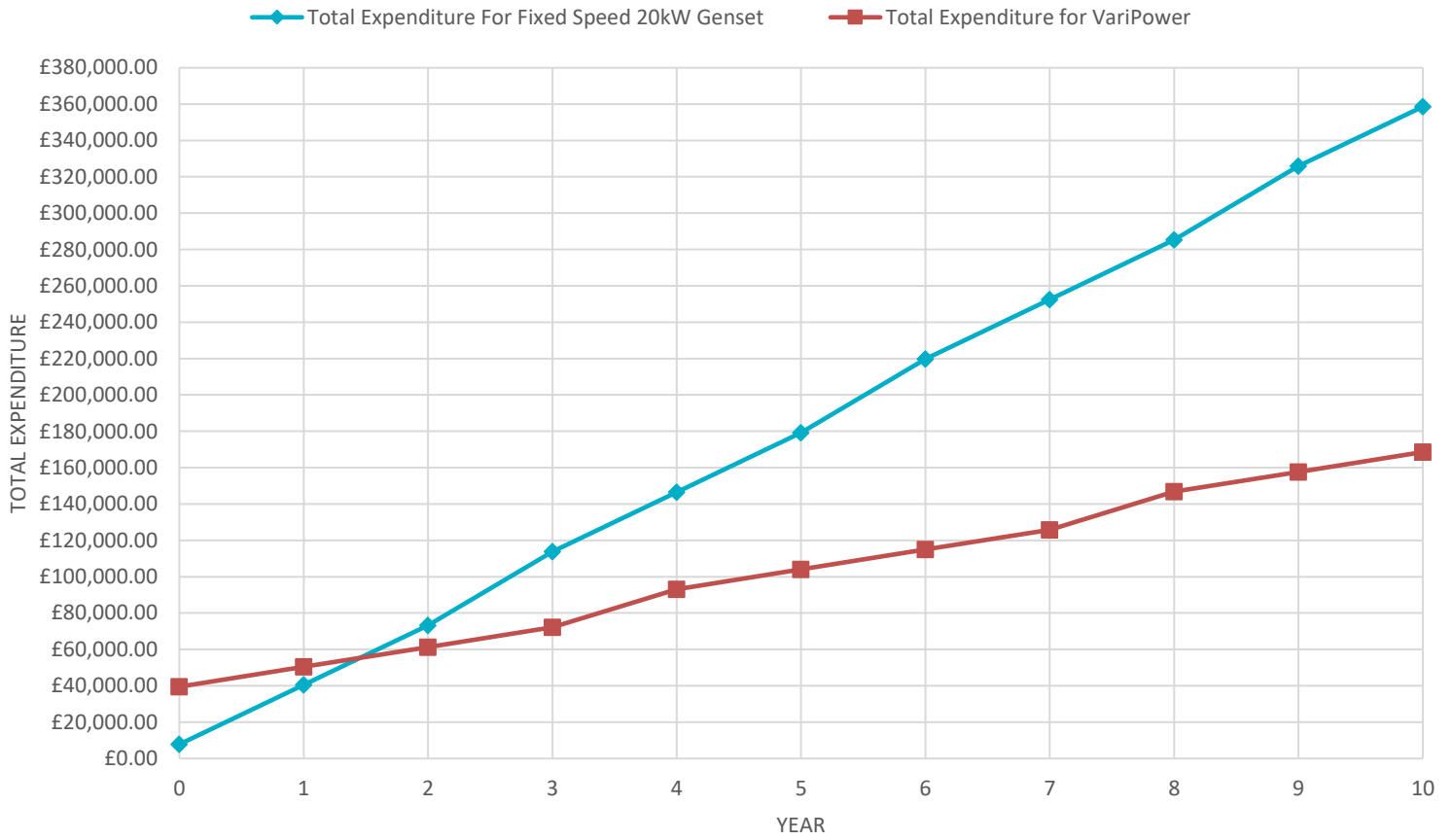
## TOTAL COST OF OWNERSHIP

Based on a 2kW average load for the duration of its use, a VariPower unit would start to deliver savings in terms of fuel, emissions and noise from Day 1, and the capital expenditure is repaid within 1 year and 5 months by the reduction in fuel and servicing costs. The expenditure figures also include replacement of the fixed speed generator every 3 years based on a lifespan of 20,000 hours of runtime along with replacement of the lithium batteries in the VariPower every 4 years as they reach the end of their cyclic life. Over a 10 year period of use, the overall total savings for the VariPower are £189,967.52 compared to running a fixed speed generator for the same load requirements.

Year	Total Expenditure For Fixed Speed 20kW Genset	Total Expenditure for VariPower
0	£7,800.00	£39,500.00
1	£40,535.23	£50,408.48
2	£73,270.46	£61,316.96
3	£113,805.70	£72,225.44
4	£146,540.93	£93,133.92
5	£179,276.16	£104,042.40
6	£219,811.39	£114,950.88
7	£252,546.62	£125,859.36
8	£285,281.86	£146,767.84
9	£325,817.09	£157,676.32
10	£358,552.32	£168,584.80
Cost per kWh Over 10 Years	£2.05	£0.96

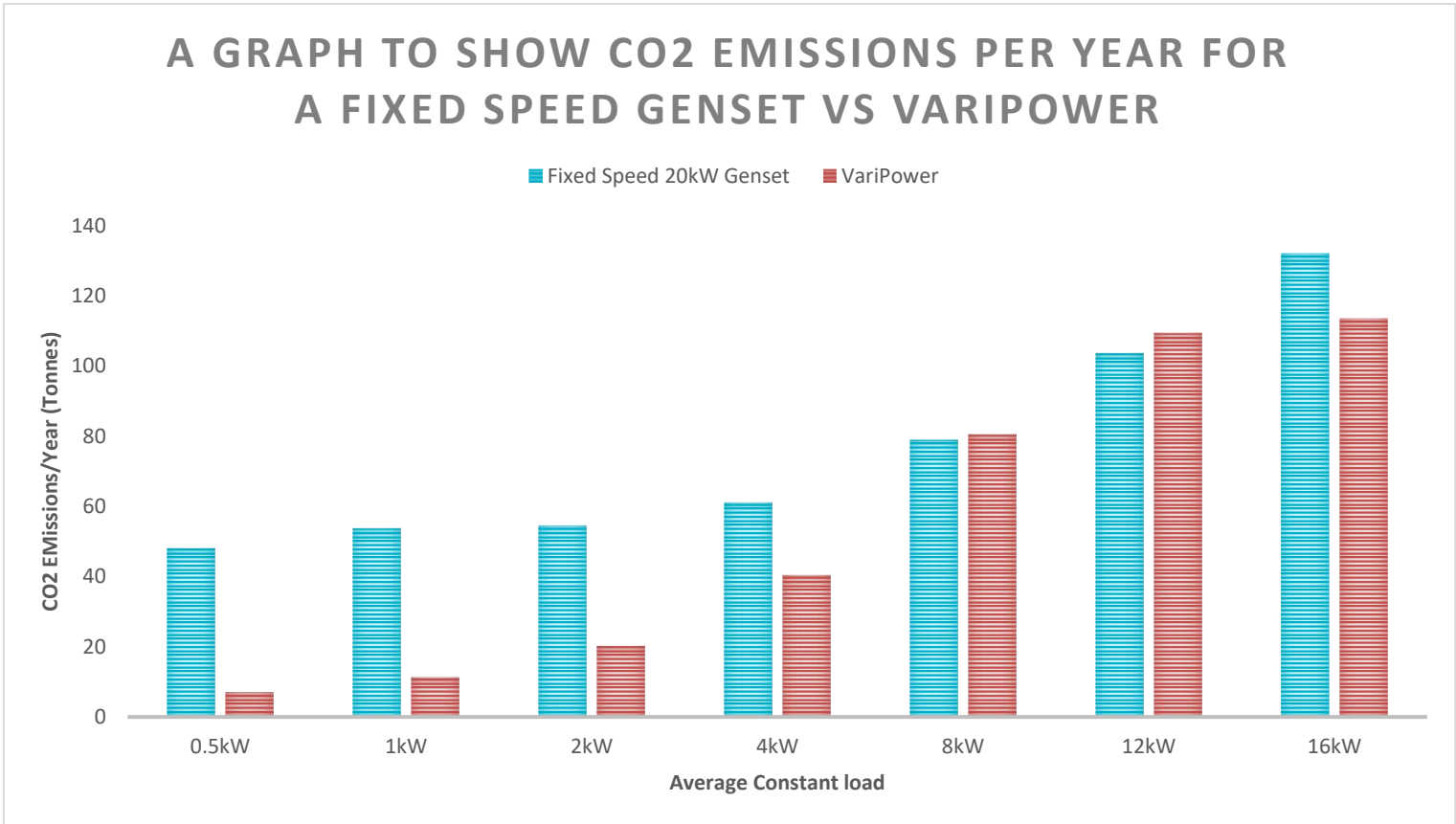
Purchase Cost Of VariPower = £39,500
Purchase Cost of Fixed Speed 20kW Genset = £7,800
Investment (Difference in Capital Cost) = £31,700
<b>Return on Investment = 1 YEAR 5 MONTHS</b>

## TOTAL EXPENDITURE (CAPEX + OPEX) - FIXED SPEED GENSET VS VARIPOWER - REMOTE TELECOMS SITE



**CARBON DIOXIDE EMISSIONS – VARIPOWER VS FIXED SPEED GENERATOR**

The bar chart below shows the CO2 emissions in tonnes per year for a range of average constant loads for the VariPower versus a standard fixed speed generator:



## ASSUMPTIONS

The bullet points below outline the assumptions we have made in our total expenditure calculations:

- The 20kW fixed speed generator would need replacing after 20,000 hours of runtime. Based on running 24 hours a day, this would be every 2 years and 4 months.
- The VariPower has the standard 15kWh lithium battery bank and has not been upgraded to have additional capacity.
- The cost of replacing the 15kWh lithium battery bank in the VariPower is £10,000. This includes the cost of the batteries plus installation labour charges.
- The lithium batteries in the VariPower are only discharged by a depth of 65% to improve cyclic life. The table below details lifespan of the batteries we can expect for the average constant loads discussed in this document based on a cyclic life of 5000 cycles:

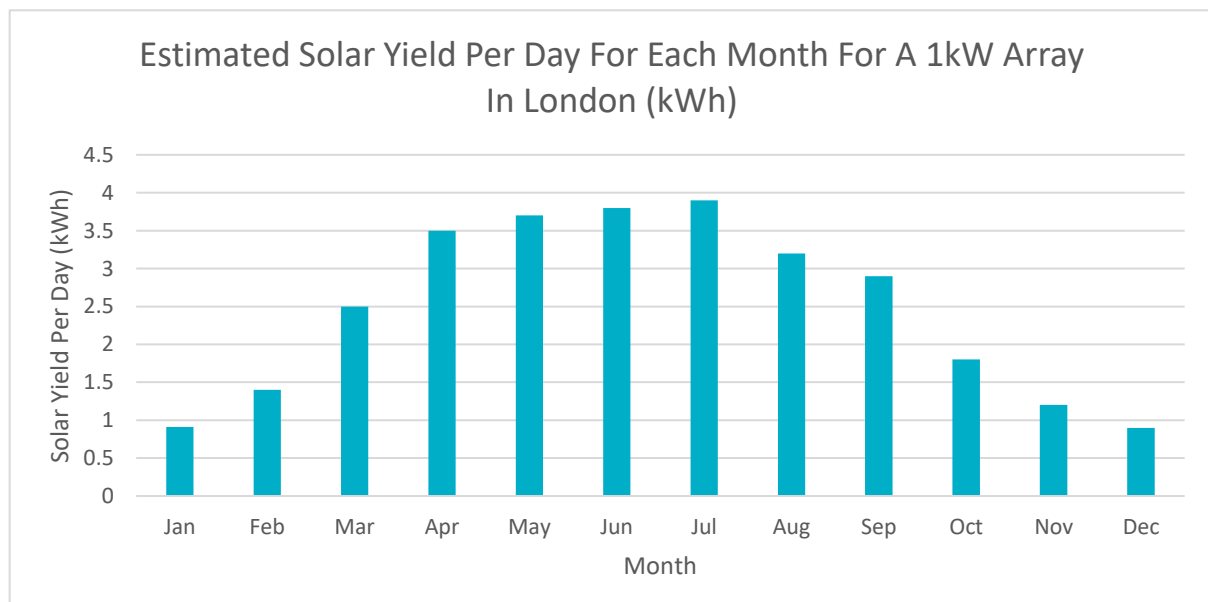
	Average Constant Load		
	500W	1kW	2kW
Cycles Per Year at 65% DOD	377	726	1346
Life Span of Batteries	13.3 YEARS	6.9 YEARS	3.7 YEARS

## ADDITION OF RENEWABLES

All calculations in this whitepaper assume that no renewables have been connected to the VariPower unit. If solar or wind was to be connected, it would further reduce the engine runtime for the VariPower, giving greater savings and a lower cost per kWh of usage for the VariPower unit.

## SOLAR

The graph below shows an estimated solar yield per day for different months for a 1kW solar array installed in London, UK:



Taking the estimated solar yield data from the year, we get an average estimated daily yield of 2.5kWh for a 1kW array in London. This equates to an average of 100W solar yield per hour per 1kW of solar.

## WIND

Based on a 1kW wind turbine with an average wind speed of 5m/s, the estimated daily power generation is 3.8kWh. This equates to an average of 160W output per hour for a 1kW wind turbine.