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Kemsley Sustainable Energy Plant, Sittingbourne

Carbon Analysis Final Report

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On behalf of

ST REGIS PAPER COMPANY LIMITED & E.ON ENERGY FROM WASTE UK LIMITED

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1 Overview

1.1 Security of power supply is a major concern to energy intensive industry. With conventional fossil fuel supplies in decline operators are seeking to secure future energy supply from alternative means through fuel diversification. The proposals for the Kemsley Sustainable Energy Plant (SEP) are being developed for this very purpose. The burning of fuels comprising or derived from waste within the proposed facility will reduce reliance on power and heat supplied from the existing gas fired plant.

1.2 In addition the extensive suite of legislation limiting and controlling the options for waste disposal has been growing over recent years. A key driver has been the Landfill Directive, which limits the quantities of waste that can be disposed of within landfills. One of the key purposes of the Landfill Directive is to help limit and control the volumes of methane (a powerful greenhouse gas) that are released to the atmosphere as biodegradable wastes break down under anaerobic conditions in the landfill site.

1.3 The challenge with managing waste is therefore not only to provide reliable and effective waste management but also to limit, as far as possible, the amount of greenhouse gases arising from the disposal of the waste.

1.4 The most effective management of greenhouse gas emissions from waste disposal is obviously to limit the quantities of waste being disposed of in the first place. However, alongside waste stream management measures the strategic waste disposal system still requires the management and disposal of the residual waste stream and outputs from intermediate waste management facilities. The proposed SEP facility will take wastes and thermally treat it, dramatically reducing the waste volume, recovering the useful embodied energy within the materials and rendering the combustion residues inert in terms of greenhouse gas releases.

1.5 This document provides a greenhouse gas assessment of the proposed SEP. This includes an estimate of the operational carbon footprint for the facility. For reference, a comparison with the carbon footprint associated with the current power generation plant is also provided.

2 Methodology and Assumptions

2.1 This assessment has focused on providing an estimate of the greenhouse gas emissions from the inclusion of proposed SEP as part of the power generation plant for the St Regis Paper Mill Site, whilst also providing a comparison with the existing power generating plant to contextualise the emissions. It is anticipated that this report will provide information to assist with the decision making process by providing contextualised information on greenhouse emissions.

Approach to the assessment

2.2 The majority of potential greenhouse gas emissions arise through the operational phase of the project and therefore for the purposes of this assessment attention has been focused on the operational phase only. The combination of power plant and their operational strategy is defined by the heat (steam) requirements of the St Regis paper mill operations. Steam requirements vary from 15 tonnes per hour (tphr) with all paper machines out of operation up to approximately 215 tphr when all 3 paper machines are operating (at capacity). Electrical demand varies from 15 MWe with no machines running up to 58MWe at capacity.

2.3 The paper mill power requirements to the paper mill activities are currently provided by a gas fired CHP unit and sludge combustor. The proposals for the SEP will provide both heat and power replacing a portion of the power generated by the gas fired CHP unit.

2.4 In evaluating these requirements previous and future operational requirements have been considered i.e. accounting for times where the mill is operating at full capacity (3 paper machines running); and reduced capacity with only 2, 1 or no paper machines in operation. For both the current and proposed operation the same operational requirements have been applied.

2.5 In assessing greenhouse gas emissions it is necessary to establish both the boundaries and the constituent elements of the assessment, which have been defined as follows (any exceptions are outlined under each option):

- **Transportation** – collection of the wastes and delivery to site alongside transportation of other key reagents/chemicals required to support the operation of the facility.

- **Process emissions** – these are the greenhouse gas emissions from the power generation processes or from landfilling of the wastes which the new facility seeks to divert to energy generation. This may be through, for example, combustion of waste or conventional fuels in the power plant or through the release of methane from biodegradable wastes degrading in landfill sites. In addition this category includes any energy consumed in the process, such as auxiliary fuels or electricity. Consideration of the process releases associated from generation of the SRF are excluded – it is assumed that these releases would occur irrespective of the proposals, although the SEP plant would provide an outlet for the SRF it is assumed that under the current scenario that these materials would go to landfill. This assumption has been made on the basis that the proposed facility will create a demand for SRF and drive the need for facilities diverting unprocessed MSW away from landfill to intermediate waste management facilities which will produce SRF.
- **Avoided emissions** – these are the emissions that are avoided by the production or recovery of useful products from the waste which displace the need to consume resources, thereby releasing emissions to the atmosphere. For example, heat and electricity recovered from the SEP can avoid the need to consume fossil fuels directly in he production of this energy at power stations or in the home. Producing power and heat from the onsite CHP plant achieves much higher efficiency of power generation than the combined efficiency of power from the national grid. This is due to the efficiency benefits from cogeneration of power and heat in the onsite CHP unit as opposed to electricity from the grid which includes facilities generating electricity only. Another example is recycling where re-use of the residues (for example bottom ash) can avoid the need to consume resources in the replacement of such materials.
- **Disposal** – these are the emissions associated with the disposal of the residues from the treatment process. For example, residuals containing biodegradable waste can be disposed of in landfill where they continue to degrade and can result in the release of methane emissions.

2.6 The assessment of both the current and proposed power generation strategy at the Mill consider all of the above categories.

Power Generation Options

2.7 Two options for power and heat generation have been considered.

- Existing generation: Electricity and steam supply from the gas fired combined heat and power (CHP) plant (K1) and steam supply from the sludge combustor (K2).

- Proposed operation: Reduced electricity supply from the gas fired combined heat and power (CHP) plant (K1); steam supply from the sludge combustor (K2) and power and heat supply from the proposed SEP (K3).

2.8 These options are discussed in turn below.

2.9 However to aid understanding of the assessment it is important to understand the distinction between shortcycle (or biogenic) carbon sources from those which are fossil (or non-biogenic) sources. Box 1 provides an overview of these terms.

Box 1: Short-cycle (biogenic) and fossil (non-biogenic) carbon
Essentially there are two types of carbon that are considered within greenhouse gas footprint assessments. The so-called biogenic (short-cycle) carbon and the non-biogenic (fossil) carbon. The biogenic sources feed the short-term carbon cycle, which assumes such carbon was taken up recently by the biomass when it grew, and if such materials are grown sustainably an equilibrium is reached between carbon taken up from and that released to the atmosphere. Conversely, non-biogenic (fossil) sources feed the long-term carbon cycle, which prior to combustion was stored underground for a long time and hence is regarded as a net addition to the atmosphere. Intergovernmental Panel on Climate Change guidelines on greenhouse gas assessment and reporting stipulate that biogenic emissions of carbon should not be included in the assessment of emissions from waste. *'Consistent with the 1996 Guidelines (IPCC,1997), only CO_2 resulting from oxidation during incineration and open burning of carbon in waste of fossil origin (e.g. plastics, certain textiles, rubber, liquid solvents, and waste oil) are considered net emissions and should be included in the national CO_2 emissions estimate. The CO_2 emissions from combustion of biomass materials (e.g. paper, food, and wood waste) contained in the waste are biogenic emissions and should not be included in national total emission estimates. However, if incineration of waste is used for energy purposes, both fossil and biogenic CO_2 should be estimated. Only fossil CO_2 should be included in national emissions under Energy Sector while biogenic CO_2 should be reported as an information item also in the Energy Sector.'* Biogenic emissions are considered to be from biomass sources and are therefore treated, like biomass renewables, as having a zero carbon emissions factor.

Current Power Generation Strategy

2.10 The existing power generation strategy combines heat production from K1 and K2 with K1 also producing electricity. The load profiles for operation of these two plant which formed the basis of the assessment is provided in Appendix 1. This data was provided by E.ON UK and developed in conjunction with data from St Regis Paper Mill on steam demand.

2.11 Transport emissions have been incorporated for deliveries of key reagents (urea and activated carbon) and disposal of residues (bottom ash and APC residues). Internal movement of wastes to K2 (sludges and plastics) have been accounted for and a travel distance of 0.5km for this material is assumed. For the SRF which will be burned within the proposed SEP, in this scenario where it is landfilled an average travel distance of 30km from source to landfill site is assumed.

2.12 Bottom ash is disposed of to landfill near Peterborough at a distance of 210km from the site and APC residues to a site in Gloucester at a distance of 280km from the site.

2.13 Emissions associated with energy to deliver natural gas from the network to the site has been excluded.

2.14 Process Emissions. Process releases from combustion of natural gas in K1 are based on the thermal input data for this plant in Appendix 1. Process contributions from K2 include only the non-biogenic releases, biogenic releases are calculated but are not included in the overall carbon balance reported.

2.15 For the waste streams which will be burned within the proposed SEP (K3), under this scenario it is assumed that these are sent to landfill. Greenhouse gas emissions are released from a landfill site over time as the waste degrades. The emissions from waste landfilled have been estimated using the default greenhouse gas IPCC methodology1. This method treats greenhouse gas emissions as if they have been produced instantaneously after the waste has been landfilled. This approximation which is reasonable for the purposes of this study, where the main focus is on the estimation of emissions from the energy recovery plant.

2.16 Key parameters are:

- Degradable organic carbon content (DOC) – fraction of waste that is biodegradable carbon.
- Dissimilable DOC – fraction of DOC that mineralises to CO_2 and or CH_4. The remainder is assumed not to degrade to gaseous products under the landfill conditions.
- Methane content of the landfill gas (the rest is assumed to be carbon dioxide).

2.17 For this study we have assumed the following:

- 60% of landfill gas is CH_4 (the remainder is short-cycle CO_2).

[1] Intergovernmental Panel on Climate Change 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5 Waste.

- CH_4 usable capture rate at landfill is 50% of the methane after accounting for oxidisation
- CH_4 oxidisation to CO_2 by microbes is not assumed in this assessment
- Landfill gas engine efficiency is 37.5%
- While emissions occur over a long time period assessment has been completed assuming that all emissions arise today.

2.18 Avoided emissions. Avoided emissions from the onsite power plant are also considered to account for variations in generating efficiency compared with similar energy supplied from the grid. Avoided emissions as a result of the generation of electricity from landfill gas via onsite landfill gas engines are also accounted for. This avoids the need to generate the equivalent electricity using conventional fossil fuel generation. The emissions factors applied are described in **Box 2.**

2.19 As waste can be preserved in the anaerobic conditions that exist within the structure of a landfill site, a proportion of the short-cycle CO_2 that would have been released as biodegradable waste degrades is locked up. In assessing the carbon emissions from a landfilled process we have included the avoidance of the release of such carbon as a credit to the carbon footprint. The logic for this step is that such carbon is prevented from re-entering the natural carbon cycle for at least 100 years and therefore results in a net reduction within the 100-year time horizon. This is calculated as the difference between the DOC and DDOC.

2.20 Disposal. It is assumed that K2 produce inert residues (bottom ash and APC residues) that do not result in the production of methane when disposed of at the landfill site.

Box 2: Electricity and Heat Displaced – Greenhouse Gas Emissions Factors

Energy can be recovered in usable forms via heat or electricity. If processes result in the production of heat or electricity for export and use, this can avoid the need to take electricity from the national grid or to combust fossil fuels to produce heat.

To enable a consistent assessment of the emissions avoided through the recovery of heat it was necessary to derive emissions factors that can be applied to every unit of heat or electricity captured and used.

Electricity

Electricity has been assumed to displace electricity drawn from the national grid. As the electricity in the grid comprises coal, oil, gas, nuclear and renewable origins it is necessary to account for all these sources in the emissions factors. Data from Table 5-6 of the Digest of UK Energy Statistics 2008 (DUKES) provides the total fuel used, and electricity generated and supplied in the UK. This was used to derive the total CO_2 for the year using the emissions factors related to fuel consumption from DEFRA 2009 as outlined in the table below. Finally the total CO_2 was divided by the total electricity supplied (including Nuclear and renewables) to provide the composite emissions factor:

Fuel type	GWh fuel used	tCO_2 released	GWh Energy supplied	Proportion of total generation	tCO_2 release/MWh generated	Generation weighted emissions factor (tCO_2/MWh)
	a	b = a x EF	c	d	e = b / (c x 1000)	e x d
Coal	371,396	115,151,330	125,559	38%	0.92	0.34
Oil	8,718	2,312,885	1,949	1%	1.19	0.01
Gas	319,836	58,715,493	146,452	44%	0.40	0.18
Total		176,179,708	333,783			**0.53**

Where: EF = emissions factors coal 0.31 $kgCO_2$/kWh; fuel oil 0.265 $kgCO_2$/kWh; and gas 0.18 $kgCO_2$/kWh. Note it was assumed for the purposes of this assessment that nuclear and renewables have greenhouse gas emissions factors of zero.

An emissions factor of 0.53 $kgCO_2$/kWh electricity supplied was obtained. As a sensitivity test the long-term projected emissions factor of 0.43 $kgCO_2$/kWh was also applied.

Heat

There are a number of possible outlets for heat that have been divided into two generic categories for this assessment: industrial and domestic/commercial.

Industrial heat displacement assumes that the fuel displaced is gas (with an emissions factor of 0.19 $kgCO_2$/kWh) and a conversion efficiency of 75% to 90%. This provides an industrial heat displacement emissions factor of 0.21 to 0.25 $kgCO_2$/kWh.

Proposed Energy Generation Strategy

2.21 The proposals provide for replacement of some electrical power and heat currently provided by K1 (burning natural gas) with heat and electricity from burning SRF within the new SEP (K3).

2.22 The SEP facility processes SRF reducing the bulk of the waste to an inert inorganic ash residue which is recycled. Biogenic carbon compounds are oxidised to short-cycle CO_2 and water vapour which are discharged to the atmosphere. Fossil carbon compounds are also oxidised, however, these form non-biogenic CO_2 and other compounds which are discharged to the atmosphere.

2.23 Transport. Emissions from transport have been assessed based on the same assumptions outlined above for the current scenario with the exception that the SRF is sent to the proposed SEP and not to landfill with an average journey distance of 100km.

2.24 In addition K3 produces bottom ash and APC residues. The bottom ash is to be reused and a transport distance of 100km is assumed, whilst for the APC residues it is assumed that these will be disposed of at the same site used to dispose of the APC residues for K2, at a distance of 175km from the site. Ferrous and non ferrous metals are recovered and transported 50km to a recovery site.

2.25 K3 also requires reagent supply. Activated carbon is assumed to be sourced from the same location as that used in K2. Ammonium hydroxide and lime are assumed to be sourced within a distance of 500 km from the site.

2.26 Process emissions. Process emissions arise from the combustion of the natural gas, waste sludge and SRF in K1, K2 and K3 respectively. Emissions reported in the balance exclude biogenic releases although in line with IPPC guidelines1 these have been calculated for information purposes.

2.27 Avoided emissions. As noted above it is possible for energy to be recovered in the form of heat and electricity avoided emissions for the proposed scenario have been evaluated on a similar basis to those for the existing scenario. In addition it is assumed that ferrous metals are recovered at an efficiency of 95% from the bottom ash and non-ferrous metals are recovered at an efficiency of 70% from the bottom ash. Further the reuse of the treated bottom ash as aggregate avoids the need for virgin aggregate extraction with associated energy savings. It is assumed that 100% of the treated bottom ash is reused. The emissions saved from this recovery are defined in Table 2.1.

2.28 It is also possible to avoid emissions through the sale of the combustion residues to the construction industry, again avoiding the need to consume resources in the production of virgin materials. For this assessment given that ash processing plant is incorporated it has been assumed that all suitable residues will be re-used and a transport distance of 100 km has been assumed for this material.

2.29 Disposal. It is assumed that the SEP and K2 produce inert ash that does not result in the production of methane when disposed of at the landfill site.

Table 2.1: Emissions avoided via materials recovery

Materials Composition	Unit	Avoided Emissions
Aggregate	t CO_2 / t	0.0023
Ferrous metal	t CO_2 / t	1.487
Non-ferrous metal	t CO_2 / t	9.074

Source adapted from: AEAT 2001[2], Defra 2006[3]

Type of Fuel

2.30 This study assesses the greenhouse gas footprint for the existing and proposed energy strategies at the Kemsley and Sittingbourne Paper Mill Installation. Incorporating the proposed SEP facility, which will primarily burn a combination of solid recovered fuel (SRF); commercial and industrial (C&I) waste and municipal solid waste (MSW). For the purpose of this assessment it is assumed that C&I wastes will have a similar composition to that for MSW. The SEP will also accept a small amount of plastic rich waste produced from the St Regis Paper Mill operations and which is in excess of that which can be burned within the existing sludge combustor.

2.31 The basis of the assessment assumes up to 550,000 tonnes per annum of SRF input into the SEP including plastics from the paper mill. For the purpose of the assessment the split of waste fractions is assumed to be as follows:

- 52% SRF
- 19% C&I similar to MSW
- 24% MSW having undergone some pre-treatment
- 5% Plastics

2.32 In determining the composition for the SRF fraction it has been assumed that the SRF will have been generated from intermediate waste management facilities providing mechanical and biological treatment (MBT) of residual MSWs. The composition of the feed SRF has been taken from other similar facilities.

[2] AEAT 2001, Waste management options and climate change, Study for European Commission Environment DG.

[3] Defra 2006, Carbon balances and energy impacts of the management of UK wastes, R&D project completed for Defra by ERM and Golder Associates

2.33 The composition of the waste assumed for this assessment is provided in Table 2.2 and Table 2.3:

Table 2.2: Assumed Composition of Waste from the Paper Mill

Materials Composition	K2 Waste Composition (%)[a]
Paper	0.0
Cardboard	57.7
Plastic film	13.8
Dense plastics	0.0
Textiles	0.0
Miscellaneous non-combustibles (including soil)	28.5
Glass	0.0
Putrescibles (including garden and kitchen waste)	0.0
Ferrous metal	0.0
Non-ferrous metals (cans)	0.0
Miscellaneous combustibles (inc. furniture, nappies and fines)	0.0

Source: Adapted from St Regis Paper Mill analysis

Table 2.3: Assumed Composition of SRF

Materials Composition	MSW and C&I waste composition (%)[a]	SRF Composition (%)[b]	Plastic rich stream from paper mill (%)[c]	Combined (%)	Total carbon content % dry waste [d]	Fossil carbon fraction % of total carbon (%)[e]	Proportion of total carbon degradable (%)[e]	Dissimilable Degradable Organic Carbon, DDOC (%)[f]
Paper	14.0	17.5	0.0	15.2	39.1	1	100	13.7
Cardboard	7.0	17.5	43.2	14.2	39.1	1	100	13.7
Plastic film	2.8	4.5	43.2	5.6	47.8	100	0	0
Dense plastics	4.5	8.8	0.0	6.6	54.8	100	0	0
Textiles	1.8	3.2	0.0	2.5	39.8	50	50	6
Miscellaneous non-combustibles (including soil)	10.8	0.0	13.7	5.3	n/a	n/a	n/a	n/a
Glass	5.8	0.7	0.0	2.8	n/a	n/a	0	n/a
Putrescibles (including garden and kitchen waste)	30.5	29.7	0.0	28.7	18.7	0	100	12
Ferrous metal	4.7	0.1	0.0	2.0	n/a	n/a	0	n/a
Non-ferrous metals (cans)	0.8	0.0	0.0	0.3	n/a	n/a	0	n/a
Miscellaneous combustibles (inc. furniture, nappies and fines)	17.3	18.0	0.0	16.9	38.4	50	75	10.1

- a Source: Adapted from EA Wrate 2006
- b From operational plant
- c From discussions with Kemsley Mill
- d Source: Adapted from Environment Agency 1994 and Defra 2006[4]
- e Source: Adapted from IPCC 2006[5]
- f Source: Calculated

[4] Environment Agency 1994, National Household Waste Analysis Project
[5] IPCC 2006, Intergovernmental Panel on Climate Change, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Waste.

3 Results

3.1 This section summarises the results of the analysis.

Table 3.1: Summary of results (tCO_2 equivalent)

Assessment option	Transport	Process	Avoided	Total
Current Operation				
Energy Generation from K1 and K2; K3 wastes to landfill	2,813	572,805 to 583,221	(144,471) to (91,237)	431,147 to 494,797
Proposed Facility				
Energy Generation from K1, K2 and K3	10,513	547,071	(250,010) to (171,155)	307,575 to 386,430

Notes:
Please refer to the assumptions underpinning this analysis as described in earlier sections of this report.
The tonnes equivalent are presented as ranges to encompass the different CO_2 intensities assumed for the provision/use of electricity and heat as set out earlier in the report.
Figures in brackets represent a GHG saving; figures without brackets represent a GHG emission.
Biogenic releases from burning of wastes for each of the two scenarios is as follows
Current Operation 67,872 tCO_2 equivalent per annum
Proposed Operation 480,129 tCO_2 equivalent per annum

3.2 Both current and proposed options give rise to net green house gas emissions from the production of energy and supply to the site. This would be expected given the including of fossil carbon within the fuels burned. However, considering the potential annual emissions from the current and proposed scenarios it can be seen that there is a net saving in emissions from generating energy from the proposed SEP. The net annual greenhouse gas emissions saving (i.e. the difference between the total current green house gas emissions and total proposed green house gas emissions as indicated in Table 3.1) ranges from approximately 108,000 to 124,000 tCO_2 equivalent emissions per annum.

3.3 Further, if the greenhouse gas savings from avoiding sending waste to landfill are also included then additional savings of between 114,000 – 130,000 tonnes per annum are achieved thereby providing net savings of between 237,000 – 238,000 tonnes per annum.

3.4 Although the proposals do not give rise to zero emissions of greenhouse gases, compared to the existing power generating plant substantial savings equivalent to the annual emissions of greenhouse gases from approximately 40,000 homes or 96,000 cars could be achieved.

4 Effect on Plant Efficiency

4.1 Whilst the greenhouse gas performance has been considered in the previous sections, consideration of energy efficiency is also important. Based on the current and proposed operational scenarios which formed the basis of the greenhouse assessment the effect on plant efficiency has also been considered. This analysis is detailed within Appendix 1 and summarised in Table 4.1 below:

Table 4.1: Efficiency Comparison

Assessment Option	Integrated Plant Efficiency (%)	Integrated Fossil Fuel Plant Efficiency (%)
Energy Generation from K1 and K2; K3 wastes to landfill	80	84
Energy Generation from K1, K2 and K3.	61	96

4.2 The comparison provided in Table 4 indicates that whilst the overall effect from including the proposed SEP lowers the combined efficiency, if analysis considers the effect on fossil carbon efficiency there are significant benefits providing over a 10% increase in the integrated plant efficiency.

5 Conclusions

5.1 The assessment of the potential carbon footprint for the existing and proposed energy generation options shows that the proposed SEP facility performs well, providing an estimated reduction in the greenhouse gas emissions footprint compared with the current energy plant.

5.2 The estimates within this study indicate that between approximately 237 and 238 thousand tonnes of CO_2 equivalent emissions per annum could be avoided through the installation of the facility (if all assumptions remain constant) and accounting for savings from avoided emissions from landfill. This equates to the annual emissions from approximately 40,000 homes or 96,000 cars.

5.3 Further, over the expected life time of the facility (assumed to be 25 years) this amounts to savings of between 5.9 and 6.0 million tonnes of CO_2 equivalent emissions.

5.4 In addition to significant greenhouse gas benefits, the proposals also provide clear efficiency benefits, increasing the overall fossil fuel energy efficiency from 84% to 96%.

5.5 In summary, the proposal is anticipated to have a positive impact on greenhouse gas emissions, particularly when compared with current practice and provide significant fossil energy efficiency benefits.

APPENDICES

APPENDIX 1

Steam Load and Efficiency Calculations

The Table below details the steam and electrical consumption for the proposed operations, with steam and electricity being provided by K1, K2 and K3

Site Energy Demand (data from St Regis).								% of year in operating mode		Steam Flows (kg/s) to meet site demand.					Predicted Fuel Inputs (MW LHV)				Predicted Turbine Loads (Gross MWe)			Predicted Generation (Nett MWe)		Predicted LP Steam Load (MWt @ 10 Bar-230 Deg C)			Integrated Plant Nett Efficiency (%).	
Machines Running	% of year	t/hr	MW(e)	kg/s	GT Nox Steam (kg/s)	Total Demand (kg/s)	K1, K2 & K3 Integrated Plant Operating Mode.	K2 Load Factor (%)	% of year	K3	K2	K1	Total Capacity	K3 Average	K3 ST	K1 (GT + HRSGs)	K2 Gas	K2 Solid Fuel).	K3 ST	K1 ST	K1 GT	K3 ST	K1 (ST + GT)	K3	K2	K1		
0	0.20	15	15	4.17	3.50	7.67	K1 Off, K2 Running, K3 no steam export (additional MWe).	75.00	0.15	0.00	9.00	0.00	9.00	0.00	200	0	9	20	54	0	0	48	0	0	22	0	0.30	0.00
							K1 Package Boiler, K2 Outage, K3 no steam export (additional MWe).	25.00	0.05	0.00	0.00	8.00	8.00	0.00	200	27	0	0	54	0	0	48	0	0	0	23	0.31	0.00
1	3.90	105	30	29.17	3.50	32.67	K1 Off, K2 Running, K3 controlling steam load (reduced MWe).	75.00	2.93	24.00	9.00	0.00	33.00	0.70	200	0	9	20	39	0	0	33	0	70	26	0	0.56	0.02
							K1 Off, K2 Outage, K3 controlling steam load (additional MWe).	25.00	0.98	18.00	0.00	15.00	33.00	0.18	200	124	0	0	42	0	40	36	38	52	0	43	0.52	0.01
2	28.30	160	47	44.44	3.50	47.94	K1 Running, K2 Running, K3 controlling steam load (reduced MWe).	75.00	21.23	24.00	9.00	15.00	48.00	5.09	200	124	9	20	39	0	40	33	37	70	26	43	0.59	0.13
							K1 Running, K2 Outage, K3 controlling steam load (additional MWe).	25.00	7.08	18.00	0.00	30.00	48.00	1.27	200	193	0	0	42	11	40	36	49	52	0	87	0.57	0.04
3	67.60	215	58	59.72	3.50	63.22	K1 controlling steam load, K2 Running, K3 Running.	75.00	50.70	21.00	9.00	33.00	63.00	10.65	200	203	9	20	41	13	40	34	50	61	26	96	0.62	0.31
							K1 controlling steam load, K2 Outage, K3 Running.	25.00	16.90	21.00	0.00	42.00	63.00	3.55	200	232	0	0	41	18	40	34	56	61	0	122	0.63	0.11
									100.00	**K3 Annual Average**				**21.44**													**Annual Eff**	
										K3 Annual Average (t/hr)				**77.19**													**60.65**	
4	N/A	287		79.72	3.5	83.22	K1 controlling steam load, K2 Running, K3 Running.	75	N/A	21	9	53	83.00	N/A	200	267	9	20	43	24	40	36	61	61	26	154	0.68	N/A
	N/A	287		79.72	3.5	83.22	K1 controlling steam load, K2 Running, K3 Running.	25	N/A	21	0	62	83.00	N/A	200	296	0	0	43	31	40	36	68	61	0	180	0.70	N/A

Proposed Model

Predicted Fuel Inputs (MWh LHV)				Predicted Turbine Loads (Gross MWhe)			Predicted Generation (Nett MWhe)		Predicted LP Steam Load (MWht @ 10 Bar-230 Deg C)		
K3 ST	**K1 (GT + HRSGs)**	**K2 Gas**	**K2 Solid Fuel).**	**K3 ST**	**K1 ST**	**K1 GT**	**K3 ST**	**K1 (ST + GT)**	**K3**	**K2**	**K1**
2628	0	118.26	262.8	709.56	0	0	624.15	0	0	289.08	0
876	118.26	0	0	236.52	0	0	208.05	0	0	0	101.54592
51246	0	2306.07	5124.6	9992.97	0	0	8327.475	0	17821.309	6682.9909	0
17082	10590.84	0	0	3604.302	0	3416.4	3049.137	3224.2275	4455.3272	0	3712.7727
371862	230554.44	16733.79	37186.2	72513.09	0	74372.4	60427.575	68794.47	129318.73	48494.523	80824.206
123954	119615.61	0	0	26154.294	6817.47	24790.8	22125.789	30213.788	32329.682	0	53882.804
888264	901587.96	39971.88	88826.4	179873.46	55516.5	177652.8	151004.88	219845.34	270289.85	115838.51	424741.2
296088	343462.08	0	0	59957.82	26647.92	59217.6	50334.96	82534.53	90096.618	0	180193.24
1752000	**1605929.2**	**59130**	**131400**	**353042.02**	**88981.89**	**339450**	**296102.02**	**404612.36**	**544311.52**	**171305.1**	**743455.76**

The Table below details calculates the combined efficiency and combined fossil fuel efficicency for the proposed operations, with steam and electricity being provided by K1, K2 and K3

Site Energy Demand (data from St Regis).								% of year in operating mode		Steam Flows (kg/s) to meet site demand.					Predicted Fuel Inputs (MW LHV)				Predicted Turbine Loads (Gross MWe)			Predicted Generation (Nett MWe)		Predicted LP Steam Load (MWt @ 10 Bar-230 Deg C)			Integrated Plant Nett Efficiency (%).	
Machines Running	**% of year**	**t/hr**	**MW(e)**	**kg/s**	**GT Nox Steam (kg/s)**	**Total Demand (kg/s)**	**K1, K2 & K3 Integrated Plant Operating Mode.**	**K2 Load Factor (%)**	**% of year**	**K3**	**K2**	**K1**	**Total Capacity**	**K3 Average**	**K3 ST**	**K1 (GT + HRSGs)**	**K2 Gas**	**K2 Solid Fuel).**	**K3 ST**	**K1 ST**	**K1 GT**	**K3 ST**	**K1 (ST + GT)**	**K3**	**K2**	**K1**		
0	0.20	15	15	4.17	3.50	7.67	K1 Off, K2 Running, K3 no steam export (additional MWe).	75.00	0.15	0.00	9.00	0.00	9.00	0.00	66	0	9	6	54	0	0	48	0	0	22	0	0.86	0.00
							K1 Package Boiler, K2 Outage, K3 no steam export (additional MWe).	25.00	0.05	0.00	0.00	8.00	8.00	0.00	66	27	0	0	54	0	0	48	0	0	0	23	0.76	0.00
1	3.90	105	30	29.17	3.50	32.67	K1 Off, K2 Running, K3 controlling steam load (reduced MWe).	75.00	2.93	24.00	9.00	0.00	33.00	0.70	66	0	9	6	39	0	0	33	0	70	26	0	1.58	0.05
							K1 Off, K2 Outage, K3 controlling steam load (additional MWe).	25.00	0.98	18.00	0.00	15.00	33.00	0.18	66	124	0	0	42	0	40	36	38	52	0	43	0.89	0.01
2	28.30	160	47	44.44	3.50	47.94	K1 Running, K2 Running, K3 controlling steam load (reduced MWe).	75.00	21.23	24.00	9.00	15.00	48.00	5.09	66	124	9	6	39	0	40	33	37	70	26	43	1.02	0.22
							K1 Running, K2 Outage, K3 controlling steam load (additional MWe).	25.00	7.08	18.00	0.00	30.00	48.00	1.27	66	193	0	0	42	11	40	36	49	52	0	87	0.86	0.06
3	67.60	215	58	59.72	3.50	63.22	K1 controlling steam load, K2 Running, K3 Running.	75.00	50.70	21.00	9.00	33.00	63.00	10.65	66	203	9	6	41	13	40	34	50	61	26	96	0.94	0.47
							K1 controlling steam load, K2 Outage, K3 Running.	25.00	16.90	21.00	0.00	42.00	63.00	3.55	66	232	0	0	41	18	40	34	56	61	0	122	0.91	0.15
									100.00	**K3 Annual Average**				**21.44**													**Annual Eff**	
										K3 Annual Average (t/hr)				**77.19**													**96.23**	
4	N/A	287		79.72	3.5	83.22	K1 controlling steam load, K2 Running, K3 Running.	75	N/A	21	9	53	83.00	N/A	200	267	9	20	43	24	40	36	61	61	26	154	0.68	N/A
	N/A	287		79.72	3.5	83.22	K1 controlling steam load, K2 Running, K3 Running.	25	N/A	21	0	62	83.00	N/A	200	296	0	0	43	31	40	36	68	61	0	180	0.70	N/A

Predicted Fuel Inputs (MWh LHV)				Predicted Turbine Loads (Gross MWhe)			Predicted Generation (Nett MWhe)		Predicted LP Steam Load (MWht @ 10 Bar-230 Deg C)		
K3 ST	**K1 (GT + HRSGs)**	**K2 Gas**	**K2 Solid Fuel).**	**K3 ST**	**K1 ST**	**K1 GT**	**K3 ST**	**K1 (ST + GT)**	**K3**	**K2**	**K1**
869.868	0	118.26	78.84	709.56	0	0	624.15	0	0	289.08	0
289.956	118.26	0	0	236.52	0	0	208.05	0	0	0	101.54592
16962.426	0	2306.07	1537.38	9992.97	0	0	8327.475	0	17821.309	6682.9909	0
5654.142	10590.84	0	0	3604.302	0	3416.4	3049.137	3224.2275	4455.3272	0	3712.7727
123086.32	230554.44	16733.79	11155.86	72513.09	0	74372.4	60427.575	68794.47	129318.73	48494.523	80824.206
41028.774	119615.61	0	0	26154.294	6817.47	24790.8	22125.789	30213.788	32329.682	0	53882.804
294015.38	901587.96	39971.88	26647.92	179873.46	55516.5	177652.8	151004.88	219845.34	270289.85	115838.51	424741.2
98005.128	343462.08	0	0	59957.82	26647.92	59217.6	50334.96	82534.53	90096.618	0	180193.24
579912	**1605929.2**	**59130**	**39420**	**353042.02**	**88981.89**	**339450**	**296102.02**	**404612.36**	**544311.52**	**171305.1**	**743455.76**

The Table below details the steam and electrical consumption for the current operations, with steam and electricity being provided by K1 and K2																						
Site Energy Demand (data from St Regis).							**K1 & K2 Integrated Plant Operating Mode.**	**% of year in operating mode.**		**Steam Flows (kg/s) to meet site demand.**			**Predicted Fuel Inputs (MW LHV)**			**Predicted Turbine Loads (Gross MWe)**		**Predicted Generation (Nett**	**Predicted LP Steam Export (MWt @ 10 Bar**		**Integrated Plant Efficiency (%).**	
Machines Running	**% of year**	**t/hr**	**MW(e)**	**kg/s**	**GT Nox Steam (kg/s)**	**Total Demand (kg/s)**		**K2 Load Factor (%)**	**% of year**	**K2**	**K1**	**Total Capacity**	**K1 (GT + HRSGs)**	**K2 Gas**	**K2 Solid Fuel).**	**K1 ST**	**K1 GT**	**K1 (ST + GT)**	**K2**	**K1**		
0	0.20	15	15	4.17	3.50	7.67	K1 Off, K2 Running.	75.00	0.15	9.00	0.00	9.00	0	9	20	0	0	0	22	0	0.76	0.00
							K1 Package Boilers, K2 Outage.	25.00	0.05	0.00	8.00	8.00	27	0	0	0	0	0	0	23	0.86	0.00
1	3.90	105	30	29.17	3.50	32.67	K1 & K2 Running.	75.00	2.93	9.00	24.00	33.00	183	9	20	7	40	44	26	70	0.66	0.02
							K1 Running, K2 Outage.	25.00	0.98	0.00	33.00	33.00	203	0	0	13	40	50	0	96	0.72	0.01
2	28.30	160	47	44.44	3.50	47.94	K1 & K2 Running.	75.00	21.23	9.00	39.00	48.00	222	9	20	16	40	53	26	113	0.77	0.16
							K1 Running, K2 Outage.	25.00	7.08	0.00	48.00	48.00	250	0	0	21	40	59	0	139	0.79	0.06
3	67.60	215	58	59.72	3.50	63.22	K1 & K2 Running.	75.00	50.70	9.00	54.00	63.00	269	9	20	25	40	62	26	156	0.82	0.42
							K1 Running, K2 Outage.	25.00	16.90	0.00	63.00	63.00	300	0	0	31	40	69	0	183	0.84	0.14
																					Annual Eff	
																					0.80	
4	N/A	287		79.72	3.5	83.22	K1 & K2 Running.	75	N/A	9	74	83.00	336	9	20	34	40	71	26	214	0.85	N/A
	N/A	287		79.72	3.5	83.22	K1 Running, K2 Outage.	25	N/A	0	83	83.00	367	0	0	35	40	72	0	241	0.85	N/A

Current Model

Predicted Fuel Inputs (MW LHV)			Predicted Turbine Loads (Gross MWe)		Predicted Generation (Nett	Predicted LP Steam Export (MWt @ 10 Bar - 230 Deg C)	
K1 (GT + HRSGs)	**K2 Gas**	**K2 Solid Fuel).**	**K1 ST**	**K1 GT**	**K1 (ST + GT)**	**K2**	**K1**
0	118	263	0	0	0	289	0
118	0	0	0	0	0	0	102
46890	2306	5125	1794	10249	11274	6683	17821
17338	0	0	1068	3416	4292	0	8168
412767	16734	37186	29749	74372	98543	48495	210143
154943	0	0	13015	24791	36411	0	86212
1194715	39972	88826	111033	177653	275362	115839	695031
444132	0	0	45894	59218	101780	0	270290
2270903	**59130**	**131400**	**202552**	**349699**	**527663**	**171305**	**1287767**

The Table below details calculates the combined efficiency and combined fossil fuel efficicency for the current operations, with steam and electricity being provided by K1 and K2

Site Energy Demand (data from St Regis).							K1 & K2 Integrated Plant Operating Mode.	% of year in operating mode.		Steam Flows (kg/s) to meet site demand.			Predicted Fuel Inputs (MW LHV)			Predicted Turbine Loads (Gross MWe)		Predicted Generation (Nett	Predicted LP Steam Export (MWt @ 10 Bar		Integrated Plant Efficiency (%).	
Machines Running	**% of year**	**t/hr**	**MW(e)**	**kg/s**	**GT Nox Steam (kg/s)**	**Total Demand (kg/s)**		**K2 Load Factor (%)**	**% of year**	**K2**	**K1**	**Total Capacity**	**K1 (GT + HRSGs)**	**K2 Gas**	**K2 Solid Fuel).**	**K1 ST**	**K1 GT**	**K1 (ST + GT)**	**K2**	**K1**		
0	0.20	15	15	4.17	3.50	7.67	K1 Off, K2 Running.	75.00	0.15	9.00	0.00	9.00	0	9	6	0	0	0	26	0	1.74	0.00
							K1 Package Boilers, K2 Outage.	25.00	0.05	0.00	8.00	8.00	27	0	0	0	0	0	0	23	0.86	0.00
1	3.90	105	30	29.17	3.50	32.67	K1 & K2 Running.	75.00	2.93	9.00	24.00	33.00	183	9	6	7	40	44	26	70	0.71	0.02
							K1 Running, K2 Outage.	25.00	0.98	0.00	33.00	33.00	203	0	0	13	40	50	0	96	0.72	0.01
2	28.30	160	47	44.44	3.50	47.94	K1 & K2 Running.	75.00	21.23	9.00	39.00	48.00	222	9	6	16	40	53	26	113	0.81	0.17
							K1 Running, K2 Outage.	25.00	7.08	0.00	48.00	48.00	250	0	0	21	40	59	0	139	0.79	0.06
3	67.60	215	58	59.72	3.50	63.22	K1 & K2 Running.	75.00	50.70	9.00	54.00	63.00	269	9	6	25	40	62	26	156	0.86	0.44
							K1 Running, K2 Outage.	25.00	16.90	0.00	63.00	63.00	300	0	0	31	40	69	0	183	0.84	0.14
																					Annual Eff	
																					83.69	
4	N/A	287		79.72	3.5	83.22	K1 & K2 Running.	75	N/A	9	74	83.00	336	9	20	34	40	71	26	214	0.85	N/A
	N/A	287		79.72	3.5	83.22	K1 Running, K2 Outage.	25	N/A	0	83	83.00	367	0	0	35	40	72	0	241	0.85	N/A

Predicted Fuel Inputs (MW LHV)			Predicted Turbine Loads (Gross MWe)		Predicted Generation (Nett	Predicted LP Steam Export (MWt @ 10 Bar - 230 Deg C)	
K1 (GT + HRSGs)	**K2 Gas**	**K2 Solid Fuel).**	**K1 ST**	**K1 GT**	**K1 (ST + GT)**	**K2**	**K1**
0	118	79	0	0	0	343	0
118	0	0	0	0	0	0	102
46890	2306	1537	1794	10249	11274	6683	17821
17338	0	0	1068	3416	4292	0	8168
412767	16734	11156	29749	74372	98543	48495	210143
154943	0	0	13015	24791	36411	0	86212
1194715	39972	26648	111033	177653	275362	115839	695031
444132	0	0	45894	59218	101780	0	270290
2270903	**59130**	**39420**	**202552**	**349699**	**527663**	**171359**	**1287767**