twma

LOW CARBON DRILLING.

TCC ROTOMILL WELLSITE PROCESSING VS SKIP & SHIP.

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TWMA.
The world's drilling waste specialist.

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY.

The key aim of this project is to establish the comparative carbon footprint for a portable TCC-RotoMill unit treating drill cuttings on a standard offshore platform versus that of a typical skip and ship to shore operation whereby cuttings are transported and treated at an onshore treatment facility; a further requirement was to develop a carbon calculator to enable TWMA and their clients to establish the carbon footprint for any well within the North Sea.

TWMA already have various environmental initiatives in place including ISO 14001 certification; they are members of the Business Environment Partnership and the Chartered Institution of Wastes Management. The company have provided the oil and gas sector with specialist equipment and services since 2000; they operate on a global scale and are at the forefront of reducing the environmental impact of drilling and other associated wastes. TWMA has a significant interest in treating the drill cuttings associated with oil and gas drilling activity the company has developed the only portable TCC-RotoMill for use on offshore platforms. Although this treatment method has been perceived to have less of an environmental impact than that of a skip and ship to shore operation; the company were keen to establish the carbon footprint comparison between each method.

This report establishes the system boundaries and highlights the methodology for each process associated with each method of treatment; calculations have been included to establish the CO2e emissions associated with each of these processes. Alongside this report a carbon calculator has been developed to assist TWMA and their clients in identifying the comparative carbon footprint associated with each method of treatment, for any well within the North Sea.

Results reveal the carbon footprint of the current skip and ship operation is almost 2 times that of a portable unit treating at source on an offshore platform. Furthermore, and based on the lower estimate of drill cuttings produced on the UK Continental Shelf, additional benefits will include the diversion of 28,000 tonnes of waste powder from landfill; 6000m^3 of produced oil will be re-used in the offshore drilling system and 6000m^3 of water would require no further wastewater treatment. This project has also increased the awareness of the CO2e emissions associated with each process and highlights where future savings may be made.

2 INTRODUCTION TO GHG.

In response to the increased awareness of global warming, countermeasures against greenhouse gas emissions were prepared by the United Nations Conference on Environment and Development [UNCED] at the Rio Earth Summit held in Brazil in 1992. Since then, international efforts have continued to reduce greenhouse gas emissions through the Kyoto Protocol in 1997 and the Copenhagen Accord in 2009. Most Recently, the Paris Climate Agreement was signed which aims to bring all nations into a common cause to undertake more ambitious efforts to combat climate change and adapt to its effects.

Many countries around the world have outlined action plans to reduce greenhouse gas emissions and are preparing policies that include their reduction goals. Among developed countries, examples of reduction goals by the year 2020 include 34% in the UK, 20% in the EU, 17% in the US and 15% in Japan. **[1]**

Concern over climate change has stimulated interest in estimating the total amount of greenhouse gasses [GHG] produced during the different stages in the —life cycle of goods and services — i.e. their production, processing, transportation, sale, use and disposal. The outcome of these calculations is often referred to as —product carbon footprints [PCFs], where 'carbon footprint' is the total amount of GHGs produced for a given activity and 'product' is any goods or services that are marketed. PCFs are thus distinct from GHG assessments performed at the level of projects, corporations, supply chains, municipalities, nations or individuals.

Product carbon footprinting is currently dominated by private standards and by certification schemes operated by small for-profit and not-for-profit consultancy companies and in a few cases by large retailers and manufacturers. Government support to PCF schemes and standards has been limited so far. The exceptions are the PAS 2050 standard, the development of which was supported by the UK Department for Environment, Food and Rural Affairs [Defra]; Japan's pilot Carbon Footprint Scheme, launched in April 2009; and the assistance provided by the French Agence de l'Environnement et de la Maîtrise de l'Energie [ADEME] in the development of a scheme operated by the food retailer Casino. At the international level, PCF standards are being developed by the World Resources Institute [WRI] and the World Business Council for Sustainable Development [WBCSD-WRI], through its Greenhouse Gas Protocol; and by the International Office for Standardisation. international level, PCF standards are being developed by the World Resources Institute [WRI] and the World Business Council for Sustainable Development [WBCSD-WRI], through its Greenhouse Gas Protocol; and by the International Office for Standardisation. **[2]**

[1] Woosik Jang, Hyun-Woo You [2015] *Quantitative Decision-Making Model for Carbon Reduction in Road Construction Projects Using Green Technologies*. Sustainability, 7 [1], pp.11240-11259

[2] Simon Bolwig, Peter Gibbon [2009] *Counting Carbon in the Marketplace*. Global Forum on Trade: Trade and Climate Change, OECD.

3 SCOPE, AIMS AND OBJECTIVES.

Aims and Objectives.

The primary aim of this project is to establish a carbon footprint comparison for the treatment of drill cuttings between the use of a mobile TCC-RotoMill unit [see Section 6 for a fuller description] on an offshore platform in the North Sea, as compared to the carbon footprint of a similar skip and ship to shore operation whereby cuttings are transported to the company's Peterhead treatment facility; further to this a Carbon Footprinting Calculator was an additional requirement to assist clients in identifying the comparative CO2e emissions associated with each method of treatment for any well within the North Sea.

- Investigate the carbon footprinting process and interpret recognised guidance before setting system boundaries and emission scopes;
- Calculate the carbon footprint associated with each method of treatment;
- Develop a Carbon calculator to establish a carbon footprint comparison for any well within the North Sea.

Scope - System Boundaries.

The PAS 2050 Guide defines the system boundary as "the scope for the product carbon footprint, i.e. which life cycle stages, inputs and outputs should be included in the assessment".

Therefore, before any data collection or analysis could be carried out, the TCC-RotoMill technology and processes needed to be understood. The PAS 2050 guide explains how to calculate the Greenhouse Gas emissions associated with the life cycle of a product or service and one of the first stages of this particular project was to develop a process map [Appendix A]; this was necessary to establish the system boundaries associated with each method of treatment.

The system boundaries for each method of treatment clearly show which processes have been included and excluded from the CO2e calculation. In this instance the Life Cycle Analysis for the TCC-RotoMill will not include the extraction, refining and distribution of raw materials and the fossil fuels required to operate the TCC-RotoMill; furthermore, the TCC-RotoMill manufacturing process will not be included.

The Life Cycle Analysis for the processing of cuttings on an offshore platform will include the transportation involved in commissioning and decommissioning a portable TCC-RotoMill unit; and any direct emissions associated with the processing of cuttings. The Life Cycle Analysis for a skip and ship to shore operation will include the transportation of empty cuttings bins to the offshore platform; the transportation of full cuttings bins back to the onshore processing site at Peterhead; any direct emissions associated with the treatment of cuttings; the transportation of all wastes and any emissions associated with the further processing of water and oil. The CO2e emissions associated with landfill operations will not include within the boundary of this project.

Functional Unit.

The PAS 2050 Guide describes the functional unit as the "quantified performance of a product for use as a reference unit" [Carbon Trust, 2008]. The functional unit in this instance will be 'kg CO_2e produced per tonne of cuttings processed'; however, in this project a number of variables will need to be established before this can be measured. The variables used were as follows:

- Average platform distance from Peterhead;
- Average total well depth;
- Average total weight of cuttings produced per well.

These variables will be used to establish the baseline data required to calculate the footprint.

4 DATA REQUIREMENTS.

Baseline Requirements.

The information required to establish the baseline data included analysing data from 'End of Well Reports' for previously drilled wells using each method of treatment [3]. In total the data for nine wells from four different platforms were analysed; five of these wells employed a mobile TCC-RotoMill unit to treat cuttings offshore with the remaining four using the alternative skip and ship to shore method, transporting cuttings to the Peterhead site for treatment.

This information was used to establish the baseline data requirements; the complete data can be viewed in Appendix B, however the key requirements for calculating the carbon footprint have been summarised as follows:

- Average platform distance from Peterhead - 264km
- Average total well depth - 7,664ft
- Average total weight of cuttings produced per well - 582t

[3] TWMA has more recently been collating more information for each End of Well Report than was done previously; these wells represent the latest and most complete information for wells drilled using each method of treatment.

Additional Data Requirements.

Further to the baseline data mentioned in Section 3.1 each Scope within the footprint calculation required the collection and verification of additional data.

As previously mentioned, Scope 1 emissions relate directly to engine fuel usage and company owned vehicles; in this instance, emissions for the items in Table 4.1 were included in Scope 1.

TABLE 4.1 SCOPE 1 EMISSIONS.

Onshore Treatment Process	Offshore Treatment Process
Diesel Fuel Usage in TCC-RotoMill engine	Diesel Fuel Usage in TCC-RotoMill engine
Transportation of Powder to plastics company by company owned vehicle	

The indirect emissions associated with the use of mains electricity are incorporated into Scope 2; within the boundaries of this project the TCC-RotoMill has several processes which use electricity, these are listed in Table 4.2.

TABLE 4.2 SCOPE 2 EMISSIONS.

Onshore Treatment Process	Offshore Treatment Process
CST Unit [75kW motor]	CST Unit [75kW motor]
Feed Skid [18.5kW motor]	Feed Skid [18.5kW motor]
8 x Cooling Fans [2.2kW motors]	Cooling Pump

Emissions have been calculated for each of these items with the exception of the offshore water-cooling pump; it is understood from operational experiences that these pumps would be running on an offshore platform whether a portable TCC-RotoMill unit has been commissioned or not.

Within the boundaries of Scope 3 are the indirect emissions associated with third party road and ship transportation, none of which are owned or directly controlled by the company; further to this Scope 3 also includes emissions associated with third party processes. Table 4.3 lists the requirements for Scope 3.

TABLE 4.3 SCOPE 3 EMISSIONS.

Onshore Treatment Process	Offshore Treatment Process
Road transport of cuttings bins to/from shore	Commissioning and decommissioning road transport of a portable TCC-RotoMill unit
Ship transport of cuttings bins to/from offshore platform	Commissioning and decommissioning sea transport of a portable TCC-RotoMill unit
Road transport of produced oil to SHEP	
Waste water treatment of produced water from RotoMill	
Red diesel fuel deliveries associated with running onshore processing of drill cuttings	

5 ASSUMPTIONS.

Onshore ‘skip and ship’ processing.

In calculating the onshore ‘skip and ship’ processing of drill cuttings by TWMA at their Peterhead site, the following assumptions have been made by Carbon-Zero:

- Loading percentage of cooling fans has been estimated as 90%
- An average dead weight tonnage of 3500DWT for Supply Vessels used in North Sea commissioning of well cuttings has been taken
- A ratio split of 70/15/15% of powder/water/oil has been used as an estimate for produced element

Offshore processing.

In the calculation of the North Sea based offshore processing of drill cuttings by TWMA, the following assumptions have been made by Carbon-Zero:

- A ratio split of 70/15/15% of powder/water/oil has been used as an estimate for produced elements

6 METHODOLOGY.

This Carbon Footprint Assessment has been carried out using the UK Government GHG and BEIS Conversion Factors for 2018.

7 UNDERSTANDING THE PROCESSES.

The TCC-RotoMill process uses hammermill technology to raise the temperature of drill cuttings to approximately 260°C in order to flash evaporate oil and water from rock dust solids; this is known as thermal desorption. Both onshore and offshore treatment methods use the same TCC-RotoMill process; however, each method involves different logistical processes for the treatment of cuttings to be completed.

On a skip and ship to shore operation drill cuttings are transported from the offshore platform to the Peterhead processing site where they are treated using the afore-mentioned technology. There, the three main waste products are dealt with by differing means; recovered oil is sent to a third party as fuel for municipal incinerator or used within the site's processing plant; recovered water is treated onsite for discharge to SEPA requirements; and the recovered powder is currently sent to a plastics maker to be used as an aggregate filler material.

On a mobile TCC-RotoMill processing cuttings offshore, the treatment and disposal of waste products is greatly reduced. Owing to the relatively low temperatures associated with thermal desorption, the properties of the recovered oil remain unchanged meaning it can be reused onsite within the drill mud system; the water can safely and legally be discharged into the sea or used to dampen the rock dust powder before again being discharged into the sea, where it is dispersed by marine currents. The impact to marine life is minimal due to the low levels of oil remaining on the discharged solids which typically amounts to 0.092% of residual oil on treated cuttings [Offshore Industry Committee, 2005].

8 TABLES AND CHARTS.

Based on the data provided, site visit and discussions, the Carbon-Zero assessment and subsequent clarifications the following tables and graphs indicate the source and scale of carbon emission per Scopes, 1 2 & 3 of the GHG Protocol. (Fig. 8.1, Fig. 8.2)

Results	Offshore Treatment (KgCO2e)	Onshore Treatment (KgCO2e)	Difference (Kg CO2e)	% Difference
Scope 1				
Diesel Fuel	86,441	86,441		
Transport of produced powder to plastics factory by company owned vehicle		60,462		
Road transport returning empty from plastics factory by company owned vehicle		3,859		
Total Scope 1 Emissions	***86,441***	***150,762***	***64,321***	***42.66%***
Scope 2				
Feed Skid	638.04	638.04		
CST Unit	222.78	222.78		
Cooling Fans		509.24		
Total Scope 2 Emissions	***860.82***	***1,370.06***	***638.04***	***46.57%***
Scope 3				
Commissioning Road Transport of Portable TCC-RotoMill Unit	66.39			
Commissioning Ship Transport of Portable TCC-RotoMill Unit	45.13			
Decommissioning Ship Transport of Portable TCC-RotoMill Unit	45.13			
Decommissioning Road Transport of Portable TCC-RotoMill Unit	66.39			
Road Transport of Empty Cuttings Bins to Shore		930.8		
Ship Transport of Empty Cuttings Bins to Offshore Installation		632.81		
Ship Transport of Full Cuttings Bins to Shore		2,799.24		
Road Transport of Full Cuttings to Process Site		4,117.43		
Road Transport of Produced Oil to 3rd Party for Further Processing		26,308.77		
Scottish Water emissions associated with produced water treatment		61.81		
Total Scope 3 Emissions	***223.04***	***34,850.86***	***34627.76***	***99.36%***
TOTAL KG CO2e EMISSIONS	87,399.06	186,982.92	99,586.86	53.26%
KG CO2e EMISSIONS PER TONNE OF CUTTINGS	150.17	321.28	171.11	53.26%

FIG. 8.1 CARBON EMISSIONS TABLE – 1

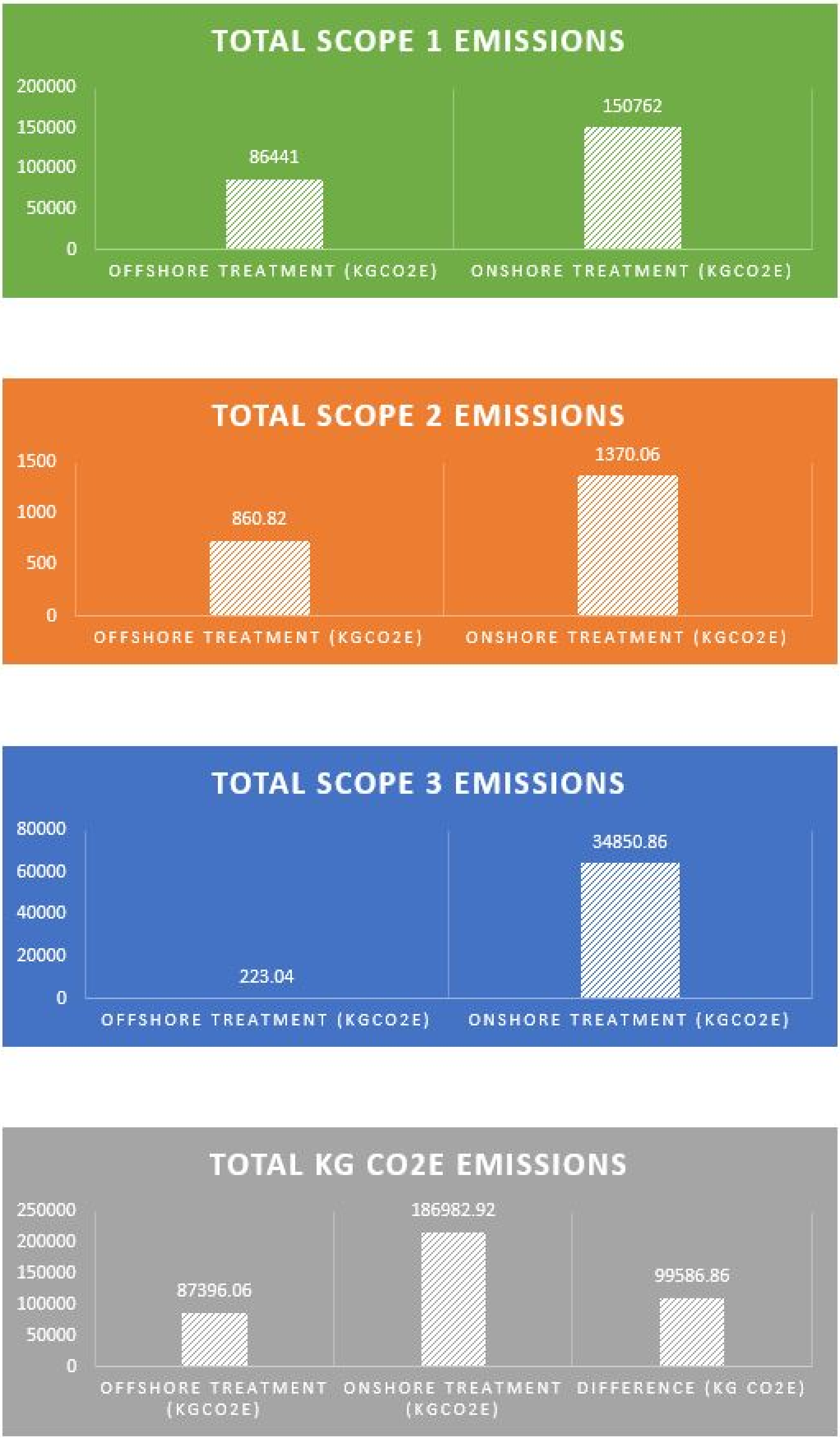

FIG. 8.2 EMISSIONS CHARTS

9 APPENDIX A – PROCESS MAP.

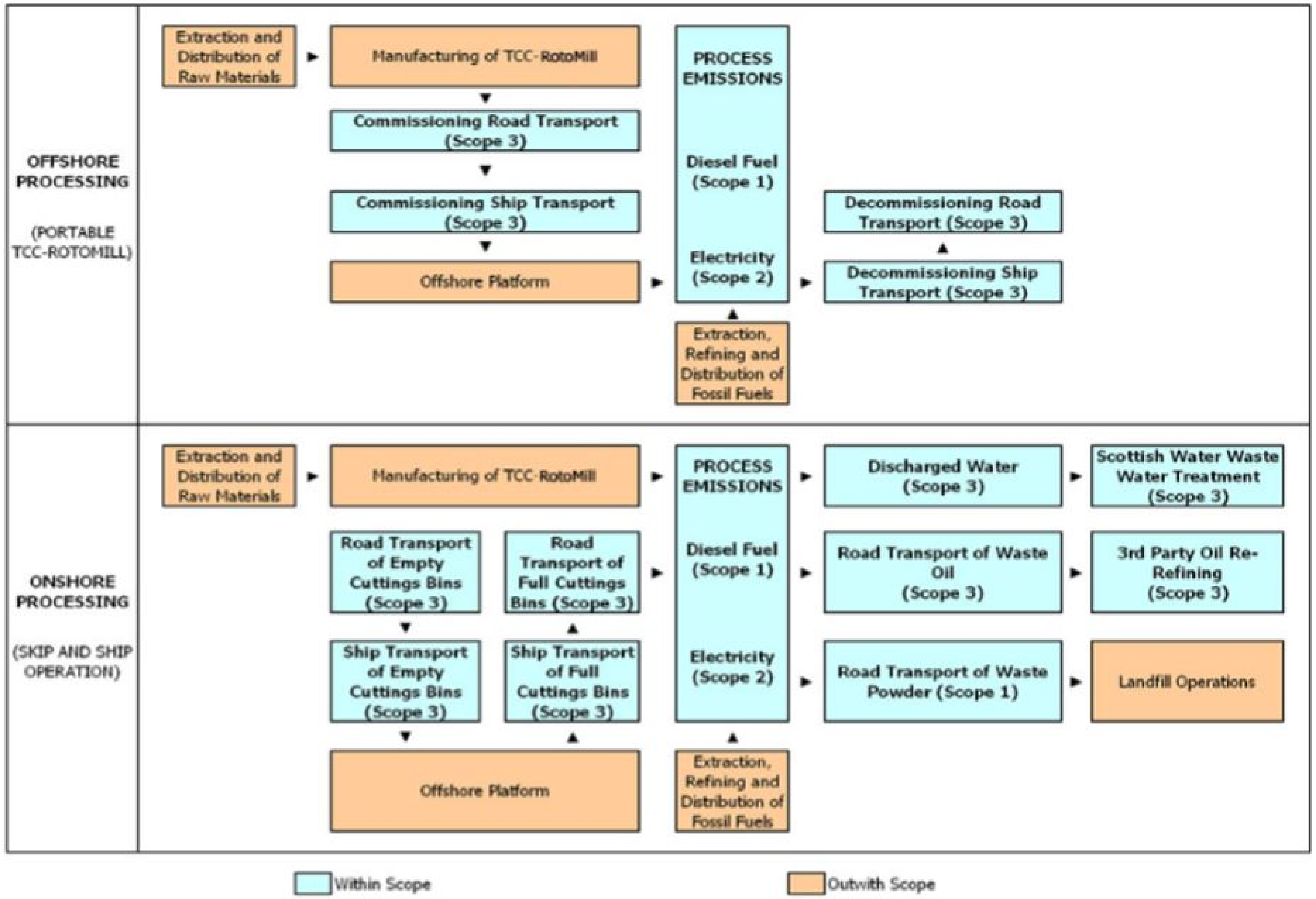

FIG. 9.1 PROCESS MAP

10 APPENDIX B – CALCULATIONS.

Scope 1 Calculations

The total kg CO2e associated with the diesel engine in the TCC-RotoMill were based on the following information:

- Type of fuel used: Gas Oil
- Associated BEIS emissions factor – kg CO2e per litre: 2.97049
- Average total weight of cuttings produced per well: 582 t
- Average weight of cuttings processed per hour: 5 t
- Diesel engine fuel required per hour: 250 l

The calculation to establish the total running hours required to process 582 tonnes of cuttings is as follows:

Average tonnes of cuttings produced per well / average tonnes processed per hour:

582 / 5 = 116.4 total running hours

The following calculation was then carried out to establish the total litres of gas oil required:

Total running hours x litres of gas oil per hour

116.4 * 250 = 29,100 total litres of gas oil

To calculate the associated CO2e emissions the total litres of gas oil were then multiplied by the associated BEIS CO2e factor; the following calculation shows the result:

29,100 * 2.97049 = 86,441 kg CO2e

The total kg CO2e associated with the road transport of produced powder to plastics factory by company owned vehicle was based on the following information:

- Rigid truck gross weight: >17 t
- Associated BEIS emissions factor – kg CO2e per tonne km: 1.09934
- Estimated weight of powder produced: 407.4 t
- Distance travelled from Peterhead treatment site to plastics factory: 135 km

The calculation to establish the kg CO2e was as follows:

Estimated weight of powder produced x km travelled x CO2e factor

407.4 x 135 x 1.09934 = 60,462 kg CO2e

The total kg CO2e associated with road transport returning empty from the plastics factory by company owned vehicle was based on the following information:

- Rigid truck gross weight: >17 t

- Associated BEIS emissions factor – kg CO2e per tonne km: 1.09934
- Estimated weight of powder produced: 407.4 t
- Average weight of powder transported per journey: 16.09 t
- Distance travelled from Peterhead treatment site to plastics factory: 135 km

The calculation to establish the number of truck journeys was as follows:

Estimated weight of powder produced / Average weigh of powder transported per journey

407.4 / 16.09 = 26 Truck Journeys

The calculation to establish the kg CO2e was as follows:

No of Truck Journeys x km travelled x CO2e factor

26 x 135 x 1.09934 = 3858.8 kg CO2e

Scope 2 Calculations

The total kg CO2e associated with the electric motors employed during the process were

based on the following information:

Electric Motors	Total kW	Efficiency Rating	Hours in Use	Loading Factor	Estimated kWh
1 x CST Unit	75	85%	12.5	71%	787
8 x Cooling Fans	18.5	85%	116.4	71%	1799
1 x Feed Skid	17.6	81.8%	116.4	90%	2254

The associated BEIS emissions factor in this instance refers to the latest grid rolling average figure of 0.28307 per kWh used. The following calculations relate to each electric motor to ascertain the total CO2e emissions associated with Scope 2:

CST kWh used x CO2e factor

787 x 0.28307 = 222.78 kg CO2e

Cooling Fans kWh used x CO2e factor

1799 x 0.28307 = 509.24 kg CO2e

Feed Skid kWh used x CO2e factor

2254 x 0.28307 = 638.04 kg CO2e

Scope 3 Calculations

Sea Freight Calculations

Based on the average deadweight tonnes of all 26 Platform Supply Vessels (PSV), and with the assistance of the Department of Business, Energy and Industrial Strategy (BEIS), the Department for Transport and the Marine and Coastguard Agency, the CO2e emissions factor for a General Cargo ship 0-4999 DWT.

- Average Vessel deadweight tonnes: 3550 DWT
- General Cargo Ship 0-4999 DWT CO2e factor per tonne/km: 0.01410 KgCO2e

The total kg CO_2e associated with the ship transport commissioning and decommissioning of a portable TCC-RotoMill unit was based on the following information:

- Type of Ship Employed: PSV
- Calculated emissions factor – kg CO_2e per tonne km: 0.01410
- Weight of 1 x Engine Module: 25 t
- Weight of 1 x Mill Module: 18 t
- Weight of 1 x Process Module: 16 t
- Weight of 1 x Feed Skid: 14 t
- Weight of 2 x CST Units: 24 t
- Total Weight: 97 t
- Average distance travelled from shore to offshore platform: 264 km

Estimated number of wells drilled per commissioned unit: 8 The calculation to establish the kg CO_2e was as follows:

Total tonnage of equipment x km travelled / estimated number of wells drilled per commission x CO_2e factor

97 x 264 / 8 x 0.0141 = 45.13 kg CO_2e

The total kg CO_2e associated with the ship transport of empty cuttings bins from the shore to the offshore platform was based on the following information:

- Type of Ship Employed: PSV
- Calculated emissions factor – kg CO_2e per tonne km: 0.01410
- Tare weight of each empty cuttings bin: 1 t
- Number of empty cuttings bins required: 170
- Distance travelled from shore to offshore platform: 264 km

Again, to establish the kg of CO_2e per tonne km, the following calculation was carried out:

Number of bins x tonnage of each bin x km travelled x CO_2e factor

170 x 1 x 264 x 0.0141 = 632.81 kg CO_2e

The total kg CO_2e associated with the ship transport of full cuttings bins from the offshore platform to shore was based on the following information:

- Type of Ship Employed: PSV
- Calculated emissions factor – kg CO_2e per tonne km: 0.0141
- Average weight of cuttings per bin: 3.43 t
- Tare weight of each empty cuttings bin: 1 t
- Average total weight of cuttings produced per well: 582 t
- Total number of cuttings bins required: 170
- Distance travelled from offshore platform to shore: 264 km

Firstly, the total tonnes transported needed to be established; this included the total tonnage of empty cuttings bins plus the total tonnage of cuttings produced; the following shows this calculation:

Total tonnes of cuttings + total tonnes of empty cuttings bins

582 + 170 = 752 total tonnes transported

Again, to establish the kg of CO2e per tonne km, the following calculation was carried out:

Total tonnes transported x km travelled x CO2e factor

752 x 264 x 0.0141 = 2799.24 kg CO2e

Road Transport Calculations

The total kg CO2e associated with the road transport commissioning and decommissioning of a portable TCC-RotoMill unit were based on the following information:

- Articulated truck gross weight: >33 t
- Associated BEIS emissions factor – kg CO2e per tonne km: 1.09506
- Weight of 1 x Engine Module: 25 t
- Weight of 1 x Mill Module: 18 t
- Weight of 1 x Process Module: 16 t
- Weight of 1 x Feed Skid: 14 t
- Total weight of 2 x CST Units: 24 t
- Distance travelled from Peterhead site to shore: 5 km
- Estimated number of wells drilled per commissioned unit: 8

The calculation to establish the kg CO2e was as follows:

Total tonnage of equipment x km travelled / estimated number of wells drilled per commission x CO2e factor

97 x 5 / 8 x 1.09506= 66.39 kg CO2e

The total kg CO2e associated with the road transport of empty cuttings bins from the Peterhead treatment site to shore was based on the following information:

- Articulated truck gross weight: >33 tonnes
- Associated BEIS emissions factor kg CO2e per tonne km: 1.09506
- Average total weight of cuttings produced per well: 582 t
- Average weight of cuttings per bin: 3.43 t
- Tare weight of each empty cuttings bin: 1 t
- Distance travelled from Peterhead site to shore: 5 km

The calculation to estimate the number of cuttings bins required to carry 582 tonnes was as follows:

Average tonnes of cuttings produced per well / Average weight of cuttings per bin

582 / 3.43 = 170 cuttings bins

Once this was established the kg of CO2e per tonne km could be calculated as follows:

Number of bins x tonnage of each bin x km travelled x CO2e factor

170 x 1 x 5 x 0.06090 = 51.76 kg CO2e

The total kg CO2e associated with the road transport of full cuttings bins from shore to the Peterhead treatment site was based on the following information:

- Articulated truck gross weight: >33 tonnes
- Associated BEIS emissions factor – kg CO2e per tonne km: 1.09506

- Average weight of cuttings per bin: 3.43 t
- Tare weight of each empty cuttings bin: 1 t
- Average total weight of cuttings produced per well: 582 t
- Total number of cuttings bins required: 170
- Distance travelled from offshore platform to shore: 264 km

Again, the total tonnes transported needed to be calculated before the CO2e per tonne km could be established; the subsequent calculation was as follows:

Total tonnes transported x km travelled x CO2e factor

752 x 5 x 1.09506= 4117.43 kgCO2e

The total kg CO2e associated with the road transport of produced oil to the third party was based on the following information:

- Articulated truck gross weight: >33 tonnes
- Associated BEIS emissions factor – kg CO2e per tonne km: 1.09506
- Estimated weight of waste oil transported: 87.3 t
- Distance travelled to third party: 275.2 km

Therefore, the calculation to establish the kg of CO2e was as follows:

Estimated tonnes transported x km travelled

87.3 x 275.2 x 1.09506= 26308.77 kg CO2e

Produced Water Treatment

The total kg CO2e associated with waste water treatment was based on the following information:

- Tonnes of waste water discharged: 87.3 t
- Volume of waste water discharged: 87,300 l or 87.3m3
- Water treatment emissions factor – kg CO2e per cubic metre: 0.708

The calculation to establish the kg of CO2e was as follows:

Cubic Metres of water x CO2e factor

87.3 x 0.708 = 61.808 kg CO2e

The total estimated kg CO2e associated with re-refining produced oil at the third party was based on the following information:

- Tonnes of waste oil produced: 87.3 t
- Volume of waste oil produced: 87,300 l
- Estimated emissions factor – kg CO2e per litre: 0.708

The calculation was as follows:

Litres of waste oil produced x CO2e factor

87,300 x 0.708 = 61,808 kg CO2e

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