Cambridge Waste Water Treatment Plant Relocation Project
Anglian Water Services Limited

Appendix 10.1: GHG Calculations

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1 Introduction

1.1 Overview

1.1.1 This Appendix presents the supporting calculations for the carbon assessment of the Proposed Development. The assessment is split into construction, land use change, operation, decommissioning of the Existing WWTP, and carbon over the lifetime of the assessment.

1.1.2 The assessment of the carbon emissions from the construction and operation of the Proposed Development has been based on the Applicant's asset level carbon models.

1.1.3 Any carbon emissions assessment at design stage is an estimate based on best available data and using industry standard emissions factors. There is an inherent limitation in carbon assessments as the assessment is based on the scheme design at the time. The final constructed asset will not have the same carbon emissions as estimated due to differences in the final materials' procurement specification and construction practices on site.

1.2 Aims and Objectives

1.2.1 This appendix sets out the carbon footprint calculations support the assessment of effects and should be read in conjunction with Chapter 10: Carbon (Application Document Ref 5.2.10)

1.2.2 A detailed description of the Proposed Development is included in Chapter 2: Project Description (App Doc Ref 5.2.2) of the Environmental Statement.

2 Greenhouse Gas Emissions

2.1 Construction

2.1.1 The assessment of the carbon emissions from the construction of the Proposed Development has been based on the Applicant's asset level carbon models.

2.1.2 Mitigation options to reduce the impact have been identified and implemented throughout the development of the design, in line with the methodology set out in PAS 2080 and the Applicant's carbon reduction targets. Carbon is a primary metric of the options evaluation process during design development, previous model iterations are presented in Table 2-1 demonstrating this process.

2.1.3 Note that all carbon estimates are rounded to the nearest 10 tonnes.

Table 2-1: Carbon footprint by site area

Data source	Site Area	Baseline model		Previous model iterations as part of design process				DCO application model		
		DM0 - tCO2e	DM1 - tCO2e	October Post ROV - tCO2e	November Post ROV - tCO2e	December Post ROV - tCO2e	January Post ROV - tCO2e	April Post ROV - tCO2e	June - tCO2e	DCO - tCO2e
Applicant Model	Tunnel & Final Effluent Discharge	39,960	17,780	17,780	17,780	17,780	13,660	13,660	13,660	13,660
	Final Settlement Tank	5,060	5,870	4,850	4,850	4,850	4,890	4,890	5,020	5,820
	Aeration Tank	7,850	4,850	5,870	5,870	5,870	3,480	3,480	3,480	5,280
	Primary Settlement Tank	3,890	3,430	3,090	3,090	3,090	3,090	3,090	3,090	3,550
	Storm Tank	10,720	3,310	2,810	2,810	2,810	2,480	2,480	2,480	2,100
	Import Area (Screening and Thickening)	1,640	3,090	1,930	1,930	1,930	1,930	1,930	2,020	2,020
	Buildings	1,480	2,810	1,740	1,740	1,740	1,740	1,740	1,740	800
	TPS	1,290	1,930	2,440	2,440	1,730	1,730	1,730	1,730	1,710
	Roads	5,970	1,740	3,310	3,310	3,310	3,310	1,670	1,670	3,140
	Inter process Pumping	1,380	1,480	1,320	1,320	1,320	1,320	1,320	1,320	1,320
	Inlet Works	2,660	1,320	1,240	1,240	1,240	1,240	1,240	1,240	1,220
	Sand Filtration	4,210	1,240	850	850	850	850	850	1,130	1,130
	Electrical Distribution	440	1,010	1,010	1,010	1,010	1,010	1,010	1,010	1,010
	Digestion	1,940	980	910	890	890	890	890	890	1,080
	LTP	960	630	630	630	630	630	630	630	630

Data source	Site Area	Baseline model			Previous model iterations as part of design process			DCO application model		
		DM0 - tCO2e	DM1 - tCO2e	October Post ROV - tCO2e	Novemb er Post ROV - tCO2e	Decemb er Post ROV - tCO2e	January Post ROV - tCO2e	April Post ROV - tCO2e	June - tCO2e	DCO - tCO2e
	Boundary Fencing	400	600	600	600	600	600	600	600	600
	Biogas Area - Storage + CHP/BUP	720	380	310	420	420	420	420	420	420
	Common Control (MCC)	490	310	380	380	380	380	380	380	380
	Dewatering	250	310	380	380	380	380	380	380	380
	HPH	1,100	280	310	310	310	310	310	310	310
	FE Discharge Pipework	-	260	280	280	280	280	280	280	280
	Odour Control	490	240	220	220	220	220	220	220	220
	Landscaping	1,080	220	210	210	210	210	210	210	1,080
	Ferric Dosing	700	210	190	190	190	190	190	190	190
	Pressure Water System	20	190	260	260	180	180	180	180	180
	Site Services	-	140	140	140	140	140	140	140	140
	Additional Items	2,050	-	-	-	-	-	-	-	-
Built-up from EPDs (see Table 2-2)	Solar Panels	-	-	-	-	-	-	-	-	2,150
TOTAL		**96,750**	**54,610**	**53,060**	**53,150**	**52,360**	**45,560**	**43,920**	**45,560**	**50,800**
% Change	Change from DM0		43.6%	45.2%	45.1%	45.9%	52.9%	54.6%	52.9%	47.5%

Data source	Site Area	Baseline model			Previous model iterations as part of design process			DCO application model		
		DM0 - tCO2e	DM1 - tCO2e	October Post ROV - tCO2e	Novemb er Post ROV - tCO2e	Decemb er Post ROV - tCO2e	January Post ROV - tCO2e	April Post ROV - tCO2e	June - tCO2e	DCO - tCO2e
	Distance from 70% target	26.4%	24.8%	24.9%	24.1%	17.1%	15.4%	17.1%	22.5%	

2.1.4 The embodied carbon associated with the solar panels has been estimated based on technical datasheets and EPDs of individual components for similar capacity panels. For this calculation is has been assumed that 2 x 3600 kW panels will be required.

Table 2-2: Solar panel capital carbon estimate

Component Type (3600 kW panel)	tCO_2e/unit including 1% uplift allowing for unmodelled components
Solar Panels (monofacial)	670
Inverters	620
Mounting structure (fixed)	390
DC Cable	10
TOTAL	1080

2.1.5 Table 2-3 shows the change achieved between DM0 and DCO designs.

Table 2-3: Changes between DM0 and DCO design

Site Area	% of DCO	Reduction from DM0 to DCO (tCO2e)
Tunnel & Final Effluent Discharge	26.9%	26,300
Final Settlement Tank	11.4%	-760
Aeration Tank	10.4%	2,570
Primary Settlement Tank	7.0%	330
Storm Tank	4.1%	8,620
Import Area (Screening and Thickening)	4.0%	-380
Buildings	1.6%	680
TPS	3.4%	-410
Roads	6.2%	2,830
Inter process Pumping	2.6%	60
Inlet Works	2.4%	1,440
Sand Filtration	2.2%	3,080
Electrical Distribution	2.0%	-570
Digestion	2.1%	860
LTP	1.2%	320
Boundary Fencing	1.2%	-210
Biogas Area - Storage + CHP/BUP	0.8%	300
Common Control (MCC)	0.8%	110
Dewatering	0.7%	-130
HPH	0.6%	780
FE Discharge Pipework	0.5%	-280
Odour Control	0.4%	260
Landscaping	2.1%	-
Ferric Dosing	0.4%	520
Pressure Water System	0.3%	-160
Site Services	0.3%	-130
Additional Items	0.0%	2,050

Table 2-4 summarises the estimated emissions by site area and shows the change between DM0 baseline model and the DCO Proposed Development design.

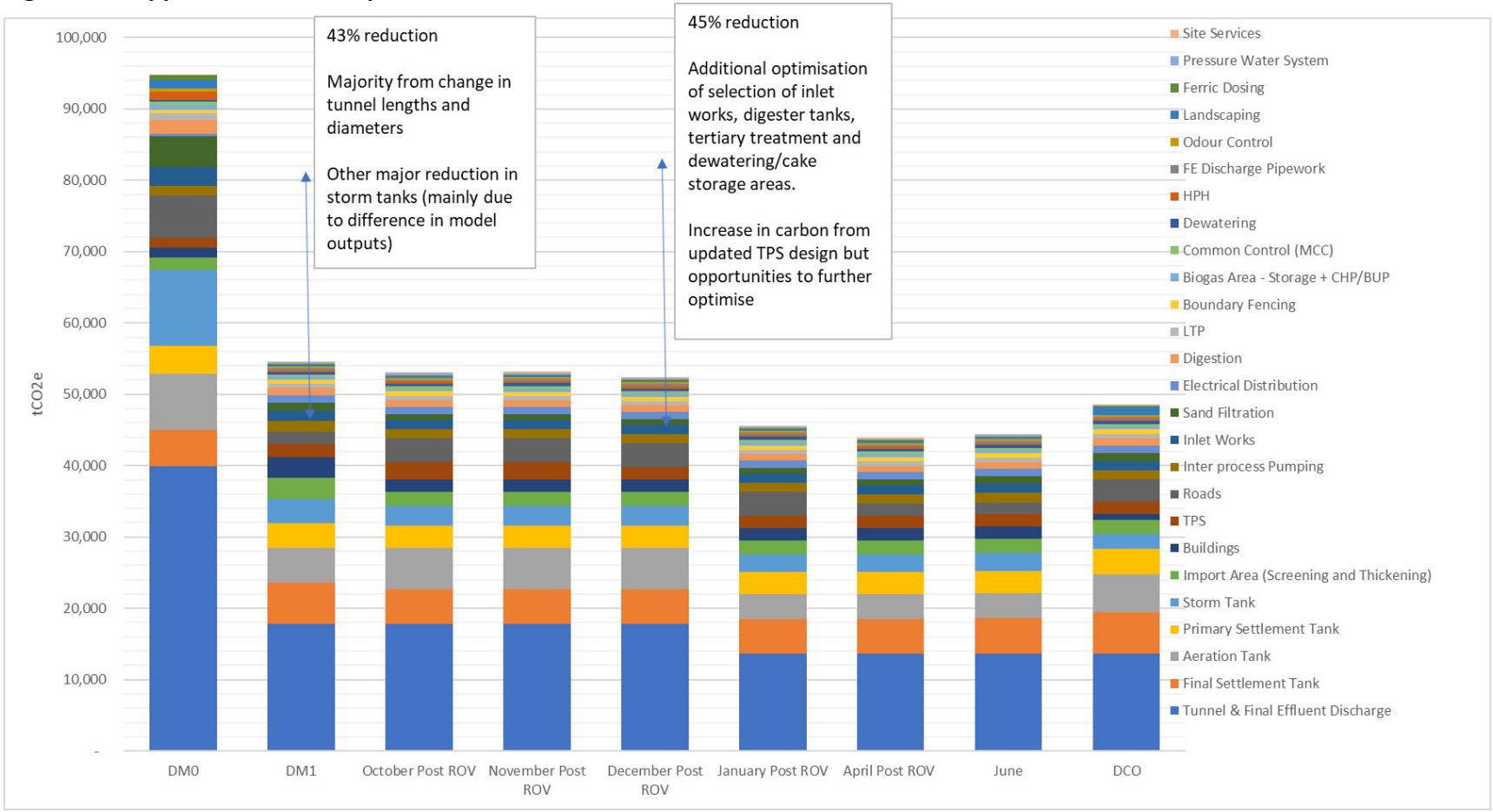
Table 2-4: Summary table

Site Area	DM0 Baseline Design (tCO2e)	DCO Proposed Development Design (tCO2e)	% Change
Tunnel & Final Effluent Discharge	39,960	13,660	-27%
Final Settlement Tank	5,060	5,820	1%
Aeration Tank	7,850	5,280	-3%
Primary Settlement Tank	3,890	3,550	0%
Storm Tank	10,720	2,100	-9%

Site Area	DM0 Baseline Design (tCO2e)	DCO Proposed Development Design (tCO2e)	% Change
Import Area (Screening and Thickening)	1,640	2,020	0%
Buildings	1,480	800	-1%
TPS	1,290	1,710	0%
Roads	5,970	3,140	-3%
Inter process Pumping	1,380	1,320	0%
Inlet Works	2,660	1,220	-1%
Sand Filtration	4,210	1,130	-3%
Electrical Distribution	440	1,010	1%
Digestion	1,940	1,080	-1%
LTP	960	630	0%
Boundary Fencing	400	600	0%
Biogas Area - Storage + CHP/BUP	720	420	0%
Common Control (MCC)	490	380	0%
Dewatering	250	380	0%
HPH	1,100	310	-1%
FE Discharge Pipework	-	280	0%
Odour Control	490	220	0%
Landscaping	1,080	1,080	0%
Ferric Dosing	700	190	-1%
Pressure Water System	20	180	0%
Site Services	-	140	0%
Additional Items	2,050	-	-2%
Solar Panels	-	2,150	2%
TOTAL	96,750	50,790	-48%

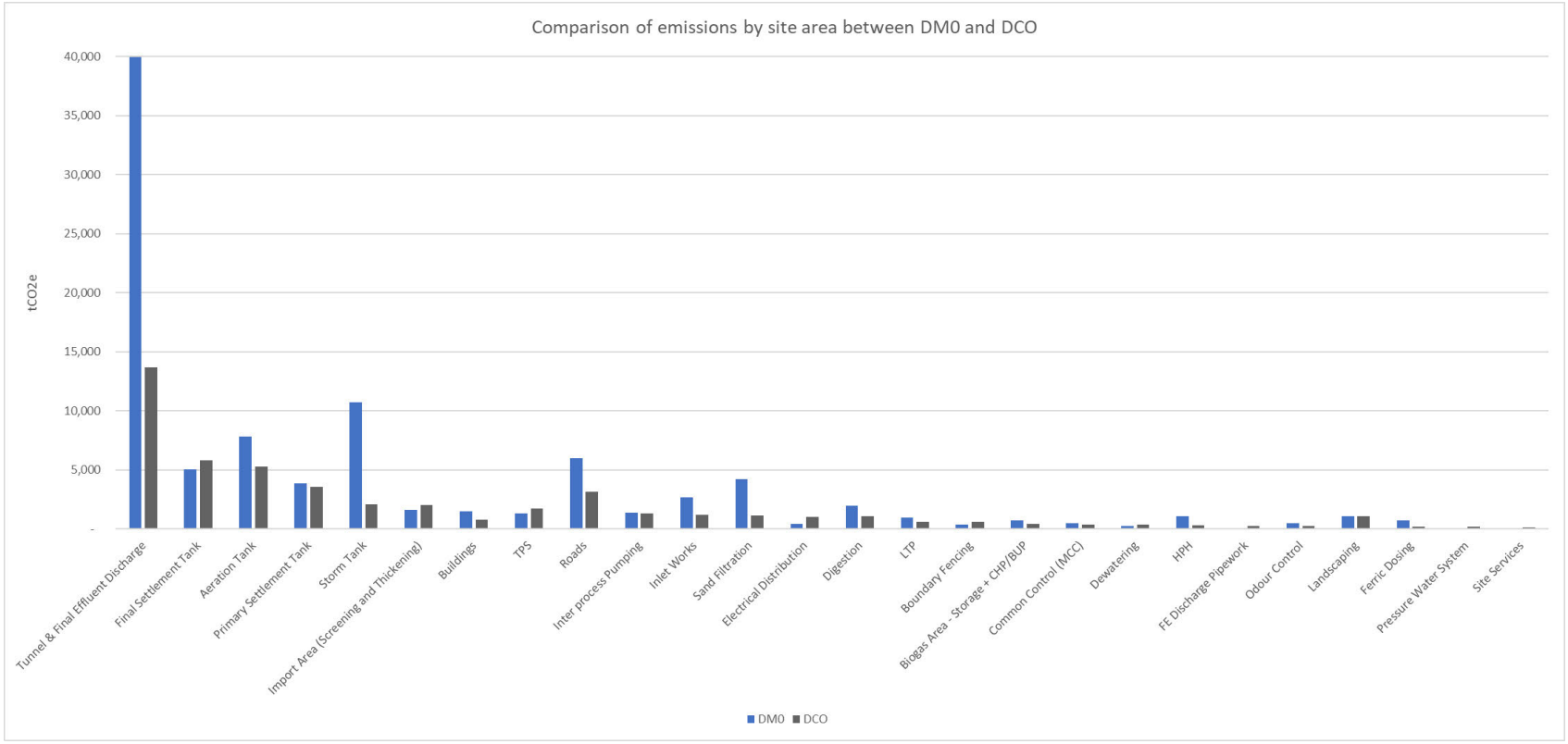
2.1.6 Figure 2.1 below shows the outputs from the Applicant's models, with commentary for the key reductions achieved.

Figure 2.1: Applicant model outputs



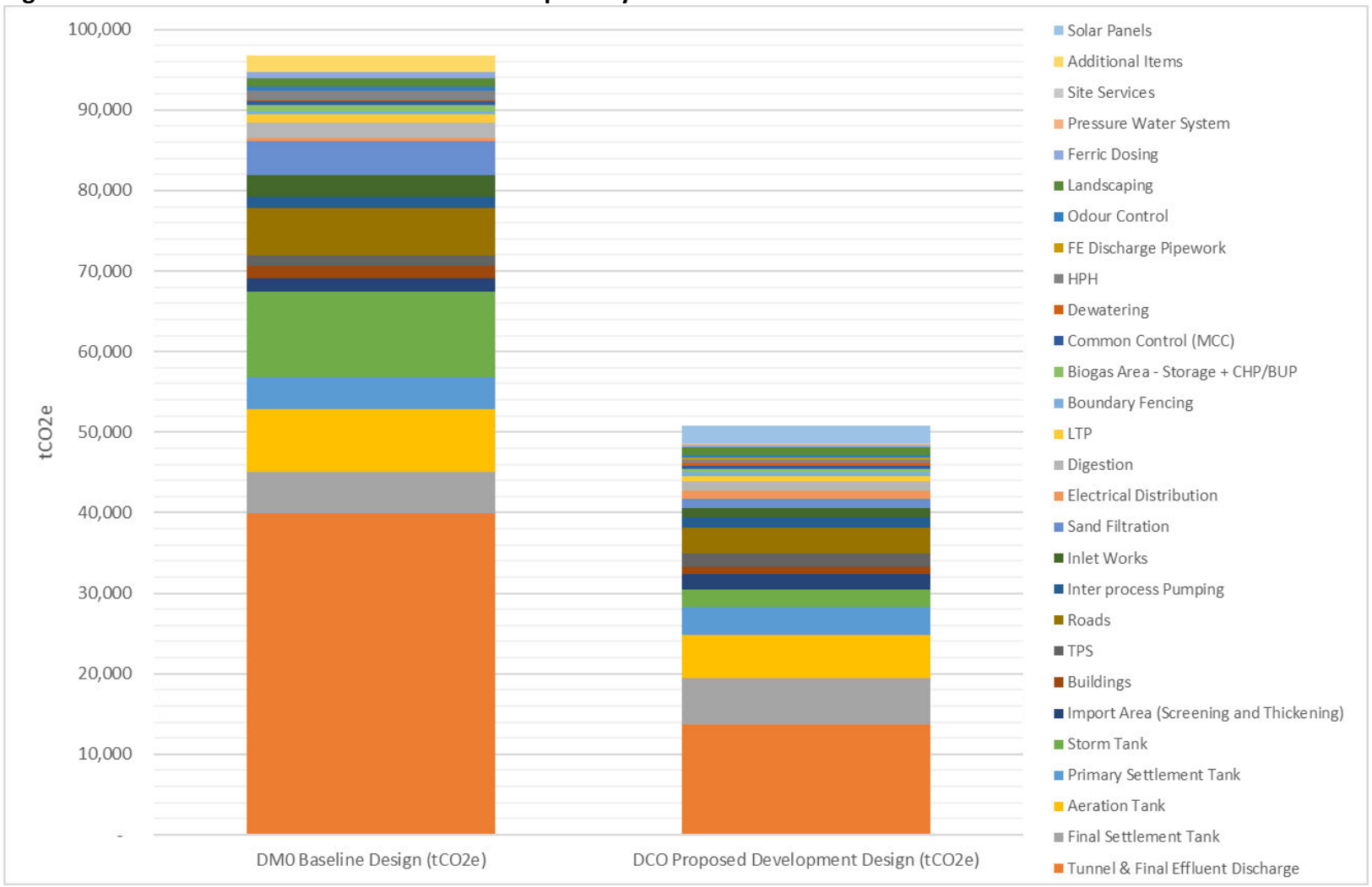
2.1.7 Figure 2.2 below shows the outputs from the Applicant's models, comparing DM0 baseline and DCO design outputs.

Figure 2.2: Comparison by site area



2.1.8 Figure 2.3 below shows the outputs from the Applicant's models, comparing the total construction footprint for DM0 baseline and DCO design outputs, broken down by the different site areas.

Figure 2.3: Breakdown of total construction footprint by site area



2.2 Land Use Change

2.2.1 The impact of the Proposed Development on carbon sequestration within the study area was assessed using the areas and types of landscaping identified from the proposed landscape plan within the Landscape Ecology and Recreation Management Plan (LERMP) (Appendix 8.14, App Doc Ref 5.4.8.14). The baseline for the land use change assessment is the current land use of the site.

2.2.2 Note that negative numbers in Table 2-5 are carbon sequestration.

Table 2-5: Carbon sequestration change in Proposed Development opening year

Land use	C seq. rates for habitats	Baseline		Proposed Scheme		Overall change	
		Area (Ha)	C Seq. (tCO_2e/yr)	Area (Ha)	C Seq. (tCO_2e/yr)	C Seq. (tCO_2e/yr)	Total additional C seq. (tCO_2e)
Woodland – (deciduous)	-5	1	-6	22	-109	-103	-2066*
Woodland – (coniferous)	-13	0	-1	0	-1	0	0
Grassland	0	29	-12	39	-15	-4	-119
Arable land	0	145	-16	93	-10	6	169
Shrub	-1	5	-3	5	-3	0	0
Total			-38		-139	-102	-2015

** NOTE - this value accounts for the 10 year estimated period that it takes for trees to mature enough to sequester carbon. 20 years to end of management plan period*

2.2.3 Carbon sequestration rates shown in Table 2-6 are taken from the Committee on Climate Change (JBA Consulting, 2018).

Table 2-6: Carbon sequestration rates for broad habitat types

Land use type	C Seq rate (tCO2e/ha/yr)
Woodland - (deciduous)	4.97
Woodland – (coniferous)	12.66
Arable Land	0.107
Pastoral land	0.397
Peatland - Undamaged	4.11
Peatland - Overgrazed	-0.1
Peatland - Rotationally burnt	-3.66
Peatland - Extracted	-4.87
Grassland	0.397
Heathland	0.7
Shrub	0.7
Saltmarsh	5.188
Urban	0

Land use type	C Seq rate (tCO2e/ha/yr)
Green Urban	0.397

2.2.4 Whole life carbon sequestration has also been assessed over the lifetime of assessment, assuming a 30-year management plan (see Table 2-7).

2.2.5 Table 2-7 shows the sequestration over the management plan lifetime. The change at 2038 accounts for the 10-year estimated period that it takes for trees to mature enough to sequester carbon.

Table 2-7: Management plan lifetime sequestration

Year	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	
Relative year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
DCO Design	construction	construction	construction	-30	-30	-30	-30	-30	-30	-30	-30	-30	-30	-139	-139	-139	
Baseline	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	
Year	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057
Relative year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
DCO Design	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139
Baseline	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38

2.3 Operational Carbon – Baseline DM0

2.3.1 The operation phase assessment includes annual emissions from year 1 of operation. This section covers the DM0 (baseline) model which uses biogas in CHP engines on-site. Data is sourced from the Applicant's models.

2.3.2 Using CHP reduces the grid electricity demand of the development. Avoided grid electricity emissions are presented in the net emissions, shown as negative numbers. UK average grid electricity emissions factor forecast to 2028 (0.069 $kgCO_2e/kWh$) has been used to calculate the emissions avoided (Department for Business Energy & Industrial Strategy, 2021).

2.3.3 Note that all carbon estimates in Table 2-8 and Table 2-9 are rounded to the nearest 10 tonnes, totals may not sum due to rounding.

Table 2-8: Baseline DM0 operation Applicant's model outputs

Water Recycling Centre (WRC)		
Process Units	**Annual Power Consumption (kWh)**	**Carbon emission (tCO_2e)**
Preliminary Treatment	960,517	70
Primary	254,752	20
Secondary ASP	3,628,667	250
Secondary FST	904,210	60
Tertiary Treatment	3,247,988	230
Liquor Treatment Plant	951,314	70
	Total	**690**
Infrastructure		
Process Units	**Annual Power Consumption (kWh)**	**Carbon emission (tCO_2e)**
Terminal Pumping Station (TPS)	6,676,835	460
FE Main and Outfall	1,855,295	130
	Total	**590**
Sludge Treatment Centre (STC)		
Process Units	**Annual Power Consumption (kWh)**	**Carbon emission (tCO_2e)**
Sludge and Import Screening	2,220,764	150
Sludge Thickening	2,777,515	190
HPH	2,893,548	200
Digestion	1,463,016	100
Dewatering	1,648,664	110
Biogas CHP power gen	-14,826,962	-1,030
	Total	**-270**
Use of chemicals		
Chemicals		**Carbon emission (tCO_2e)**
Chemicals (Ferric)		10
Chemicals (Poly)		<10

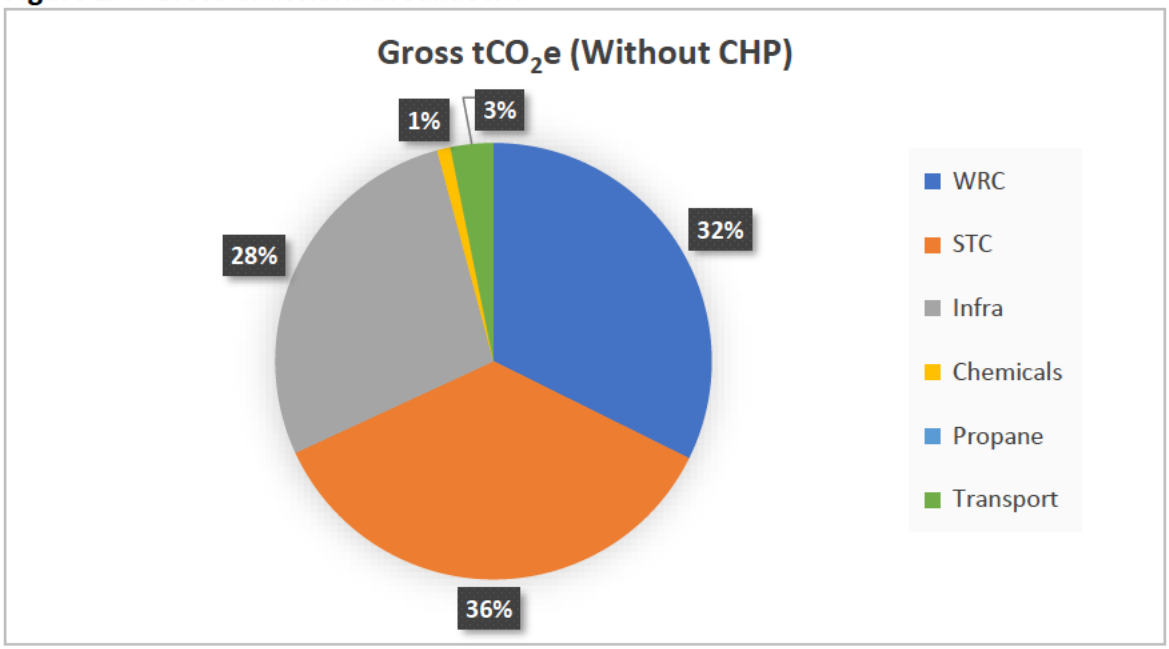
Water Recycling Centre (WRC)	
Total	**20**
Other Items	
Item	**Carbon emission (tCO_2e)**
Propane	*no propane use - all biogas used in CHPs*
Transport	70

Table 2-9: Summary of construction inputs

Summary	Gross tCO_2e	Net tCO_2e
WRC	690	690
STC	760	-270
Infra	590	590
Chemicals	20	20
Propane	*no propane use - all biogas used in CHPs*	
Transport	70	70
TOTAL	**2,130**	**1,110**

2.3.4 Figure 2.4 below shows the breakdown of operations emissions in year one by emissions source.

Figure 2.4: Gross emissions breakdown



2.4 Operational Carbon – Biomethane production (DCO preferred option)

2.4.1 The operation phase assessment includes annual emissions from year 1 of operation. This section covers the DCO preferred option model which exports biomethane to the grid. Data is sourced from the Applicant's models.

2.4.2 Biomethane supply to the gas grid replaces other sources of gas, and so avoids emissions from gas generated (wholly or partially) from other more carbon intensive sources. Avoided emissions are presented in the net emissions, shown as negative numbers. The UK average natural gas emissions factor has been used to calculate the emissions avoided (Department for Business Energy & Industrial Strategy, 2021).

2.4.3 Note that all carbon estimates in Table 2-10 and Table 2-11 are rounded to the nearest 10 tonnes, totals may not sum due to rounding.

Table 2-10: DCO Preferred Option operation Applicant's model outputs

Water Recycling Centre (WRC)		
Process Units	**Annual Power Consumption (kWh)**	**Carbon emission (tCO_2e)**
Preliminary Treatment	960,517	70
Primary	254,752	20
Secondary ASP	3,628,667	250
Secondary FST	904,210	60
Tertiary Treatment (updated to washwater system option)	2,725,212	190
Liquor Treatment Plant	951,314	70
	Total	650
Infrastructure		
Process Units	**Annual Power Consumption (kWh)**	**Carbon emission (tCO2e)**
Terminal Pumping Station (TPS)	3,144,849	220
FE Main and Outfall	706,909	50
	Total	270
Sludge Treatment Centre (STC)		
Process Units	**Annual Power Consumption (kWh)**	**Carbon emission (tCO2e)**
Sludge and Import Screening (Combined Import tanks with No RO3)	2,519,458	180
Sludge Thickening (Volutes Duo RVP 802)	1,939,165	140
HPH	2,893,548	200

Water Recycling Centre (WRC)		
Digestion	1,463,016	100
Dewatering	1,616,910	110
G2G power demand	1,415,266	100
	Total	820
Use of chemicals		
Chemicals		**Carbon emission (tCO2e)**
Chemicals (Ferric)		10
Chemicals (Poly)		30
Sand (TTP)		10
	Total	50
Other Items		
Item		**Carbon emission (tCO2e)**
Propane		860
Transport		70

Table 2-11: Summary of construction inputs

Summary	Gross tCO2e	Net tCO2e
WRC	650	650
STC	820	820
Infra	270	270
Chemicals	50	50
Propane	860	860
Export of biomethane		-6,210
Transport	70	70
TOTAL	**2,730**	**-3,490**

2.4.4 Figure 2.5 below shows the breakdown of gross operations emissions in year one by emissions source. Figure 2.6 below shows a comparison of gross and net emissions.

Figure 2.5: Gross emissions breakdown

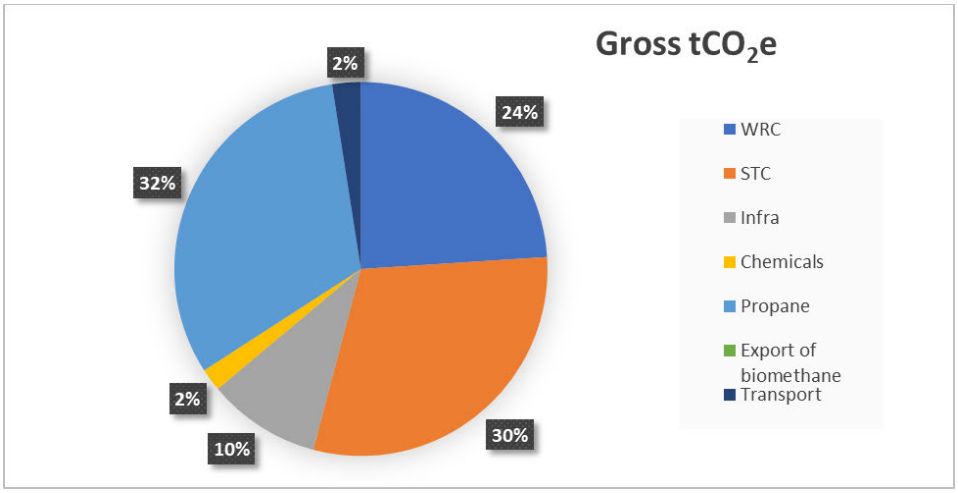
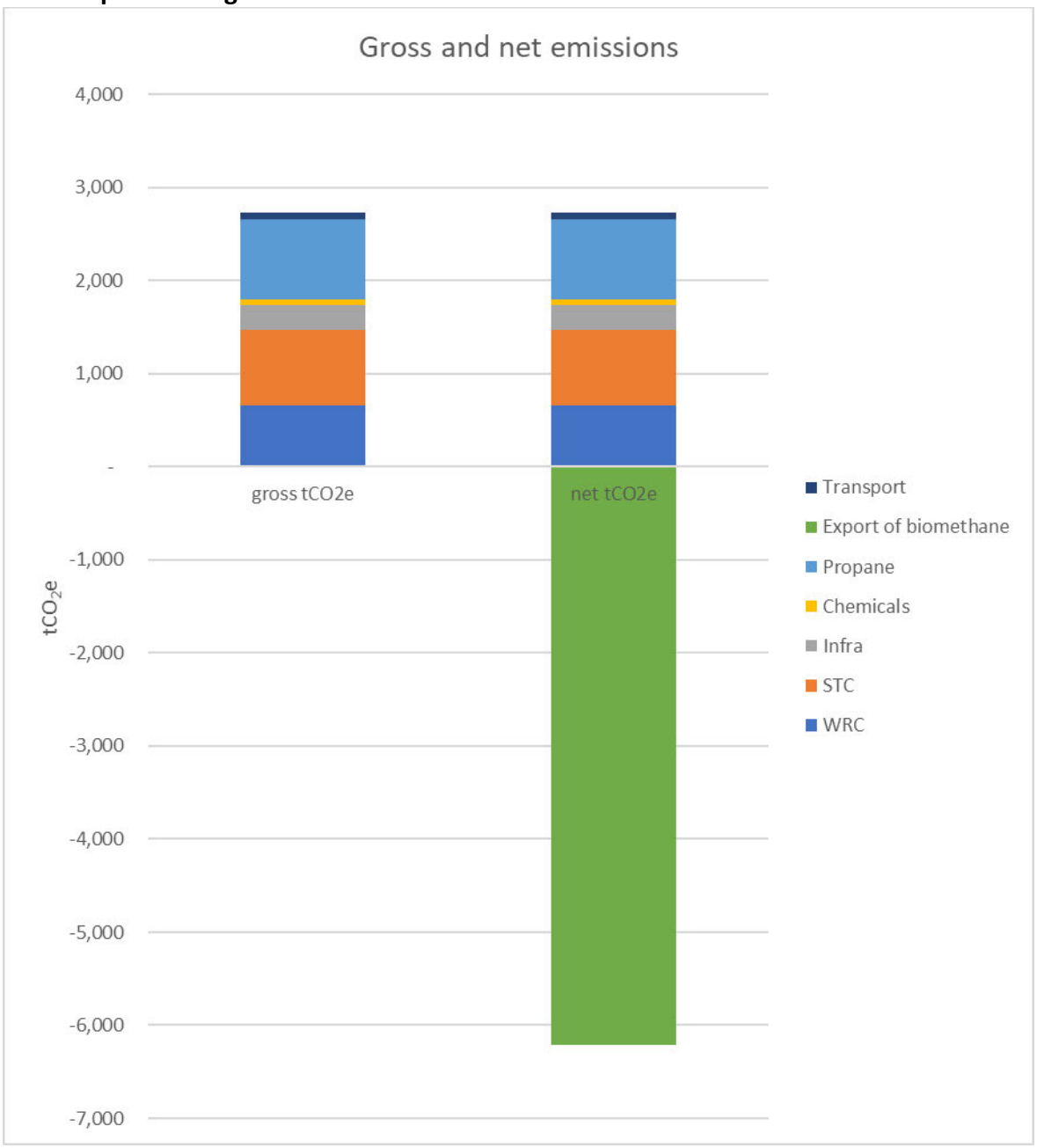


Figure 2.6: Comparison of gross and net emissions



2.5 Operational Carbon – comparison of DM0 and DCO models

2.5.1 The operational carbon assessment includes annual emissions from year 1 of operation. This section covers the DM0 (baseline) which uses biogas in CHP engines on-site, and the DM1 through to DCO model which take into account biomethane production. Table 10 compares different models and captures the net and gross total emissions. Data is sourced from the Applicant's models.

2.5.2 In 2019, UK net greenhouse gas emissions were estimated at 455 MtCO2e (million tonnes of carbon dioxide equivalent) (Department for Business, Energy & Industrial Strategy, 2021). The water supply and sewage services sector accounted for 0.8% of UK GHG emissions in 2019 (~3,640,000 tCO_2e). The DCO model operation is approximately 0.08% of this sector baseline.

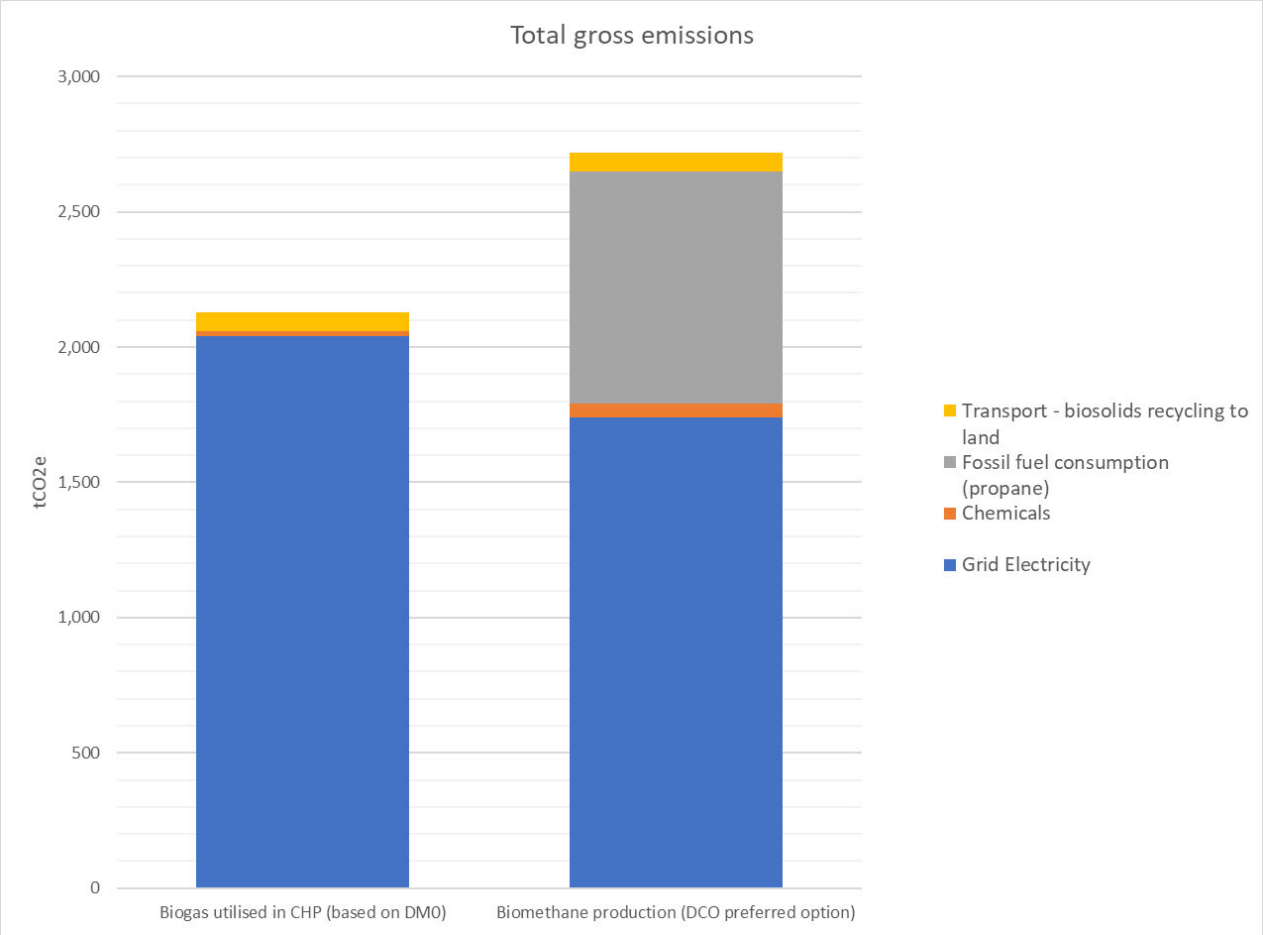
2.5.3 Note that all carbon estimates in Table 2-12 are rounded to the nearest 10 tonnes, totals may not sum due to rounding.

Table 2-12: Operational Carbon emissions in tCO2e

Summary	DM0	DM1	October	November	December	DCO
WRC	690	910	900	900	860	650
STC	760	1,130	1,080	1,080	1,080	820
Infra	590	670	350	350	380	270
Chemicals	20	20	50	50	50	50
Propane	-	860	860	860	860	860
Transport	70	70	70	70	70	70
Gross Total (exc gas to grid or CHP exports) (tCO2e)	2,130	3,660	3,320	3,320	3,300	2,730
Grid electricity saving from CHP	- 1,030	-	-	-	-	-
Natural gas emissions saved (due to biomethane)	-	- 6,180	- 6,180	- 6,210	- 6,210	- 6,210
Net Total (tCO2e)	1,110	-2,520	- 2,860	- 2,900	-2,920	- 3,490
Ml capacity (l/s)	2000					2000
Ml per year (Ml/y)	63072					63072
Gross tCO2e/Ml	0.034					0.043
Net tCO2e/Ml	0.018					-0.055

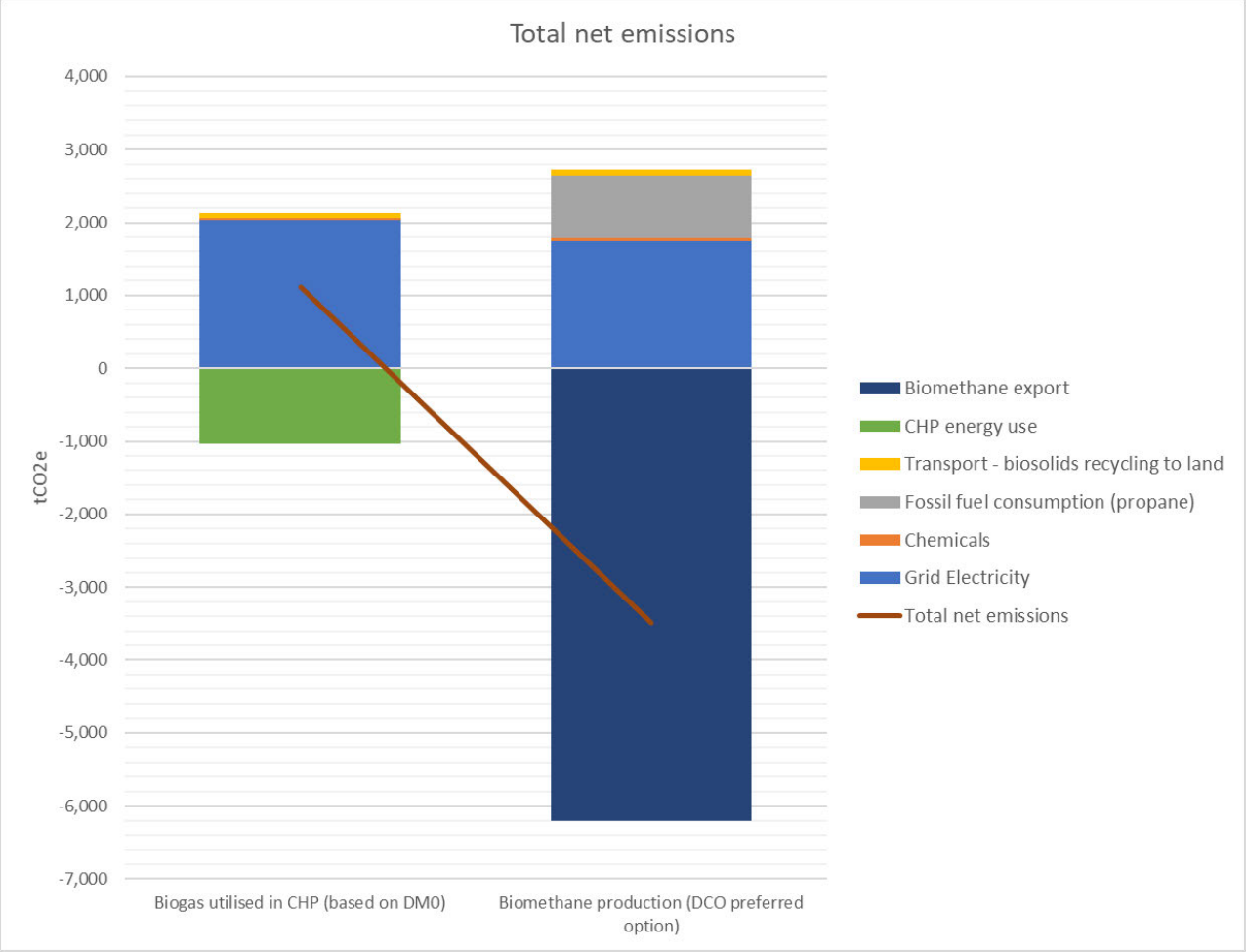
2.5.4 Figure 2.7 below shows the breakdown of gross operations emissions in year one by emissions source for DM0 and DCO models.

Figure 2.7: Comparison of total gross emissions for different models



2.5.5 Figure 2.8 below shows a comparison of total net emissions. The DCO model shows that the biomethane export avoids more emissions that it emits and its total net emissions is lower than the DM0 model using CHP.

Figure 2.8: Comparison of total net emissions for different models



2.6 Decommissioning

2.6.1 Table 2-13 shows activity data and emissions factor to calculate the carbon emissions associated with decommissioning activities. This was calculated based on estimated vehicle numbers and movements and results are summarised in Table 2-14.

2.6.2 Total on site vehicle movements was assumed at 1 movement per day for 7 days per week. Distance across site ('on-site movement') was agreed at 1 mile with contractors.

2.6.3 Total off site vehicle movements was assumed 30 miles travel to and from site (60 miles total)

2.6.4 Emission factors are sourced from the UK Government GHG Conversion Factors for Company Reporting (Department for Business Energy & Industrial Strategy, 2021). Emissions factor used are: Medium Van (Diesel Class II (1.305 to 1.74 tonnes)), Transit Truck (Diesel Class III (1.74 to 3.5 tonnes)), Tanker (All HGVs (Diesel)).

Table 2-13: Carbon emissions associated with decommissioning activities

Activity / Area	Medium Vans (No.)	Transit Trucks (No.)	Tanker (No.)	Duration (weeks) estimate	Duration (days) estimate	Medium Van Movements	Transit Trucks Movements	Tanker Movements
TPS	3	1	2	2	14	42	14	28
Inlet Screen Structure	3	1	2	2	14	42	14	28
Washwater	3	1	2	2	14	42	14	28
General Site Utilities	2	0	0	3	21	28	0	0
PSTs	3	1	8	2	14	42	14	112
Stream D forward feed pumping station	3	1	2	2	14	42	14	28
Stream C Distribution Chamber	3	1	2	2	14	42	14	28
ASP structures	3	1	8	4	28	42	14	112
FSTs	3	1	6	2	14	42	14	84

Activity / Area	Medium Vans (No.)	Transit Trucks (No.)	Tanker (No.)	Duration (weeks) estimate	Duration (days) estimate	Medium Van Movements	Transit Trucks Movements	Tanker Movements
FE Outfall Pipework	1	1	0	1	7	14	14	0
SAS	3	1	1	1	7	42	14	14
STC, Monsal, Digestion and CHP area	3	1	3	2	14	42	14	42
Sludge Import Area	3	1	6	3	21	42	14	84
Sludge Blending Tanks & Drum Thickeners	3	1	3	2	14	42	14	42
Redundant Sand Filter	3	1	6	2	14	42	14	84
Storm Tanks and Storm	3	1	2	2	14	42	14	28
Iron Salt Dosing	3	1	1	1	7	42	14	14
Innovation's centre	3	1	0	2	14	42	14	0
Total vehicles	51	17	54		Total on site vehicle movements	714	238	756
Distance units	miles	miles	miles		Distance units	miles	miles	miles
Distance travelled off site	60	60	60		Distance travelled per on site movement	1	1	5
Total distance travelled off site	3060	1020	3240		Total distance travelled on site	714	238	3780

Table 2-14: Summary of decommissioning footprint

	Medium Van Movements	Transit Trucks Movements	Tanker Movements
Total distance travelled (miles)	3774	1258	7020
Emissions factors (kgCO2e/mile)	0.29476	0.42695	1.6114
kgCO2e	1,112	537	11,312
Total tCO2e (rounded to nearest 10 tonnes)	10		

2.7 Assessment lifetime – Primary and Tertiary Mitigation

2.7.1 Electricity data to calculate assessment lifetime emissions was sourced from UK Government projections (Department for Business Energy & Industrial Strategy, 2021). This provides forecast emissions factors for grid electricity. For reference the factors are presented below in Table 2-15.

Table 2-15: BEIS Grid electricity emissions factors

kgCO2e/kWh	Year	Relative year
0.12299741	2025	0
0.090669463	2026	1
0.075037163	2027	2
0.069386204	2028	3
0.064966458	2029	4
0.051561568	2030	5
0.040833192	2031	6
0.035292957	2032	7
0.030649461	2033	8
0.02782403	2034	9
0.024821674	2035	10
0.020533091	2036	11
0.018263413	2037	12
0.017839912	2038	13
0.016891475	2039	14
0.015306375	2040	15
0.012706409	2041	16
0.012058575	2042	17
0.01181238	2043	18
0.011102443	2044	19
0.009428549	2045	20
0.008560331	2046	21
0.007892985	2047	22
0.007491263	2048	23
0.006970927	2049	24
0.006851249	2050	25
0.006851249	2051	26
0.006851249	2052	27
0.006851249	2053	28
0.006851249	2054	29
0.006851249	2055	30
0.006851249	2056	31
0.006851249	2057	32

2.7.2 Data is set out per year of assessment in Table 2-17, Table 2-18, and Table 2-19. Totals over the assessment lifetime for each option are summarised below Table 2-16. This includes emissions associated with the primary and tertiary processes over 33 years, this accounts for three years of construction, then operation over a 30 year period (covering the extent of the landscape management plan period).

Table 2-16: Assessment lifetime emissions by design option

Design Option	Emissions Source	Total tCO2e
DCO Design - preferred option		
DCO Design	Capital Carbon	50,790
DCO Design	Capital Replacements	9,600
DCO Design - preferred option	Operational Carbon - Power	14,500
DCO Design - preferred option	Operational Carbon - Non-power	29,520
DCO Design - preferred option	Gross Annual Emissions	104,410
DCO Design - preferred option	Biomethane Export	-136,710
DCO Design	Sequestration	-30
DCO Design - preferred option	Net Annual Emissions	-32,330
DCO Design	Cumulative sequestration	-30
DCO Design - CHP		
DCO Design	Capital Carbon	50,790
DCO Design	Capital Replacements	9,600
DM0 Design	Operational Carbon - Power	17,010
DM0 Design	Operational Carbon - Non-power	2,660
DCO Design - CHP	Total Gross Annual Emissions	80,070
DM0 Design	CHP Power Generation	-8,560
DCO Design	Sequestration	-30
DCO Design - CHP	Total Net Annual Emissions	71,480
DCO Design	Cumulative sequestration	-30
Baseline		
DM0 Design	Capital Carbon	96,750
DM0 Design	Capital Replacements	16,270
DM0 Design	Operational Carbon - Power	17,010
DM0 Design	Operational Carbon - Non-power	2,660
DM0 Design	Total Gross Annual Emissions	132,700
DM0 Design	CHP Power Generation	-8,560
Current site	Sequestration	-1,240

Design Option	Emissions Source	Total tCO2e
DM0 Design	Total Net Annual Emissions	122,900
Current site	Cumulative sequestration	-21,070

Table 2-17: Primary and tertiary mitigation assessment lifetime: DCO Design - preferred option

Relative year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Capital Carbon	16,930	16,930	16,930	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capital Replacements	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Operational Carbon - Power	-	-	-	1,743	1,632	1,295	1,026	887	770	699	624	516	459	448	424	385	319
Operational Carbon - Non-power	-	-	-	984	984	984	984	984	984	984	984	984	984	984	984	984	984
Gross Annual Emissions	16,930	16,930	16,930	2,727	2,616	2,279	2,010	1,871	1,754	1,683	1,608	1,500	1,443	1,432	1,408	1,369	1,303
Biomethane Export	-	-	-	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214
Sequestration	-	-	-	-30	Only 1 year sequestration due to management plan being secondary mitigation												
Net Annual Emissions	16,930	16,930	16,930	-3,517	-3,598	-3,935	-4,204	-4,343	-4,460	-4,531	-4,607	-4,714	-4,771	-4,782	-4,806	-4,846	-4,911

Relative year	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Capital Carbon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capital Replacements	-	1	-	-	-	-	8,962	-	-	-	-	640	-	-	-	-

Relative year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Operational Carbon - Power	303	297	279	237	215	198	188	175	172	172	172	172	172	172	172	172	
Operational Carbon - Non-power	984	984	984	984	984	984	984	984	984	984	984	984	984	984	984	984	
Gross Annual Emissions	1,287	1,282	1,263	1,221	1,199	1,182	10,134	1,159	1,156	1,156	1,156	1,796	1,156	1,156	1,156	1,156	
Biomethane Export	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-	-	-	-	-	-	-	-	
Sequestration	Only 1 year sequestration due to management plan being secondary mitigation																
Net Annual Emissions	-4,927	-4,933	-4,951	-4,993	-5,015	-5,032	3,920	-5,055	1,156	1,156	1,156	1,796	1,156	1,156	1,156	1,156	

Table 2-18: Primary and tertiary mitigation assessment lifetime: DCO Design - CHP option

Relative year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Capital Carbon	16,930	16,930	16,930	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capital Replacements	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Operational Carbon - Power	-	-	-	2,046	1,915	1,520	1,204	1,041	904	820	732	605	538	526	498	451	375
Operational Carbon - Non-power	-	-	-	89	89	89	89	89	89	89	89	89	89	89	89	89	89
Gross Annual Emissions	16,930	16,930	16,930	2,134	2,004	1,609	1,293	1,129	992	909	821	694	627	615	587	540	463
CHP Power Generation	-	-	-	-1,029	-963	-765	-605	-523	-454	-413	-368	-304	-271	-265	-250	-227	-188
Sequestration	-	-	-	-30	Only 1 year sequestration due to management plan being secondary mitigation												
Net Annual Emissions	16,930	16,930	16,930	1,076	1,041	844	687	606	538	496	452	390	356	350	336	313	275

Relative year	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Capital Carbon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capital Replacements	-	1	-	-	-	-	8,962	-	-	-	-	640	-	-	-	-

Operational Carbon - Power	356	348	327	278	252	233	221	206	202	202	202	202	202	202	202	202
Operational Carbon - Non-power	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89
Gross Annual Emissions	444	438	416	367	341	321	9,272	294	291	291	291	931	291	291	291	291
CHP Power Generation	-179	-175	-165	-140	-127	-117	-111	-103	-102	-102	-102	-102	-102	-102	-102	-102
Sequestration	Only 1 year sequestration due to management plan being secondary mitigation															
Net Annual Emissions	265	262	251	227	214	204	9,160	191	189	189	189	829	189	189	189	189

Table 2-19: Primary and tertiary mitigation assessment lifetime: Baseline DM0

Relative year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Capital Carbon	32,250	32,250	32,250														
Capital Replacements	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Operational Carbon - Power	-	-	-	2,046	1,915	1,520	1,204	1,041	904	820	732	605	538	526	498	451	375
Operational Carbon - Non-power	-	-	-	89	89	89	89	89	89	89	89	89	89	89	89	89	89
Gross Annual Emissions	32,250	32,250	32,250	2,134	2,004	1,609	1,293	1,129	992	909	821	694	627	615	587	540	463
CHP Power Generation	-	-	-	-1,029	-963	-765	-605	-523	-454	-413	-368	-304	-271	-265	-250	-227	-188
Sequestration	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38
Net Annual Emissions	32,212	32,212	32,212	1,068	1,003	807	650	568	500	459	415	352	319	313	299	275	237

Relative year	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Capital Carbon																

Capital Replacements	-	2	-	-	-	-	15,873	-	-	-	-	398	-	-	-	-
Operational Carbon - Power	356	348	327	278	252	233	221	206	202	202	202	202	202	202	202	202
Operational Carbon - Non-power	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89
Gross Annual Emissions	444	439	416	367	341	321	16,182	294	291	291	291	689	291	291	291	291
CHP Power Generation	-179	-175	-165	-140	-127	-117	-111	-103	-102	-102	-102	-102	-102	-102	-102	-102
Sequestration	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38	-38
Net Annual Emissions	228	226	214	189	177	167	16,034	153	152	152	152	549	152	152	152	152

2.8 Assessment lifetime – Secondary mitigation

2.8.1 Data is set out per year of assessment in Table 2-21 and Table 2-22. Totals over the assessment lifetime for each option are summarised below in Table 2-20. This includes emissions associated with all mitigation measures (including secondary mitigation) over 33 years, this accounts for three years of construction, then operation over a 30 year period (covering the extent of the landscape management plan period). Note that the baseline is shown in Table 2-16.

2.8.2 The same assumptions were used for electricity emissions factors as shown in Table 2-15.

Table 2-20: Assessment lifetime emissions by design option

Design Option	Emissions Source	Total tCO2e
DCO Design - preferred option		
DCO Design	Capital Carbon	50,790
DCO Design	Capital Replacements	9,600
DCO Design - preferred option	Operational Carbon - Power	14,500
DCO Design - preferred option	Operational Carbon - Non-power	29,520
DCO Design - preferred option	Gross Annual Emissions	104,410
DCO Design - preferred option	Biomethane Export	-136,710
DCO Design	Sequestration	-720
DCO Design - preferred option	Net Annual Emissions	-32,020
DCO Design	Cumulative sequestration	-15,550
DCO Design - CHP		
DCO Design	Capital Carbon	50,790
DCO Design	Capital Replacements	9,600
DM0 Design	Operational Carbon - Power	17,010
DM0 Design	Operational Carbon - Non-power	2,660
DCO Design - CHP	Total Gross Annual Emissions	80,070
DM0 Design	CHP Power Generation	-8,560
DCO Design	Sequestration	-720
DCO Design - CHP	Total Net Annual Emissions	71,480
DCO Design	Cumulative sequestration	-15,550

Table 2-21: Secondary mitigation assessment lifetime: DCO Design - preferred option

Relative year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Capital Carbon	16,930	16,930	16,930	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capital Replacements	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Operational Carbon - Power	-	-	-	1,743	1,632	1,295	1,026	887	770	699	624	516	459	448	424	385	319
Operational Carbon - Non-power	-	-	-	984	984	984	984	984	984	984	984	984	984	984	984	984	984
Gross Annual Emissions	16,930	16,930	16,930	2,727	2,616	2,279	2,010	1,871	1,754	1,683	1,608	1,500	1,443	1,432	1,408	1,369	1,303
Biomethane Export	-	-	-	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214
Sequestration	-	-	-	-30	-30	-30	-30	-30	-30	-30	-30	-30	-30	-139	-139	-139	-139
Net Annual Emissions	16,930	16,930	16,930	-3,517	-3,628	-3,965	-4,234	-4,373	-4,490	-4,561	-4,636	-4,744	-4,801	-4,921	-4,945	-4,985	-5,050

Relative year	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Capital Carbon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Capital Replacements	-	1	-	-	-	-	8,962	-	-	-	-	640	-	-	-	-
Operational Carbon - Power	303	297	279	237	215	198	188	175	172	172	172	172	172	172	172	172
Operational Carbon - Non-power	984	984	984	984	984	984	984	984	984	984	984	984	984	984	984	984
Gross Annual Emissions	1,287	1,282	1,263	1,221	1,199	1,182	10,134	1,159	1,156	1,156	1,156	1,796	1,156	1,156	1,156	1,156
Biomethane Export	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-6,214	-	-	-	-	-	-	-	-
Sequestration	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139
Net Annual Emissions	-5,066	-5,072	-5,090	-5,132	-5,154	-5,171	3,781	-5,194	1,017	1,017	1,017	1,657	1,017	1,017	1,017	1,017

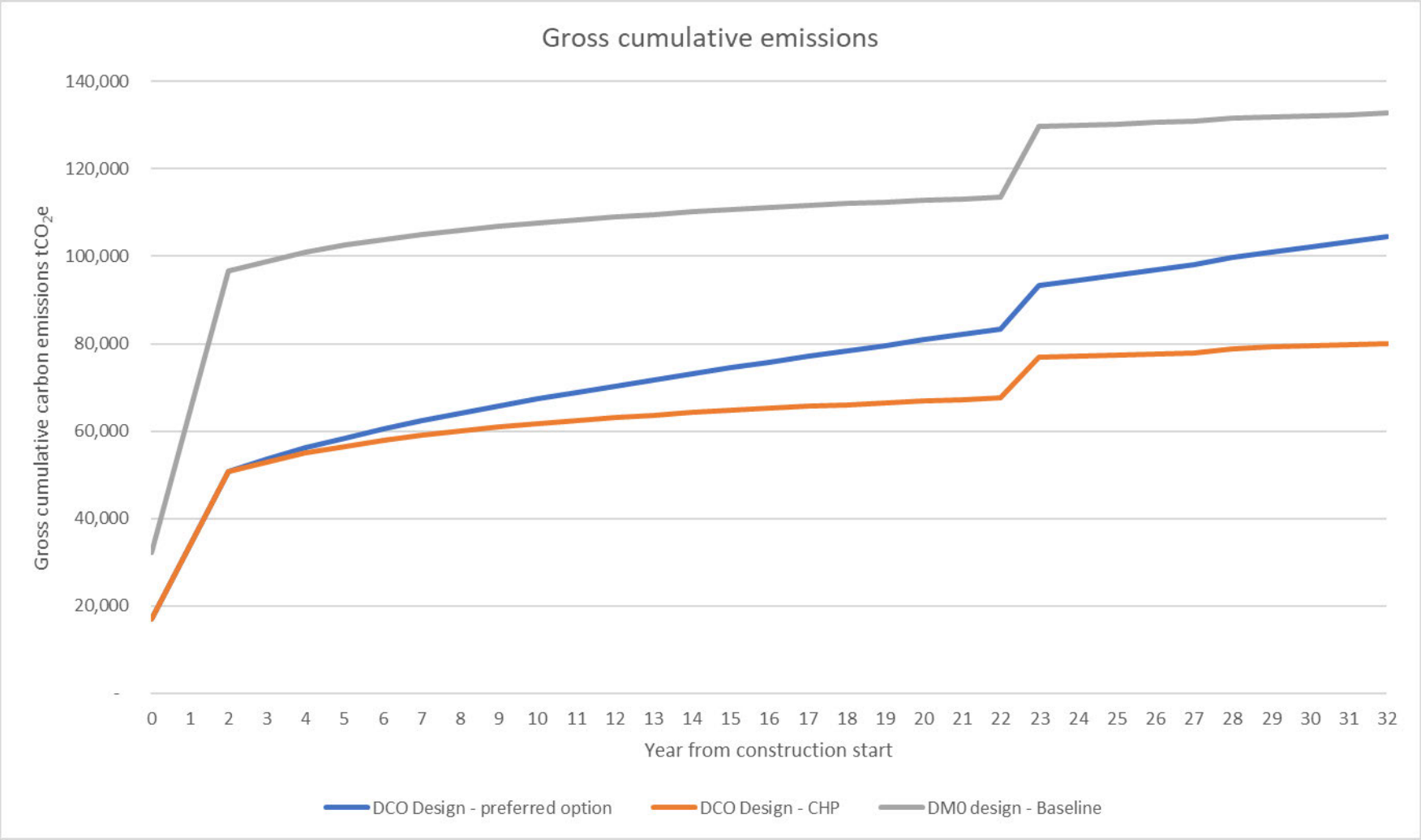
Table 2-22: Primary and tertiary mitigation assessment lifetime: DCO Design - CHP option

Relative year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Capital Carbon	16,930	16,930	16,930	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capital Replacements	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Operational Carbon - Power	-	-	-	2,046	1,915	1,520	1,204	1,041	904	820	732	605	538	526	498	451	375
Operational Carbon - Non-power	-	-	-	89	89	89	89	89	89	89	89	89	89	89	89	89	89
Gross Annual Emissions	16,930	16,930	16,930	2,134	2,004	1,609	1,293	1,129	992	909	821	694	627	615	587	540	463
CHP Power Generation	-	-	-	-1,029	-963	-765	-605	-523	-454	-413	-368	-304	-271	-265	-250	-227	-188
Sequestration	-	-	-	-30	-30	-30	-30	-30	-30	-30	-30	-30	-30	-139	-139	-139	-139
Net Annual Emissions	16,930	16,930	16,930	1,076	1,011	815	657	576	508	467	423	360	327	211	197	174	136
Relative year	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	
Capital Carbon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Capital Replacements	-	1	-	-	-	-	8,962	-	-	-	-	640	-	-	-	-
Operational Carbon - Power	356	348	327	278	252	233	221	206	202	202	202	202	202	202	202	202
Operational Carbon - Non-power	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89
Gross Annual Emissions	444	438	416	367	341	321	9,272	294	291	291	291	931	291	291	291	291
CHP Power Generation	-179	-175	-165	-140	-127	-117	-111	-103	-102	-102	-102	-102	-102	-102	-102	-102
Sequestration	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139	-139
Net Annual Emissions	126	123	112	88	75	65	9,021	52	50	50	50	690	50	50	50	50

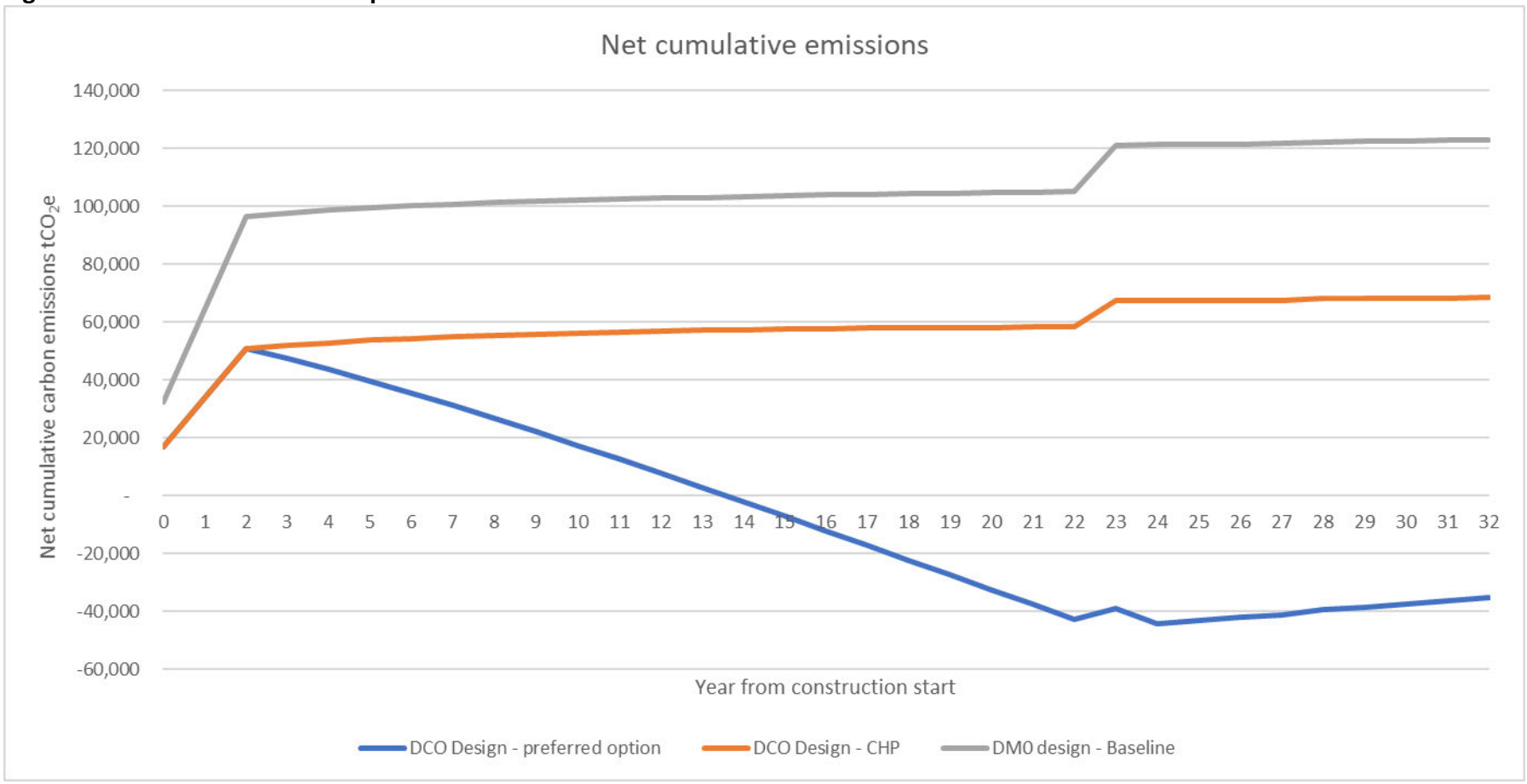
2.8.3 Figure 2.9 below shows the comparison of gross cumulative carbon emissions for the DCO (preferred option and CHP option) and DM0 design models.

Figure 2.9: Gross cumulative comparison



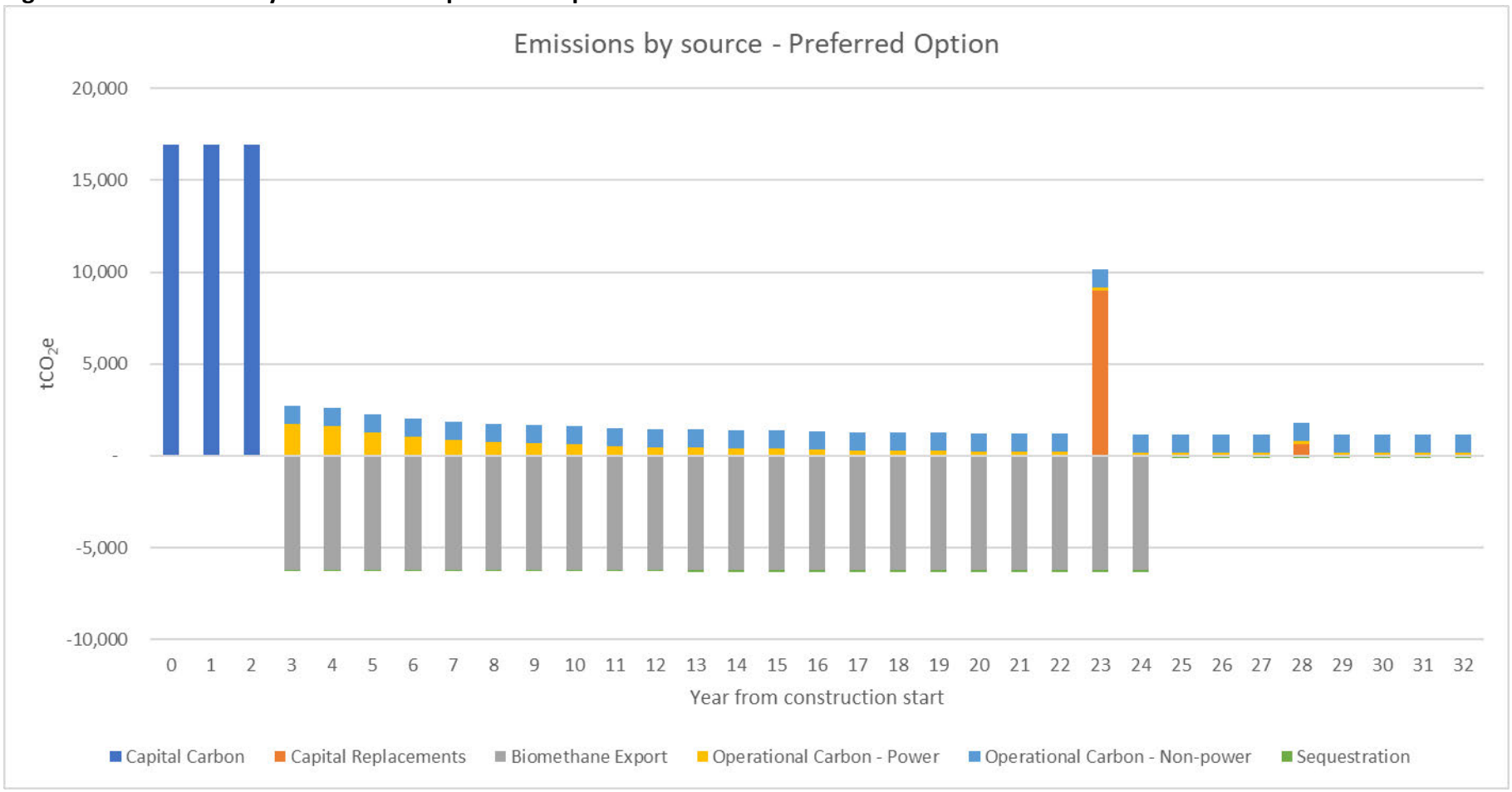
2.8.1 Figure 2.10 below shows the comparison of net cumulative carbon emissions for the DCO (preferred option and CHP option) and DM0 design models. The preferred option is the only option to reach negative net cumulative carbon emissions.

Figure 2.10: Net cumulative comparison



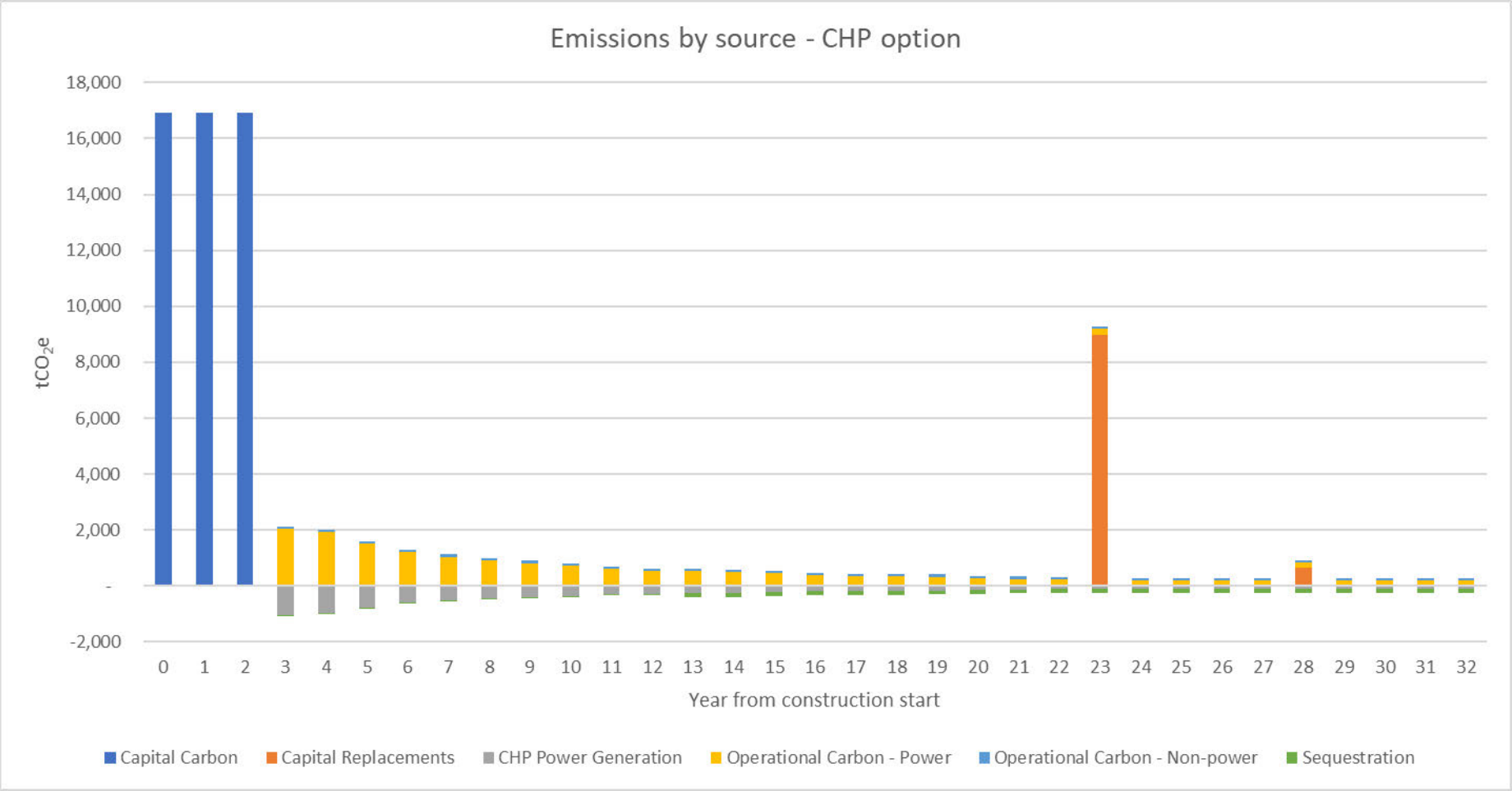
2.8.2 Figure 2.11 below shows that the emissions for the preferred option is relatively low beyond year 2 with a spike in year 23 due to capital replacement. It is assumed that export of biomethane cannot be claimed as avoided emissions post 2050. The overall cumulative outlook shows that more carbon is avoided than emitted.

Figure 2.11: Emissions by source for the preferred option model



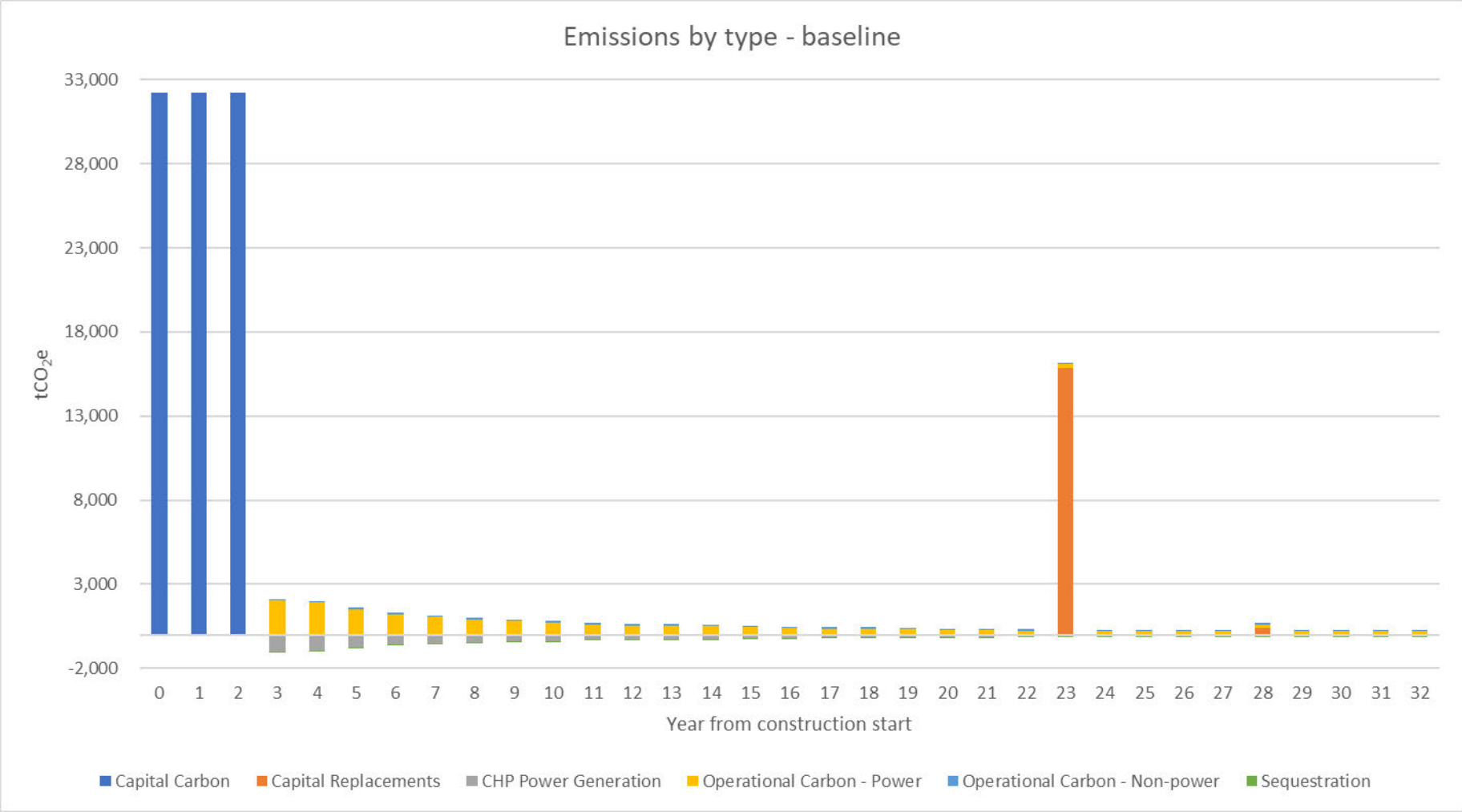
2.8.3 Figure 2.12 below shows the emissions by source for the assessment lifetime. The emissions for the CHP option are relatively low in operation, with lower avoided emissions than the preferred option, and with a spike in year 23 due to capital replacement.

Figure 2.12: Emissions by source – CHP option



2.8.4 Figure 2.13 below shows the emissions by source for the assessment lifetime. The emissions for the baseline option are high for construction, with relatively low operational emissions (although lower avoided emissions than the preferred option), with a spike in year 23 due to capital replacement.

Figure 2.13: Emissions by type – baseline



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