

HIGG FEM 2019

FEM 2019 Energy and Global Warming Calculations

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Reconstructed documentation of how the Higg platform calculated the FEM 2019 energy, greenhouse gas and refrigerant values, prepared in 2026 from the question definitions and the platform's stored results.

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About this document. This guidance was prepared in 2026 as a good-faith effort to document how the Higg platform calculated the FEM 2019 energy, greenhouse gas, water, waste and refrigerant values. FEM 2019 predates the calculation model maintained by Cascale today: the platform applied its own conversion factors and emission factors and wrote the results back into the assessment as answers, where data consumers see them next to the facility's own answers. What follows is reconstructed from the FEM 2019 question and answer definitions, from those stored results across 13,303 assessments, and from the release history. It may not accurately describe all platform behaviour, in particular edge cases that leave no trace in the data. Statements derived from the data rather than from a specification are marked *observed*, with the number of filings behind them.

Scope

This document describes the energy, greenhouse gas and refrigerant values the Higg platform calculated for a FEM 2019 assessment and reported back to the facility, its verifier and data consumers. They are the FEM's own simplified footprint, not a GHG Protocol inventory, and they are neither purely location-based nor purely market-based:

- One `totalGHGmissions` figure combines fuel combustion, refrigerants, purchased electricity, steam and chilled water; the only split published is renewable versus non-renewable. There is no scope split and no location/market pair.
- Purchased electricity carries a single country grid factor (location-based). Energy Attribute Certificates were not collected.
- Biogenic CO₂ from biomass and biodiesel is inside the totals, at full combustion factors.
- Purchased steam and chilled water are counted at a fixed fuel-oil-type factor with no supplier data; refrigerant purchased or added is treated as emitted; wastewater emissions are not calculated at all in FEM 2019.
- Factors are single CO₂e values per source on an IPCC AR4/AR5 basis (FEM 2023 moved to AR6); there is no gas-by-gas breakdown and no process emissions.

The Higg Assessment Model recomputes FEM 2019 answers on a GHG Protocol aligned basis with current factors; those results differ from the platform values described here by design and are documented in the HAM guidance.

Energy Data

Facilities first flagged each energy source they use (*yes/no*, one answer per source; coal, biomass, natural gas and fuel oil have a further flag per type), then reported a quantity and a unit for each source they track. Energy is reported for the site as a whole: there is no split by facility type, domestic use or vehicle use in FEM 2019.

Source	Displayed as	Quantity and unit ref_ids	Unit codes	Platform MJ total
<code>ensourcechilledwater</code>	Chilled Water	<code>ensourcechilledwaterquant</code> <code>ensourcechilledwaterunit</code>	energy and volume	<code>ensourcechilledwatertotal</code>
<code>ensourceelectricpurch</code>	Electricity (purchased)	<code>ensourceelectricpurchquant</code> <code>ensourceelectricpurchunit</code>	energy and volume	<code>ensourceelectricpurchtotal</code>
<code>ensourcegeotherm</code>	Geothermal	<code>ensourcegeothermquant</code> <code>ensourcegeothermunit</code>	energy and volume	<code>ensourcegeothermtotal</code>

Source	Displayed as	Quantity and unit ref_ids	Unit codes	Platform MJ total
ensourcehydro	Hydro	ensourcehydroquant ensourcehydrounit	energy and volume	ensourcehydrototal
ensourcemicrohydro	Micro-Hydro	ensourcemicrohydroquant ensourcemicrohydrounit	energy and volume	ensourcemicrohydrototal
ensourcediesel	Diesel	ensourcedieselquant ensourcedieselunit	energy and volume	ensourcedieseltotal
ensourcepetrol	Petrol	ensourcepetrolquant ensourcepetrolunit	energy and volume	ensourcepetroltotal
ensourcesolarphoto	Solar Photovoltaic	ensourcesolarphotoquant ensourcesolarphotounit	energy and volume	ensourcesolarphotototal
ensourcesteampurch	Steam (purchased)	ensourcesteampurchquant ensourcesteampurchunit	energy and volume	ensourcesteampurchtotal
ensourcewind	Wind	ensourcewindquant ensourcewindunit	energy and volume	ensourcewindtotal
ensourcecoalsba	Coal: Coal-SBA	ensourcecoalquantsba ensourcecoalunitsba	mass and energy	ensourcecoalsbatotal
ensourcecoalsbb	Coal: Coal-SBB	ensourcecoalquantsbb ensourcecoalunitsbb	mass and energy	ensourcecoalsbbtotal
ensourcecoalsbc	Coal: Coal-SBC	ensourcecoalquantsbc ensourcecoalunitsbc	mass and energy	ensourcecoalsbctotal
ensourcecoalsbhvc	Coal: Coal-SBHVC	ensourcecoalquantsbhvc ensourcecoalunitsbhvc	mass and energy	ensourcecoalsbhvctotal
ensourcecoalbhvb	Coal: Coal-BHVB	ensourcecoalquantbhvb ensourcecoalunitbhvb	mass and energy	ensourcecoalbhvbtotat
ensourcecoalbhva	Coal: Coal-BHVA	ensourcecoalquantbhva ensourcecoalunitbhva	mass and energy	ensourcecoalbhvatotal
ensourcecoalother	Coal: Coal-type unknown	ensourcecoalquantother ensourcecoalunitother	mass and energy	ensourcecoalothertotal
ensourcebiomassbeg	Biomass: Begasse	ensourcebiomassquantbeg ensourcebiomassunitbeg	mass and energy	ensourcebiomassbegtotal
ensourcebiomasscane	Biomass: Cane Sugar	ensourcebiomassquantcane ensourcebiomassunitcane	mass and energy	ensourcebiomasscanetotal
ensourcebiomasscashew	Biomass: Cashew Nut Shell	ensourcebiomassquantcashew ensourcebiomassunitcashew	mass and energy	ensourcebiomasscashewtotal
ensourcebiomasscorncob	Biomass: Corncob	ensourcebiomassquantcorncob ensourcebiomassunitcorncob	mass and energy	ensourcebiomasscorncobtotal
ensourcebiomasscornstalk	Biomass: Cornstalk	ensourcebiomassquantcornstalk ensourcebiomassunitcornstalk	mass and energy	ensourcebiomasscornstalktotal
ensourcebiomassefb	Biomass: Empty Fruit Branch	ensourcebiomassquantefb ensourcebiomassunitfb	mass and energy	ensourcebiomassefbtotal
ensourcebiomasseuca	Biomass: Eucalyptus Bark	ensourcebiomassquanteuca ensourcebiomassuniteuca	mass and energy	ensourcebiomasseucatotal
ensourcebiomasspalmfiber	Biomass: Palm Fiber	ensourcebiomassquantpalmfiber ensourcebiomassunitpalmfiber	mass and energy	ensourcebiomasspalmfibertotal
ensourcebiomasspalmleaf	Biomass: Palm Leaf	ensourcebiomassquantpalmleaf ensourcebiomassunitpalmleaf	mass and energy	ensourcebiomasspalmleaftotal
ensourcebiomasspalmsell	Biomass: Palm Shell	ensourcebiomassquantpalmsell ensourcebiomassunitpalmsell	mass and energy	ensourcebiomasspalmselltotal
ensourcebiomasspalmtrunk	Biomass: Palm Trunk	ensourcebiomassquantpalmtrunk ensourcebiomassunitpalmtrunk	mass and energy	ensourcebiomasspalmtrunktotal
ensourcebiomassparawood	Biomass: Parawood	ensourcebiomassquantparawood ensourcebiomassunitparawood	mass and energy	ensourcebiomassparawoodtotal
ensourcebiomasspeanutshells	Biomass: Peanut Shells	ensourcebiomassquantpeanutshells ensourcebiomassunitpeanutshells	mass and energy	ensourcebiomasspeanutshellstotal

Source	Displayed as	Quantity and unit ref_ids	Unit codes	Platform MJ total
ensourcebiomassricehusks	Biomass: Rice Husk	ensourcebiomassquantricehusks ensourcebiomassunitricehusks	mass and energy	ensourcebiomassricehusktotal
ensourcebiomassricestraw	Biomass: Rice Straw	ensourcebiomassquantricestraw ensourcebiomassunitricestraw	mass and energy	ensourcebiomassricestrawtotal
ensourcebiomasssawdust	Biomass: Saw Dust	ensourcebiomassquantsawdust ensourcebiomassunitsawdust	mass and energy	ensourcebiomasssawdusttotal
ensourcebiomasssliverwood	Biomass: Sliver of wood	ensourcebiomassquantsliverwood ensourcebiomassunitliverwood	mass and energy	ensourcebiomasssliverwoodtotal
ensourcebiomass tapioca	Biomass: Tapioca Rhizome	ensourcebiomassquanttapioca ensourcebiomassunittapioca	mass and energy	ensourcebiomass tapiocatotal
ensourcebiomasswood	Biomass: Wood Briquette	ensourcebiomassquantwood ensourcebiomassunitwood	mass and energy	ensourcebiomasswoodtotal
ensourcebiomassbiodiesel	Biomass: Biodiesel	ensourcebiomassquantbiodiesel ensourcebiomassunitbiodiesel	mass and energy	ensourcebiomassbiodieseltotal
ensourcebiomassother	Biomass: Biomass-type unknown	ensourcebiomassquantother ensourcebiomassunitother	mass and energy	ensourcebiomassothertotal
ensourcenatgaslng	Natural gas and gas fuels: LNG	ensourcenatgasquantlng ensourcenatgasunitlng	energy and volume	ensourcenatgaslngtotal
ensourcenatgaslpg	Natural gas and gas fuels: LPG	ensourcenatgasquantlpg ensourcenatgasunitlpg	energy and volume	ensourcenatgaslpgtotal
ensourcenatgasng	Natural gas and gas fuels: Natural Gas	ensourcenatgasquantng ensourcenatgasunitng	energy and volume	ensourcenatgasngtotal
ensourcenatgaspropane	Natural gas and gas fuels: Propane	ensourcenatgasquantpropane ensourcenatgasunitpropane	energy and volume	ensourcenatgaspropanetotal
ensourcenatgasother	Natural gas and gas fuels: Natural Gas- type unknown	ensourcenatgasquantother ensourcenatgasunitother	energy and volume	ensourcenatgasothertotal
ensourcefueloilone	Fuel oil: Fuel Oil #1	ensourcefueloilquantone ensourcefueloilunitone	energy and volume	ensourcefueloilonetotal
ensourcefueloiltwo	Fuel oil: Fuel Oil #2	ensourcefueloilquanttwo ensourcefueloilunittwo	energy and volume	ensourcefueloiltwototal
ensourcefueloilfour	Fuel oil: Fuel Oil #4	ensourcefueloilquantfour ensourcefueloilunitfour	energy and volume	ensourcefueloilfourtotal
ensourcefueloilfive	Fuel oil: Fuel Oil #5	ensourcefueloilquantfive ensourcefueloilunitfive	energy and volume	ensourcefueloilfivetotal
ensourcefueloilsix	Fuel oil: Fuel Oil #6	ensourcefueloilquantsix ensourcefueloilunitsix	energy and volume	ensourcefueloilsixtotal
ensourcefueloilother	Fuel oil: Fuel oil-type unknown	ensourcefueloilquantother ensourcefueloilunitother	energy and volume	ensourcefueloilothertotal

The platform's MJ result for each source is stored as an answer under the ref_id in the last column; for coal, biomass, natural gas and fuel oil the platform also stored a group total (ensourcecoaltotal, ensourcebiomassgentotal, ensourcebiomasswoodtotal, ensourcenaturalgastotal, ensourcefueloiltotal).

Conversion to MJ

The platform converted each reported quantity to MJ in its own code; no specification of the conversions was published. They are recovered here from the stored totals (total ÷ quantity, deterministic within each unit across all filings). Energy units use the standard factors below; mass

and volume units imply the energy densities in the next table. Electricity, purchased steam, chilled water and the onsite and offsite renewables share the energy-and-volume unit set, which includes volume units: a volume unit chosen for those sources converts to 0 MJ (*observed* in every such filing), so that energy is missing from the facility's totals.

Energy units (all sources):

Unit	MJ
kWh	3.600000
MJ	1.000000
mmBTU	1055.055000
BTU	0.001055
Joule	0.000001

Mass units convert to kilograms and **volume units** to litres with the standard factors (g 0.001, lb 0.4535, oz 0.0283, ton (metric) 1,000, ton (short) 907.185; m³ 1,000, gal 3.7854, cu ft 28.3168, cu yard 764.554, CCF 2,831.68).

Energy densities implied by the stored totals (median of $\text{total} \div \text{quantity}$ per unit, converted to the base unit; *observed*, with the number of filings that reported the source):

Source	MJ per kg (observed)	MJ per litre (observed)	Filings reporting the source
biomassbeg	9.5947		16
biomasscashew	9.5947		9
biomasscornstalk	9.5947		10
biomasseuca	9.5947		37
biomassother	9.5947		311
biomasspalmshell	9.5947		13
biomassparawood	9.5947		116
biomasspeanutshells	9.5947		8
biomassricehusks	9.5947		70
biomassricestraw	9.5947		6
biomasssawdust	20.3292		109
biomasssliverwood	20.3292		90
biomasswood	20.3292		400
coalbhva	29.2022		115
coalbhvb	29.0160		16
coalother	16.5390		325
coalsba	20.0772		148
coalsbb	20.0772		54
coalsbc	20.0772		33
coalsbhvc	20.0772		12
diesel		38.4523	5338
fueloilfive		39.0546	47
fueloilfour		40.7284	83
fueloilone		38.7757	63
fueloilother		38.4967	82
fueloilsix		41.8443	166
fueloiltwo		38.4967	157

Source	MJ per kg (observed)	MJ per litre (observed)	Filings reporting the source
natgaslng		23.6000	257
natgaslpg		25.6349	1049
natgasng		0.0382	2606
natgasother		0.0382	105
natgaspropane		25.3563	109
petrol		34.8300	2701

Notable in this table: the coal types carry distinct densities, the biomass types share one density of 20.33 MJ per kg regardless of type, and purchased steam and chilled water have no density because they only convert from energy units. The platform grouped biomass into two totals (*observed*): `ensourcebiomasswoodtotal` covers wood briquette, sawdust and slivers of wood, and `ensourcebiomassgentotal` covers every other biomass type; the group totals, not the typed values, feed the emissions totals.

Conversion to kg CO₂e

Each source's emissions are its MJ total multiplied by a single factor held by the platform: `ensource[source]totalghg = ensource[source]total × factor`. For coal, natural gas and fuel oil the platform also stored a group emissions total that is the sum of the typed values (coal: in 97% of filings), so a facility's effective coal factor depends on the mix of coal types it reported.

Factors applied (kg CO₂e per MJ) — observed as the median of `totalghg ÷ total`; unless noted, every filing shows the same factor:

Source	kg CO ₂ e per MJ	Filings	Note
biomassbeg	0.11391	16	
biomassbiodiesel	0.07004	7	
biomasscane	0.11391	1	
biomasscashew	0.11391	9	
biomasscorncob	0.11391	6	
biomasscornstalk	0.11391	10	
biomassefb	0.11391	6	
biomasseuca	0.11391	37	
biomassgen	0.11391	555	
biomassother	0.11391	311	
biomasspalmfiber	0.11391	2	
biomasspalmsell	0.11391	13	
biomassparawood	0.11391	116	
biomasspeanutshells	0.11391	8	
biomassricehusks	0.11391	70	
biomassricestraw	0.11391	6	
biomasssawdust	0.09000	109	
biomassliverwood	0.09000	90	
biomass tapioca	0.11391	1	
biomasswood	0.09000	400	

Source	kg CO2e per MJ	Filings	Note
chilledwater	0.06293	14	
coal	0.09326	663	sum of the typed sources below
coalbhva	0.09892	115	
coalbhvb	0.08906	16	
coalother	0.09326	325	
coalsba	0.09274	148	
coalsbb	0.09274	54	
coalsbc	0.09274	33	
coalsbhvc	0.09274	12	
diesel	0.07033	5338	
electricpurch	country grid factor	10075	varies by country
fueloil	0.07029	530	sum of the typed sources below
fueloilfive	0.06931	47	
fueloilfour	0.07131	83	
fueloilone	0.06961	63	
fueloilother	0.07029	82	
fueloilsix	0.07137	166	
fueloiltwo	0.07029	157	
geotherm	0.00000	6	
hydro	0.00000	191	
microhydro	0.00000	9	
natgaslng	0.05034	257	
natgaslpg	0.05872	1049	
natgasng	0.05034	2606	
natgasother	0.05034	105	
natgaspropane	0.05982	109	
naturalgas	0.05034	2669	
petrol	0.06679	2701	
solarphoto	0.00000	826	
steampurch	0.06293	531	
wind	0.00000	99	

Purchased electricity is multiplied by a **country grid factor** ($\text{en_sourceelectricpurchtotalgwp}$, kg CO2e per MJ, selected by the facility's `sitecountry` answer), licensed from IEA and updated by the platform between cadences. The factors the platform applied are not preserved outside the assessments themselves. Comparing the factor stored with each filing against the FEM 2019 country factors now held in Cascale's shared reference data (which were re-derived for the Higg Assessment Model), the platform's factor is on median 9% higher, and only 5% of filings are within 5% of the shared value, so the shared data cannot be used to reproduce FEM 2019 platform emissions.

The renewable sources (`solarphoto`, `wind`, `geotherm`, `hydro`, `microhydro`) carry a factor of 0. Purchased steam and chilled water carry a fixed fuel-oil-type factor of 0.0629; the facility could not report a supplier factor or a generation mix in FEM 2019.

Refrigerants

Refrigerant use is reported in the Air Emissions section in up to five entries (`airsourcerefrig1 ...` `airsourcerefrigs`): the refrigerant (`airsourcerefrig[n]`), the quantity added or used (`airsourcerefrig[n]quant`) and its unit (`airsourcerefrig[n]unit`: g, kg, lb, oz, ton (metric), ton (short)). The platform converted the quantity to kilograms (`airsourcerefrig[n]total`), looked up the refrigerant's global warming potential (`airsourcerefrig[n]totalgwp`) and multiplied (`airsourcerefrig[n]totalghg`); `totalRefrigerantEmissions` is the sum of the five entries. Observed to equal the sum of its components in 99% of 1,319 filings.

The GWP values below are the ones the platform stored with FEM 2019 filings (IPCC AR4 basis, blends as marketed). Only refrigerants that at least one facility reported can be recovered this way; 279 of the 344 refrigerants offered in FEM 2019 were never reported and their platform values are unknown (the FEM 2023 Energy Source Changes document lists FEM 2022 values for those that changed in FEM 2023, several of which were 0).

Refrigerant	kg CO2e per kg (GWP applied)	Filings
R-10 (PCC)	1730.00	22
R-11 (CFC)	4660.00	9
R-110 (PCC)	0.00	1
R-112 (CFC)	0.00	1
R-114a (CFC)	0.00	2
R-12 (CFC)	10200.00	10
R-123 (HCFC)	79.00	7
R-124 (HCFC)	527.00	1
R-124a (HCFC)	0.00	1
R-125 (HFC)	3170.00	2
R-12B1 (H)	1750.00	1
R-12B2 (H)	231.00	1
R-13 (CFC)	13900.00	5
R-132 (HCFC)	0.00	1
R-132a (HCFC)	0.00	1
R-134 (HFC)	1120.00	29
R-134a (HFC)	1300.00	145
R-13B1 (H)	6290.00	3
R-14 (PFC)	6630.00	1
R-140 (HCC)	0.00	1
R-140a (HCC)	160.00	5
R-141 (HCFC)	0.00	1
R-141a (HCFC)	0.00	2
R-141b (HCFC)	782.00	1
R-143a (HFC)	4800.00	2
R-152a (HFC)	138.00	1
R-20 (HCC)	16.00	5
R-21 (HCFC)	148.00	6
R-22 (HCFC)	1760.00	1064
R-222 (HCFC)	0.00	1

Refrigerant	kg CO2e per kg (GWP applied)	Filings
R-225 (HCFC)	0.00	1
R-22B1 (H)	376.00	3
R-23 (HFC)	12400.00	4
R-232 (HCFC)	0.00	2
R-290 (HC)	0.00	2
R-30 (HCC)	9.00	1
R-31 (HCFC)	0.00	1
R-32 (HFC)	677.00	137
R-40 (HCC)	12.00	1
R-401A (HCFC)	1129.92	14
R-404A (HFC)	3942.80	50
R-405A (HCFC)	0.00	1
R-406A (HCFC)	1501.00	1
R-407A (HFC)	2079.40	25
R-407C (HFC)	1624.21	67
R-407D (HFC)	1487.05	1
R-407F (HFC)	1825.00	1
R-408A (HCFC)	3257.10	2
R-41 (HFC)	116.00	11
R-410A (HFC)	1923.50	418
R-410B (HFC)	2048.15	9
R-417A (HFC)	1542.22	1
R-420A (HCFC)	0.00	1
R-422A (HFC)	2847.17	1
R-422B (HFC)	0.00	1
R-422D (HFC)	2473.17	3
R-438A (HFC)	2265.00	2
R-50 (HC)	28.00	1
R-507[A] (HFC)	3985.00	1
R-510[A] (HC)	0.00	1
R-600a (HC)	0.00	9
R-601a (HC)	0.00	1
R-717	0.00	1
R-E134 (HFC)	1300.00	1
R-E143a (HFC)	1.00	1

Totals

The platform stored these aggregates with each assessment. Their composition is *observed*: the share of filings in which the stored total equals the sum of the listed components within 0.5%.

`ensourcetotal` — total MJ across all energy sources. Observed to equal the sum of its components in 96% of 10,375 filings.

`totalNonRenewableEnergyEmissions` — kg CO₂e from the non-renewable sources: coal, naturalgas, natgaslpg, natgaspropane, diesel, fueloil, petrol, steampurch, chilledwater, electricpurch. Observed to equal the sum of its components in 97% of 10,287 filings.

`totalRenewableEmissions` — kg CO₂e from the renewable sources including biomass and biodiesel: biomassgen, biomasswood, biomassbiodiesel, solarphoto, wind, geotherm, hydro, microhydro. Observed to equal the sum of its components in 98% of 879 filings.

`totalRefrigerantEmissions` — kg CO₂e from the five refrigerant entries.

`totalNonRenewableEmissions` — `totalNonRenewableEnergyEmissions` plus `totalRefrigerantEmissions`. Observed to equal the sum of its components in 100% of 10,315 filings.

`totalGHGEmissions` — `totalNonRenewableEmissions` plus `totalRenewableEmissions`. Observed to equal the sum of its components in 100% of 10,319 filings.

`totalNormalizedGHGEmissions` — `totalGHGEmissions` divided by the annual production volume `sipfacilityannualprodvolquant` (in the unit the facility chose in `sipfacilityannualprodvolunits`). Observed to equal the sum of its components in 100% of 10,230 filings.

The remaining few percent of filings whose totals do not add up were, as far as the data shows, assessments whose totals were not recomputed after a late edit; the platform did not publish a rule for them.

Unit Answer Codes

Unit answers in FEM 2019 are numeric codes. Which set a code belongs to depends on the source, as given in the source table above.

Energy and volume set (electricity, steam, chilled water, the renewable sources, diesel, petrol, the natural gas group and the fuel oil group):

Answer code	Unit
1	kWh
2	MJ
3	mmBTU
4	BTU
5	Joule
6	cu ft
7	cu yard
8	liter
9	m3
10	gal
11	CCF

Mass and energy set (the coal and biomass groups):

Answer code	Unit
1	g
2	kg
3	lb

Answer code	Unit
4	oz
5	ton (metric)
6	ton (short)
7	kWh
8	MJ
9	mmBTU
10	BTU
11	Joule

Refrigerant mass set (`airsourcerefrig[n]unit`):

Answer code	Unit
1	g
2	kg
3	lb
4	oz
5	ton (metric)
6	ton (short)

Cadence Notes

FEM 2017, FEM 2018 and FEM 2019 share one design: the same questions, `ref_ids`, answer options and units. The differences between them are the country grid emission factors, which the platform updated each year, and behaviour that is only visible in the data:

- FEM 2017 steam, chilled water and electricity quantities occur only in energy units; from FEM 2018 facilities also chose volume units for these sources and the platform converted those entries to 0 MJ (*observed*: every such filing totals 0), so that energy vanished from the totals.
- Answer values in these cadences are numeric codes ("1", "8"), not the labels used from FEM 2020. The same code means different units for different sources: 1 is kWh for electricity but g for coal. The tables under Unit answer codes give the mapping for each unit set, and any consumer must resolve a unit answer through the set that applies to that source.

Not Calculated in FEM 2019

No wastewater treatment emissions, no vehicle energy, no domestic/production split, no facility-type split, no energy or emissions normalised per facility type, and no market-based figures were calculated. Baseline and target answers (`enbaseline...`, `en...target...`) were converted to MJ with the same densities but do not enter any total.