Innovators and transformers: a benchmarking study of online carbon emission calculators for freight transport

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Abstract

Purpose – Carbon emissions commonly serve as an indicator for environmental friendliness, and so more and more carbon emission calculators (CECs) are offered that allow an estimation of the environmental footprint of freight transport operations. Unfortunately, their exact measurement is challenging due to the availability or poor quality of necessary input data and a multitude of possible calculation methods that may result in highly inaccurate to very misleading figures.

Design/methodology/approach – A structured online search was conducted to identify suitable online carbon emission calculators (OCECs) for further assessment in the form of a benchmark case that includes different modes of transport from road and rail to air and sea between China and Europe. Further comparison resulted in a ranking of OCECs along the categories of transparency (routing system, data sources and calculation method), completeness (input options) and accuracy (data output).

Findings – Different predefined inputs and calculation methods employed by the OCECs assessed inevitably result in a wide spread of more or less reliable carbon footprint measurement results.

Practical implications – All potential users of CECs, including policymakers, actors from the transport industry and other stakeholders, are well advised to question greenhouse gas (GHG) emission statements that are not backed by transparent procedures and internationally recognized calculation standards.

Originality/value – This study, including a benchmark case and a ranking, offers a guideline for potential users of CEC to avoid major pitfalls coming along with the present carbon footprint measurement of freight transport operations.

Keywords Freight transport, Carbon footprint, GHG emissions, Carbon emission calculator, Benchmarking study

Paper type General review

Introduction

According to the ITF (2023), the whole transport sector accounted for 23% of energy-related CO_2 emissions in 2018, with freight transport contributing 30% (ITF, 2015), with projections so far indicating that greenhouse gas (GHG) emissions related to transport will rise again in the aftermath of the COVID-19 pandemic (ITF, 2023; IEA, 2023). However, the need to reduce

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them is pressing, as the global carbon footprint should have peaked by 2020 and then be reduced substantially within the following decades toward a net-zero CO_2 level (WRI, 2017; UNEP, 2023; IPCC, 2023) to ensure that we remain within the climate target of the Paris Agreement (UN, 2021).

To effectively manage and reduce GHG emissions, there is a clear baseline and appropriate methodology for calculating comparable emission values necessary. Unfortunately, so far no single globally binding guideline or standard for calculating GHG emissions in freight transport has been established. As a result, various calculation methods are adopted, and at least some of them lead to very different outcomes, which makes comparisons considerably more difficult (Auvinen *et al.*, 2014; Lewis *et al.*, 2016). The same holds for GHG calculation systems or carbon emission calculators (CECs). The number of available CECs for freight transport is large (CE Delft *et al.*, 2014; Auvinen *et al.*, 2014; Ehrler *et al.*, 2016; Saharidis and Konstantzos, 2018; Chocholac *et al.*, 2019, 2021; Wild, 2021). Yet, some of them are based on different calculation methods taking varying input data, resulting in a loss of consistency of outcomes (Ehrler *et al.*, 2016; Šimenc, 2016; Kellner and Schneiderbauer, 2019; Murphy *et al.*, 2021; Wild, 2021; Hörandner *et al.*, 2023). The fact that stakeholders often cannot rely on sound information about GHG emitted makes it difficult for them to effectively manage and reduce their GHG emissions (Auvinen *et al.*, 2014; Lewis *et al.*, 2016). However, effective GHG management and systematic reductions of GHGs are critical to decarbonizing the transport sector and thus to achieving our societal climate goals.

Previous studies like CE Delft *et al.* (2014), Šimenc (2016), Murphy *et al.* (2021) or Hörandner *et al.* (2023) have shown that a direct comparison of CECs regularly delivers different outcomes even for one and the same transport operation. Therefore, it is reasonable to assume that some CECs provide more accurate and reliable outcomes than others. In this study, our focus is on CECs that are free of charge and available online without access restrictions. Furthermore, they should also follow an internationally recognized calculation method and cover multiple transport modes like road, rail, sea and air. The high practical relevance led to the adoption of a pragmatic research philosophy. Therefore, our methodological choice was a mixed-method approach comparing quantitative outcomes of GHG emission calculations obtained by a defined benchmark case, followed by a more qualitative overall assessment of the online carbon emission calculators (OCECs).

In the following, a brief overview concerning present developments in GHG emission calculation approaches is provided before our sampling process to find OCECs for further assessment is outlined. Then a benchmarking case is set up to compare CEC outcomes of these selected OCECs, followed by their qualitative assessment along the principles of transparency, completeness and accuracy. In summary, our study aims to offer practical guidance to avoid major pitfalls coming along with the present carbon footprint measurement of freight transport operations.

Background

For environmental efficiency targets like the Paris Agreement (UN, 2021) to be meaningful, there must be a clear baseline and associated methodology for calculating comparable GHG emission levels. As production processes, including transportation operations, became even more international and complex than in the past, methods used to calculate GHG emissions must be comparable on a global basis. Consequently, various standardization efforts and guidelines are under constant development that show the ambitions to establish a reliable global standard in the context of GHG emissions calculation. However, these guidelines and standards still contain ambiguities and possible conflicts (Davydenko *et al.*, 2014; Kellner, 2016). In addition, there is no organizational body available that could establish a globally applicable, recognized and binding regulation (Auvinen *et al.*, 2014; Lewis *et al.*, 2016).

Firstly, there is a stream of literature that concentrates on modeling GHG emissions at the country level, including international trade flows (Martinez *et al.*, 2014; Yamano and Guilhoto, 2020; Doll *et al.*, 2020) that lay the foundation for regular GHG emission reports by the International Transport Forum (ITF, 2023) or the International Energy Agency (IEA, 2023).

Secondly, there are general standards for calculation of corporate carbon footprint available, where GHG emissions are to be calculated as an absolute value for an entire company or broken down to single products (Kronborg Jensen, 2012). This also includes transports carried out by and for companies. The two best-known representatives of this category on company level are ISO 14064-1:2018 and the GHG Protocol Corporate Accounting and Reporting Standard (WRI and WBCSD, 2004), further refined by the GHG Protocol system (WRI and WBCSD, 2011, 2013, 2023). Both rely on a scope structure that defines system boundaries of GHG emissions to be calculated (i.e. Scope 1, Scope 2 and Scope 3). The methodological basis of the two standards is largely similar, with the notable exception that ISO 14064-1:2018 also includes a system for validation of a GHG emission statement (Yaman, 2023).

In addition to this, there are various initiatives issuing guidelines or standards aimed at harmonizing the calculation of GHG emissions dedicated to transport operations (Bekaroo *et al.*, 2021; Wild, 2021). Some of these guidelines or standards focus on the calculation of GHG emissions of transport operations in certain regions, such as *SmartWay* in North America (Bynum *et al.*, 2018). Others concentrate on a specific transport mode. *International Air Transport Association* (IATA, 2022) and *International Civil Aviation Organization* (ICAO, 2018), for example, deal with GHG emissions in air transport, whereas *Clean Cargo* (SFC, 2024, formerly called *Clean Cargo Working Group*, cf. CCWG, 2015) and *International Maritime Organization* (IMO, 2018) focus on GHG emissions in maritime shipping. Some, like the GLEC framework from the *Global Logistics Emissions Council* (SFC, 2019, 2023) cover several transport modes. Another one is EN 16258:2012, a European standard that involves all transport modes and is not dependent on interest groups or individual research institutions (Osorio-Tejada *et al.*, 2018; Dobers *et al.*, 2019; Fridell *et al.*, 2019; Kellner and Schneiderbauer, 2019). A common scope of all these guidelines or standards is the Well-to-Wheel (WTW) approach, i.e. both GHG emissions from generation, production or distribution of energy or fuel (Well-to-Tank, WTT) and those emitted by performing transport operations (Tank-to-Wheel, TTW) are included.

However, concerns regarding the omission of GHG emissions caused by transport-related logistics operations in EN 16258:2012 (Kellner, 2016; Saharidis and Konstantzos, 2018) led to the development of ISO 14083:2023 and subsequently to an updated GLEC framework (as of 2023) that now explicitly demands quantification and reporting of GHG emissions arising from end-to-end transport chain operations, including passenger and cargo handling operations in between. Given their comprehensive scope, there is a good prospect that ISO 14083:2023 and GLEC framework (as of 2023) will achieve a wide-spread adoption in the transport industry as a de facto standard for CEC and will be soon subject to scholarly publications, too.

Identification of carbon emission calculators

As already indicated before, a first step was to find and compare different CECs for freight transport for further assessment.

Selection criteria

Firstly, CECs had to focus on freight transport, be available in English, and be easily accessible to anyone without prior registration or payment of fees. Furthermore, the following exclusion criteria have been established in a second stage of selection:

Web-based application: Basically, a web-based application is a software program stored on a remote server that uses web technologies and web browsers to provide service to an end-user. This implies that it is not necessary to download any software to use it.

Suitable for different transport modes: GHG emissions accruing from transport operations should be calculated equally for the four transport modes of road, rail, maritime and air.

Integrated routing system: The CEC should have a routing system implemented so that no additional information on either the distance traveled or fuel consumed has to be provided.

Based on globally recognized standards: To ensure a certain degree of validation and comparability of results, the CEC must be based on a globally recognized GHG emission calculation standard. Hence, it was assumed that a provider that tries to comply with such a standard will visibly disclose it.

Structured internet search procedure

Given that many CECs developed in recent years are not well reflected by academic literature yet, a structured literature review employing scholarly databases was therefore not considered to be an appropriate approach. It was therefore decided to search for CECs using internet search engines to include all currently online available CECs meeting the aforementioned selection criteria. However, several studies have found that a non-reflected use of internet search engines such as Google is not in line with scientific principles of transparency, reproducibility and rigorousness (Curkovic, 2019; Piasecki *et al.*, 2017), as they tend to provide results based on ever-changing search engine criteria and/or user preferences that lead to more personalized search results.

Chocholac *et al.* (2019, 2021) searched for CECs and made use of the Google search engine. In doing so, two independent researchers used the keywords “emission freight calculator” and “emission calculator” and selected the first ten emission calculators in their results. A similar, but more comprehensive approach was followed in our context. Firstly, two independent devices were used for the search. One was in the University Library, accessible to all students at the university. The other one was in the National Library, accessible for everybody who pays a small entrance fee. Choosing these two devices that are used by a broad community is a first step to reducing the bias of personalized search results. On both devices, Firefox was installed as an internet browser, which was then used in private browsing mode to minimize the bias of search history and cookies. Other settings were all set on default. On each device, then three different internet search engines were used, namely Google, Bing and Yahoo. All of them were fed with the following search query: (“calculator” OR “tool”) AND (“carbon” OR “emission” OR “CO2”) AND (“freight” OR “transport”). From each of these six search runs, the first 100 results found were further analyzed. A total of 42 CECs were then either found via direct links to them or via websites or articles that referenced them. The only criteria to be fulfilled at that stage were that they had to be available in English, focus on the calculation of GHG emissions in freight transport, and most basic information about the CEC had to be available without signing a membership or paying a fee.

Being aware that perfect reproducibility can hardly be given for this research method, it can still be argued that CECs that could not be found despite the above-proposed precautions are rather hard to find for ordinary people searching online for CECs. However, this would also stay in contrast to our selection criteria of free and easy access.

Further selection process

At this stage, selection of OCECs based on the criteria defined before with only those CECs that met all were used for further inquiry. It should be noted that at least some of the providers indicated that, if further information is needed, one should contact them. Only data and information that was freely accessible on the website of the provider or the OCEC itself was used; none of them was contacted in this respect, as we followed a mystery shopping approach in the form of a "concealed participant observation in a public environment" (Wilson, 1998, 2001). Hence, background information about an OCEC was mostly obtained via short explanations posted in the web application, FAQs published by the provider and/or documents for download (like EWI, 2024).

Finally, a total of six OCECs – namely *DHL*, *CarbonCare*, *NTMCalc*, *LogWARD, EcoTransIT* and *GEODIS* – were identified that met all selection criteria; see Table A1 in the Appendix for more details. Indeed, this was a non-standardized data collection with no clearly predefined parameters for where to find information about the OCEC. It is therefore entirely possible that information has been overlooked despite all efforts and/or the provider added or removed some information in the meantime.

Assessment of carbon emission calculators

With all six remaining OCECs, a benchmark case of a generic shipment of one twenty-foot-equivalent unit (TEU) container containing ten tons of general cargo from Shanghai to Hamburg was performed. Due to the large landmass between these two locations with an established transport infrastructure, it was possible to ensure that the cargo could be transported by all four modes of transport, and practice shows that this is really done under the Chinese Belt-and-Road Initiative umbrella (Zhang and Schramm, 2020).

Benchmark case setting

The aim of this benchmark case was to test how these six OCECs work in practice, which input options are available, and what outcomes they produce. Furthermore, it should shed light on the transparency of calculation methods and underlying data used.

Cargo weight was specified at ten tons, mainly due to the fact that this is the recommended conversion factor to TEU by the GLEC standard as well as the CCWG (CCWG, 2015; SFC, 2023). Whenever volume of cargo had to be specified, 33 cbm were chosen, which corresponds to the intake capacity of a standard TEU container in line with ISO 668:2020.

Further, an attempt was made to select uniform transport vehicles. However, the available input options of the six OCECs differed greatly. For road transport, for example, they ranged from a choice of over 13 different vehicles to no choice at all. Whenever there was the option to choose a road vehicle, the most energy-efficient truck with 40 tons of maximum admissible weight was selected, and when it was not available, the next smaller one was chosen. Regarding train transport, a freight train, for sea transport, a container vessel and for air transport, a cargo plane was chosen whenever possible. In case it was allowed to specify other parameters, such as load factor or idle factor (also referred to as empty running), were available, the default values from the provider were kept unalternated.

Next, exact starting and ending points were to be determined. However, they varied slightly between the individual modes of transport. For example, sea transport typically starts and ends at a seaport and air transport at an airport. Even though the emissions of possible pre-carriage and on-carriage are hardly significant compared to the emissions of the main transport, an attempt was made to calculate the GHG emissions for one transport mode at a time. Intermodal calculations were therefore intentionally avoided. For road and rail transport, it was assumed that transport operations start and end in the respective city centers. For air transport, Shanghai Pudong International Airport (IATA code PVG) and Hamburg Airport Helmut Schmidt (IATA code HAM) were chosen as origin and destination of the transport operation. Accordingly, in the case of sea transport, the Port of Shanghai (UN/LOCODE CNSGH) and the Port of Hamburg (UN/LOCODE DEHAM) were chosen as the origin and destination. When it was not possible to select these seas or airports directly, again city centers were chosen as the origin and destination of the transport operation.

The goal of this benchmark case was to gain as much information as possible about the OCECs through practical application. The information gathered should then allow a comparison between them, highlighting any shortcomings or inadequacies.

Firstly, we collected general information about the OCEC, like (1) the provider, (2) the CEC provided online, (3) the structure of its frontend, (4) the input options provided, (5) the routing system, (6) the carbon emission calculation method applied and (7) which data sources are given for the GHG emission factors used – most important results of this inquiry are summarized in Table A1 in the Appendix. The amount of information available online on the individual OCECs varied greatly. For some, information found about calculation methods, load factors and the like were limited to a few lines. For certain questions of our framework, some OCECs did not provide any information at all. In contrast, some OCECs provided very detailed information. In these cases, an attempt has been made to focus on the most crucial information, as it is beyond the scope of this paper to discuss all background information on calculation methods, routing, etc. in depth.

Secondly, we collected further information for each transport mode (i.e. road, rail, sea and air) about (1) input options available, (2) routing system and (3) data sources used for GHG emission factors before we assessed them in line with our benchmarking case. Here, we focused on (1) the origin/destination selection process, (2) the routing chosen and (3) the GHG emission factors used, and resulting outcomes in terms of distance and GHG emissions reported by the CEC.

Comparison of benchmark case outcomes

The following section compares the outcomes obtained from the benchmark case by identifying similarities, explaining differences and finding reasons for outliers. For each mode of transport, first, calculated distances (in km) and CO_2 emissions (expressed in kg of CO_2e-Well-to-Wheel (WTW) equivalents) on the main haul (i.e. road, rail, sea and air) were compared and analyzed as shown in Table 1.

As outlined before, an attempt was made to select consistently origins and destinations for transport operations. In case of road and rail transport modes, the city centers of Shanghai and Hamburg were chosen. For sea and air transport, the respective sea- and airports were selected whenever available. However, even if it was not always possible to determine the exact starting and ending point as indicated, resulting shortfalls in our benchmarking case are rather negligible compared to the total transport distance, as both sea and airports are within a range of about 10 km around Hamburg city center and 30–40 km in the case of Shanghai, resulting in a deviation of less than 1% concerning the distance calculated by any OCEC assessed. Accordingly, one could assume that the OCECs should come up with similar results since great efforts were made to make the input data for each transport mode as similar as possible.,

To quantify differences in outcomes obtained from the OCECs, a coefficient of variation (CV) was calculated for each transport mode. As it indicates the ratio of the standard deviation to the mean value of the entire data set, it allows to compare the dispersion of figures, regardless of how large their absolute values are. Apparently, the values of CO_2 emissions spread widely than the corresponding distances in Table 1.

In the case of road transport, it can be stated that routing of all OCECs worked well and provided consistent results with notable exception of *CarbonCare* (used just great circle distance for all its route calculations) and *NTMCalc* (for road it did not find a routing crossing Chinese borders, so that we had to be split in two parts, and in case of rail and sea, a proper routing had to be enforced by defining custom waypoints). Nevertheless, differences in

	Road		Rail		Sea		Air	
Provider	Distance in km	CO2e-WTW in kg	Distance in km	CO2e-WTW in kg	Distance in km	CO2e-WTW in kg	Distance in km	CO2e-WTW in kg
DHL	10651.00	6282.40	10569.00	2885.46	23076.00	1548.87	8670.00	66200.63
CarbonCare	8521.71	5334.59	10659.02	1227.30	19874.96	711.52	8542.62	47582.27
NTMCalc	10628.75	8754.00	9937.73	1615.44	20281.63	1065.00	8721.00	53420.00
LogWARD	9871.25	12270.90	10772.62	3154.70	19951.41	1660.70	8746.29	72274.80
EcoTransIT	10586.29	7970.00	11192.05	3930.00	19960.15	1280.00	8821.65	67800.00
GEODIS	10600.85	10526.00	11190.70	3299.00	22945.17	1024.00	8821.65	67803.00
Mean	10143.51	8522.98	10838.52	2685.32	21014.89	1215.02	8720.54	62513.45
CV	7.64%	27.77%	3.97%	35.51%	6.74%	26.60%	1.10%	14.16%

Source(s): Table by authors

Table 1. Comparison benchmark case results for all OCEC in May 2023

distances caused a dispersion of CO_2 emissions. Sometimes, small differences in distances seem not likely to be the main reason for a large dispersion of the CO_2 emission outcomes. For example, the distances calculated by *LogWARD* and *CarbonCare* for sea transport are about the same, but the CO_2 emission outcome of *LogWARD* is twice as large as that of *CarbonCare*. However, an explanation for such a higher dispersion in CO_2 emissions is not as easy to find as many factors interact through sometimes untransparent calculation methods, further complicating the understanding of differing CO_2 emission measures. Moreover, much of the large dispersion of the CO_2 emissions outcomes is likely due to different input options of the OCEC. For example, Murphy *et al.* (2021) showed that CO_2 emissions can double just by asking another carrier to offer joint transport operations on a liner service loop with one and the same vessel and port call sequence. Whenever no input options are available, results can still be enriched with additional information to increase their significance. For example, *GEODIS* does not allow a selection of specific vehicles, but their reports always indicate which vehicle, load factor and idle factor was chosen. In contrast, *LogWARD* does not provide any information about the vehicle used or other parameters, which makes it almost impossible to interpret its sometimes strikingly deviating results in comparison to other OCECs.

In addition, different data sources concerning GHG emission factors are likely to have a great influence on the large dispersion of CO2e-WTW figures as shown in Table 1. However, which data source provides the most accurate GHG emission factors is beyond the scope of our study, as our benchmarking case is just about a generic shipment. Apparently, transport and logistics service providers as well as shippers commonly show a lack of willingness and/or ability to provide detailed data on transport operations for specific shipments (i.e. they simply do not know it and/or do not care about it). Furthermore, it can be expected that different calculation methods contributed to such differences in CO_2 emission results to a high extent so that including a wider range of location pairs with different distances would not have led to much more insights, as all OCECs follow a common logic based on distance transported multiplied by GHG emission factors.

Qualitative assessment

Whenever OCECs come up with different outcomes of a CEC for the same transport operation, the question arises, which of them delivers the most reliable results. There have already been isolated attempts to evaluate, compare and analyze CECs (Padgett *et al.*, 2008; Amani and Schiefer, 2011; CE Delft *et al.*, 2014; Šimenc, 2016; Saharidis and Konstantzos, 2018; Chocholac *et al.*, 2019, 2021; Murphy *et al.*, 2021; Bekaroo *et al.*, 2021; Hörandner *et al.*, 2023). In our case, a stress was laid on its transparency, as this provides at least some degree of confidence that valid data sources and calculation methods were employed. Consequently, the following three categories were introduced: *transparency of routing system*, *transparency of data used* and *transparency of calculation method*. As the underlying benchmark case shows that a richer set of input options makes it possible to determine a certain transport operation more precisely, leading to better outcomes, a category *data input* was included. Finally, the goal of each OCEC is to deliver accurate outcomes, and this was considered under the category *output data*.

These assessment categories also correspond to three of the fundamental pillars of the GHG Protocol on carbon accounting, namely transparency, accuracy and completeness (WRI and WBCSD, 2011, 2013). The *principle of transparency* is met with the first three assessment categories: transparency of routing system, data sources and calculation method. The *principle of accuracy* is considered with the output data category since here it is evaluated to what extent and whether estimated CO_2 emission outcomes are sufficiently reported. The *principle of completeness* is met with the input option category, as more input options allow a transport operation to be reflected in the OCEC in more detail.

Each OCEC was evaluated in May 2023 in all these categories with "–" (not met at all), "+- " (partly met), or "++" (met in full) as shown in Table 2 and subsequently updated in May 2024 to take into account recent adoption of ISO 14083:2023 and GLEC framework (as of 2023) by most of these OCEC providers in the meantime (see also Table A1 in the Appendix). This provides a comprehensive assessment about how precisely a transport operation can be defined and how transparent the calculation procedure is from the entry of data inputs to the presentation of CO_2 emission results. Finally, the resulting ranking can thus be understood as a recommendation for which of the OCECs assessed may be preferred.

Conclusions

To manage GHG emissions and subsequently reduce them effectively, many actors in the transport industry use CEC. Using a structured online search, 42 different OCECs were found, and six met all selection criteria, having their own routing system, being suitable for all transport modes, and their calculation methods being based on globally recognized standards.

These six OCECs were then further analyzed and compared in a benchmark case study. Our results confirmed findings from previous evaluations of CECs: Despite all efforts to select one and the same input options for each CEC, calculated results differed significantly. In most cases, no to only partial explanations could be found for these large differences between the outcomes of these OCECs, mainly due to a lack of transparency of the underlying calculation methods and data sources the CECs were based on.

In general, it can also be said that the more one knows about the context of a transport operation, the more precisely one can simulate it, and the better outcomes of a CEC correspond to actual GHG emissions. Here, too, there was a considerable discrepancy between OCECs in the ability to determine transport operations exactly, so that outcomes of such CECs that do not provide any option or information regarding exact means of transport should be treated with great caution.

In a next step, the six OCECs were evaluated along five categories, with a special focus laid on transparency about routing system, data sources and underlying calculation method. Each of them received full credits at least in one category, with only one that met in full all five categories at the time of our qualitative assessment.

However, some delimitations are notable. Concerning our structured search procedure for OCECs using internet search engines, a possible inherent selection bias cannot be completely denied. Moreover, following our mystery shopping approach, information about OCECs was exclusively obtained directly from the respective websites, including documents available

		Transparency			Completeness	Accuracy
Rank	Provider	Routing system	Data Source	Calculation method	Input Options	Output Data
1	*EcoTransIT*	++	++	++	++	++
2	*NTMCalc*	–	++	++	+-	++
3	*DHL*	++	+-	+-	+-	+-
4	*CarbonCare*	+-	++	+-	+-	+-
5	*GEODIS*	+-	++	+-	–	+-
6	*LogWARD*	–	+-	+-	–	++

Source(s): Table by authors

Table 2. Qualitative assessment of online carbon emission calculators

for download there. Although the authors made a recommendation, it does not guarantee that the outcomes of an OCEC assessed are necessarily correct, as we only checked whether and to what extent the calculation method of a CEC and its underlying data are declared.

It is also in the nature of things that the result of any CEC can always only approximate actual GHG emissions generated by a transport operation. Its exact value can only be determined by direct measurement, which could be the aim of further studies thoroughly checking the accuracy of CECs. This, of course, then needs physical measurement of GHG emissions from a transport operation and its comparison with results from CEC calculations. Finally, the focus of our evaluation of OECs was set on transparency, input options and output data. For further research, other criteria such as user-friendliness may be included, too.

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Appendix

Table A1. Characteristics of online carbon emission calculators selected

		EcoTransIT	NTMCalc Basic 4.0	Carbon Care	Deutsche Post DHL	LogWARD	GEODIS
Provider	Link	IVE (2024)	NTM (2024)	CarbonCare (2024)	DHL (2024)	LogWARD (2024)	GEODIS (2024)
	Name	EcoTransIT Initiative	Network for Transport Measures	WildVenture GmbH	Deutsche Post DHL	LogWARD	GEODIS
	Organization type	Industry driven platform	Non profit organization	Software company	Transport and logistics company	Software company	Transport and logistics company
Web application		yes	yes	yes	yes	yes	yes
Free access		yes	yes	yes	yes	yes	yes
Implemented routing system		yes	yes	yes	yes	yes	yes
Transport mode covered	Road	yes	yes	yes	yes	yes	yes
	Rail	yes	yes	yes	yes	yes*	yes
	Sea	yes	yes	yes	yes	yes	yes
	Air	yes	yes	yes	yes	yes	yes
Compliance of OCEC online	GHG Protocol	no	no	no	yes	no	no
	ISO 14046-1	no	no	no	yes	no	no
	EN 16258:2012	yes	yes	yes	yes	no	no
	ISO 14038:2023	yes	no**	yes	no	yes	no
	GLEC Framework V2.0	yes	no**	no	no	yes	yes
	GLEC Framework V3.0	yes	no**	yes	no	yes	yes
Further Remarks		–	–	Verified by SGS	Verified by SGS	Powered by EcoTransIT	Developed with EcoTransIT

Note(s): *LogWARD does not cover rail any longer, **No indication on the website that NTM Basic 4.0 follows GLEC Framework and ISO 14038:2023 despite NTM elsewhere mentioned active participation in their development
Source(s): Table by authors