Emission Values for European Inland Navigation Fuels

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Summary

The Central Commission for the Navigation of the Rhine (CCNR) is aiming to elaborate a proposal for an emission label, which will express an inland vessel's emission performance across two pillars: air pollutants emissions and greenhouse gas (GHG) emissions. For the GHG emissions, the emission label will follow the approach of a Well-to-Wake (WtW) GHG intensity (in grams of CO_2eq per MegaJoule of energy). For the GHG emissions pillar, the CCNR, through the Dutch Ministry of Infrastructure and Water Management, involved additional expertise of RVO (Rijksdienst voor Ondernemend Nederland, or Netherlands Enterprise Agency).

RVO was tasked to put forward a proposal for a comprehensive, transparent, and verifiable methodology for GHG emissions accounting as well as for applicable GHG emission factors for energy carriers relevant for inland navigation. For the WtT (Well-to-Tank) part of the WtW approach, RVO built on its own expertise. For the TtW (Tank-to-Wake) part, RVO involved additional technical expertise from TNO (TNO report is included in the Annex of this report).

The underlying report presents proposals for WtW Inland Waterway Transport (IWT) default values for the energy carriers relevant for inland navigation, of which a list was developed by RVO and TNO in consultation with the CCNR. These proposed IWT default values can be used as a basis for further development of the GHG protocol of the CCNR. The report also includes proposals and recommendations for the broader systematic for GHG emission values within the emission labelling system.

As a starting point for their research, RVO and TNO analysed and assessed the GHG emissions approach of the FuelEU Maritime regulation for seagoing shipping, following the considerations of the CCNR to use this approach as a basis for the GHG methodology for inland navigation. The findings of the analysis of RVO of the WtT part of the GHG emissions calculation approach in this regulation are that it, in principle, could be directly translated for application to the inland navigation sector, provided that it comprises a technology-neutral approach, in order words, without taking into account reward factors or policy incentive related choices that promote certain technologies.

Regarding the TtW part of the FuelEU Maritime approach, TNO concludes that since TtW CO_2 emissions are directly related to fuel properties and are similar between different modes of transport, the emission factors for CO_2 included in FuelEU Maritime can be directly applied to inland navigation for internal combustion engines (irrespective of the age class of the vessel's engine) and fuel cells. However, because CH_4 and N_2O emissions are dependent on the combustion conditions in the engine, further elaboration of TtW emission factors of CH_4 and N_2O is proposed for specific application of the methodology to inland navigation. TNO also proposes to use a different methane slip factor that is aligned with the limit values for Stage V engines.

A specific element is how to incorporate wind/sail (-assisted) propulsion in the WtW GHG emissions approach suitable for the inland navigation sector. Since RVO recommends to eliminate the reward factor for wind-assisted propulsion from the equations of FuelEU Maritime to keep the overall approach policy-independent and technology-neutral, an additional methodology for including this technology in the GHG emissions approach for inland navigation vessels is presented in the report, in

line with the methodology included in the air pollution protocol, developed for the inland navigation emission labelling system.

The CCNR expressed a preference for an approach for the WtW GHG emissions as part of the emissions labelling system where both actual values and proposed IWT default values can be used. In order to implement a system that would enable the use of actual WtT values, the certification of fuel supply chains as well as the transfer of GHG emission data to the inland vessel owners would be required. In order to also have an approach that would be simpler and require less administrative efforts at the initial stage, RVO, in consultation with the CCNR, built their further research on exploring two alternative routes for a GHG systematic for obtaining the proposed IWT default values.

The first route comprises the use of CCNR Member State reported data on the use of alternative fuels and their WtT GHG emissions. Since data appeared not to be readily available for all Member States, RVO, through the CCNR secretariat, put forward a data request to all Member States of the CCNR (which include EU Member States Belgium, France, Germany and the Netherlands, and in addition Switzerland) in order to explore what data are available and on what level of detail. The outcomes of this data request were analysed and included in the IWT default value proposals. The second route uses WtT GHG emissions values derived from EU legislation, i.e. RED and FuelEU Maritime. Both approaches are used for establishing proposed IWT default values, which are presented in the report in various tables, with different levels of detail. In order to obtain WtW GHG emission values, the WtT values are combined with the proposed TtW values from the TNO report, which are also presented. For determining these values the Global Warming Potential (GWP) values from the Fifth Assessment Report (AR5) of the IPCC are applied.

For electricity, several approaches (a single value, Member State-specific values and setting the WtT GHG emissions to zero) have been analysed. In order to stay aligned with FuelEU Maritime, to minimize administrative burden, and to avoid possible disincentives for electrification in the inland navigation sector, it is proposed as a first step to set the WtT GHG emissions of electricity at zero, with a time-bound review clause, in order to re-assess this choice at a later stage, as the share of electricity in the energy mix for inland navigation increases further, and to be aligned with a consistent WtW approach for all energy carriers.

The proposals for WtW GHG emission factors and the broader systematic for obtaining and using these values as included in this report comprise a first, workable step for including a GHG emissions pillar into an emission labelling system for inland navigation. The ingredients for the GHG emissions approach in this report have been proposed while keeping the data demand and administrative burden on vessel owners and fuel suppliers as low as possible. Basically, based on data on the use of energy carriers combined with the proposed IWT default values, the GHG intensity of the vessel can be calculated.

Regarding its further elaboration and implementation, RVO highlights several points of attention and recommendations regarding future data collection, selection and updating, as well as database integration. The report also addresses transfer of data to the inland navigation vessel owner, and alignment with existing developments and systematics such as the Proof of Sustainability (PoS), Proof of Compliance (PoC), and the Union Database for Biofuels (UDB). These issues are important to take into consideration when further developing and implementing the GHG emissions approach into the inland navigation emission labelling system.

1 Introduction

1.1 Background for the research

The Central Commission for the Navigation of the Rhine (CCNR) is currently working on a proposal for a standard that comprises a methodology for measuring and calculating emissions from inland navigation vessels as part of a broader process aiming to develop an international emission labelling system for inland navigation. The development of such standard is part of the CESNI work programme as well, CESNI is the European Committee for drawing up technical standards for inland navigation. The development of the standard is done in coordination with the European Commission (DG MOVE) and the Horizon Europe project PLATINA4Action.

The CCNR is aiming to elaborate a proposal for an emission label, which will express an inland vessel's emission performance across two pillars: air pollutants emissions and greenhouse gas (GHG) emissions. The emission label is intended to support multiple possible purposes supporting the reduction of emissions of inland navigation vessels: fleet investment decisions by shipowners, incentive design and local measures by ports and authorities, fleet-wide emission monitoring by national/EU institutions, subsidy allocation, and supply-chain reporting.

A CCNR Correspondence Group, in which all CCNR Member States are represented, is currently developing emission measurement and calculation protocols for both the air pollutant emissions and the GHG emissions pillar of the labelling system. For the GHG emissions pillar, within the CCNR context referred to as the "draft GHG protocol", the CCNR involved additional expertise through tasking RVO (Rijksdienst voor Ondernemend Nederland, or Netherlands Enterprise Agency) the further methodological elaboration.

1.2 Netherlands Enterprise Agency (RVO)

RVO is a governmental agency, which operates under the Dutch Ministry of Economic Affairs and Climate Policy and plays a key role in bridging policy implementation and market innovation. Established in its current form in 2014 through several agency mergers, RVO executes national and EU policy in areas such as renewable energy, climate, innovation, and sustainable entrepreneurship. In its intermediary role, RVO connects policymakers and the private sector, translating regulatory frameworks into workable market instruments and supporting entrepreneurs in accelerating the energy transition.

Within RVO, the GAVE (Gasvormige en Vloeibare Energiedragers, Gaseous and Liquid Energy Carriers) Cluster provides in-depth expertise on topics such as renewable fuel legislative systems, sustainability and certification, and greenhouse gas accounting across the transport modalities road, aviation, maritime, and inland navigation. The GAVE Cluster advises Dutch ministries on the implementation of European regulatory frameworks such as REDIII, FuelEU Maritime, ReFuelEU Aviation, ETS/ETS2, and related global frameworks from ICAO (aviation) and IMO (maritime), ensuring coherence between global, European and national regulation. The GAVE Cluster's work covers both policy design and support of market development, which also comprises advising on developing labelling and certification systems such as Digital Product Passports (DPP) and renewable fuel registries.

1.3 Objective and scope of the research

RVO was tasked by the Dutch Ministry of Infrastructure and Water Management, as part of the work in the CCNR Correspondence Group, to put forward a proposal for a comprehensive, transparent, and verifiable methodology for GHG emissions accounting as well as for applicable GHG emission factors for energy carriers relevant for inland navigation (hereafter also referred to as "proposed IWT[1] default values"). These proposals are to be used as a basis for further development of the draft GHG protocol.

Before the involvement of RVO in the development of the GHG protocol, the CCNR Correspondence Group already explored various existing methodologies for GHG accounting and assessed their possible applicability within the emission label proposal. As a result of this exploration, the CCNR decided to apply a Well-to-Wake (WtW) approach to GHG emissions – meaning the GHG emissions resulting from the entire fuel supply chain as well as the use of the fuel on the inland navigation vessel - based on the methodology of the European FuelEU Maritime Regulation for the maritime sector. Following this approach, the WtW GHG emissions factors for the energy used on board of inland navigation vessels, expressed in grams CO_2eq/MJ, is chosen as the metric to express GHG emissions in the future emission labelling system. <u>Since this metric is independent of vessel type, engine performance, and practical operation of the vessel, only the amount and type of fuel used and the GHG emission factors for the fuel(s) used are determinant for the WtW GHG emission performance of a vessel. Therefore, the research of RVO focuses on putting forward proposals for the WtW GHG emission factors of fuels</u>. Absolute GHG emissions (expressed in tonnes of CO_2eq) are also considered relevant by the CCNR Correspondence Group but serve for reporting purposes only. Methodologies for determination of absolute GHG emissions are considered outside of the scope of the research by RVO.

A WtW approach to GHG emissions consists of two main parts, i.e. Well-to-Tank (the emissions in the fuel chain, hereafter: WtT) and Tank-to-Wake (the emissions resulting from combustion/use of the fuel onboard, hereafter: TtW). In the underlying report, the approach and results of the assignment to RVO are presented. The research by RVO comprises proposals for a comprehensive WtW methodology as well as for WtW GHG emission factors for energy carriers that are relevant for inland navigation vessels, as a basis for further development of the (draft) GHG emissions protocol as part of the emission labelling system.

In the research laid down in the underlying report, for the WtT part of the WtW approach, RVO builds on its own expertise on WtT GHG emission factors and GHG emissions accounting, and the broader systematic of GHG and sustainability data collection, transfer and verification in various systems that are already in place or currently under development. This report will also include proposals and recommendations for the broader systematic for GHG emission values within the emission labelling system for inland navigation.

For the TtW part of the WtW approach, RVO involved additional technical expertise from TNO in this research assignment. In this report, the focus will be on the WtT part as well as on the integration of the WtT and TtW parts into a comprehensive WtW approach. For the detailed analysis and proposals for the TtW methodology and TtW GHG emission factors, reference is made to the TNO report "Default values for calculation of Tank-To-Wake GHG Emissions from Inland Waterway Transport" (2025), which is included in the Annex to this report.

[1] Inland Waterway Transport

1.4 Reading guide to this report

The report will start with an analysis and assessment of the approach to WtW emissions as established in the FuelEU Maritime Regulation for seagoing shipping and its applicability to the proposed emissions labelling system for inland navigation. Subsequently, the proposals and findings of RVO regarding the WtT GHG emissions will be presented in Chapter 3. The integration of the WtT and TtW parts into a comprehensive WtW approach is laid down in Chapter 4. For details regarding the analysis and proposals for the TtW part, references are made to the separate report by TNO. Finally, Chapter 5 of this report contains points of attention and recommendations regarding further implementation of the WtW GHG emissions methodology and possible next steps.

2 Assessment of the FuelEU Maritime WtW GHG methodology

2.1 Introduction

After consideration of various GHG accounting frameworks, the CCNR chose the GHG emissions methodology as established in the EU FuelEU Maritime Regulation for seagoing shipping (Regulation (EU) 2023/1805) as the basis for further elaboration of the GHG emissions methodology for the proposal for the emission labelling system for inland navigation. After evaluating different metric options, such as GHG emissions expressed in grams of CO_2eq per MJ, grams of CO_2eq per tonne-km, and absolute grams of CO_2eq, the metric grams of CO_2-equivalents per MJ of energy, which is also used as the GHG-intensity metric for fuels under FuelEU Maritime, was selected as the module to be further developed and included in the standard and a future emission label system. The main rationale behind this is that it depends only on the fuel type and its GHG emissions, ensuring consistency and comparability across different ship sizes and operations. The absolute grams of CO_2eq is also considered for incorporation into a future emission labelling system, but further analysis of this metric was not within the scope of the research by RVO and TNO.

Following these findings of the CCNR Correspondence Group, analysis and assessment of the FuelEU Maritime methodology was used by RVO and TNO as the starting point for the research into a comprehensive GHG emissions methodology and accompanying emission factors. When analysing the applicability of the approach of the FuelEU Maritime Regulation to an emission labelling system for inland navigation, two elements of the regulation need to be taken into consideration, i.e. <u>FuelEU Maritime as:</u>

a) <u>a framework for well-to-wake (WtW) GHG emissions calculations, and</u>
b) <u>a broader GHG emission reduction framework, with policy incentives, certification, chain of custody and information transfer throughout the fuel supply chain up to the (maritime) vessel owner</u>**.**

The analysis of the FuelEU Maritime regulation approach concludes that the GHG emissions calculation methodology of FuelEU Maritime can largely be applied for determination of the WtW GHG emissions for inland navigation. However, this GHG calculation framework cannot be seen completely independent from the elements of the FuelEU Maritime approach that are related to its character as a policy incentive framework aiming to reduce the GHG emissions of the energy used by ships. RVO concludes that these policy-related elements cannot be directly translated for application to the emission label for inland navigation. These findings and recommendations are further detailed in this Chapter below, and they also form the basis for the approach to further elaboration of the proposed IWT default values in Chapter 3 and 4.

2.2 FuelEU Maritime WtW GHG emissions calculation methodology

2.2.1 FuelEU Maritime overall WtW GHG emissions approach

In Annex I of the FuelEU Maritime regulation, the WtW GHG emission calculation methodology is outlined. The methodology is built on three equations, which are presented below. For calculating the WtW GHG intensity (in g CO_2eq/MJ) – which was chosen as the main metric for GHG emissions for the inland navigation emission labelling system - the methodology is established in Equation (1). The WtW GHG intensity is calculated by adding together the WtT and TtW GHG emissions of all energy carriers used. In FuelEU Maritime, this covers the total amount of energy carriers (sum of all fuel types) used by a ship over a one year period. This is reflected in the set-up of Equations (2) and (3), which establish the calculation rules for the WtT GHG emissions and TtW GHG emissions, respectively.

$$GHG\ intensity\left[\frac{gCO_{2eq}}{MJ}\right] = f_{wind} \times (WtT\ + TtW)\ (1)$$

$$WtT = \frac{\sum_i^{n\ fuel} M_i \times CO_{2eq\ WtT,i} \times LCV_i + \sum_k^c E_k \times CO_{2eq\ electricity,k}}{\sum_i^{n\ fuel} M_i \times LCV_i \times RWD_i + \sum_k^c E_k}\ (2)$$

$$TtW = \frac{\sum_i^{n\ fuel}\sum_j^{m\ engine} M_{i,j} \times \left[\left(1-\frac{1}{100}C_{slip\ j}\right)\times\left(CO_{2eq,TtW,i,j}\right)+\left(\frac{1}{100}C_{slip\ j}\times CO_{2eq\ ,slip,i,j}\right)\right]}{\sum_i^{n\ fuel} M_i \times LCV_i \times RWD_i + \sum_c^k E_k}\ (3)$$

The different factors and notations used in the equations above are explained in the table below.

Table 1 Explanation of the factors and notations in the FuelEU Maritime equations (source: FuelEU Maritime Regulation (EU) 2023/1805, Annex I)

Term	Explanation
i	Index corresponding to the fuel type delivered to the ship in the reporting period
j	Index corresponding to the fuel consumer units on board the ship. For the purpose of this Regulation, the fuel consumer units considered are the main engine(s), auxiliary engine(s), boilers, fuel cells, and waste incinerators
k	Index corresponding to the OPS connection points
n	Total number of fuel types delivered to the ship in the reporting period
c	Total number of OPS connection points
m	Total number of fuel consumer units
$M_{i,j}$	Mass of fuel i consumed by fuel consumer unit j [gFuel]
E_k	Electricity delivered to the ship per OPS connection point k [MJ]
$CO_{2eq\ WtT,i}$	WtT GHG emission factor of fuel i [gCO_{2eq}/MJ]
$CO_{2eq\ electricity,k}$	WtT GHG emission factor associated with the electricity delivered to the ship at berth per OPS connection point k [gCO_{2eq}/MJ] *For the purposes of this Regulation,* $\sum_k^c E_k \times CO_{2eq\ electricity,k}$ *shall be set to zero.*
LCV_i	Lower calorific value of fuel i
RWD_i	Where the fuel is of non-biological origin, a reward factor of 2 from 1 January 2025 to 31 December 2033 can be applied. Otherwise RWD_i =1
$C_{slip\ j}$	Non-combusted fuel coefficient as a percentage of the mass of the fuel i consumed by fuel consumer unit j [%]. C_{slip} includes fugitive and slipped emissions.
$C_{f\ CO_{2i,j}}$, $C_{f\ CH_{4,i,j}}$, $C_{f\ N_2O_{i,j}}$	TtW GHG emission factors by combusted fuel i in fuel consumer unit j [gGHG/gFuel]

$CO_{2eq,TtW\ i,j}$	TtW CO_2 equivalent emissions of combusted fuel i in fuel consumer unit j [gCO_{2eq}/gFuel] $CO_{2eq,TtW\ i,j} = C_{f\,CO_{2\,i,j}} \times GWP_{CO_2} + C_{fCH_{4\,,i,j}} \times GWP_{CH_4} + C_{fN_2O_{i,j}} \times GWP_{N_2O}$
$C_{sf\,CO_{2\,i,j}}$, $C_{sf\,CH_{4\,i,j}}$, $C_{sf\,N_2O_{i,j}}$	TtW GHG emission factors by slipped fuel i towards fuel consumer unit j [gGHG/gFuel]
$CO_{2eq,TtWslip\ i,j}$	TtW CO2 equivalent emissions of slipped fuel i towards fuel consumer unit j [gCO_{2eq}/gFuel] $CO_{2eq,TtWslip\,i,j} = \left(C_{sf\,CO_{2\,j}} \times GWP_{CO_2} + C_{sf\,CH_{4\,j}} \times GWP_{CH_4} + C_{sfN_2\,O_j} \times GWP_{N_2O}\right)$ Where: C_{sfCO2}, and $C_{sfN2O} = 0$ $C_{sfCH4} = 1$.
GWP_{CO_2},GWP_{CH_4},GWP_{N_2O}	CO_2, CH_4, N_2O Global Warming Potential over 100 years, which are defined in Directive (EU) 2018/2001, paragraph 4 of Part C of Annex V
f_{wind}	Reward factor for wind-assisted propulsion

The Section below highlights some general observations considering this set of equations for calculating the WtW GHG intensity, i.e. the use of reward factors, the approach to accounting for the WtT GHG emissions of electricity, and the application of values for the Global Warming Potential (GWP) of greenhouse gases in the FuelEU Maritime methodology.

Use of reward factors

An important notion when considering the equations of the FuelEU Maritime regulation is that they contain reward factors – marked in red - for RFNBOs[2] (RWD_i in Equations (2) and (3)) as well as for wind-assisted propulsion (f_{wind} in Equation (1)). The impact of the reward factor for RFNBOs is that the CO_2 equivalent values for the WtT part in Equation (2) as well as the TtW part in Equation (3) are divided by an additional factor 2, thus providing an additional incentive for the use of RFNBOs. In Equation (1) the reward factor for wind-assisted propulsion, since $f_{wind} < 1$, reduces the GHG intensity of the energy used on-board by that factor, which provides in that way a reward for applying this technology on-board of a vessel.

RVO recommends to eliminate these reward factors from the equations above with the purpose of their further application for the WtW GHG emissions methodology for the inland navigation emission label. The reasoning behind this is that these reward factors as included in FuelEU Maritime reflect policy considerations/incentives. Within the RVO research, the task is to develop a GHG emissions methodology that is policy-independent and reflects emissions in an objective manner. If the emission labelling system for inland navigation is to cover also policy incentives for certain technologies, then including such a factor, or use of other approaches depending on the exact policy goals, could be taken into consideration. However, this is outside of the scope of the current research by RVO.

Accounting of WtT GHG emissions of electricity used for OPS

It should also be noted that in the FuelEU Maritime regulation, the factor - marked in red - included in the calculation of the WtT GHG emissions representing the upstream GHG emissions of electricity used for Onshore Power Supply (OPS) ($\sum_k^c E_k \times CO_{2eq\ electricity,k}$) is set at zero. Like the inclusion of reward factors for certain technologies described above, this is also a policy-incentive related choice, since it does not take into account the actual GHG emissions related to electricity for OPS.

[2] Renewable Fuels or Non-Biological Origin (as defined by the Renewable Energy Directive, RED; Directive (EU) 2023/2413), often also referred to as renewable synthetic fuels, or e-fuels.

Therefore, this approach in FuelEU Maritime cannot be directly translated for application to the emission labelling system for inland navigation without careful consideration of the impacts of such a choice. Therefore, proposals for how to take into account WtT GHG emissions of electricity used in OPS for inland navigation are outlined in Chapter 3, Section 3.6.

Please note that setting the WtT GHG emissions for electricity in the FuelEU Maritime regulation at zero only applies to electricity provided by OPS and does not apply to electricity used for propulsion or other purposes, for example shore-side battery charging and battery swapping for vessels. Such technologies are classified as Zero-Emission Technologies (ZET, see Annex III of the FuelEU Maritime regulation), which are allowed to be used as an alternative to OPS for the OPS requirements for ships in FuelEU Maritime[3]. However, although ZET are referenced as equivalent to OPS, and while WtT GHG emissions of electricity delivered to the ship by OPS can be counted as zero, no such reference is made for WtT GHG emissions of ZETs. This means that for ZETs being 'on board electrical storage' the upstream emissions need to be taken into account[4].

Use of Global Warming Potential values for greenhouse gases
To translate the emissions of CH_4 and N_2O into CO_2 equivalents, the emissions are converted with the Global Warming Potential (for a period of 100 years). For applicable values within FuelEU Maritime, the regulation refers to a less recent version of RED (Directive (EU) 2018/2001 or REDII). REDII contains a fixed set of values, i.e. 1 for CO_2, 25 for CH_4 and 298 for N_2O, which are based on an older version of the assessment report of IPCC, i.e. the Fourth Assessment Report (AR4, 2007).

However, in Commission Implementing Regulation (EU) 2022/996 under the RED this has been updated with a reference to the Fifth Assessment Report (AR5) of IPCC from 2014. Latest insights from IPCC are reflected in the Sixth Assessment Report (AR6) from 2021. In a further analysis of GWP values referred to in various relevant legislative frameworks, TNO concludes that the use of GWP values is not harmonised among these documents, as they are based on different versions of the Assessment Reports of IPCC (see also Section 3.2 of the TNO report in the Annex). Considering these differences, a choice needs to be made regarding what GWP values to use in the underlying research. This will be further addressed in Chapter 4 of this report (see Section 4.4.3).

In the paragraphs below, the details of the WtT (2) and TtW (3) equations are further analysed in detail for their application within the WtW GHG emissions methodology for the inland navigation sector.

2.2.2 *FuelEU Maritime WtT GHG emissions methodology*

Equation (2) describes the determination of the WtT GHG emissions. The WtT GHG emissions of the energy carriers used by a ship over a one year period are weighted according to the energy amount used for each energy carrier. The methodology is therefore also suitable for taking into account various blends of fuels, since the amounts of various fuels used by a ship will simply be added according to the

[3] See recital 39 of the FuelEU Maritime regulation: In addition to OPS, other technologies might be capable of offering equivalent environmental benefits in ports. When the use of an alternative technology is demonstrated to be equivalent to the use of OPS, a ship should be exempted from the obligation to use OPS.
[4] See the European Commission Guidance on the FuelEU Maritime regulation: d4426ccc-ef46-4292-8b6d-5bf7a620f5ba_en (paragraph 6.2)

equation (weighted sum). It also takes into account the amount of electricity used through On-Shore Power Supply (OPS) and its associated WtT GHG emissions.

The WtT GHG emissions are calculated by combining the following elements:

1. The mass of fuel i consumed (M_i in grams of fuel)
2. The WtT GHG emission factor for fuel i ($CO_{2eq\ WtT,i}$)
3. The energy content of fuel i consumed (Lower Calorific Value, LCV_i in MJ/gram of fuel)
4. The amount of electricity delivered to the ship (E_k) (in MJ) and its WtT GHG emission factor ($CO_{2eq\ electricity,k}$)

Each of these components is further analysed below.

1.Amounts (mass) of fuel used

As a first component, the consumed amounts for each fuel should be known in order to make the WtT GHG emissions calculation. In the context of compliance with the FuelEU Maritime regulation and EU-ETS, seagoing ships within the scope of this legislation (> 5000 GT) are already familiar with reporting their fuel use for the EU regulation for Monitoring, Reporting and Verification of greenhouse gas emissions from maritime transport (Regulation (EU) 2015/757) to a system called THETIS-MRV. For inland navigation, such a specific reporting system does not exist (yet) (see also Chapter 5).

2.The WtT emission factor of the fuel

The values for the WtT emission factors for fuels relevant for maritime shipping are included in Annex II of the FuelEU Maritime regulation. In this Annex II, a distinction is made between fuel classes, such as fossil fuels, biofuels, and e-fuels (RFNBOs).

For fossil fuels, only the default values that are provided in Annex II of the regulation shall be used. So companies are not allowed to use actual values (own calculations) for the WtT emissions of fossil fuels.

For other fuels, the general approach is that companies may use default values if available, or use actual values (own calculations, meaning values based on the Proof of Sustainability (PoS) or equivalent) in case of a better GHG performance compared to the default value or in the absence of default values. Actual values must be verified by an independent auditor, so in other words, these values need to be provided by a fuel supply chain that is certified by a certification scheme recognized by the European Commission. Details regarding the use of PoS for actual values and certification of fuel supply chains are explained further down this Section.

For biofuels and biogas (bio-LNG), Annex II of the FuelEU Maritime regulation stipulates that the WtT GHG emission value for Equation (2) must be calculated as follows (Annex I, column 4):

$$WtT = E - \frac{CfCO2}{LCV} \quad (4)$$

In this Equation (4), the factor "E" denotes the greenhouse gas emissions from the production and use of biofuels / biogas. For determining this value, reference is made to the RED (Directive (EU) 2018/2001 Annex V part C and Annex VI part B, REDII; the revised RED is Directive (EU) 2023/2413, REDIII). In the equation, $CfCO_2$ refers to the TtW CO_2 emissions of the fuel, and LCV to its Lower Calorific

Value. The reasons and implications of applying this credit factor are explained in more detail further below in this Section.

For the determination of the "E" value of these types of fuels, either default values or actual (own calculation) values can be used. The main difference is explained below; a more detailed analysis of this is included in Chapter 4. Default values in RED (if available) must be used by fuel suppliers for demonstrating compliance with obligations from RED. Typical values in RED are not to be used for demonstrating compliance but serve for reporting purposes only. It should be noted that the default values included in RED are deliberately established at a conservative level. This was done with the aim to provide an incentive to fuel suppliers (and in that way, also to the suppliers and producers in the entire fuel supply chain) to demonstrate a better GHG performance than the default value through making own actual calculations. In other words: the default values in RED are not representative of a market average GHG performance. In case of the absence of default values in RED for certain biofuel pathways, own actual calculations also need to be made. More detailed information on the use of default, typical, and actual values within the context of RED is provided in Section 3.3 of this report.

For e-fuels (RFNBOs) and Recycled Carbon Fuels (RCFs) the Commission Delegated Regulation (EU) 2023/1185 must be used for calculating the actual WtT GHG emissions, since for these fuel types there are no default values available (yet) from EU legislative frameworks.

For low-carbon fuels that are within the scope of the Hydrogen & Gas Directive (Directive (EU) 2024/1788) there are no default values available yet either. For these fuels, the FuelEU Maritime regulation refers to the Hydrogen & Gas Package, which was not yet adopted at the time. This reference implies that the actual WtT GHG emissions of low-carbon fuels must be calculated in accordance with the Commission Delegated Regulation specifying a methodology for assessing greenhouse gas emissions savings from low-carbon fuels (2025).

3.The energy content of the fuel used
The values for fuels relevant for maritime shipping are included in Annex II of the FuelEU Maritime regulation. For all fossil fuels and most e-fuels (RFNBOs) concrete values are included in Annex II. For biofuels, reference is made to the RED (Annex III). Electricity does not have a LCV.

4.The amount of electricity and WtT GHG emission factor for electricity
Although Equation (1) for the calculation of the WtT GHG emissions of the energy used is equipped to take into account the WtT GHG emissions upstream for electricity used by ships, for the purposes of the FuelEU Maritime regulation, $\sum_k^c E_k \times CO_{2eq\ electricity,k}$, as part of the equation, is set at zero for electricity from OPS (see FuelEU Maritime Annex I).

As a result, the amount of electricity used by a ship through OPS is counted as part of its total energy use, but at the same time the possible upstream (WtT) GHG emissions of the electricity used are not counted towards its total WtT GHG emissions. This therefore is a policy incentive, for which the rationale is explained in recital (44) of the FuelEU Maritime regulation:

"Considering the positive effects of the use of OPS on local air pollution and the need to incentivise the uptake of that technology in the short term, the carbon intensity of the production of the electricity supplied at berth should be counted as zero. The

Commission should envisage the possibility to take into account the actual GHG emissions related to the electricity delivered through OPS at a later stage."

The approach to WtT GHG emissions of electricity from OPS and other electricity uses in the FuelEU Maritime regulation and its applicability to inland navigation will be further addressed in Chapter 3, Section 3.6.

Conclusions on the applicability of the FuelEU Maritime WtT approach
The findings of the analysis of RVO of the WtT GHG emissions calculation approach of the FuelEU Maritime Regulation are that this approach in principle could be directly translated for application to the inland navigation sector, provided that it is a technology-neutral approach, in order words, without necessarily taking into account reward factors or all policy incentive related choices that promote certain technologies.

However, there are two main points of attention, which are further detailed below. Firstly, it should be noted that in the FuelEU Maritime and RED frameworks, the WtT GHG emission values build upon default values and actual values originating from a certified fuel supply chain. Certification of the supply chain is a mechanism applied in practice as a recognised means for checking compliance with the sustainability and GHG emissions requirements established in RED. This means that a company that is part of the fuel supply chain is checked by an independent Certifying Body operating under a certification scheme, recognised by the European Commission, and if the company is compliance with all requirements of the scheme, it becomes certified. This means that the company, based on that fact that it is certified, is allowed to accompany its products with a Sustainability Declaration or Proof of Sustainability (PoS) as evidence for compliance with RED requirements.
By means of these PoS, information on GHG emission values (as well as other sustainability aspects required by RED) is transferred from one certified company to another. This must be done along the entire fuel supply chain, so from the feedstock producer or collector up to the fuel supplier. The fuel supplier then delivers the fuel to the transport sector and uses this PoS for demonstrating compliance with RED obligations. For end-users downstream the fuel chain, like maritime shipping companies, a PoS or and equivalent document (i.e. Proof of Compliance, PoC[5]) is needed for compliance with FuelEU Maritime and EU-ETS obligations. This approach has further implications for the broader systematic of the application of the FuelEU Maritime framework and its applicability to the inland navigation sector, which is further addressed in Section 2.2.6 of this Chapter.

Secondly, it is important to note that in the FuelEU Maritime regulation the choice was made not to set the CO_2-emissions of the use of renewable fuels (i.e. biofuels / biogas and RFNBOs that meet the requirements of the RED) at zero, like it is done within the RED and EU-ETS frameworks. In contrast, the TtW CO_2-emission factors for the burning of the fuels are kept at the level which is in accordance with the amount of CO_2 released to the atmosphere when burning the fuel (TtW emissions). However, in order to obtain accurate WtW GHG emissions, this requires an adjustment in the WtT calculation to reflect the biogenic nature of these TtW CO_2 emissions. In the case of biofuels and biogas, the CO_2 released to the atmosphere when burning the fuel is considered to be equal to the uptake of CO_2 during biomass growth. As described earlier in this Section, this approach is reflected in column 4 of the table in Annex II of the FuelEU Maritime regulation, see also Equation (4) in this report. Here it is stipulated that the WtT GHG emission factor of biofuels and biogas

[5] See "Report on Marine Fuels Certification Procedures to support implementation of Fuel EU Maritime" by the European Sustainable Shipping Forum (May 2025).

should be calculated as the "E" value (based on RED Annex V/VI) minus a factor compiled from the TtW CO_2 emission factor of the fuel, divided by its energy content (LCV). Please note that such a credit only applies to the emissions of CO_2 of biofuels and biogas; non-CO_2 (CH_4, N_2O) GHG emissions are still included. For e-fuels (RFNBOs) and low-carbon fuels the certified E value (from PoS/PoC) determines the GHG emissions. To calculate the WtT emissions from RFNBOs or e-fuels, the emissions from the fuel in use (e_u) include all combustion emissions and should be deducted. This aims to avoid double counting of emissions under FuelEU Maritime where the TtW GHG emissions are added separately (see equations in Section 2.2). A deduction of the TtW CO_2 emissions as done for biofuels and biogas, is not needed[6].

2.2.3 *FuelEU Maritime TtW GHG emissions methodology*

Equation (3) establishes the calculation methodology for the TtW GHG emissions. This formula was analysed in the research by TNO and their detailed findings are included in the TNO report included in the Annex to this report. The main conclusions are summarised below.

Equation (3) for the TtW GHG emissions follows a similar approach as the WtT GHG emissions methodology, i.e. by weighing the TtW emission factors of the energy used by a ship based on the mass amounts of the fuels used and their respective LCV values. TNO concludes that calculating the TtW GHG emissions in the simplest form, i.e. without engine slip, use of RFNBOs, use of OPS, only depends on the TtW GHG emissions in CO_2 equivalents (sum of CO_2, CH_4 and N_2O) and the energy content (LCV) of the fuels used. In case multiple fuels or blends are used, the share of the individual fuels or the share of blended fuels are taken as individual components in the calculation. The amount of electricity used through OPS is also considered part of the energy use of the ship (denominator of Equation (3)).

For the emission factors of greenhouse gases CO_2, CH_4 and N_2O, default values (if available) are included in Annex II of the FuelEU Maritime regulation. Within the context of FuelEU Maritime it is allowed for shipping companies to deviate from Annex II default values, with the exception of fossil fuels, provided that the actual values are covered by certified measurements.

Another component of the TtW methodology consists of the GHG emissions resulting from non-combusted fuel (slip) at the ship engine. The further analysis of the TtW part of the WtW GHG calculation by TNO shows that in the FuelEU Maritime regulation, slip factors for CO_2 and N_2O are considered to be zero, which means that in the TtW calculation in Equation (3), only methane slip (CH_4) emissions are taken into account. FuelEU Maritime Annex II only includes methane slip factors for LNG powered vessels.

Finally, TNO concludes that the metric used in FuelEU Maritime (g CO_2eq/MJ) only considers the GHG intensity of the energy carrier(s) used by the ships. Therefore, wind-assisted propulsion or other energy-efficiency measures have no effect on this metric, and thus no effect in this context on the TtW GHG emissions of a vessel.

Conclusions on the applicability of the FuelEU Maritime TtW approach

The main findings and proposals regarding the TtW part of the GHG emissions methodology are included in Chapter 4 of this report. In its analysis of the TtW GHG emissions approach of the FuelEU Maritime regulation and its applicability to inland

[6] See "Report on calculation methodologies under Regulation (EU) 2023/1805 (FuelEU)" by the European Sustainable Shipping Forum (May 2025).

navigation, TNO concludes that the FuelEU Maritime approach is considered transferable and robust for application to the inland navigation sector, offering a flexible and fuel-neutral method that accommodates current and future alternative fuels and blends.

TNO concludes that since TtW CO_2 emissions are directly related to fuel properties and are similar between different modes of transport[7], the emission factors for CO_2 included in FuelEU Maritime can be directly applied to inland navigation for internal combustion engines (irrespective of the age class of the vessel's engine) and fuel cells. However, because CH_4 and N_2O emissions are dependent on the combustion conditions in the engine, further elaboration of TtW emission factors of CH_4 and N_2O are proposed for specific application of the methodology to inland navigation. TNO also proposes to use a different methane slip factor that is aligned with the limit values for Stage V engines. This is further elaborated upon in Chapter 4.4.

A specific element is how to incorporate wind/sail (-assisted) propulsion in the WtW GHG emissions approach suitable for the inland navigation sector. Since RVO recommends to eliminate the reward factor for wind-assisted propulsion from the equations of FuelEU Maritime to keep the overall approach policy-independent and technology-neutral (see Section 2.2.1), an additional methodology for including this technology in the GHG emissions approach for inland navigation vessels must be developed. Proposals for the application of the methodology and its further elaboration are included in the report of TNO.

2.2.4 *FuelEU Maritime scope of maritime fuels*

As stated in Section 2.2.2, in Annex II of the FuelEU Maritime regulation, a list of maritime fuels with their WtT and TtW emission values is included. This list was taken into consideration by RVO when establishing a list of fuels relevant for inland navigation, for which proposals for the GHG emissions will be put forward. The list of energy carriers relevant for inland navigation was established in consultation with the CCNR Correspondence Group and TNO and is further elaborated in Chapter 3, Section 3.2.

2.2.5 *Policy incentives included in the FuelEU Maritime framework*

Besides its WtW GHG emissions methodology the FuelEU Maritime comprises a broader policy incentive framework. This Section summarises the policy choices that have been included there. Firstly, as described earlier in this Chapter, the FuelEU Maritime framework focuses only on the WtW GHG intensity in grams of CO_2 equivalents per MJ of fuel as the metric. So therefore, the policy instrument does not take into account or provide an incentive for increasing the energy efficiency of ships and/or the logistic system, or for modal shift.

Secondly, the FuelEU Maritime framework includes policy incentives for certain fuels and technologies, which can be observed from the original formulation of Equation (2) and (3). These equations contain reward factors for RFNBOs and wind-assisted propulsion in order to provide to these an additional incentive for their application on ships. In addition, FuelEU Maritime also includes an incentive for OPS by setting the possible upstream GHG emissions of electricity at zero instead of accounting for the actual WtT emissions of electricity at this stage (see Section 2.2.1 and 2.2.2).

Furthermore, it is important to note that the FuelEU Maritime regulation also aims to disincentivize the use of certain fuels, for example, the use of biofuels produced

[7] « CO_2 emissions are produced when a hydro-carbon fuel is completely combusted. The carbon (C) in the fuel combines with oxygen (O_2) from the air to form carbon dioxide (CO_2)."

from food and feed crops (as defined by RED). Use of these biofuels is disincentivized by setting their emission factors equal to the least favourable fossil fuel pathway. The same approach applies for fuels that do not meet their respective minimum GHG emission reduction requirements, and in the case of biofuels also sustainability requirements, as established in EU legislation (Renewable Energy Directive, Hydrogen & Gas Directive). Such fuels are also considered to have the same emission factors as the least favourable fossil fuel pathway for the type of fuel in question.

Moreover, for many fuels under the FuelEU Maritime scope, the calculation of certified actual values for the WtT GHG emissions is incentivized in order to demonstrate a better GHG performance in comparison with the conservatively set default values included in RED and due to the current absence of default values for fuels that are relatively new to the maritime fuels market.

Possible (dis)incentivizing elements, if any, included in a broader GHG framework such as the ones described above should be considered carefully when designing an emission labelling system for inland navigation. In setting up a GHG emissions framework for inland navigation RVO aims to develop a harmonized approach for all fuels, without the inclusion of any (dis)incentives as described above. However, choices regarding the promotion or eligibility of certain fuels within the inland navigation emission labelling system could be made at a later stage by the CCNR and involved standardization/regulatory bodies, which may also have their implications to the GHG methodology and the broader system.

2.2.6 *Demonstrating the WtW GHG intensity within the FuelEU Maritime framework*

Demonstrating compliance with the GHG intensity reduction targets by ship owners for each ship within the scope of the FuelEU Maritime regulation is built on two pillars:

a) Reporting / registration of the amounts of fuels used, per fuel type
b) Use of default values and/or actual (own calculated) values

It should be noted that for the WtT GHG emissions, actual values are allowed, provided that they originate from a certified fuel supply chain. This is with the exception of fossil fuels, for which only default values are allowed and fuel supply chain certification is not applicable. For TtW GHG emissions, actual values are allowed as well, with the exception of fossil fuels, provided that they are covered by certified measurements.

Translating this framework to inland navigation would require reporting / registration by inland vessel owners of the amounts of fuels used, for each fuel type. In addition, it would require the vessel owners to obtain WtT GHG emissions data for each delivery of fuel used supported by documentation from a certified fuel supply chain, as was explained in Section 2.2.2. At this stage, an overarching EU reporting system or register which would enable the implementation of such a system in practice does not exist yet. Moreover, in order for inland vessel owners to obtain the GHG emissions data from certified fuel supply chains for the fuels supplied to them, this would require additional administrative operations on their side (for further analysis and proposals regarding data provision and transfer for the purposes of the inland navigation emission label, see Chapter 5). The use of actual values for TtW GHG emissions could be considered and for this measurement requirements and certification would have to be developed. This is not further elaborated in the underlying research, so when actual values are mentioned, this always refers to actual values for the WtT part (fuel supply chain).

Taking into account these considerations, the CCNR prefers to have an approach for the WtW GHG emissions as part of the emissions labelling system where both actual values and proposed IWT default values can be used. Considering the analysis in this Chapter, it becomes clear that in order to implement a system that would enable the use of actual values, the certification of fuel supply chains as well as the transfer of GHG emission data to the inland vessel owners would be required. In order to also have an approach that would be simpler and require less administrative efforts at this stage, RVO, in consultation with the CCNR, built their further research on exploring two alternative routes for a GHG systematic for obtaining the proposed IWT default values, which could be used within the emission labelling system, i.e.:

a) with CCNR Member State data on the use of alternative fuels and their WtT GHG emissions.
b) with WtT GHG emissions values derived from EU legislation

The rationale behind these approaches for the WtT emission values and their further details are elaborated in Chapter 3. The TtW IWT default emission values as well as the integration of WtT and TtW into WtW IWT default value proposals are further detailed in Chapter 4.

3 WtT GHG emission factors approach and proposals

3.1 Introduction

This Chapter comprises the further analysis and elaboration of proposals for the WtT GHG emission factors for relevant energy carriers in inland navigation. For this research, first, the list of energy carriers to be included in the analysis was established. Furthermore, the components of the WtT GHG emission factors and their variations are analysed, followed by proposals for the emission factors based on Member State reporting and EU legislation. For inclusion of upstream GHG emissions of electricity for use in Onshore Power Supply (OPS) and propulsion of vessels, a specific analysis has been made (see Section 3.6).

The initial approach of RVO was to collect publicly reported GHG performance data for renewable fuels from all CCNR Member States, which appeared not to be readily available for all Member States. In order to obtain the available GHG data on Member State level, RVO, through the CCNR secretariat, put forward a data request to all Member States of the CCNR (which include EU Member States Belgium, France, Germany and the Netherlands, and in addition Switzerland) in order to explore what data are available and on what level of detail. The outcomes of this data request are part of the analysis and proposals included in this Chapter.

3.2 List of energy carriers relevant for inland navigation

The proposal for the emission labelling system is aiming to cover all energy carriers that are relevant for inland navigation. Therefore, as a basis for putting forward proposals for the WtW GHG emissions, RVO compiled a list of energy carriers, in consultation with the CCNR Correspondence Group and TNO. Energy carriers – meaning fuels and electricity - are deemed relevant if they are already used in inland navigation, or can be used in existing engines, or are currently investigated in the form of pilots or demonstration projects. The list of fuels for this research is based on the most recent CCNR/CESNI fuels list provided by the CCNR secretariat, combined with the FuelEU Maritime fuel list in Annex II of the Regulation.

The list of energy carriers for inland navigation is presented in Table 2 below. The table includes the various end-fuels that are or can be used in inland navigation vessels, including a further classification into fossil, biobased and e-fuels (RFNBOs), depending on the origin of the various feedstocks for these fuels. In Sections 3.3.1 and 3.3.2 further detailing of these feedstocks and their respective WtT GHG emissions is presented. In order to establish this list of energy carriers, firstly sea shipping fuels have been removed from the FuelEU Maritime fuels, being HFO, LFO, MGO and MDO. As a next step, LPG has also been removed from the list, since adoption of this fuel in the inland shipping sector is deemed unlikely. EN 590 diesel was added to the list, since it is the most-used fuel in inland navigation at present (but it was not included in the fuels list of FuelEU Maritime). Finally, ethanol was added to the list, considering that it has similar properties and interest as methanol, with multiple renewable production pathways. Ammonia is considered due to potential synergies with maritime, although currently no pilot projects of inland vessels uses this fuel.

Table 2: List of fuels that are or can be used in inland navigation.

Fuel category	Fuel type	Feedstock category
Diesel	Fossil diesel (EN590)	Fossil
	Fischer-Tropsch (FT) diesel	Fossil, Biobased and e-fuel
	FAME	Biobased
	HVO	Biobased
	DME	Fossil, Biobased and e-fuel
Gas	Liquefied gaseous fuels	Fossil (LNG), Biobased (Bio-LNG or LBM) and e-fuel (PTG)
Alcohols	Methanol	Fossil, Biobased and e-fuel
	Ethanol	Biobased
Other fuels	Hydrogen	Fossil , Biobased and e-fuel
	Ammonia	Fossil , Biobased and e-fuel
Electricity	Electricity	Grid mix

3.3 Analysis of WtT emission factors / factor components

3.3.1 Data types and data sources for WtT GHG emission factors

The WtT component captures upstream GHG emissions from feedstock extraction, fuel production, transport, and distribution. At present, in the inland navigation sector, mainly fossil fuels are being consumed. EN 590 diesel, which is the most used fuel in inland navigation, is not included in the FuelEU Maritime fuels list. So for EN 590 diesel a WtT emission factor needs to be derived from an additional source, specifically the RED Implementing Regulation 2022/996, which contains a WtW emissions of 95.1 gCO_2eq/MJ. Please note that for fossil fuels, only default WtT emission factors are to be used, so not actual values, in line with the approach in FuelEU Maritime (see Section 2.2.2).

For renewable and low-carbon fuels, in order to fully incorporate the actual-representative WtT GHG performance of a fuel into the WtW GHG emissions at the inland navigation vessel, this would require a Proof of Sustainability (PoS), or equivalent, for every fuel delivery, originating from a certified fuel supply chain. Such a PoS serves as evidence for the accurate use of either default (if available) and/or actual values for the WtT GHG emissions of the fuels supplied/used. Such an approach is currently in use for compliance with RED, ETS and FuelEU Maritime obligations (see also Section 2.2.2 for further explanation).

Although such an approach would lead to the most accurate WtT GHG emissions data, this would entail additional reporting and registration of fuel use and its GHG emission characteristics for inland vessel owners. Reporting of this type of information is a relatively complex system to implement in comparison with for example a system which includes default emission factors for each fuel, which are applicable to all vessel owners and which do not require evidence supporting the GHG emission factors applied. Moreover, since reporting of this kind of information is not (yet) in place for inland navigation, implementing such a reporting or registration system would lead to a higher administrative burden for inland vessel owners (see also Chapter 2).

Taking into account these considerations, RVO proposes to also use an alternative approach for obtaining GHG emission factor values for renewable energy carriers (proposed IWT default values) that can be applied within an emission labelling system for inland navigation. RVO proposes to only use data that have a legal basis in the EU, so data that are either originating from Member State reporting or derived from EU legislative documents (RED, FuelEU Maritime).

The basis for this approach is that for RED and FQD EU Member State (MS) reporting aggregated fuel GHG performance data has to be reported to the European Commission. RVO proposes to use these aggregated Member State data, as they are actual values that are accepted for reporting on renewable performance within an international labelling system. With this approach there is accurate data with minimal complexity and administrative burden on the inland navigation sector.

Alternatively, default or typical WtT GHG emission values included in RED may be used (only for biofuels and biogas[8]). On the one hand, this would lead to using the same WtT GHG emission factors for all CCNR Member States. On the other hand, however, these values would not be as accurate as reported values by Member States. Furthermore, using the same values for all CCNR Member States would eliminate the possibility of differentiating the GHG performance between countries. Moreover, it should be noted that RED default values – which for biofuels and biogas are the basis for their WtT GHG emissions in FuelEU Maritime - are deliberately set on a conservative level. The rationale behind this is to provide an incentive to fuel suppliers (and the full fuel supply chain) to demonstrate a better GHG performance (see also 2.2.2). These default values are therefore not market-representative, probably showing a too low GHG emission reduction, which may negatively affect the GHG performance of the inland navigation sector within an emission labelling system. Alternatively, RED typical values may be used. These values are included in the legislative text for reporting purposes (so not for demonstrating compliance with RED obligations by fuel suppliers). Unlike RED default values, RED typical values are not set at a conservative level, but it should be noted that these typical values are not based on the most recent data and technologies (the values included always lag behind compared to the actual performance realized in the current market).

In Table 3, the definitions, pros and cons of the various data sourcing approaches described above are summarized, in the view of their possible application for putting forward proposals for WtT GHG emission factors.

[8] For RFNBOs and low-carbon fuels default or typical values are not (yet) available through applicable legislation, i.e. RED and the Hydrogen & Gas Directive.

Table 3 Summary of definitions, pros and cons of different data types included in the EU Renewable Energy Directive (RED)

Data type	RED Definition	Pros of this data type	Cons of this datatype
Actual values	The greenhouse gas emissions savings for some or all of the steps of a specific biofuel, bioliquid or biomass fuel production process, calculated in accordance with the methodology laid down in Part C of Annex V or Part B of Annex VI (RED).	This is the most accurate data source reflecting the actual GHG performance of inland navigation vessels as the basis for defining GHG emission classes in the emission labelling system. Shipowners will be able to have bigger influence on their GHG emissions and thus to the assignment of a label to their vessels label. They can increase their GHG performance and thus get a better label for their vessels by using more renewable fuels and by using fuels with better WtW GHG emission values. This can build upon existing practices and experience, since actual values are already in use in the context of compliance obligations from RED (fuel suppliers) and FuelEU Maritime / ETS1 (maritime vessel owners). For all alternative fuels, calculation methodologies for the WtW GHG emissions are available through EU legislation (all renewable as well as low-carbon fuels).	The administrative burden for actual values is high and the calculation of actual values is often considered to be quite complex. The administrative efforts result from making the calculations and from the needed transfer of GHG data along the fuel supply chain up to the vessel owner. Per delivery of bunkered fuels a PoS, or equivalent, would be needed to prove the GHG emission of the fuels used by the vessel. Currently, is it not possible for shipowners to gain access to this information, since at present these data (through a PoS) is not transferred from fuel suppliers to vessel owners in inland navigation. Depending on the purpose and working of the emission label, marginal increases in GHG-performance will provide no additional revenue or other benefits to vessel owners in inland navigation.
Default values	A value derived from a typical value by the application of pre-determined factors and that may, in circumstances specified in the Directive (RED), be used instead of an actual value.	Default values are pre-determined and available for the common renewable fuels. Using default values removes the need for fuel suppliers and vessel owners to make own actual calculations, thus reducing the administrative burden in the fuel supply chain to provide a GHG emission value. Default values have been set at a more conservative level, thus preventing too optimistic/ overestimation of the GHG emission reduction achieved by inland vessels.	Default values are not based on the most recent available data. RED only presents a specific set of fuel production pathways. New fuels or alternative production pathways for current fuels are not included, so for these production pathways own calculation to come up with actual values would still have to be made. Due to a policy-driven conservative setting of default values in RED, these values will not be representative of the real GHG emission performance of the market. It may therefore lead to an underestimation of the actual GHG emission reduction achieved by inland vessels.
Typical values	An estimate of the greenhouse gas emissions and greenhouse gas emissions savings for a particular biofuel, bioliquid or biomass fuel production pathway, which is representative of the EU consumption.	Typical values comprise a relatively accurate representation (compared to default values as included in RED) of the GHG-emissions of different fuels as it is based on peer reviewed data, thus guaranteeing the representativeness. Typical values are pre-determined and available for the common renewable fuels. Using typical values removes the need for fuel suppliers and vessel owners to make own actual calculations, thus reducing the administrative burden in the fuel supply chain to provide a GHG emission value.	Typical values are not based on the most recent available data. RED only presents a specific set of fuel production pathways. New fuels or alternative production pathways for current fuels are not included, so for these production pathways other sources or calculations are needed.

3.3.2 *Observations from the results of the data request to CCNR Member States*

Currently, the main volume of renewable fuels used in the inland shipping sector consists of two types of biofuels, i.e. HVO and FAME. RVO obtained detailed data of the GHG performance for both biofuel types based on official public data, through the data request to Member States of the CCNR. An important observation from these data is that the GHG performance of renewable energy carriers is not static, as it varies depending on the feedstock and production process. This poses a challenge with trade-offs when trying to obtain one single default value per fuel type.

Another reason for possible variations in emission factors among Member States lies in the set-up of the RED. Since RED is a directive, individual EU Member States have some freedom in transposing the RED legislative framework into national legislation, which may include national policy choices as well. This diversity of national legislations causes variation among Member States in the renewable fuels mix used in the transport sector, for example the amount of biofuels produced from food and feed feedstocks versus from waste feedstocks. As both the actual GHG performance and the composition of the fuel mix vary among Member States, the proposed inland navigation WtT emission factors need to take this variation into account. This situation has been proposed to the CCNR Correspondence Group and it was decided to compose a weighted average of the Member State fuel GHG emissions.

From the results of the data request, it appeared that for the GHG emissions of HVO and FAME, there is a lot of EU data available. However, for renewable or low-carbon fuels with less market volume like Hydrogen, Methanol, Ethanol, RFNBOs etc. no reported values could be obtained through the CCNR data request. For these fuel types such information is not available in public data either. So this means that for these fuel types an alternative approach would have to be used in order to put forward proposals for their WtW GHG emission factors.

3.4 Emission factor data: Member State reporting

RVO explored the GHG emission data of different member states, following from their reporting of the REDII implementation. This was possible for the reporting of the Netherlands (2024), Germany (2023) and France (2024) and Belgium (2024).

It is important, as already indicated, to take note of the fact that the national choices for the RED implementation influence the market shares of the different fuels that are used, as well as their sustainability and GHG characteristics. The Netherlands currently has a system where fuel suppliers need to fulfil their RED obligation based on renewable energy shares. In contrast to this, in Germany, targets are set based on WtW GHG emission reduction. Both countries also differ in the way they promote or limit specific renewable feedstocks. This will have an impact on the data presented in this Section.

The data (and where possible the ranges) for different feedstocks will be presented for the following biofuels: FAME, HVO, Ethanol and LBM (Bio-LNG). For other fuels there is no reported data available that can be used for the WtT part of this analysis.

Per fuel type, the amount of energy supplied to the mobility sector will be presented with the average GHG emissions per fuel. There is little data available to present inland navigation specific GHG values, but it can be assumed that the emissions per fuel type are similar for the inland shipping sector and the mobility sector. To present the complete data, an initial differentiation will be made for crop-based fuels and waste-based fuels. The differentiation between crops and wastes has been made because the use, or exclusion, of these feedstocks is policy driven by every individual Member State. Below, the data provided by Germany and the Netherlands will be further analysed.

3.4.1 *Germany*

In Germany the Federal Office for Food and Agriculture yearly publishes a report with information on the use of sustainable biomass, the Evaluation and Progress report 2023 (Evaluations-und Erfahrungsbericht für das Jahr 2023) is the most recent version (BLE, 2024)[9]. The report presents an overview of the fuels used in the whole mobility sector, the volumes supplied and for a few fuels more elaborated data on the GHG emissions and the variation per feedstock. It should be noted that this is not done for HVO and Bio-LNG. For bio-LNG it is reported that only 110 TJ of this fuel was used, all of it based on wastes. The data also specifies the emission reduction per origin of the feedstock, from Germany, EU and Third countries, but this is not further elaborated upon in this report as it is too detailed.

The WtT GHG emissions for biofuels used in transport in Germany are summed up in Table 4, based on the data provided by BLE. In the last column, the food crop based and waste based GHG emissions are combined in a weighted average for the four fuel types in this analysis.

Table 4: WtT GHG emissions data from biofuels used in Germany

Emissions ranges for biofuels		**Energy supplied (TJ)**	**Average emissions (gCO_2eq/MJ)**	**Range (gCO_2eq/MJ)**	**Average emissions per fuel type (gCO_2eq/MJ)**
FAME	Waste based	58,800	11	2 – 35	14
	Crop based	25,000	22	-20 – 45	
HVO	Waste based	16,700	Not reported	Not reported	12
	Crop based	25	Not reported	Not reported	
Bio-LNG	Waste based	300	-73	Not reported	-73
	Crop based	0	-	-	
Ethanol	Waste based	2,100	9	-20 – 25	9
	Crop based	30,900	9	-20 – 45	

3.4.2 *The Netherlands*

In the Netherlands, the Dutch Emissions Authority (Nederlandse Emissieautoriteit, NEa) publishes a yearly report on the usage of renewable energy. The most recent version shows the details of the renewable energy carriers used in the transport sector in the year 2024 (NEa, 2025)[10]. It reports GHG emission reduction data per feedstock and used feedstocks per fuel type. Detailed data on the emissions was

[9] TitelseiteEvalBericht_2023
[10] Rapportage hernieuwbare energie in Nederland 2024 | Nederlandse Emissieautoriteit

received from the NEa, which made it possible to also present the average emissions per fuel type and the bandwidth in the emission data. In the Netherlands, in the national system, there is a strict limit on crop-based fuels following from the REDII as well as national policy-driven feedstock choices. This results in the absence of crop-based HVO and biogas/bio-LNG in the renewable fuel mix for the transport sector. For FAME, supply of crop-based fuel was very limited (a few TeraJoule, TJ).

The data published by the NEa is also differentiated per sector, so there is data available that is specific for the inland navigation sector. Although it is useful to have data available on that level of detail, analysis of the data shows relatively little difference in the GHG emissions for those fuels used, comparing all mobility sectors. Data that is specific for the inland navigation sector, is not presented here as it would not be possible to compare the values to other Member States. Moreover, it should be noted that the inland shipping sector in the Netherlands still uses relatively low volumes of renewable energy carriers in comparison with the road transport sector. This makes these inland navigation-specific data unsuitable for deriving overall accurate conclusions on the GHG performance.

The WtT GHG emissions for biofuels used in transport in the Netherlands derived from the public data by the NEa are summarized in Table 5. In this table, again, in the last column the crop-based and waste-based emissions are combined in a weighted average resulting in the average emissions in the Netherlands for these four fuel types.

Table 5: WtT GHG emissions data from biofuels used in The Netherlands

Emissions ranges for biofuels		**Energy supplied (TJ)**	**Average emissions (gCO_2eq/MJ)**	**Range in emissions (gCO_2eq/MJ)**	**Average emissions per fuel type (gCO_2eq/MJ)**
FAME	Waste based	18,000	14	2 – 36	14
	Crop based	5	31	28 – 42	
HVO	Waste based	20,600	13	2 – 33	13
	Crop based	0	-	-	
Bio-LNG	Waste based	300	3	-7 – 21	3
	Crop based	0	-	-	
Ethanol	Waste based	5,800	8	-23 – 36	19
	Crop based	4,800	32	-1 – 45	

3.4.3 *France*

In France, the Ministère des Transports maintains a database with yearly biofuel usage[11]. The data for the year 2025 was not yet complete, so the data of 2024 was used in this analysis. It reports GHG emission reduction data per feedstock and used feedstocks per fuel type. The database only presents data for alternative diesel fuels, being HVO and FAME, thus there is no data for ethanol and bio-LNG.
In France, 99% of the FAME used is based on crops-based feedstocks and these volumes have been consistent since 2014. The most used crop for the production of this FAME is Rapeseed, with a big supply originating from Germany and France.

[11] https://metabase.carbure.beta.gouv.fr/public/dashboard/7850c353-c225-4b51-9181-6e45f59ea3ba?annee=2024

For HVO a more diverse mix of crop-based and waste-based feedstocks is seen. There is also a feedstock that has not been discussed earlier: "Category 3 animal fats".[12] Animal fats not fit for consumption or other uses, will be categorized in categories 1 and 2. In such they are also seen as a waste product under RED. However, Category 3 animal fats are useful for consumption, mainly in the pet food sector. Therefore they are not a waste, but also not defined as crop. Under RED they are described as "other biofuels", so in this analysis there will be a separate emission factor for other biofuels in the table. The methodology to come to a final average emission factor per fuel type will remain the same, a weighted average of the 3 feedstock types.

The WtT GHG emissions for biofuels used in transport in the France derived from the public data by the Ministère des Transports are summarized in Table 6Table 5. In this table, again, in the last column the crop-based and waste-based emissions are combined in a weighted average resulting in the average emissions in the Netherlands for these four fuel types.

Table 6: WtT GHG emissions data from biofuels used in France

Emissions ranges for biofuels		**Energy supplied (TJ)**	**Average emissions (gCO_2eq/MJ)**	**Range in emissions (gCO_2eq/MJ)**	**Average emissions per fuel type (gCO_2eq/MJ)**
FAME	Waste based	73,500	15	10 – 16	36
	Crop based	800	36	32 – 36	
HVO	Waste based	3,200	11	9 – 21	14
	Crop based	6,600	26	25 – 26	
	Other	4,000	9	-	

3.4.4 *Belgium*

The data for Belgium was received from the "Federal Public Service Health, Food Chain Safety and Environment". The data was not available in a yearly report, so they were received via contacts of the CCNR.

Similar to the other countries it was not possible to differentiate the data to the inland navigation sector. For FAME there is a mix of crop-based and waste-based feedstocks, while the used HVO is mainly waste-based. The WtT emissions for FAME and HVO can be seen in Table 7.

[12] Animal by-products - Food Safety - European Commission

Table 7: WtT GHG emissions data from biofuels used in Belgium

Emissions Ranges for biofuels		Energy supplied (TJ)	Average emissions (gCO_2eq/MJ)	Range in emissions (gCO_2eq MJ)	Average emissions per fuel type (gCO_2eq/MJ)
FAME	Waste based	9,300	12	-	24
	Crop based	14,600	31	-	
HVO	Waste based	9,100	10	-	10
	Crop based	300	30	-	

3.5 Emission factor data: EU legislation

The other option for obtaining WtT values is to use data that is established in EU legislation. In FuelEU Maritime and RED, data on fossil and renewable fuels is presented that can provide input for the incorporation of GHG emissions into the emission label. In this Section all available data from legislation will be presented in the form of bandwidths, to show the variation per fuel type and per feedstock type.

For the fossil fuels, the reference data is derived from the FuelEU Maritime regulation (Annex II) as it presents the most recent WtT emission data for all but one of the fossil fuels that are included in the fuels list for inland navigation for this research. Of the relevant fossil fuels, only EN590 Diesel is not included in the list of reference fuels in FuelEU Maritime. For that reason, the most recent value from RED is used. For fossil-based FT-diesel and DME no WtT data is available in legislation even though such fossil based pathways are possible for maritime shipping. For FAME, HVO and ethanol, no fossil reference value is included as those fuels are only produced using biobased feedstocks.

For all biofuels included in the fuels list, FuelEU Maritime refers to RED (Annex V and VI). In RED, the WtW GHG-emissions calculation method is established for biofuels and biogas. It also includes a set of Typical and Default values for the WtT GHG emissions for a number of biofuel production pathways. With the revision of the RED, values for more fuel production pathways are added, however there are still gaps between the pathways covered by RED and the fuels list drawn up in Chapter 3.2. This implies that there will be no WtT values originating from a legal basis for most crop based fuels when they do not meet the GHG reduction requirements. For Bio-LNG, there are no values available from RED either.

For e-fuels (hydrogen or hydrogen-derived synthetic fuels), or RFNBOs, no typical or default values are readily available from RED or in the underlying Commission Delegated Regulation (EU) 2023/1185, which specifically covers the GHG methodology for RFNBOs. The only information on such fuel production pathways would come from literature, which would not have a legal basis. As an alternative to typical or default values, RVO proposes the approach to use the minimum WtW GHG emission reduction threshold included in RED that has been established as a requirement for an e-fuel to qualify as a renewable fuel (RFNBO) and to be eligible to count towards the targets of the Directive. RED requires an emission reduction of at least 70% for RFNBOs, in comparison with the fossil fuel comparator in RED (94 g CO_2eq/MJ; please note that the fossil fuel comparator is different from the one in FuelEU Maritime, which is 91.16 g CO_2eq/MJ). The calculation methodology for this has been established in Commission Delegated Regulation (EU) 2023/1185. A second Delegated Regulation (EU) 2023/1184 specifies additional requirements for RFNBOs in order to qualify as a renewable fuel. From the same legislation also follows that negative emissions are (nearly) impossible with RFNBOs, meaning that an emission reduction over 100% is also unlikely. This makes it possible, in the absence of legally based default or typical values, to still present a bandwidth for the WtW GHG emissions of all RFNBO's.

In *Table 8* an overview is given of the data available from EU legislation for fossil, biobased and e-fuels. The emission ranges for all biofuel pathways are presented. A split has been made between waste based and crop based fuels, and again for Default values and Typical values.

Table 8: Inland navigation fuel list with all available WtT GHG emissions data ranges for fossil fuels, biofuels and e-fuels following from EU legislation (RED and FuelEU Maritime).

Fuel category		**Feedstock category and WtT-emissions (gCO2/MJ)**					
	Fuel type	**Fossil**	**Waste - Typical**	**Crops - Typical**	**Waste - Default**	**Crops - Default**	**e-Fuel RFNBO**
Diesel	Fossil diesel (EN590)	21	-	-	-	-	-
	FT-diesel	N/A	10-17	N/A	10-17	N/A	0 – 28
	FAME	-	11-15	40-64	15-21	45-76	-
	HVO	-	12-16	39-62	16-22	44-73	-
	DME	N/A	10-16	N/A	10-16	N/A	0 – 28
Gas	Liquefied gaseous fuels	19	N/A	N/A	N/A	N/A	0 – 28
Alcohols	Methanol	31	10-16	N/A	10-16	N/A	0 – 28
	Ethanol	-	14-14	20-60	16-16	23-72	-
Other fuels	Hydrogen	132	N/A	N/A	N/A	N/A	0 – 28
	Ammonia	31	N/A	N/A	N/A	N/A	0 – 28
Electricity	Electricity		-	-	-	-	-

3.6 WtT GHG emission factor for electricity

3.6.1 Introduction

For Onshore Power Supply (OPS) and battery-electric operation of vessels there are no onboard (TtW) emissions; the WtW GHG emission factor equals the WtT GHG emission factor of the electricity supplied. The WtT GHG intensity depends on the electricity generation mix. The applicable value for this may be set at country level or EU average, in both situations using official EU values per EU Member State. Alternatively, an average value may be set only taking into account the countries relevant for inland navigation.

3.6.2 Approach to GHG emissions of electricity use in RED and FuelEU Maritime

RED mandates electricity for transport counted via a Member State two-year average renewable share with the exception of renewable electricity supplied through a direct connection, because in that case a zero value for the WtT GHG emissions can be assigned. Within the context of the RED, the GHG emission reduction achieved by the use of electricity is calculated relative to the RED fossil comparator for electricity generation with a value of 183 g CO_2eq/MJ (please note that this fossil comparator is different from the fossil fuel comparator which is applicable to renewable fuels, which has a value of 94 g CO_2eq/MJ).

In contrast to RED, FuelEU Maritime uses a mixed approach to the WtT GHG emissions of electricity supplied through OPS. On the one hand, looking at Annex II of the regulation, which contains the emission factors for energy carriers in seagoing shipping, reference is made to the EU energy mix for the WtT part. On the other hand, Annex I of the regulation stipulates that, at present, the WtT GHG emissions of electricity shall be set at zero (this may be revised in the future according to recital 44 of the regulation). From the European Commission Guidance on the FuelEU Maritime regulation, it can be concluded that the WtT GHG emissions for electricity from OPS can be counted as zero, whereas for electricity used by other technologies, the upstream GHG emissions of electricity generation do need to be taken into account in the GHG intensity calculation[13].

3.6.3 EU data sources for the WtT GHG intensity of electricity generation

Looking at available data for the WtT GHG intensity of electricity generation in the EU, there are two options within the EU legislative framework from which these data may be derived:

1. Commission Delegated Regulation (EU) 2023/1185 supplementing Directive (EU) 2018/2001 (REDII), which specifies a methodology for assessing GHG savings from RFNBOs (i.e. fuels produced from renewable electricity; therefore the delegated regulation includes relevant information on electricity emissions factors).
   This delegated regulation provides a 2020 baseline table in g CO_2eq/MJ for each individual Member State, with updates allowed as newer JRC/Eurostat data appear.
2. Commission Delegated Regulation C(2025) 4674 supplementing Directive (EU) 2024/1788 (Hydrogen & Gas Directive), which specifies a methodology for assessing GHG savings from low-carbon fuels
   This delegated regulation contains the five most recent annual values (2019 until 2023) used for the respective countries

[13] See European Commission Guidance on the FuelEU Maritime regulation: d4426ccc-ef46-4292-8b6d-5bf7a620f5ba_en (paragraph 6.2).

Both sources contain official EU data and contain data that reflect actual GHG performance of the electricity generation. However, since Commission Delegated Regulation C(2025) 4674 contains the most recent data, data from this regulation will be used for analysing and proposing WtT GHG emission factors for electricity for EU Member States. Since Switzerland is not an EU Member State, additional data for Switzerland were provided through the 4 July 2025 BFE report[14]. Table 9 below provides an overview of the GHG performance of electricity generation for the CCNR Member States.

Table 9: GHG intensity values for electricity generation at country level (based on Commission Delegated Regulation C(2025) 4674 for EU Member States and the 4 July 2025 BFE report for Switzerland)

Country	**GHG intensity of electricity [gCOeq/MJ]**				
	2019	**2020**	**2021**	**2022**	**2023**
Germany	110.5	99.7	110.2	117.2	103.8
France	18.8	17.8	18.3	25.0	15.4
Belgum	57.0	58.2	47.9	53.2	48.2
The Netherlands	123.9	99.7	101.8	96.0	77.8
Switzerland	N/A	N/A	35.3		

3.6.4 *Options for establishing a WtW GHG emission factor for electricity*

The considerations and data described above lead to various possible approaches to the WtT GHG emission factor for electricity to be applied for the inland navigation sector. These options with their pros and cons for application to the inland navigation emission labelling system are further explored below.

Option A – A single average value

The straight-forward option for establishing a WtT GHG emission factor for electricity would be to use a single average value. Since an overall EU average value would not be appropriate to reflect the GHG performance of electricity used by inland navigation, here it is proposed to establish a CCNR average value. A value that can easily be extended to an average value taking into account other relevant inland navigation countries in Europe. This average value should be based on the reported GHG performance of electricity generation in the individual CCNR Member States. Since it would be a weighted average, the weight will then be determined by the contribution of the Member State to the total CCNR inland navigation energy use, matching the methodology used for the renewable fuels.

Application

Using the weighted average based on the tonne-km data also applied in Section 3.4 of this report, the average CCNR electricity GHG performance will be: 83.3 gCO_2eq/MJ. Applying this value would mean that all registered electrical consumption of vessels will be attributed the same WtT GHG emission factor presented above in the emission labelling methodology.

Pros

- This approach reflects the most accurate way to attribute a single WtW GHG emission factor for electricity use in inland navigation based on actual performance.
- Establishing a single CCNR WtW GHG value does not differentiate between Member States performances, so reporting would only require the overall

[14] Energieetikette für Personenwagen: Umweltkennwerte 2025 der Strom- und Treibstoffbereitstellung

electricity use (in kWh) of a vessel, irrespective of the country of origin of the electricity, thus resulting in a limited administrative burden.

Cons

- A system enabling registration of electricity use by inland navigation vessels would need to be implemented in order to enable this approach.
- Member States with a better GHG performance of the electricity grid would not be able to make use of that within the approach of a single CCNR value.
- The calculated performance is close to the fossil fuel reference, which would diminish the incentive for the electricity use by inland navigation vessels compared to using fossil fuels.

Considering the cons described for using a single CCNR average value, RVO also explored alternative approaches.

Option B — Use official European electricity intensity on Member State level

As outlined above, public official EU data, which are updated periodically, exist for country-level WtT/WtW GHG intensities for electricity. As an alternative to establishing a single CCNR average value, these data are also suitable for attributing a GHG intensity value to each individual CCNR Member State. This option is explored further below. For EU Member States, values can be derived from the Delegation Regulation as mentioned above, but for Switzerland an additional data source has been used in order to be able to differentiate for all CCNR Member States.

Application

This option comprises assigning the Member-State level yearly average GHG intensity for electricity (in g CO_2e/MJ) to the electricity used by inland navigation vessels in the respective countries. These values would have to be updated on a regular basis e.g. when the European Commission refreshes the EU Commission Delegated Regulation C(2025) 4674 dataset[15].

Pros

- Using individual values for each CCNR Member State reflects national performance and rewards electricity grids with a higher share of renewable energy sources.

Cons

- A system enabling registration of electricity use by inland vessels would need to be implemented in order to enable this approach.
- In Member States with a high GHG intensity of electricity (close to or higher than the fossil reference value), there would not be an incentive for using electricity in inland navigation, since it would offer no advantage compared to using fossil fuels.
- With a differentiation of GHG intensity values per Member State, data would be needed for electricity use by inland navigation vessels in each Member State, so this would imply processing extra data, i.e. the electricity use (in kWh per country) and the location. This extra data processing would entail an additional administrative effort and would be relatively complex to integrate into the emission label.

Conclusion

Implementation of country averages is the only means of integrating differentiated

[15] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=intcom:C(2025)4674

WtW GHG emissions of electricity in the inland navigation emission label. While technically compatible with EU attribution rules, the increase in administrative burden and possible disincentives for electrification developments within the inland navigation are important disadvantages for this option to take into consideration for the emission labelling system.

Option C — Set WtT GHG emissions of electricity to zero (FuelEU Maritime)
Within the FuelEU Maritime GHG emissions framework, at present, a level of zero WtT GHG emissions is assigned to electricity used in OPS (see FuelEU Maritime Annex I, and Chapter 2 of this report), so electricity supplied at berth. In other words, this approach uses the same value for the electricity use on board of a vessel through OPS, irrespective of its origin and upstream WtT GHG emissions of electricity generation. In FuelEU Maritime, this approach does not apply to other uses of electricity by vessels[16].

This choice for zero counting of WtT GHG emissions of OPS electricity can be considered as not being consistent with the overall WtW GHG emissions approach in the Fuel EU Maritime regulation, since this approach does not reflect the actual upstream GHG emissions, as it does for other energy carriers. However, as a policy choice, applying a similar zero factor for inland navigation would remove administrative burden and create a strong, immediate incentive for electrification.

Application
This option comprises setting the WtT GHG emission factor for electricity use at zero for the purposes of the emission labelling system for inland navigation (clearly marked as a sector-specific policy choice). Here, a review period should be included in order to re-assess feasibility of moving to country averages, more accurately reflecting the WtT GHG emissions of electricity, as the share of electricity in the energy mix for inland navigation increases over time.

Pros
- Very low administrative burden.
- Strong signal favouring electrification investments.
- Mirrors a currently implemented approach in FuelEU Maritime and EU Taxonomy.

Cons
- Using a zero factor for upstream WtT GHG emissions for electricity would be a deviation within an overall comprehensive and consist WtW GHG emissions approach.
- This aggregated approach will not differentiate between electricity produced from mainly renewable sources or more fossil-intensive grids.

Conclusion
This option would operationally be the most feasible now and it would be aligned with the current FuelEU Maritime approach to OPS. It would also provide an incentive for using OPS within the overall GHG emissions framework of the inland navigation emission labelling system. If this approach is to be selected, then within the GHG protocol of the standard for the emission labelling system, it should be documented as a pragmatic deviation from a comprehensive WtW GHG emissions

[16] Following the FuelEU Maritime approach, regarding the use of electricity by other technologies on-board of a vessel, the WtT GHG emissions would have to be taken into account, based on either a single average value (Option A) or Member State level values (Option B).

methodology. It should also be accompanied by a future review clause, re-assessing this choice at a later stage, as the share of electricity in the energy mix for inland navigation increases further.

4 Proposals for the WtW GHG emission factors

4.1 Summary of the WtW GHG emissions approach

For obtaining emission factor values for the well-to-wake (WtW) GHG performance of energy carriers, the WtT GHG emission factors and the TtW GHG emission factors must be added together, according to Equation (1) of the FuelEU Maritime regulation:

$$GHG\ intensity\ \left[\frac{gCO_{2eq}}{MJ}\right] = (WtT\ + TtW)\ (1)$$

For an accurate, fact-based assessment of WtT and TtW GHG emission factors independent of policy (dis)incentives, the reward factors included in Equations (2) and (3) of the FuelEU Maritime regulation should be set equal to 1, which eliminates them from the equations (see Chapter 2). The WtT and TtW GHG emission values are then determined in the following way by Equations (2) and (3) (for the explanation of each factor included in the equations, please see Chapter 2):

$$WtT = \frac{\sum_i^{n\ fuel} M_i \times CO_{2eq\ WtT,i} \times LCV_i + \sum_k^c E_k \times CO_{2eq\ electricity,k}}{\sum_i^{n\ fuel} M_i \times LCV_i + \sum_k^c E_k}\ (2)$$

$$TtW = \frac{\sum_i^{n\ fuel} \sum_j^{m\ engine} M_{i,j} \times \left[\left(1 - \frac{1}{100} C_{slip\ j}\right) \times \left(CO_{2eq,TtW,i,j}\right) + \left(\frac{1}{100} C_{slip\ j} \times CO_{2eq\ ,slip,i,j}\right)\right]}{\sum_i^{n\ fuel} M_i \times LCV_i + \sum_c^k E_k}\ (3)$$

This Chapter includes a summary of the findings of the analysis of and proposals for the WtT GHG emission factors for energy carriers relevant for inland navigation by RVO as well as for the TtW GHG emission factors by TNO. Based on this research, the proposals for the WtW GHG emission factors are compiled. An overview of the proposed WtW GHG emission factors is presented in the table below (Table 10). A more detailed version of this table (Table 14) is included in the Annex to this report.

Table 14 presents a complete overview of the WtW emission values from Member State data and EU legislation data, combining the WtT data presented in Chapter 3. In Table 1 the available bandwidths of the WtT and WtW emission factors are shown, as well as the WtW emission factors from legislation for HVO, FAME, Bio-LNG and ethanol. Table 10 shows a single value for every fuel based, combining the WtW emission values data from Chapter 3 with the proposals done by RVO on approach as described in this chapter.

For the Global Warming Potential (GWP) values of CH_4 and N_2O, the values from the Fifth Assessment Report (AR5) of IPCC are used for the determination of the proposed IWT default values in Table 10 and Table 14 (for further analysis and considerations regarding this choice, see Section 4.4.3).

TNO concludes that since TtW CO_2 emissions are directly related to fuel properties and are similar between different modes of transport, the emission factors for CO_2 included in FuelEU Maritime can be directly applied to inland navigation for internal combustion engines (irrespective of the age and emission class of the vessel's engine) and fuel cells.

FuelEU Maritime includes values for ammonia and hydrogen but not on application of methanol in Fuel Cells. Methanol can be applied in fuel cells directly or through a reforming process to hydrogen. In both technologies, CO_2 (and to lesser extent CO) remains a main by-product[17]. Therefore, the same value for CO_2 can be applied for methanol in fuel cells (with or without reformer) as with application in an ICE (Internal Combustion Engine). Very little is known on CH_4 and N_2O emissions with hydrogen fuel cells.

Because CH_4 and N_2O emissions are dependent on the combustion conditions in the engine, emission factors of CH_4 and N_2O are proposed for specific application of the methodology to inland navigation. Reasons for this are that in inland navigation different engines are used compared to seagoing vessels and that in Annex II of FuelEU Maritime emission factor values are not available for all fuel types.
TNO also proposes to use a different methane slip factor that is aligned with the limit values for Stage V engines.

[17] Research on methanol fuel cells often includes carbon capture as part of the system. See for instance: Pluijlaar, D. & L. van Biert (2022), Using renewable methanol, PEM fuel cells and on-board carbon capture to reduce well-to-propeller ship emissions

Table 10: Overview of WtW GHG emission factors for inland navigation energy carriers. Green WtT values follow from Member State data, Blue from FuelEU Maritime and Red from the Renewable Energy Directive (RED). All CO_2-values are in the unit gCO_2eq/MJ.

Fuel list			Feedstock category	WtT-Emissions		TtW emissions	WtW emissions
Fuel category	**Fuel type**	**Lower Calorific Value (LCV) (MJ/g)**		**WtT Emissions**	**Short carbon cycle Negative CO_2**	**TtW emissions**	**WtW emissions**
Diesel	Fossil diesel (EN590)	0.0431(2)	Fossil	20.8	-	74.3	95
	FT-diesel	0.0431(1)	Fossil	N/A	-	74.3	N/A
			Biobased	10.2	-73.2	74.3	11
			RFNBO	0.0	-73.2	74.3	1
	FAME	0.037(1)	Biobased	16	-76.6	77.8	17
	HVO	0.044(1)	Biobased	12	-70.8	71.8	13
	DME	0.028(4)	Fossil	N/A	-	69.8	N/A
			Biobased	10.2	-68.2	69.8	12
			RFNBO	0.0	-68.2	69.8	2
Gas	Liquefied gaseous fuels	0.0491	Fossil	18.5	-	77.3	96
		0.05(1)	Biobased	-31	-55.0	74.5	-11
		0.0491	RFNBO	0.0	-56.0	75.9	20
Alcohols	Methanol	0.0199	Fossil	31.3	-	71.3	103
			Biobased	10.4	-69.1	71.3	13
			RFNBO	0.0	-69.1	71.3	2
	Ethanol	0.027(1)	Biobased	12	-70.9	72.5	14
Other fuels[18][19]	Hydrogen	0.12	Fossil	132.0	-	0.4	132
			Biobased	N/A	0.0	0.4	N/A
			RFNBO	0	0.0	0.4	0
	Ammonia	0.0186	Fossil	121.0	-	2.3	123
			Biobased	N/A	0.0	2.3	N/A
			RFNBO	0	0.0	2.3	2

Main data source: FuelEU Maritime Annex II
(1) Annex III of Directive (EU) 2018/2001;
(2) JEC (2020), JEC Well-To-Wheels report v5
(3) CE Delft (2025), STREAM Personenvervoer 2024
(4) JEC (2020), JEC Tank-To-Wheels report v5: Heavy duty vehicles

[18] For low-carbon fuels (blue hydrogen, blue ammonia; not included), a similar approach could be used since for these fuels also a 70% minimum GHG emission reduction requirement is applicable in EU legislation. The GHG emission values for low-carbon fuels have not been further elaborated in this research.

[19] Hydrogen and ammonia combustion engines will have different TtW emissions compared to fuels cells due to (likely) lower rate of N_2O formation. Very little is known regarding these emissions in fuels cells. FuelEU Maritime presents the same values for ammonia and hydrogen for both application in Internal Combustion Engines and Fuel Cells. See the TNO report. These values can be updated when more information on the TtW emissions of fuel cells becomes available from research and measurements.

Further explanation and attention points regarding the values presented in the table above are given in the following paragraphs regarding the WtT and TtW GHG emission factors for fuels, including for weighted average and possible bandwidths, and the approach to inclusion of electricity and wind energy (sail propulsion) by inland vessels.

4.2 Proposals for the WtT GHG emission factors for fuels (RVO research)

The data described in Chapter 3 and

Table 8 leads to various possible approaches to determine a list of WtT GHG emissions for the different fuels relevant for the inland navigation sector. The most important considerations, with their pros and cons for incorporation into the emission labelling system, are further explained below.

Consideration 1: Data source - Member state data, legislation data or a combination
There are differences between Member State data and legislation data, but also differences within the datasets of these data sources. For all feedstock types the options will be presented as well as the RVO recommendations where possible.

For fossil fuels, RVO recommends to use the GHG emission values following from legislation within the inland navigation labelling system, so that they are in line with each other. For fossil fuels, there are also no real alternative data sources whose use is justifiable for incorporation into a European emission label.

For biofuels there are more available options. RVO recommends to use Member State data where possible, as it is the most representative of the actual GHG emissions of the fuels being currently used in the transport sector (mostly not specific (yet) for inland navigation). Therefore, using Member State data is the best available proxy for using actual values, while remaining low in the need for information of on the side of the shipowners. In order to maintain their accurateness and representativeness for GHG performance of the fuel mix, the Member State data should be periodically updated. Currently, four renewable fuels are being used in mobility that are also on the inland navigation fuel list: FAME, HVO, Bio-LNG and Ethanol. A weighted average of the GHG-emissions of each of those renewable fuels can be used for the emission labelling system. The weighting is done base on the inland waterway transport performance (in tonne-km) on the national territory of each CCNR member state as shown in CCNR annual report of 2025[20]. Note that the weighting is done based on the performance of the whole country, not only that on the Rhine.

Remaining biofuel pathways, for which Member State reporting does not provide data (yet), are FT-diesel, bio-DME and bio-methanol, for which the data should follow from legislation. For these biofuel types, RVO recommends the use of the RED typical values, as they follow from legislation based on peer-reviewed literature, and, unlike default values, they have been established without inclusion of policy incentives. Even though the typical values included in RED are a few years old, they are still considered representative of the real GHG performance of fuels currently supplied to the European transport fuel market. Using these values also ensures that the inland navigation emission labelling system aligns with other sustainability reporting that make use of typical values for the WtT GHG emissions of fuels.

[20] CCNR_annual_report_NL_2025_WEB.pdf

For e-fuels there are no reference values available (yet) in EU legislation or in Member State data, as these fuels are still used to a limited extent. For an e-fuel to be classifiable as a renewable fuel (RFNBO) and to be able to count towards the targets of RED and FuelEU Maritime, the RED provides a minimum GHG emission reduction value that must be achieved (70% reduction; which translates into an emission value of 28 g CO_{2eq}/MJ, see Table 10). Similarly, the calculation method for GHG emissions provides a theoretical maximum emission reduction value (100% reduction, so an emission value of 0 g CO_{2eq}/MJ), in a case where all energy used in the fuel supply chain is derived from renewable sources. Combination of these two approaches leads to a bandwidth for WtT GHG emissions of e-fuels based on the current EU legislation.

For low-carbon fuels (blue hydrogen, blue ammonia; not included in Table 10), a similar approach could be used since for these fuels also a 70% minimum GHG emission reduction requirement is applicable in EU legislation. The GHG emission values for low-carbon fuels have not been further elaborated in this research.

Consideration 2: Bandwidths in the data - Lower end, higher end, or otherwise
For both biofuels and e-fuels a bandwidth in the emissions data is presented in this chapter. For the fuels with no or a very small share in the renewable fuel mix (niche fuels), both the lower end of the bandwidth and the higher end are possible options to choose as the WtT GHG emission factor for these fuels, depending on the goal of the emission labelling system.

The lower end of the bandwidth (low emissions) can be used when further stimulation is desired, in the case of niche fuels. In this way the emissions label may support the further development and application of the technology. For this reason, RVO advises to take the lower end of the bandwidth, as is also represented in the values in Table 10. This is the advice for the fuels without any member state data, for the advice on those fuels see Consideration 1, since there a weighted average is preferred. Since these fuel types will represent only a small portion of the inland navigation sector fuel mix, likely with more expensive fuels and engines, this also will not interfere with the rest of the fuel use within the sector. When the fuel becomes further adopted in the sector, updated data from either legislation or Member State reporting shall be used instead. So this requires monitoring of the actual use of alternative fuels in the inland navigation sector.

The high end of the bandwidth (high emissions) can also be chosen. This approach avoids that the reporting of GHG data that might be too positive, leading to a possible overestimation of the GHG reduction of the inland navigation sector. This would also prevent a situation where an inland navigation vessel label becomes worse over time, due to the initial underestimation of the actual GHG emissions. If this risk is not acceptable, the values in Table 10 need to be adjusted according to the preferred values within the bandwidth. For the overview of the WtW-bandwidths, see Annex: Detailed overview of emission values
Table 14 in the Annex.

As described earlier, for some biofuel production pathways the typical values and default values do not comply with the applicable minimum GHG-emission reduction requirement in RED to count as renewable. RVO recommends to adjust the bandwidths for these minimum values so that they represent the minimum GHG emission reduction of 65% for FT-diesel, bio-DME and bio-methanol. This is the minimum emission reduction requirement in RED for biofuels produced in newer installations, which will be the case for these fuel types as they are still in a development phase. If typical or default values are used for FAME, HVO, Bio-LNG or ethanol, RVO recommends to adjust the values to correct for the minimum GHG emission reduction requirement in RED for older installations (50%), since these are biofuels that have already been produced and used for a long(er) period of time.

Consideration 3: Differentiation per end-fuel type – separate or combined values
In this report, there is a lot of attention dedicated to biofuel feedstocks and their differences in GHG emissions (see Chapter 3). However, the overview of proposed WtW GHG emission factors shows that there are much larger differences within one type of end-fuel – e.g. FT-diesel, liquefied gaseous fuels, methanol or hydrogen – when comparing the values among various feedstock/energy origins and related production pathways for such a single end-fuel type (see column "Fuel type" in Table 10).

For example, for FT-diesel, although the WtW value for fossil-based FT-diesel was not established in this research, the GHG performance is expected to roughly be in the same range of that of conventional (diesel) fuels. However, for synthetic FT-diesel based on bio-wastes, the value is expected to be similar to that of HVO and FAME produced from bio-wastes. For renewable synthetic FT-diesel (RFNBO/e-fuel) the value can be even lower, in the best case as low as 0 g CO_2eq/MJ, under the condition that all fossil energy sources are eliminated in the entire fuel supply chain and only renewable energy sources are used.

Another illustrative example for the significant differences within one end-fuel type is that of methanol. In the case of a fossil origin (methanol produced from natural gas) the value appears to be higher (103 g CO_2eq/MJ) than that of conventional (diesel) fuel, but for renewable methanol, either biofuel or e-fuel, the value can be very low, and even close to zero.

A similar significant difference applies to different forms of hydrogen. Here, fossil-based hydrogen leads to much higher GHG emissions (132 g CO_2eq/MJ) than that of conventional fuel. In case carbon capture and storage (CCS) is applied in hydrogen production from fossil sources, the emissions for this "blue" hydrogen may be (much) lower (not included in the RVO research). However, for reaching net zero GHG emissions on a WtW basis, producing and using renewable hydrogen is a prerequisite.

From the viewpoint of setting up an emission labelling system, the examples above illustrate that for an accurate assessment of the GHG performance of inland navigation vessel, it would not be sufficient if only the type of end-fuel is known to the inland vessel owner. So for greater accuracy in the emission labelling system and the reported emissions, it would be de desirable to make a distinction between different fuel types within one single end-fuel type, as is done in the calculation of the emission factors. In other words, the WtT emission value for fuels based on their origin would be needed in order to take this variation into account and to accurately reflect the significant differences in GHG performance.

However, for incorporating this into the emission labelling system, it would require extra administration by inland vessel owners. This would be needed for the following fuels: synthetic (FT) diesel, DME, Liquefied gaseous fuels, methanol, hydrogen and ammonia. For the fuels that are currently mainly used in inland navigation, namely fossil diesel (EN590), FAME and HVO, such a distinction would not be needed, so one value would suffice. However, as noted before, for FAME and HVO there is a large difference in the GHG performance within the range of biobased feedstocks used, i.e. of bio-wastes compared to that of bio-crops. In order to distinguish between these feedstock categories, information on the feedstock used would be needed, which would require a Proof of Sustainability (PoS).

4.3 Proposal for electricity (RVO research)

In the FuelEU Maritime regulation for Onshore Power Supply (OPS), so electricity at berth, the WtT GHG emissions of electricity are set at zero, for the purposes of the regulation. This approach comprises a policy choice aiming to incentivize the use of electricity from OPS by seagoing vessels. However, treating the upstream term as zero in the GHG intensity calculation means a derogation from a consistent policy- and technology-neutral overall WtW GHG emissions methodology for all energy carriers. RVO therefore explored, besides the FuelEU Maritime approach, two other options for inclusion of the WtT GHG emissions of electricity in the emission labelling system for inland navigation. This report therefore presents the following three options for the WtT GHG emissions of electricity:

A. A single CCNR weighted average value
B. Individual Member-State average values
C. Zero WtT GHG emissions

Considering CCNR's aim to stay aligned with FuelEU Maritime where it simplifies implementation, to minimize administrative burden, and to avoid possible disincentives for electrification in the inland navigation sector, RVO proposes, as a first step: setting the WtT GHG emissions of electricity at zero (Option C) with a time-bound review clause, in order to re-assess this choice at a later stage, as the share of electricity in the energy mix for inland navigation increases further. This proposal is supported by the CCNR Correspondence Group.

The CCNR Correspondence Group decided to apply the zero counting of WtT GHG emissions (Option C) not only to electricity from OPS but to electricity used for propulsion as well, in the view of the importance of significant uptake of battery-electric vessels in inland navigation.

4.4 Proposals for TtW GHG emission factors for fuels (TNO research)

4.4.1 *TtW emission factors for CO_2*

In their analysis, TNO concluded that the TtW CO_2 emission factors are directly related to fuel properties and are similar between different modes of transport[21]. The emission factors for CO_2 from FuelEU Maritime are therefore directly applicable to inland navigation vessels for internal combustion engines and fuels cells.

FuelEU Maritime includes values for ammonia and hydrogen but not on application of methanol in Fuel Cells. Methanol can be applied in fuel cells directly or through a reforming process to hydrogen. In both technologies, CO_2 (and to lesser extent CO) remains a main by-product[22]. Therefore, the same value for CO_2 can be applied for methanol in fuel cells (with or without reformer) as with application in ICE.

4.4.2 *TtW emission Factors for CH_4 and N_2O*

Because CH_4 and N_2O emissions are dependent on the combustion conditions in the engine, the TtW emission factor values for CH_4 and N_2O needed further analysis and

[21] « CO_2 emissions are produced when a hydro-carbon fuel is completely combusted. The carbon (C) in the fuel combines with oxygen (O_2) from the air to form carbon dioxide (CO_2)."

[22] Research on methanol fuel cells often includes carbon capture as part of the system. See for instance: Pluijlaar, D. & L. van Biert (2022), Using renewable methanol, PEM fuel cells and on-board carbon capture to reduce well-to-propeller ship emissions.

refinement to better reflect inland fleet characteristics. In doing so, TNO verified these values against data from the Dutch Emission Inventory for inland shipping. From this evaluation, slight deviations were identified: CH_4 emissions were marginally higher for older vessels (vessels equipped with CCR I and pre-CCR type approved engines) compared to the FuelEU Maritime values, whereas N_2O emissions appeared to be slightly lower, particularly for engines equipped with SCR after-treatment. From the analysis, TNO concludes that the overall contribution to the total CO_2-equivalent emissions of CH_4 and N_2O remains limited (≈1–2 %). In addition, the range in differences found for the different age classes of vessels is relatively small (0.024 g CO_2eq/g of fuel).

As a conclusion, given the presence of assumptions and uncertainties in the methodologies and the limited impact on the overall TtW-emissions, TNO proposes to use one level for CH_4 and N_2O emissions for all inland navigation vessels for diesel (EN590) and for HVO and FAME. As a future-proof value, using the level of a Stage V engine (over 130 kW) would be a good first step. This would therefore be a slightly lower value than the one published in FuelEU Maritime.

For internal combustion engines and fuel cells with alternative fuels (methanol, ethanol, ammonia) in inland shipping, test results for CH_4 and N_2O emissions are limited and there are no officially published factors available. As a proxy, the Dutch Emission inventory currently uses the same factors as diesel. Given the limited impact of CH_4 and N_2O emissions, TNO also proposes to use the diesel values for CH_4 and N_2O to the other fuel types where applicable. FuelEU Maritime legislation includes a clause where new insights on the CH_4 and N_2O emissions of alternative energy carriers can be implemented at a later stage. Differences in efficiency between internal combustion engines and fuel cells do not impact these outcomes since all emissions are calculated on a basis of gCO_{2eq}/MJ.

4.4.3 *Global Warming Potential values*

The Global Warming Potential (GWP) values relative to CO_2 are periodically published by the IPCC in assessment reports, and different legislative documents refer to different report figures. The values presented in the various Assessment Reports of IPCC are shown in the table below (based on Table 3.6 in the TNO report).

Table 11: IPCC Global Warming Potential (GWP) values relative to CO_2 for 100 year time horizon (based on TNO report, Table 3.6)

GWP (100 years)	**CO_2**	**CH_4 non-fossil**	**CH_4 fossil**	**N_2O**
Fourth Assessment Report (AR 4, 2007)	1	25		298
Fifth Assessment Report (AR5, 2014)	1	28	30	265
Sixth Assessment Report (AR6, 2021)	1	27	29.8	273

In order to assess the impact of these variations on the end results for the TtW GHG emissions, TNO analysed this for a Stage Va diesel engine. The results of this analysis are summarised in the table below (see also Table 3.7 in the TNO report).

Table 12: Differences in TtW emissions for a Stage Va diesel engine (> 300 kW) expressed in CO_2eq using the values from the latest three assessment reports for a 100 year time horizon (see Table 3.6 and 3.7 in the TNO report in Annex I)

GWP (100 years)	**CO_2 (g/g fuel)**	**CH_4 in CO_2eq (g/g fuel)**	**N_2O in CO_2eq (g/g fuel)**	**CO_2eq total (g/g fuel)**
Fourth Assessment Report (AR 4, 2007)	3.157	0.001	0.047	3.205
Fifth Assessment Report (AR5, 2014)	3.157	0.001	0.042	3.200
Sixth Assessment Report (AR6, 2021)	3.157	0.001	0.043	3.201

The TNO analysis shows that the CO_2eq values from different assessment reports show only (very) small differences for a Stage V vessel. TNO therefore concludes that the difference between the values for the GWP is insignificant for inland shipping. In its report, TNO recommends to use the values from the most recent report AR6. However, TNO adds there that if it is more appropriate to use values from a different assessment report in order to be aligned with other EU legislation, the results will be comparable.

While taking into account these considerations as well as EU legislative references and developments, RVO chose to apply the GWP values from IPCC AR5 for determination of the proposed IWT default values (see Table 10) (instead of using the values from the most recent AR6. The rationale behind this choice is that the FuelEU Maritime regulation provides the basis for the GHG calculation methodology in this research, and this regulation contains a reference to RED. This reference is to an older version of RED (REDII), which contains the GWP values from IPCC AR4. However, there has been an update of this in the Implementing Regulation 2022/996 under RED which refers to AR5. In addition to this, in December 2025 the update of Annex V and VI of the RED was published for public consultation[23], which also refers to and contains the GWP values included in AR5. So in order to remain consistent with FuelEU Maritime and RED references, for the proposed IWT default values in this report also the GWP values from AR5 are used.

4.4.4 Methane slip emissions for LNG powered inland vessels

According to the TNO analysis, the methane slip emissions also needed further research for applicability for inland navigation vessels. In doing so, TNO considered several data sources. According to the TNO research, for gas engines, methane slip (and other non-combustion releases) materially affect TtW and overall WtW GHG emissions and therefore must be included using engine-appropriate factors. At the same time, accurately assessing methane slip remains the main uncertainty area, requiring further measurements. TNO concludes that for inland vessels, it seems likely that the total CH_4 emissions for LNG powered vessels comply with the Stage V maximum limit of 6.19 g/kWh or 0.0338 gCH_4/g fuel LNG. This translates into 1.013 gCO_2eq/g fuel for LNG, when applying the Global Warming Potential factor of 30 in accordance with FuelEU Maritime, this results in an emission of 21 gCO_2eq/MJ.

[23] See: Renewable energy – revising biofuel, bioliquid and biomass fuel production pathway values and modifying methodology

4.4.5 Summary proposal for TtW emission factors

Table 13 below presents an overview of the proposed TtW emission factors as proposed by TNO in their report. This is an overview of the emission factors from Annex II of FuelEU Maritime with additional sources, such as the RED or reports from JRC, for other relevant energy carriers. When a source other than FuelEU Maritime is used, this is mentioned in the table. It shows the TtW emissions per greenhouse gas and the total TtW emissions in CO_2-equivalents.

Table 13: TtW GHG emission values (for details, see TNO report)

Fuel category	**Fuel type**	**Lower Calorific Value (MJ/gfuel)**	**TtW-emissions**			
			CO_2 (gCO_2 / gfuel)	CH_4 (gCH_4 / gfuel)	N_2O (gN_2O / gfuel)	Total CO_{2eq} emissions (gCO_{2eq}/MJ) [24]
Diesel	Fossil diesel (EN590)	0.0431(2)	3.157(2)	0.00005	0.00016	74.3
	FT-diesel	0.0431(1)	3.157(2)	0.00005	0.00016	74.3
	FAME	0.037(1)	2.834	0.00005	0.00016	77.8
	HVO	0.044(1)	3.115	0.00005	0.00016	71.8
	DME	0.028(4)	1.91(4)	0.00005	0.00016	69.8
Gas	Liquefied gaseous fuels	0.0491	2.75	0.0338	0.00011	77.3
	Bio-LNG	0.05(1)	2.75	0.0338	0.00011	74.5
Alcohols	Methanol	0.0199	1.375	0.00005	0.00016	71.3
	Ethanol	0.027(1)	1.913	0.00005	0.00016	72.5
Other fuels[25]	Hydrogen	0.12	0	0	0.00016	0.4
	Ammonia	0.0186	0	0	0.00016	2.3

Main source : FuelEU Maritime Annex II
(1) Annex III of Directive (EU) 2018/2001
(2) JEC (2020), JEC Well-To-Wheels report v5
(3) CE Delft (2025), STREAM Personenvervoer 2024
(4) JEC (2020), JEC Tank-To-Wheels report v5: Heavy duty vehicles

[24] Assuming a Global Warming Potential of 28 for non-fossil CH_4, 30 for fossil CH_4 and 265 for N_2O in accordance with FuelEU Maritime and the latest draft for RED Annex V: Renewable energy – revising biofuel, bioliquid and biomass fuel production pathway values and modifying methodology.

[25] Hydrogen and ammonia combustion engines will have different TtW emissions compared to fuels cells due to (likely) lower rate of N_2O formation. Very little is known regarding these emissions in fuels cells. FuelEU Maritime presents the same values for ammonia and hydrogen for both application in Internal Combustion Engines and Fuel Cells. See the TNO report. These values can be updated when more information on the TtW emissions of fuel cells becomes available from research and measurements.

4.5 Proposal for inclusion of wind/sail(-assisted) propulsion (TNO research)

Since the FuelEU Maritime GHG calculation methodology uses CO_2eq/MJ as the metric, it only considers the GHG intensity of the energy used. It therefore does not adequately incorporate WtW GHG emissions of sail(-assisted) propulsion vessels that are only using their diesel engine for a limited share of their operation. This means that an additional approach would have to be implemented in order to take into account these vessels into the emission labelling system for inland navigation. Since TNO does not have any data available on the average energy consumption of this type of vessels or the share of their activities where they are using their engine, TNO proposes to <u>align the methodology for taking into account wind propulsion with the one included in the air pollution pillar of the emission labelling system</u>. In this methodology, <u>wind propulsion is taken into account based on the number of sailing hours of the wind propulsion vessel</u>. The calculation is done with the following equation (see also Section 3.2 of the TNO report):

$$En_{sail} = \sum_j ((T_v(h) - T_j(h)) \cdot P_{j\,propulsion}(kW) \quad (5)$$

In Equation (5), En_{sail} is the amount of energy provided from sails during a period of one year. The factor (j) refers to the engine. (Tv) represents the total navigation time in a year, and (Tj) comprises the time when the engine is running. (P_j) denotes the engine maximum power (in kW). This equation could be used to implement a factor for wind propulsion into the overall GHG (WtT and TtW) methodology. Using this approach would require ship owners to keep track and provide data on their total navigation time as well as the time they use their engine. If however navigation time is a requested parameter for the label for air pollutants, this would not entail any additional administrative burden for ship owners.

4.6 WtW GHG emission factors in relation to the EU Taxonomy

The EU Taxonomy (Taxonomy Regulation 2020/852/EU) allows financial and non-financial companies to share a common definition of economic activities that can be considered environmentally sustainable. For inland navigation vessels to be considered sustainable in terms of their contribution to climate mitigation, the EU Taxonomy contains requirements for the purchase, financing, leasing, rental and operation of inland vessels (for retrofitting and upgrading of vessels other requirements apply, which are not included in the analysis here). In the Taxonomy, a distinction is made between inland water freight transport and inland water passenger transport, but the requirements for both segments are the same as of 1 January 2026. The two criteria for inland navigation vessels are outlined below, in relation to the WtW GHG emission factor proposals for relevant fuels included in this chapter.

<u>*Criterion 1: Zero direct (tailpipe) CO_2 emissions*</u>

A vessel qualifies as a sustainable investment if it has zero direct (tailpipe) CO_2 emissions. So this includes vessels with only battery-electric, fuel-cell-electric with fuels that do not contain carbon (hydrogen, ammonia) or monofuel combustion engines with the same fuels.

It should be noted here that this approach included in the EU Taxonomy is different from that in the FuelEU Maritime regulation, since it is built on a direct (tailpipe) or tank-to-wake (TtW) emissions approach, whereas in FuelEU Maritime a well-to-wake (WtW) approach to GHG emissions is applied. For electricity, in both legal frameworks, the WtW GHG emissions are considered to be zero, although in FuelEU Maritime this only applies to electricity from OPS and not for electricity used for propulsion (see also Chapter 2 and 3, where this is further detailed for FuelEU Maritime).

However, a difference exists in GHG emission approach to fuels that do not contain carbon, such as hydrogen. In the EU Taxonomy all hydrogen is eligible under criterion (1), since it does not entail any direct (tailpipe) CO_2 emissions, independent from whether if concerns hydrogen of a fossil or renewable origin. Although renewable hydrogen may lead to very low or almost zero WtW GHG emissions, this is not the case for fossil-based hydrogen. Fossil-based hydrogen usually causes WtW GHG emissions that are (much) higher than that of conventional fossil fuels such as diesel. Incentivising this may lead to an additional contribution to global warming, this is reason for caution. It is therefore preferred to take into account the real GHG impact of the use of fuels, so including the GHG emissions associated with the feedstock, production process and fuel chain characteristics.

RVO therefore recommends to apply the WtW GHG emissions approach for all fuels, without any derogations, so also for carbon-free fuels such as hydrogen, in line with the FuelEU Maritime regulation. This proposal is supported by the CCNR Correspondence Group. In that way, all renewable synthetic fuels (RFNBOs), so hydrogen and hydrogen-derived fuels (either carbon-containing or carbon-free) are treated in the same way regarding their GHG emissions impact.

Criterion 2: Gradually decreasing limits for the WtW GHG intensity of fuels
If it is not technologically and economically feasible for a vessel to comply with criterion C1, alternatively, from 1 January 2026 onwards, the vessel can qualify as a sustainable investment if the yearly average GHG intensity of the energy used on-board by the ship or a company's fleet during a reporting period does not exceed the following limits:

(a) 76,4 g CO_2eq/MJ from 1 January 2026 until 31 December 2029;
(b) 61,1 g CO_2eq/MJ from 1 January 2030 until 31 December 2034;
(c) 45,8 g CO_2eq/MJ from 1 January 2035 until 31 December 2039;
(d) 30,6 g CO_2eq/MJ from 1 January 2040 until 31 December 2044;
(e) 15,3 g CO_2eq/MJ from 1 January 2045 until 31 December 2049;
(f) 0 g CO_2eq/MJ from 1 January 2050.

From this it can be concluded that FuelEU Maritime and EU Taxonomy use a similar approach, since both frameworks use as a metric CO_2eq/MJ of the energy used on board. However, the values of the limits are different; they are more stringent in the EU Taxonomy compared to FuelEU Maritime.

Looking at the proposals for the WtW GHG emission values for the fuels for inland navigation included in this Chapter and comparing them to the limits established by the EU Taxonomy, it can be concluded that in the first phase all alternative fuels – if applied in pure form - will be able to comply with the limit set for the period 2026-2029, except for EN 590 diesel, LNG, and fossil-based methanol, hydrogen and ammonia. Although WtW values have not been proposed for fossil-based FT-diesel and DME, it is expected that these fuels will not be able to comply with the limit. Considering the next limit for the period 2030 - 2034, also some crop-based biofuel types (FAME, HVO) have a GHG performance above the limit. Looking at the limit of 30.6 g CO_2eq/MJ for the period 2040 – 2044 basically only biofuels produced from bio-wastes and RFNBO's will be able to comply, and this set of fuels will become smaller when the limits become more stringent up to zero GHG emissions in 2050. Such a limit implies that ultimately only RFNBOs with 100% renewable energy in the fuel supply chain and other fuels with near zero GHG emissions that make use of carbon capture would be considered sustainable within the framework of EU Taxonomy. It should be noted that this short analysis is based on the proposed IWT default values proposed in this research, without the possibility of fuel suppliers and vessel owners to be able to demonstrate a better GHG performance in the lifecycle than these values. As the GHG performance limits become more stringent, and also if certain fuel supply chains have a GHG emission factor that is close to a limit as defined in EU Taxonomy, the use of actual (own calculated) values becomes much more important over time.

5 Recommendations for further implementation

5.1 Introduction

This report outlines a coherent framework for establishing WtW GHG emission factor values for energy carriers relevant for inland navigation, for implementation into an emission labelling system. It builds upon the FuelEU Maritime GHG emissions methodology and data derived from Member State reporting and EU legislation, within inland navigation-specific adjustments where needed and possible.

The proposals for WtW GHG emission factors and the broader systematic for obtaining and using these values as included in this report comprise a first, workable step for including a GHG emissions pillar into an emission labelling system for inland navigation. The ingredients for the GHG emissions approach in this report have been proposed while keeping in mind its feasibility for the inland navigation sector in the first step, in other words to keep the data demand and administrative burden on vessel owners and fuel suppliers as low as possible. Basically, based on data on the use of energy carriers combined with the proposed IWT default values included in Chapter 4, the GHG intensity of the vessel can be calculated. On this basis, a first general division into classes of GHG performances of vessels could be further developed by the CCNR / CESNI.

As noted above, the proposed approach can be used as a first step, and considering expected developments in the EU legislative framework (RED, FuelEU Maritime, CountEmissionsEU, EU Taxonomy, etc.) it can be further extended and finetuned in the future. Therefore, this Chapter contains an elaboration of considerations for further implementation of the WtW GHG emissions framework for inland navigation over time.

5.2 Discussion with regard to proposed WtW GHG emission factors

During the process of developing the proposed IWT default values for energy carriers relevant for inland navigation, a number of discussion points came forward, with regard to the data as well as the broader systematic. These are highlighted in the paragraphs below, for taking these into consideration in further developing the GHG emissions standard for the inland navigation emission labelling system.

5.2.1 Future GHG emission factors: impact of national legislation

Under REDIII, Member States may pursue either an energy share target for renewable energy consumption, or a WtW GHG intensity reduction target as the basis for an obligation for fuel suppliers that supply fuels to the transport sector. Divergent choices in implementation of the REDIII by EU Member States, combined with other national choices, for example regarding feedstock use, may lead to (further) dispersion over time of the flows of fuels and their GHG emission characteristics among Member States. For example, fuels with the highest GHG emission reduction will have the highest financial value in Member States where the obligation on fuel suppliers is based on the of the WtW GHG performance of the fuels. This development will have an impact on the average values that can be derived from Member States reporting over time. As a result, the values supplied by the underlying report will, over time, become less representative for the actual market performance and therefore require frequent (e.g. every 2-3 years) updating or a move towards only use of actual (certified) values for the WtT GHG emissions.

5.2.2 *Data selection: Sector-wide vs sector-specific GHG performance*

Considering the metric of the GHG intensity of fuels (in g CO_2eq/MJ), the analysis of the national data for the Netherlands indicates a minimal modal spread between inland navigation and other domestic transport segments when averaged at Member State level. From this, it can be concluded that aggregated datasets containing GHG emission data for fuels used in domestic transport modes may often be sufficient for proxying inland navigation WtT/WtW GHG emission factors, in the case where inland navigation-specific data are missing.

Practically, this means that EU or Member State-aggregated monitored values can be used as representative values for the inland navigation sector. It should however be noted that in the future the GHG performances among transport modalities may differ as a result of sector-specific policies. It is therefore recommended to monitor as to whether the GHG performance of inland navigation remains aligned with other domestic sector or not.

5.2.3 *Delivery note: minimum data for WtT GHG emissions of fuels*

Fuel deliveries to inland navigation vessels are accompanied by a bunker delivery note that contains the amount and type of fuel supplied. Additional information, which is not yet part of the delivery note, can theoretically be supplied by adding a separate document to the delivery note, supplied with the delivery. Whether adding this information is feasible or other options for receiving this data need to be considered has not been part of the research for this report and needs to be assessed during the further implementation process of an emission labelling system.

For inland navigation, the delivery note or separate document should explicitly capture the blend composition of the fuel supplied (e.g., 20% FAME / 80% diesel by energy or mass). It is important that also the energy content of the fuel (Lower Calorific Value (LCV)) per component and for the blend is known. This information can be supplied as additional information, since it is not included in the delivery note yet, or the values as included in Chapter 4 of this report could be used.

It should be noted that this minimum information from the fuel supplier is needed, in combination with GHG emission factors for the fuels or fuel blends, for determining the WtT GHG emissions for the inland vessel. In order to assign more detailed, and thus more accurate, WtT GHG emissions to fuels, more information must be made available to the inland vessel owner by the fuel supplier using information arising from the fuel supply chain regarding the origin and the characteristics of the fuel, i.e. a Proof of Sustainability (PoS) or equivalent document (like the Proof of Compliance (PoC) or Clean Fuel Contract (CFC)). The practical feasibility of this approach for inland navigation has not yet been assessed within the scope of this research, but is important to address in the further implementation process of an emission labelling system.

5.2.4 *Data consistency and updates*

The analysis by RVO has used a limited but representative data subset to reflect the entire CCNR community. RVO recommends a standing process that includes Member State inputs, which must be structurally onboarded and refreshed on a fixed cycle (e.g., annually, or every 2 to 3 years). The process should integrate official Member State datasets for EU reporting of GHG emission factors of fuels as well as the GHG intensity of electricity generation. This approach would keep the values to be used in the emission labelling system up-to-date and market-representative while minimising an additional reporting burden through using existing EU reporting by Member States that is already in place as a result of reporting obligations from RED.

5.3 Attention points for further development

The CCNR Correspondence Group expressed a preferred approach for the GHG emissions as part of the emissions labelling system where both actual values and the proposed IWT default values can be used. In order to be able to determine the GHG performance of an inland navigation vessel, in both cases the amount and type of energy carrier(s) used would be required data, combined with either an IWT default value or with an actual value (based on a PoS or equivalent). IWT default values can be derived from the proposed values in this report for immediate use by inland navigation vessel owners. However, as already stated in Chapter 2, in order to implement a system that would enable the use of actual values, the certification of fuels supply chains as well as the transfer of WtT GHG emission data (through a PoS or equivalent) to the inland vessel owners would be required.

Please note that actual WtT GHG emission values, in order to obtain an overall WtW GHG emission value, could be combined with either an IWT default value or an actual value for the TtW GHG emissions of the vessel. The use of actual TtW values, could be considered for the inland navigation emission labelling system, building on an approach similar to that of FuelEU Maritime. Within the FuelEU Maritime regulation, the use of actual TtW values is allowed, with the exception of fossil fuels, provided that the actual values are based on certified measurements (see Section 2.2.3). This approach has however not been further elaborated in the underlying research. So when actual values are mentioned below, this refers to actual values for the WtT part (fuel supply chain).

It should be noted that, the data that would be needed for further implementation of the GHG emissions pillar of an emission labelling system are not available through one single source; these data are included in multiple data bases, systems and methods (vessel registries, fuel certification, port/OPS records). The RVO WtW values and methodology provide a solid starting point for incorporating the GHG emissions into an emission labelling system but it is recommended to connect to European wide developments for GHG values and data acquisition. In the more detailed elaboration of implementation aspects below, the GHG values and data acquisition have been split with, accompanied by a recommendation for each point.

5.3.1 Recommendation 1— Facilitate the use of "actual" WtT GHG emission values

The current table containing proposed IWT default values presented in this report is built on official monitored values; it does not yet reward companies (either fuel suppliers or inland vessel owners) whose specific fuels outperform the proposed IWT default values as presented in this report. With the incorporation of the use of actual values the GHG performance in the market would be better reflected and it would enable vessel owners to demonstrate a better GHG performance relative to the IWT default value, with a possible impact on the emission label assigned to the vessel. RVO therefore recommends a phased admission of "actual values" in line with the FuelEU Maritime (and RED / ETS) approach, keeping the IWT default values as the fallback option, during the gradual increase of the use of actual values over time.

Phase 1 (current):

RVO recommends in a first phase to use the set of proposed IWT default values provided in this report to start with the emission labelling system. With the data set GHG performance can be accounted for on different levels: EU or CCNR average, Member State average, or Member State average specific according to feedstock category. More specific data will result in more accurate assessment of the WtW GHG emissions and thus in a more accurate reward for the inland vessel owners' GHG performance. Using a digital accounting system, the administrative burden could be minimised for the inland navigation sector.

Phase 2 (after implementing):
In a next phase, the use of actual values for the WtT GHG emissions of fuels could be further implemented (please note that is approach would not be applicable to fossil fuels, in line with FuelEU Maritime). As described in Chapter 2, the actual values comprise own calculated values by companies that are part of a certified fuel supply chain. These actual values are based on documents that serve as proof for the GHG performance and other sustainability characteristics within the EU legislative context, i.e. Proof of Sustainability (PoS), Proof of Compliance (PoC; in use by maritime shipping and aviation) or equivalent. To prevent double counting, the PoS (or equivalent) linked to an alternative energy carrier supplied physically to the inland navigation sector must be uniquely administered to be accepted in the emission labelling system.

A possible option to implement this is to use the same approach as is currently being implemented for maritime shipping, which is described in the Guidance on the FuelEU Maritime Regulation by the European Commission (October 2025)[26]. In Chapter 5.2 in this Guidance, the approach is outlined, which builds on the use of the Union Database for Biofuels (UDB). The UDB is a global traceability tool to trace consignments of renewable and recycled carbon fuels and the respective raw materials used for their production, from the point of origin of the raw materials, to the point where fuels are put on the EU market for final consumption. Through the UDB, the sustainability and GHG emissions information can be transferred throughout supply chains. It also aims to prevent double counting of emission reductions by multiple parties taking credit for the same fuel or saved emissions. In the current phase of the UDB, economic operators such as feedstock producers, fuel producers, and fuel suppliers, are included. So fuel suppliers, through the UDB, will be able to demonstrate compliance with national obligations under RED.

To support the transparency and traceability of renewable and low-carbon fuels in the maritime sector, it is foreseen, in early 2026, to include ships/shipping companies in the UDB as well. This system update is anticipated to offer a PoS electronic delivery service within the database, enabling a marine fuel supplier to send a PoS to a ship operator via the specific IMO number of the ship which received the fuel as per the relevant Bunker Delivery Note (BDN). In the current situation, shipping companies need to obtain a paper or electronic Proof of Sustainability (PoS) or Proof of Compliance (PoC) managed outside the UDB, so without central registration or verification. The UDB may ultimately facilitate compliance with multiple obligations from different pieces of legislation at different points in the fuel chain (RED, ETS, FuelEU Maritime, ReFuelEU Aviation) and thus support a more robust traceability in renewable and low-carbon fuel supply chains for all transport sectors.

Inland navigation could also build upon this systematic, as well as on the systematic of the PoC, as an equivalent to the PoS in the absence of a PoS for use down the fuel chain, which is further detailed in the European Commission Guidance as well as in the underlying report on fuel certification of the European Sustainable Shipping Forum (ESSF SAPS)[27]. So when translating this to the emission labelling system of the inland navigation sector, GHG emission values, either default values from EU legislation or actual values, in this way could be transferred to inland navigation

[26] See: d4426ccc-ef46-4292-8b6d-5bf7a620f5ba_en
[27] See https://transport.ec.europa.eu/document/download/1dd51746-c10e-4d87-a607-0494713cd416_en?filename=ESSF_SAPS_WS2_Report_on_Fuel_Certification-March_2025.pdf

vessel owners, possibly replacing the proposed IWT default values (see Phase 1). If the unique UDB volumes can be linked to the inland emission label an automatic data entry for actual GHG values will have to be implemented. This approach would result in alignment with practices in FuelEU Maritime, ETS and RED, while the path towards including this adoption can be kept flexible.

Furthermore, RVO would like to highlight embedding two EU-level developments in the GHG emissions approach, i.e. to align with Count Emissions EU (ISO 14083-based method for transport service emissions) and CLEVER (an EU project creating harmonized, validated default emission factors across fuels and modes) for GHG emissions of transport services expressed in gCO_2/tonne-km. Together they set the direction for comparable, verifiable WtW figures and future re-use of inland navigation GHG data in wider supply-chain sustainability reporting.

5.3.2 Recommendation 2 — Database integration

As indicated above, essential vessel and fuel data needed for adequate operation of an emission labelling system are scattered across systems (e.g., EHDB for vessel identity/certificates, CDNI for waste registration and PoS for RED sustainability and GHG information). To make the inland navigation emission labelling system workable and fraud-resistant, these data systems and information flows should interoperate so that the label can reliably combine relevant information.

The EU now provides two enabling building blocks:

- the Eco-design for Sustainable Products Regulation (ESPR) with its Digital Product Passport (DPP) concept for cross-system product data exchange
- the EU Digital Identity (eIDAS 2.0) Wallet rules for verifiable electronic attestations (attributes/credentials) and certified wallets.

Aligning inland navigation emission label data exchange to these frameworks lets CCNR link EHDB/CDNI and PoS/PoC/UDB without inventing a new system, reduce duplicate reporting, and prepare for future EU-wide interoperability. This approach for actual values would thus minimize administrative burden for CCNR members, and would be in line with EU developments of upcoming digitalization requirements that can help the sector differentiate on freight GHG performance as Europe moves towards standardised EU sustainability reporting.

6 Annex: Detailed overview of emission values

Table 14: Overview of WtT, TtW and the resulting WtW emissions. Green WtT values follow from Member State data, Blue from FuelEU Maritime and Red from the Renewable Energy Directive. All CO_2-values are in the unit gCO_2eq/MJ.

Fuel list – Member state and policy data overview			Feedstock category	WtT-Emissions			TtW emissions	WtW emissions	
Fuel category	**Fuel type**	**Lower Calorific Value (LCV) (MJ/g)**		**WtT Emissions low**	**WtT Emissions high**	**Short carbon cycle CO2 values**	**Total CO2eq emissions(5)**	**WtW Emissions low**	**WtW Emissions high**
Diesel	Fossil diesel (EN590)	0.0431(2)	Fossil	20.8		-	74.3	95	
	Ft-diesel	0.0431(1)	Fossil	N/A		-	74.3	N/A	
			Bio- waste	10.2	16.7	-73.2	74.3	11	18
			Bio- crops	N/A	N/A	-73.2	74.3	N/A	N/A
			RFNBO	0	28.2	-73.2	74.3	1	29
	FAME	0.037(1)	Bio – MS average	16		-76.6	77.8	17	
			Bio- waste	11.2	15.3	-76.6	77.8	12	17
			Bio- crops	40.0	63.5	-76.6	77.8	41	65
	HVO	0.044(1)	Bio – MS average	12		-70.8	71.8	13	
			Bio- waste	11.9	16	-70.8	71.8	13	17
			Bio- crops	39.4	62.2	-70.8	71.8	40	63
	DME	0.028(4)	Fossil	N/A	N/A	-	69.8	N/A	N/A
			Bio- waste	10.2	16.2	-68.2	69.8	12	18
			Bio- crops	N/A	N/A	-68.2	69.8	N/A	N/A
			RFNBO	0	28.2	-68.2	69.8	2	30
Gas	LNG	0.0491	Fossil	18.5		-	77.3	96	
	Bio-LNG	0.05(1)	Bio – MS average	-31		-55.0	74.5	-11	
			Bio- waste	N/A	N/A	-55.0	74.5	N/A	N/A
			Bio- crops	N/A	N/A	-55.0	74.5	N/A	N/A
	e-LNG	0.0491	RFNBO	0	28.2	-56.0	75.9	20	48
Alcohols	Methanol	0.0199	Fossil	31.3		-	71.3	103	
			Bio- waste	10.4	16.2	-69.1	71.3	13	18
			Bio- crops	N/A	N/A	-69.1	71.3	N/A	N/A
			RFNBO	0	28.2	-69.1	71.3	2	30
	Ethanol	0.027(1)	Bio- MS average	12		-70.9	72.5	14	
			Bio- waste	13.7	13.7	-70.9	72.5	15	15
			Bio- crops	19.5	59.5	-70.9	72.5	21	61
Other fuels[28]	Hydrogen	0.12	Fossil	132		-	0.4	132	
			Bio- waste	N/A	N/A	0.0	0.4	N/A	N/A
			Bio- crops	N/A	N/A	0.0	0.4	N/A	N/A
			RFNBO	0	28.2	0.0	0.4	0	29
	Ammonia	0.0186	Fossil	121		-	2.3	123	
			Bio- waste	N/A	N/A	0.0	2.3	N/A	N/A
			Bio- crops	N/A	N/A	0.0	2.3	N/A	N/A
			RFNBO	0	28.2	0.0	2.3	2	31

[28] For low-carbon fuels (blue hydrogen, blue ammonia; not included in Table 6), a similar approach could be used since for these fuels also a 70% minimum GHG emission reduction requirement is applicable in EU legislation. The GHG emission values for low-carbon fuels have not been further elaborated in this research.

Table 15: Overview of the WtT member state data from Chapter 3.4. All CO2-values are in the unit gCO2eq/MJ.

Fuel list – Member state overview			Member state	Energy supplied (TJ)	WtT-Emissions			
Fuel category	**Fuel type**	**Feedstock type**			**WtT Emissions low**	**WtT emissions average**	**WtT Emissions high**	**Average final emissions**
Diesel	FAME	Wastes	Germany	58,000	2	11	35	16
			The Netherlands	18,000	2	14	36	
			France	73,500	10	15	16	
			Belgium	9,300	-	12	-	
		Crops	Germany	25,000	-20	22	45	
			The Netherlands	5	28	31	42	
			France	800	32	36	36	
			Belgium	14,600	-	31	-	
	HVO	Wastes	Germany	16,700	Not reported	Not reported	Not reported	12
			The Netherlands	20,600	2	13	33	
			France	3,200	9	11	21	
			Belgium	9,100	-	10	-	
		Crops	Germany	25	Not reported	Not reported	Not reported	
			The Netherlands	0	-	-	-	
			France	6,600	25	26	26	
			Belgium	300	-	30	-	
		Other	France	4,000	-	9	-	
Gas	Bio-LNG	Wastes	Germany	300	Not reported	-73	Not reported	-31
			The Netherlands	0	-7	3	21	
		Crops	Germany	0	-	-	-	
			The Netherlands	0	-	-	-	
Alcohol	Ethanol	Wastes	Germany	2,100	-20	9	25	12
			The Netherlands	5,800	-23	8	36	
		Crops	Germany	30,900	-20	9	45	
			The Netherlands	4,800	-1	32	45	

Main source : FuelEU Maritime Annex II
(1) Annex III of Directive (EU) 2018/2001
(2) JEC (2020), JEC Well-To-Wheels report v5
(3) CE Delft (2025), STREAM Personenvervoer 2024
(4) JEC (2020), JEC Tank-To-Wheels report v5: Heavy duty vehicles
(5) Assuming a Global Warming Potential of 28 for non-fossil CH_4, 30 for fossil CH_4 and 265 for N_2O in accordance with FuelEU Maritime and the latest draft for RED Annex V: Renewable energy – revising biofuel, bioliquid and biomass fuel production pathway values and modifying methodology.

7 Annex: TNO TtW GHG emissions report

Default values for calculation of Tank-to-Wake GHG-emissions from inland waterway transport

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Default values for calculation of Tank-to-Wake GHG-emissions from inland waterway transport

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Summary

Following the CESNI work program, the Central Commission for the Navigation of the Rhine (CCNR) is currently preparing a proposal for a draft standard that sets out a methodology for measuring and calculating emissions from inland navigation vessels and defines emission classes. This initiative forms part of a broader process towards establishing an international labelling system for inland navigation. This label will consist of an element related to air pollutant emissions and greenhouse gases.

RVO, with a contribution of TNO, was asked to develop a methodology and propose standard Well-to-Wake (WtW) values for greenhouse gas emissions to the CCNR working group that is developing this proposal. The methodology used in FuelEU Maritime served as a base for this methodology. This report presents the input for the Tank-to-Wake part and serves as an Annex for the report from RVO[7].

The methodology used in FuelEU Maritime is well transferable to inland shipping and gives good insights in the greenhouse gas emissions of the energy carrier that is being used.

- The methodology considers the effect of the greenhouse gas emission of CO_2, CH_4 and N_2O as well as CH_4-slip.
- Because it considers the environmental performance of the share of individual energy carriers that are being used, it is a flexible methodology. It is suitable for different energy carriers that are currently considered for Inland Waterway as well as differences in fuel blends or the use of hybrid systems that combine battery electric propulsion with the use of fuels.
- The methodology uses CO_{2eq} per MJ as a metric, so the emissions are only determined by the characteristics of the energy carrier(s) that are used. The effects of technical efficiency measures or logistics measures are not included. It also does not enable a comparison with other modalities (for instance to assess the impact of modal shift).
- The methodology is in line with several other EU legislative proposals such as EU Taxonomy, but deviates from the methodology used in the proposal for CountEmissions EU and the ISO standard for quantification and reporting of greenhouse gas emissions (ISO 14083:2023).

The new IWT label can partly use the emission factors of FuelEU Maritime.

- The emission factors for CO_2 can be transferred. In this document, some values for additional energy carriers that are or could be applied in Inland Waterway Transport (IWT) are presented. This includes, most notably, the value for diesel (EN 590).
- We propose to deviate from the default values for CH_4- and N_2O-emissions and to use slightly lower values than FuelEU Maritime. Although the values for CH_4 and N_2O depend on the age of the engine and the presence of a Selective catalytic reduction (SCR) aftertreatment system, we propose to use one value per energy carrier.
  The impact of CH_4 and N_2O in total greenhouse gas emissions is limited (1 to 2% of the total emissions in terms of CO_2eq for diesel).

[7] RVO (2025), Emission Values for EU Inland Navigation Fuels

- Results from emission measurements of LNG powered pilot vessels show that the methane emissions are in line with Stage V requirements. Recent newbuild LNG vessels are most likely equipped with 'lamda=1' engines, that comply with Stage V with the catalyst system. It is therefore proposed to deviate from FuelEU Maritime and take the Stage V emission limit for CH_4 as a base for methane slip.
- FuelEU Maritime refers to values for the Global Warming Potential[2] of CH_4 and N_2O from the IPCC Assessment Report of 2007. Since then, two new versions of the report have been published (2014 and 2021) with (slightly) different values. It is noted that different EU documents refer to different versions of the IPCC assessment reports. It is recommended to use the latest scientific insights from the sixth assessment report from 2022, but it is acceptable to use values from the two earlier reports in order to align to specific EU legislation. The impact of the differences between the values on the total emissions of an IWT vessel in CO_2eq are negligible.
- Sailing vessels that are only using their diesel engine for a limited share of their activities, will have their label based on the amount of fuel that they are using when running on diesel. Although correct according to the methodology, this might give an undesired impression of their environmental performance. The proposed label system for air pollutants presents a reward factor based on a calculated "energy saved with a propulsion system". Using the same approach, a reward factor can be applied for the TtW (and WtT) GHG-emissions.

[2] The Global warming Potential allows comparison of the global warming impacts of different gases. It is used in this report to convert CH_4 and N_2O emissions into CO_2 equivalents.

Contents

1 Introduction

1.1 Background and aim

Following the CESNI work program[3], the CCNR (Central Commission for the Navigation of the Rhine) is currently preparing a proposal for a draft standard that sets out a methodology for measuring and calculating emissions from inland navigation vessels and defines emission classes. This initiative forms part of a broader process towards establishing an international labelling system for inland navigation.

This label will consist of an element related to air pollutant emissions and greenhouse gases. The Ministry of Infrastructure and Water Management has commissioned RVO to contribute expertise in the field of sustainability assurance and calculation of greenhouse gas emissions (Well-to-Wake) to the CCNR working group that is developing this proposal.
RVO has been asked to advise on greenhouse gas emissions for the entire chain. For the Well-to-Tank part, RVO uses its own expertise; for the Tank-to-Wake part, RVO asks TNO for support. This report presents the input for the Tank-to-Wake part and serves as an annex for the report from RVO[4].

The aim of this research is to develop a methodology and propose standard values for greenhouse gas emissions of inland vessels, based on the calculation methodology of the FuelEU Maritime regulation for seagoing vessels.

- Develop and implement a consistent methodology for determining greenhouse gas emissions from inland vessels in energy conversion for relevant energy carriers for inland navigation.
- Determination of reliable emission factors per energy carrier, based on scientifically sound and internationally recognized methodologies, based on the FuelEU Maritime approach.

The result of the research into greenhouse gas emissions, combined with the research that RVO is conducting into WTT greenhouse gas emissions, should lead to a coherent approach with regard to the WTW greenhouse gas emissions for the fuels relevant to inland navigation that can be applied within the emission label system that is being developed by the CCNR working group.

1.2 Methodology

Our approach follows two tasks:

- Establish a consistent methodology for determining TTW-emissions for inland navigation.
- Determining the associated emission factors.

[3] https://www.cesni.eu/wp-content/uploads/2024/12/CESNI_work_prog_25_27_EN.pdf
[4] RVO (2025), Emission Values for EU Inland Navigation Fuels

The methodology for calculating the TtW GHG-emissions has been based on the calculation methodology from Annex I and II of FuelEU Maritime. An overview of this methodology is presented in chapter 2. The chapter also includes a brief overview of other metrics and methodologies (such as EU Taxonomy, CSRD, CountEmissions EU, ISO 14083:2023 and AGVV).

Based on the chosen methodology, a further elaboration of the emission factors for CO_2, N_2O and CH_4 has been made, which is presented in chapter 3. Firstly, the factors presented in FuelEU Maritime were complemented with factors for additional energy carriers (see Table 1.1). The applicability of these factors for IWT was verified by comparing them to other sources.

Table 1.1: Energy carriers taken into account.

Energy Carrier	Energy Conversion Onboard
Diesel	Combustion
HVO	Combustion
FAME	Combustion
E-diesel	Combustion
LNG	Combustion / Fuel Cell
CNG	Combustion / Fuel Cell
Methanol	Combustion / Fuel Cell
DME	Combustion / Fuel Cell
Ethanol	Combustion / Fuel Cell
Ammonia	Combustion / Fuel Cell
Hydrogen	Combustion / Fuel Cell
Battery-electric	Electric motor

2 Methodology for determining GHG emissions

In this chapter an overview is presented of the methodology used in FuelEU Maritime for calculating the greenhouse gas emissions. Furthermore, an overview of other relevant policy documents that calculate the greenhouse gas intensity of inland shipping is presented.

2.1 FuelEU Maritime

The methodology for GHG-emissions has been based on the calculation methodology from Annex I and II of FuelEU Maritime. This methodology was chosen as a base by the CCNR working group. The methodology calculates the Tank-to-Wake-emissions in terms of grams CO_2eq per MJ energy (g/MJ). Main benefit of this metric is that it is consistent for different types of vessels and is only dependent on the type of fuel that is being used. The formula from Fuel EU Maritime (annex I) consisting of both Well-to-Tank and Tank-to-Wake emissions is shown below. The formula for Tank to wake is highlighted in yellow.

Equation 2.1: FuelEU Maritime equation

GHG intensity $\left[\frac{gCO2eq}{MJ}\right] = f_{wind} \times (WtT + TtW)$ Equation (1)	
WtT	$\frac{\sum_i^{n\ fuel} M_i \times CO_{2eq\ WtT,\ i} \times LCV_i + \sum_k^c E_k \times CO_{2eq\ electricity,k}}{\sum_i^{n\ fuel} M_i \times LCV_i \times RWD_i + \sum_k^c E_k}$
TtW	$\frac{\sum_i^{n\ fuel} \sum_j^{m\ engine} M_{i,j} \times \left[\left(1 - \frac{1}{100} C_{slip\ j}\right) \times (CO_{2eq,\ TtW,i,\ j}) + \left(\frac{1}{100} C_{slip\ j} \times CO_{2eq\ TtW,\ slip,\ i,j}\right)\right]}{\sum_i^{n\ fuel} M_i \times LCV_i \times RWD_i + \sum_k^c E_k}$
f_{wind}	Reward factor for wind-assisted propulsion

The different elements of the TtW formula are summarised in Table 2.1.

Table 2.1: Elements of the FuelEU Maritime TtW formula.

i	Index corresponding to the fuel types delivered to the ship in the reporting period.
j	Index corresponding to the fuel consumer units on board the ship. For the purpose of this Regulation the fuel consumer units considered are the main engine(s), auxiliary engine(s), boilers, fuel cells and waste incinerators.

Mi.j	Mass of fuel i consumed by fuel consumer unit j [gFuel].
C_slip j	Non-combusted fuel coefficient as a percentage of the mass of the fuel i consumed by fuel consumer unit j [%]. Cslip includes fugitive and slipped emissions.
CO2eq.ttw_i.j	TtW CO_2 equivalent emissions of combusted fuel i in fuel consumer unit j [gCO_2eq/gFuel]. Includes emissions of CO_2, CH_4 and N_2O.
LCV_i	Lower calorific value of fuel i [MJ/gFuel].
RWD_i	Where the fuel is of non-biological origin. a reward factor of 2 from 1 January 2025 to 31 December 2033 can be applied. Otherwise RWDi = 1.
E_k	Electricity delivered to the ship by OPS connection point k [MJ].

Base calculation of the formula
The formula consists of a few different elements. For ships without (methane) slip, without use of Renewable Fuels of Non-Biological Origin (RFNBO), and without use of shore power, the TTW equation simplifies to:

Equation 2.2: TTW equation without methane slip, RFNBO or shore power

$$\frac{\sum_i^{n_{fuel}} \sum_j^{m_{engine}} M_{i,j}\, CO_{2eq,ttw,i,j}}{\sum_i^{n_{fuel}} M_i\, LCV_i}$$

If the vessel uses a single fuel, the equation simplifies further to:

Equation 2.3: Simplified TTW equation for a single fuel

$$\frac{\sum_j^{m_{engine}} (M_{i,j} * CO_{2eq,ttw,i,j})}{M_i * LCV_i} = \frac{CO_{2eq,ttw,i}}{LCV_i}$$

In case of multiple fuels or blends used, Equation 2.2 can be used, in which the share of the individual fuels or the share of fuels within the blend are taken as individual components.

Annex II of FuelEU Maritime presents reference values for CO_2, CH_4 and N_2O in terms of g/g fuel and the LCV for a subset of fossil fuels, biofuels and RFNBOs (see next chapter).

The calculation is influenced by the use of RFNBO and onshore power supply.
- For the share of RFNBO (RWD_i) a reward factor is used where the CO_2eq values are divided by an additional factor 2 for the fuel mass.
- Onshore power supply is only used in the denominator (for the TtW part) of the formula.

Slip
Besides emissions of CO_2, N_2O and CH_4, there is also a factor for non combusted fuel. The CO_2eq value of slip is calculated as follows:

Equation 2.4: TTW calculation for non combusted fuel

$$CO_{2eq,TtWslip_{i,j}} = (C_{sfCO_2,j} \times GWP_{CO_2} + C_{sfCH_4j} \times GWP_{CH_4} + C_{sfN_2O,j} \times GWP_{N_2O})_i$$

Where: $Csf\,CO2$, and $Csf\,N2O$, = 0.

$C_{sfCH4j} = 1$.

Therefore, only methane slip is taken into account. Fuel EU maritime only shows methane slip factors for LNG powered vessels (see next chapter)

Wind assist/ wind powered

The metric used in Fuel/EU maritime (CO_2eq g/ MJ) only considers the GHG intensity of the energy carrier used. Wind assist or other fuel efficiency measures have no effect on this metric. Fuel EU maritime uses a “reward factor” for wind assist on the WtT as well as the TtW emissions.

2.2 Other policy documents

Besides FuelEU Maritime there are also other documents which give guidance for identifying the GHG-emissions or GHG intensity that are relevant for inland shipping. This includes other EU regulations or proposals of regulations and international standards or protocols.
As Table 2.2 shows, there are some differences in the metric that is being used or the scope of the GHG emissions that are taken into account.

For the metric that are some different considerations:

- FuelEU Maritime and EU taxonomy use CO_2e/MJ, which is mainly targeted at which energy carrier is being used onboard. This metric makes it relatively easy to set clear targets for a whole fleet, that is not influenced by other factors such as the size or the load factor of the vessel. The metric does not allow to take into account the effect of technical fuel-efficiency measures and logistics or operational measures.
- ISO 14083 and the proposal for CountEmissions EU take the transported persons or goods as a base and use CO_2eq/ton.km or CO_2eq/passenger.km as a base. This allows for comparison between different transportation modes for a similar journey (IWT vs truck) and allows for calculation of the total GHG-emissions (or intensity) of a journey that has multiple transport legs. Besides the effects of different energy carriers, also the effects of other GHG reduction measures can be taken into account. This includes technical fuel efficiency measures and operational measures on the level of the vessel and logistics measures such as modal shift and increasing the load factor.
- The GHG protocol and the Corporate Sustainability Reporting Directive (CSRD) only consider the total absolute annual GHG-emissions (in tonnes). This therefore is mainly dependent on the size of the vessel and the activities. The metric is less suitable for comparison within the fleet.
- In earlier reports on the emission label (see Platina 4[5]) the metric CO_2eq/kWh is considered. Main consideration was that this metric also takes into account different aspects of engine efficiency. This metric is also used in the Dutch voluntary label system. The Dutch voluntary system uses TtW as a basis.

[5] Platina4Action (2024), D3.1 State of play and requirements for the label for inland vessels

Table 2.2: Overview of different policy documents involving GHG-emissions or intensity.

Regulation/ Protocols	Document	Metric	GHG scope
FuelEU Maritime	Regulation (EU) 2023/1805	CO_2eq/MJ	WtW
EU Taxonomy	Regulation (EU) 2020/852	CO_2eq/MJ	WtW
CountEmissions EU (proposal)	COM(2023) 441/2 2023/0266 (COD)	CO_2eq/tkm or CO_2eq/pkm	WtW
ISO standard	ISO 14083:2023: Quantification and reporting of greenhouse gas emissions arising from transport chain operations	CO_2eq/tkm or CO_2eq/pkm	WtW
GHG Protocol	GHG Protocol: Corporate Accounting and Reporting Standard	Absolute CO_2e	WtW
Corporate social responsibility directive	Directive (EU) 2022/2464	Absolute CO_2e	WtW
General Block Exemption Regulation	Regulation (EU) No 651/2014	Freight: CO_2e/tkm Passenger transport: based on technology onboard	TtW
Dutch voluntary emission label	Platina3 (2021), Report on implementation of European IWT emission label / energy index / GLEC for vessels D2.6 binnenvaartemissielabel.nl/	CO_2e/kWh	TtW

3 Tank-to-Wake emission factors

This chapter presents an overview of the Tank-to-Wake emission factors that can be used for inland waterway transport (IWT). The chapter starts with the factors that are presented in FuelEU Maritime, complemented with factors for additional energy carriers. This is followed by a section on the verification of the different elements of the formula, in order to see whether the factors can be transferred to IWT or whether there are alternative values which are better aligned.

3.1 TTW emission factors

Table 1.1 presents an overview of the emission factors from Annex II of FuelEU Maritime with additional values for other relevant energy carriers:

- The most relevant energy carrier for inland shipping is EN 590 diesel, which is the same as diesel that is being used for road transport. Since February 13, 2023, the specifications for fuel used in inland shipping (VOS ULS2023) have been equalized with EN590[6].
- FuelEU Maritime does not present the lower caloric value for biofuels, since this depends partly on the feedstock that is being used. The values presented in this table are the ranges that are published in Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources. The value that should be applied here depends on the choices made in the methodology for the WtT- emissions. To reduce uncertainty and unclarity, it would be preferable to use one standard value.
- For CNG different values exist based on the caloric value of the gas that is being used. For CNG in road transport in the Netherlands, traditionally low caloric gas is being used. However, CNG can also be produced with high caloric gas. Since, there is very limited experience with CNG in Inland Shipping, it is recommended to publish a range.
- FuelEU Maritime has currently no information yet on CH_4- and N_2O-emissions for methanol, DME and ethanol or of N_2O-emissions of ammonia and hydrogen.
- FuelEU Maritime presents the same values for ammonia and hydrogen for both application in Internal Combustion Engines (ICE) and Fuel Cells (FC).
- No mention is made in FuelEU Maritime on application of methanol in Fuel Cells. Methanol can be applied in fuel cells directly or through a reforming process to hydrogen. In both technologies, CO_2 (and to lesser extend CO) remains a main byproduct[7]. Therefore, the same value for CO_2 can be applied as with application in ICE. Very little is known on CH_{4}- and N_2O-emissions with hydrogen fuel cells.

[6] Stichting VOS (2023), VOS-specificatie is geheel gelijk getrokken met EN590
[7] Research on methanol fuel cells often includes carbon capture as part of the system. See for instance: Pluijlaar, D. & L. van Biert (2022), Using renewable methanol, PEM fuel cells and on-board carbon capture to reduce well-to-propeller ship emissions

FuelEU Maritime does not have default values for fuel blends, but uses the share of different energy carriers and feedstocks. Since REDIII targets for transport can be implemented differently between EU countries and also differs over time, it is recommended to take over this methodology, preferably on the level of an individual ship. As stated in chapter 2, in case of the use of multiple fuels or blends, the weighted sum of the individual fuels or the share of fuels within the blend are taken to calculate the emissions.

Table 3.1: Default values derived from FuelEU Maritime and additional sources

		TTW emissions		
	LCV (MJ / g)	CO_2 (gCO_2 / g fuel)	CH_4 (gCH_4 / g fuel)	N_2O (gN_2O / g fuel)
Diesel (EN590)/ E-diesel	0.0431 (2)	3.157 (2)	0.00005	0.00018
MGO/ e-MGO	0.0427 (1)	3.206	0.00005	0.00018
HVO	0.044 – 0.046 (1)	3.115	0.00005	0.00018
FAME	0.037 – 0.038 (1)	2.834	0.00005	0.00018
LNG/ e-LNG	0.0491	2.750	0 (ex. Slip)	0.00011
Bio-LNG	0.05 (1)	2.750	0 (ex. Slip)	0.00011
CNG	0.038 (3) / 0.048 (4)	2.143 (3) / 2.69 (4)	0 (ex. Slip)	0.00011
Methanol / e-methanol	0.0199	1.375	TBM	TBM
DME	0.0284 (4)	1.91 (4)	TBM	TBM
Ethanol	0.027 (1)	1.913	TBM	TBM
Ammonia/ e-ammonia	0.0186	0	0	TBM
Hydrogen/ e-H2	0.12	0	0	TBM
Battery-electric	n/a	0	0	0

Main source : FuelEU Maritime Annex II
(1) Annex III of Directive (EU) 2018/2001
(2) JEC (2020), JEC Well-To-Wheels report v5
(3) CE Delft (2025), STREAM Personenvervoer 2024
(4) JEC (2020), JEC Tank-To-Wheels report v5: Heavy duty vehicles

The following table presents the default factors for methane slip as used for FuelEU Maritime. Methane slip is only considered in case of LNG and can be extended to CNG (not applicable in maritime shipping), so therefore not included in Fuel EU Maritime.
Besides methane slip, ammonia slip may also be an issue for ammonia engines. This may lead to additional N_2O-emissions. However, there is currently very little experience with ammonia engines, so no default values are presented in FuelEU Maritime.

Table 3.2: Default methane slip emission factors used in FuelEU Maritime.

Fuel Type	Engine Type	C_slip (% of total fuel mass)
LNG/ Bio-LNG/ e-LNG CNG	LNG Otto (dual fuel medium speed)	3.1
	LNG Otto (dual fuel slow speed)	1.7
	LNG Diesel (dual fuel slow speed)	0.2
	lean burn spark ignited engines	2.6

CO_2-equivalent factors
To translate N_2O and CH_4 into CO_2-equivalents, the emissions are converted with the Global Warming Potential (for a period of 100 years). FuelEU Maritime refers to paragraph 4 of Part C of Annex V of Directive (EU) 2018/2001. This Directive refers to a fixed set of values that is presented in the table below.

Table 3.3: Global warming potential as presented in Directive (EU) 2018/2001.

	CO_2	CH_4	N_2O
GWP (100 year)	1	25	298

3.2 Verification of emission factors

In this paragraph, the different factors that were discussed in section 3.1 are verified. Main goal of this section is to identify whether the maritime emission factors can be transferred to IWT.

Emission factors for CO_2
CO_2-emissions are produced when a hydro-carbon fuel is completely combusted. The carbon (C) in the fuel combines with oxygen (O_2) from the air to form carbon dioxide (CO_2). This process is dependent on the fuel properties and are similar between different modes of transport. The values from FuelEU Maritime can thus easily be applied to IWT.

Emission Factors for CH_4 and N_2O
The emissions found in FuelEU Maritime were compared to data from the Dutch emission inventory (Pollutant Release and Transfer Register (PRTR)). Within the inventory, Emissions from all relevant Dutch sources are every year calculated in the 'Emission Registration'. This includes sources such as agriculture, industry and traffic and transport. As of 2022, the total annual emissions of the professional inland shipping sector are calculated bottom-up: the real-world behaviour of all ships is combined with specific ship information to calculate time-dependent emissions. The analysis uses emission factors that are specific for IWT, based on measurements and literature[8]. The analysis found some small differences for the emissions of CH_4 and N_2O.

CH_4-emissions are part of the emissions of Volatile Organic Compounds (VOC). The level of VOC-emissions is dependant on the combustion of the engine. In the Dutch emission inventory, there are different levels of VOC based on the age of the vessel, in which younger vessels have (slightly) lower VOC-emissions. The Emission Inventory assumes a fixed composition of different components of VOCs for inland shipping. The fraction of CH_4 as part of VOCs is set at 4% for diesel (EN590).

For N_2O-emissions, a difference is made in the emission inventory between vessels with or without a SCR aftertreatment system. N_2O is a byproduct of SCR systems, which use ammonia (from AdBlue) to reduce NO_x emissions. The level of N_2O-emissions depends on the catalyst formulation, system design and the operating conditions[9]. At present N_2O-emissions are not regulated for NRMM engines. SCR-aftertreatment is applied on vessels with a Stage V engine of over 130 kW.

[8] Geilenkirchen, G., Bolech, M., Hulskotte, J., Dellaert, S., Ligterink, N., van Eijk, E., (2024). Methods for calculating the emissions of transport in the Netherlands, Rijksinstituut voor Volksgezondheid en Milieu RIVM, DOI: 10.21945/RIVM-2024-0023
[9] https://dieselnet.com/tech/cat_scr_diesel.php

The following table presents an overview of the different emission factors for CH_4 and N_2O for different age classes and compares them to the factor set by FuelEU Maritime. The table shows, that for older engines (CCR1 and pre CCR vessels), the CH_4 emission factors are (slightly) higher than the level published in FuelEU Maritime. The emission factors for N_2O for inland shipping are lower than FuelEU Maritime, although only slightly for Stage V vessels (over 130 kW).

Table 3.4: Emission factors for CH_4 and N_2O for different age classes when using EN590 diesel.

Age class inland vessel engine	CH_4 g/g fuel	N_2O g/ g fuel
1900 – 1974	0.00020	0.00008
1975 – 1979	0.00014	0.00008
1980 – 1984	0.00012	0.00008
1985 – 1989	0.00011	0.00008
1990 – 1994	0.00014	0.00008
1995 – 2002	0.00010	0.00008
2003 - 2007 ccr-1	0.00007	0.00008
2007 - 2021 ccr-2	0.00005	0.00008
2019 - 2050 Stage Va 1, 2 (< 130 kW)	0.00004	0.00008
2019 - 2050 Stage Va 3 (130 - 300 kW)	0.00003	0.00016
2019 - 2050 Stage Va 4 (> 300 kW)	0.00005	0.00016
FuelEU Maritime	0.00005	0.00018

To assess the impact of the found differences in CH_4 and N_2O levels, Table 3.5 shows the total TTW-emissions for the different age categories expressed in CO_2eq. The table shows that the impact of CH_4- and N_2O-emissions in the overall CO_2eq-emissions is limited (1% to 2%).[10] The range in differences found for the different age classes is 0.024 g CO_2eq per g fuel.

Table 3.5: TTW-emissions for different age classes for diesel-powered engines expressed in CO_2eq (according to the GWP values used in FuelEU Maritime).

Age class inland vessel engines	CO_2	CH_4 in CO_2eq (g/g fuel)	N_2O in CO_2eq (g/g fuel)	CO_2eq Total (g/g fuel)
1900 – 1974	3.157	0.005	0.022	3.185
1975 – 1979	3.157	0.003	0.022	3.183
1980 – 1984	3.157	0.003	0.022	3.183
1985 – 1989	3.157	0.003	0.022	3.182
1990 – 1994	3.157	0.003	0.022	3.183
1995 – 2002	3.157	0.003	0.023	3.182
2003 - 2007 ccr-1	3.157	0.002	0.023	3.182

[10] Since diesel is used as reference fuel in this analysis, this does not include methane slip.

Age class inland vessel engines	CO_2	CH_4 in CO_2eq (g/g fuel)	N_2O in CO_2eq (g/g fuel)	CO_2eq Total (g/g fuel)
2019 - 2021 ccr-2	3.157	0.001	0.023	3.181
2019 - 2050 Stage Va 1, 2 (< 130 kW)	3.157	0.001	0.023	3.181
2019 - 2050 Stage Va 3 (130 - 300 kW)	3.157	0.001	0.047	3.205
2019 - 2050 Stage Va 4 (> 300kW)	3.157	0.001	0.047	3.205
FuelEU Maritime	3.157	0.001	0.054	3.212

Given that there are assumptions and uncertainties in the methodologies and the limited impact on the overall TTW-emissions, we would propose to use one level for CH_4 and N_2O emissions for all inland shipping for diesel (EN590) and for HVO and Fame). As a futureproof value, using the level of a Stage V engine (over 130 kW) would be a good first step. This would therefore be a slightly lower value than the one published in FuelEU Maritime.
As an alternative, a stage specific emission factor could be used that uses the same classes as the methodology for air pollutants.

For internal combustion engines with alternative fuels (methanol, ethanol, ammonia) in inland shipping, test results for CH_4- and N_2O-emissions are limited and there are no officially published factors available. As a proxy, the emission inventory currently uses the same factors as diesel. Given the limited impact of CH_4- and N_2O-emissions, we also propose to use the diesel values for CH_4 and N_2O to the other fuel types. FuelEU Maritime legislation includes a clause where new insights on the CH_4- and N_2O-emissions of alternative energy carriers can be implemented at a later stage.

Emission factors for methane slip
A large recent investment in LNG engines was done by Shell, who ordered 40 LNG powered tanker vessels in 2021. Using the IVR database on technical data of inland vessels, several of these vessels could be identified. Most likely, these vessels are equipped with lamda=1 engines that comply with Stage V with the catalyst system.

From the project "LNG Binnenvaart", results on CH_4-emissions for three LNG powered pilot projects are available[11]. From the reports, it is unclearwhich type of engine is used on the vessels and what kind of aftertreatment was installed on the vessels. Results from the measurement campaigns show that the total CH_4-emissions are below or around the NOx Stage V limit.

For inland vessels, it seems likely that the total CH_4-emissions for LNG powered vessels comply with the Stage V limit of 6.19 g/kWh or 0.0338 gCH_4/g fuel LNG[12]. This translates into 0.844 gCO_2eq / g fuel LNG (using the GWP factor of 25 from Fuel EU Maritime).

Global Warming Potential
The Global Warming Potential values relative to CO_2 are periodically published by the IPCC in assessment reports. The values for CO_2, CH_4 and N_2O for the last three assessment reports are presented in the table below.

[11] See: LNG Binnenvaart (2020), Breakthrough LNG deployment in Inland Waterway. Transport Activity 2.3 Evaluation pilot test results
[12] Assuming 40% engine efficiency.

The fifth and sixth assessment reports make distinction between fossil and non-fossil CH_4. The difference lies in the s added radiative forcing effect from CO_2 that is formed from the oxidation of methane. Greenhouse Gas Protocol (2024) advises to use "non-fossil" GWP for mobile and stationary combustion emissions. "The GWP also does not include the methane oxidation to CO_2 as this radiative forcing is typically already accounted for through the estimation of combustion CO_2-emissions for the same emission source; therefore, it would be double counting to apply the higher fossil GWP value."[13]

Table 3.6: IPCC Global Warming Potential (GWP) values relative to CO_2 for 100 year time horizon

Source	Publication year	CO_2	CH_4 – non-fossil	CH_4 – fossil	N_2O
Fourth Assessment Report (AR4)	2007	1	25		298
Fifth Assessment Report (AR5)	2014	1	28	30	265
Sixth Assessment Report (AR6)	2021	1	27	29.8	273

Source: Greenhouse Gas Protocol (2024), IPCC Global Warming Potential Values

Different legislative documents refer to different assessment report figures:

- Directive (EU) 2018/2001 (the values used in for FuelEU Maritime) uses the values presented in the Fourth assessment report from 2007.
- Commission Implementing Regulation (EU) 2022/996 on rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria refers in Annex IX to values of the fifth assessment report from 2014. IR 2022/996 is a further elaboration of REDII.
- The AR5 values are also applied in DG CLIMA's Guidance on the MRV and ETS for shipping companies. The commission recognizes that different GWP values are applied in MRV compared to FuelEU Maritime, and that these values may be subject to change.

The impact of the difference between the values for the global warming potential is insignificant for inland shipping. The CO_2eq-values of values from different assessment reports show only (very) small differences for a Stage V vessel (see Table 3.7).

Table 3.7: Difference in TTW-emissions for a Stage Va diesel engine (> 300kW) expressed in CO_2eq using the values from the latest three assessment reports for a 100 year time horizon

GWP (100 years)	CO_2	CH_4 in CO_2eq (g/g fuel)	N_2O in CO_2eq (g/g fuel)	CO_2eq Total (g/g fuel)
Fourth Assessment Report (AR4)	3.157	0.001	0.047	3.205
Fifth Assessment Report (AR5)	3.157	0.001	0.042	3.200
Sixth Assessment Report (AR6)	3.157	0.001	0.043	3.201

It is recommended to use the values from the most recent report (sixth assessment report). However, if it is more appropriate to use values from a different assessment report in order to be aligned with other EU legislation, the results will be comparable.

[13] Greenhouse Gas Protocol (2024), IPCC Global Warming Potential Values
See also: IPCC (2022), Climate Change 2022. Mitigation of Climate Change. Annex II, table 3. The value of 27 is recommended for fossil-combustion and biogenic CH_4-emissions.

Emission factor for sailing vessels
As discussed in section 2.1, the metric used in FuelEU Maritime (CO_2eq g/ MJ) only considers the GHG intensity of the energy carrier used. Sailing vessels that are only using their diesel engine for a limited share of their activities, will have their label based on the fuel that they are using when running on diesel. The IVR database identifies 185 sailing vessels with an engine. We have no data available on the average energy consumption of this type of vessels or the share of their activities where they are using their engine.

In the proposal for the labelling system for air pollutants, a methodology is proposed for taking into account wind propulsion based on the number of sailing hours of the vessel with wind propulsion, using the following equation:

Equation 3.1: Approximation for taking into account the energy use of wind propulsion.

$$En_{sail} = \sum_j ((T_v(h) - T_j(h)) \cdot P_{j\ propulsion}(kW)$$

En_{sail} is the amount of energy provided from sails during a period of one year. The factor (Tv) represents the total navigation time in a year, and (Tj) comprises the time when the engine is running. (P_j) denotes the engine maximum power (in kW). The assumption is that when the vessel is navigating but the engine was off, the sails must have been doing the work. The energy the sails provided is equivalent to the energy the engine would have used during that time.

The document gives the following example:

- *Vessel with single engine for propulsion of 200 kW*
- *Total navigation time in a year (T_v) = 1,000 hours*
- *Total time the engine was running (T_j) = 600 hours*
    - *T_v - T_j = 1,000 hours - 600 hours = 400 hours. This means the sails provided propulsion for 400 hours.*
    - *Equivalent energy provided by the sails: En_sail = 400 hours * 200 kW = 80,000 kWh*

This calculation provides a value for En_sail of 80,000 kWh that is then plugged into the denominator of the main emission formula. By quantifying the energy from sails, it increases the total energy in the denominator, which in turn lowers the vessel's relative emissions expressed in g/kWh for pollutant emissions, since the formula below is for pollutant emissions only. This rewards the use of wind/sail energy in a practical way even when their direct power output isn't measured.

By replacing (kW) in formula 3.1 to MJ * LCV from formula 2.1 and 2.2, a similar approach can be applied for calculating a “reward factor” in the methodology for greenhouse gas emissions. This should be applied for the WtT as well as the TtW-emissions. It would involve some administrative burden for sailing vessel owners since they need to keep track of their total navigation time as well as the time they use their engine. If however navigation time is a requested parameter for the label for air pollutants, there would be no additional administrative burden.

Alternatively, just as in FuelEU Maritime, a general “reward factor” could be considered for sailing vessels (up to 0 to mark them as zero emission).

4 Conclusions

This report reviews a methodology for calculating the Tank-to-Wake emissions for greenhouse gas emissions as part of an emission labelling system by CCNR.
The methodology used in FuelEU Maritime is well transferable to inland shipping and gives good insights in the greenhouse gas emissions of the energy carrier that is being used.
The methodology considers the effect of CO_2- CH_4-and N_2O-emissions as well as methane slip. Because it considers the environmental performance of the share of individual energy carriers that are being used, it is a flexible methodology, suitable for the different solutions that are currently considered as well as differences in fuel blends or the use of hybrid systems that combine battery electric propulsion with the use of fuels.

The methodology uses CO_2eq per MJ as a metric, so the WtW emissions are only determined by the characteristics of the energy carrier used. Therefore, the effects of technical efficiency measures or logistics measures are not included. It also does not enable a comparison with other modalities (for instance to assess the impact of modal shift).

In chapter 3 an overview of the emission factors of FuelEU Maritime and some additional sources is presented.

Validation of the key figures gave the following results:

- We propose to deviate from the default values for CH_4- and N_2O-emissions to slightly lower values than FuelEU Maritime. Although the values for CH_4 and N_2O depend on the age of the engine and the presence of an SCR aftertreatment system, we propose to use one value per energy carrier. The impact of the proposed emission factors on CH_4 and N_2O in the total Greenhouse Gas-emissions is limited (1 to 2% of the total emissions in terms of CO_2eq for diesel).
- Results from emission measurements of LNG powered pilot vessels show that the methane emissions are in line with Stage V requirements. Recent newbuild LNG vessels are most likely equipped with lamda=1 engines, that comply with Stage V with the catalyst system. It is therefore proposed to use the Stage V emission limit as a base for methane slip.
- Different EU documents refer to different versions of the IPCC assessment reports for the global warming potential of CH_4 and N_2O. The impact of these differences is negligible.
- Sailing vessels that are only using their diesel engine for a limited share of their activities, will have their label based on the fuel that they are using when running on diesel. Although correct according to the methodology, this might give an undesired impression of their environmental performance. The proposed label system for air pollutants presents a reward factor based on a calculated “energy saved with a propulsion system”. Using the same approach, a reward factor can be applied for the TtW (and WtT) GHG-emissions.

Signature

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