



SEVENTH FRAMEWORK PROGRAMME



**THEME [7]**

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**SuperGreen**

**SUPPORTING EU'S FREIGHT TRANSPORT LOGISTICS ACTION  
PLAN ON GREEN CORRIDORS ISSUES**

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**CLASSIFICATION AND APPROVAL**

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## Document summary information

### Authors and contributors

Initials	Author	Organisation	Role
VR	Valerio Recagno	DAPP	Task 3.1 leader
FV	Francesca Vio		
AW	Aud Marit Wahl	MAR	Task 3.1 partner
CG	Chara Georgopoulou	DNV	Task 3.1 partner
JD	Jorge D’Almeida	PSAS	Task 3.1 partner
TA	Taneli Antikainen	FMA	Task 3.1 partner
CY	Carole Yché	SFI	Task 3.1 partner
MT	Mehmet Tursak	TCDD	Task 3.1 partner
AS	Andrea Dorothea Schoen	SCH	Task 3.1 partner
KP	Konrad Putz	NPRA	Task 3.1 partner

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All partners of the project consortium via a return email have approved the final version of this SuperGreen Deliverable.

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## 0 Executive Summary

This document is Deliverable D3.1 of the Task 3.1 “Identify Green Technologies” of SuperGreen project. It presents the results achieved during the first working session (M1-M12) of Task 3.1. The main objective of Task 3.1 is the identification of Green Technologies to be applied in the selected SuperGreen corridors to solve the bottlenecks and to make corridors greener.

On the basis of different sources (literature review; research projects (both national and at European level); personal know-how) technologies have been identified with reference to the following transport mode:

- waterborne transport (Inland waterway and maritime);
- railway transport;
- road transport;
- multimodal transport.

An extensive collection has been carried out and many innovative technologies have been identified in the following categories:

- engines and propulsion systems;
- fuels and energy sources;
- cargo handling and transfer technologies;
- cargo preparation technologies;
- heating and cooling technologies;
- innovative loading units and their treatment;
- vehicles;
- navigation technologies;
- best practices of technologies integration.

The complete list of technologies identified within Task 3.1 of the project is reported in Appendix II to this document.

The collected technologies have been further analyzed, as reported in Section 5, in order to identify the most promising in terms of greening potential, which will be applied in the Green Corridors identified in the scope of SuperGreen project. The complete results of the analysis process are reported in Appendix III to this deliverable.

## **1 Introduction**

The purpose of this document is to describe the work done in SuperGreen Work Package 3 under Task 3.1 “Identify Green Technologies”. This task is dedicated to the identification of Green Technologies suitable to a set of applications (i.e. selected Green Corridors as defined by the cargo owners, operators and other stakeholders involved in the project). Technologies have been grouped into different categories, as detailed in Section 4.1 of the document.

Green technologies have been surveyed and analysed on the basis of the experience of the project partners and on past and current research projects. Data and information have been gathered in terms of the main indicators that will be used in Task 3.3 for Benchmarking purposes, such as Energy Consumption, Green-House Gases Emissions, Life-Cycle Costs, External Costs, Social and Spatial Planning aspects, etc.

Task 3.1 started on month M2 of the project and the first session is concluded with this report.

The main activities of Task 3.1 can be summarised as follows:

1. definition of the template to collect information on technologies;
2. collection of the information on technologies;
3. definition of the matrix “Technologies vs. Indicators”;
4. analysis of technologies collected;
5. population of the matrix “Technologies vs. Indicators”.

The template to collect information on technologies has been prepared starting at month M2. The template is organized considering nine categories of technologies (engines and propulsion systems; fuels and energy sources; cargo handling and transfer technologies; cargo preparation technologies; heating and cooling technologies; innovative loading units and their treatment; vehicles; navigation technologies; best practices of technologies integration) with reference to different transport mode.

The template has been used to collect information on technologies. The collection activity has been performed from month M3 to month M9. The result of this activity consists in 197 technologies identified in respect to waterborne transport (inland waterway and maritime), railway, road and multimodal transport.

At month M9 the analysis of the technologies identified during the collection phase has been started, in order to select the most relevant technologies for the project.

Section 2 of this report describes the objectives of the Work Package 3 and of Task 3.1. In Section 3, the methodology applied for Task 3.1 is described. The Technologies Collection activity is described in Section 4 of this report and the Analysis of Technologies is reported in Section 5. Section 6 presents the conclusions reached up until this first stage of the Task 3.1. The collection of Green Technologies will be amendment in the next stages of the Task.

## **2 Objectives**

### **2.1 Work Package 3 - Sustainable Green Technologies & Innovations**

The work package 3 aims at identifying, selecting and benchmarking Green Technologies, to be applied into specific Green Corridors while solving bottlenecks to their effective operation. Technologies to be investigated include, among others, novel propulsion systems and engines, alternative fuels, cargo handling and transfer technologies, or any kind of novel concepts relevant for multimodal corridors.

It is a matter of providing a sound coverage of the most promising technologies, techniques and procedures to be applied in Green Corridors both over the different transport legs and at transshipment points, and assessing which of them would be useful to reduce the sustainability footprint of the overall logistics chain.

Transport operators, logistics providers, terminal operators, shippers and policy makers would then benefit from a comprehensive analysis of the Green Technologies, with a comparison between them on different possible applications (selected Green Corridors), on the basis of a series of what – where – how use-case scenarios.

The analysis made, including the comparison with respect to the current baseline and any other information collected in the current work package will be made available by means of a web-based data knowledge base, which will be accessible to the users and the stakeholders by means of a user-friendly wizard.

### **2.2 Task 3.1 - Identify Green Technologies**

Task 3.1 is dedicated to the identification of Green Technologies suitable to a set of applications (i.e. selected Green Corridors as defined by the cargo owners, operators and other stakeholders involved in the project). Technologies have been grouped into different categories, which are further described in the following sections of this document.

Green technologies have been surveyed and analysed on the basis of the experience of the project partners and on past and current research projects. Data and information have been gathered in terms of the main indicators that will be used in Task 3.3 for Benchmarking purposes, such as Energy Consumption, Green-House Gases Emissions, Life-Cycle Costs, External Costs, Social and Spatial Planning aspects, etc.

### 3 Methodology for Task 3.1

In order to achieve the objective of identification of the Green Technologies the following main activities have been planned:

1. definition of the template to collect information on technologies: the common template for the collection of potentially interesting innovative technologies has been prepared taking into account different groups of technologies;
2. collection of the information on technologies: the collection of the information/data on the different technologies has been done with reference to the transport modes;
3. definition of the matrix “Technologies vs. Indicators”: the spreadsheet will contain different sheets dedicated to each category of technologies considered, and will be based on selected Key Performance Indicators;
4. analysis of technologies: starting from the list of technologies previously collected, a first analysis has been conducted on their characteristics in order to identify those more promising accordingly with SuperGreen scope and objectives;
5. population of the matrix “Technologies vs. Indicators”.

The mentioned activities will be performed during the whole project lifetime in 3 different working sessions, accordingly with the following schedule:

- 1° session of work: M1-M12
- 2° session of work: M13-M24
- 3° session of work: M25-M36

A new release of the present document will be issued at the end of each session.

## 4 Technologies Collection

The technologies collection phase has been performed accordingly with the following steps:

1. Definition of technology categories;
2. Definition of relevant indicators characterizing each category;
3. Creation of a dedicated template on the basis of the previous steps;
4. Circulation of the template to concerned partners.

### 4.1 Definition of Categories

In order to facilitate the process dedicated to the identification of innovative technologies to be analysed in the scope of SuperGreen, it has been decided to consider the following categories:

- Engines and propulsion systems: innovative technologies concerning engines and propulsion systems in general, which can be applied to any kind of transport modes on Green Corridors;
- Fuels and energy sources: technologies related to energy production, including for instance solar panels, wind turbines and other renewable energy sources; furthermore innovative fuels will also be considered;
- Cargo handling and transfer technologies: technologies related to loading or unloading or cargo, transfer of loading units between different transport modes, internal handling of transport units;
- Cargo preparation technologies: this category is relevant to all the technologies used to prepare the cargo before it is transported, such as preservatives for perishable goods, packaging, sealing, etc;
- Heating and cooling technologies: this category includes innovative heating or cooling technologies embedded into transport vehicles, implemented into warehouses or used during handling and transfer operations;
- Innovative loading units and their treatment (cleaning, etc): this category includes new loading units able to reduce and optimize time requested for loading/unloading and transfer operations, as well as energy consumption and pollution emissions in case they embed heating/cooling devices. It also considers any ancillary technology needed for pre or post transport treatment of the loading unit;
- Vehicles: new vehicle concepts with the purpose of improving transport time and reducing pollution emissions shall be reported in this category;
- Navigation technologies: this category is referred to technologies facilitating vehicles navigation during transport, including tracking/tracing, and automatic vehicles identification (AVI);

- Best practices of technologies integration: this category is dedicated to the identification of best practices derived from real use cases, related to the integration of innovative technologies on transport systems, with particular reference to their impact on energy and carbon footprint reduction, and their potential for exportability on different frameworks.

## **4.2 Definition of Indicators**

The Green Technologies collected during the first phase of Task 3.1 shall be characterised by means of well defined indicators; this will allow the analysis of their relevant characteristics, representing the baseline for the process which will lead to the identification of the most promising technologies to be further explored in the scope of SuperGreen project.

The indicators which have been finally included in the technology template circulated to partners can be divided into two classes:

1. Information common to all the considered categories;
2. Specific indicators for each single category.

### **4.2.1 Common technologies information**

The identified set of common information describing each technology includes:

- Technology name;
- Short description;
- Transport mode;
- Provider/Manufacturer;
- Technology readiness level;
- Time to market;
- Needed supporting measures;
- Polluting emissions;
- Life cycle cost.

A brief description of each mentioned indicator is reported in the following paragraphs.

#### **4.2.1.1 Technology name**

It represents registered name of the technology, or the name with the technology is commonly known.

#### **4.2.1.2 Short Description**

The purpose of the short description is to provide in a few lines information concerning the most relevant characteristics, including its field of application and the foreseen potential for improvement.

4.2.1.3 Provider/Manufacturer

It indicates the company(ies) owing the patent for the considered technology; in case it is referred to a technology not completely developed and released to the market, it indicates the company(ies) or organization(s) which are involved in the research and/or technological development activities.

4.2.1.4 Technology readiness level

Technology Readiness Level (TRL) is a measure used by some United States government agencies and many of the world's major companies (and agencies) to assess the maturity of evolving technologies (materials, components, devices, etc.) prior to their incorporation into a system or subsystem.

Generally speaking, when a new technology is first invented or conceptualised, it is not suitable for immediate application. Instead, new technologies are usually subjected to experimentation, refinement, and increasingly realistic testing. Once the technology is sufficiently proven, it can be incorporated into a system/subsystem.

The readiness level is identified through a range of values from 1 to 9, as detailed in the following table:

**Table 1: Technology readiness level**

<b>Technology Readiness Levels</b> (Source: Defence Acquisition Guidebook)	
<b>Technology Readiness Level</b>	<b>Description</b>
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Example might include paper studies of a technology's basic properties.
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is "low fidelity" compared to the eventual system. Examples include integration of 'ad hoc' hardware in a laboratory.

<b>Technology Readiness Levels</b> (Source: Defence Acquisition Guidebook)	
<b>Technology Readiness Level</b>	<b>Description</b>
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include 'high fidelity' laboratory integration of components.
6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.
8. Actual system completed and 'flight qualified' through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9. Actual system 'flight proven' through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.

#### 4.2.1.5 Time to market

It represents the time (generally expressed in years) necessary for completing the development of the technology and make it available on the market. Along with the Technology Readiness Level, this parameter can be taken into account in order to estimate the real impact of the considered technology (e.g. a technology with a high potential but in an early research stage and foreseen to be implemented in more than 5 years might be less relevant than a similar technology with less potential but almost ready for the market).

#### 4.2.1.6 Needed supporting measures

The implementation of a given technology might request the realization of additional measures (e.g. modification of existing infrastructures, introduction of new working procedures, implementation of other technologies, etc). This aspect might influence the effective applicability of a considered technology into a Green Corridor (or portion of it); furthermore, it should be taken into account while calculating investment costs or the whole Life Cycle Cost.

#### 4.2.1.7 Polluting emissions

The following categories of polluting emissions have been taken into account:

- Carbon footprint (CO<sub>2</sub> emissions);
- Sulphur emissions (SO<sub>2</sub>);
- Nitrogen emissions (NO<sub>x</sub>);
- Dust and particles (PM<sub>10</sub>).

This indicator has been applied to all categories with the exception of “Cargo Preparation”, “Navigation Technologies”, and “Best Practices”, as the related technologies are not concerned by emissions of pollutants.

Polluting emissions can be assessed using different units of measure, depending on the category considered, as detailed in Section 4.2.2 below.

#### 4.2.1.8 Life cycle cost

The life cycle cost represents the total sum of all costs incurred for the usage of a technology, from its purchase to its disposal, including maintenance costs, operational costs, renewal/revamping costs, etc....

A precise calculation of Life Cycle Cost would require to take into account interest rates and taxation in the country where the technology will be applied. As is it would be difficult to define a precise estimation of the evolution of those parameters in the near future, LCC will be calculated considering non discounted costs.

This indicator has been applied to all categories with the exception of “Fuels and sources of energy” and “Best Practices”, as the life cycle cost concept can not be applied to the related technologies.

### 4.2.2 Specific technologies information

The following sections describe the specific indicators identified for each of the considered groups of technologies.

#### 4.2.2.1 Engines and propulsion systems

##### *Energy Source*

This indicator specifies if the considered propulsion system is based on the usage of electrical power or fuel, and the typology of fuel used.

*Nominal power*

Maximum power generated by the propulsion system during normal working conditions, expressed in kilo Watts (kW). This nominal value is normally made available by the technology manufacturer, accordingly with specific industrial standards.

*Efficiency*

For electrical propulsion systems, the efficiency is represented by the ratio between the nominal power generated and the power consumed as input. Concerning thermal propulsion systems, the parameter is expressed by the ratio between the amount of energy generated, and the total energy contained in the fuel consumed.

The efficiency parameter is expressed as percentage.

*Polluting emissions*

Polluting emissions of engines and propulsion systems are calculated as emissions after the exhaust pipe, i.e. including eventual catalytic converters and other pollution abatement processes.

The mentioned indicators are referred to the energy produced by the propulsion system, and have therefore to be expressed in grams per kiloWatt-hours (g/kWh).

*Mean Time Between Failures (MTBF)*

The MTBF represents the predicted elapsed time between two consecutive failures in operation of the propulsion system, providing an indication of the reliability of the system. It is expressed in hours, and it is normally made available by the manufacturer, accordingly with specific industrial standards.

*Life Cycle Cost*

In order to take into account the different size (power) of the considered propulsion system, this indicator is calculated by dividing the total cost calculated by the nominal power expressed by the system; the indicator is therefore expressed in euros per kW (€/kW).

4.2.2.2 Fuels and sources of energy

*Energy source produced*

It indicates the category of energy made available by the considered source (e.g. electrical, chemical...).

*Renewable*

It indicates whether the considered energy source is renewable or not.

### *Life Cycle Cost*

In order to take into account the different size (power) generated by the considered system, this indicator is calculated by dividing the total cost calculated by the nominal power generated; the indicator is therefore expressed in euros per kW (€/kW).

### *Polluting emissions*

Emissions of primary energy sources, if not directly known, can be derived from tables made publicly available by the European Commission and by Member States, which indicate the average emissions by country or at EU level.

The mentioned indicators are referred to the energy produced by the system, and have therefore to be expressed in grams per kilowatt-hours (g/kWh).

#### 4.2.2.3 Cargo handling and transfer technologies

### *Average loading cycle time*

This parameter represents the maximum number of moves which can be performed by the handling or transfer system in one hour, and is therefore expressed in moves/hour.

### *Cost per move*

This parameter represents the total cost related to a single handling/transfer procedure, divided by the number of necessary moves, and is therefore expressed in €/moves.

### *Mean Time Between Failures (MTBF)*

The MTBF represents the predicted elapsed time between two consecutive failures in operation of the propulsion system, providing an indication of the reliability of the system. It is expressed in hours, and it is normally made available by the manufacturer, accordingly with specific industrial standards.

### *Power supply*

It indicates the energy source (e.g. electrical, fuel...) used by the system.

### *Energy consumption*

This parameter represents the amount of energy consumed per each tonne moved by the system. It is measured in kW/ton.

### *Polluting emissions*

In case the considered technology makes use of electrical power, the emissions are calculated referring to the primary energy source. Average values of polluting emissions produced by primary sources can be obtained from tables made publicly by the European Commission and Member States.

The mentioned indicators are referred to the operations performed by the system, and have therefore to be expressed in grams per tonne moved (g/ton).

*Life cycle cost*

In order to take into account the different operational capacities of the considered systems, this indicator is calculated by dividing the total cost calculated by the total volume moved by the system; the indicator is therefore expressed in euros per tonne (€/ton).

4.2.2.4 Cargo Preparation technologies

*Type of packaging allowed*

It indicates all the typologies of packaging (e.g. pallets, boxes....) which can be handled by the considered technology.

*Possibility to recycle*

This parameter indicates whether the considered packaging type can be recycled or reused for several transport. In case the related technology is able to handle different packaging typologies, this indication will be repeated for each single typology.

*Special procedures applied*

This indicator reports particular handling procedures allowed by the considered technology, e.g. for treating goods implying risk of explosion, of dangerous gases emissions, release of polluting substances, etc....

*Life cycle cost*

Life cycle cost for Cargo Preparation technologies is expressed in Euros.

4.2.2.5 Heating and cooling technologies

*Size*

This parameter expresses the maximum energy exchange capacity of the system, expressed in kilo-Watt (kW). It is a nominal value made available by the technology manufacturer accordingly with specific industrial standards.

*Efficiency*

Efficiency is expressed by the ratio between the heating or cooling power produced and the power absorbed, and it is represented as percentage.

*Power Supply*

It indicates the energy source (e.g. electrical, fuel...) used by the system.

*Polluting emissions*

In case the considered technology makes use of electrical power, the emissions shall be calculated referring to the primary energy source. Average values of polluting emissions produced by primary sources can be obtained from tables made publicly by the European Commission and Member States.

The mentioned indicators are referred to the heating or cooling capacity of the considered technology, and are therefore expressed in grams per kilo Watt (g/kW).

*Life cycle cost*

Life cycle cost for Heating and Cooling technologies is expressed in Euros.

4.2.2.6 Innovative loading units and their treatment

*Transport modes served*

List of all transport modes in which the considered loading unit can be used.

*Dimensions*

Indication of the spatial dimensions (expressed in millimetres) of the loading unit, as indicated by the technology manufacturer. Such information is reported in the following format:

*Width x Height x Length*

*Weight*

Maximum weight which can be carried by the unit, expressed in tonnes (ton), as indicated by the technology manufacturer.

*Space productivity*

Amount of back-up land occupied per transported tonne, expressed in square meters (m<sup>2</sup>).

*Heating/cooling unit*

It indicates whether the considered loading unit embeds a heating or cooling system.

*Power supply*

Source of power supply used for heating or cooling system (if present); the indication “Y” or “N” has to be provided.

*Energy consumption*

Energy consumed by the heating or cooling system (if present), by tonne of goods transported; it is expressed in kW/ton.

*Polluting emissions*

In case the considered technology makes use of electrical power, the emissions are calculated referring to the primary energy source. Average values of polluting emissions produced by primary sources can be obtained from tables made publicly by the European Commission and Member States.

The mentioned indicators are referred to the total amount of goods transported by the loading unit, and are therefore expressed in grams per tonne moved (g/ton).

*Life cycle cost*

Life cycle cost for loading units is expressed in Euros.

4.2.2.7 Vehicles

*Mass*

This indicator represents the maximum allowable mass of the full loaded vehicle, expressed in tonnes (ton), as indicated by the technology manufacturer.

*Capacity*

This indicator represents the maximum loading capacity of the vehicle, expressed in cubic meters (m<sup>3</sup>), as indicated by the technology manufacturer.

*Propulsion*

Typology of engine used by the considered vehicle (e.g. electrical, diesel...).

*Loading units transported*

List of all loading units which can be transported by the considered vehicle.

*Energy consumption*

Energy consumed by the considered vehicle per tonne of transported goods, expressed in kilowatt-hour per tonne (kWh/t).

*Polluting emissions*

Polluting emissions of vehicles systems are calculated as emissions after the exhaust pipe, i.e. including eventual catalytic converters and other pollution abatement processes.

The mentioned indicators are referred to the path travelled by the vehicle, and are therefore expressed in grams per kilometre (g/Km).

*Life cycle cost*

In order to take into account the different capacities of the considered vehicles, this indicator shall be calculated by dividing the total cost calculated by the total weight of goods transported; the indicator is therefore expressed in euros per tonne (€/ton).

4.2.2.8 Navigation technologies

*Coverage*

This parameter indicates the maximum distance between the transmitting source and the receiver which allows a clear and complete reception of the signal. It is expressed in Kilometres (Km).

*Tracking/tracing allowed*

It indicates if the considered technology allows the tracking and tracing of a vehicle.

*Automatic identification*

It indicates if the considered technology allows the automatic vehicle identification (AVI).

*TLC media*

It indicates the communication media used by the technology to trace the position and communicating information from and to the vehicle.

*Life cycle cost*

Life cycle cost for Navigation technologies is expressed in Euros.

4.2.2.9 Best practices

*Geographical coverage*

It provides information concerning the area covered by the considered case, defining if it is relevant at local/regional level, national level or European level.

*Transport modes involved*

List of the transport modes involved by the considered use case.

*Technologies involved*

List of innovative technologies involved by the considered use case, with reference to the technologies included in each of the previously defined category.

*Energy consumption reduction*

It is necessary to provide at least an estimation of the energy consumption reduction allowed by the considered practice, taking into account all typologies of energy sources involved. It is expressed as percentage.

*Carbon footprint reduction*

This indicator represents an estimation of the carbon footprint (CO<sub>2</sub> emissions) reduction allowed by the considered practice, taking into account all sources of pollution emissions involved. It is expressed as percentage.

*Potential for transferability*

This parameter provides an estimation of the possibility to replicate the procedures applied in the considered best practice into other real use cases, in order to obtain similar advantages in terms of energy consumption and carbon footprint reduction. It is assessed by means of the following set of values:

Not possible: none of the procedures applied in the considered use case can be replicated in a different situation.

- Low: it indicates that it is possible to replicate only a minor part of the procedures applied in the use case, or that the replicable procedures are the less

significant (i.e. having a minor impact on energy and/or carbon footprint reduction);

- Medium: it indicates that most of the applied procedures can be replicated in a different case, but at least one of the most relevant (i.e. having a major impact on energy and/or carbon footprint reduction) can not be transferred;
- High: it indicates that all the considered procedures, or at least all the most relevant ones, can be replicated in an alternative case;

The mentioned values can be selected by means of a drop-down list included in the template.

### 4.3 Definition of the Template

The template has been realized on the basis of a Microsoft© Excel workbook, which includes a worksheet for each of the nine technology categories mentioned in Section 4.1. Each sheet has been formatted in order to contain the relevant indicators mentioned in Section 4.2.

Technologies reported into the template have been given an identification code, which is formed by two letters providing an indication of the category to which the technology belongs to, and a two-digit progressive number. The complete list of identification codes associated to each category is reported below:

- Engines and Propulsion Systems: EN;
- Fuels and Sources of Energy: FU;
- Cargo Handling and Transfer: HT;
- Cargo Preparation: CP;
- Heating and Cooling: HC;
- Innovative Loading Units and their Treatment: LU;
- Vehicles: VE;
- Navigation Technologies: NA;
- Best Practices: BP.

Where applicable, the Template provides *drop-down* lists, to support users in selecting the appropriate values referred to specific indicators.

#### 4.3.1 User manual

In order to support project partners in reporting promising Green Technologies, a user manual describing the usage of the template has been prepared (see Appendix 1).

The purpose of the manual is to provide indications for the usage of the template, in order to ensure an appropriate balance between the information requested and the coverage of potentially interesting technologies. It has to be taken into account that part of the

mentioned indicators needs to be filled in by means of hard quantitative data, which precise value might not be known to the user; therefore, it is necessary to ensure that also in this case users are able to report promising technologies, with an adequate level of completion of related indicators. With this purpose, the following recommendations are reported in the manual:

- where possible, best estimation of the quantitative value has to be provided, accordingly with user’s experience. In this case, it is requested to include a comment in the Excel cell containing the value, to indicate that the provided value is estimated;
- in case the first option is not applicable, at least a qualitative estimation of the indicator shall be provided, based on a scale from 1 to 5. The meaning of the values in such scale will depend on the characteristics of the considered indicator; as general rule, it is suggested to make reference to the a well-known technology already present on the market, indicating with 1 that the performance of the innovative technology, related to the considered indicator, is much worse than the reference case. Also in this case a comment to the relevant Excel cell shall be added, to provide a brief description of the numeric value reported.

In case none of the proposed approaches can be applied to a specific indicator, it is suggested to include anyway the relevant technology in the template, leaving the corresponding cell blank. Users are requested to report all promising technologies they consider relevant, although it is not possible to find or estimate some of the requested indicators.

#### **4.4 Sources**

The green technologies have been collected and assessed by partners on the basis of different sources:

- Literature review;
- Research projects (both national and at European level);
- Personal know-how.

##### **4.4.1 Literature review**

Documental sources have been used both for identifying potential technologies indicated in the collections, and to complete the information concerning indicators for technologies derived from other sources.

The complete list of all the documental sources used in reported in Table 2 below; the information collected from the mentioned documents has supported mainly the collection of technologies related to road and inland waterway transport modes.

**Table 2: List of documental sources**

<b>Author</b>	<b>Document Title</b>
Adamkiewicz, A., Kolwzan, K	“Marine Power Plant Pollutant Emissions”

Author	Document Title
Blomberg, J	Power generation concepts for generic FPSO vessels
Concawe/Eucar/JRC	Well-to-Wheels analysis of future automotive fuels and power trains in the European context Tank-to-Wheels report version 3, October 2008
Corbett, J., Koehler, H	Updated emissions from ocean shipping
European Commission	Directive 2009/28/EC on the promotion of the use of energy from renewable resources
European Commission	Environmental Impact of Inland Navigation – Final Report
Econ	Potensialstudie for flytende biobrensel (Study of the potential for liquid bio fuels)
Häkkinen, P	Laivan koneistot (Ship Machinery Systems)
Hyytiäinen, M	Matkustajaaluksen propulsiokoneiston suunnittelu (Design of passenger ship's propulsion machinery)
Kettunen, A	Voimalaitoksen ajotavan vaikutus DATaluksen elinkaaritalouteen ja turvallisuuteen avovedessä (The effect of power plant usage on life cycle economy and safety of DAT vessel in open sea)
Lehtinen, J	Risk Analysis for the Operation of Dual Fuel Electric Machinery in LNG Carrier
Russell Hensley, Stefan Knupfer, and Dickon Pinner	Electrifying cars: How three industries will evolve
Man B&W	Exhaust Gas Emission Control Today and Tomorrow Application on MAN B&W Two stroke Marine Diesel Engines
U.S. Energy Information Administration (EIA)	The Impact of Increased Use of Hydrogen on Petroleum Consumption and Carbon Dioxide Emissions
Eurelectric	Eurelectric environment and sustainable development report 2007-2008
Helland, Å.	Well-to-wheel CO <sub>2</sub> analysis of electric and ICE vehicles: are global CO <sub>2</sub> emission reductions possible?, Int. J. Global Warming
IMO	Guidance on the application of AIS binary messages
IMO	Guidance on the use of AIS binary messages
International Energy Agency (IEA)	Energy Technology Essentials 5. Hydrogen production and distribution

Author	Document Title
International Energy Agency (IEA)	Advanced Motor Fuels (IEA-AMF)
IFEU Heidelberg Öko-Institut IVE / RMCON	EcoTransIT World. Ecological Transport Information Tool for Worldwide Transports. Methodology and Data. 2nd Draft Report
Kytö, M. et.al	Effect of heavy fuel oil quality on particulate emissions of a medium speed diesel engine
Kytö, M., Erkkilä, K., Nylund	Heavy-duty vehicles: Safety, environmental impacts, and new technology “RASTU”
Murtonen, T. Nylund	Fuel effects on emissions from non-road engines
P.A. Ioannou, E. B. Kosmatopoulos, H. Jula, A. Collinge, C.-I. Liu, A. Asef-Vaziri	Handling Technologies
Pauli, G.	The greening of inland navigation – The case of Rhine navigation
PLANCO Consulting GmbH/BFG	Economical and Ecological Comparison of Transport Modes: Road, Railways, Inland Waterways
Porthin, M., Zetterberg, R. and Sonninen, S.	AIS Binary Messages – Developments in the Baltic and progress in IMO
Simola, N.	Risteilyaluksen propulsiokoneiston valinta (Propulsion machinery evaluation for cruise ship)
Sipilä, T	Single Screw Low Speed Machinery Alternatives for Modern Ice Class Aframax Tankers
Tikkanen, O	LNG:n käyttö polttoaineena matkustajaluksissa (Use of LNG as a fuel in passenger vessels)
Various Authors	Technical support for European action to reducing Greenhouse Gas Emissions from international maritime transport
Wayne, W.S., Hodgson, M.	The Options and Evaluation of Propulsion Systems for the Next Generation of LNG Carriers
Winners, H., Fridell, E.	Particle emissions from ships: dependence on fuel type

#### 4.4.2 Research Projects

The activities performed and the results achieved in the scope of the following projects, co-funded by the European Commission within the 6<sup>th</sup> and 7<sup>th</sup> Framework Programme, have been analysed:

- Railenergy - Innovative Integrated Energy Efficiency Solutions for Railway Rolling Stock, Rail Infrastructure and Train Operation;
- GHG TransporD – Reducing greenhouse gases emissions in transport;
- Cleanest Ship;
- CREATING;
- PLATINA – Platform for the implementation of NAIADES;
- PROMIT – Promoting Innovative Intermodal Freight Transport.

#### 4.4.2.1 Railenergy

The overall objective of Railenergy is to cut the energy consumption within an optimised railway system thus contributing to a reduction in the life cycle costs of railway operation and of CO<sub>2</sub> emissions per seat/kilometre or tonne/kilometre. The project target is to achieve a 6% reduction in the specific energy consumption of the rail system by 2020, assuming that traffic volumes double in comparison with current figures.

To reach its goal, the project analyzed energy saving potential of a selected number of technologies, by considering the following domains:

- Innovation in Energy Needs and Key Performance Indicators;
- Innovation in Energy Efficient Management;
- Innovation in Trackside;
- Innovation in On-board Components;
- Innovation in On-Board Traction;
- Innovation in On Board Electrical Equipment Topologies.

The publicly available results of Railenergy project allowed to identify greening technologies related to the Railway transport mode, with particular reference to Vehicles category.

#### 4.4.2.2 GHG TransporD

The project aims at developing an integrated European strategy that links R&D efforts with other policies and measures to achieve substantial GHG emission reductions in transport that are in line with the overall targets of the EU. As part of this strategy, the project will propose GHG reduction targets for transport as a whole as well as for each transport mode for 2020 and 2050.

The project will backcast from existing GHG emission reduction targets set at the level of the overall economy to the contribution required from the transport sector. As a starting point, GHG-TransPoRD will describe the European innovation system of the transport sector considering the global context as well. At the same time it will analyse the GHG emission mitigation potentials offered by a broad portfolio of transport technologies and measures. The desk research will be complemented by a model-based comparison of

ambitious technology pathways with present policies and measures. This will also reveal areas with a largely under-exploited mitigation potential. GHG-TransPoRD will then further assess the R&D and other measures that can mobilise additional reduction potentials so as to achieve GHG emission reductions in line with the overall EU commitments until 2050.

The results of GHG TransporD project allowed to identify technologies related to Maritime, Railway and Road transport modes, covering the categories Fuels and Sources of Energy, Engines and propulsion systems, Vehicles, Loading Units and Navigation technologies.

#### 4.4.2.3 CREATING and Cleanest Ship

CREATING was a research project within the 6<sup>th</sup> Framework Programme of the European Commission, comprising 23 partners from 9 European countries. Its objective was to stimulate inland waterborne transport in an economical way and improve its competitive position versus road transport. An important part of maritime cargo is transported to the hinterland via inland waterways. Continental cargo, however, is still mainly transported by road. The ever increasing transport flows, road congestion and air pollution require the exploration of other transport solutions.

Cleanest Ship represents a demonstration project for the results achieved in the scope of CREATING. The project is carried out on the motor tank vessel “Victoria”, owned by BP and managed by Verenigde Tankrederij (VT). The vessel, now on long term charter to BP Marine Lubricants, is operating in the Port of Rotterdam and Antwerp areas. Lasting one year till the end of 2008, the demonstration was launched in November 2007. Fuel consumption, energy output of the main engine in kWh, distance sailed in km and NOX emissions are directly measured; CO<sub>2</sub> and SOX emissions are calculated from fuel consumption and energy output in kWh, whereas particulate matter emissions are evaluated using the emission reduction potential estimated on the test stand. The latter is done because accurate measurement of particulate matter emissions at service conditions is difficult.

The information gathered from those two projects have been used for identifying technologies related to Inland Waterway transport mode, with particular reference to the calculation of polluting emissions.

#### 4.4.2.4 PLATINA

The NAIADES action plan is an initiative of the European Commission to enhance the use of inland navigation as part of intermodal freight solutions, in order to create a sustainable, competitive and environmentally friendly European wide transport network.

This objective was embraced by the inland navigation sector, which, together with the Commission have created PLATINA, an FP7 project consisting of 22 partners from nine different countries, in order to accelerate the achievement of the NAIADES aims. This multi-disciplinary knowledge network will allow PLATINA to create the momentum necessary to achieve the NAIADES objectives.

One of the most relevant objectives of the project is represented by the development of an Innovation Database, based on the “Wiki” approach, with the objective of collecting and

making publicly available information on innovating technologies related to Inland Waterway transport mode. Though being still in a preliminary development phase, the PLATINA database represented a very useful source of information, in particular for completing indicators information concerning technologies collected from other sources.

#### 4.4.2.5 PROMIT

PROMIT is a European Coordination Action (CA) for intermodal freight transport initiating, facilitating and supporting the coordination and cooperation of national and European initiatives, projects, promotion centres, technology providers, research institutes and user groups related to this most complex transport form. The strategic PROMIT objective is to contribute to a faster improvement and implementation of intermodal transport technologies and procedures and to help promoting intermodal logistics and mode shift by creating awareness on innovations, best practices and intermodal transport opportunities for potential users as well as for politicians and for the research community. PROMIT allowed to raise synergies in the European intermodal community and contribute to policy initiatives on national and European level supporting the shift of transports from road to Intermodal transport modes.

The final outcomes of PROMIT project allowed to identify technologies related to Innovative Units, Heating and Cooling technologies and Cargo Handling and Transfer categories.

#### 4.5 Collection Process and Results

During the first session of work in Task 3.1 (M1-M12) three rounds dedicated to the collection of greening technologies have been organized.

During the first round, the template for the collection of Green Technologies has been distributed to partners involved in Task 3.1, along with the dedicated user manual. In order to ensure a good coverage of all transport modes, including multimodality, partners have been requested to provide inputs on technologies referred to the domain in which they have major experience.

The first round led to the identification of a preliminary list including around 108 promising technologies proposed by partners. An analysis of the list of technologies has been conducted, in order to assess the quality of coverage considering the selected categories (see Section 4.1), and the completeness of the information reported for the requested indicators (see Section 4.2). Partners involved in the collection have been further contacted, with the purpose of completing the missing indicators and proposing additional technologies in order to have a more complete collection.

The list has been re-circulated to all concerned partners, with the purpose of completing and expanding the coverage achieved in terms of number of technologies collected and completeness of indicators reported; the additional information gathered during this second round of collection allowed to expand the number of collected technologies up to 135.

After the second round, it has been decided to extend the collection process by involving also SuperGreen beneficiaries not directly involved in the activities of Task 3.1; such extension was necessary in order to ensure that the relevant knowledge in terms of greening technologies, owned by SuperGreen consortium in general, was fully taken into account within the list of technologies collected within the scope of the Task.

Moreover the collection has been updated with two important issues: the addition of a new modality for waterborne transport and the indication of the transport mode associated to the technology. In fact, following a suggestion received during the PCM meeting held in Helsinki, the transport mode “Inland waterway” has been added to the list of available transport mode. Moreover the collection has been upgraded by adding the general indicator “Transport Mode” associated to each single technology in the collection.

Following the addition of the indicator “Transport mode”, the total number of technologies collected per category increased, as some technologies have been considered applicable to two or more different transport modes.

The third round of technologies collection, involving all the Beneficiaries participating to SuperGreen, ensured an improvement of the technologies list in terms of transport mode coverage, as well as concerning the completeness of the information provided to detail the most relevant characteristics of the proposed technologies.

Table 3 below provides the summary of the results achieved after the conclusion of the third round of collection, indicating the number of technologies collected detailed per category, considering each different transport mode.

**Table 3: List of collected technologies**

Transport mode	Engines and Propulsion Systems	Fuels and Sources of energy	Cargo handling and Transfer	Cargo Preparation	Heating and Cooling	Innovative units and Treatment	Vehicles	Navigation technologies	Best practices	TOTAL
Inland Waterways	2	10	3	0	0	0	4	1	0	20
Maritime	10	18	26	0	0	2	3	14	2	75
Railway	5	12	3	0	0	1	9	3	7	40
Road	5	18	0	0	1	1	13	2	1	41
Multimodal	0	2	14	0	2	3	0	0	0	21
<b>TOTAL</b>	<b>22</b>	<b>60</b>	<b>46</b>	<b>0</b>	<b>3</b>	<b>7</b>	<b>29</b>	<b>20</b>	<b>10</b>	<b>197</b>

Table 4 provides a synthesis of all the technologies collected in each considered category, regardless the transport mode. It has to be underlined that the totals identified within the two tables do not match, as a single technology could have been considered applicable to more than a single transport mode.

**Table 4: Synthesis of technologies**

	Engines and Propulsion Systems	Fuels and Sources of energy	Cargo handling and Transfer	Cargo Preparation	Heating and Cooling	Innovative units and Treatment	Vehicles	Navigation technologies	Best practices	TOTAL
<b>Technologies</b>	21	24	32	0	3	5	28	16	9	138

The complete list of technologies identified by SuperGreen partners within Task 3.1 of the project is reported in Appendix II to this document.

#### 4.6 Next Steps for Technologies Collection

The additional working sessions planned during the second and third year of SuperGreen project will have the purpose of guaranteeing further expansion and refinement of the technology list, by including future technologies which may be conceived or introduced into the market in the near future, and implementing suggestions and recommendations which will be eventually proposed during the above mentioned phases in Task 3.1 and 3.2.

In particular during the next year of the project, the collection will be updated with technologies concerning Cargo Transfer category and Inland Waterway transport mode, already identified by Task participants. Furthermore, the next working sessions will allow to expand and complete, where necessary, the information concerning indicators for technologies already collected.

## 5 Analysis of Technologies

Subsequent to the collection of all data on the different types of technologies by the partners described above, an analysis and selection of the most relevant technologies for the project was carried out. In addition, coordination and population of the matrixes presented as different spreadsheets were performed.

The analysis of technologies started from the list of technologies previously collected. This first analysis has been conducted in order to identify technologies that are promising accordingly with SuperGreen scope and objectives. The analysis divided the technologies into 6 different categories:

**A – Very important.** These technologies are believed to have a large impact on the greening potential of cargo transportation in a transport corridor. The technologies are mature and are considered to influence the greening potential in near future.

**B – Important.** These technologies are believed to have an impact on the greening potential of cargo transportation in a transport corridor. The technologies are mostly mature and are considered to influence future greening.

**C – Low importance.** These technologies are believed to have less impact on the greening potential of cargo transportation in a corridor or are less mature than those found in category A or B but are still considered valuable to the project.

**D – Merged.** These technologies are regarded special cases of the technologies that are placed in the A, B or C category, and are considered as valuable information to the project in this phase.

**X – Need information.** More information is necessary to evaluate these technologies. The analysis will be performed next year if more relevant information is made available.

**Z – Not relevant.** These technologies are regarded as not relevant for SuperGreen project and are not included in the final selection.

The results achieved by applying the methodology above described are detailed in Table 5 below.

**Table 5: Impact levels for identified technologies**

Partner	Engines and Propulsion Systems	Fuels and Sources of energy	Cargo handling and Transfer	Cargo Preparation	Heating and Cooling	Innovative units and Treatment	Vehicles	Navigation technologies	Best practices	TOTAL
A – Very important	5	4	4	0	0	0	4	2	2	21
B – Important	1	3	2	0	1	0	2	7	3	19
C – Low importance	1	5	2	0	0	0	0	2	0	10
D – Merged	4	8	4	0	0	0	5	2	1	24
X – Need info	3	0	8	0	1	4	6	0	1	23
Z – Not relevant	7	4	12	0	1	1	9	3	2	39
-	0	0	0	0	0	0	2	0	0	2
<b>TOTAL</b>	<b>21</b>	<b>24</b>	<b>32</b>	<b>0</b>	<b>3</b>	<b>5</b>	<b>28</b>	<b>16</b>	<b>9</b>	<b>138</b>

The tables below show the technologies believed to have the largest potential for the SuperGreen project and show technologies that were placed in either A, B or C category at

this stage of the project. The technologies belonging to the D category are not explicitly showed but are included in the technologies described as either A, B or C. The X & Z categories are not referred to in the tables below.

The tables present the most relevant technologies grouped into the main areas described in 4.1 with two exceptions. The group “Cargo preparation” did not receive any suggestion on technologies with a greening potential for this first analysis and are thus not included in the overview below. The group “Innovative units and treatment” consisted of technologies that needs more information in order to do a valid analysis and is therefore not presented in this report.

**Table 6: Most relevant technologies for "Engines and propulsion systems"**

ID	Category	Technology Name	Transport Mode	Description
EN02	A	Directly driven propeller	Maritime	Slow speed engine directly connected to propeller shaft, 20 year life time, running 5500 h/a.
EN03	A	Mechanically connected propeller	Maritime	Medium speed engine connected by a reduction gear to the propeller shaft, 20 year life time, running 5500 h/a
EN07	A	Diesel-mechanic propulsion with high speed engine	Maritime	High speed engine connected by a reduction gear to the propeller shaft, 20 year life time, running 5500 h/a.
EN16	A	Full/parallel hybrid	Road	Electrical support of engine power by saving and re-use of break-energy; combination of 6 cylinder engine plus electrical engine
EN21	A	Nauticlean S System	Inland Waterways	It consists of two reactors with a selective-catalytic reduction (SCR)
EN06	B	Mechanical azimuthing thrusters	Maritime	The engine runs generator. An electric motor is located inside the ship where it runs propeller shaft. 20 year life time, running 5500 h/a.
EN 15	C	PG Engine Diesel Locomotives	Railway	A propulsion system for a four-axle, standard-gauge, centre-cab locomotive using a liquefied petroleum gas (LPG) engine instead of conventional diesel

**Table 7: Most relevant technologies for "Fuels and sources of energy"**

<b>ID</b>	<b>Category</b>	<b>Technology name</b>	<b>Transport Mode</b>	<b>Description</b>
FU02	A	Ethanol and bio-diesel	Maritime Road	Investigation about using alternative fuels.
FU03	A	CGN ( compressed natural gas)	Multimodal	Cleaner fuel for yard handling equipment (Prime movers)
FU08	A	LNG	Multimodal	Liquefied natural gas
FU18	A	Biogas	Multimodal	Biogas is mainly produced from bio-waste, agricultural residues and residues from sewage treatment plants
FU05	B	AMP	Maritime	Alternative Maritime Power is a shore-side power source, that transforms the shore-side power voltage to match the vessel power system
FU06	B	Wind energy	Maritime Inland Waterways	Wind turbines which will generate clean energy to power 14 Container Terminal Quay cranes, reefer containers, repair workshops and other power consumption needs
FU13	B	Electricity	Road Railway	Electricity is today produced from fossil fuels, nuclear energy and renewable energy sources
FU01	C	Ultra-low sulphur diesel	Maritime Inland Waterways Railway Road	Switch from industrial diesel oil (IDO 0,5% sulphur) to ultra-low sulphur diesel (ULSD 0,005%) for PMs and RTGs.
FU04	C	Solar power network	Multimodal	A 6.600 square-meter solar panel able to generate clean energy which will reduce reliance on oil and cut electricity-related greenhouse gas emissions
FU07	C	HFO	Maritime Railway Road	Heavy fuel oil
FU14	C	Hydrogen	Road Inland Waterways	Hydrogen is today mainly produced from steam reforming of fossil gas - some production from electricity and renewable sources
FU23	C	Nuclear Power	Inland Waterways Maritime	Nuclear Power

**Table 8: Most relevant technologies for "Cargo handling and transfer"**

ID	Category	Technology Name	Transport Mode	Description
HT01	A	Conversion of RTGs from diesel to electric power	Maritime Multimodal	RTGs fitted with electrical components in place of traditional hydraulic parts. Conversion will eliminate black emissions and lower noise levels of engines
HT03	A	Hybrid hydraulic drive Terminal tractors	Maritime	Storing braking energy into hydraulic system for acceleration and system
HT07	A	Low emission engines	Multimodal	Euro III/ IV compliant engines burn diesel more efficiently, reducing emission of CO2 and providing up to 5% reduction on fuel consumption
HT10	A	Metrocargo	Railway	Containers cargo handling in overhead electrified railways with a horizontal movement system from an automated platform to train wagons.
HT06	B	MP-RTGs	Multimodal	Mains-powered RTGs transfer the power generation from the engine of the yard crane to a far more efficient power station. Power station can be up to 40% more efficient than equipment engine.
HT11	B	Cargo Cassette and Translifter	Maritime	Wheel less cargo cassette is a loading platform which is used together with a translifter in a cassette system. Translifter is a steerable lifting trailer which together with cassettes replaces roll trailers in Ro-Ro and StoRo handling.
HT20	C	BEX	Inland Waterways	Barge Express is an integrated concept for transport for automated handling of large scale barge container at terminals
HT24	C	FCT	Maritime	The Floating Container Terminal collects and distributes containers originating from small calls, and bundles these currents with containers

**Table 9: Most relevant technologies for "Heating and cooling"**

ID	Category	Technology Name	Transport Mode	Description
HC02	B	Intelligent unit	Multimodal	Refrigerated boxcars will be built with energy efficient cooling systems, GPS tracking, fresh air exchange and the ability to remote monitoring the systems. RFID (Radio Frequency Identification) for tracking services are the main support.

**Table 10: Most relevant technologies for "Vehicles"**

ID	Category	Technology Name	Transport Mode	Description
VE02	A	NS 999 Electric Locomotive	Railway	NS 999 is an entirely electric locomotive that uses a lead-acid energy storage system without the use of a diesel engine and with zero exhaust emissions.
VE03	A	M2eHybrid Freightliner	Road	Support engine plus auxiliary drive to operate an elevating platform of the truck; combination of 6 cylinder engine plus electrical engine
VE09	A	Battery-electric vehicles	Road	Battery-electric vehicles
VE10	A	Euro VI vehicles	Road	Euro VI is compulsory for new trucks from 2013, replacing Euro V
VE01	B	Hybrid Locomotive	Railway	Hybrid Locomotive was developed with the goal of creating the cleanest, most fuel-efficient high-horsepower diesel locomotive ever built.
VE25	B	Braking energy recovery	Railway	Reversible DC Substation for recovering of dynamic braking energy and restitution to national grid

**Table 11: Most relevant technologies for "Navigation technologies"**

ID	Category	Technology Name	Transport Mode	Description
NA02	A	Automatic Identification System (AIS)	Maritime	Ship-to-ship, ship-to-shore and shore-to-ship system. Main purpose is collision avoidance, ship tracking and tracing. Works on VHF (Very high frequency, 30–300 MHz) radio frequency.
NA15	A	WiMax	Maritime RailwayRoad	Worldwide Interoperability for Microwave Access. Long range, high bandwidth wireless Internet
NA01	B	Train Control System	Railway	Train control and tracking system based on a special GPRS method.
NA05	B	ECDIS	Maritime	An Electronic Chart Display and Information System (ECDIS) is a computer-based navigation information system that can be used as an alternative to paper nautical charts. Integrates position information from GPS and other navigational sensors (radar, AIS). It may also give Sailing Directions and fathometer.
NA09	B	Radarsat 1 and 2	Maritime	Canadian earth observation satellite that monitors environmental changes and the planet's natural resources. Equipped with a synthetic aperture radar (SAR), it acquires images of the Earth day or night, in all weather and through cloud cover, smoke and haze. Can enhance marine surveillance, ice monitoring, disaster management, environmental monitoring, resource management and mapping
NA12	B	GEO satellites	Maritime	Geosynchronous Satellite whose orbital track on the Earth repeats regularly over points on the Earth over time. If such a satellite's orbit lies over the equator and the orbit is circular, it is called a geostationary satellite.

ID	Category	Technology Name	Transport Mode	Description
NA13	B	LEO satellites	Maritime	A low Earth orbit (LEO) is generally defined as an orbit within the locus extending from the Earth's surface up to an altitude of 2,000 km. Given the rapid orbital decay of objects below approximately 200 km, the commonly accepted definition for LEO is between 160 - 2,000 km (100 - 1,240 miles) above the Earth's surface.
NA14	B	Inmarsat	Maritime	British satellite telecommunications company, offering global, mobile services. It provides telephony and data services to users worldwide, via portable or mobile terminals which communicate to ground stations through eleven geosynchronous telecommunications satellites.
NA16	B	ATM	Inland Waterways	The advising Tempomaat (ATM) is a computer program advising the skipper on the most economical combination of route and speed, enabling the vessel to arrive on time with a most efficient use of fuel leading to a reduction of fuel consumption and emissions.
NA07	C	Global Navigation Satellite Systems or GNSS	Maritime Railway Road	Global Navigation Satellite Systems (GNSS) is the standard generic term for satellite navigation systems ("sat nav") that provide autonomous geo-spatial positioning with global coverage. GNSS allows small electronic receivers to determine their location (longitude, latitude, and altitude) to within a few metres using time signals transmitted along a line-of-sight by radio from satellites.
NA11	C	LRIT	Maritime	The Long Range Identification and Tracking (LRIT) of ships. Consists of the ship borne LRIT information transmitting equipment, Communications Service Providers (CSPs), Application Service Providers (ASPs), LRIT Data Centers, the LRIT Data Distribution Plan and the International LRIT Data Exchange.

Table 12: Most relevant “Best practices”

ID	Category	Technology Name	Transport Mode	Description
BP04	A	Traffic Flow Management	Railway	A system for online optimization of rail traffic flow to have minimum delays and minimum energy consumption, developed by Emkamatik on behalf of SBB
BP07	A	Carbon-free rail freight transport	Railway	DB Schenker Rail replaces the electricity required for your freight transport with regenerative energy that comes 100% from renewable sources in Germany. This helps to avoid carbon emissions right from the outset. Even the smallest quantities can be transported in this way without carbon emissions, on a national and international scale.
BP02	B	TDS	Railway	Train Control System based on a GPS application method
BP03	B	GEKKO	Railway	A system to provide guidance to energy efficiency driving and timetable optimization, developed for Danish State Railways
BP08	B	Coaster Express (CoEx)	Maritime	Short sea transport concept directed to bundling the transport flows, scaling-up the short sea facilities and standardization and automation of the transition processes.

## **5.1 Next Steps for Analysis of Technologies**

The analysis of the different technologies will be performed two more times following the same procedure as described for the initial analysis presented in this report. Next analysis will be performed in due time for the delivery of the updated report in month 24. A special focus in the next phase must be given to the merged technologies (category D) and the technologies that lacked information in the first analysis (category X). Further, it will be important to identify relevant technologies in the “Cargo Preparation” group and to collect more data in order to perform an analysis of the “Innovative Units and Treatment” group. The third analysis will finalize this work and the result presented in the final report from 3.1 in month 36.

## 6 Conclusions

The first year of activities in Task 3.1 – Identify Green Technologies have been mainly dedicated to achievement of the following objectives:

- identification of macro categories to facilitate the identification of potential Green technologies;
- selection of dedicated indicators for each category, in order to characterise the proposed technologies and facilitate the analysis and selection phase;
- creation of a template to support the collection of greening technologies proposed by beneficiaries, along with a manual to clarify its usage;
- organization of three different rounds of collection involving beneficiaries participating to Task 3.1 and to SuperGreen Project;
- identification of 197 green technologies associated to the following transport mode:
  - waterborne transport (inland waterway and maritime);
  - railway transport;
  - road transport;
  - multimodal transport.
- identification the most relevant green technologies for the project.

In particular the collection rounds led to the identification of 197 potential technologies proposed by project participants. This list of technologies has been assessed in the scope of the Task, in order to verify that it ensures a proper coverage of both the selected categories and the considered transport modes, and to verify that each technology is sufficiently described and characterized by means of the information provided by involved partners filled in the requested indicators.

A detailed analysis has been conducted on the full set of collected technologies, in order to identify the most promising ones suitable for applications into the Green Corridors identified in the scope of SuperGreen. In particular, the potential technologies above mentioned have been divided into 6 groups according to their potential impact, from “Very important” to “Non relevant”; this allowed to identify, for each of the categories mentioned in Section 4.1, the technologies having the most relevant impact in terms of greening potential.

## **Appendix I: User Manual for Technology Template**

## **Appendix II: Collection of Green Technologies**

## **Appendix III: Results of the Analysis on Green Technologies**