

Results of green technologies benchmarking

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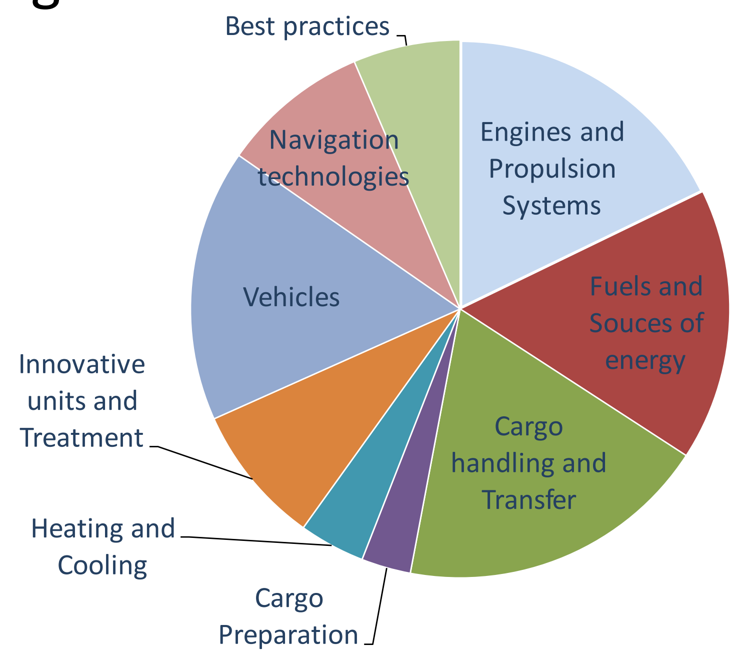
- Definition of the **Application Areas for Green Technologies**.
- **Benchmark Green Corridors with Green Technologies** based on the estimation of the impact with respect to the baseline.

Identification of technologies (1/3)

An extensive collection has been carried out and many innovative technologies have been identified through:

- literature review;
- past and current research projects (both national and at European level);
- personal know-how of partners.



9 categories have been taken into account with reference to the following transport modes:

- Waterborne transport
- Railway transport
- Road transport
- Multimodal transport

More than 200 technologies have been identified.

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Identification of technologies (2/3)

Technologies might be applied to more than one mode of transport

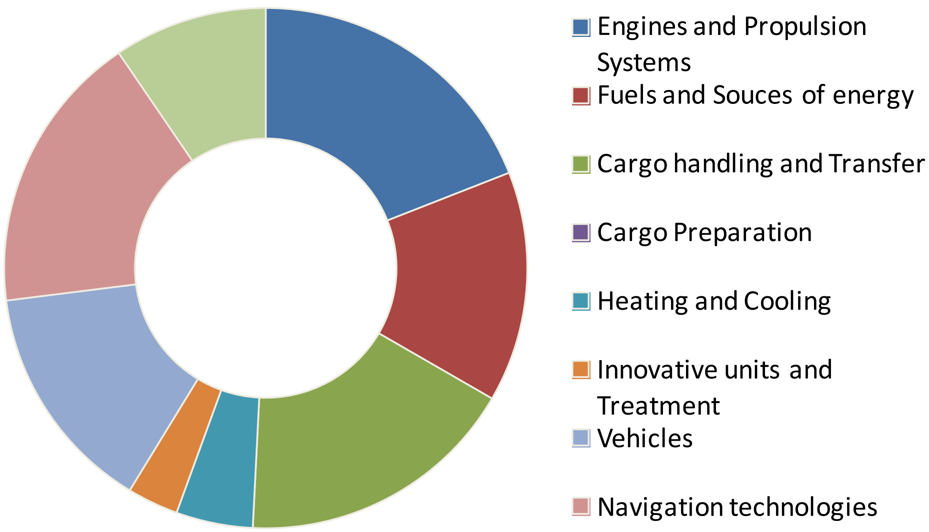
Transport mode	Engines and Propulsion Systems	Fuels and Souces of energy	Cargo handling and Transfer	Cargo Preparation	Heating and Cooling	Innovative units and Treatment	Vehicles	Navigation technologies	Best practices	TOTAL
Inland Waterways	11	10	3	0	0	0	4	2	0	**30**
Maritime	11	21	29	0	1	2	3	14	2	**83**
Railway	8	17	4	0	0	13	12	3	11	**68**
Road	7	18	0	0	2	1	17	3	1	**49**
Multimodal	0	3	16	6	5	3	0	0	0	**33**
TOTAL	**37**	**69**	**52**	**6**	**8**	**19**	**36**	**22**	**14**	**263**

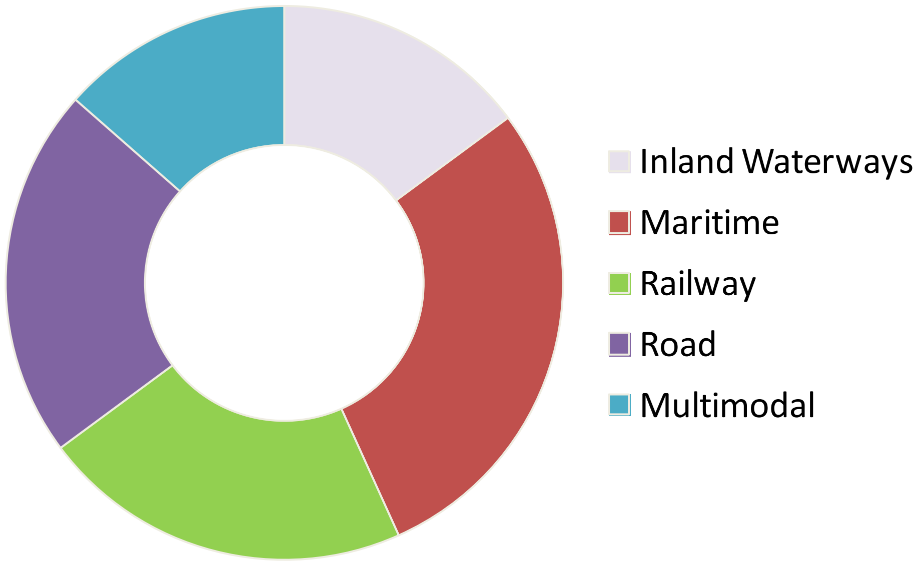
The identified technologies have been then analysed in order to identify the most promising in terms of greening potential.

The analysis classified the technologies into 6 different categories from “Very Important” to “Not Relevant”

Identification of technologies (3/3)

About 30% of the identified technologies have been determined as promising in terms of greening potential.



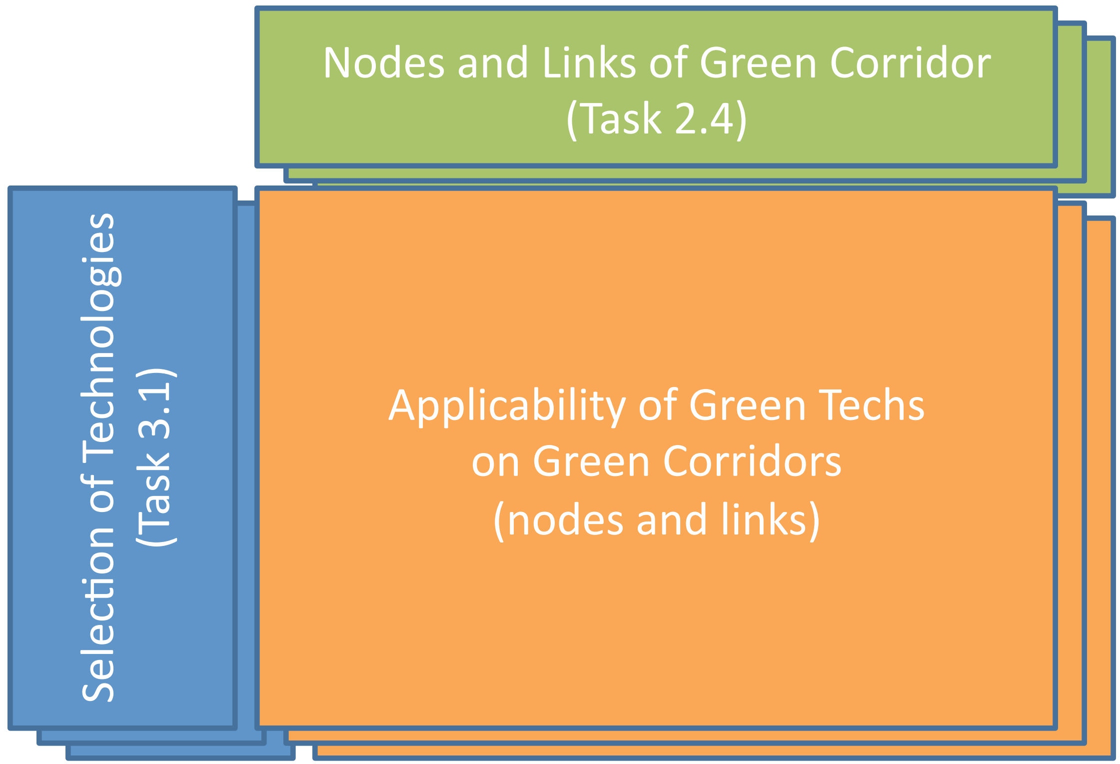


The selected technologies have been applied on the Green Corridors identified in the scope of SuperGreen project.

Allocation of Technologies on Corridors

To assess the usability of the selected technologies to Green Corridors a *Technology vs. Application Matrix* has been prepared

The matrix records possible applications of the selected technologies on either transport segments or nodes of the SuperGreen corridors



Allocation of Technologies on Corridors

Engines and Propulsion Systems:

- Full/parallel Hybrid

Fuels and sources of energy:

- Liquefied Natural Gas
- Bio-diesel

Cargo Handling and Transfer:

- Metrocargo

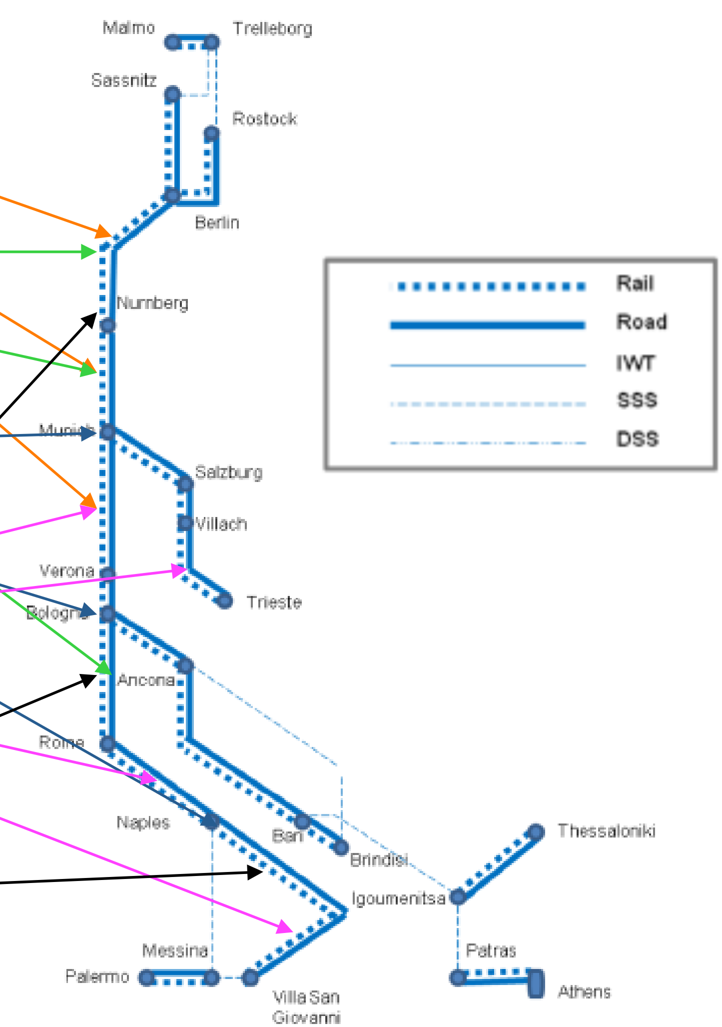
Vehicles:

- Euro VI vehicles
- NS 999 Electric Locomotive

Best Practices:

- Traffic Flow Management
- NS 999 Electric Locomotive

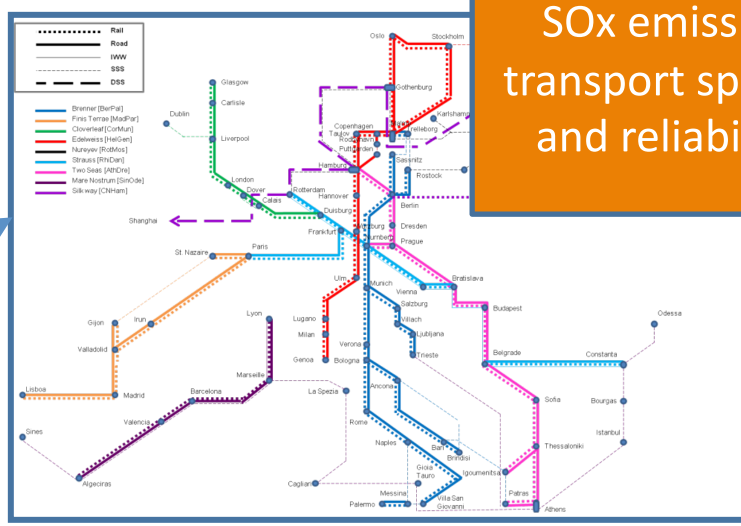
Brenner [BerPal]



Benchmarking of Green Corridors with Green Technologies

The benchmark evaluates the impact due to the application of Green Technologies on specific segments or nodes of the Green Corridors accordingly with selected set of KPIs.

Selected Technologies



KPI: transport cost, CO_2 and SOx emissions, average transport speed, frequency and reliability of service

Benchmark

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KPI factorization

- Identify factors affecting the KPIs
- Create a mapping between KPIs, KPI factors and the green technologies specifications

KPI	KPI factors	Green technology specifications
Relative cost	Fuel cost; Operating costs; General costs	Savings in fuel consumption; Savings in taxes or consumption of resources (e.g. use of chemicals)
CO_2 emissions	CO_2 emissions caused during the operation of the vehicles. The effort is to collect information on both Tank-to-Wheel (TTW) and Well-to-Wheel (WTW) emissions.	Reduction of CO_2 emissions
SOx emissions	SOx emissions caused by the vehicles used. The effort is to collect information on both Tank-to-Wheel (TTW) and Well-to-Wheel (WTW) emissions.	Reduction of SOx emissions
Average speed	Vessel/vehicle speed. Typical delays of the transport operations; Duration of the loading/unloading process	Increase in the speed of the vehicle/vessel; Decrease in loading/unloading times; Mitigation of problems that cause delays (e.g. weather)
Frequency of service	Potential increase in trips per week (possibility to increase frequency, as a result of delays reduction)	Decrease in loading/unloading times; Mitigation of problems that cause delays (e.g. weather)
Reliability & solution of bottlenecks	Accidents occurring per year (%); Thieveries per year (%)	Mitigation of accidents
	Problems caused by weather	Mitigation of problems that cause delays because of bad weather

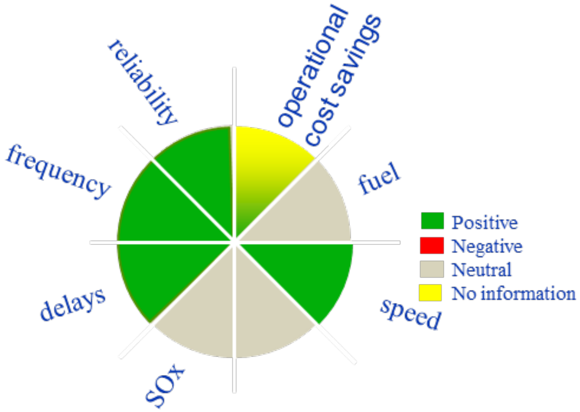
High Level Benchmarking

Non-corridor specific: Green Techs & KPIs

- Estimation of the Green Technology impact on the KPI factors
- Comparison with the baseline (current standard performance evaluated on corridors with conventional technologies).

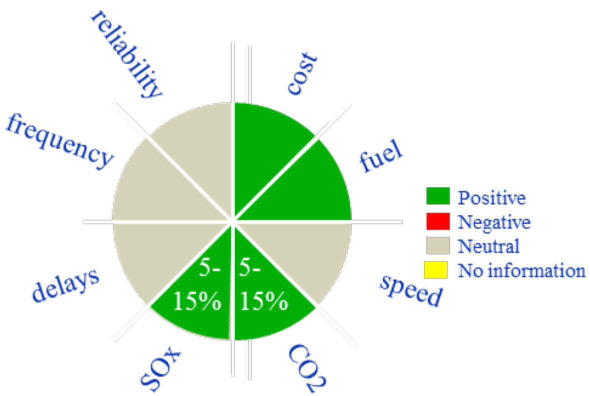
Cargo cassette translifter

Baseline Connventional cargo handling systems



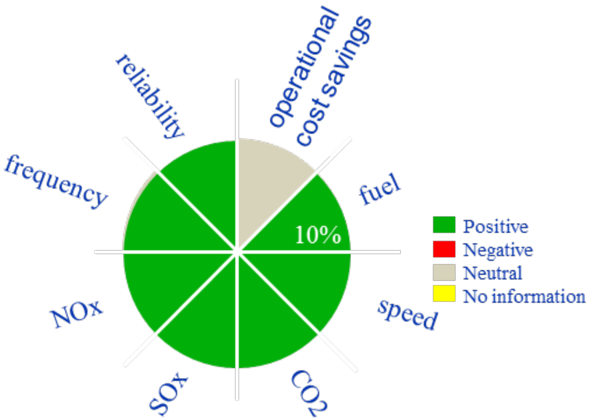
Counter rotating propeller

Baseline: single propeller system

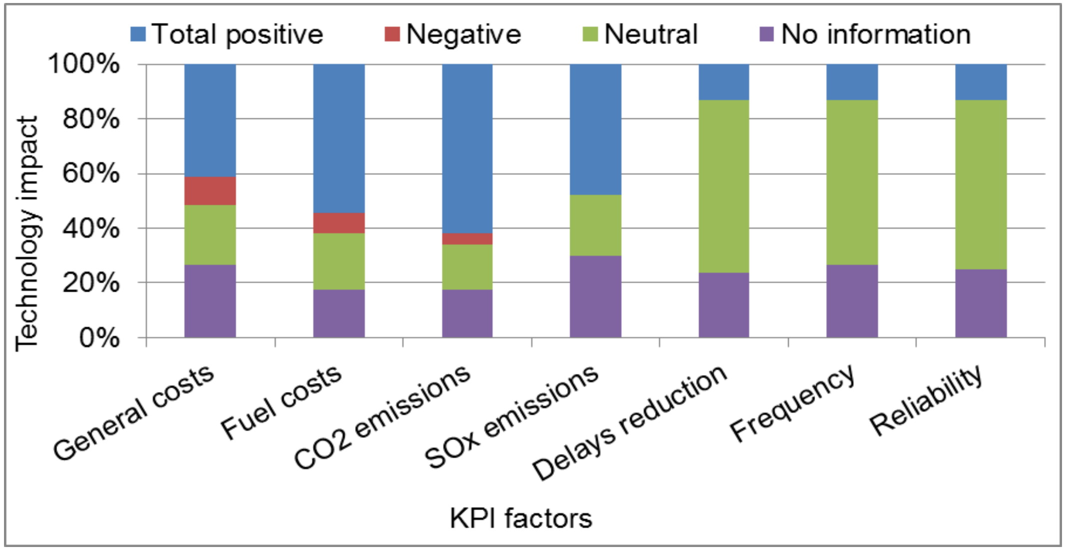


Route optimisation

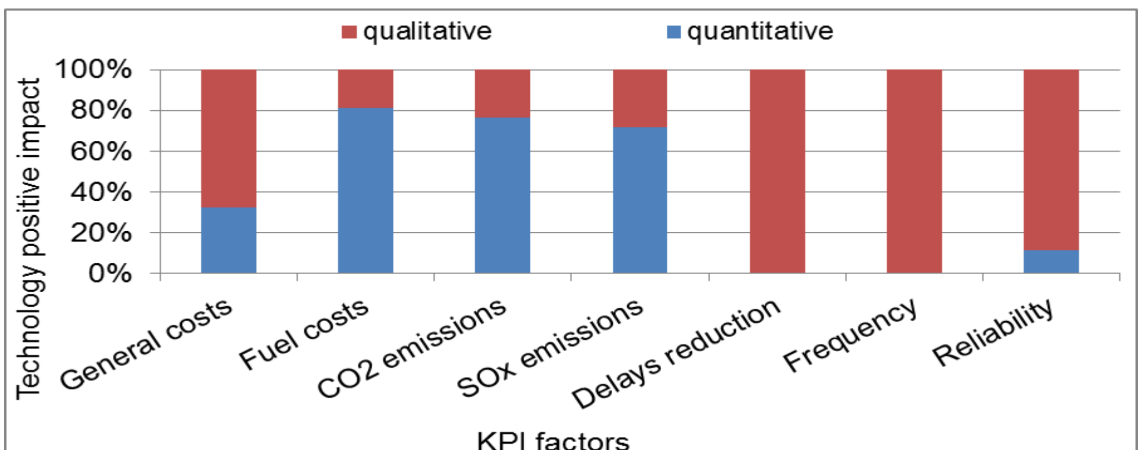
Baseline: non aided route scheduling



High Level Benchmarking
Results



A qualitative evaluation has been performed when specific data on technologies were not available in order to allow a quantitative approach.



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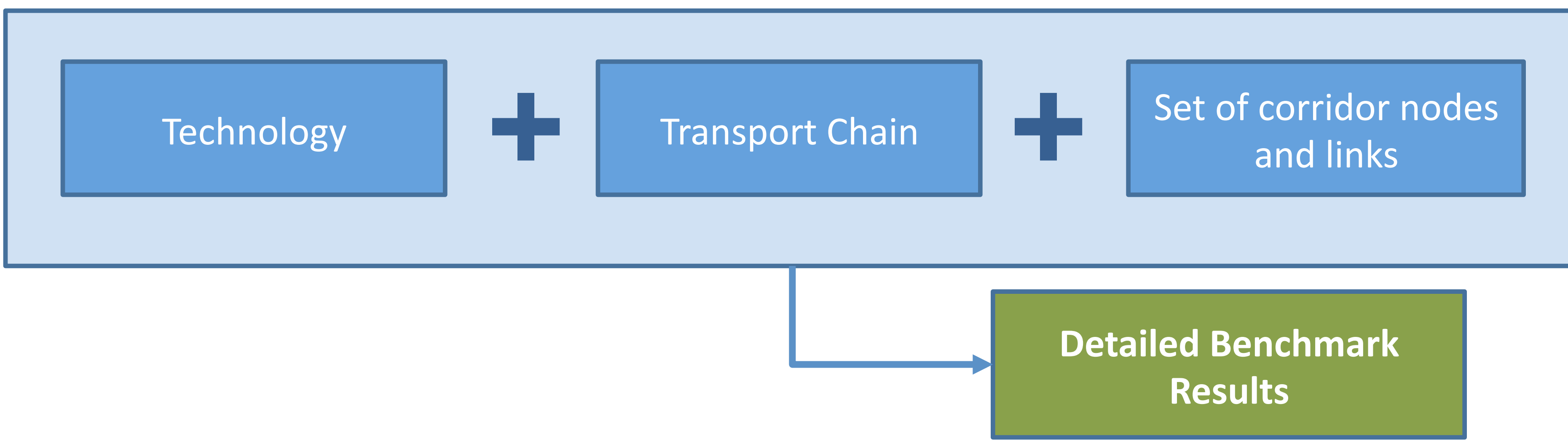
Detailed Benchmarking:
Corridor-specific: Techs – KPIs – Corridors

The greening impacts have been assessed with respect to the current corridor performance for selected case studies.

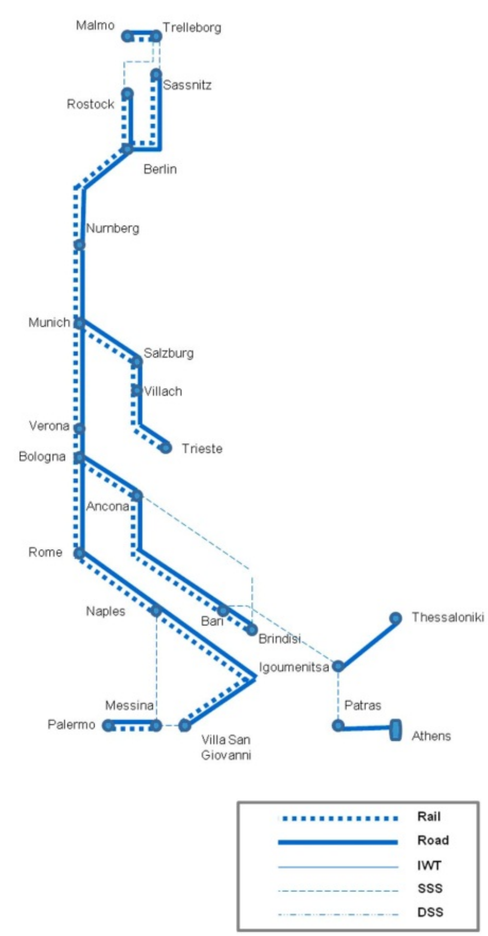
The benchmark is based on a combination of a green technology and a set of corridor segments and nodes.



Detailed Benchmarking: *Brenner Example*

- Road transport chain
- International – long distance: Brescia – Verona – Munich – Berlin
- Fleet of EURO V & III refrigerated trucks
- 18-24 tonnes
- 90% loading factor
- Target: Energy efficiency, emissions reductior

Brenner [BerPal]



Technology	KPI	Min impact	Max impact	Drawbacks
Hybrid trucks	Fuel savings [euro/tn.km]	6%	7%	High capital cost
	CO_2 emissions [gr/tn.km]	25%	25%	
Aerodynamic drag improvements	Fuel savings [euro/tn.km]	3%	4%	Gains depends on the operational patterns
	CO_2 emissions [gr/tn.km]	10%	26%	
	SOx emissions [gr/tn.km]	13%	25%	
Low rolling resistance tires	Fuel savings [euro/tn.km]	0%	1%	Traction and braking performance
	CO_2 emissions [gr/tn.km]	2%	4%	

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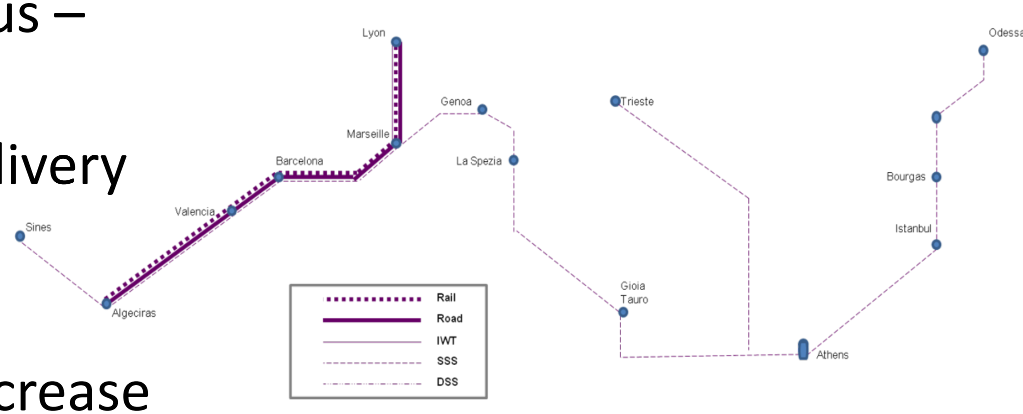
Detailed Benchmarking:
Mare Nostrum Example

- Maritime container transportation
- Any route connecting: Barcelona – Valencia – Gioia Tauro – Piraeus – Istanbul
- Typical loading factor 70%, delivery time: 55hrs
- Target: Energy efficiency, SO_2 emissions reduction, speed increase

Mare Nostrum [SinOde]



	KPI	Min impact	Max impact	Drawbacks
Waste heat recovery systems	Fuel savings [euro / tn.km]	1%	5%	Space requirement – possible loss of cargo capacity – capital cost
	CO_2 emissions [gr / tn.km]	2%	5%	
	SOx emissions [gr/ tn.km]	1%	5%	
Exhaust abatement systems	Fuel savings [euro / tn.km]	-4%	-1%	Increase of consumption causes CO_2 emission increase
	Total chain SOx emissions [gr/ tn.km]	57%	73%	
	Trip SOx emissions [gr/ tn.km]	90%	96%	
Integrated short sea transport	Average speed [km/hr]	5%	8%	Conceptual level

Detailed Benchmarking: *Results* (1/3)

Technology name	Corridor	Mode of Transport	SuperGreen KPI	Impact compared to baseline [%]
Hybrid trucks	Brenner	Road	Cost [euro/tn.km]	6% to 7%
			CO_2 [gr/tn.km]	25%
	Cloverleaf	Road	Cost KPI [euro/tn.km]	13% to 23%
			CO2 [gr/tn.km]	-49% to 25%
			SOx [gr/tn.km]	10% to 26%
Aerodynamic drag improvements	Brenner	Road	Cost [euro/tn.km]	3% to 4%
			CO2 [gr/tn.km]	10% to 26%
			SOx [gr/tn.km]	13% to 25%
	Cloverleaf	Road	Cost KPI [euro/tn.km]	2% to 8%
			CO2 [gr/tn.km]	10% to 26%
			SOx [gr/tn.km]	10% to 26%
Low rolling resistance tires	Brenner	Road	Cost [euro/tn.km]	0% to 1%
			CO2 [gr/tn.km]	2% to 4%
EREX	Cloverleaf	Railways	Cost KPI [euro/tn.km]	1%
Braking energy recovery & On-board energy storage systems	Silkway	Railways	Energy savings [kWh/tn.km]	30% to 40%

Detailed Benchmarking: *Results* (2/3)

Technology name	Corridor	Mode of Transport	SuperGreen KPI	Impact compared to baseline [%]
Waste heat recovery systems	Mare Nostrum	Maritime	Cost [euro/tn.km]	1% to 5%
			CO_2 [gr/tn.km]	2% to 5%
			SOx [gr/tn.km]	1% to 5%
Exhaust abatement systems	Mare Nostrum	Maritime	Cost [euro/tn.km]	-4% to -1%
			SOx [gr/ tn.km]	90% to 96%
	Strauss	IWW	Cost KPI [euro/tn.km]	0% to 1%
			CO_2 [gr/tn.km]	-5% to 8%
Integrated short sea transport	Mare Nostrum	Maritime	Average speed [km/hr]	5% to 8%
Contra rotating propeller	Nureyev	Maritime	CO_2 [gr/tn.km]	5% to 15%
			SOx [gr/tn.km]	4% to 16%
Mechanical azimuth thrusters	Nureyev	Maritime	CO_2 [gr/tn.km]	0% to 20%
			SOx [gr/tn.km]	0% to 21%
Wind propulsion - Sails	Nureyev	Maritime	CO_2 [gr/tn.km]	0% to 15%
			SOx [gr/tn.km]	0% to 14%
LNG	Nureyev	Maritime	CO_2 [gr/tn.km]	10% to 20%
			SOx [gr/tn.km]	98% to 100%
	Strauss	IWW	CO_2 [gr/tn.km]	10% to 19%
			SOx [gr/tn.km]	95% to 100%
Cargo casette translifter	Nureyev	Maritime	Average speed [km/hr]	0% to 38%
			Frequency [times/year]	0% to 6%
			Reliability [%]	0% to 6%
Route optimisation systems	Strauss	IWW	Cost KPI [euro/tn.km]	1% to 1%
			CO_2 [gr/tn.km]	10% to 10%
			SOx [gr/tn.km]	10% to 10%

SuperGreen Knowledge base

The SuperGreen Knowledge Base is a web-based repository developed to store all the information previously introduced:

- Information/data on the most promising technologies
- Potential area of application, Green Corridors, for the identified technologies
- Benchmarking of Green Corridors with selected technologies

The SuperGreen Knowledge Base is hosted at:

http://88.32.124.84/SuperGreen/Login.aspx

Further needs of research

- Methodology to collect statistical information on corridors' transport flows and their features.
- Methodology to estimate the performance changes of various technological concepts applied on different areas of the transport corridors.
- Methodology to collect quantitative performance data for green hub technologies and best practices.
- Evaluation of the adoption of green technologies on an aggregated level (fleet basis), including their return of investment on a corridor level, in the benchmarking of Green Corridors.
- Focus on large volume paradigms for intermodal transport, considering also indices related to regulatory barriers or benefits on national or community level, as well as the infrastructure capacity to facilitate the adoption of the technologies.

Thank you for your attention!

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