Green Cranes

Co-financed by the European Union

Trans-European Transport Network (TEN-T)

INTERMEDIATE INFORMATION DAYS

- Actions carried out and results achieved for Activities: 2

Global Service and lab. PERCRO - Scuola Superiore Sant'Anna

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INTERMEDIATE INFORMATION DAYS

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Consortium:

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Autorità portuale Livorno

Scuola Superiore Sant'Anna di Studi Universitari e di Perfezionamento

RINA

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ABB

KONECRANES

Activity 2: Evaluation of Eco-Efficient GREENCRANES alternatives

Actions carried out by PERCRO-SSSA and Global Service in Activity 2:

1) Analysis of reach stackers main components, fuel consumption and GHG emissions

2) Analysis of alternative to improve the Eco-Efficiency of reach stacker:

a. adaptation of reach stackers to be powered with hydrogen and fuel cells

b. adaptation of reach stackers to be powered with compressed natural gas (CNG)

c. adaptation of reach stackers to be powered with liquefied natural gas (LNG)

d. adaptation of reach stackers to be powered with LNG dual fuel system

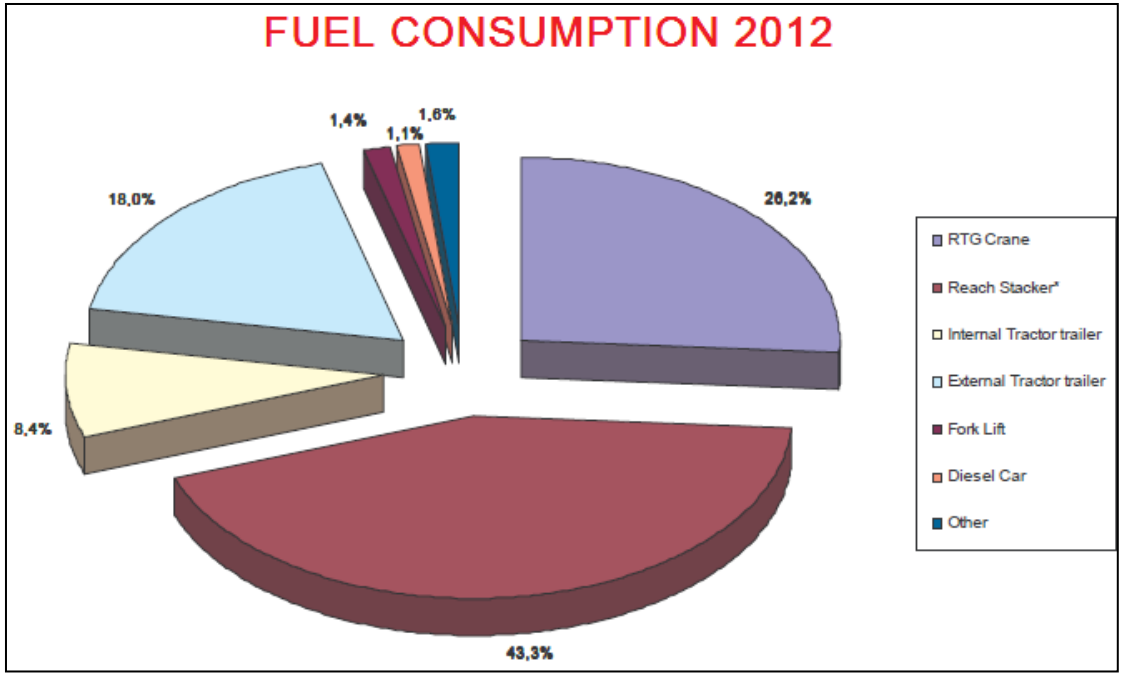
3) Selected solution for TDT Livorno

Activity 2: Evaluation of Eco-Efficient GREENCRANES alternatives

Actions carried out by PERCRO-SSSA and GS:

1) Analysis of reach stackers main components, fuel consumption and GHG emissions

The fuel consumption analysis of Livorno Terminal Darsena Toscana (TDT) shows that Reach Stackers vehicles are the most responsible of fuel consumption (about 600,00 liters) and GHG emissions (about 1,300 CO_2eq Ton)



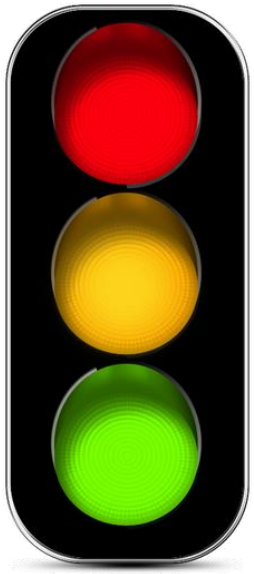
Activity 2: Evaluation of Eco-Efficient GREENCRANES alternatives

Actions carried out by PERCRO-SSSA and GS:

1) **Analysis of reach stackers main components, fuel consumption and GHG emissions**

2) Analysis of alternative to improving the Eco-Efficiency of reach stacker:

LEGENDA of main aspects evaluated



The aspect has technical or costs issues that can hardly be addressed within the framework of this project

The aspect request high design and costs efforts - OR The solution does not give strong environmental benefits

The aspect doesn't need high efforts to be faced - OR The solution gives considerable environmental benefits

Activity 2: Evaluation of Eco-Efficient GREENCRANES alternatives

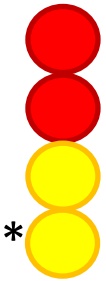
Actions carried out by PERCRO-SSSA and GS:

1) **Analysis of reach stackers main components, fuel consumption and GHG emissions**

2) **Analysis of alternative to improving the Eco-Efficiency of reach stacker:**

a. adaptation of reach stackers to be powered with Hydrogen Fuel Cells

Main Technical Aspects → Tank NET volume 5 to 10 times actual Diesel tank
Vehicle adaptation design and costs efforts
Refueling station
«Refueling station dependent»: service disruptions*



Environmental Aspects → 0 local impact

* Due to the low reliability of a new refueling line which would be a novelty in Toscana territory

Hydrogen cells SWOT analysis

	HELPFUL	HARMFUL
INTERNAL	Strengths: - Zero impact on local environment;	Weakness: - Difficulties in finding enough room on-board to reach stackers to install an equivalent autonomy fuel tank (hydrogen cylinders); - High cost for the reach stackers adaptation; - High impact on reach stackers mechanics; - High cost of refueling station;
EXTERNAL	Opportunity: - Evaluate and test a further hydrogen powered infrastructure; - Integration with local H_2 production from renewable energy.	Threats: - Reduce the autonomy of reach stackers to reduce volume of hydrogen cylinders;

Activity 2: Evaluation of Eco-Efficient GREENCRANES alternatives

Actions carried out by PERCRO-SSSA and GS: ;

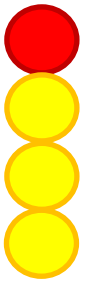
1) Analysis of reach stackers main components, fuel consumption and GHG emissions

2) Analysis of alternative to improving the Eco-Efficiency of reach stacker:

a. **adaptation of reach stackers to be powered with hydrogen cells**

b. **adaptation of reach stackers to be powered with CNG**

Main Technical Aspects → Tank NET volume 4 actual Diesel tank
Vehicle adaptation design and costs efforts
Refueling station costs
«Refueling station dependent»: service disruptions



Environmental Aspects → Lower emissions of particulate, non-methane hydrocarbon emissions, nitrogen oxides and GHG.

Compressed natural gas (CNG) SWOT analysis

	HELPFUL	HARMFUL
INTERNAL	Strengths: - Lower local emissions of particulate, non-methane hydrocarbon emissions, nitrogen oxides and CO_2;	Weakness: - Difficulties in finding enough room on reach stackers to install an equivalent autonomy fuel tank (CNG cylinders); - High cost for the reach stackers adaptation; - High impact on reach stackers mechanics; - Longer refuelling time;
EXTERNAL	Opportunity: - Evaluate and test a further CNG powered infrastructure.	Threats: - Reduce the autonomy of reach stackers to reduce volume of CNG cylinders but this would additionally lengthen refuelling time;

Activity 2: Evaluation of Eco-Efficient GREENCRANES alternatives

Actions carried out by PERCRO-SSSA and GS: ;

1) Analysis of reach stackers main components, fuel consumption and GHG emissions

2) Analysis of alternative to improving the Eco-Efficiency of reach stacker:

a. adaptation of reach stackers to be powered with hydrogen cells

b. adaptation of reach stackers to be powered with compressed natural gas (CNG)

c. adaptation of reach stackers to be powered with LNG

Main Technical Aspects → Tank NET volume 1.5 times actual Diesel tank
Vehicle adaptation design and costs efforts
Refueling station
«Refueling station dependent»: service disruptions

Environmental Aspects → Lower emissions of particulate, non-methane hydrocarbon emissions, nitrogen oxides and GHG.

Cost/Benefit Aspects → Payback will be 5 years and IRR will be 25.79%

Liquefied natural gas (lng) SWOT analysis

	HELPFUL	HARMFUL
INTERNAL	Strengths: - Lower local emissions of particulate, non-methane hydrocarbon emissions, nitrogen oxides and CO_2; - Safer then CNG or H_2 - Payback time 5 years with a ROI of 25,79%	Weakness: - Some problem in finding enough space on reach stackers to install an equivalent autonomy fuel tank (at least 2 LNG tanks); - High cost for the reach stackers adaptation; - High impact on reach stackers mechanics; - Refuelling issues
EXTERNAL	Opportunity: - Evaluate and test a further LNG powered infrastructure.	Threats: - Reducing the autonomy of reach stackers to reduce volume of LNG cylinders would additionally lengthen refuelling time;

Activity 2: Evaluation of Eco-Efficient GREENCRANES alternatives

1) Analysis of reach stackers main components, fuel consumption and GHG emissions

2) Analysis of alternative to improving the Eco-Efficiency of reach stacker:

a. adaptation of reach stackers to be powered with hydrogen cells

b. adaptation of reach stackers to be powered with compressed natural gas (CNG)

c. adaptation of reach stackers to be powered with liquefied natural gas (LNG)

d. adaptation of reach stackers to be powered with LNG Dual Fuel system

Main Technical Aspects →	Additional LNG tank Vehicle adaptation design and costs efforts Refueling station It is not «refueling station dependent» and avoid service disruptions
Environmental Aspects →	Lower emissions of particulate, non-methane hydrocarbon emissions, nitrogen oxides and GHG.
Cost/Benefit Aspects →	Payback will be 7 years and IRR will be 11.89%.

Dual fuel system SWOT analysis

	HELPFUL	HARMFUL
INTERNAL	Strengths: - Its installation is not invasive and the system is reversible; - the system can be changed in 100% diesel or dual fuel at any time; - does not penalize the original performances of the reach stacker; - reduces the carbon emissions of the reach stacker; - allows an important operating fuel costs saving. - Safety of LNG compared to CNG and H_2 - Converting 10 reach stackers the payback time would be 7 years with a ROI of 1,89%	Weakness: - refueling issues - Still persist a residual emissions of particulate, hydrocarbon emissions, nitrogen oxides and CO_2 due to diesel fuel; - Cost-benefit results are affected by the demand curve of reach stackers: with the actual demand it wouldn't be convenient to convert all reach stackers fleet, but an optimization of reach stackers demand curve would increase economic benefits of the conversion to dual fuel technology.
EXTERNAL	Opportunity: - the entire TDT reach stacker fleet can be easily converted to dual fuel.	Threats: - The time that a LNG refueling station can be installed the Darsena Toscana is not predictable.

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Actions carried out by PERCRO-SSSA and GS: ;

1) **Analysis of reach stackers main components, fuel consumption and GHG emissions**

2) Analysis of alternative to improving the Eco-Efficiency of reach stacker:

a. **adaptation of reach stackers to be powered with hydrogen cells**

b. **adaptation of reach stackers to be powered with compressed natural gas (CNG)**

c. **adaptation of reach stackers to be powered with liquefied natural gas (LNG)**

d. **adaptation of reach stackers to be powered with LNG dual fuel system**

3) Selected solution for TDT Livorno

Selected solution for TDT Livorno

All conversion solutions have advantages and disadvantages. H_2, CNG and LNG solutions include technical challenges that can hardly be addressed as part of this project:

- The most important difficulties concern the installation of **fuel tanks** for giving the reach stackers an equivalent autonomy as in case of diesel original diesel engine and tank;
- Furthermore these solutions require **high design and costs efforts** including the installation of new engines;
- Finally these solutions are **«refueling station dependent»** and may introduce **service disruptions** due to the low reliability of a new refueling line which would be a novelty in Toscana territory.

Selected solution for TDT Livorno

On the other hand **Dual-fuel solution** has these characteristics:

- A smaller LNG tank volume reduce installation issues;
- It is less invasive and the system is reversible;
- It is not «refueling station dependent» and avoid service disruptions (because the engine may work with 100% diesel);
- It introduces less efforts to convert the existing fleet and gives good results under cost-benefits aspect point of view;
- It is a greener solution compared to diesel (even if it gives lower benefits for the environment compared to the other alternative).

For all of these reasons the final decision foresees the adaptation of Reach Stackers to be powered with Dual Fuel Technology LNG/Diesel.

Selected solution for TDT Livorno

Cost-benefits results by converting 10 reach stackers with Dual-fuel Technology:

10	nº YEARS
10,00%	WACC
700.000,00 €	δ INVESTMENT
57.145,02 €	NPV
11,89%	ROI
7	Payback

If TDT will reduce the shifts with 0 or few reach stackers assigned, in the future it might be convenient to convert all TDT fleet vehicles.

THANKS FOR YOUR ATTENTION!

GREENCRANES, AN ACTION DEVELOPED THANKS TO:

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Trans-European Transport Network (TEN-T)

TEN-T EA
Trans-European Transport Network Executive Agency

European Commission
Mobility & Transport

Consortium:

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