APPRAISAL REPORT

FOR PULA AIRPORT PILOT ACTION

European Regional Development Fund

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CONTENT

I. EXECUTIVE SUMMARY

The main objective of the ADRIGREEN project is to improve the integration of Croatian and Italian ports and airports with other modes of transportation to enhance the processing of passengers during the summer seasons and to improve the environmental performances of the Adriatic maritime and aviation systems.

According to project life cycle progress, an international investigation has been performed to identify the best existing solutions for lowering airports/ports environmental impact. Further, these identified solutions have been summarized in the Joint Action Plan definition for each region/partner.

Pula Airport pilot action objective included the adoption of smart solutions to improve waste & water management and to reduce energy consumption in small-medium regional Airports.

Within the ADRIGREEN project, Pula Airport has invested in three multi-standard DC charging stations for six electric vehicles on the airport landside and electrical towing tractor for ground handling. After the pilot action implementation, PUY has assessed the environmental impact and benefits of the pilot action implemented for PUY and the wider public, described in the latter stages of this report.

According to environmental analysis implemented pilot action has reduced CO_2 emission within PUY premises from which not only PUY employees have benefited, but also passengers of PUY airport and the local community.

Analysis performed within the ADRIGREEN project gives PUY Management Board a clear understanding and recommendations for improvement of the environmental management process in all different environmental aspects. In this report energy fuel consumption is appraised for the pilot action implemented, however in other ADRIGREEN deliverables, especially in the Joint Action Plan definition, clear recommendations are given on the strategical and operational level.

II. BACKGROUND OF THE PROJECT IMPLEMENTATION

Green and intermodal solutions for Adriatic ports and airports - ADRIGREEN is a project approved under the INTERREG V-A Italy Croatia CBC Programme 2014-2020. The programme is funded by the European Regional Development Fund under the European Territorial Cooperation objective during the programming period 2014-2020.

Project description

One of the main problems that characterize the Adriatic coastal area is the imbalance in the development of infrastructures and modes of transport, caused by a low level of investments and an insufficient approach to innovation. In Italy and Croatia, there are many maritime cities, which have to deal with a very high number of passengers, especially during the peak season. Even though road transportation is still predominant, the number of people that are reaching Adriatic cities by ferries and aeroplanes is significantly increasing year by year. However, most Adriatic ports and airports are suffering from a lack of integration with various modes of transportation, causing serious traffic congestion problems during the summer season.

The aim of the project is to improve the integration of Adriatic ports and airports with other modes of transportation by testing several intermodal operational and technological solutions. By identifying and analysing already existing procedures, the project partners will test a number of intermodal practices in order to evaluate their adaptability and transferability into the Programme area.

Also, it is very important to create more environmental-friendly and less polluting transport between ports (cities) and airports by reducing CO_2 emissions. This can be achieved by purchasing electric vehicles for transport routes between ports and airports, or for use in port/airport premises.

Background of project implementation

ADRIGREEN project consists of several technical work packages as follows:

1. WP T1 – Identification of innovative solutions and Action plan definition
2. WP T2 – Testing phase
3. WP T3 – Networking and training on Green and intermodal solutions

WP T1 – identification of innovative solutions and Action plan definition

Within first technical work package (WP T1) several activities were performed:

A) Replicability research and analysis replicable operational and technological solutions
B) Environmental assessment
C) Joint Action plan definition

Activities have been started in June 2019 and finalised as of December 2020.

A) Replicability research and analysis replicable operational and technological solutions

The partnership has made a general overview of existing solutions for lowering airports/ports environmental impact and for intermodal connection of ports/airports with other means of transportation. Within this activity SWOT analysis of each project, the partner was performed to assess the current situation and fields for improvement. Also, international investigation research was conducted to identify and analyse the best solutions already implemented worldwide that can be easily implemented in the Adriatic region. One of the main focus areas of international investigation included ongoing operational and technical initiatives for making ports/airports environmentally friendly with particular attention to maintenance activities.

Summary of practical sustainable applications to achieve carbon reductions at airport and port infrastructures are as follows:

Solution	Brief description	Port reference case studies	Airport reference case studies
Solar panels	Solar panels installed in different areas of the port/airport (e.g., rooftops of buildings and warehouses) for generating renewable energy.	Rotterdam, Amsterdam, and Gothenburg	Copenhagen, and Helsinki Airport
Geothermal heat pump/ Aquifer thermal energy storage[1]	Renewable thermal energy for large heating and cooling loads. Cooling/heating system employs a water-based thermal energy storage system that stores heat/cold in ground- water reservoirs.	Marseille	Paris-Orly, Nashville, Calgary, Stockholm-Arlanda, and Copenhagen Airport
Energy monitoring system	Monitoring system of the energy consumption of airport/port equipment, buildings and other facilities for supporting decision-making and implementation of measures for improving energy efficiency.	Valencia, Koper, and Jade Weser Port	Copenhagen Airport
Smart grid	Electricity network based on digital technology that can cost-efficiently integrate the behaviour and actions of all generators and consumers that are connected to the grid.	Antwerp	-
Daylighting strategy	A daylighting strategy can reduce electricity for lighting and peak electrical demand, cooling energy and peak cooling loads, maintenance costs associated with lamp replacement, and electrical service to the building.	Yokohama	Denver, and San Francisco Airport

[1] Baxter et al. (2018). An assessment of airport sustainability, Part 2—Energy management at Copenhagen Airport. *Resources*, *7*(2), 32.

	Maximize south glazing and minimize east- and west-facing glass[2].		
Green roofs	Green roofs are covered with vegetation and a growing medium planted over a waterproofing membrane. When weight restrictions need to be considered, it is possible to utilize substrates that provide an adequate nutrient supply with relatively low specific weight. Main environmental goals: absorbing rainwater, providing insulation, and helping to mitigate the heat island effect in the built environment.	Värtahamnen, and Copenhagen	Frankfurt, Ibiza, Munich Airport, Paris Orly, and Bordeaux–Mérignac Airport
Concrete pavement instead of asphalt	Pavers are lower maintenance and generally have a longer lifespan compared to asphalt.	Värtahamnen	-
LED	Light emitting diode (LED) is a highly energy efficient lighting technology.	Venice, Hamburg, and Los Angeles	Stockholm Arlanda, Copenhagen, Schiphol, and Oslo Airport

Source: international investigation ADRIGREEN

For more details, please see related document international investigation ADRIGREEN.

[2] https://www.lrc.rpi.edu/programs/daylighting/pdf/guidelines

B) Environmental assessment

Next step in project implementation comprised of producing an Environmental Impact Assessment (EIA) for each project partner based on ad-hoc guidelines produced by a technical expert in the project, Polytechnic University of Marche. To assess the current situation in each partner, an evaluation grid for EIA was produced to cover different environmental aspects; environmental impact of local air quality, waste and water management, energy consumption, carbon footprint and noise pollution.

There are different levels of implementation of efficient environmental management within ADRIGREEN airports as can be summarised in table below:

Activity	Implemented in airports
Water management	
Education and training of airport staff	4/6
Monitoring of water consumption	3/6
Harvest and reuse rainwater	2/6
Surface water and groundwater quality monitoring	4/6
Runoff water management	5/6
Waste management	
Waste handling – more fractions (paper, metal…)	3/6
Aircraft waste advanced handling	1/6
Waste prevention initiatives	1/6
Training on recycling	2/6
Mitigation measures in place	3/6
Electricity and fuel consumption	
Photovoltaic systems installed	3/6
LED lighting	6/6
Operational and maintenance procedures in place	5/6
Initiatives to reduce energy consumption	3/6
Energy audit	2/6
GHG emission–high (0,2-0,3 kg CO2eq/pax)	4/6
Switch to electrical or bio-fuel vehicles	4/6
Charging stations	5/6

Data extracted from: ADRIGREEN WP3-D2 APT

For more details, please see related document EIA ADRIGREEN.

C) Joint action plan definition

A joint action plan definition has been produced by Polytechnic University of Marche with recommendations for improvement for each type of environmental activity (please see: Adrigreen_WP3_D3_200218_Final):

Since Pula Airport pilot action comprises of “adoption of smart solutions to improve waste & water management and to reduce energy consumption in small-medium regional Airports” below are presented reference case studies for actions aimed at decreasing energy consumption:

General measure	**Specific action**	**Metrics**	**Airport reference case studies**
Decreasing energy consumption	Building management system	Total energy consumed (electricity consumption (kWh); fuel consumption (m3; l; kg)); GHG emissions (kg CO2eq/m3; kg CO2eq/passenger)	A3 airport (this study).
Decreasing energy consumption	Cogeneration plant	Total energy consumed (electricity consumption (kWh); fuel consumption (m3; l; kg)); GHG emissions (kg CO2eq/m3; kg CO2eq/passenger)	Website of Leonardo da Vinci Airport (—); Malpensa Airport (SEA Energia 2019).
GHG = Greenhouse Gases.			

Source: Adrigreen_WP3_D3_200218_Final

Also, according to survey reported by the European Environment Agency (2019), the purchase of electric vehicles is the most popular mitigation action to contain the environmental impact of the airports’ vehicle fleet as can be seen from table below.

	Share of (51) EU28 European Free Trade Association airports [%]
Electric vehicles	86
Hybrid vehicles	47
Vehicles that run on sustainable alternative fuel	35
Provide incentives for taxis that use 'green' vehicle solutions	18

Source: Adrigreen_WP3_D3_200218_Final

Therefore, within ADRIGREEN project Joint action plan definition, following measures were underlined regarding decreasing of fuel consumption:

General action	**Specific action**	**Metrics**	**Airport reference case studies**
Decreasing fossil fuel consumption	Purchase of electric vehicles (e.g., electric aircraft tug, electric baggage tractor, etc.)	Electricity consumption (kWh) versus kg or l of fossil fuel; GHG emissions (CO_2eq)	Copenhagen Airport (2018).
Decreasing fossil fuel consumption	Provide charging stations for electric vehicles	Electricity consumption (kW); GHG and airborne pollutants emissions	A1 airport (this study); Helsinki Airport (Finavia 2019).
Decreasing fossil fuel consumption	Anti-idling communication campaign	GHG and airborne pollutants emissions	Copenhagen Airport (2018).
Decarbonizing fuel consumption	Use of alternative renewable fuels (diesel from waste and residue) for diesel vehicles	Consumption of renewable fuel vs fossil fuel (l); GHG emissions (CO_2eq)	Helsinki Airport, and other Lapland Airports (Finavia 2018).
GHG = Greenhouse Gases			

Source: Adrigreen_WP3_D3_200218_Final

Since within ADRIGREEN project PUY pilot action comprises of purchasing three multi-standard DC charging stations for six electric vehicles on the airport landside and electrical towing tractor for ground handling to achieve a reduction of fossil fuel consumption. PUY pilot action is in line with recommendations specified in the Joint Action plan definition.

WP T2 – Testing phase

The testing phase is the core phase of the project where identified solutions and best practices are to be put in place and tested within each partner pilot action. The first deliverable of this work package is related to the Feasibility study for each pilot action where initial financial and environmental analysis has been performed.

Initial financial and environmental assessment of Pula Airport pilot action demonstrated a feasible and sustainable plan for reducing fuel consumption and CO_2 emission using three multi-standard DC charging stations for six electric vehicles and an electrical towing tractor for ground handling.

This plan is to be carried on by PUY in the future until the full replacement of old diesel vehicles with electric ones. In the latter stages of this document PUY needs analysis as well as pilot action implemented and environmental analysis are explained.

III. PULA AIRPORT NEEDS ANALYSIS SUMMARY

Pula Airport had rapid traffic growth in the last years that has introduced the airport to new environmental challenges, such as an increase in air pollutions and integration of environmental protective measures. Such challenges are mostly elaborated and mitigated through airport major infrastructure projects such as the Pula Airport Development project. Pula Airport highly invests in partnership with the Pula Port and other stakeholders in order to coordinate and collaborate on environmental issues, which result from the increase of traffic and tourist demand, and to mitigate the negative effects of increasing airport traffic.

In order to cope with new environmental challenges, Pula Airport has planned to increase the level of multimodality/intermodally and environmental performance at the airport through a number of dedicated projects. With the completion of the Pula Airport Development project in Spring 2020, the airport is facing a significant challenge in how to effectively integrate new infrastructure in existing systems. The introduction of new facilities has dislocated the number of airport organizational units due to safety and performance needs. Now the internal communication and transport between those units is representing organizational and environmental challenges. Such needs should be met with environmental-friendly solutions taking into account specifics of airport technology and operations.

The ADRIGREEN project represents a unique opportunity for Pula Airport to continue its development toward an environmentally friendly airport. In addition, thanks to the project, the Airport will analyse and evaluate existing and future strategies, concepts and techniques to improve intermodal solutions. Pula Airport is especially interested in improving and integrating communication and transport between units, and in opportunities to implement new innovative technologies according to the latest environmental and sustainable development principles.

The new solutions tested at the Airport will reduce airport air pollution and will better integrate airport systems. Gained experience and benchmark information will provide inputs for the future sustainable development of the whole region.

IV. DESCRIPTION OF PILOT ACTION IMPLEMENTED

Pula Airport pilot action is divided into two main areas:

- three multi-standard DC charging stations for six electric vehicles on the airport landside,
- electrical towing tractor for ground handling.

Purchase and implementation of three multi-standard DC charging stations for six electric vehicles on the airport landside will significantly lower CO_2 emission. The major benefit of DC charging stations for electric cars is the contribution that they can make towards improving air quality in towns and cities.

This reduces air pollution considerably. It will be visible to the stakeholders and general public contributing to the airport green field policy and zero emission strategy adopted within Pula Airport and presented to the public.

Daily operative activities performed by ground handling staff on the apron are supported by towing tractor for ground handling which has good manoeuvrability and a small turning radius and reduces congestion around the aircraft. These congestions have influenced the optimization of Pula Airport airside processes, resulting in non-cost-effective processes.

During the ADRIGREEN project, Pula Airport monitored the performance of airport staff and business processes flow comparing usage of electrical and non-electrical towing tractor and concluded that airport processes are more cost-effective and environmentally friendly at the same time by usage of an electrical towing tractor.

Therefore, within the ADRIGREEN project, Pula Airport has purchased an electrical towing tractor for handling ground support equipment on daily basis to reduce consumption and airborne pollutant emissions.

V. ENVIROMENTAL ANALYSIS

Financial analysis

Pula Airport has performed a financial analysis of equipment purchased and used. In conducting financial analysis following assumptions were taken into the consideration:

- purchase price of new chargers for electrical vehicles,
- purchase price of new vehicle and old,
- additional yearly maintenance expenses for electrical vehicle,
- additional yearly maintenance expenses for electrical chargers,
- the economic life usage period of chargers (15 years),
- the economic life usage period of electrical vehicle (8 years).

Other information:

- chargers Terra 54 for electric vehicles was purchased and put in use in June 2020.
- electric vehicle VET-17kN for aircraft handling process was purchased and put in use in June 2021.

According to financial analysis, purchase of electric vehicles is more feasible on respected period. Financial analysis is presented in Feasibility study for Pula Airport pilot action, for more details please see related document.

Environmental analysis

Within Feasibility study for Pula Airport pilot action initial environmental analysis has been performed which related to basic calculation of CO_2 emissions according to technical specifications of equipment purchased compared to the one replaced.

Accordingly, listed below are technical specifications of pilot actions:

- Towing tractor – old diesel vehicle CO_2 emission is 162 [g/km], on a yearly basis, 1.500 [km], it is 243.00 [g] per vehicle. Electric vehicles emission factor was 234,81 [g] CO_2 [eq/kWh] in Croatia in 2017.

VI. ANNEX I – TECHNICAL SPECIFICATIONS

Figure 1. *The technical specifications of Terra 54 multi-standard DC charging station*

Outlet specifications	C (default)	J (option)	G (option)	T (option)
Charging standard	CCS	CHAdeMO 2.0	Type 2 cable	Type 2 socket
Maximum output power	50 kW	50 kW	22 or 43 kW	22 kW
Output voltage Terra 54	150 - 500 V_{DC}	150 - 500 V_{DC}	400 V +/- 10%	400 V +/- 10%
Output voltage Terra 54HV	150 - 920 V_{DC}	150 - 500 V_{DC}	400 V +/- 10%	400 V +/- 10%
Maximum output current	125 A_{DC}	125 A_{DC}	63 A	32 A
Connector/socket type	CCS 2 / IEC 62196 Mode-4	CHAdeMO 2.0 / JEVS G105	IEC62196 Mode-3 Type-2	IEC62196 Mode-3 Type 2
Cable length	3.9 m	3.9 m	3.9 m	-

New features Terra 54

- Charging batteries at 150 – 500 V (Terra 54), or at 150 – 920 V (Terra 54HV)
- New ingenious connector holders, for easier handling and more stable holding
- Optional CCV or Nayax payment terminal, suited for an increasing number of countries
- Prepared for options like MID metering, integration with building management systems, cable management, etc.

Possible configurations

Terra 54 is available in the following configurations, all with CCS cable from left, and CHAdeMO cable (optional) from right side:

- Terra 54 CJG: CCS, CHAdeMO and (22 or) 43 kW AC connector
- Terra 54 CJT: CCS, CHAdeMO and 22 kW AC socket
- Terra 54 CJ: CCS and CHAdeMO
- Terra 54 CT: CCS and 22 kW AC socket

Possible configurations (from left to right): Terra 54 CT, Terra 54 CJ, Terra 54 CJT, Terra 54 CJG with optional payment terminal (not shown, amongst other, Terra 54 CG, Terra 54 CJ UL, and Terra 63 GB for Chinese market).

Further optional features

- Customized branding possibilities, including customizable user interface
- Parking bay occupance detection
- PIN code authorization
- Site load management, for one or more chargers, to avoid expensive grid upgrades
- Web tools for statistics and access management
- Integration with back-offices, payment platforms and smart grid energy systems

General specifications	
Charging sessions	1 DC session 1 DC & 1 AC session (G & T models)
Efficiency	94 % at nominal output power
EMC emission EMC immunity	IEC 61000-6-3 Class B - Residential IEC 61000-6-2 Industrial
Environment of use	Indoor / outdoor
Protection rating	IP54, IK10 (cabinet), IK8 (screen)
Operating temperature	-35 °C to +55 °C (de-rating characteristics apply)
Dimensions (D x W x H)	780 mm x 565 mm x 1900 mm
Mass	350 kg
Grid Interface	
Input AC power connection	3 Phases + Neutral + PE
Input voltage range	400 VAC +/- 10 % (50 Hz or 60 Hz)
Max. rated input current & power (@ 50 Hz)	C, CJ : 80 A, 55 kVA CT, CJT : 112 A, 77 kVA CJG, CG : 143 A, 98 kVA
Power factor (full load)	> 0.96
THD in all operating points	< 4.5 %
Operating Noise level	< 60 dBA
User & Network Interfaces	
Screen	7" touchscreen
RFID system	ISO/IEC 14443A/B, ISO/IEC 15393
Network connection	Cellular modem: GSM / 3G / 4G LAN: 10/100 Base-T Ethernet
Communication protocol	Open Charger Point Protocol (OCPP) 1.6 (and previous versions)
Options	
Local payments	Credit Cards and NFC (including Apple Pay) reader
Power meter	DC & AC certified meters
Cable management system	Charger prepared for CMS installation

***Figure 2**. The technical specifications of VET-17kN* electrical towing tractor for ground handling

OSOBINE / FEATUERS	SPECIFICIRANO / SPECIFIED	PONUĐENE SPECIFIKACIJE / SPECIFICATIONS OFFERED
Traktor za vuču/guranje opreme za prihvat i otpremu zrakoplova Towing tractor for handling ground support equipment		
Vučna sila Drawbar pull	≥ 16 kN	16 kN
Maksimalna brzina Top speed	- najmanje 25 km/h (≥) - at least 25 km/h (≥)	25 km/h
Dužina traktora Tractor length	< 3000 mm	2995 mm
Priključak za rudu: manualni u 2 nivoa Tow hitch: 2-levels manual rear hitch	- Da - Yes	Da
Prednji priključak za rudu Front tow hitch	- Da - Yes	Da
Upravljanje Steering	- Hidraulični, „servo" upravljač - The hydraulic, power-assisted steering	Hidraulični, „servo" upravljač
Dobra pokretljivost i mali radijus okretanja Good maneuverability and small turning radius	< 4000 mm – od zida do zida < 4000 mm – wall to wall	3995 mm
Sistem svjetala prema prometnim propisima Lighting system compliant to road traffic regulations	- Da - Yes	Da
2 vanjska retrovizora 2 outside rearview mirrors	- Da - Yes	Da
Sirena za vožnju unatrag Reverse horn	- Da - Yes	Da
Rotaciona svjetla – LED Rotating beacons – LED	- Da - Yes	Da
Prekidač za zaustavljanje u slučaju opasnosti Emergency stop push button	- Da - Yes	Da
Vatrogasni aparat (suhi prah) Fire extinguisher (dry-powder)	- smješten u kabini vozila - located in truck's cab	smješten u kabini vozila
Boja Colour	- RAL 9016	RAL 9016
Aerodromski logo Airport Logo	- Ne - No	Ne
AC elektromotor AC electro motor	- Da - Yes	Da
Nazivni napon Nominal voltage	80 V	80V
Snaga motora Motor power	≥ 22 kW	22kW
Kontroler Controller	80 V inverter	80 V inverter
Manualno upravljanje sporog primicanja opremi Manually controlled slow movement during the approach to the equipment ("Inching system")	- Da - Yes	Da
Baterija Battery	≥ 620 Ah	620Ah
Brzi punjač zaštićen od atmosferilija (maksimalno 8 sati) Fast weatherproof charger (max. 8 hours)	- Da - Yes	Da

VII. ANNEX II – PICTURES

Figure 3. *Terra 54 multi-standard DC charging station*

Figure 4. *VET-17kN electrical towing tractor for ground handling*