APPRAISAL REPORT

FOR RIMINI AIRPORT PILOT ACTION

Project acronym	ADRIGREEN
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Author (s)	Laura Bianchini
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CONTENT

I. EXECUTIVE SUMMARY

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

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

According to application form of Adrigreen project, Rimini Airport should implement its pilot action covering one of the four main pilot action goals identified:

- Adoption of smart solutions to improve waste and water management and to reduce energy consumption in small-medium regional Airports.

RIMINI Airport pilot action objective included adoption of smart solutions to reduce energy consumption in small-medium regional Airports.

In order to reduce energy consumption RMI mid-term strategy is to replace current diesel fuel gse park with electric one.

Within ADRIGREEN project RMI has purchased three electric vehicles used for airplan handling support.

According to environmental analysis implemented pilot action has reduced CO2 emission within DBV premises from which not only DBV employees have benefited, but also passengers of DBV airport and local community.

Analysis performed within ADRIGREEN project gives DBV Management Board clear understanding and recommendations for improvement of environmental management process in all different environment aspects. In this report energy fuel consumption is appraised for the pilot action implemented, however in other ADRIGREEN deliverables, especially in 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.

The managing body of the Cooperation Program is the Veneto Region, Italy. The national body of the Republic of Croatia coordinating the implementation of the joint programme with other participating countries is the Ministry of Regional Development and European Union funds.

The project has started in January 2019 and it is expected to end by January 2022. The total budget approved for the project amounts to 2.104.217,00 EUR, 85% of which is co-financed through the ERDF fund (European Regional Development Fund). The project will be implemented by 10 project partners.

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 low level of investments and 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 the road transportation is still predominant, the number of people that are reaching Adriatic cities by ferries and airplanes is significantly increasing year by year. However, most of Adriatic ports and airports are suffering from 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 CO2 emissions. This can be achieved by purchasing electric vehicles for transport routes between ports and airports, or for use in port/airport premises.

Steps of Adrigreen 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) Research and analysis of 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) Research and analysis of replicable operational and technological solutions

AIRiminum 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 partner was performed to assess current situation and fields for improvement.

The analysis was useful to know and evaluate all types of solutions, to choose the most applicable and useful to achieve the goal set by our airport.

Among the activities carried out by the partners there is an international investigation research was conducted in order to identify and analyse the best solutions already implemented worldwide that can be easily implemented in Adriatic region. One of the main focus areas of international investigation included on-going 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

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

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. Maximize south glazing and minimize east- and west-facing glass[2].	Yokohama	Denver, and San Francisco Airport
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	-

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

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.

B) Environmental assessment

The second step project implementation comprised of producing Environmental Impact Assessment (EIA) for each project partner based on ad hoc guidelines produced by technical expert in the project, Polytechnic University of Marche.

The technical partner provided an evaluation grid for the EIA to cover different environmental aspects, in order to assess the current situation of each partner.

With the data provided by each partner, the Polytechnic University of Marche analyzed:

- environmental impact of local air quality,

- waste and water management,

- energy consumption,

- carbon footprint,

- noise pollution.

To implement this step of the project, AIRiminum carried out a further in-depth study on the environmental impact of the airport, to improve the data provided to the coordinating partner.

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

Joint action plan definition has been produced by Polytechnic University of Marche with recommendations for improvement for each type of environmental activitiy (*please see: Adrigreen_WP3_D3_200218_Final*).
For each partner, pilot actions have been defined to be implemented.

The pilot action of Rimini Airport focuses on "the adoption of intelligent solutions to improve waste and water management and to reduce energy consumption in small and medium-sized regional airports" below are presented cases reference study for actions aimed at reducing 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

In 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

As part of the Adrigreen project, the pilot action of the Rimini airport includes the purchase of electric tractors in order to replace existing diesel vehicles with electric ones, to obtain a reduction in the consumption of fossil fuels.

The company's pilot action is in line with the recommendations specified in the definition of the joint action plan.

WP T2 – Testing phase

The testing phase is the central part of the project where the identified solutions and best practices must be put in place and tested within each partner pilot action.
First final result of this work package relating to the feasibility study for each pilot action where initial financial and environmental analyzes were performed.

The initial financial and environmental assessment of the Rimini airport pilot action demonstrated a feasible and sustainable plan to reduce fuel consumption and CO2 emissions by replacing old diesel GSEs with new electric ones.
The assessment took into consideration all the variables of economic, financial and environmental sustainability.

In the future, the project to replace diesel vehicles will be carried out from Rimini Airport until the complete replacement of old diesel vehicles with electric ones.
In addition, the project has given a push for the complete assessment of the entire infrastructure, and has indicated the best ways to go to achieve an economic and environmental sustainability of the airport terminal.

III. RIMINI AIRPORT NEEDS ANALYSIS SUMMARY

Rimini Airport has experienced rapid traffic growth in recent years which has introduced the airport to new environmental challenges, such as increased air pollution and the integration of environmental protection measures. This growth declined sharply with the arrival of the COVID-19 pandemic, which reduced the airport's air traffic by more than 90%.

Despite this slowdown, the airport continues to invest in environmental improvements, as they are considered important at the time of the resumption of air traffic.

Rimini airport is very close to city centers, which is why it is particularly sensitive to environmental issues and to cope with new environmental challenges, Rimini airport has planned several targeted projects to increase the level of multimodality / intermodality and the environmental performance of the airport.

The airport is planning how to effectively integrate the new infrastructures into existing systems, with targeted projects and collaboration of the Municipality.

These needs should be met with environmentally friendly solutions that take into account the specificities of airport technology and operations.

The ADRIGREEN Project represents a unique opportunity for Rimini 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 technology to improve intermodal solutions. Rimini 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.

Consequently, Rimini Airport pilot action includes purchasing of electric vehicles to be used in airside as ground support equipment, covering the following pilot action field:

- adoption of smart solutions to improve wastewater management and to reduce energy consumption in small-medium regional Airports

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 future sustainable development of the city’s area.

IV. DESCRIPTION OF PILOT ACTION IMPLEMENTED

Rimini Airport pilot action implemented is in compliance to third main pilot action field identified within the project: "*adoption of smart solutions to improve waste & water management and to reduce energy consumption in small-medium regional Airports*". The focus of the Rimini airport is to reduce energy consumption and carbon emissions, the proposed intervention is

- Replacement of diesel tractors with new electric tractors used for aircraft assistance activities (handling)

According to the need's analysis performed, Rimini Airport has identified following fields for improvement in landside and airside area:

- energy efficiency improvements within airport processes,
- cost effective optimisation of business processes.
- CO2 emission reduced.

Purchase and implementation of the electric vehicle for handling process will significantly lower CO2 emission and it will reduce energy consumption in performing daily processes within Rimini Airport premises since old diesel vehicles are fully replaced and put out of the function.

Also, since these vehicles are used on the airside area, it will be visible to the airlines company and general public contributing to the airport green field policy and zero emission strategy adopted within Rimini Airport and presented to the public.

V. ENVIROMENTAL ANALYSIS

Financial analysis

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

- purchase price of new vehicle (electric or diesel);
- For electric tractors, the replacement of a battery every 5 years (€ 5.600) is considered, while for diesel tractors an extraordinary maintenance for engine and traction system rectification is estimated around the 8th and 9th year (5,000 €).
- economic life usage period of vehicles (10 years).
- In 2019 the diesel tractors used for the handling activities inside the Rimini airport were used for a total of hours, and a consumption of average 1012 liters of fuel, for a total fuel cost of € 1.204,28€.
- For this analysis, the maintenance costs of the vehicles are considered similar (1.500€ every year).
- The tires will be considered to be replaced annually for both scenarios (400€);
- From the data provided by the supplier, electric tractors consume 7.3 kw / h according to the EN16796-2 standard.
- The cost of the energy considered (excluding fixed costs) is 0.6 kW/h. The estimated fuel cost (without increases) is 1.19 €/lt.
- The tractors will be used for aircraft handling operations, therefore the evaluations of use over the ten years are made through the use of traffic forecasts.

Other information:

- electric vehicles are purchase and will put in use in Febrary 2021.

Environmental analysis

Environmental analysis has been performed in two major steps:

1. Initial environmental analysis within FS of Rimini pilot action

In FS study, the environmental analysis performed relates to basic calculation of CO2 emissions according to technical specifications of equipment purchased compared to the one replaced.

Consequently, the annual CO2 production is estimated below, considering that:

- Electric tractor - CO2 emissions are estimated at 172 g / km, on an annual basis, I assume 5,000 km, that's 860 kg.
- New Diesel Tractor - CO2 emissions are estimated at 532 g / km, on an annual basis, 5,000 km, is 2,660 kg.

2. Environmental analysis based on evaluation grid for specific pilot action

Next step in conducting environmental analysis included development of evaluation grid based on specifics of each pilot action implemented and type of electric vehicles and equipment purchased.

Evaluation grid has been developed by Polytehnic University of Marche based on methodology provided by European environment agency (*1.A.4 Non road mobile machinery 2019*).

Main purpose of evaluation grid and appraisal report is to asses pilot action performance and to show how the environment and transit of passengers benefited from pilot actions.

In the paragraph below, the emissions of airborne pollutants (NOx and PM) and CO2 deriving from diesel tractors and the greenhouse gasses deriving from the use of electric tractors will be evaluated.

Emissions of airborne pollutants (NOx and PM) and CO2 deriving from diesel tractors

For the sue of 3 diesel tractors, the emissions of NOx, PM, and CO2 were evaluated following Tier 1 according to Ntziachristos et al. (2019), as follows:

$$E_i = \sum_j EF_j \times FC_j \times \frac{d}{1000}$$

where E_i is the emission value of NOx [g], PM [g], and CO2 [kg]; EF_j is the emission factor specific for the type of fuel and the type of tractor (Table 1), [g/t fuel] for PM and NOx; [kg CO2/t fuel] for CO2; FC_j is the yearly mean fuel consumption related to one of the tractors that are going to be replaced (Table 2) [g/km]; d density of diesel fuel, 0.835 [kg/l]; $\frac{1}{1000}$ is for converting kilograms to tonnes of fuel.

Sector	Fuel	Airborne pollutants and CO2	Unit of emission factor	Emission factors
Industry	Diesel	NOx	[g/t fuel]	32629
Industry	Diesel	PM10	[g/t fuel]	2104
Industry	Diesel	CO2	[kg CO2/t fuel]	3160

Table 1 Tier 1 emission factors for diesel tractors; adapted from Ntziachristos et al. (2019).

Vehicle category	Typical fuel consumption [l]
Tractor	892

Table 2 Yearly mean fuel consumption of one of the diesel tractors that are going to be replaced (source: Rimini Airport).

Emissions of greeenhouse gases deriving from electric tractors

For each electric tractor, the CO2 equivalent emission (E_i) was evaluated as follows:

$$E_i = \sum_j EF_j \times EC_j$$

where EF_j is the emission factor of 397 g CO2 eq/kWh that was determined for Italy in 2017 (Gestore Servizi Elettrici 2018); EC_j is the yearly mean electricity consumption to recharge the battery of each electric tractor [kWh]. For each electric tractor, the yearly mean electricity consumption is about 1667 kWh (source: Rimini Airport).

Results

Each year, the utilization of 3 diesel tractors would result in emitting about 3.6 times the greenhouse gases deriving from the electricity related to the use of 3 electric trcators (Figure 1). End of waste and the life cycle assement of diesel and electric tractors were not assessed.

Local emissions of airborne pollutants such as NOx and particulate matter with a diameter equal or less than 10 μm (i.e., PM10) is assumed to be null for the electic vehicles. However, the emission of airborne pollutants should be considered depending on the location of production and the technology utlised for producing electicity.

On the contrary, utilising the diesel tractors would result in local emissions of NOx and PM10 (Figure 2).

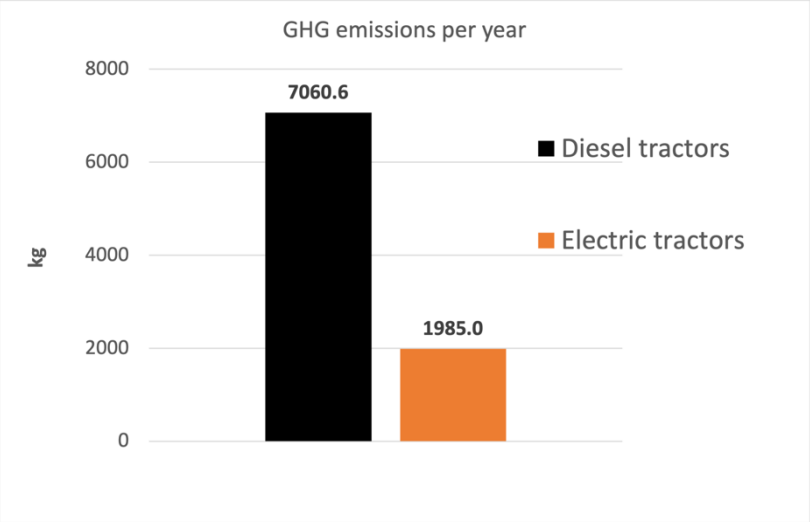

Figure 1 Comparison between greenhouse gases emissions deriving from diesel tractors (CO2) and electric tractors (CO2 equivalent) per year.

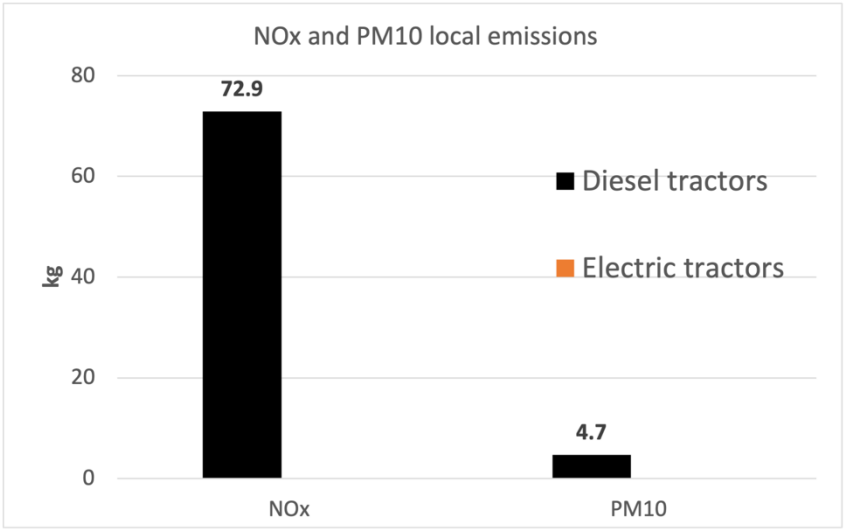

Figure 2 Comparison between local emissions of airborne pollutants (i.e., NOx and PM10) deriving from diesel tractors and electric tractors per year.

References

Ntziachristos, L.; Samaras, Z., et al. 2019. EMEP/EEA air pollutant emission inventory guidebook 2019. Available at https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/view

Gestore Servizi Elettrici. 2018. Valore del fattore emissivo relativo all'energia elettrica fornita ai veicoli stradali a trazione elettrici. Available at https://www.gse.it/documenti_site/Documenti%20GSE/Servizi%20per%20te/EMISSIONI%20DI%20CO2%20NEI%20TRASPORTI/Valore%20FE%20GHG%20energia%20elettrica%20fornita%20ai%20veicoli%20stradali%20elettrici.pdf

VI. ANNEX I – TECHNICAL SPECIFICATIONS

PRESTAZIONI	5.1	Velocità operativa a carico / a vuoto		Km/h	14 / 25
	5.5	Sforzo al gancio orario con carico		N	-
	5.5.1	Sforzo al gancio orario senza carico		N	5800
	5.6	Sforzo al gancio massimo con / senza carico		N	- / 18000
	5.7	Pendenza superabile a carico / a vuoto		%	vedi diagramma
	5.8	Massima pendenza superabile a carico / a vuoto		%	
	5.10	Freno di servizio / parcheggio (I=Idraulico E=Elettromagn. M=Meccanico)			I / I
	5.10.1	Tipo freno di servizio anteriore/posteriore			disco / dischi multipli
MOTORE ELETTRICO	6.1	Potenza nominale motore trazione S2 60 min		kW	2*10
	6.1.1	Potenza nominale motore sterzo S2 60 min		kW	0,6
	6.3	Batteria secondo DIN 43531 /35 /36 A, B, C, no			DIN 43536A
	6.4	Voltaggio batteria	U	V	80
	6.4.1	Capacità nominale	K_5	Ah	620
	6.5	Peso batteria		Kg	1565
	6.6	Consumo di energia (ciclo VDI)		kWh/h	-
VARIE	8.1	Tipo di trasmissione			inverter AC
	8.4	Livello del suono all'orecchio dell'operatore DIN 12053		dB(A)	69
	8.5	Accoppiamento di traino, tipo DIN			-

Figure 3 The technical specifications of Simai TE252.

References Available at *(https://www.simai.it//wp-content/uploads/2021/01/09IT-TE252-293-0554I1120.pdf)*

VII. ANNEX II – PICTURES

Figure 5: Electric Tractor

Figure 6: Electric Tractors