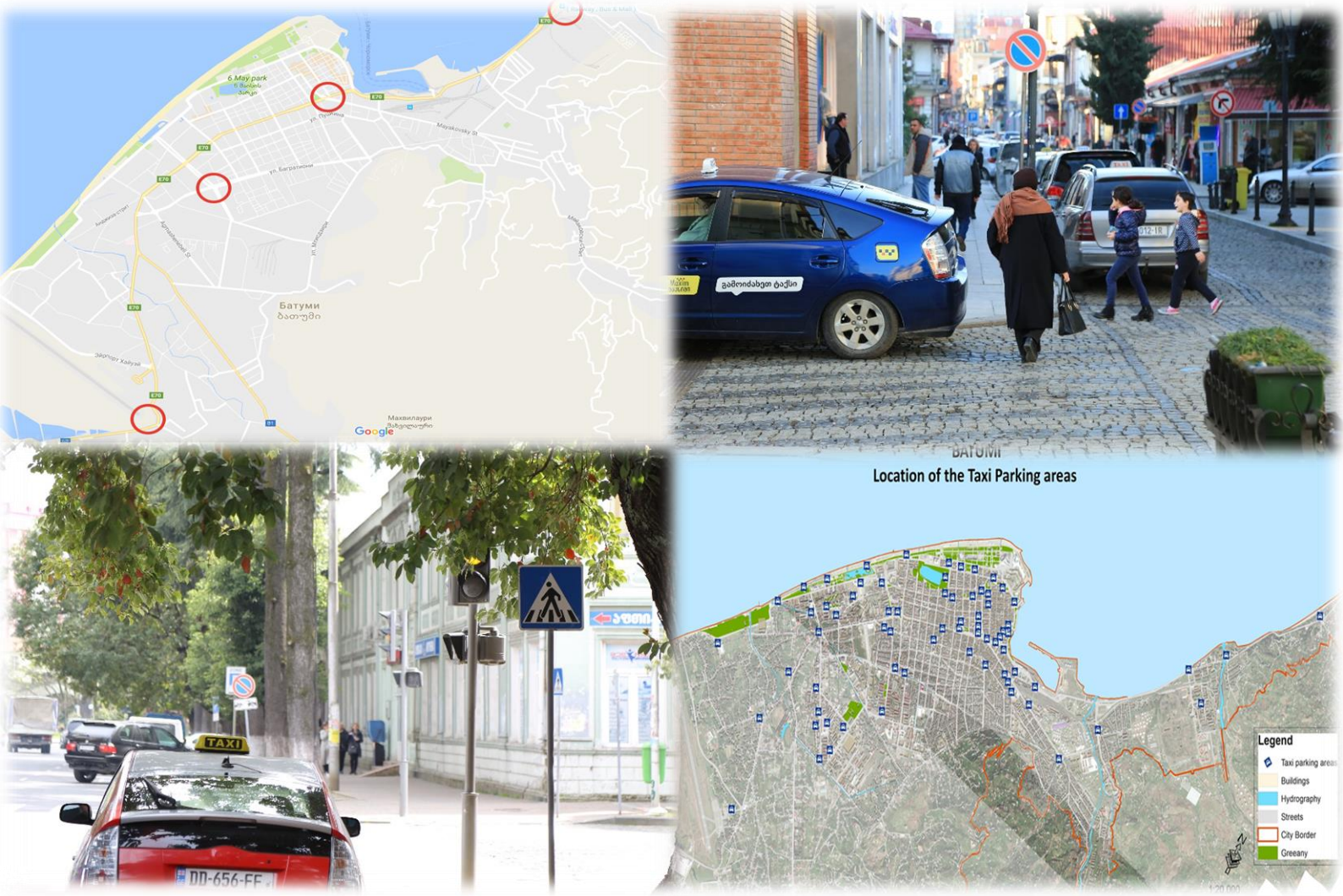
E-Taxi System for Batumi

Technical Report #7



The report has been prepared by a team of experts from A+S Consult GmbH

Sub-project: Feasibility Studies for Pilot Low-Carbon Urban Transport Corridor and Integrated Sustainable Urban Mobility Plan for the City of Batumi (ISUMP)

Output 7: Feasibility Study for Introduction of Electric Vehicles for Taxi Sector in Batumi

The report has been prepared by A+S Consult GmbH

CEO **Dr. Veit Appelt**

Team Leader **Daniel Wolf**

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INTRODUCTION

The Green Cities: ISTBAR Project seeks to initiate efforts towards reduction of transport-related GHG emissions through a green approach and in an environmentally sustainable manner. In particular, the Project will focus on the urban transport sector, a priority identified in theTNC where GHG emissions are continuously rising. As Georgia's leading tourist destination located on the Black Sea and with close economic relations with neighbouring countries, City of Batumi has an increasingly important role and function both as a sea resort and as a sea and land gate of Georgia. Due to its growth in area from 18 km2 in 1990 to 65 km2 through the inclusion of neighbouring towns and villages, Batumi's image has changed from a relatively small city into a non-uniform conglomerate with highly developed districts with modern architecture. The city's image, however, is evolving into a much larger urban conglomerate with increasingly congested streets that contribute to a growing air pollution problem. More recently, the City has shown a strong interest in green urban development and sustainable transport based on the active involvement of the City administration on these issues, and the willingness of the City to implement a demonstration for sustainable transport that can be replicated in other cities in Georgia.

This given report is a feasibility study about the possibilities of introducing an E-Taxi fleet to the city of Batumi. The study contains a baseline assessment about the current situation in the taxi sector and gives an overview about the problems that exist. Further a deeper analysis of the legislation related to taxi is elaborated and recommendations for legislation improvements are given. The following technical block will introduce to charging technology, present current models of E-Vehicles on the market and will give recommendation on the setup of an E-Taxi fleet in Batumi. The last chapters discuss the possibilities of institutional arrangements for the operation of the E-Taxi fleet and calculation of the possible reductions in GHG emissions when introducing the E-Taxi fleet.

1 BASELINE ASSESSMENT

Batumi is one of the most densely populate and fast growing city of Georgia. According to the National Statistics Office, 2010 total number of inhabitants was recorded as 140 thousand in 2010. This number reached 153.1 thousand in 2015. An increase of the city's population have led to the significant growth of the traffic flow causing the rise of CO2 emissions from the transport sector and as well as other related factors - overloaded traffic conditions, green line loss, environmental pollution and excessive noise.

In 2015 the greenhouse gas emissions of the energy sector of Adjara goes to the transport sector. The largest part (86%) of emissions from the transport sector is being spread from the territory of Batumi /1/.

In accordance with the data of 2015 the average number of vehicle registered in the region of Adjara was 750 thousand (Source: The Ministry of Internal Affairs of Georgia). The main load was on Batumi. It is also worth mentioning the role of Batumi as the tourist city, where the demand on transport services increases significantly during tourist seasons. Tourist arrivals dynamics shows how greatly overloaded is the city with urban transport means including traffic within as well as from the outside of the country. Traffic intensity in Batumi, as in the tourist city is divided into 2 phases - seasonal and non-seasonal. The Season includes about 3-month period when the intensity of traffic is 60-80% higher than the non-seasonal one /2/. The main load falls on cars. The following table shows number of visitors in Adjara according to 2014 and 2015 years.

Year	2014	2015
Total number of visitors	431 678	443 667
Domestic visitors	170 603	178 175
Foreign visitors	261 075	265 492

Table 1 - Dynamics in the number of visitors to Autonomous Republic of Adjara (years 2014-2015)
(Source: Department of Tourism and Resorts of Autonomous Republic of Adjara)

As Table 1 shows, there is a tendency of an increasing number of tourists. Tourists use various transport options that contributes to an increase in overall traffic flow. However, besides tourist season traffic intensity in Batumi is steadily observed for the entire year as well.

Table 2 shows taxi flows intensity per year for the past two years.

Fuel Category	**Units of measurement**	**2014 year**	**2015 year.**
Gasoline	Unit	370	425
Diesel	Unit	785	835
Electricity (hybrid)	Unit	125	145
Gas	Unit	465	580
Total		**1 745**	**1 985**
Average distance covered	(km/car)	60	60
1 Average number of passengers carried by taxi in a day	(passenger)	10	10
Average expenditure for 1 gasoline engine car	(L/100 km)	10	10
Average expenditure for 1 diesel engine car	(L/100 km)	8	8
Average energy expenditure for electricity	(kilowatt. h/100 km)	20	20
Average fuel expenditure for gas	(cubic m/100 km)	10	10
Total fuel expenditure for all vehicles – Gasoline	(Tone)	15 540	17 850
Total fuel expenditures for all vehicles – Diesel	(Tone)	26 376	28 056
Total fuel expenditures for all vehicles - Gas	(Cubic/m)	19 530 000	24 360 000

Table 2 - Traffic flow dynamics for taxi in Batumi (years 2014-2015) /1/

In addition, it should be emphasized that 60-70% /2/ of taxis operating in the city are moving in a disorganized manner. Most of them have bad technical conditions, damaged fuel regulation system and expired operational period, which is important in terms of GHG emissions in the atmosphere and from passengers' safety perspective as well. Most of the taxis operating in the city are owned by individuals, the

rest of them are owned by commercial companies which have necessary infrastructure to ensure organized traffic in the city.

Taxi fare is determined in relation to fuel prices and market conditions. Average fare within the city is 0.60-0.70 Gel per 1 km (consultants investigation) which can be considered as quit high and not affordable for the majority of population.

In addition, disorganized flow is a negative factor for ensuring a competitive environment for the development of taxi system in Batumi.

There are about 10 operating taxi companies in Batumi that own transport fleets with 150 cars in total /2/.

2 LEGISLATION

2.1 Existing Situation

There are no separately ratified laws and regulations of transport system for Autonomous Republic of Adjara. However, laws adopted by the Parliament of Georgia, agreements between the Government of Georgia and foreign countries and existing legal acts as well regulate transport and transport-related activities throughout the country. In addition, Georgia as a country that recognizes principles of democracy is adhered to various conventions that are important towards elimination of transport-related problems and harmonization of standards for the minimization of environmental impact.

Technical regulation in the transport sector is realized by the subordinate regulatory acts, in particular, list of technical regulations is given in the order №1-1/883 of the Minister of Economy and Sustainable Development of Georgia. Elaboration of orders and their adoption is delegated to the Legal Entities of Public Law under the umbrella of the Ministry of Economy and Sustainable Development of Georgia - Civil Aviation Agency and Maritime Transport Agency, while the Land Transport Agency elaborates technical regulations for the land transport but it is adopted by the order of the Minister of Economy and Sustainable Development of Georgia.

Law of Georgia on Management and Regulation of Transport Sector determines a main organizational principles and legal basis of management and regulation of the mentioned sector, state policy and technical regulating bodies and division of their activities.

Road transport field is regulated by the Law on Road Transport, which determines the main goals of the field, management and rule of issuing of permits.

2.1.1 Acting laws

"Law of Georgia on management and regulation of transport sector" (30.03.2007 #4593) determines a main organizational principles and legal basis of management and regulation of transport sector in Georgia. The law applies to all transport sector related actors and means of transport in Georgia. The main goal of this law is to determine legal basis of operation for technical regulatory bodies in transport field. It also determines technical parameters for safety norms and monitoring mechanisms. The law regulates measures that ensure traffic safety for passenger and freight as well as requirements for the safety of aerial works. After the enactment of this law, the Law of Georgia on Management and Regulation of Transport Sector (July 20, 2001) was invalidated. Changes were made because of transformation of the legal entity – National Commission of Transport Regulation of Georgia into the United Transport Administration – legal entity of the Ministry of Economic Development of Georgia.

Law of Georgia on Ambient Air Protection – this law regulates protection of ambient air from harmful anthropogenic impacts in the territory of Georgia. The law establishes permissible limits of emissions of harmful substances into ambient air from motor vehicles and other mobile and mechanical means.

Legal requirements are established by EU legislation. In particular: the limit values of emissions (exhaust gases) from different types of vehicles and other mobile and mechanical means polluting ambient air by harmful substances is determined according to the EEC (the European Economic Community) Council Directive 70/220/EEC of 20 March 1970 on the approximation of the laws of the Member States on measures to be taken against air pollution by emissions from motor vehicles, the EEC Council Directive 72/306/EEC of 2 August 1972 on the approximation of the laws of the Member States relating to the measures to be taken against the emission of pollutants from diesel engines for use in vehicles, the EEC Council Directive 88/99/EEC of 3 December 1987 on the approximation of the laws of the Member States relating to the measures to be taken against the emission of gaseous pollutants from diesel engines for use in vehicles and the European Community Council Directive No 96/96/EC of 20 December 1996 on the approximation of laws of the Member States relating to roadworthiness tests for motor vehicle and their trailers.

The limit values of emissions (exhaust gases) from different types of vehicles and other mobile and mechanical means polluting ambient air by harmful substances that are determined on the basis of these requirements, are approved by the Minister of Environment and Natural Resources Protection of Georgia in agreement with the Ministry of Health and Social Affairs of Georgia by the Order on the Introduction on the Territory of Georgia the limit values provided by EU legislation for emissions (exhaust gasses) from different types of vehicles and other mobile and mechanical means polluting ambient air with harmful substances. Organization of environmental monitoring is under the responsibilities of the Ministry of Environment and Natural Recourses Protection and the Ministry of Health and Social Affairs of Georgia. Organization of control system on the territory of municipalities is under the responsibility of the relevant governmental organizations.

Law of Georgia on Road Traffic Safety – determines legal basis for ensuring road traffic safety in the territory of Georgia in compliance with the Constitution of Georgia. This law envisages harmonization of technical requirements for road transport with international standards and prohibits operation of technically faulty vehicles.

2.1.2 Orders and Resolutions

Order of the Minister of Environment and Natural Resources protection of Georgia on the Approval of the Minimum Standard Number, Placement and Rules of Operation for the Ambient Air Pollution Level Observation Points/Stations, and a List of Standard Methods for Measuring Pollution Levels. (July 28, 2003. #67) – The order determines an instrumental method for measuring of the actual amount of emissions into ambient air from stationary sources of pollution and for determination

of the quantitative and qualitative properties of emissions, including coefficient of emission of harmful substances for motor vehicles during combustion of 1 ton of liquid fuel or 1000 cubic meter of compressed gas – see Table 3.

Harmful substance	**Gasoline**	**Diesel**	**Liquid Gas**	**Compressed Gas**
Carbon Dioxide CO	0,44	0,125	0,44	0,22
Nitrogen Dioxide NO2	0,025	0,035	0,025	0,025
Sulfuric Anhydride SO2	0,002	0,02	_	_
Hydrocarbons CxHy	0,08	0,055	0,08	0,05
Soot	0,0006	0,015	_	_
Lead Pb X	0,3 kg		_	_
Benzapiren C20H12	0,23 gr	0,31	_	_

Table 3: coefficient of emission of harmful substances for motor vehicles during combustion of 1 ton of liquid fuel or 1000 cubic meter of compressed gas

Resolution N124 of the Government of Georgia on Motor Fuel Quality Standards (December 31, 2004. #124) – Meeting EU requirements for environment protection in Georgia is determined as one of the priority direction of the country. Ensuring the environment protection from GHG emissions and adopting fuel quality regulations are necessary in process of introduction of EU standards.

Currently, environmental characteristics of Gasoline (in particular, content of lead, benzene, sulfur and aromatic hydrocarbon) in Georgia do not comply with EU norms. That might cause significant social problems trough increasing the risk of spreading of airborne, respiratory, and oncological diseases. In order to harmonize quality of gasoline with EU environmental quality norms, the resolution determines gasoline grades according to the national standards and number of octanes in gasoline that have been determined based on ISO standards and EU norms. The resolution does not considers restrictions.

Quality and environmental properties before 2007:

- Sulphur content mg/kg – no more than 350
- Density 150C, kg / m3 - no more than 845
- Polycyclic aromatic hydrocarbon content – no more than 11

Quality and environmental properties from January 1, 2007:

- Sulphur content mg/kg – no more than 50
- Density 150C, kg / m3 - no more than 845
- Polycyclic aromatic hydrocarbon content – no more than 11

Order of the Minister of Environment and Natural Resources protection of Georgia on the Approval of the Regulation on Environmental Impact Assessment (04.10.2011) - The order regulates legislative relations with respect to the environmental impact assessment, including determination of amount and properties for various emissions and waste generated during the different technological processes and levels. The amount and properties of emissions and waste should be considered for elaboration of plans for transportation, disposal and liquidation of their generating source.

2.1.3 International agreements

Framework of Financing Agreement between Government of Georgia and ADB (Sustainable Urban Transport Investment Program) – envisages development of urban transport in Georgia, introduction of modern urban transport systems in regions of Georgia, replacement of existing old vehicles with new environmentally-friendly ones.

2.1.4 Conventions

Resolution of the Parliament of Georgia on Road Markings Additional to the European Agreement Supplementing the Convention on Road Signs and Signals Opened for Signature at Vienna on 8 November 1968. According to this resolution, Georgia was adhered to the European Agreement Supplementing the Convention on Road Signs and Signals Opened for Signature at Vienna on 8 November 1968 done in Geneva on 1st of May 1971 and to the Protocol on Road Marking done on 1st of March 1973. The convention is designed to increase road safety and aid international road traffic by standardizing the signing system for road traffic (road signs, traffic lights and road markings) in use internationally.

European Agreement on Work of crews of Vehicles Engaged in International Road Transport (AETR) concluded at Geneva on July 1, 1970. (Was ratified in Georgia on November 19, 2011). Adhesion to the Convention ensures introduction of minimum standards for traffic safety, work conditions and competition in the road transport field.

2.1.5 Normative acts adopted by the Municipality of Batumi

Ordinance of the Executive Body of the Self-Government of Batumi – Chairman of the City Council on the Competition Announcement and Establishment of the Committee for issuing of permits for regular passenger transportation with M2 category vehicle within the territory of Batumi (May 10, 2012. #02/213). The ordinance regulates passenger service with M2 category vehicles, controls suitability of the technical requirements of vehicles and ensures reduction of number of those vehicles from 668 to 440 units.

Adhesion of Batumi Municipality to the Covenant of Mayors Initiative (July 5, 2011) – Joining this initiative Batumi took a voluntary commitment to reduce CO2 emissions on its territory trough the implementation of various actions determined by Sustainable Energy Action Plan of Batumi which was adopted by the City Council in 2014. Transport sector represents one of the major fields of activities towards the reduction of GHG emissions and meeting the requirements set by the initiative.

2.2 Recommendations for legislation and regulations

At the national level – Currently, there is no acting legislation covering the passenger traffic issues through private transportation vehicles in Georgia. Usually, having a private or rented car and a taxi sign are enough to start a taxi business. There are no regulatory frameworks for technical requirements and standards for the passenger carrying vehicles as well. Therefore, it is important that taxi-related norms and regulations are laid out in acting laws of Georgia. Even though definition of "taxi", technical requirements for vehicles, rights and obligations for all drivers and transporters (physical or legal person) are set out in the technical regulations adopted by the order of the Minister of Economy and Sustainable Development of Georgia, to the Rules on Transportation of Passengers and Goods by Vehicles (order №1-1/1559; 18.08.2011), it is not sufficient to ensure taxi operation in compliance with standards. It is crucial that the term "taxi" is defined as a small passenger-carrying vehicle at the legislative level. Based on the studies implemented in Georgian municipalities, transport-related legislation should include the following specific records:

- **Organic Law of Georgia – Local Self-Government Code** - Municipality's own powers (Article 16) - records on regulation of municipal taxi.
- **Law of Georgia on Management and Regulation of Transport Sector** (March 30, 2007. #4593) – State policy of transport sector (Article 5) – Field of activities of transport regulating bodies such as Land Transport Agency should cover taxi regulations and all issues in relation with the transport regulation mechanisms.
- **Law of Georgia on Road Transport** – even though the law determines legal, economic and organizational basis for the road transport activities and applies to all vehicle owners and road transportation actors regardless of their organizational and legal status and subordination, it

does not states anything about taxi regulations. The law shall contain record on taxi in the types of activities that are subject to the issuing of a permit (Article 51).

- **Law of Georgia on Licenses and Permits** - The Rule of Issuance of the Multiple Permit for International Automobile Transportation Set by the International Treaty of Georgia and the Rule of Issuance of the Multiple Permits for International Automobile Transportation Set on the Basis of the International Treaties of Georgia (Article 263) shall indicate what types of permits are issued, including permit for taxi operation and shall indicate relevant authorized institutions for the issuance of a license. Definition of terms, used in this law shall also contain definitions for different categories of transport, including taxi.

At the local (municipal) level – issuance of permits for regular carriage of passengers within the municipality's administration and organization of municipal transport services for the population including operation of city buses and mini-buses are regulated by various normative and subordinate normative acts. It is important to elaborate normative act for taxi regulations that will determine rules for issuing of permits, amount of permit fees, and arrangement of parking systems. It is important, that existing normative acts are reviewed and additional records are made in relation with taxi. Transport sector on municipal level is regulated by the following normative acts adopted by the City Council of Batumi Municipality:

- Ordinance of the City Council of Batumi Municipality (30.03.2012 #18) determines the rules for the announcement of a competition for issuing of permits for regular passenger transportation with M2 and M3 category vehicle within the territory of Batumi. It also sets a permit certificate and a permit registry forms and rules to fill them out. It is necessary to determine taxi as M3 category vehicle. Mini-buses, minivans and taxis should also fall under M3 category vehicles. Meanwhile, competition rules for issuing permits for taxi operators should be prepared based on the above-mentioned ordinance and within the competence of the municipality.
- Ordinance of the City Council of Batumi Municipality (30.03.2012 #73) determines lanes and routes for passenger transportation with M2 and M3 category vehicle within the territory of Batumi. It is obvious that a route for taxi cannot be determined in advance, however the ordinance shall state, that it is applied to all M2 and M3 category vehicles except – taxi. This will already indicate on other regulatory acts applied for taxi.
- Ordinance of the City Council of Batumi Municipality (30.03.2012) – determines the fees for granting a permit for regular urban carriage of passengers with M2 and M3 category vehicles within the territory of Batumi. It is important that Law of Georgia on licenses and Permits also includes records on taxi before the fees for granting a permit for taxi

is determined. It will allow the municipality to officially adopt permit for taxi operation and amount of permit fee.

- Ordinance of the City Council of Batumi Municipality (28.02.2013 #4) - sets parking system regulation norms. In particular, rules for determination and use of parking spaces. The ordinance also sets out norms and rules for use of special parking spaces designated for taxi.
- Ordinance of the City Council of Batumi Municipality (28.02.2013 #4) – The ordinance determines parking charges for use of public and special parking spaces on a daily and hourly basis. It is important that the ordinance sets parking charges for taxi separately from charges for other light vehicles.

3 CHARGING STATIONS

3.1 Charging Technology

Currently the most common solution for charging is Level 1 and Level 2 **AC charging**. It implies that there is an on-board charger, which comes factory-installed. It converts AC power from the wall to DC power that charges the battery in the vehicle. The charging speed may vary, but the most common on-board chargers are 6.6 kW upt to 9.6 kW on battery electric vehicles. The loading station can be a simple docking station to everywhere available AC current.

A typical household outlet can continuously provide up to 1.4k W, and "high-power" 240V outlets sometimes found in garages and RV parks can provide up to 9.6 kW. It is technically possible for a car to convert far more power than that, but the equipment would be bulky, heavy, expensive, and hot – and anything over 9.6kW would see infrequent use because higher-power outlets are not available.

DC charging stations have special grid hookups so they can get and convert far more power. DC stations are big, expensive and have a lot of cooling – it wouldn't be practical to put that equipment in every car, even if there was a way to plug directly in to the grid. DC charging stations are oftern refered to as Level 3 charging, as it provides much more power to quickly charge the cars battery. Hyundai Ioniq with a 28kW battery can be charged within 30 minutes to 80% of battery capacity with a 50kW DC charger. The problem with this technology, is according to reports, may shorten the long term life of the battery. Car manufacturers offer the opportunity not to buy the battery but to lease it. For the E-Taxi fleet it should be an option to lease the battery, as the charging cycle will be frequent. Leasing of battery is a common option, which is offered by car manufacturers (e.g. Renault Zoe is offered for 24.900 Euro without battery, leasing cost of battery ranges from 69 to 119 Euro per month /3/)

DC Level 3 charging includes currently three manufacturer wide protocols. CCS, Chademo and the proprietary Tesla SuperCharger protocol.

"CCS (Combined Charging System) is a quick charging method for battery electric vehicles delivering high-voltage direct current via a special electrical connector derived from the SAE J1772 (IEC Type 1) or IEC Type 2 connector" /4/. Automobile manufactures that support CCS include: Audi, Volkswagen, General Motors, BMW, Daimler, Ford, FCA, Tesla and Hyundai. The CharIN consortium that controls the CCS standard is working on a charging rate of 350 kW beginning in 2017. Several automakers have agreed to form a joint venture in Europe to build roughly 400 "ultra-fast" charging sites along highways on the continent to make long distance travel in electric cars more feasible. BMW, Volkswagen Group, Ford, and Daimler are heading up the venture, along with Audi and Porsche—both divisions of VW Group /5/. The goal is the quick build-up of a sizable number of stations in order to enable long-range travel for battery electric vehicle drivers. The projected ultra-fast high-powered charging network with power levels up to 350 kW will be significantly faster than the most powerful charging system deployed today. Construction on these sites is planned to start in 2017 and should be completed by 2020.

CHAdeMO is a protocol/port supported initially from Japanese automanufacturers. CHAdeMO is the trade name of a quick charging method for battery electric vehicles delivering up to 62.5 kW of direct current (500 V, 125 A) via a special electrical connector. CHAdeMO was formed by The Tokyo Electric Power Company, Nissan, Mitsubishi and Fuji Heavy Industries (the manufacturer of Subaru vehicles). Toyota later joined as its fifth executive member /6/. CHAdeMO has announced that they will introduce 150kW charging and possibly 350kW /7/.

Actually most of car manufactures are going to support the CCS standard and switching from CHAdeMO to CCS (e.g. Renault ZOE, which will get from 2019 CCS /8/)

CCS has support from more major auto manufacturers than CHAdeMO.

The charging time is mostly announced as time to get 80% capacity. After the battery gets 67% of the full capacity during the charging process, the loading station regulates the charging power continuously down to not damage the battery. E.g. to come from 10% to 80% it needs about 20 minutes. To come to 100% another 30 minutes are needed. That means that the advantage of DC fast charging, compared to the slower AC charging is when only fueling the battery up to 80%.

Charging time is higher with AC charging technology than with DC Fast Charing. A Nissan Leaf needs 4,5 hours on a 6,6 kW AC port to charge to 100% and gets 250km of distance range. On a 50kW DC fast charger (CHAdeMO) it needs 20 minutes to get 80% with a distance range of 200 km /9/.

For Batumi E-Taxi fleet we recommend to install as the base charging network DC fast charger (with connectors for CSS and CHAdeMO) for the ad-hoc need of charging. Additional for each Taxi there could be installed one AC slow charger at the parking location – overnight parking. This configuration will support the battery lifetime – by installing AC chargers – and the adhoc need for charging – by installing DC fast chargers. The DC fast chargers will form the first parts of a public network of e-mobility charging stations in Batumi. CCS has the necessary specification to support DC and AC.

	**DC chargers** **price 30K euro** 50kW (ABB Terra 53 CJG – CCS, CHAdeMO, Type2) (in 2017 there will be introduction of 150kW chargers – 350kW chargers are planned with CCS port in 2020)	**AC chargers** **price 1,5 K euro** 3-22 kW – 22kW is possible only with thrre phase current (not supported by the most of e-vehicles) On-car on-board chargers	

	1 CCS port 1 Chademo port 1 Type 2 (43 Kwt for new Renault Zoe)		

3.2 Technical Specifications of selected charging stations

Table 4 shows an overview of investigated charging stations for two types of application. The first five models are rapid chargers, established on public places with a maximum of 50 kw power. This allow for fast charging during the taxi operation time, when it is necessary – a Hyundai Ioniq can be charged to 80% within 30 minutes. The second part of the tables shows models for overnight charging at the home station. They are much more cheaper than the rapid chargers (more than 20 times cheaper), but more time is needed for the charging. It has to be noticed, that the maximum power, that the charging station can provide, depends on the capabilities of the power network and the house connection – the maximum of 22 kw is only possible if there is 3 phase current available with 7.7 kw on each phase.

DC Public Rapid Chargers	**Max Power**	**ChaDeMo**	**CCS**	**type 2 AC 43kw**	**price**
ChargePoint CPE200 DC Fast Charger - CHAdeMO & CCS	50 kw	x	x		32,500.00 €
Delta EV DC Quick Charger	50 kw	x			25,000.00 €
ABB Terra 53 CJG	50 kw	x	x	x	29,000.00 €
Efacec QC45 Rapid Charger	50 kw	x	x	x	29,000.00 €
Schneider EVlink 50 KW CHAdemo and SAE CCS Combo Dual Charger	50 kw	x	x		32,500.00 €
ChargePoint CPE200		**Delta EV DC Quick Charger**		**ABB Terra 53 CJG**	

		
Efacec QC45 Rapid Charger	**Schneider EVlink 50 KW**	
		

AC Local Overnight Chargers	Max Power	ChaDeMo	CCS	type 2 AC	Price
Mennekes AMTRON® Pro 11	11 kw			x	1,700.00 €
Siemens WB140A	22 kw			x	1,300.00 €
Charge IT Wallbox	22 kw			x	1,300.00 €
ChargePoint CPF25	7.7 kw			x	1,350.00 €
Efacec HomeCharger	22 kw			x	1,400.00 €

Mennekes AMTRON® Pro 11	Siemens WB140A	Charge IT Wallbox
		
ChargePoint CPF25	**Efacec HomeCharger**	
		

Table 4 - Overview of public and local charging stations

3.3 Proposed Public Locations in the City for Charging Stations

Generally, public charging infrastructure can be distinguished into:

- infrastructure for "on-street parkers" and
- for "interim charging".

The need for "on-street parking" infrastructure arises fromprivate drivers without own garage and workplace charging for employees at companies without own parking spots. The latter one is not absolutely necessary but offers large benefits for many private users. "Interim-charging" is needed for long-distance trips for both private and company cars. Depending on the trip purpose, interim charging can further be distinguished into charging with low power (AC charging) in the proximity of shops, restaurants, etc. and fast charging (DC Rapid Charging 50kw). On-street parkers could use the same infrastructure that is used for interim low-power charging. While the infrastructure is used by the first group overnight, the latter application would be during the day.

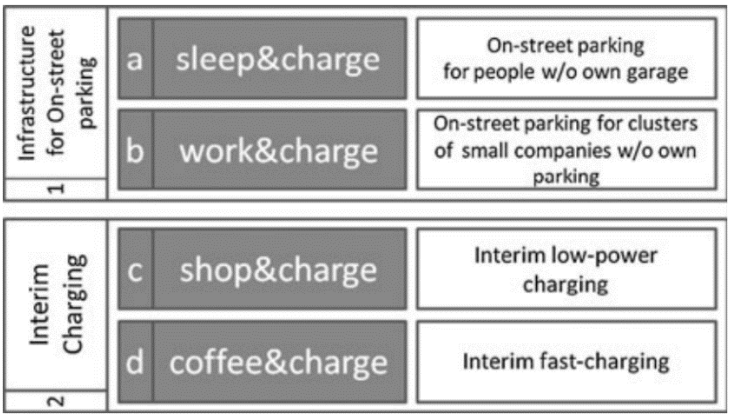

Figure 1- public charging infrastructure categorization /10/

From Table 2 - Traffic flow dynamics for taxi in Batumi (years 2014-2015)Table 2 we know, that the total kilometres per day per taxi is about 60 km. Each of the proposed cars in chapter 3 has a distance range of more than 180 km with a full battery. That means, from the point of view to operate an E-Taxi fleet, it is not necessary to establish a public charging infrastructure. It is sufficient, to have AC Local Overnight Chargers for each taxi at the home/overnight parking location and charging the car overnight with enough time. This is reasonable from the economic point of view. An AC charger costs about 1,5k Euro. This is 20 times less than one public DC rapid charger.

However, this solution will not give much strategic effect in the development of E-Mobility in Batumi as a whole. If only home-based AC slow chargers will be installed, there will be no public awareness of the availability of an e-mobility infrastructure in Batumi. The Consultant recommends to develop a network of public charging infrastructure with slow chargers for on-street parking and interim low-power charging, as well as some fast-charging stations for interim fast-charging. The setup of such an infrastructure has to be

developed in a separate project. It exists a lot of methodologies to determine the number of necessary charging stations in an appropriated region. They result in a fundamental distinction of approaches into **Maximum Possible Coverage and Demand-Oriented Coverage** /10/. While the latter takes an economic or a user-specific view, respectively, the aim of this approach is to reach a high utilisation rate of the charging infrastructure. The first approach, however, takes a more social view: a broad reachability of charging infrastructure. For each approach exist different methods for calculation.

A public charging infrastructure is not needed to operate an E-Taxi fleet in Batumi. The setup of a public charging infrastructure, not for the exclusive usage for E-Taxi is out of scope of this study. Certain calculation methodologies exist, but in the end it all depends on the strategical objectives/targets and the economical possibilities of the stakeholders (local/national authority, infrastructure operator). As well, further research is needed to determine the impact of public charging infrastructure on EV purchase decision. This is key for the understanding and prediction of real user demand for charging infrastructure.

For the moment we propose to install four rapid chargers (see Figure 2). They can serve as backup infrastructure for interim fast-charging (also for the E-Taxi), as well as a commitment of the City to the development of E-Mobility in the city.

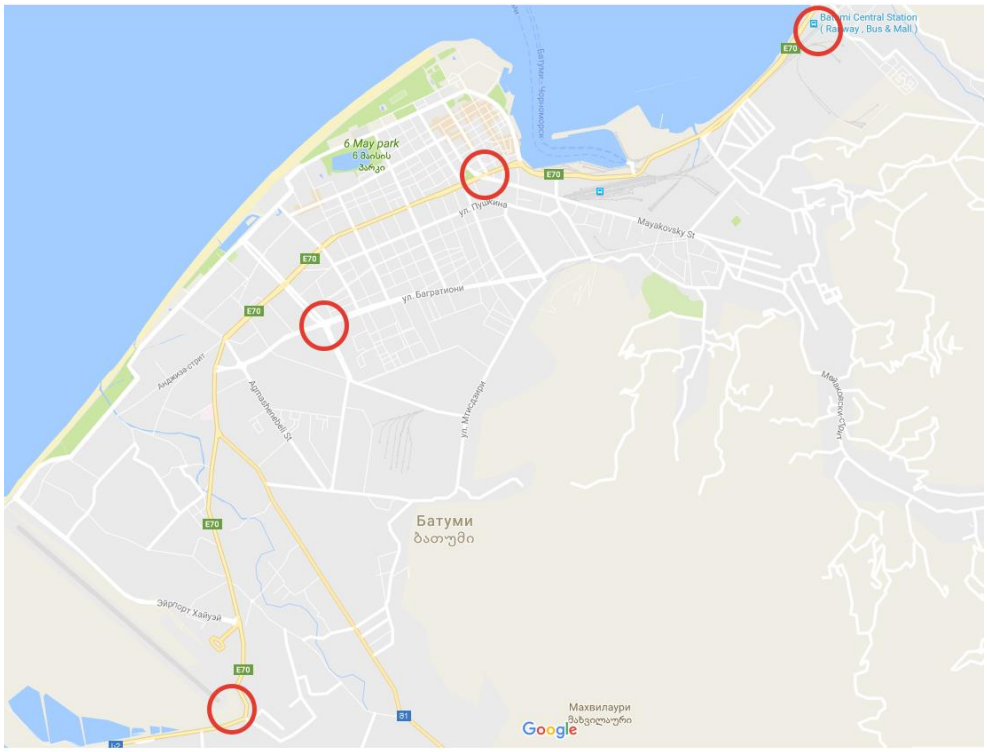

Figure 2 - proposed locations for rapid chargers (airport, train station, 2x city center)

4 ELECTRIC VEHICLES

Currently there is a lot of movement in the market for E-Vehicles. Every day announcements of new available cars are published. The development in higher battery capacity and faste charging technology is going on and has today already reached a point where the attractiveness of E-Vehicles is obviously. The consultant investigates in this chapter 4 models of E-Vehicles and compares them for the usage as part of a E-Taxi fleet in Batumi.

4.1 Technical Specifications of selected models

4.1.1 Renault Zoe

The Renault Zoe is the best selled e-car in Europe. It comes actually in a new version R400 with a 41 kWh capacity for 24.900 Euro without battery /3/. Battery costs 8.000 Euro. Renault Zoe only supports AC charging, which support up to 43 kW (if there is three-phase current available the charging time can be reduced to 30 minutes, otherwise with a normal home outlet 1-phase of 4,6 kW it takes 7,5 hours). Till 2019 Renault plans to equip the Zoe with CCS fast charging capabilities /8/. At the moment this means, that the Zoe can charged only on AC chargers and it has to be considered, that this is, due to the duration, only reasonable overnight.

The distance range regarding NEFZ standard is about 400km. Regarding the non-official, but more realistic WLTP measuring standard it should be around 290km. Assuming average daily kilometres of about 60km per taxi and day this is more than enough for the operational usage of the Renaul Zoe as taxi. The only issue may be not enough luggage space.

4.1.2 Hyundai Ioniq Electro

The Hyundai Ioniq Electro is a middle class car which has a 28 kWh battery and comes actually in a renewed version from 2016. The price is about 33k Euro. The Ioniq supports 1-phase AC charging (on 4,6 kW it takes 6,5 hours) and CCS fast charging (50kW station to 80% charge takes 30 minutes). The luggage space should be enough for taxi requirements. Distance range regarding NEFZ is 280 km, regarding WLTP it should be around 200 km.

4.1.3 Opel Ampera-e / Chevrolet Bolt

The Opel Ampera-e is one of the freshest market entries in 2017. The battery has a capacity of 60kWh, which is enough to reach a distance of 520 km by NEFZ, and 380 km by WLTP measurement method. The

price is about 40k Euro. The car supports charging with CCS (with 50kW station in 84 minutes 80% battery capacity reached). AC 1-phase charging on 4,6kW will take 13 hours to reach 100% capacity. It is recommended to charge on a more powerful AC charger (for 7,2 kW it takes about 8 hours to charge from 0 to 100%) if this is possible to install in Batumi. The Opel Ampera-e is a good solution for long distance trips, but is highly recommended to charge the car on a DC fast charger in this case. For the taxi operation only in the city there are better choices available.

4.1.4 Nissan Leaf

Nissan Leaf was one the first low level consumer oriented e-vehicles on the market. In 2014 it was the most sold e-car in the world. The latest renewed version from 2016 has a battery of 30 kW capacity which gives a distance range of 250 km NEFZ, around 180 km WLTP. It has connectors to charge by DC fast charging CHAdeMO (30 minutes to reach 80%) and AC charging (6,5 hours on 4,6 kW to reach 100%). The

Nissan Leaf doesn't have much luggage space. Next generation of the Nissan Leaf is planned for 2018 with a 60kWh battery /11/. Price for the Nissan Leaf is abour 34k Euro.

4.1.5 VW Golf-E

The Volkswagen e-Golf in the last edition has a battery capacity of 36 kWh, which allows a distance range of 300 km by NEFZ measurement, in reality it is about 220 km regarding the WLTP measurement method. The price is about 36k Euro. The car supports CCS fast charging- but only till 40kW, which increases the charging time compared to other models. AC 1-phase charging on 4,6kW will take 10 hours to reach 100% capacity. The VW e-Golf support 2-phase 7,2kW charging, which can reduce to 6,5 hours overnight charging time. The VW e-Golf is a solid car from German car manufacturer and is always an option.

4.1.6 Recommendation

Model	Distance Range WLTP	Capacity	DC Charging Time CCS/CHAdeMO 80%	AC Charging Time 1-phase 4,6 kW 100%	Price with battery
Renault Zoe	290 km	41 kWh	-	7,5 hours	33k Euro
Hyundai Ioniq	200 km	28 kWh	0,5 hours	6,5 hours	33k Euro
Opel Ampera-e	380 km	60 kWh	1,5 hours	13 hours	40k Euro
Nissan Leaf	180 km	30 kWh	0,5 hours	6,5 hours	34k Euro
VW e-Golf	220 km	36 kWh	0,75 hour	10 hours	36k Euro

Table 5: Overview of the investigated E-Vehicle models

Table 5 shows the main parameters of the investigated E-Vehicle models. For city conditions the best option is a car with a smaller battey. The average distance a taxi is driving a day is about 60km in Batumi, so the distance range of 180-200km of Hyundai Ioniq and Nissan Leaf is sufficient for one day use and overnight charging. These two models also have the opportunity to charge by DC fast charger, which gives them the advantage to be fast recharged in high demand situations. The Renault Zoe is also an option, but currently without the fast charging option. Opel Ampera-e is a little bit bigger than Zoe and Leaf, but not that decisive that it could be an argument for the Opel. The Opel is currently the most expensive within this comparison.

The consultant recommends the Hyundai Ioniq as the best variant. It has a big luggage space, a distance range enough for the city as taxi, has a fast charging capability with CCS and has a best price of about 33k Euro. The alternative recommendation is the VW e-Golf, with good quality and sufficient parameters to operate as a taxi in Batumi city.

5 OPPORTUNITIES FOR INSTITUTIONAL ARRANGEMENT OF AN ELECTRIC TAXI COMPANY

Entrepreneurs Law of Georgia allows and regulates the legal forms of the subjects of entrepreneurial activity. Entrepreneurial activity shall be made by the following business entities: an individual entrepreneur, a general partnership (GP), a limited partnership (LP), a limited liability company (LLC), a joint-stock company (JSC, corporation), and a cooperative. Acting Law also allows registration of Non-entrepreneurial (Non-commercial) organization which uses its surplus revenues to reinvest in the company, rather than distributing its surplus income to the organization's shareholders. However, establishment of LLC for the introduction of electric taxi service is more effective and flexible in comparison to other legal forms in terms of organizational and financial management.

The Consultant proposes the following possible options for the project's institutional arrangement:

- Establishment of Electric Taxi System on the basis of Batumi Autotransport LLC;
- Establishment of a new municipal non-profit organization for the provision of electric taxi service;
- Private taxi companies trough offering relevant preferences and incentives for the provision of electric taxi service;
- Hotels or travel agencies.

5.1 Batumi Autotransport LLC

Organic Law of Georgia – Local Self-Government code allows municipality to establish organizations for implementation of various activities. Batumi Municipality is able to establish new organization or use existing transport company for the introduction of electric taxi. Batumi Autotransport LLC is operating under 100% of municipal ownership and provides public transport service.

For example, Batumi Bus project was launched based on the financial agreement between Batumi City Hall and EBRD in 2007 to ensure improved municipal transport infrastructure and service,.

In 2008, 2 000 000 Gel of the capital investment from the Government of Autonomous Republic of Adjara and 2 500 000 EUR loan issued from the EBRD were allocated to purchase 76 units of Zonda buses, equipment and spare parts.

In 2012, Batumi Municipality allocated 2 800 000 Gel and purchased 21 units of FAW buses. FAW buses are equipped with advanced technologies and adapted infrastructure to ensure enhanced access for persons with disabilities.

Currently, Batumi City Municipality is applying for loan financing from the European Bank for Reconstruction and Development (the Bank) and a grant from an international donor for a project to expand the City's fleet with diesel and electric buses to be operated by the Batumi Autotransport LLC.

Batumi Autotransport LLC has arranged infrastructure for the introduction and operation of electric taxi system. Few changes and additional services can be applied to improve organizational and operational capacities. For instance, to establish a call center and additional division for maintain works, to arrange an internal charging station etc.

It is important to notice, that Batumi Autotransport LLC is in charge of administration and management of Batumvelo - the bicycle sharing system with 370 units of bicycles and 24 bicycle terminals in its ownership.

That shows, that **Batumi Autotransport LLC** is more than only a public transport bus operator, but has the opportunity to develop itself to a **Mobility Provider** with a broad spectrum of mobility services. This is in accordance with the world wide trend of public transport providers to turn into Mobility Providers.

5.2 New Municipal Non-Profit Organization

The establishment of a new municipal non-profit organization to operate the E-Taxi fleet is an option, which requires the most efforts. A completely new infrastructure has to be setup, which costs time and expenses. An advantage is the possibility to outsource the economical risks to a separate company and not to put it on already existing structures, like Batumi Autotransport LLC.

5.3 Private Taxi Companies

One option in terms of introduction of electric taxi service is to attract private service provider companies. In this case, relevant experience and infrastructure in providing and managing similar activities is already available. It is important to provide incentives for interested companies such as tax and customs preferences, preferential parking fees, arrangement of special parking spaces, provision of free charging stations etc.

5.4 Travel Agencies and Hotels

Currently, there are about 40 travel agencies and 60 registered hotels operating in the city. Only a few hotels provide passenger transportation service. Only 5 travel agencies out of 60 have their own transportation fleet consisting of minibuses and taxis. Others use rented cars or private providers of taxi service.

As for travel agencies, only few of them have transport for provision of transportation service for tourists. Their transportation fleet mostly consists of minibuses.

Taking into consideration the fact that, foreign visitors are the major customers of the above-mentioned transportation services, replacement of internal combustion engine vehicles with electric cars will ensure comfortable transit of tourists as well as will have positive impact on the performance of hotels.

Activities	Strengths	Weaknesses	Opportunities
Establishment of Electric Taxi System on the basis of Batumi Autotransport LLC	✓ Experience; ✓ Existing transport infrastructure; ✓ Regulation of fares by Batumi Municipality ; ✓ Provision of subsidy from municipal budget if necessary.	✓ Provision of additional service that requires availability of additional recourses ✓ Additional budget expenses; ✓ Absence of qualified and experienced staff for provision of service	✓ Potential to extend existing infrastructure for electric taxi; ✓ Opportunity to provide trainings and prepare technical staff for provision of electric taxi service; ✓ Meeting EU commitment ✓ Commitment to implement activities included in SEAP
Establishment of a new municipal non-profit organization for the provision of electric taxi service	✓ Regulation of fares by Batumi Municipality; ✓ Provision of subsidy from municipal budget if necessary. ✓ Is not commercially oriented and thus is able to reinvest its profit ✓ Outsource the economical risks	✓ Additional budget expenses; ✓ Necessity of additional human resources and limited capacities related to provision of training programs; ✓ Allocation of parking spaces for taxis on the territory of the city	✓ Opportunity to establish non profitable organization allowed by acting legislation ✓ Opportunity to allocate necessary financial resources in the municipal budget ✓ Commitment to implement activities included in SEAP
Attract private taxi companies trough offering relevant preferences for the provision of electric taxi service	✓ Commercially oriented; ✓ Benefits from preferences; ✓ Experience in management of taxi service; ✓ Market leader because of using cost effective transportation means.	✓ Lack of interest towards innovation; ✓ Average or low quality service (current situation); ✓ Absence of infrastructure; ✓ Poor financial conditions.	✓ Necessity of introducing new technologies (driven by market competition) ✓ Necessity of existing car fleet renewal
To offer the introduction of electric taxi service to hotels and travel agencies operating in the city.	✓ Attracts visitors through offering a new service; ✓ Attracts visitors through demonstrating high responsibility towards environmental protection; ✓ Leader in competitive environment; ✓ Opportunity to attract additional financial resources.	✓ Lack of interest towards innovation ✓ Refuse to take additional financial obligations; ✓ Lack of experience in maintenance issues; ✓ Absence of infrastructure;	✓ Increasing number of visitors; ✓ Competitive environment that forces to introduce new technologies.

6 GHG EMISSIONS

Electric cars have per definition no direct CO2 and NOx emissions. Indirect emissions from electricity production are not dicussed here.

The following assumptions for an average conventional taxi in Batumi are made for the calculation of GHG emission reductions:

- 230g/veh-km CO2 emissions
- 0.5g/veh-km NOx emissions
- 60km per day travel distance

Regarding the former assumptions we receive an annual reduction of CO2 emissions for one taxi when substituting it with a E-vehicle of about 5.037 kg. The annual reduction of NOx emissions for one taxi when substituting it with an E-vehicle is about 11 kg.

The following table shows the reduction for some sample numbers of an E-Taxi fleet:

Number of Taxis in fleet	CO2 reductions	NOx reductions
10	50.037 kg	110 kg
30	151.110 kg	330 kg
50	251.850 kg	550 kg

Table 6 - GHG emission reductions for E-Taxi fleet

7 CONCLUSION

The report has given an overview of the present technology and possibilities for introducing an E-Taxi fleet in Batumi. The discussion of current legal issues has shown certain space for improvement, especially on the local level, where some measures are elaborated to have an efficient influence on the regulation of the taxi market.

The technical discussion in chapter 3 about charging stations gave an introduction to existing charging technologies and explained the differences between AC and DC charging and where the future potential in the development of technology lies. The recommendation for setup of charging stations is to install cheap AC charging stations for overnight charging. DC fast chargers can be installed as backup chargers and for the strategic development of the E-Mobility in Batumi.

Chapter 4 introduced a comparison of 5 popular E-Vehicle models – Renault Zoe, Hyundai Ioniq, Opel Ampera-e, Nisaan Leaf and VW e-Golf - on the market. It compared main parameters of the models and resulted in a recommendation for either Hyundai Ioniq or VW e-Golf to use for the E-Taxi fleet.

Chapter 5 elaborated an overview about possible intstitutional arrangements.

In general, the feasibility study shows that the introduction of an E-Taxi fleet in Batumi makes sense and is feasible. Batumi can make a commitment on a sustainable development of the city transport infrastructure.

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