Clean energy for EU islands: Introducing e-mobility

Kassos, Greece

Clean energy
for EU islands

Technical assistance for Kassos Project: Introducing e-mobility

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Executive summary

Kassos is an island that belongs to the Karpathos-Kassos regional unit and is located in the South Aegean Region, the southernmost of the Dodecanese. Kassos has initiated the technical assistance with a goal to analyse the energy and mobility sectors on Kassos island and provide guidance on transition to e-mobility of the road transport on the island.

The Municipality of Kassos would like to electrify the transport sector, starting from the municipal fleet. They have applied for the national programme “Antonis Tritsis” for funding for procurement of 10 EVs (including busses, fire trucks, passenger vehicles etc.). The analysis in this study focuses not only on the municipality fleet but also provide insights for future involvement of rental and local vehicles.

The study provides an overview of the current state of the energy and mobility sectors on the Kassos island, based on the available information. The main characteristics of the energy sector are that Kassos is part of Karpathos-Kassos electricity system, where electricity is generated on Karpathos Island and transported to Kassos. On the other hand, when it comes to on the island mobility it is based on the road transport with passenger vehicles and no public transport available. The road transport is characterised by seasonality, as the number of the passenger vehicles on the island doubles during the summer season. Therefore, the move to electric mobility is focused on municipal vehicles, local taxi service and private passenger vehicles.

The report provides an overview of e-mobility ecosystem indicating the involved stakeholders and their connection to electricity, mobility and land use sectors. Moreover, since the Municipality is in the early stages of planning of the transition to e-mobility we review the potential strategies for implementation of charging infrastructure. The report indicates possible ways of implementation, and which are lessons learned from e-mobility implementation in Europe.

Transition to e-mobility of an island needs to help transform the local economy. Due to this the report reviews possible business models. The business models and examples indicate possible involvement of the Municipality but also other stakeholders on the island.

Based on the available information provided by the Municipality and other involved stakeholders, the report proposes two phase initial implementation of road transport e-mobility. In the phase 1 it focuses on the electrification of four municipal vehicles with installation of 2 charging stations. Phase 1 is to be used for raising awareness and increasing knowledge of local population, stakeholders, and temporary visitors. To increase the participation of electric vehicles on the road, Phase 1 could also involve the collaboration with the local rental company for initial use of electric two wheelers to further electrification of the full fleet. Since there is no local generation on the Kassos island, Phase 1 is to be implemented in parallel with small PV installation that could cover consumption through net-metering. The report provides analysis of PV installation based on the data provided by local stakeholders. Phase 2 proposes implementation of semi-public charging infrastructure that would involve parking spaces of local businesses and gas station. However, any planning of the charging infrastructure, and especially in small energy systems, needs to be done in coordination with the DSO, to assure optimal infrastructure solutions are foreseen.

To assure transition to electric mobility benefits island and the islanders, the Municipality could use the form of energy communities to assure local citizens and businesses have privileged status in use of charging infrastructure.

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1. Kassos energy and mobility

Kassos is an island that belongs to the Karpathos-Kassos regional unit and is located in the South Aegean Region, the southernmost of the Dodecanese. It has an area of 66.4 km^2, with maximum width of 7.7 km and maximum length of 19.8 km.

The Kassos Municipality includes its island Kassos—with urban areas in Fry, Agia Marina, Arvanitochori, Poli and Panagia—and surrounding islets. Based on the latest data from 2011, Kassos has a population of 1 084 inhabitants. Fry is the capital of Kassos and the main tourist location and connection point for the inhabitants. The city of Agia Marina has the highest population though (444 inhabitants) followed by Fry (357 inhabitants). Kassos contains 1 300 houses of which 300 are estimated to be vacation houses, only periodically occupied during the year.

When it comes to the island's economic activities, the primary sector (e.g. agriculture, fishery) employs 24%, the secondary sector (e.g. crafts, industry) employs 20%, the tertiary sector (e.g. services, tourism) employs 44%, while 12% of citizens require social support. The tourism sector is in development with Fry being the main tourist destination on the island. While there are nine hotels and other accommodation units with 68 rooms available, many visitors have family in Kassos and use private accommodation.

Energy system of Kassos

Kassos is not interconnected with the mainland, but it is interconnected with the neighbouring island of Karpathos with two 15 kV cables. All of the electricity production is located on Karpathos. The electricity generation plants, with total capacity of 18.7 MW, include:

- A thermal power plant, Karpathos Autonomous Production Station, with total of 16.6 MW, which includes two 5 MW units running on fuel oil, four 1 MW, one 0.8 MW, and one 1.8 MW unit running on diesel
- A wind farm with a capacity of 0.95 MW and
- Seventeen ground PV installations[1] with a total capacity of 1.16 MW.

Due to the fact that Kassos does not have its own electricity generation, security of supply is not optimal with electricity supply interruptions.

Based on its CETA, Kassos energy needs can be split into three sectors with indicated share of final energy consumption:

- Electricity – 15 %
- Heating and cooling[2] - 3 %
- Transport – 82 %
  - To and from the island – 74 %
  - On the island transport – 8 %

[1] If rooftop installations are available they are not taken into account

[2] Excluding electricity used for heating and cooling. This is included under electricity.

The heating and cooling sector encompasses the end users that use fossil fuels[3], solar thermal[4] or biomass[5] for heating.

The electricity consumption in Kassos in 2019 was 6.6 GWh, of which 83.0% was used by households, 13.7% by the tertiary sector (including services and tourism) and 2.3% corresponded to public buildings and lighting.

Kassos and Karpathos are usually referred to as one electricity system, as all of the electricity production is located on Karpathos. Data for electricity power demand is only available for Karpathos-Kassos as a unit and it is presented in Figure 1. During the off-season periods—from October to April—the power demand is 2 MW to 7 MW, with a maximum peak corresponding to January when electricity is most likely used for heating of households. However, during the summer season—from May to October—the power demand ranges from 3 MW to 10 MW with the maximum peak in August. This corresponds to the touristic summer season when the population of these two islands increases.

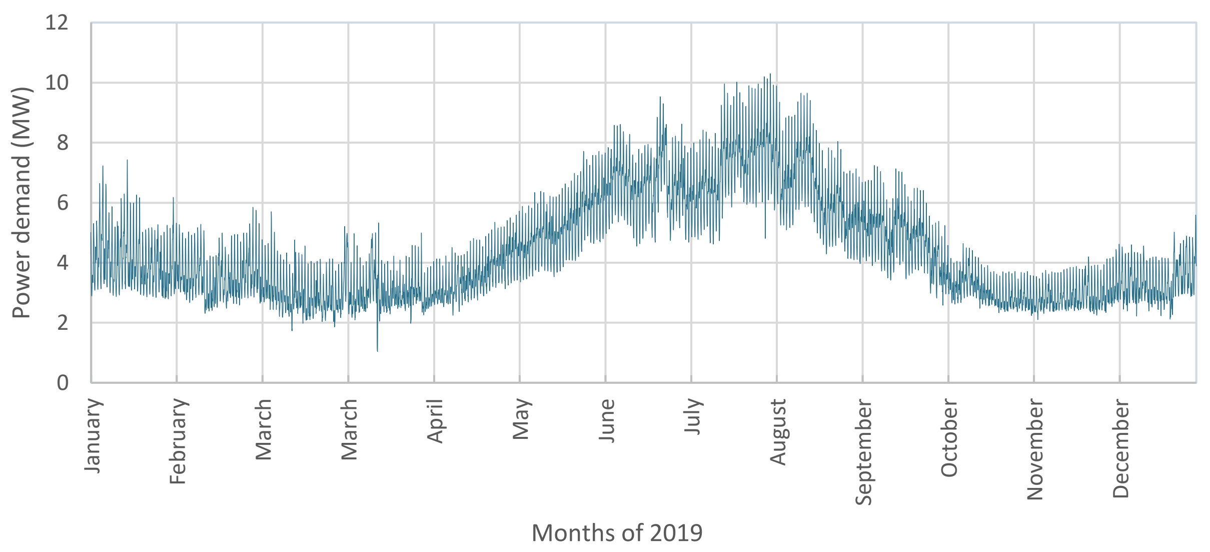


Figure 1 Annual hourly electricity demand of Kassos-Karpathos electricity system.

To analyse daily demand, we look at the average winter day, being 12 February 2019 and an average day during the summer peak of 31 July 2019, see Figure 2. Based on these, we see that the winter peak demand is from 18 to 21 h, while in the summer it is from 19 h to 22 h. Moreover, we see that the variation in daily demand on the example days in winter is within 2 MW (from 2.2 MW to 4.2 MW), while in the summer it is closer to 4 MW (from 6 MW to 10 MW). This is important to understand the system's ability to accept new renewable energy sources and their interplay with future additional electric mobility demand.

[3] CETA indicates that only the building of Gymnasium - Lyceum of Kassos uses diesel for heating.
[4] CETA indicates there is 164 homes with cca 4 m2 of solar thermal and 15 tertiary sector buildings with cca 16 m2 installed solar thermal.
[5] CETA estimated that biomass is used very rarely as heating needs are not so high, and it is used by 27 houses.

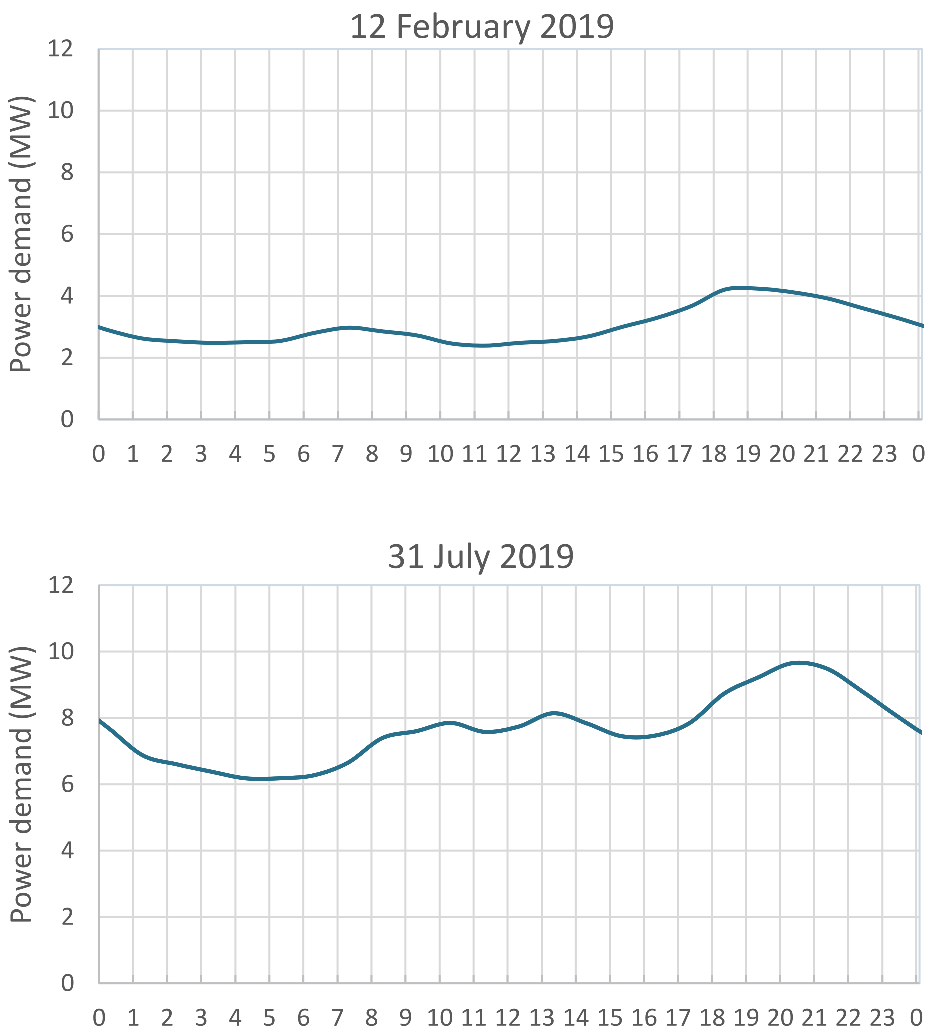


Figure 2 Daily hourly electricity demand for two example days during winter (top) and summer (bottom) period in 2019.

Mobility system of Kassos

Kassos' mobility system includes the transport to-and-from the island and transport on-the-island. Because this project focuses on the analysis of the electrification of transport system on the island, this report will focus only transport on the island.

To-and-from the island transport will be analysed only to understand the population increase on the island during the summer touristic season. In Kassos, transport to-and-from the island includes both air and marine transport.

Kassos has the Airport of Kassos Markos Malliarakis. There are daily flights during the summer season and three to four times a week in off season. The flights connect to Karpathos, and Rhodes. Air flight passenger numbers during summer season months (ca. 170) are on average four times higher than the passenger number during off season months (October – April) (ca. 40)[6].

[6] Kassos CETA 2019

Marine transport in Kassos is centred around the port in Fry. From this port there is a connection with Karpathos, and in summer Rhodes, Crete and Piraeus. Based on the data for port transport of passengers from 2012, the number of passengers during the summer season (cca 1 280) is on average three times higher than the passenger number during off-season months (cca 480), Figure 3.

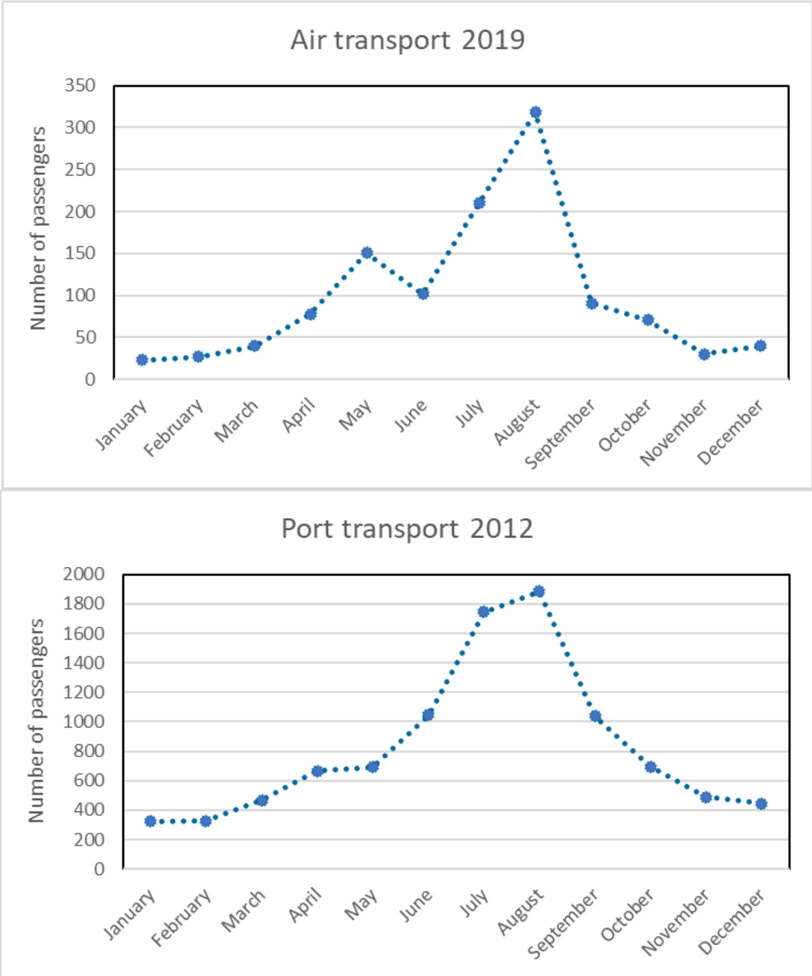


Figure 3 Number of passenger[7] transported to Kassos in 2019 using air transport (top) Number of passengers transported to Kassos in 2012 using marine transport (bottom)

The number of people in Kassos doubles during summer season if accounting for air and marine transport, assuming that all visitors to Kassos are recorded at the airport and port of Fry,. Based on the information provided by the project beneficiaries from Kassos, the number of passenger vehicles and motorcycle respectively increases from 400 and 100 during winter, to 1 000 and 200 during the summer season.

When it comes to transport on the island, all transport is road based and using passenger vehicles. Based on the information provided to the Islands secretariat, there is no public road transportation (busses) operating on the island. As previously mentioned, Agia Marina and Fry are the two urban centres on Kassos. Hence, the road infrastructure is organised to connect urban centres, airport and other areas to the port in Fry (Figure 4). There is one gas station on the island owned by the Kassos Municipality, indicated by a red dot on the bottom image of Figure 4.

[7] Provided by the Kassos Municipality

There is one rent-a-car company in Kassos with 12 vehicles and 15 motorcycles available for rent. As the number of vehicles significantly increases during the summer season, during this period most vehicles on the island arrive from outside of the island.

Figure 4 Kassos island with indicated urban populated area with major road infrastructure with blue square (top). The closer look of the area with visible local roads (bottom) Images from Google Earth.

The Municipality's fleet includes 14 vehicles, of which one is a pick-up truck, two vans, one minibus, six trucks and four industrial vehicles. There are no passenger vehicles owned by the municipality. The list of the municipal fleet vehicles indicated the municipality department that uses them, the type of fuel used, type of vehicle, brand and the year are given in Table 1.

Table 1 List of vehicles owned by the Municipality Kassos

No	**Municipality department that uses the vehicle**	**Fuel type**	**Type of vehicle**	**Brand and type**	**Year**
1	Civil protection department	Diesel	Pick-up truck	Nissan King cab	1997
2	Education department	Diesel	Van	Renault Master	2010
3	Education department	Diesel	Van	Nissan Vanette Cargo	2000
4	Administrative department	Diesel	Minibus	Otokar Cetro	2015
5	Cleaning and Environmental department	Diesel	Truck	DAF LF 230FA	2019
6	Cleaning and Environmental department	Diesel	Truck	Mitsubishi 1698 Fuso	2019
7	Cleaning and Environmental department	Diesel	Truck	Mercedes benz 814/37	2009
8	Cleaning and Environmental department	Gas	Truck	Piaggio Porter	2009
9	Technical department	Diesel	Truck	Iveco spa Magirus	2004
10	Technical department	Diesel	Industrial machine - Bulldozer	Komatsu D85EX-15	2004
11	Technical department	Diesel	Industrial machine – Motor grader	Komatsu GD 521 A1E	1999
12	Technical department	Diesel	Industrial machine – Backhoe loader	Komatsu WB93R-2	1999
13	Technical department	Diesel	Industrial machine – truck loader	Caterpillar 953	1988
14	Withdrawal		Truck	Mercedes benz 2628K/38	1989

2. Electrification of mobility on Kassos

Road transport electrification represents a main pillar of Kassos Clean Energy Transition Agenda (CETA), completed in 2019. This chapter provides an overview of the benefits and challenges that Kassos faces with the implementation of e-mobility.

Currently, all road transport on Kassos is dependent on fossil fuels. The transition to e-mobility could help decrease this dependence, decrease air pollution, and reduce CO_2 emissions. However, for e-mobility to be sustainable, the needed electricity should be produced by renewable energy sources

Kassos is a geographically small island with a compact community. This makes it ideal for the implementation of electric mobility as the distances of the return trips throughout the island do not exceed 50 km. The average range of the market's available electric vehicles today is 313 km, with the minimum range being 95 km. Assessing different aspects of electrifying road transport, presented below provides advantages or disadvantages of its implementation in Kassos:

Advantages	Disadvantages
No range anxiety due to short distances	No electricity generation on Kassos yet
Chargers in more densely populated areas due to short distances	EVs are not used by locals yet
Explore use of electric motorcycles and bikes – can serve short distances	Kassos is a small market – not many local public or fleet vehicles to start with
Regulation for no-fossil fuel-based vehicles and tax their use to fund e-mobility	EV chargers require capacities comparable to multiple single household users – roll-out has to be planned with all stakeholders involved (DSO, municipality, etc.)
EVs can serve as storage if V2G chargers are used – for integration of RES into the local grid to improve security of supply	Need for maintenance on the island/or maintenance contract for EVs
EV batteries can serve as backup to improve quality of supply	

Specifics of small island ecosystems

As an island, Kassos has a few specific characteristics which have to be taken into account when planning the switch to e-mobility. These characteristics include seasonality in the demand of mobility and a compact community with a small market.

As previously discussed, seasonality is seen not only in the electricity consumption but also in the mobility needs. Namely during summer season (May to October) the number of inhabitants of Kassos doubles. This is followed by the increase in the number of passenger vehicles and motorcycles on the roads in Kassos which also doubles during the summer months.

Therefore, Kassos' shift to e-mobility needs to be introduced to both the local transport infrastructure and the local vehicles, but also reinforced for the vehicles arriving on the island. This can be done through local regulation which would introduce a tax for vehicles with internal combustion engines entering the islands. This tax could be used to pay back the public charging infrastructure needed for electric vehicles.

In addition, Kassos represents a small market, where the Municipality should collaborate with local business owners, such as the rent-a-car company and other services to ensure the reinforced measures are coordinated with all stakeholders whose livelihood depends on local economy.

Understanding the e-mobility ecosystem

A basic understanding of all the actors involved in the e-mobility ecosystem is necessary to transition to e-mobility. This section provides an explanation of the main actors in the e-mobility ecosystem and the contractual framework needed to ensure its optimal functioning. The scheme in the Figure 5[8] shows:

- The interrelation between different stakeholders needed for e-mobility
- The contractual relations related to electricity, land use, mobility, and charging that allows for smooth operation of the system and
- The collection points of data used for the optimisation and planning of mobility, electricity and land use.

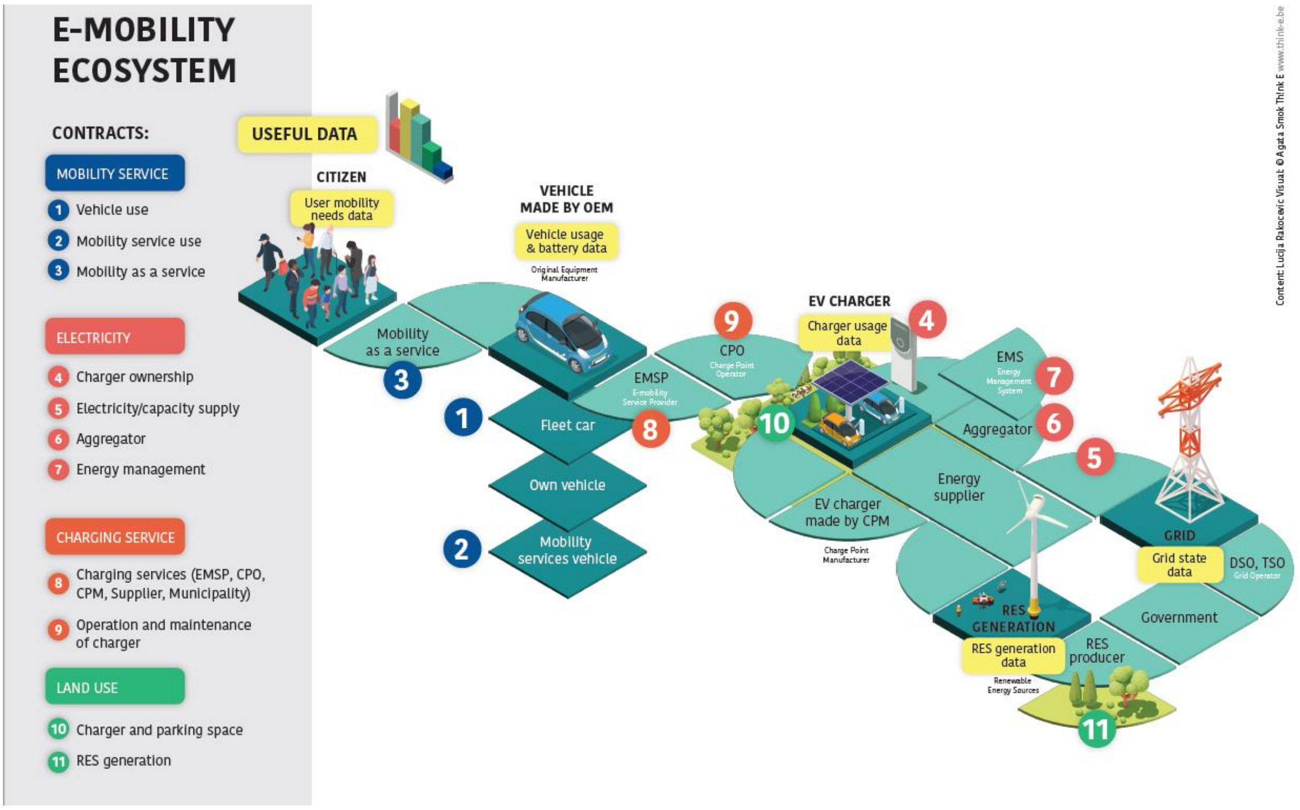
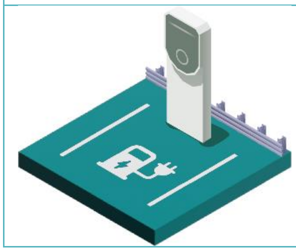


Figure 5 The scheme of e-mobility ecosystem with main actors, contractual agreements and data

E-mobility revolves around citizens who will use electric vehicles (EVs) to fulfil their mobility needs. For EVs to operate, the battery needs to be charged using electricity. The charger needs to be placed on a parking location for which land use is needed. The electricity can be used from the grid, or ideally from a local renewable energy generation source, such as PV or a wind turbine.

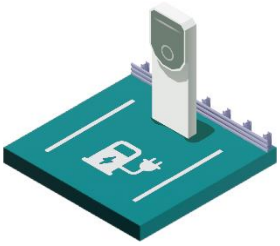
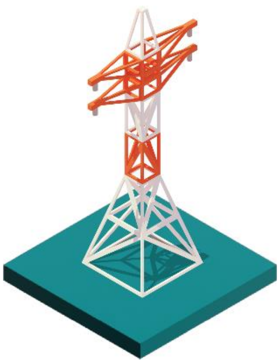
[8] The Greek translation of the Emobility ecosystem scheme is provided in Annex 1

From the **mobility** point of view there are the following stakeholders and related mobility contracts:

Icon in the scheme	Name of stakeholder	Mobility contract
	Citizen, mobility user	Mobility-as-a-service contract to choose from different mobility options (public transport, taxi, rental vehicles etc.)
	Electric vehicle owner: • citizen, • fleet operator (rent-a-car company, car sharing, etc.) • mobility service operator (taxi, public transport, etc.)	Vehicle use contract Mobility service contract
	Charger and related parking space owner	<u>Operation and maintenance of charger contract</u>

From the **electricity** point of view there are the following stakeholders with their characteristics:

Icon in the scheme	Name of stakeholder	Characteristics
	Citizen, EV user	Owner of an EV
	Mobility service provider (taxi, rent-a-car, public transport etc.)	
	Electric vehicle (EV)	Driving range (battery capacity)
	Original Equipment Manufacturer (OEM)	Vehicle-to-grid (V2G) capability
	E-mobility service provider (EMSP)	Company providing access to charging points to the EV user

	EV charging point or charger	AC or DC charging Power capacity (kW) Charging current Smart charging capable V2G capable
	Charge point manufacturer (CPM)	
	Charge point operator (CPO)	Company operating multiple chargers
	Energy management system (EMS)	Company managing energy use by an EV, charging by EV charger, electricity production by RES producer
	Aggregator	Company that aggregates energy capacity provided by multiple charger/EVs Capacity can be offered to DSO for balancing or on the wholesale energy market
	Electricity grid	Available capacity at the connection Possible current for charging
	Distribution system operator (DSO) or transmission system operator (TSO)	
	Energy supplier	Company providing electricity to the user
	Renewable energy source (RES) generation plant	At the location of a charger Separate RES plant Might include additional storage Connected to the grid or behind the meter of the charging station
	RES producer	

The function of some of the electricity stakeholders overlap. The electricity and charging contracts are:

- Charger ownership contract
  Function: Regulating ownership of the specific charger.
  Contract sides: Contract signed between new charge owner (citizen, local government, fleet company, company etc.) and the charge point manufacturer (CPM).

- Electricity/capacity supply
  Function: Contracting allowing consumption of electricity with defined capacity by the charger and in case of V2G injection of electricity into the grid by the charger.
  Contract sides: Charge point operator or charger owner and DSO, energy supplier or RES producer.

- Aggregation contract
  Function: Providing control of EV batteries through chargers to aggregate energy capacity when needed.
  Contract sides: Aggregator and EV owner and charger owner/operator.

- Energy management system contract
  Function: Controlling EV charging, RES generation and charger use to balance energy consumption and use to have the least effect on the grid or minimum price for the user.
  Contract sides: EV owner, charger owner, RES producer or DSO and EMS company

- Charging services contract
  Function: Access to specific chargers.
  Contract sides: Between EV owner (citizen, fleet company, local government, etc.) and either CPO, EMSP or CPM depending on who is operating the charger.

- Operation and maintenance of charger contract
  Function: Operation and maintenance – making sure the charger and the charging location and charger are accessible, charger is working under contracted conditions, data is provided to the contract defined actors.
  Contract sides: Contract signed between the owner of the charger (citizen, local government, fleet company, company etc.) and charge point operator (CPO or CPM).

From the **land use** point of view there are the following stakeholders and related contracts:

Icon in the scheme	Name of stakeholder	Land use contract
	Operation and maintenance provider of charger and parking space	Land use contract for charging and parking space
	RES producer	Land use contract for RES generation plant
	Land owner	Land use contract

In order to optimise energy and mobility services, data can be collected at multiple points, as indicated by the yellow icons in Figure 5. When defining a contract with any of the above-mentioned service companies, it is extremely important to define who owns the data, with whom can data be shared and how it can be used. The data can be used to track and predict:

- Mobility use and needs
- Charging infrastructure use and needs
- Renewable energy production use and needs
- Grid expansion needs

Such data is of value for the island's development planning, and the Municipality should try to ensure that this data is available to them in timely manner and in useful format.

The role of the government is multi-dimensional as different levels of government might be responsible for regulating mobility, electricity, and land use sectors. The island municipality as a stakeholder that is in charge of the local mobility and land use planning can influence and through e-mobility become active participant in the electricity sector. The local government is crucial in defining the local rules for use of vehicles, parking and should be involved in electricity grid and charging infrastructure planning.

The local government can become involved in the RES generation and planning. Moreover, the local government could establish an energy community and assure more local stakeholders including the citizens can be involved in the local energy planning, and specifically e-mobility, promoting sector coupling.

Strategies for deployment of charging infrastructure

There are three different approaches to planning the implementation of electric mobility. Different approaches can be taken for regular/normal power charging (below 22 kW) and for fast charging stations (above 22 kW). For regular power charging, it can still be different depending on whether the charger is added to the existing infrastructure (e.g. lamppost charger 3 kW -7 kW) or a standalone charger (7 kW and more).

1. Demand driven

   Location of new chargers based on EV drivers or other data.

Advantages (+)	**Disadvantages (-)**
- Good for immature markets as it assures minimum charger usage by EV owner - Less time and resources needed from the municipality upfront - Usually used for chargers that serve less users for longer time periods	- Doesn't provide coverage in low uptake areas - Finding the right location /available land close to the demand location can be time consuming

What the Municipality can do to facilitate this approach:

- Provide a heatmap of electricity grid constrains
- Provide a city planning map of areas that are suitable for charger installations
- Need to ensure community engagement and approval of the process
- Works best if the Municipality identifies upfront who is responsible for installation of the charger

Example

Amsterdam is far into the deployment of electric chargers, which started in2009. In 2016, Amsterdam chose to partner with the electricity utility company Nuon and charge point installation company Heijmans for the installation of chargers. Both the chargers and the data are owned by the municipality and the management of the chargers and the data analysis is done in collaboration with Amsterdam University. Private partners t process the charger demands from EV drivers and provide possible solutions to Amsterdam's municipality, who approves the installation of the new chargers. Moreover, if a charger usage data shows that some charger is overused then additional chargers are installed in the area.

2. Planning oriented

The Municipality defines a list of charger locations for which operators can apply.

Advantages (+)	**Disadvantages (-)**
- Saves time and money by proving predefined locations - Can encourage new uptake and demand - Works for publicly owned land but can also be applied on private owned land (car parks, stores etc.) - Usually used for chargers that are intended to be used by more users for smaller time periods - Good for mature markets	- Requires close collaboration between municipality planning sector, transport sector, electric utility - Requires accurate forecast based on available data for mobility and grid infrastructure - Requires more time and resources upfront - Can lead to under-utilized chargers

What Municipality can do to facilitate this approach:

- Make sure the the provided plan is aligned with planning offices, transport offices, housing needs, electricity grid planning and accessibility and existing and forecasted charging demand
- The Municipality could also discuss with private landowners, owners of businesses and gas stations to together offer locations on their land

Examples

Paris has opted for the planning-oriented approach, where the city coordinates with all relevant bodies (DSO, land use/planning, mobility companies, historical sites, etc.) to ensure that suitable locations are selected. The selection of locations is based on the even coverage of the city approach and not based on the drivers' demand. Once the list of the charger locations is published, the operator can apply for a specific location. While the chosen operator has to get all the needed permits, the process is coordinated with the city administration makes sure the process is underway. The connection to the grid is separate from the charger to ensure that the charger modification or replacement does not affect the grid connection. The costs for installation of the charger are split between charger costs and soft costs, so that charger represents one third of the costs.

Stockholm also uses the planning-oriented approach. The local government publishes a map of planned charging point locations. The operator can apply for any of the charging point locations. The applications are handled based on first come-first served basis. The municipality organises the meeting between potential charger point operator and the DSO/supplier to define the conditions for the connection to the grid and the needed infrastructure changes. The expression of interest is valid for six months after the meeting with the DSO. The documents are sent by the municipal traffic offices for the signature by the operator. Once the charger is installed, the data on charger usage is shared with the municipality quarterly or semi-annually for future planning.

3. Business oriented

   Deployment of chargers depends on the needs of the private sector and local government is there to regulate

Advantages (+)	**Disadvantages (-)**
- Doesn't require investment from municipality - Can lead to fast deployment - Risk of low usage on the side of the business owner/investor	- Doesn't leave a lot of say/control to municipality - Can lead to lock-in infrastructure only applicable to one type/brand of vehicles - Applicable to larger areas

What municipalities can do to facilitate this approach:

- Assure all local priorities (such as land use, locations etc.) are regulated or predefined
- Require interoperable solutions to avoid infrastructure lock-in
- Regulate electricity prices for local citizens to allow the service to be available to them

An analysis of cases in Paris, London, Oslo, Amsterdam, and Stockholm shows that for the installation of regular chargers, cities use either demand driven (Amsterdam) or planning oriented (Paris and Stockholm) approaches, or a combination of both (London and Oslo). Installation of fast chargers is typically more business oriented and mixed with planning-oriented approaches. Fast chargers are usually installed at the location of gas stations. Due to the limited size of Kassos, fast charging will most likely not be the optimal use case to implement from the beginning.

When developing charging infrastructure, municipalities should make sure to develop a good collaboration with all needed stakeholder (municipal sectors for planning, transport, electric utility, car rentals, taxi services, private landowners, public, (potential future) EV owners, charge point operators, regional or national government) so that the flow and exchange of information can be smooth, constructive and timely. They can help develop a permitting checklist and installation guidelines for potential applicants. The communication can be eased if few contact and responsible persons from the municipality side are identified.

Possible business models and examples

Business models for charger installations, operation and management

The European Investment Bank distinguishes five main contractual models that can be used to roll-out recharging infrastructure.

The public contracting model

The municipality keeps control over the infrastructure and retains most of the project risks, from construction to exploitation. This requires a high level of investment from the side of the municipality.

Advantages (+)	Disadvantages (-)
Faster implementation Infrastructure owned and operated by the city Data is owned by the city City keeps the decisions on where and how to expand the charging infrastructure Ensures minimum usage of the charger by the EV owner	Requires a lot of investment from the city Requires know-how for management and operation of the charging infrastructure

Example:

The city of Amsterdam partnered with the electricity utility company Nuon and the charge point installation company Heijmans, following a demand-driven approach to charger installation. Once a demand for a charger is received, the private partner analyses the demand and proposes the best solution. The solution is approved by the city and the city pays the installation to the private partner. The charger is owned and managed by the city of Amsterdam. The data is owned by the city and analysed in collaboration with Amsterdam University. Based on this analysis of the charger usage, decisions can be made for new charger installations.

The joint-venture model

The municipality partners with the private sector and they share the overall control of the infrastructure. The project risks are also shared. The model remains flexible on financing of the expenditure.

Advantages (+)	Disadvantages (-)
Project risks are split between the municipality and the charge point operator, and financing conditions are set at the beginning.	Requires direct involvement of the municipality in financing, operation and maintenance Requires know-how from the municipality.

Example:

Oslo is the first city that installed public chargers in Europe and is now the city with the most EVs in Europe. Therefore, they developed the know-how over the years and the human capacity to be able to own and operate their own charging infrastructure.

Oslo implements public charging through a joint-venture approach. The city's agency plans where the new public chargers will be and takes into account the demand by EV drivers to adjust its plans. The chargers are installed by the city and a single private contractor. The public chargers on public land are owned and operated by the city administration. When it comes to publicly accessible chargers on privately owned land, they are owned by private companies and operated through a collaboration of the city agency with real-estate companies. The city rents these spots during the night to make them publicly accessible to EV owners for charging.

The concession model

A private party is given the concession to run and exploit (and build) the EV charging infrastructure. The (financial) risks lie with the concessionaire. The municipality can make more demands on where and what kind of infrastructure will be rolled out according to a contract. This allows the municipality to promote smart charging infrastructure, for example, or to put restrictions on the tariffs charged to end consumers. Many aspects of the concession model can be tailored to suit the public authority's objectives and constraints.

Advantages (+)	**Disadvantages (-)**
Low financial risk for the municipality The municipality can pose demands on the type of charger, tariff charged to consumers, operation/maintenance etc. Very versatile from the operational and financial point of view	Needs to be given for a specific number of years Requires preparation from the municipality, as their current choices must be followed for X number of years Revenues are collected by the operator but can be shared.

Example:

London: the contract between the municipality and the operator determines the length of the contract, the ownership of the charger (infrastructure) and the financial arrangement (e.g. revenue share). For example, for one of the boroughs (local government units) within London, the financial arrangement is such that the charge point operator works with the municipality to find the best location for the charger, covers the cost of installation and pays a fixed annual fee to the municipality for the charger location, while the municipality provides a parking spot for each of the chargers. The charging/usage data is shared with the municipality and its authorities in order to better understand the needs for future charging infrastructure.

The availability-based model

The municipality allocates the project risks between the public and the private sector, but the municipality collects the revenues from the EV charging stations and therefore retains the demand (revenue) risk of the project. The private sector finances the expenditure and is paid back by the public authority over the duration of the contract only if the infrastructure is available for the intended use. This enables the municipality to enforce inclusive tariffs for local residents without the concern for infrastructure availability. However, this does hold a financial risk for the municipality if the recharging point is underused.

Advantages (+)	Disadvantages (-)
The Investment risk is shared between the municipality and the charge point operator The municipality owns the charger and infrastructure The municipality collects the revenue	The demand risk is on the municipality completely The charge point operator is paid for a specific number of years if the charger is operational and available for use

The license model

A party that complies with the policy rules drawn up by the public authority can be given permission to install, manage and operate charging points in the public space. The licence can include constraints over what the private sector can do. The private sector keeps the control over the infrastructure and retains most of the project risks, from construction to operation, it finances the expenditures and collects the revenues from the consumer. Through licences, it is possible to limit the number, but erection at less favourable locations cannot be enforced. Where there is a limited number of licences or even just one licence, transparency obligations can apply when granting the licence.

Advantages (+)	Disadvantages (-)
The municipality can limit the number of operators given the licences The licence can include limitations of what the operator can do The private sector finances the installation and takes over all the risk during operation This approach follows demand, which assures a minimum usage	The municipality doesn't control where the chargers are installed – no control over low penetration areas The private sector keeps control of the infrastructure

Implementation of proposed business models for charger installations

Public contracts or joint venture models put the control with the municipality but leave little room for innovation from the private sector. While the license model leaves room for private innovation, it does not guarantee an inclusive operation of chargers.

The choice of the model depends on the goal that the municipality of Kassos wants to achieve and their expected level of involvement. In addition, business models used on Kassos should ensure involvement of all needed stakeholders to allow for local stakeholder collaboration. Therefore, the joint venture model, where Kassos island stakeholders can be represented through an energy community together with the local government could be one of the solutions.

Different models can also be chosen for regular chargers and fast chargers. Moreover, the municipality can decide to implement a combination of these models.

Before deciding on a model, the municipality needs to decide the **range of services** it would like to provide and the services that a private partner should provide. The decision about the partner and its services will need to be made early, so that any aspect not covered by that relationship can be planned for by the municipality. For example, if the municipality is looking to only purchase equipment (under availability-based model), it will need to develop a plan to manage data and provide payment services for the chargers.

The above-mentioned business models represent different ways for the municipality to be involved in the operation and exploitation of publicly accessible EV recharging points. When implementing any of the models it is important to keep in mind best practices for supporting the roll-out of EV charging infrastructure.

1. Coordinate with neighbouring municipalities or islands

Throughout Europe, municipalities discover the advantages of cooperating with neighbouring public authorities. Through joint procurement of infrastructure, municipalities can lower costs, create platforms to exchange lessons learned and best practices, while at the same time ensure uniformity of charging infrastructure. Specifically for Kassos, the collaboration with Karpathos island is crucial as it serves as the main electricity provider.

2. Supporting legislation

The e-mobility challenge touches multiple sectors, it is not only a mobility challenge, but also equally challenging for the energy, building and spatial planning sectors. Policy to promote e-mobility should therefore not only focus on one specific aspect but instead attempt to apply a multi-sector approach. Successful e-mobility infrastructure rollouts are not only focused on publicly accessible charging points, which are part of the solution, but need to be seen in combination with private recharging points. Building policies to support private charging infrastructure, ensuring new buildings or parking areas are designed in a way to allow for future installation of charging infrastructure. These sort of policies, from national, regional or local government can go a long way in promoting the uptake of e-mobility. The evolution of this private (or semi-public) infrastructure directly relates to the demand of publicly accessible recharging points. Municipalities should re-evaluate their implementation strategy based on the evolution of e-mobility and user needs; data collected based on the existing infrastructure.

3. Competition for the market

Public authorities should enable open market access. Open markets lead to competitive pricing and innovation that will benefit the end consumer. There are various measures a municipality can take to support open and transparent market access:

- **Reduce financial risk for the bidders** to increase the number of participants. Municipalities can research and provide potential locations and ensure sufficient licenses or grid connections are in place (or agreements are made with the DSO to upgrade the grid capacity in the near future).
- **Put a time limit on the contract** to allow for flexibility in the fast-growing e-mobility market. As mentioned above, the EV market is very dynamic and the uptake of EVs on the island can influence the recharging point implementation strategy. It is important for the municipality to be able to change strategies based on recent developments on the island.
- **Auction locations to the highest bidder** to stimulate open market access. The optimal locations on Kassos could be determined by an additional study. This study can be used to auction individual locations based on their estimated market value. Locations close to high traffic points will represent a higher financial potential for interested parties. Choosing only

one provider for the entire island reduces the openness of the market and provides no incentive for competitive pricing or innovation. Therefore, it is a best practice to auction the locations in smaller lots.

- **Batching locations** provides the opportunity to include low traffic points with public recharging point infrastructure. By creating batches of locations of about the same economic value (combining high traffic locations with low traffic locations) the municipality can ensure all residents on the island have access to public charging infrastructure. The economic value of a location is an important result of the previous study in order to successfully apply this strategy. However, certain business models (such as the license model) do not mandate the construction of infrastructure on the acquired locations. The municipality should choose an appropriate business model where a minimum number of recharging points are required for each location.
- **Price as an award criterion** can be an incentive to ensure not only low cost for the public authority of Kassos but also for the end consumer. Especially in the early stages of EV uptake, the price of charging is important to gain traction and increase the number of EVs on the island. Other solutions to reduce the cost for end consumers include an intervention from the municipality on the charging tariff. This can be achieved through specialized RFID cards supported by the island of Kassos on which a reduction can be offered. RFID cards for the local residents allow to differentiate between locals using the charging station and tourists and apply a different pricing strategy. In addition, members of an energy community on Kassos could have a cheaper price than those that are not members, such as tourists. The difference in price can be used to pay back for the needed charging infrastructure.
  The price can also differentiate depending on time of use in order to incentivise charging during the times that RES plants are producing. Therefore, lower charging price during the periods of high-RES generation and vice versa.

4. Qualitative tender

A qualitative tender for EV charging infrastructure would take into account the following seven guidelines:

1. Recharging points are well-designed and positioned
2. Infrastructure is interoperable, both in terms of hardware (connector fits vehicle) and software (infrastructure can communicate and interact)
3. Infrastructure is future proof
4. It is easy to find and use, and users know in advance what they will pay for recharging
5. Infrastructure functions properly, with a high uptime, while errors and bugs are quickly resolved
6. It is (cyber-)secure
7. It is defined who owns and who can access the collected charger usage data and in which timeframe.

Besides the setting requirements regarding the quality of infrastructure, public authorities should make sure these can be enforced. To this end, public authorities should require guarantees from bidders or include enforcement mechanisms in their tender specifications. A common example are penalties for failure to meet uptime requirements.

Business models for usage of public or semi-public fleets and chargers

Vehicle fleets represent the easiest way to start transition to electric mobility. This is due to the fact that in the case of fleets, the business model is related to one public body or company that is making a decision to change multiple vehicles. In the case of Kassos, the municipality fleet does not contain passenger vehicles, nevertheless the fleet could serve as a starting point in the transition towards e-mobility on the island. Additionally, in order to popularise e-mobility, the municipality could co-own an E-vehicle or E-bike sharing system with local mobility service providers (taxis, rent-a-car companies) to provide additional services. This can be implemented through an energy community or a cooperative where municipality and other local stakeholders can be members of such a community. Business models for EV sharing are presented below with European examples.

With a goal to optimally use the installed e-mobility infrastructure and integrate electric mobility with the rest of the electricity sector, business models need to take into account smart charging and possible use of EV as a local storage through vehicle-to-grid. While the current regulation in Greece is limiting the use of vehicle to grid, smart charging depends on the technical specifications of the charging infrastructure and represents basics for optimal business models.

e-Car Sharing

As the transition to electric mobility has not yet started on Kassos, Kassos municipality could consider to co-own EVs (and e-bikes) with other local business owners (taxis, rent-a-cars) within an energy community. These vehicles could use the publicly available charging stations to popularise electric mobility, increase awareness and provide the option for visitors to use EVs.

The car can be used in the part of the day or weekend, when it is not used by the mobility service companies or energy community members who become subscribers to this service. Further, the local mobility service companies or energy community members could avoid the risk of vehicle ownership and the cost for car maintenance is distributed among multiple users.
The subscription fee is based on the daily or monthly driving distance of a subscriber, for the local community.

Moreover, as the municipal fleet of Kassos cannot be made available for the car sharing services, they could partner with a company that would provide EVs and car sharing services, while the municipality could offer the municipal chargers. That way these public charging locations would in certain time period be available only for the car sharing services.

Examples:

Spanish islands

E-car sharing on the Spanish islands is organised by electric utility Endesa. Endesa has installed charging stations across Spanish islands and provided EVs for e-car sharing options. This has been used to increase awareness[9] about electric mobility and provide a wide spread of charging stations that would make the use of EVs on islands by tourists or local citizens possible[10].

Malta

Car Sharing Services Malta (CSSM), a subsidiary of CAR2GO Israel, has unveiled a car sharing service using a fleet of electric cars (Renault ZOEs)[11]. The car sharing service in Malta uses a convenient,

[9] https://www.endesa.com/en/projects/all-projects/energy-transition/electric-mobility/ecar-discover-emission-free-mallorca
[10] https://www.endesa.com/en/projects/all-projects/energy-transition/electric-mobility-baleares-canarias
[11] https://www.legaleappalti.it/dip3oo0o/car-sharing-malta

free mobile application that is able to find the electric cars available nearby. The app finds the electric car that you can drive in any direction you want, before leaving it parked in one of the locations identified on islands of Malta and Gozo[12].

GoTo Malta is not just the first car-sharing club in the Mediterranean island nation, it is also resolutely post-fossil-fuel: the newly launched service provides 150 Renault ZOE EVs[13] to drive around Malta or Gozo.

Offered via a government-backed scheme, the EVs can be booked via an app and are available 24 hours a day. The Maltese government has reserved 450 parking spaces for the scheme in high-use parking areas and is planning to install 225 double-chargers throughout both islands.

There is a monthly membership fee for GoTo Smart, and fees depending on how EV is being used and for how long[14].

Pantelleria island, Italy

The island of Pantelleria has implemented amiGO car sharing for EVs[15]. The cars can be rented for the time necessary through the "amigocarsharing" app[16], which can be downloaded free of charge for the Android and IOS platforms. The cars can be picked up in the dedicated spaces and can be released either in the pick-up parking lot or in another parking lot.

The municipality is using the car sharing options to decongest road transport and to promote the shared use of the vehicles and e-mobility. The islands, especially in the summer months, are filled with tourists who very often reach them by private vehicle, complicating the local traffic situation. The amiGO car sharing in Pantelleria is the first car sharing service inaugurated for a smaller island in the Mediterranean and in addition to being useful for residents who could share the use of the car, it will serve to encourage tourists not to arrive on the island with their own private vehicle, being able to access a more sustainable solution for internal travel.

Another advantage of the service offered by amiGO concerns the possibility of using, with a single registration, the entire fleet of cars present in the localities of Sicily where this service is active. Among these we mention Palermo, Trapani , Catania, Enna , which are the main hubs of connections to and from the island.

Currently there are 5 parking stations in Pantelleria to serve the car-sharing scheme and it is expected that there will be the deployment of 10 electric vehicles (Renault ZOEs) available for the car-sharing scheme. Two of the 5 parking lots are situated at the port and city centre of Pantelleria, one at the airport and two more at Khamma-Tracino and Scauri.

The multiple services for car sharing include differences if the car is returned to the same location or a different one as with regular car-sharing services.

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[12] https://malta.italiani.it/car-sharing-a-malta-una-realta-concreta-in-crescita/
[13] https://www.fleeteurope.com/en/smart-mobility/others/article/new-car-sharer-goto-malta-uses-only-zoes?a=FJA05&t%5B0%5D=GoTo%20Malta&t%5B1%5D=car2go&t%5B2%5D=Malta&t%5B3%5D=Israel&t%5B4%5D=Car%20sharing&curl=1
[14] https://www.goto.com.mt/standard-fees/
[15] https://qds.it/pantelleria-da-domani-attivo-car-sharing-gestito-da-amat-palermo/
[16] https://www.amigosharing.it/site/amigo.php?t=map

Smart charging and Vehicle to Grid (V2G)

When setting the requirements for the charging stations Kassos should keep in mind that for the optimal integration of EVs into the electricity grid, chargers should offer smart charging[17] capabilities. Only if the charging stations can provide smart charging can they be optimally used to balance the local grids and assure security of supply. The flexibility that smart charging stations can offer for the electricity grid when vehicle is parked (Charging can be interrupted in case of high consumption periods, charging can be activated in the periods of high RES generation to assure local balancing, etc.) is a service that either municipality or charge point operator can offer to the DSO.
V2G is an advanced form of smart charging where the charger and a vehicle are capable of allowing electricity to flow in both directions, from grid to the vehicle and from vehicle (battery) to the grid. In this way the vehicle is not only parked and possibly charging but can be used for energy services to the grid when not in use.

Currently this type of service is not monetized on the local energy markets, but smart charging can also allow for aggregation of flexible assets (parked car batteries) by a third party (aggregator) to offer services on the energy market. Obviously the more EVs can be aggregated the better, and in some countries that allow for this service to be offered on the energy market, the minimum capacity of 1 MW requires aggregation of large number of EVs.

In the start of the electrification process and due to the regulatory barriers, V2G does not yet have an easily implemented business model. However, the municipality is strongly advised to require the installation of smart chargers. Smart chargers help not only allow for these business models in the future, but also allow for remote monitoring and control needed for optimal maintenance and operation.

Entry level smart charging could help limit the impact on the grid. In Section 1, the power demand peak on Kassos is observed between 18:00 and 22:00 (both summer and winter seasons). By limiting charging in this timeslot (e.g. reduced available charging power capacity, increased cost of charging) the municipality makes sure that the impact on the grid is minimised.

Example:

Porto Santo, Portugal

Island of Porto Santo[18], Portugal is a location where electricity utility EEM, Renault vehicle manufacturer and the Mobility House charge point operator are implementing a project of smart mobility for the purpose of both decarbonising the transport of the island and increase flexibility of the electricity grid to assure higher RES integration. The project includes 40 chargers, of which all but two are smart chargers and two include V2G capability. In addition, the second life batteries, mentioned in the next section are used for the implementation of stationary storage for increased grid flexibility.

[17] https://smart-cities-marketplace.ec.europa.eu/sites/default/files/2021-02/D32.1D3_Solution%20Booklet_EVs%20and%20the%20Grid.pdf
[18] https://www.mobilityhouse.com/int_en/our-references/porto-santo-emisson-free-island

Business models for other stakeholders

With transition to e-mobility, additional business models for other local stakeholders become available. In this section, we discuss just some of the business models that are related to electrification of road transport.

Second Life of Battery

An EV battery is required to be replaced when the capacity reduces to 70%-80%. However, these batteries can still be utilised for energy storage systems. Used EV batteries can be used as local storage for rooftop PV, solar streetlight applications, backup power for telecom towers, or grid flexibility storage. This extends the useful life of the battery by another 10 years before they need to be disposed. Utilising the second life of the battery also leads to a way for an EV owner to monetise the investment. Example of such 2nd life battery use can be seen in Porto Santo example above.

Battery Swapping

This business model is optimal for e-bikes or e-scooters that can be very useful for short trips on islands. Charging times are not needed as one can easily replace the empty bike or scooter battery with a charged battery from the charging station. In addition, due to controlled charging conditions, batteries last for longer charging cycles. The battery swapping provider has a contract with the customer, which contains the automated swapping of discharged to charged batteries for the e-bike or e-scooter. The swapping provider follows his/her own optimised charging strategies, whereas the customer possesses a battery for a temporary period.

Mobility as a Service

Mobility as a Service (MaaS) means the integration of various forms of transport services into a single mobility service accessible on demand. There are currently several initiatives in typically larger cities/urban areas. To meet a customer's request, a MaaS operator facilitates a large offering of transport options, be they public transport, ride-, car- or bike-sharing, taxi, car or bike rental, or a combination. The aim of MaaS is to provide an alternative to the use of private car that may be as convenient, more sustainable, help to reduce congestion and constraints in transport capacity. This development may have an impact on the business models as set out as it can replace some of the transportation by EVs with other modes of transportation. On the other hand, it may well prove to be easier to reach out to larger fleet-owners such as car sharing companies, car rental companies or similar having a professional large-scale counterpart that in turn offer EV transportation to its customers.

Demand Responsive Transport (DRT)

Demand Responsive Transport (DRT) is a transport service where day-to-day operation is determined by the requirements of its users. Typically, this involves users calling a booking service, which will then plan a route for the day to pick-up users and take them to their required destination. Increasingly, such systems are also using internet connections; via web browser or mobile apps, to enable bookings. While this has been active in private transport services, it is becoming more and more popular for public road transport services and aims to replace the traditional public transport timetables and defined paths. DRT helps reduce emissions and congestion due to removing unnecessary trips and routs, allows for cost-efficient connectivity of dispersed population and can help support citizens with limited mobility. An example of such app, Moia by Volkswagen[19] will be tested and applied with e-mobility on the Astypalea island.

Examples:

Niepolomice, Poland

The municipality of Niepolomice, Poland[20] is an example where DRT has been used to replace tradition public bus transport with tele-bus system, an on-demand bus service for three districts. With the new services users can request a journey between any two of 77 stops in the covered area, up to 30 minutes before required departure. The service has been mainly used by commuting workers, students and elderly people. The system faced initial opposition when it was introduced in 2007. However, its user base grew and currently represents a good example of cost-effective public transport.

[19] https://www.moia.io/en

[20] https://www.interregeurope.eu/fileadmin/user_upload/plp_uploads/policy_briefs/2018-06-27_Policy_Brief_Demand_Responsive_Transport.pdf

Greek islands examples

Currently there are multiple Greek islands in the process of electrifying its road transport. Even though the transition to e-mobility is at its initial stages, it has started on multiple Greek islands, mainly in close collaboration with local stakeholders. Examples of Greek islands include:

- Astypalea[21], a collaboration between several stakeholders including the Greek Government and the Volkswagen Group, where the aim is to replace all conventional vehicles on the island with EVs. The aim is to provide a successful example of smart and sustainable Mediterranean island through implementation of not only e-mobility and smart charging, but also smart mobility in combination with RES generation through implementation of hybrid plants (RES in combination with storage system).
- Chalki[22], the project is starting as a donation from Citroen to the Chalki municipality to use six EVs as part of municipal fleet. In collaboration with national government, Vinci and Akuo Greece this will continue into a project to further transition road transport and couple it with RES generation on the island.
- Kythnos, where in the framework of Kythnos Smart Island run by DAFNI and the National Technical University of Athens, multiple smart mobility applications are implemented on the island including electrification of the municipal fleet, e-bike sharing, aiming to achieve synergies between mobility and energy,
- Ai Stratis[23] where a clean energy project has been implementing in regards to the implementation of hybrid plant to increase RES penetration. E-mobility is part of the project with testing charging station being installed.

[21] https://smartastypalea.gov.gr/

[22] https://www.media.stellantis.com/em-en/citroen/press/citroen-s-innovative-approach-to-sustainable-mobility-helps-transform-chalki-into-a-smart-and-zero-emission-island

[23] https://www.aistratis-greenisland.gr/

3. Phases of implementation

Phase 1 – Fleet and public charging

In order to succeed in a widespread transition into more sustainable mobility, social acceptance is a factor that cannot be underestimated. Therefore, the main objective of phase 1 should be to raise awareness amongst residents and business owners on the island. The municipal fleet could serve as a starting point in this transition towards e-mobility on the island as this is fully under governmental control. Next to the municipality fleet, a strategic partnership with the rent-a-car company can be established, as the rent-a-car company fleet provides an opportunity to replace combustion-based vehicles on the island.

The municipal fleet consists out of four industrial machines, six trucks and four smaller cargo vehicles. In the initial phase, the electrification of industrial machines and trucks forms a challenge as the required energy and power to operate these vehicles is significantly higher compared to the smaller cargo vehicles. In order to electrify these four vehicles of the municipal fleet, suitable charging infrastructure should be provided. Depending on the driving patterns of the vehicles (range, idle time) there is need for two charge points, each servicing up to two vehicles simultaneously.

Regular power charge points (up to 2 x 11 kW) will allow one vehicle to charge for up to 100 km in a one-hour charge session or two vehicles to charge at half power simultaneously. Given the size of the island and the average capacity of electric vehicles there is no need for fast charging on the island. This has as a bonus that the impact on the electricity grid will be less with regular power chargers compared to fast chargers. Nevertheless, as the number of chargers on the island will grow, planning together with the DSO is important to assure the security of supply on the Kassos island. Entry level smart charging as described in Section 2 could help limit the impact on the grid. In Section 1 the daily power demand peak is observed between 18:00 and 22:00 (both summer and winter seasons). By limiting charging in this timeslot (e.g. reduced available charging power capacity, increased cost of charging) the municipality makes sure that the impact on the grid is minimized.

Considering that the main objective of phase 1 is raising awareness with the residents of the island of Kassos, the location of the two regular power chargers is vital to achieving this goal. Public chargers are placed on municipality owned land and should be placed in high traffic areas. Not only does this provide the opportunity to the maximum number of residents to use the charge points, but it also maximises the visibility of the charging infrastructure. Suitable locations on the island are the urban areas in Fry and Agia Marina. The municipality should keep in mind that planning and selecting of charge point infrastructure should always occur in consultation with the DSO. Adding promotional materials (posters, billboards, visible solar infrastructure) near charge point locations will help to promote electric mobility as well.

Two vehicles of the municipal fleet belong to the education department, this provides a unique opportunity to raise awareness for electric mobility among children on the island. A charger located at school property in combination with an educational program is a very efficient measure to reach out to the future generations. Additionally, the impact of intergenerational learning is not to be underestimated when it comes to educating the parents of the children.

A strategic partnership with the rent-a-car company provides another way to gain access to a fleet. As there is only one stakeholder to take into account when transforming fleets (the fleet owner) this usually means there are fewer barriers to overcome in the process. Agreements between the rent-a-car company and the municipality can be made in order to facilitate the transition. These can be in the form of an energy community, where the rent-a-car company can take advantage of beneficial financial charging schemes of public charging infrastructure in exchange for electrifying its fleet. The energy community can be expanded to include other residents or local business, leaving only tourists to pay full price when charging. Incentive schemes could start by supporting electric motorcycles for rent and expand towards electric mobility once infrastructure has grown to be able to support this.

Tourist vehicles are a challenge in Kassos (the amount of cars and motorcycles doubles over the summer). The municipality could tax incoming combustion vehicles with a pollution tax which would be used to pay back the initial investment in the charging infrastructure. Alternatives to combustion-based vehicles can be provided in the form of an elaborate e-bike sharing system. The size of Kassos is ideally suited for transportation by e-bike. This can be combined with a battery swapping service as described in Section 2.

As is the case with all integration of electric transportation, phase 1 requires a collaboration between different stakeholders on the island. It is important to select suitable locations for EV charging in collaboration with the DSO, and local business owners. In doing so, the municipality ensures the transformation towards electric mobility is sustained and supported by the main stakeholders on the island.

Phase 2 – Semi-public charging

The main objective of phase 2 is to speed up the roll-out of EV charging infrastructure by maximising the opportunities for installing charge points. In phase 1 chargers are only placed on municipality owned land, phase 2 makes use of the potential synergy with local business owners by installing public chargers on private owned land. So called semi-public charging allows all vehicles to charge at privately owned infrastructure. Possible locations are parking infrastructure of a store or hotel, the gas station or the airport.

The municipality can support the uptake of e-mobility by facilitating the purchase of charging infrastructure on private property under the condition that the charger will be accessible to the public. Additional requirements such as smart-charging capability can be ensured in the same manner. Although the main objective of phase 2 is no longer raising awareness amongst the residents of Kassos island, this aspect should be taken into account. Placing charge points at frequently visited stores or attractions will provide additional exposure for e-mobility.

Due to the size of Kassos, charging in the more urban areas of Fry and Agia Marina should be prioritised. There are 68 rooms available throughout the island, most likely in urban areas. Installing charging infrastructure at hotels or other places where tourists spend the night facilitates the adoption of EVs with seasonal visitors. This could be bringing their own electric vehicle to the island or renting an electric vehicle locally. Additional investments in e-bike infrastructure will allow tourists to visit Kassos island without using vehicles all together. The size of Kassos makes it ideally suited for advanced e-bike sharing systems.

Similar to phase 1, the municipality should coordinate all actions with the DSO to find possible charging locations. Additionally, they should plan the construction of production plants (such as solar panels) on strategic locations to minimise the impact of charging on the grid capacity. Compared to phase 1, the synergy with local business owners is vital for the success of semi-public charging schemes.

4. PV energy supply for e-mobility

In order to provide the 22 kW (2 x 11 kW) EV chargers with renewable energy, this section determines how much solar PV capacity would need to be installed. The solar PV is assumed to be installed on the most suitable location from a meteorological point of view. This implies that a free-standing PV installation is considered instead of a carport solution. Furthermore, as the location is not exactly known, this analysis does not incorporate losses due to shading from the surroundings. The solar PV production will be matched to the EV charger consumption based on virtual net metering. This is a mechanism that enables solar PV system to feed excess electricity into the grid and receive a credit for the amount of electricity contributed. It thus allows to generate solar power in one place and use it in a different place. In practice, this means that the total yearly PV production should match the total yearly EC charging station consumption, but that these two should not match at every moment in time.

First, the specific yearly PV production on the island is estimated. Second, the yearly consumption by one 22 kW EV charging station is assessed. Lastly, the required capacity solar PV is determined by bringing the previous two points together.

The specific PV production

The Solargis Prospect tool was consulted in order to determine the yearly specific PV production on Kassos. The location modelled is the centre of Kassos with coordinates 35.387° latitude and 26.912° as indicated in Figure 6. The yearly irradiation equals 1 806 kWh/m², which makes Kassos (as the rest of Greece) one of the most interesting locations for solar PV in Europe.

Figure 6: Map of selected location on Kassos with yearly irradation (source: Solargis Prospect tool, unit: kWh/m²)

The solar irradiation is then converted to PV output using the Solargis Prospect tool. The modelled PV system assumes a grounded-mounted system with a fixed axis towards the south and a tilt of 28° [24]. The yearly specific PV production then equals 1 643 kWh/kW in the first year. The monthly production is shown in Figure 7 and shows that while the production increases in Summer due to increased irradiation, the performance ratio slightly drops due to the increased temperature.

[24] Other model parameters include: inverter efficiency=97.8%, monthly soiling losses up to 3.5%, monthly snow losses up to 3.5%, DC cabling losses=2%, DC mismatch losses=0.3%, AC cabling losses=0.5%, system availability=0.5%

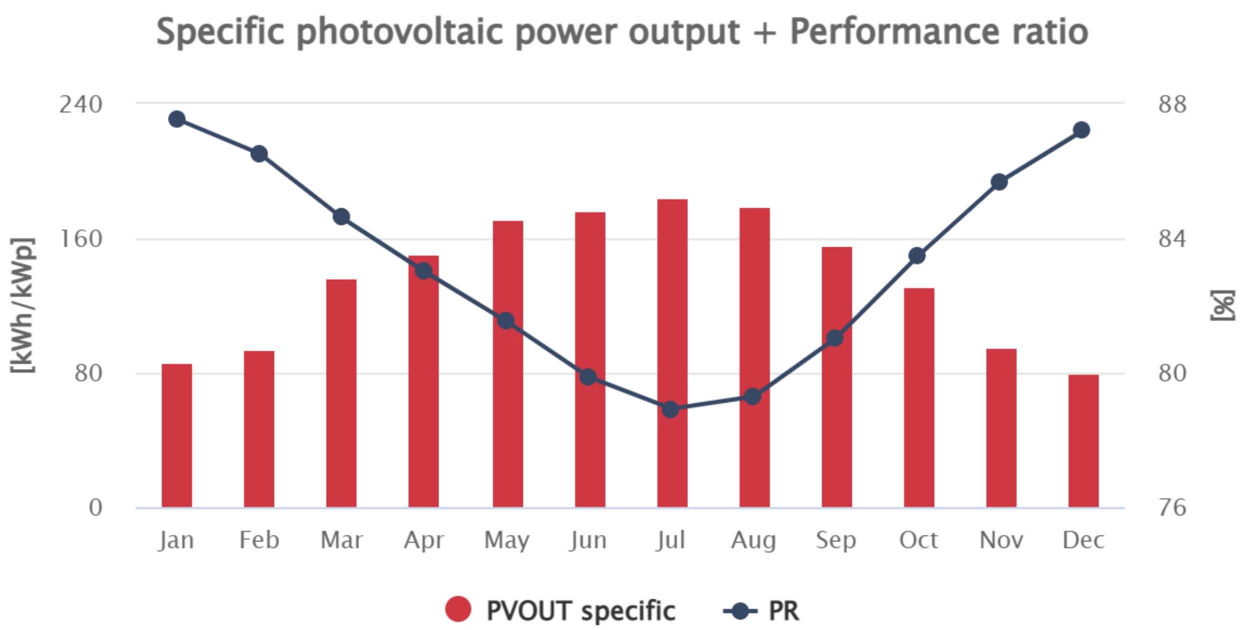

Figure 7: Specific PV production on Kassos (source: Solargis Prospect tool)

The EV charging station consumption

At the moment of writing, the exact usage and the accompanying utilisation rates of the EV charging stations are still largely unknown. Therefore, external references are consulted in order to determine the average utilization rate of public charging stations in Europe. These can differ greatly depending on the location; airport parking spaces are greatly used, up to 95% while other more remote charging stations are located to a lesser degree. Based on data by Virta, a renowned public charging station provider in Europe, the average charging station utilization rate equals about 10%[25]. Considering a 22 kW charging station, the yearly energy consumption then equals 19 272 kWh[26].

Determining the required solar PV capacity

As explained in the prior two subsections, the yearly specific PV production on Kassos equals approximately 1 643 kWh/kW while the yearly energy consumption for a 22 kW charging station is about 19 272 kWh. Considering virtual net metering, the required PV installation size is 11.73 kW for one 22 kW EV charging station.

[25] Here's how EV drivers charge their cars across Europe, Virta, 2021, source: https://www.virta.global/blog/how-are-we-charging-a-deep-dive-into-the-ev-charging-station-utilization-rates
[26] 8760 hours x 22 kW x 0.1 utilization rate = 19,272 kWh

5. Conclusions

Kassos island is at the beginning of the transition towards sustainable mobility. This report aims to provide guidance on how to take the first step of the process. Further exploitation models are presented in the case the e-mobility market becomes more mature.

Section 1 presents the current situation on Kassos island with regards to energy and mobility. At the moment of writing, the island is completely dependent on the neighbouring island of Karpathos for its energy supply. This complicates the integration of electric vehicles in the electricity grid of the island. As with many islands, Kassos is subjected to seasonal mobility demands where the number of vehicles during the summer period doubles compared to the winter. This provides both a challenge and an opportunity for the electrification of mobility.

Section 2 provides an overview of the e-mobility ecosystem and possible business models the municipality of Kassos can implement. The provided graphical explanation will help to increase the understanding of various stakeholders on the island when decisions with regards to e-mobility need to be taken. Examples of possible business models from all over Europe are provided as a reference, different exploitation models can be identified. In the early stages of EV uptake, the municipality should focus on the strategy for the deployment of EV infrastructure where the planning – oriented approach is suited for an island the size of Kassos. Likewise, the size of the island provides opportunities for the inclusion of e-bikes in the moblility plan.

Section 3 describes concrete steps the municipality of Kassos can take to support the uptake of electric vehicles on the island. In a first phase the municipal fleet can be electrified in combination with the installation of highly visible public charge points. A second phase explores possible synergies between the municipality and local business owners by implementing semi-public charge infrastructure.

The last section estimates the PV energy supply that is required to power a charge point on the island. These calculations are taken into account when formulating concrete recommendations for implementations.

The sustainable integration of electric mobility in the island's electricity grid requires collaboration between different stakeholders on the island. It is vital to include the DSO and local business owners when planning for e-mobility infrastructure. In doing so, the municipality ensures the transformation towards electric mobility is supported by the main stakeholders on the island and the security of supply remains guaranteed.

References

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ANNEX 1: E-mobility ecosystem scheme (Greek)