D2.10 IANOS Islands Decarbonisation Master Plan

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Executive Summary

This document presents IANOS Deliverable D2.10 – Islands Decarbonisation Master Plan for the Lighthouse and Fellow Islands and will capitalize on the results of Task 2.1 to 2.3 to understand the actual and future requirements and barriers as well as the most important KPIs for island decarbonisation.

This deliverable presents the greenhouse gas (GHG) emissions characterisation for each of the project islands as well as illustrating the different project solutions for the Lighthouse Islands (Terceira and Ameland).

The characterisation contemplates the historical information, the current status and the main objectives defined for each of the sectors. The division of the sectors is different from island to island since it depends on the sources that were used.

In the next sections, it will be made a brief description of the various project solutions and the planned investments for the lighthouse islands. There will also be presented a SWOT analysis in order to understand the most important aspects for the success of the proposed solutions.

Given that this is the first version of this deliverable, there is still to be calculated the replication potential therefore it will only be presented in the next version, as it depends on the other deliverables of this WP.

The current Master Plan will be continually updated with deliverables foreseen for months 19 and 26 and thus build upon the knowledge obtained from the demonstration activities on both LH islands

It is predictable that with the last deliverable (month 26), that we shall have a fully replicable master plan for the fellow islands and others.

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Abbreviations and Acronyms

AEC	Amelander Energie Coöperatie
BEI	Baseline Emissions Inventory
BESS	Battery Energy Storage System
DSO	Distribution System Operator
EDA	Electricidade dos Açores
EMI	Emissions Monitoring Inventory
ESD	Effort Sharing Decision
ETS	Emissions Trading System
EU	European Union
FEID	Fog-Enabled Intelligent Device
HEMS	Home Energy Management System
iVPP	Intelligent Virtual Power Plant
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
IRERPA	Regional Inventory of Emissions by Sources and Removals by Sinks of Air Pollutants
KPI	Key Performance Indicator
LULUCF	Land Use, Land Use Change and Forestry
PAESC	Action Plan for Sustainable Energy and Climate
PV	Photovoltaic
UC	Use Case
V2G	Vehicle-to-Grid
WP	Work Package

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1. Introduction

1.1 Purpose and Scope of the Deliverable

IANOS project aims, amongst others, to decarbonise the energy systems of its Lighthouse Islands (Ameland and Terceira) and explore the possibility of replication in the Fellow Islands (Bora-Bora, Lampedusa, Nisyros).

For this purpose, a Decarbonisation Master Plan will be developed to form the stakeholders' consensus on the decarbonisation pathways, focusing on three different time horizons: short-term (end of project), mid-term (2030) and long-term (2050).

Nevertheless, in the present version, the plan will only include the current available information, a description of the GHG emissions distribution of the various islands and the main targets defined by their respective governments. Within this information and the work developed in the other deliverables of this task, the replication potential shall be estimated in the next version of this document. The deliverables from IANOS expected to contribute to the master plan are the "Report on Islands requirements engineering and UCs definitions" (D2.1)," Report on regulatory/legal and financial aspects" (D2.4) and "IANOS KPIs and evaluation metrics report" (D2.7).

1.2 Kyoto Protocol and Paris Agreement

Kyoto Protocol

On 11 December 1997, the Kyoto Protocol was adopted in Kyoto (Japan), and entered into force on the 16th of February 2005. This Protocol had 2 commitments periods: the first started in 2008 and ended in 2012, and the second was the extension until 2020 (known as Doha Amendment).

This Protocol aimed to commit industrialised countries and economies in transition to limit and reduce greenhouse gases in accordance with agreed individual targets [1]. Also, this Protocol allows Annex I Parties to add to or subtract from their initial assigned amount, thus raising or lowering the level of their allowed emissions over the commitment period, by trading Kyoto units with other Parties. All participating countries emissions must be monitored in order to confirm that the objectives are being accomplished.

Paris Agreement

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The Paris Agreement is a "*legally binding international treaty on climate change"* that was adopted by 196 Parties, on 12 December 2015 and entered into force on the 4th November 2016 [2].

The objective of this Agreement is to "*limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial (1990) levels"* [2]. Developed countries will provide financial resources to help the developing ones and a review of the funds and objectives will be carried out every 5 years.

The European Union aims to **reduce its emissions by at least 55% by 2030** [3] and reach **Climate neutrality by 2050** [4]. The EU wants to transform Europe into the first carbon-neutral continent, investing around one third of the overall amount of the recovery plan, thus becoming a modern, efficient, and competitive economy.

EU Emissions Trading System

This System "*is a cornerstone of the EU's policy to combat climate change and its key tool for reducing greenhouse gas emissions cost-effectively. It is the world's first major carbon market and remains the biggest one*" [5]. And operates in all EU countries (plus Iceland, Liechtenstein, and Norway), limits the emissions from 10,000 installations of the power sector, manufacturing industry, and also the airlines operating in the previously mentioned countries. The EU ETS covers around 40% of Europe's GHG emissions

Effort Sharing

This legislation "*establishes binding annual greenhouse gas emission targets for Member States for the periods 2013–2020 and 2021–2030. These targets concern emissions from most sectors not included in the EU Emissions Trading System (EU ETS), such as transport, buildings, agriculture and waste*" [6]. The emissions covered by these sectors accounts for almost 60% of total domestic EU emissions.

All of these policies are important to transform Europe in a low-carbon economy, increase the energy security and achieve the carbon neutrality in 2050.

1.3 Structure of the Deliverable

Deliverable D2.4 is structured as follows:

- Chapter 2: Terceira Demonstrator GHG emissions distribution is characterised. This chapter contains a general characterisation of the emissions of GHG by sector (historical data, current status, major measures and forecast for

2025/2030/2050). Followed by a characterisation of the energy sector, in particular the electricity and transport subsectors of the island.

- Chapter 3: Ameland Demonstrator GHG emissions distribution is characterised. This chapter contains a general characterisation of the emissions of GHG by sector (historical data, current status, major measures and forecast for 2025/2030/2050). Followed by a characterisation of the energy sector, in particular the electricity and gas subsectors.
- Chapter 4: An overview of the GHG emissions distribution and the main policies will be presented for each Fellow Island (Lampedusa and Nisyros).
- Chapter 5: Conclusions and Next Steps.

1.4 Relation to other deliverables

This task is related to the other deliverables of the Requirements Engineering & Decarbonisation Roadmapping (WP2), as it will capitalize on the results of Tasks 2.1 to 2.3 to understand the current and future requirements and barriers as well as the most important KPIs in island decarbonisation.

The replication potential of this project for the Fellow Islands will be calculated based on the UCs and the description of the IANOS solutions. However, it will only be presented in the next versions of this document as the submission deadline of the deliverables with the necessary information is very close to this one. Also, the Report on regulatory/legal and financial aspects (D2.4) will be important for this deliverable however the submission date is the same as this work.

The Decarbonisation Master Plan will be important for the other tasks in the project as it will indicate environmentally friendly pathways for integrated energy streams.

2 Terceira Demonstrator

2.1 GHG emissions per sector (historical data, current status, major measures and forecast for 2025/2030/2050)

The Regional Inventory of Emissions by Sources and Removals by Sinks of Air Pollutants [7] is one of the main elements of the Azorean Regional Climate Change Program, approved by the Regional Legislative Decree No. 30/2019/A, of 28 November. This document enables the Azorean government to better understand the reality of the regional greenhouse gas emissions. Furthermore, it also allows to systematize and organize the regional information to be submitted and contribute to the improvement of the Portuguese National Inventory of Emissions by Sources and Removals by Sinks of Air Pollutants (INERPA). The most recent IRERPA was published on July 2020 with results from 2018.

Despite its importance, IRERPA considers the emissions of the Region as a whole, meaning that there is no desegregated data for each of the 9 islands on the archipelago. Given that limitation, and that the current document is exclusively for Terceira Island, as a lighthouse island on IANOS project, it was needed to estimate the greenhouse gas emissions of that particular island. It was assumed the ratio of 0,2337 , that is the correlation between the electricity consumed in the year 2020 in Terceira island vs the energy consumed in the Azores. This ratio was chosen because the consumption of electricity is related to economic growth since the industrial revolution, however "*the effect of energy consumption on economic growth decreases as the income level of the country increases"* [8]. Furthermore, this ratio is also validated by 2007 Regional Strategy for climate Action [9], a document published by the Azorean Regional Government which mentions that Terceira is responsible for the emission of 23% of the total, and thus validating the ratio previously stated.

2.1.1 Total

The Greenhouse gas emissions (GHG) in Terceira totalled 429.7 kt CO2eq, according to IRERPA results from 2018.Given that the Land Use and Forestry sector is responsible for a net sequestration of 112.3 kt CO2eq, the net balance emissions stands at 317.4 kt CO2eq.

The total emissions of GHG represent a decrease of 0.5% from the previous year and a 65% rise from the values registered in 1990.

As for the emissions profile by sector (figure 1), the values remain stable, with the energy sector representing 54% of emissions, followed by the agriculture sector with 40% (raising from 36% in 1990) and the waste sector with 6%, (decreasing from 11% in 1990). The Industrial Process and Product Use sector is neglectable in the Azores and only represents about 0.1% of total GHG emissions.

According to figure 2, Azores were not far from carbon neutrality back in 1990. From

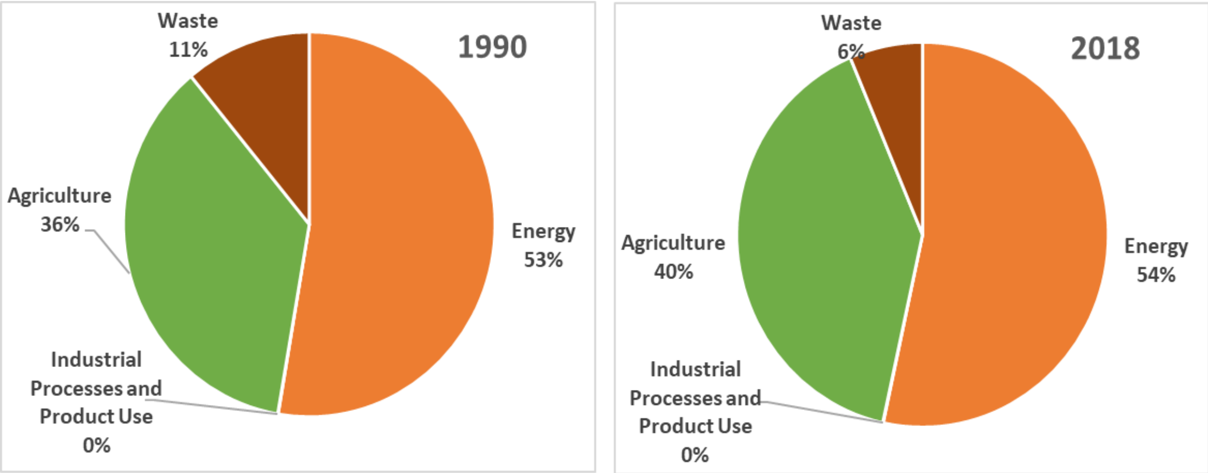

Figure 1- GHG Emissions Profile by sector in 1990 and 2018.

1990 to 2009 there was a growth in GHG emissions, due to the development of this ultra-peripheral region. From 2010 until 2014 there was a reduction on emissions, mainly because the high economic global crisis that hit the Portuguese economy hard. It should also be noted that the sink capacity of the (LULUCF sector) is reported constant over the years from 1990 until 2014, in part due to lack of data from the Azorean government. The values above the LULUCF line on figure 2, represent the net balance emissions.

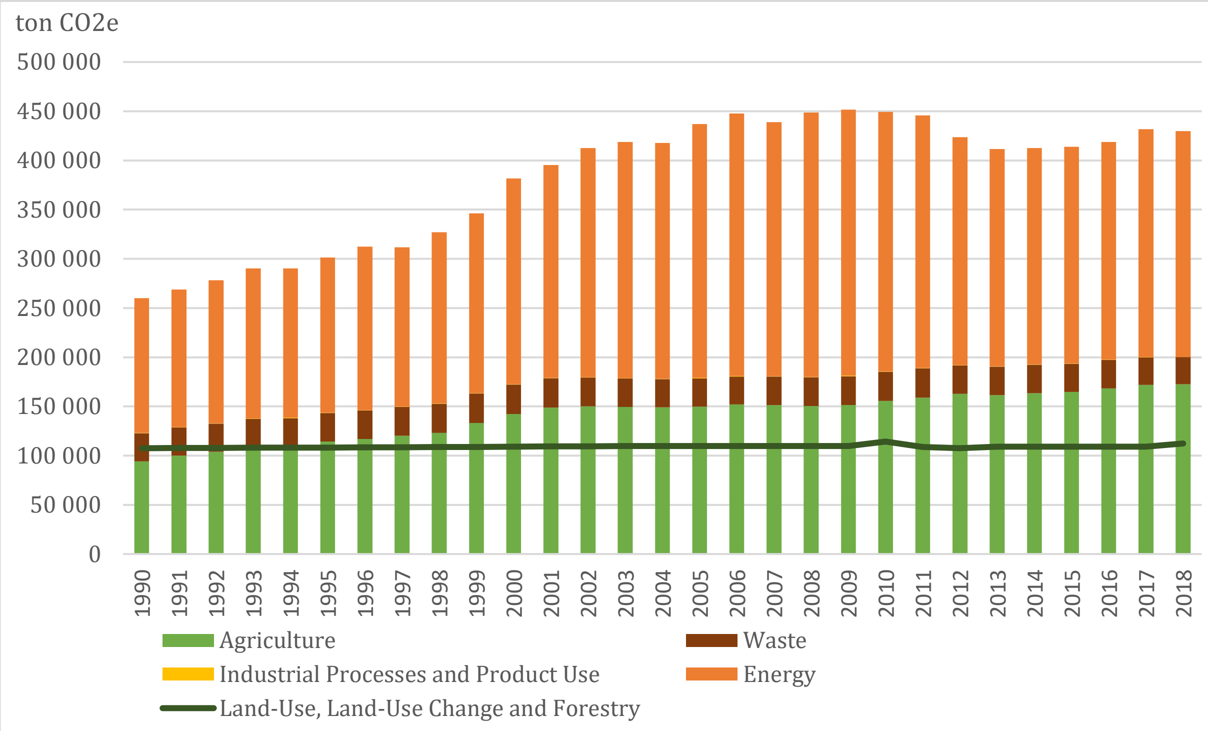

Figure 2- Total GHG Emissions (1990-2018).

2.1.2 Agriculture

In the Azores, agricultural activity is highly focused on livestock farming and related activities. Within this sector, there is a great impact and specialization in cattle, particularly in the dairy industry and meat market. It should also be mentioned that the number of cattle in the Azores surpass the number of inhabitants.

This sector currently represents 40% of the emissions of the Autonomous Region and covers the emissions resulting from livestock production; the application of fertilizers and correctives in agricultural soils and pastures; and the intentional burning of agricultural waste.

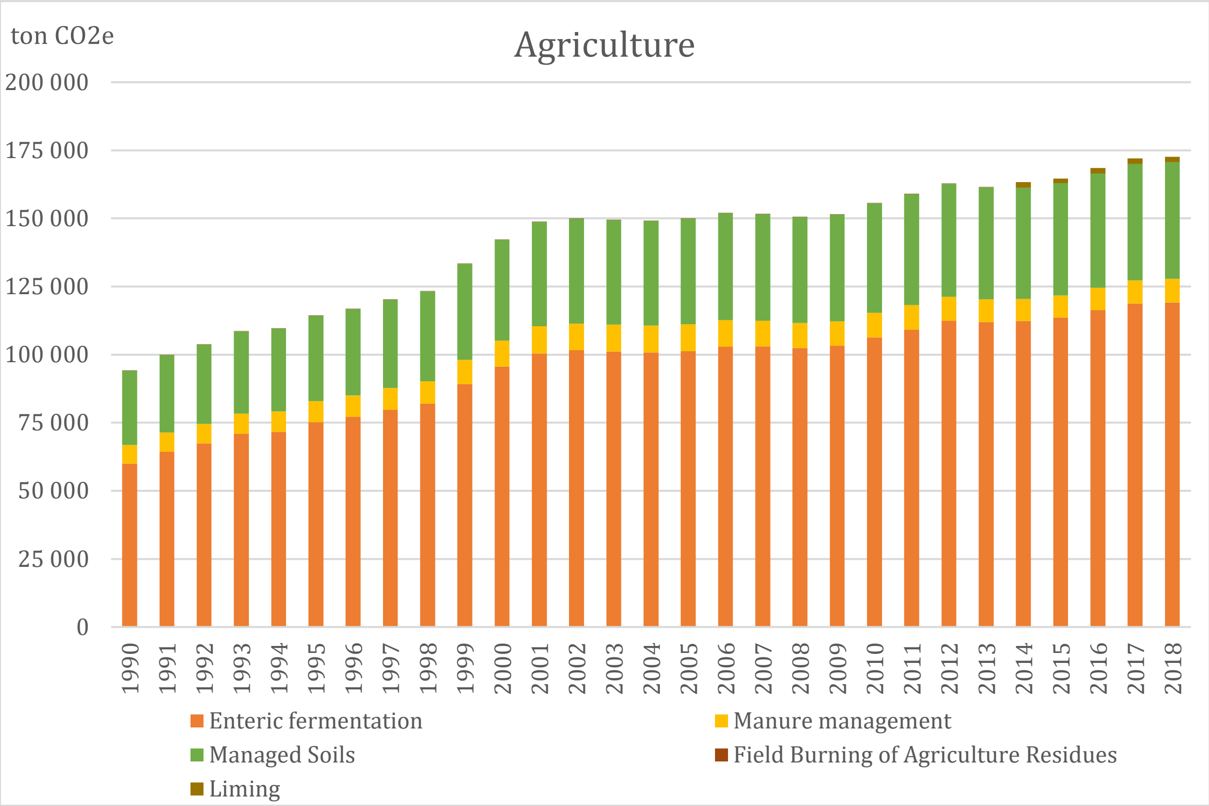

Figure 3- Agriculture Sector GHG Emissions (1990-2018).

The sub-sector with the highest weight in emissions is enteric fermentation resulting from the digestive process in ruminant animals and responsible for methane (CH4) emissions.

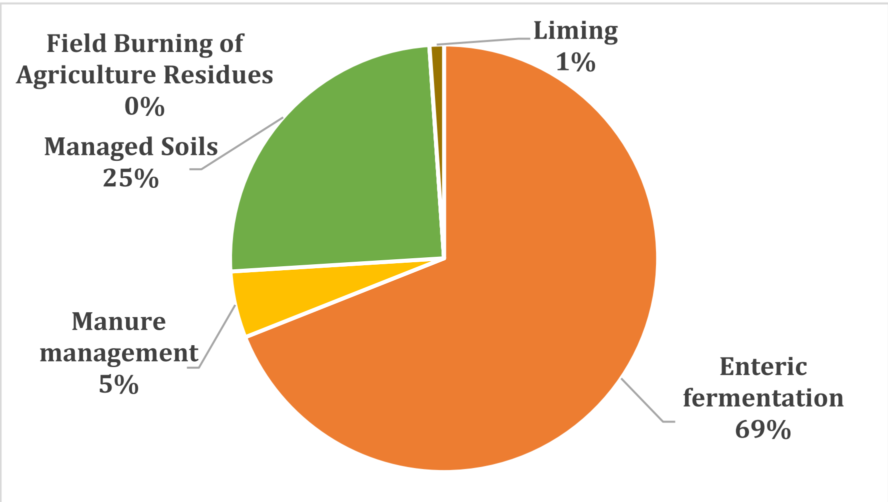

Figure 4- Distribution of Agriculture sub-sectors.

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2.1.3 Energy

The Energy sector currently represents 54% of GHG emissions, raising from 53% in 1990. This sector experienced a very substantial increment of 67,7% of the GHG emissions observed in 1990.

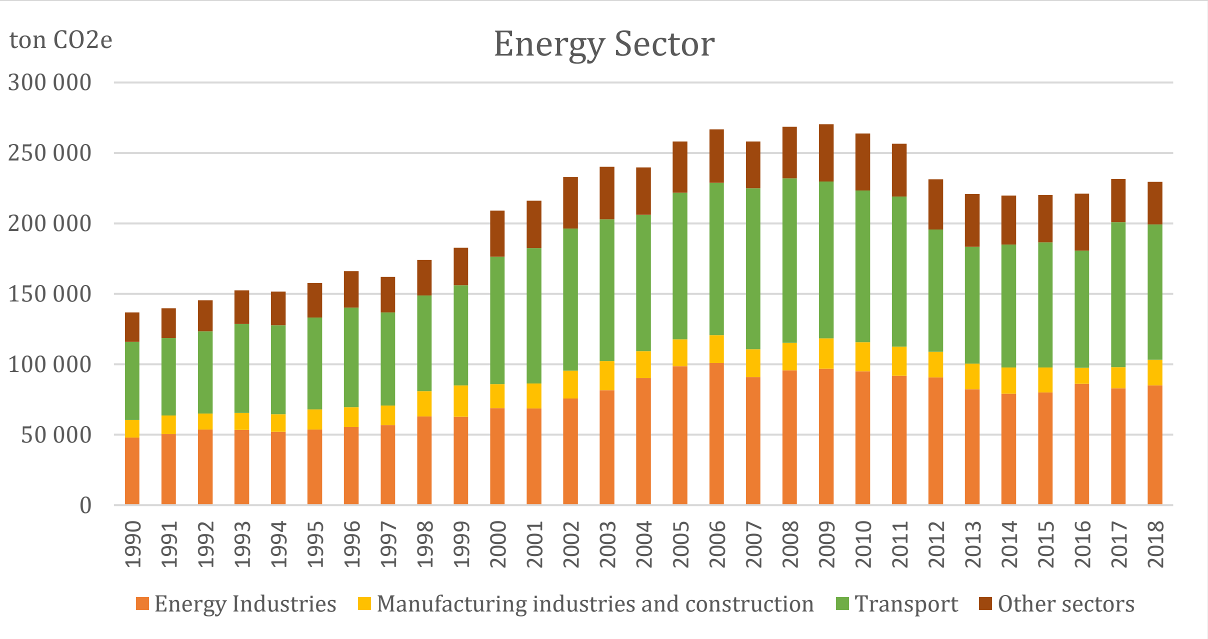

Figure 5- Energy Sector GHG Emissions (1990-2018).

According to figure 6, the transport subsector is the main contributor for GHG emissions with 42% of the energy sector, closely followed by the energy industries subsector with 37 %.

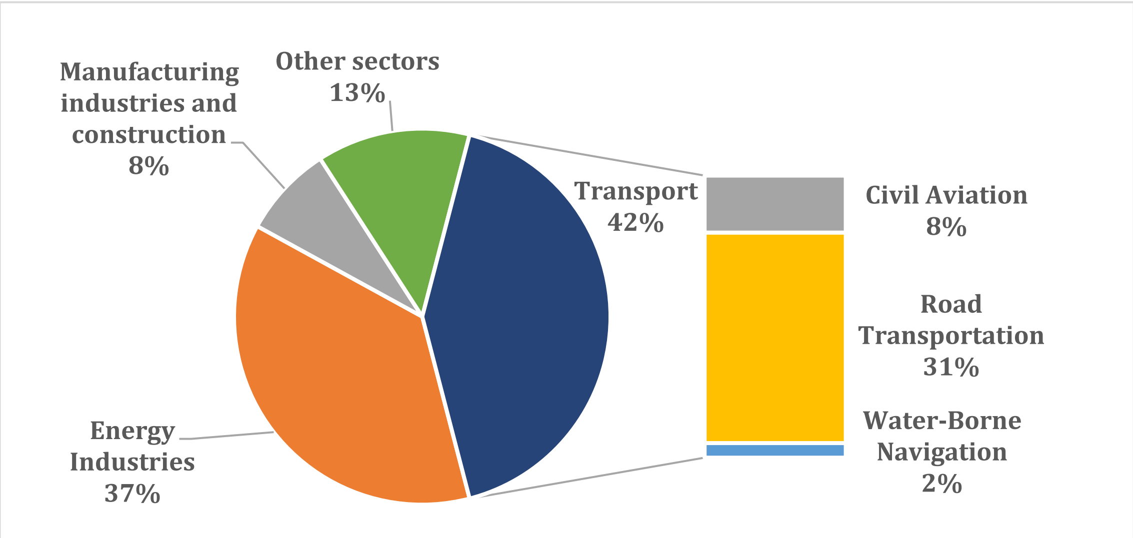

Figure 6- Distribution of Energy sub-sectors.

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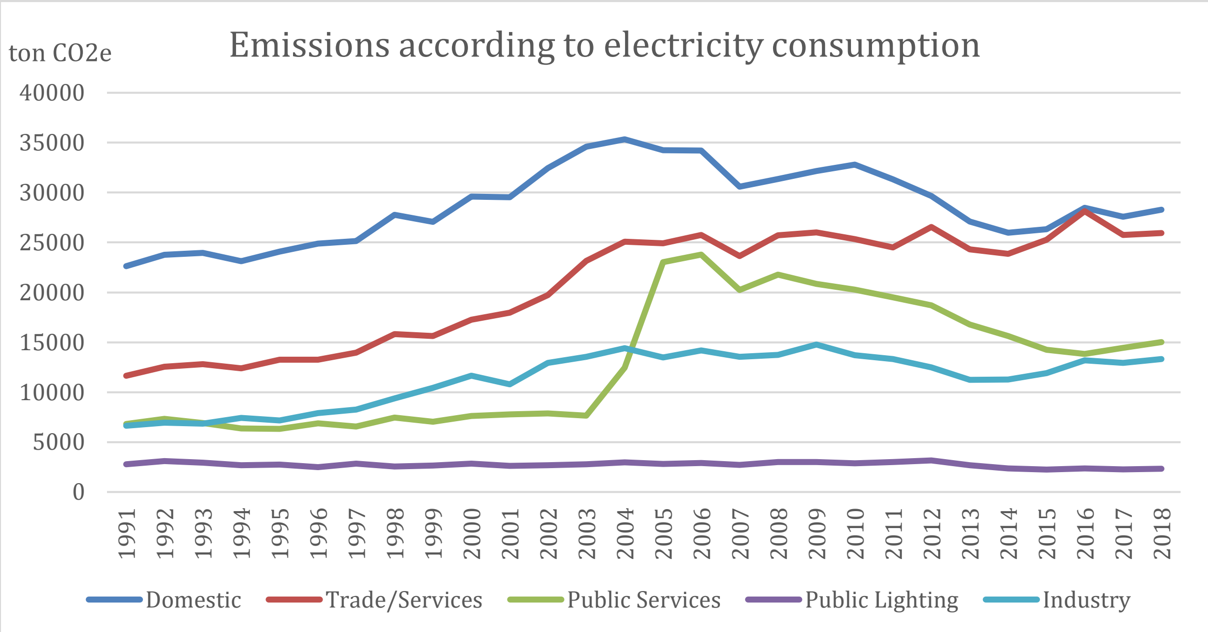
About 75% of emissions of the transport subsector are originated by road transportation. This reality will be difficult to change due to the fact that public transport on the islands is limited, since the routes are not always direct, resulting in more stops and the schedules are sometimes not followed, which leads the population to prefer the personal car. Thus, the strategy for the reduction of GHG in this subsector will be to improve public transport and the electrification of the transport. Thus, the strategy for the reduction of GHG in this subsector will be to improve public transport and the electrification of the transportation.

Electricity production (this subsector will be described in Electricity Subsector) was responsible for 37% of emissions in 2018, this subsector shows a similar evolution to the economy. That is, between 2007 and 2014 the trend was downward (recession period) while in the remaining periods, the trend was of increasing the emissions.

Figure 7- Emissions according to electricity consumption.



Given the emissions related to electricity production and the distribution of consumption by sector, we obtained the figure presented above.

The Domestic sector is the one with the highest consumption, and consequently the highest CO2e emissions. However, in recent years the Trade/Services sector has presented similar consumption.

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2.1.4 Industrial Process and Product Use

The Industrial Process and Use of Product sector represents merely 0.1% of the emissions of the Autonomous Region. There is a lack of diversity of industries in the Azorean island and Terceira only contributes with the use of lubricants for this sector.

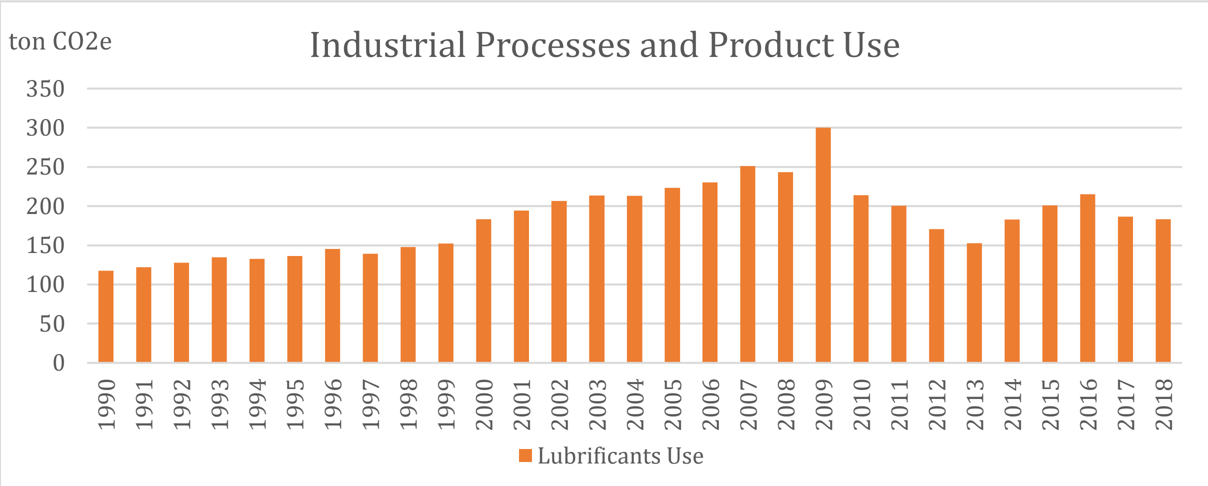

Figure 8- Industrial Processes and Product Use Sector GHG Emissions (1990-2018).

2.1.5 Land Use, Land Use Change and Forestry

The Land Use, Land Use Change and Forestry (LULUCF), or sink capacity is the amount of CO_2 from the atmosphere that can be captured and stored permanently.
The value shown was estimated based on the forest area of Terceira island; according to the forest inventory [9]. Terceira Island has a forest area that corresponds to 13.24% of the Azorean forest.
According to IRERPA, the regional LULUCF suffered a reduction of almost 40% in 2014. This was due to the conversion into vineyards of abandoned land. Nevertheless, according to information gathered from the Regional Directorate of Forest Resources, it had no impact on Terceira island and so a constant value was assumed between 2014 and 2017. Moreover, according to the Occupation of Land Use Map [10], 61.53% of the island is occupied by Agriculture, mainly the pastures that occupy 57.53% while the Forest occupies 27.23%.
Unlike other sectors, the LULUCF sector is responsible for both greenhouse gas emissions (conversion to urban areas) and carbon dioxide sinks (Forestry and Pastures). This sector allows a net reduction of emissions corresponding to -26.1% of the total emissions.

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This capacity to offset emissions is today lower than it was in 1990 (-41.4%), due to the increase of emissions in the remaining sectors. The net sink capacity of the Land Use and Forestry sector increased by 4.2% between 1990 and 2018.

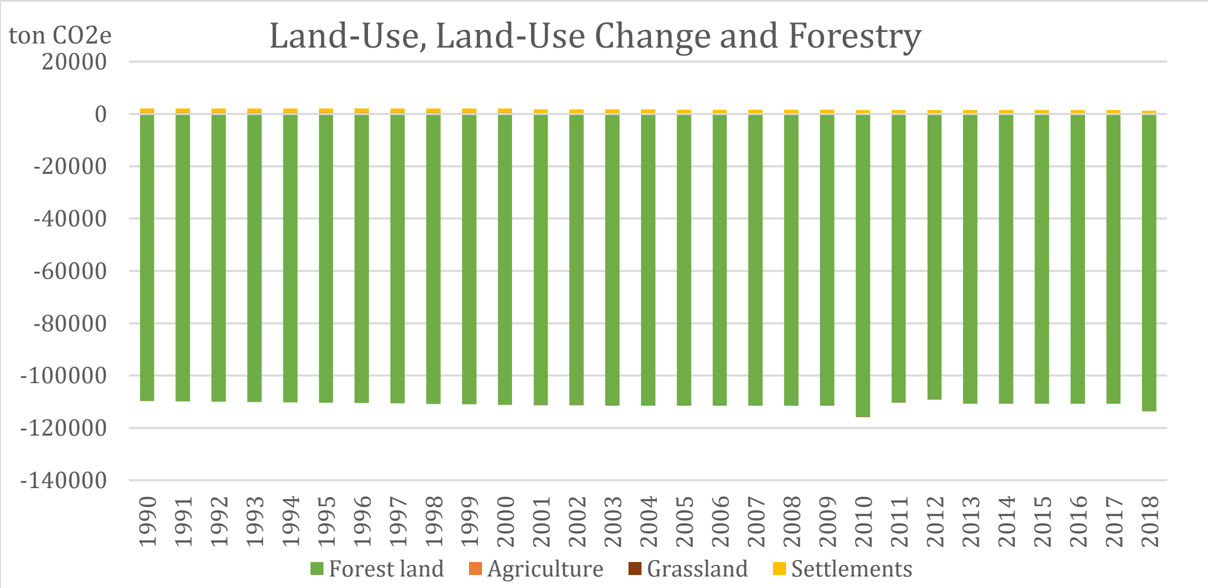

Figure 9- Land Use, Land-Use Change and Forestry Sector GHG Emissions (1990-2018).

2.1.6 Waste

The waste sector currently embodies 6% of total emissions in the Azores, which represents a decrease in its weight of 11% in total emissions in 1990.

The weight reduction in the contribution to the total emissions in the archipelago is due to its maintenance over the years versus a high increase on the other sectors.

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This sector covers emissions from the disposal of solid waste, the biological treatment of waste, the incineration and open burning of waste and the treatment and discharge of wastewater. Emissions from incineration for electricity generation were included in the energy sector.

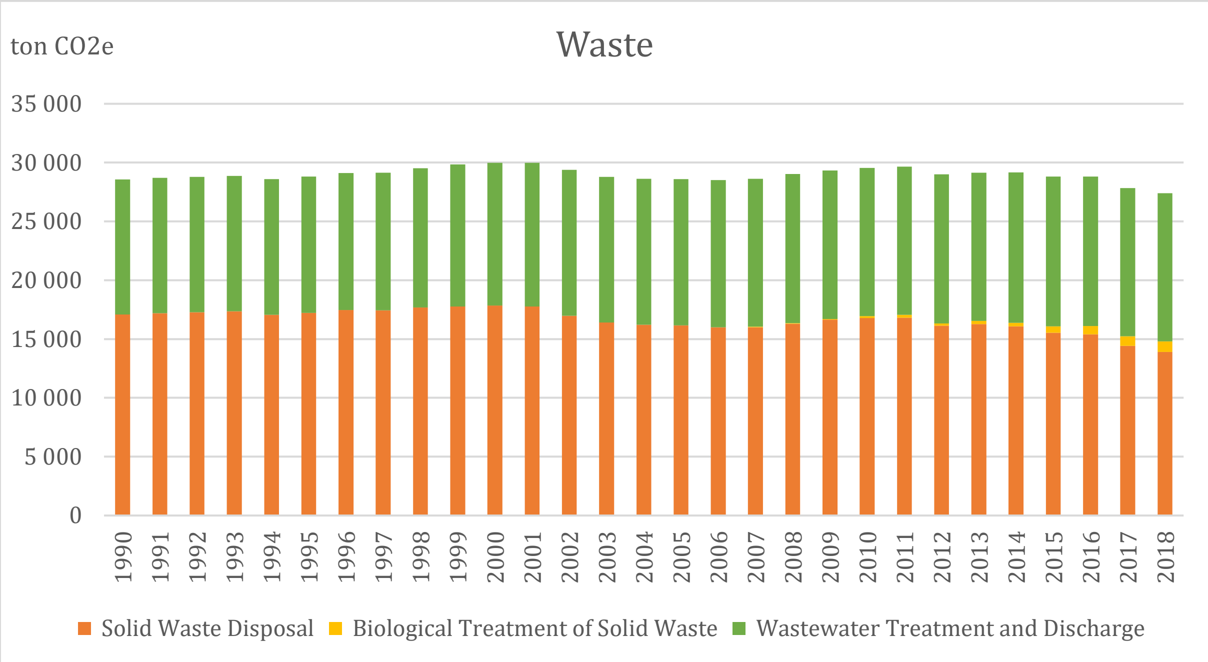

Figure 10-Waste Sector GHG Emissions (1990-2018).

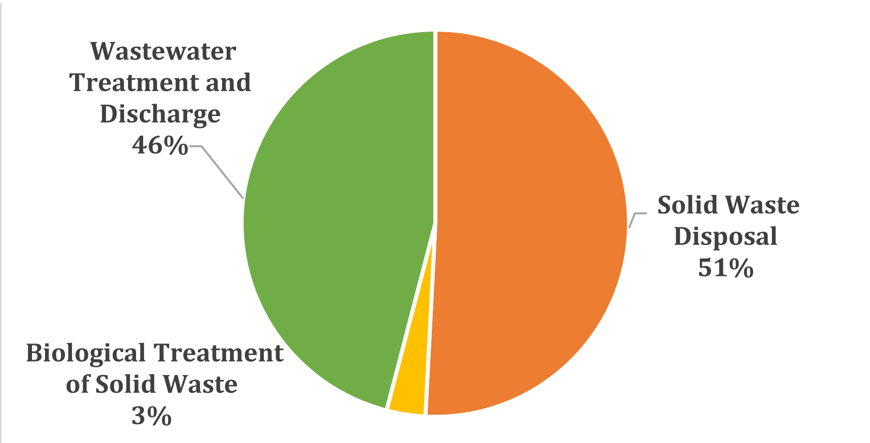

Figure 11- Distribution of Waste sub-sectors.

According to data on the treatment of waste on Terceira Island [12] and presented in the following figure, the amount of waste deposited in landfills has fallen as a result of the incinerator coming into operation. It should also be noted that the amount of waste produced has been decreasing in recent years.

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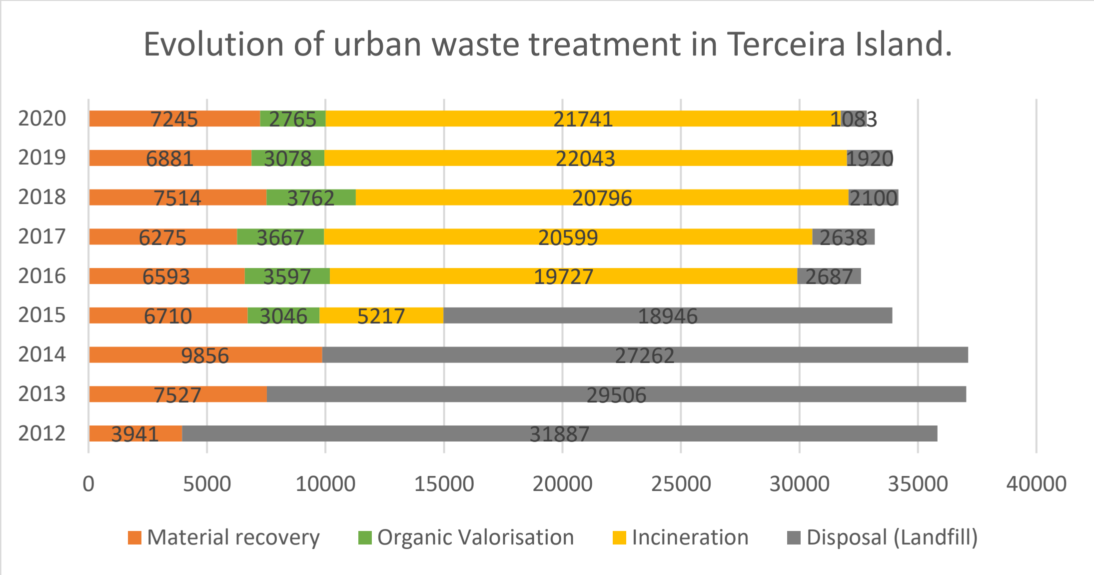

Figure 12- Evolution of urban waste treatment in Terceira Island (ton/year).

2.1.7 Forecast for 2025 and 2030

On the Regional Program for Climate Change in Azores, published in December 2017 and referencing data from the year 2014, it was set 2 different scenarios for the 2030 horizon, one with an increase and one with a decrease of the GHG emissions. Given the current policy applied by the EU, it was opted for this study the scenario predicting a decrease in the GHG emissions.

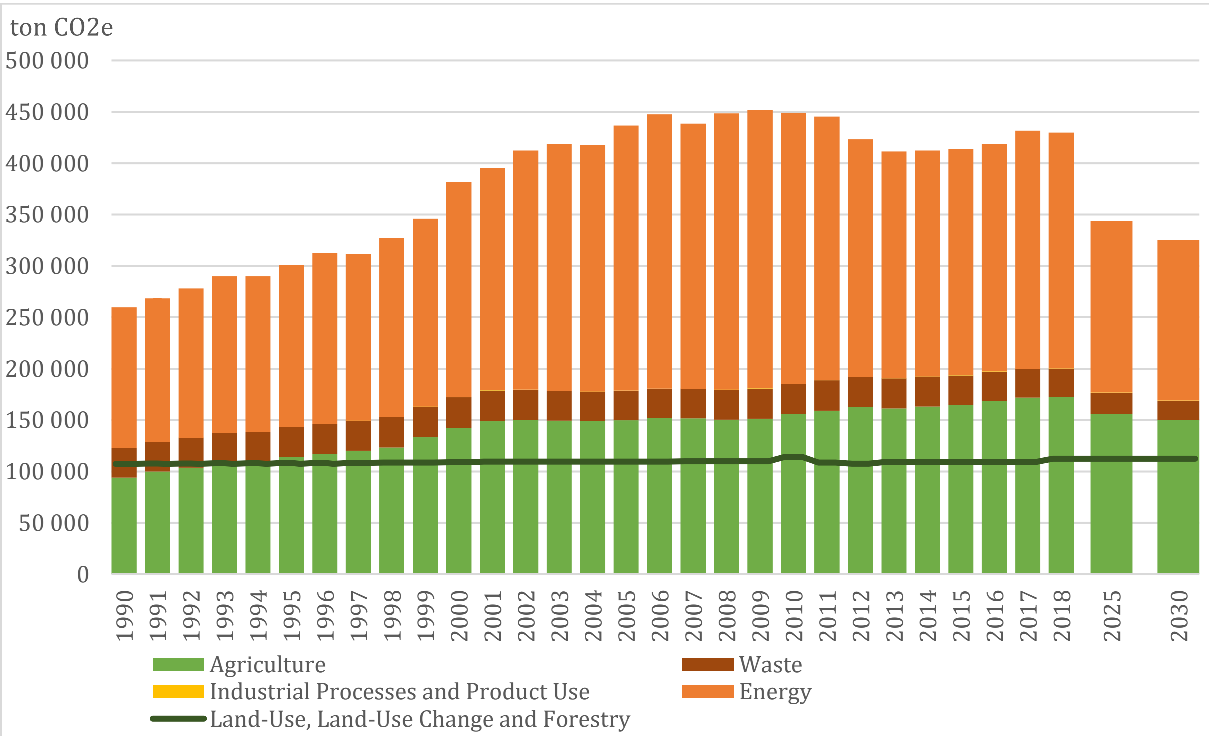

Figure 13- GHG Emissions (1990-2018) and the forecast for 2025 and 2030.

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Even though the EU targets defined in the various protocols and agreements point to 1990 as the value of reference, in Portugal, the year used as base for the predictions was 2005, given that it stands as the maximum value of yearly greenhouse gas emissions.

Table 1- Comparison of the values for 1990, 2005, 2018 versus 2030.

Sectors	1990	2005	2018
Energy	14%	-39%	-32%
Industrial Processes and Product Use	56%	-18%	0%
Agriculture	59%	0%	-13%
Land-Use, Land-Use Change and Forestry (LULUCF)	4%	2%	0%
Waste	-34%	-34%	-31%
Total with LULUCF	40%	-35%	-33%
Total without LULUCF	25%	-25%	-24%

The table above shows that the sink capacity is able to absorb almost the entirety of the emissions with the exception of the energy sector, thus, it will be in this sector where it should be targeted more measures to implement.

Therefore, to reduce greenhouse gas emissions, it will be necessary to increase the integration of renewable sources and promote electrification and/or invest in alternative fuels for road transport.

The main measures to reduce greenhouse gas emissions in the Azores are:

- 80% of electricity production to come from renewable energy sources;
- Increase energy efficiency in transport, buildings and enterprises;
- Promote electric mobility.

The IANOS project solutions (at their scale) will help the Azores to reduce GHG emissions. These solutions will reach a limited number of residences however it aims to demonstrate the benefits and encourage their replicability.

The development of a virtual power plant with the aggregation of small distributed systems, associated smart meters, bidirectional chargers, hybrid transformer and flywheel will allow their users to provide grid flexibility for the DSOs. These technologies will optimize energy consumption, resulting in savings for its users.

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2.2 Characterisation of the Energy Sector (Current status and forecast for 2025/2030/2050)

The energy sector has a significant contribution in the emission of GHG, reason why the sub-sectors of electricity production and road transport will be studied in more detail.

The road to decarbonisation in this sector was defined by the Azorean Energy Strategy 2030, which consists in the following principles:

- Energy Efficiency;
- Electrification of consumptions;
- Increase in the production of electricity with renewable origin.

2.2.1 Electricity Subsector

The electricity subsector of the energy sector is one of those that will be scrutinized to the most, with significant changes with a high target to increase the electrification of consumption, abandoning LPG use for space and water heating and so getting a further step in to decarbonisation. Therefore, it is necessary to increase the production of renewable/endogenous origin as well as its installed capacity.

Given the high depth of the oceanic floor and the severe tides of the Azorean sea, there is no interconnection between the islands, therefore each island of the Azores archipelago has its own electricity production system with a strong dependence on fossil-based production. In the case of Terceira island, in 2020 about 62.17% of production was of fossil fuel origin and the remaining 37.83% was from renewable sources, being the most important wind (16.66%), geothermal (12.86%) and waste (7.39%).

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Table 2- Electricity Production (2020).

Type of Production	Installed Capacity (kW)	Energy Produced (kWh)	Energy Produced (%)
Thermal	58 116	114 768 032	62,17%
Fuel Oil	9 116	114 477 308	62,01%
Diesel Fuel	49 000	290 724	0,16%
Hydro	1 432	1 629 014	0,88%
Geothermal	4 675	23 741 735	12,86%
Wind	12 600	30 748 324	16,66%
Mini / Microgeneration	-	70 931	0,04%
Waste	2 720	13 651 126	7,39%
Total		184 609 162	100,00%

At present day, renewable energy is subject to Curtailment, the grid cannot absorb all the renewable production without compromising stability.

EDA is currently building a Battery Energy Storage System (BESS) with a power of 15 MW and a capacity of 10.5 MWh to increase the integration of renewables, it's worth also mention that until the end of the IANOS Project the installed power of the geothermal power plant will increase to 10 MW.

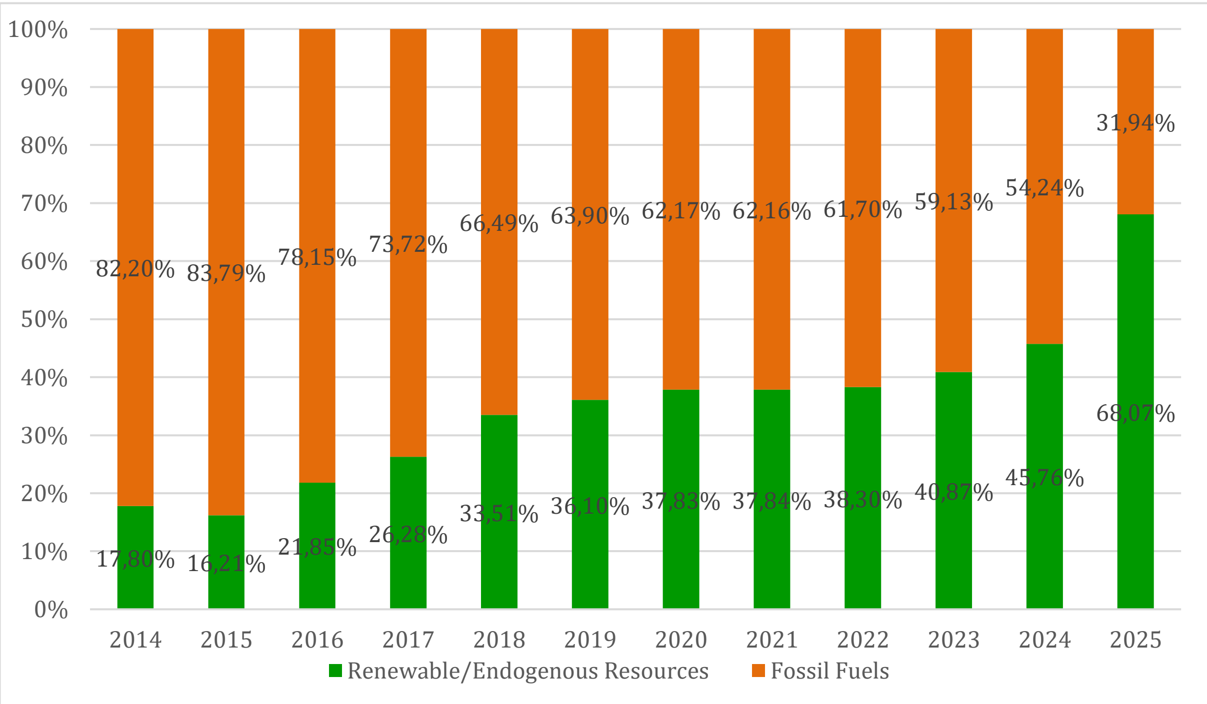

Figure 14- Evolution of the percentage of renewable/endogenous electricity production vs fossil fuels.

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According to the previous figure, production from renewable sources will increase significantly due to the BESS and the increased installed capacity of the geothermal power plant.

It is expected that the contribution from RES reaches 70% by the end of 2025 and so achieving one of the main goals of IANOS project.

The Azorean Energy Strategy [11] points to a target of **80%** in 2030 and the entirety of all electricity produced by RES (**100%**) in 2050.

2.2.2 Transport Subsector

The transportation subsector includes besides Road Transportation also Civil Aviation and Water-Borne Navigation. Given that there are no solutions with TRL 7 or bigger for water navigation and civil aviation, we will focus this chapter exclusively on Road Transportation.

Given that public transportation only accounts for 16.4 of the population [13], private transportation is the main transportation mode in the Azores being used by about 65.1% of the population [12].. Thus, the decarbonisation of this subsector involves mainly the electrification of vehicles and an increase in the use of the public transport. To encourage a change into electric mobility, the Regional Government provides incentives that can reach up to 4,550€ for the purchase of electric vehicles and up to 500€ for the purchase of the charger [14].

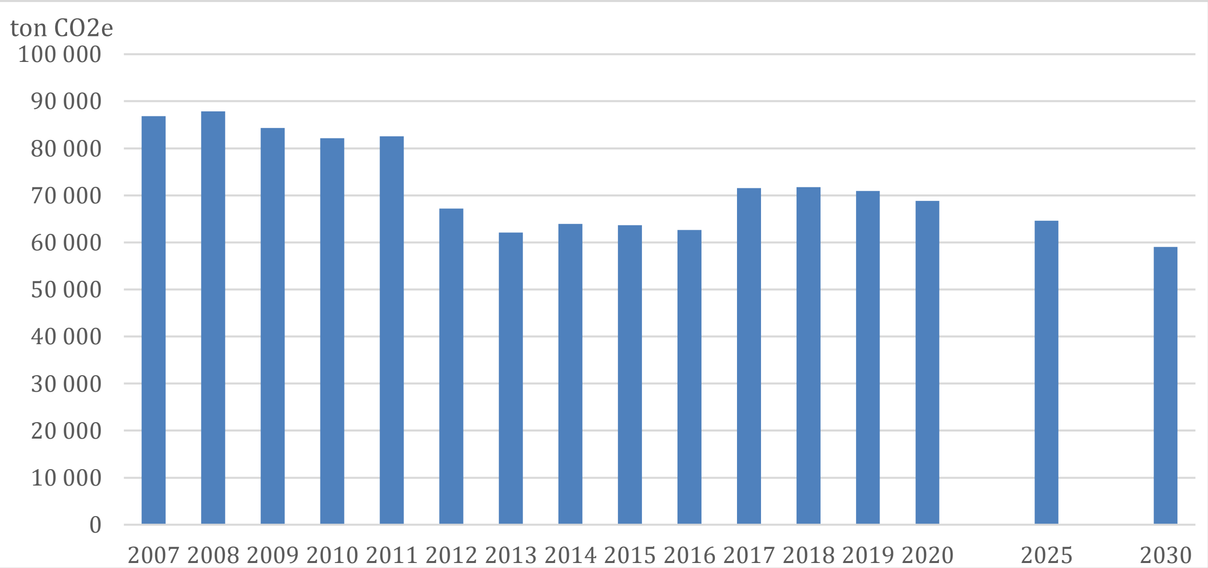

Figure 15- Road Transportation Emissions.

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According to the previous figure, there was a reduction in emissions until 2016 and in 2017 there was an increase that can be explained by the growth in tourism due to the liberalization of airspace.

2.3 IANOS Project

In the next section a brief description of the solutions for Terceira Demonstrator will be presented. For further information, please consult the deliverable D2.1- Report on Islands requirements engineering and UCs definitions.

The other deliverable "Report on regulatory/legal and financial aspects" (D2.4) will be important to understand the main barriers and the most important aspects for decarbonisation. However, we will only be able to the information from D2.4 in a next version as the submission deadline is coincident with this document.

Although we mention the investments in the Solar Farm, the Geothermal power plant, and the BESS, these are not in the scope of this project but will help to achieve the defined targets/KPI, and so a short description of them will be made.

2.3.1 Equipment and system specification

2.3.1.1 PV panels with microinverter

The nominal power for each installation will be 1500W (5x300W) and requires $10m^2$ (around $2m^2$ per panel).

2.3.1.2 Electrochemical batteries

Sixteen distributed electrochemical batteries (3 kWh) will be installed in customer premises in Terceira. These batteries will be standard batteries, with no innovation feature associated.

2.3.1.3 Heat Batteries

Twenty-four heat batteries developed by SUNAMP (UniQ eHW 3 +iPV) will enable to produce domestic hot water heating by using grid electricity and surplus PV energy. These batteries allow to maximize the thermal power by immersing a powerful heat exchanger into the Phase Change Material used as storage medium. The heat storage capacity is 3.5 kWh and the volume of hot water available at 40ºC is 85 L.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 957810

2.3.1.4 Electric Water heaters

The solution developed by UNINOVA allows the non-intrusive characterisation and use of energy flexibility provided by (existing) electric water heaters. It comprises a set of sensors coupled and installed in a non-intrusive manner (there is no need to change or modify a classical water heater) to individual water heaters and the iVPP will provide high level instructions on the grid's flexibility There will be five electric water heaters deployed in Terceira in the context of IANOS with 1.5 kW and a maximum capacity of 150L.

2.3.1.5 V2G chargers

Two V2G chargers (with rated power of 10 kVA) developed by EFACEC MOBILITY will be installed in Terceira. V2G chargers are smart chargers that apart from providing energy to electric vehicles also have the capability of providing control algorithms for ancillary services and grid support.

2.3.1.6 Flywheel

The Flywheel developed by Teraloop will allow to provide fast frequency regulation support and power quality, meeting the demands of unpredictable charge/discharge conditions and presenting an inertial load for the iVPP.

The maximum power rating is 100 kW, max. energy rating is 3 kWh and as an efficiency of 95%.

2.3.1.7 Smart Energy Router

The Smart Energy Router developed by UNINOVA is a power electronics device that manages the energy transfer from/to different sources (distribution grid, RES-based distributed generators), loads and electricity storage systems. In IANOS project, the Smart Energy Router will be located at building level (behind the meter). The Energy Router collects data from various energy assets, like PVs (generation profile) and batteries (charge state) and will receive higher level instructions from the iVPP to control individual assets accordingly. It thus acts as an intermediary between the iVPP and individual assets at building level.

There will be 2 smart energy routers deployed in Terceira in the context of IANOS.

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2.3.1.8 Hybrid Transformer

The hybrid transformer developed by EFACEC ENERGIA incorporates two technologies, electrical and electronic, operating simultaneously. These combined technologies will allow the stepless, phase by phase, voltage regulations at the LV side with power factor control and monitoring.

The rated power is 400 kVA and rated voltage is 15.000 V ± 2 x 2,5%/420 V/242 V ± 12%.

2.3.1.9 FEID-PLUS

The FEID-Plus developed by CERTH is a fog-enabled computing device equipped with special functions to control I/O, phase width modulation and analog signals. It employs enough processing capacity for applying distributed computing such as information capturing and storing, algorithms execution and control over the installation. Additionally, it also has the capacity to interface with several field elements for instance controllable building loads, storage and EV charging stations through appropriate protocols.

2.3.1.10 HEMS

The HEMS developed by VPS will allow to remotely monitor, manage, and control the technological solutions that will be installed within the customer premises.

The system is composed by the hardware (Smart Meters, Sensors and Actuators), Data Management (Communication, Data Processing, and other modules) and User Interfaces.

2.3.1.11 Solar Farm

A Solar Farm of 2 MWp (8,602*265 Wp) will be installed in Praia da Vitória.

2.3.1.12 Geothermal Power Plant

EDA has invested 26 M€ in the execution of 3 geothermal wells and if they are viable, they will allow us to saturate the production as well as to increase the installed capacity from 3.5 MW to 10 MW.

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2.3.1.13 Battery Energy Storage System

This system has 15 MW (power), 10.5 MWh (capacity) and represents an investment of 15 M€. Its main functions are the substitution of the rotating reserve for the static one, regulation of voltage and frequency, and increase the integration of renewable resources.

2.3.2 SWOT Analysis for IANOS Solutions

A SWOT analysis identify Strengths, Weaknesses, Opportunities, and Threats orientated for the different technologies of this project. This will be important to understand the key factors that influence success/ failure of the solutions.

In this first version of the Decarbonisation Master Plan, a simpler SWOT analysis will be presented (see next page) since this depends on the other deliverables of this task, in particular the deliverables Report on regulatory/legal and financial aspects (D2.4) and IANOS KPIs and evaluation metrics report (D2.7) and will be updated as the project is developed.

Table 3- SWOT analysis for IANOS solutions (Terceira).

Solution	Strengths	Weaknesses	Opportunities	Threats
PV panels with microinverter	• Easy installation • Reduces electricity consumption from the grid	• Intermittency and unpredictability of solar energy	• Reduce the energy bill of the participants	•
Electrochemical batteries	• Easy installation • Reduces electricity from the grid	•	• Reduce the energy bill of the participants • Charged by the PV	•
Heat Batteries	• Improve the comfort	• Reduced water capacity	• Reduce the energy bill of the participants • Charged by the PV	•
Electric Water heaters	• Improve the comfort • Grid Flexibility (controllable by iVPP)	• Long heating time	• Reduce the energy bill of the participants	•
V2G chargers	• Ancillary services • Grid Flexibility (controllable by iVPP)	• High cost compared to a regular charger	• Income for the EV owners	• Not yet proven tech
Flywheel	• Improve power quality • Grid Flexibility (controllable by iVPP)	•	•	• Reduced effect on the grid
Smart Energy Router	• Manages energy sources • Provide information to iVPP	•	• Optimize the energy consumptions • Flexibility services	•
Hybrid Transformer	• Improve power quality (Voltage Regulation)	• High cost compared to a regular transformer	•	• Not yet proven tech
FEID-PLUS	• Collect real time data	•	• Flexibility services	• Not yet proven tech

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HEMS	• Monitor, manage and control the solutions • Allow the centralized operation of all grid assets	•	• Optimize the energy consumptions • Flexibility services	•
Solar Farm	• Increase renewable production	• Intermittency and unpredictability of solar energy	•	• Curtailment
Geothermal Power Plant Expansion	• Increase endogenous production • Sustainable/reliable source of energy (base-load power)	• High Investment	• Make the power plant economically viable	•
BESS	• Improve power quality • Increase the renewable integration	• High Investment	• Decrease the curtailment	• Low expectancy of life for the high investment involved

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3 Ameland Demonstrator

3.1 GHG emissions per sector (historical data, current status, major measures and forecast for 2025/2030/2050)

The Dutch Climate Policy [15] states that in 2050 the total CO_2 emissions have to be 0. In 2019, the municipality of Ameland adopted a policy program indicating that Ameland wants to achieve the goals set for climate policy by 2035 – 15 years ahead of the National Policy. In addition to this ambitious objective, Ameland has formulated a number of more qualitative goals: to meet its own energy needs as much as possible, to actively involve the population in the transition process and to share knowledge about Sustainable Ameland projects [16].

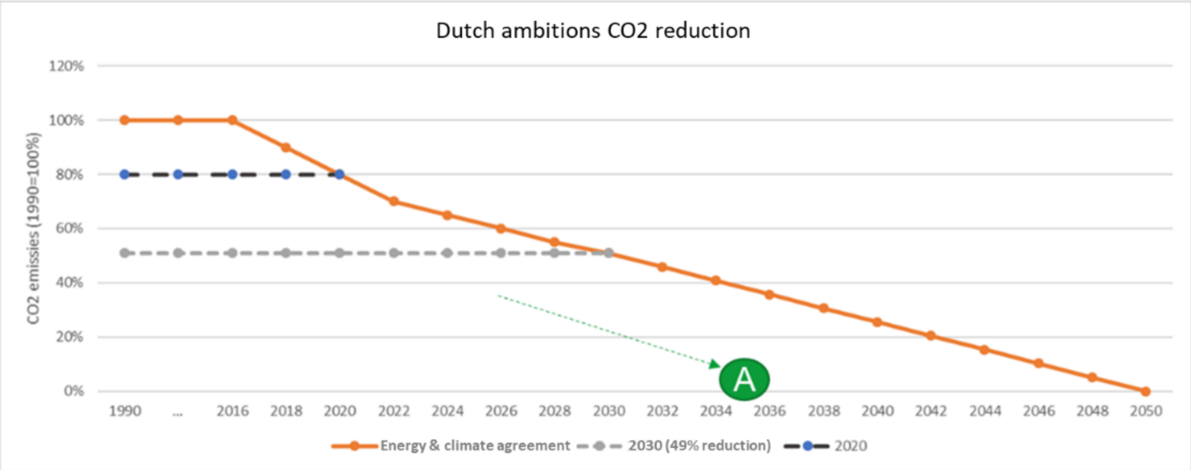

Figure 16- GHG emissions reduction goals for Ameland.

In this policy the municipality acts as a partner in larger projects, as owner of grounds and buildings (including the municipal housing company), and as a facilitator of new projects.

In the coalition agreement - the policy agreements in the college of mayor and aldermen, the Municipal Executive has stated that all possible projects to contribute to sustainable Ameland will be carried out, provided they are financially responsible. Financially responsible projects are projects for which a positive business case is expected, or projects where the contribution from the municipality fits within the budget.

The website Climate Monitor (Klimaatmonitor [16]), a site of the Dutch government, keeps track of all climate related data per municipality. All data used in this chapter is obtained from Klimaatmonitor, including the figures. This website itself does not enrich information but uses existing information, such as statistics, subsidy schemes, sector

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reports and data from individual institutions and companies. This information is fragmented across all these sources and is therefore not easily found or presented in an accessible manner. The Klimaatmonitor bundles, combines, and integrates this data and presents it in a uniform and accessible way.

3.1.1 Total

The greenhouse gas emissions (GHG) on Ameland totalled 34 kt CO2eq. in 2018. The emissions have gradually increased mostly because of increased emissions by the transport sector (see Traffic and Transport).

Figure 17- Total GHG emissions per year.

Ameland's energy demand can be divided into the following sectors and sub-sectors. A different demand profile and CO_2 emissions profile applies per sector and sub-sector, which means that measures to reduce this demand also differ:

1. Built environment: households; holiday homes and hotels; other buildings;
2. Traffic and Transport: public and private transport (including ferry);
3. Industry, Energy, Waste and Water;
4. Agriculture, forestry and fishing.

Tourism - an important sector on Ameland - is (now) divided as a subsector of built environment, and traffic and transport.

Figure 18- GHG Emissions by sector.

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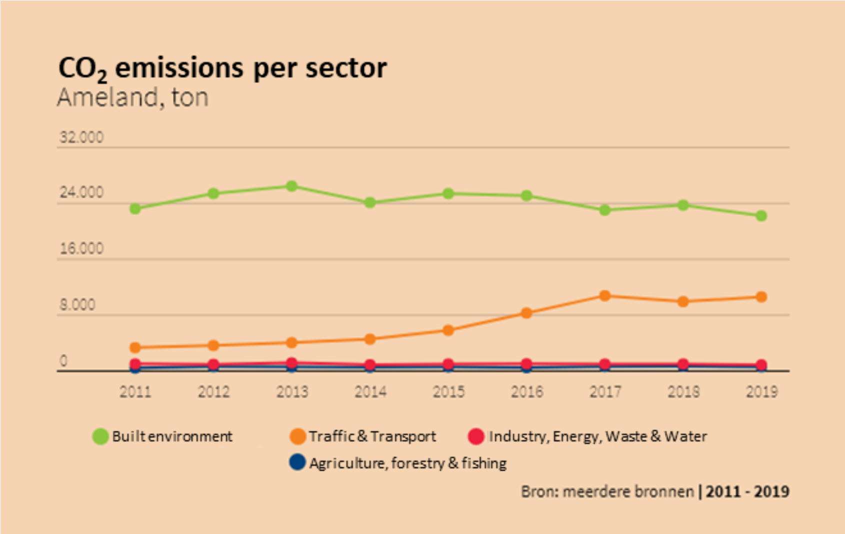

In these graphs the emissions from the NAM-platform are excluded. The platform will be fitted with new equipment in the period 2021-2023 which will reduce these emissions by 51 kt CO_2 eq. After decommissioning the platform, expected in 2035 another 30 kt CO_2 eq. will be saved.

According to TNO calculations, the projects already implemented have led to an estimated decrease in CO_2 emissions of 7 ktonnes per year.

3.1.2 Built Environment

The main sector Built Environment is responsible for 22 kt CO2 eq. per year. The sector is divided in three subsectors, namely Houses, Commercial Buildings and Public Buildings. The graph below shows the part of the GHG emissions these subsectors are responsible for.

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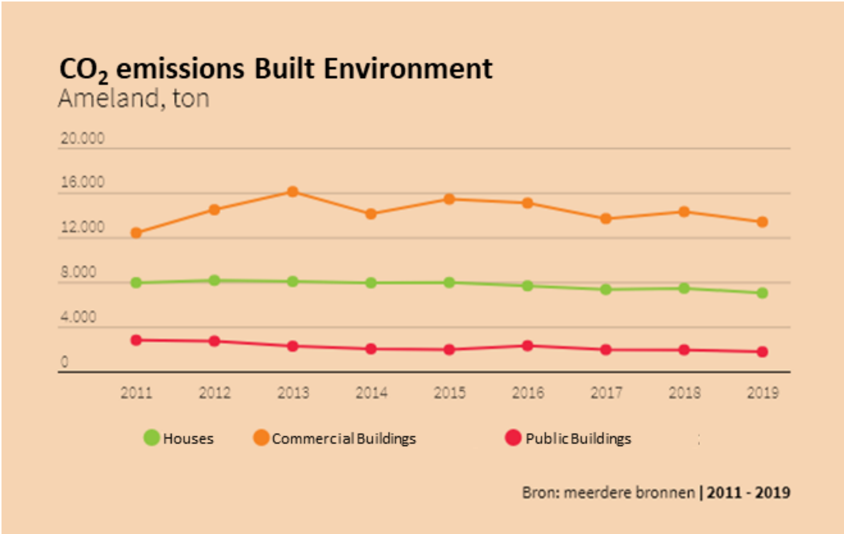

Figure 19- GHG emissions per subsector of Built Environment.

It is noticeable that the Commercial Buildings are responsible for the majority of the GHG emissions and most buildings in this subsector are recreational buildings for hotels, bars, restaurant, etc. A lot can be gained by this subsector.

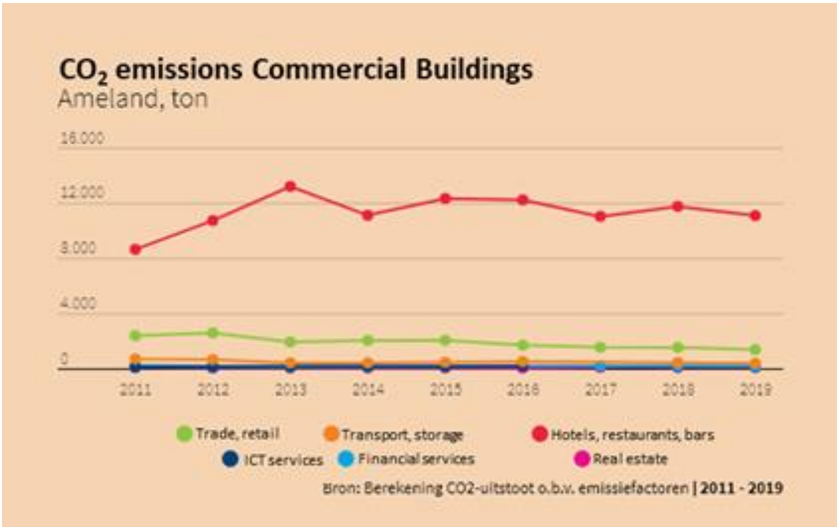

Figure 20- GHG emissions commercial buildings.

3.1.3 Traffic and Transport

The Traffic and Transport sector on Ameland emits 10.5 kt CO2 eq. per year in 2019. The emissions of this sector are at 275% of the level of 2005.

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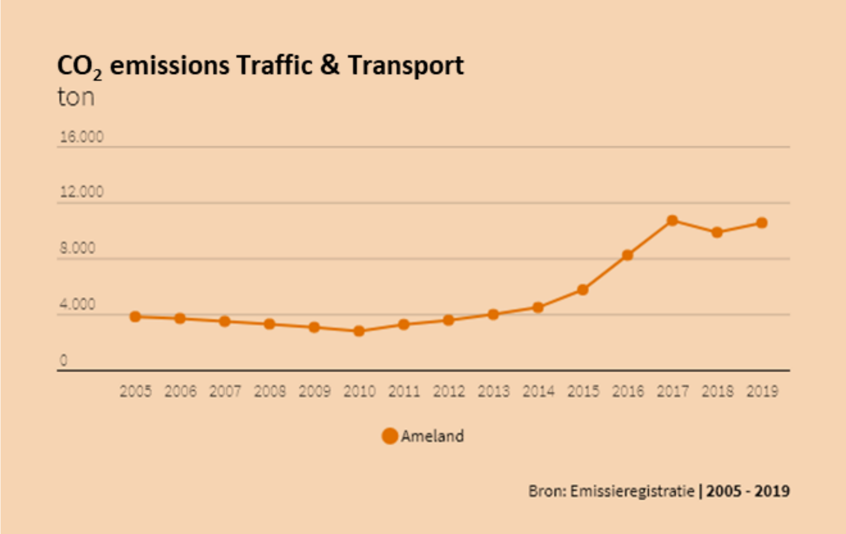

Figure 21-Total emissions of the sector Traffic and Transport.

All subsectors increased their emissions in the past years, but the graph below clearly shows the large increase of the emissions by the subsector Shipping and Fishing. From 2015 onwards the fairway is being dredged with first 1 ship, later on expanding to 2 ships in 2016 and 3 in 2017.

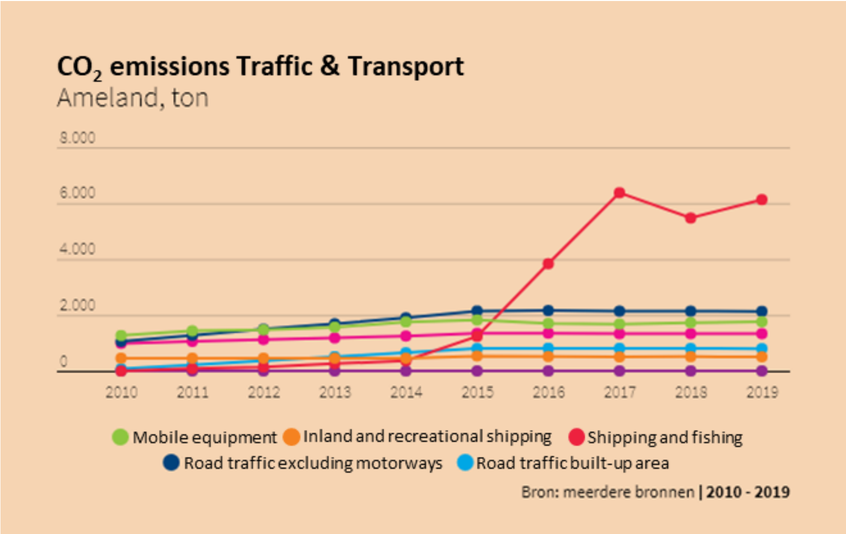

Figure 22- Emissions of subsectors Traffic and Transport.

The subsector Road Traffic has also increased in the past 10 years with almost 90% because of more tourists and more tourists bringing their cars to the island.

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3.1.4 Industry

The sector Industry is very small on Ameland. In 2019 the sector in total produced 801 ton CO_2 in GHG emissions. The subsectors construction industry and industry each produce 219 tons of CO_2 and the water treatment plan produces 360 tons of CO_2. Other subsectors are negligible.

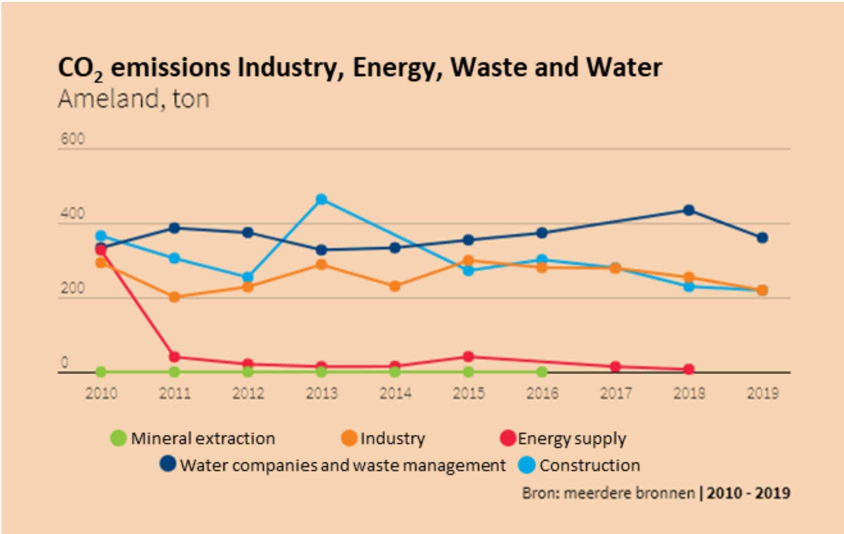

Figure 23- GHG emissions of the sectors Industry, Energy, Waste and Water.

3.1.5 Agriculture

The Agricultural sector of Ameland produces 518 tons of CO_2 per year. This is – compared to the total of emissions – a small number.

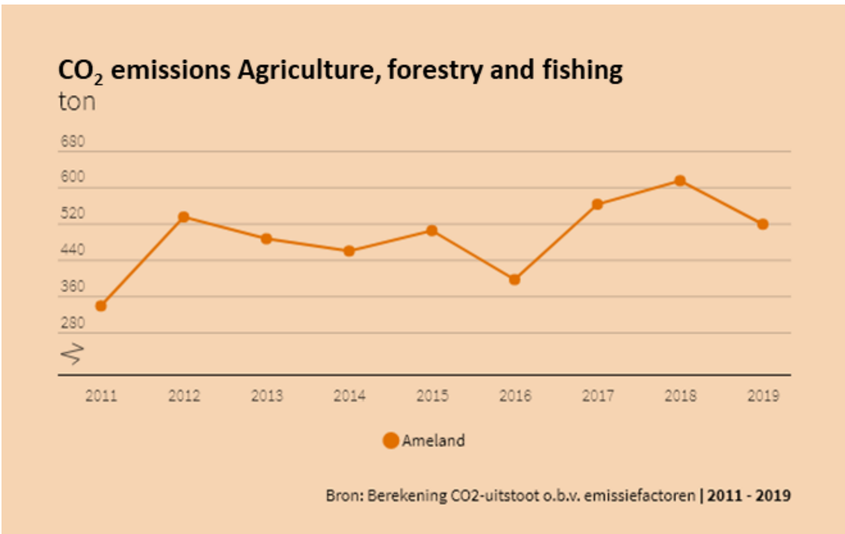

Figure 24- GHG emissions of the sector Agriculture, Forestry and Fishing.

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3.2 Characterisation of the Energy Sector (Current status and forecast for 2025/2030/2050)

The Energy sector on Ameland consists of one solar farm operated by the Amelander Energie Coöperatie (AEC), Eneco and the Municipality of Ameland. Besides that, a number of solar panels are installed on residential housing. All other energy is imported from the mainland by cable, pipe or tank trucks.

A lot of effort on Ameland is set to produce (renewable) energy locally. Besides the continuous effort of AEC to help companies, farmers and residents to install solar panels, a number of larger projects are underway, planned or envisioned.

These projects will reduce the CO_2 emissions from 88% to 22% of the level of 1990. A

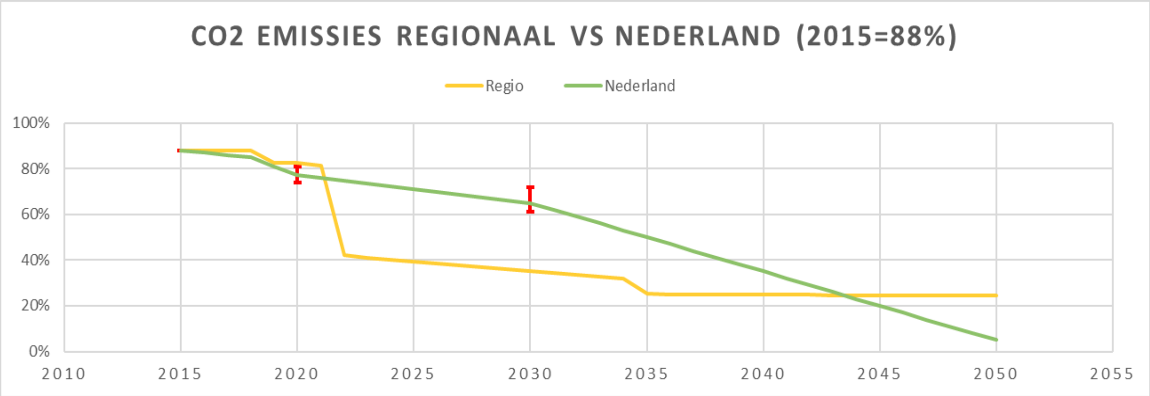

Figure 25- Planned CO_2 emissions on Ameland.

large part of that is done within the IANOS project. A number of projects make more efficient use of energy, i.e. reducing the demand-side. A number of projects increase the supply of renewable energy, such as a solar farm, tidal kite and digester, i.e. increase the supply-side with low or no carbon emissions.

The policy program of the municipality of Ameland sets the goals for a further reduction of CO_2 emissions and adopting more renewable resources in the energy mix. In general, the goal is to meet its own energy needs as much as possible while working on this together with inhabitants and tourists.

3.2.1 Electricity

The municipal policy to meet its own energy needs is especially applicable to the electricity demand. Ameland installed the first large solar park in the Netherlands in 2015 and will continue to install as much renewable energy sources as possible.

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Within the IANOS project period there are plans for a new solar park (Zonnepark Ballumerbocht) and plans for a trial of the tidal kite. During the project new plans will be formed for more solar energy, tidal energy, and wind energy.
Electricity will not be the end-product in all cases. When necessary, the electricity can be converted to hydrogen for alternative energy use.

3.2.2 Gas

Because of the fine-meshed gas network in the Netherlands, most of the households and companies are connected to this grid. In the past years a number of programs were in effect to insulate houses with support of the national and local government, to reduce the demand for natural gas. At this moment there are more plans to install a national insulation program.
Within the IANOS project period a digester will be realized producing 100.000 cubic meters of green gas (equivalent to natural gas). This is in energy equivalent 3,3 TJ. This digester will be fed with all possible biomass (waste) available so that the production of green gas might increase over time. However, this is only 3% of the current demand for natural gas.

3.3 IANOS Project

In the next section a brief description of the solutions for Terceira Demonstrator will be presented. For further information, please consult the deliverable D2.1- Report on Islands requirements engineering and UCs definitions.
The other deliverables Report on regulatory/legal and financial aspects (D2.4) and IANOS KPIs and evaluation metrics report (D2.7) will be important to understand the aspects for decarbonisation, as well as the main barriers and the most relevant KPIs needed to estimate the replication potential.
Still, as mentioned before, it will only be submitted in the current document after the conclusion of the above deliverables. This is due to the proximity or coincidence of the deadline for the current document.

3.3.1 Equipment and system specification

3.3.1.1 Residential solar panels

There are several consumers which have solar panels installed on their roofs. However, it is not known which panels or inverters are installed.

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3.3.1.2 Solar farm

In February 2016, the 6 MWp solar park started operation. In the last 5 years this solar park produced 6600 MWh per year on an average basis. This Park has 3 owners: the municipality of Ameland, Eneco and the Amelander Energy Cooperative. This was the first ground based solar park in the Netherlands. There are 23,000 REC 260PE solar panels installed together with 165 ABB TRIO 27.6 TL OUTD inverters. The electricity is transformed to 10KV by three transformers and runs from the solar park in Ballum to the distribution in Nes by a 6 km cable and distributed to the households in Ameland. Another Solar Park is planned in the Ballumerbocht the specifications of this park will be defined in 2021.

3.3.1.3 Micro-CHP

Three houses equipped with a battery pack (3.5 kWh), solar panels (1 kWe) and micro-CHP (5.5 kWth) will be located at multiple locations in Ameland.

3.3.1.4 Private Methane Fuel Cells

Thirty-five privately owned Methane Fuel Cells (2 kWe) fed by the methane district grid on 35 individual homes are already in operation and funded by the National Project Slimme Stroom Ameland.

3.3.1.5 Fuel Cell

On the largest recreational park of the island, a 500 kWe Fuel Cell will be installed. This Fuel Cell will work as an innovative CHP where the heat produced by the Fuel Cell will be fed into an already existing local heat net. Along with the 500 kWe Fuel Cell, the park also has 2*75kWe CHPs.

3.3.1.6 Hybrid Heat Pumps

One hundred and thirty-five hybrid heat pumps are already installed in residential houses in Ameland. These hybrid heat pumps are fitted with a 20 kWth boiler and a 1.1 kWe/5 kWth heat pump. The units can switch between natural gas and electricity independently depending on weather conditions. These hybrid heat pumps are pre-pared to run on biogas as well.

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3.3.1.7 Biobased saline batteries

SuWoTec will install a 120 kWh (50 kW charging capacity) biobased battery close to a new construction with 13 houses in the city of Nes.

3.3.1.8 Hydrogen water taxis

The hydrogen water taxis which are planned to be developed during the IANOS project have not been designed yet. At this moment there is no information on these taxis.

3.3.1.9 Tidal Kite

The TidalKite development, installation, testing and operation will be executed in a separate project. The IANOS scope focuses on integrating the TidalKite into the Ameland grid and in the central dispatcher. The SeaQurrent TidalKite technology is developed to harness energy from tidal flows. It consists of an underwater kite that makes it possible to cover a larger energy harvesting area, perpendicular to the flow.
The TidalKite test setup near Ameland consists of a monopile mooring that anchors the TidalKite system and a grid connection cable connected to the Ameland electricity grid as operated by Liander.
A standard TidalKite has a capacity of 500 kW and it is connected to the grid via a 10kV power cable.

3.3.1.10 Auto generative High-Pressure Digester

The AHPD is planned to start to be built in the end of 2021. Prerequisites for this digester are that all financial and contractual parts are ready before ordering materials for the digester.

3.3.1.11 Electrolyzer

The electrolyzer will be bought via a European tender. At this moment there is no information on its installation requirements and product specifications.

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3.3.2 SWOT analysis for IANOS solutions

As the name implies, a SWOT analysis identify strengths, weaknesses, opportunities, and threats orientated for the different technologies of this project. This will be important to understand the key factors that influence success/ failure of the solutions

In this first version of the Decarbonisation Master Plan, a simpler SWOT analysis will be presented (see next page) since this depends on the other deliverables of this task, in particular, the Results Report on regulatory/legal and financial aspects (D2.4) which will be submitted on the same date as this document and the IANOS KPIs and evaluation metrics report (D2.7) and will be updated as the project is developed.

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Table 4- SWOT analysis for IANOS solutions (Ameland).

Solution	Strengths	Weaknesses	Opportunities	Threats
Residential solar panels	• Easy installation • Low costs • Reduces electricity import	• Not controllable • Only 1.000 hours/year • High peaks	• Participation of residents • Local storage	• Regulations protected village view
Solar farm	• Easy installation • Low costs • Reduces electricity import	• Not controllable • Only 1.000 hours/year • High peaks	• (financial) participation of residents	• Congestion
Micro-CHP	• Grid Flexibility (controllable by iVPP)	• Uses fossil fuel	• Can operate on biogas and H2	•
Private Methane Fuel Cells	• Grid Flexibility (controllable by iVPP)	• Owner has to participate	•	• Owner can sell the device
Fuel Cell	• Grid Flexibility (controllable by iVPP)	•	•	• Owner can sell the device
Hybrid Heat Pumps	• Grid Flexibility (controllable by iVPP)	• Owner has to participate	•	• Owner can sell the device
Biobased saline batteries	• Grid Flexibility (controllable by iVPP)	• Reduced capacity	•	• Not yet proven tech
Hydrogen water taxis	• Reduces CO2-emissions locally	• No filling points	• Build a hydrogen network in Wadden area	• No plans available • Not yet proven tech
Tidal Kite	• Reduces electricity import • Predictable power supply • Not visible deployment, fully submerged	• Not fully proven • Sufficient flow velocity needed	• Continuous power supply with small storage (to cover periods around high/low tide with no/low velocity) • Lower system integration cost, no/low	• Not yet proven tech • Stakeholders focus on (LCOE) production cost only, not on value of production shape and system + storage benefits

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	• Low cost: deployment near shore possible, deployment with small local vessels for towing • Kites cover a larger area, enabling operation at lower velocities		fossil backup or storage needed • favourable seasonal production profile • higher value electricity production	
Auto generative High-Pressure Digester	• Reduces waste	• Complex system	•	• Not yet proven tech
Electrolyzer	• Grid Flexibility (controllable by iVPP)Prevent congestion	• High costs, unprofitable top • Energy loss	• Part of Energy Rounabout • Build a hydrogen network in Wadden area	• No consumers

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4 Fellow Islands

4.1 Lampedusa

4.1.1 Overview of the current situation and future scenarios

The Effort-sharing Decision (ESD) for the 2013-2020 period required Italy to reduce its non-ETS GHG emissions by 13 % compared with 2005 and for the 2021-2030 period, Italy must reduce its emissions by 33 % against 2005 levels. Italy has remained consistently within its allocated emission allowances and estimates that its planned measures will result in the country slightly exceeding the 2030 target. Key measures for building stock include training, awareness activities and tax deductions, with 110 % refunds for some retrofits through the latest 'ecobonus' scheme, and more general energy retrofitting support available from the National Fund for Energy Efficiency. Heat pumps are expected to play a significant role for households, with business and public sector incentives to invest in cogeneration and district heating through the 'conto termico' and 'white certificate' schemes.

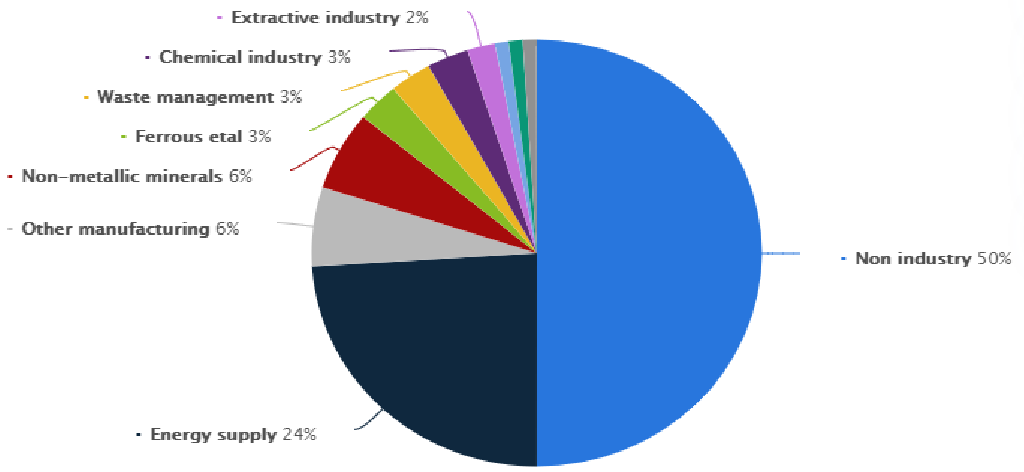

Figure 26- Distribution of industrial greenhouse gas emissions in Italy in 2019, by sector.

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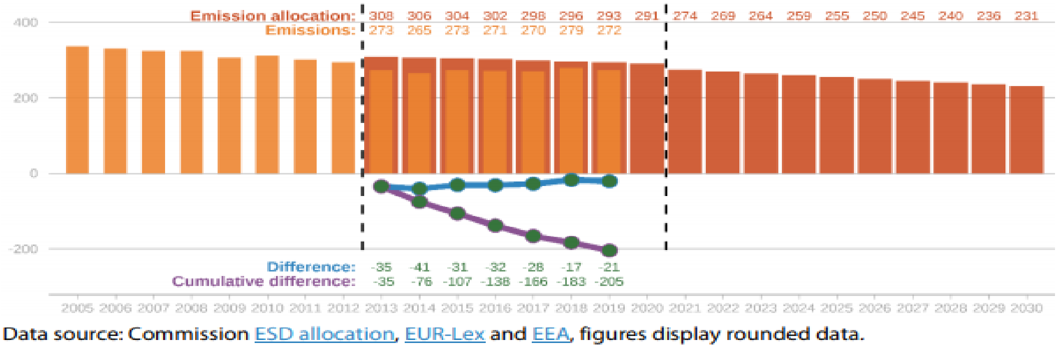

Figure 27- Italy's emissions under the Effort-sharing Decision/Regulation (MtCO2e).

According to a report by Legambiente and CNR-IIA entitled [19], the greatest limits to development for the smaller islands are not technological and have significantly slowed the development of renewable energy. Here, the contribution of renewable energy to energy requirements does not exceed 6%, whereas in the rest of Italy the figure averages 32% [19]. In order to change this paradigm, the Italian government has encouraged the installation of renewable sources, the reduction of energy consumption and energy efficiency on the smaller islands not connected to the mainland grid.

The Municipality of Lampedusa uses the Baseline Emissions Inventory (BEI) which quantifies the CO_2 emissions in the territory during the reference year 2018. This data has been presented within the: "Action Plan for Sustainable Energy and Climate. (PAESC)" within the Pact of the Leaders for Climate and Energy. This pact involves thousands of local and regional authorities committed on a voluntary basis to achieve, on their territory, the EU objectives for energy and climate. With their commitment, the new signatories aim to reduce CO_2 emissions by at least **40% by 2030** and to adopt an integrated approach to address mitigation and adaptation to climate change. The Lampedusa Action Plan allows to identify the main anthropogenic sources of CO_2 emissions and, therefore, to assign the appropriate priority to the relevant reduction measures. The elaboration of the IBE is of crucial importance since the inventory will be the tool that will allow local authorities to measure the impact of their actions on climate change. The IBE shows the baseline for the local authority and subsequent emission monitoring inventories will show progress against the target. Lampedusa, decided to adhere to the Covenant of Mayors for Climate and Energy by committing individually to the target of **40% reduction in emissions** and strengthening resilience to climate change. The Municipality of Lampedusa and Linosa, as well as many other

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municipalities, has decided not to consider, at least in this initial phase, the CO_2 equivalent emissions related to other greenhouse gases such as CH_4 and N_2O and to use for the calculations the standard emission factors identified by the Guidelines prepared by the Joint Research Centre (JRC) of the European Commission. The standard emission factors, in line with IPCC principles, include all CO_2 emissions from energy consumed in the municipal area, both directly, through fuel combustion within the local authority, and indirectly, through fuel combustion associated with electricity and heat/cooling use in the municipal area. In addition, as many other municipalities, has decided not to consider, at least in this initial phase, the CO_2 emissions from the sustainable use of biomass and biofuels, as well as emissions from certified green electricity are considered zero. In addition to this inventory, emission inventories will be compiled in subsequent years in order to monitor progress against the target. This type of inventory is referred to as an Emissions Monitoring Inventory (EMI).

4.1.2 Total

In accordance with European guidelines, the electrical and thermal consumption, and related emissions of the Municipality of Lampedusa as consumer/producer of energy will be taken into account for the following sectors:

- **Buildings /Industries and Plants:**
  - Buildings, public buildings, and facilities (Municipal/public);
  - Buildings, technical equipment/ plants (not public);
  - Technical buildings;
  - Municipal public lighting;
  - Industries (not included the in the EU Emissions Trading System ETS)
- **Transports**:
  - Local car fleet/categories;
  - Public Transport;
  - Private and Commercial transport logistic.

Lampedusa used the "Standard emission factors" in line with IPCC principles: the inventory includes all CO_2 emissions resulting from the final energy consumption that take place within the municipal territory, i.e. the sum of direct emissions from fossil fuel combustion, including transport, plus the indirect ones that derive from the consumption of heat/cooling and electricity consumption in end uses. The standard emission factors are based on the carbon content of each fuel, as is the case for the national

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greenhouse gas inventories compiled under the European Union's Greenhouse Gas Inventory [20]. In particular, the final energy consumption and corresponding CO_2 emissions have been defined, in 2018, for the following sectors and sub-sectors is presented in the table above.

Table 5- CO_2 Emissions Distribution (2018).

Sectors/ Sub-sectors	**tCO_2**	**% over the Total**
Transport		
- Local car fleet/categories	218.40	0.87 %
- Public Transport (including ferry)	7.466.38	29.88 %
- Private and Commercial transport /logistic (including ferry)	196.99	0.79 %
Buildings, technical equipment/ plants		
- Agriculture	0.0	0.0%
- Residential Buildings households; holiday homes	6.377.62	25.53%
- Public buildings, Plants and other facilities (Municipal/public)	2.076.61	8.31%
- Commercial Buildings, other technical facilities/ plants (not public), and hotels; other buildings	6.058.41	24.25%
- Municipal public lighting	519.23	2.08%
- Industries (not included the in the EU Emissions Trading System ETS)	2.072.07	8.29%
Other		
- Waste Water Treatment	0.0	0.0%
- Solid Waste Treatment	0.0	0.0%
- Other	0.0	0.0%

Tourism - an important sector in Lampedusa - is (now) included within subsectors of Residential building, other technical facilities, and traffic and transport.

The CO_2 emissions of the Municipality of Lampedusa and Linosa, for the reference year 2018 (IBE year), are equal to 24,985.7 tons (4.1 tons of CO_2 per inhabitant); in order to meet the target to 2030 (4% less than the emissions of 2018) it will be necessary to reduce them by more than 9,994 tons. The Municipality of Lampedusa and Linosa aims to reduce emissions by 15771 tons of CO_2, that is 63% compared to 2018.

4.1.3 Building Environment

The main sector Building Environment is responsible for 70% of CO_2 emissions per year. The sector is divided in six subsectors, namely: Agriculture, Residential buildings/Holiday homes, Commercial Buildings/Plants and others, Public Buildings, Municipal public lighting, Industries. The graph below shows the part of the GHG emissions six subsectors are responsible for.

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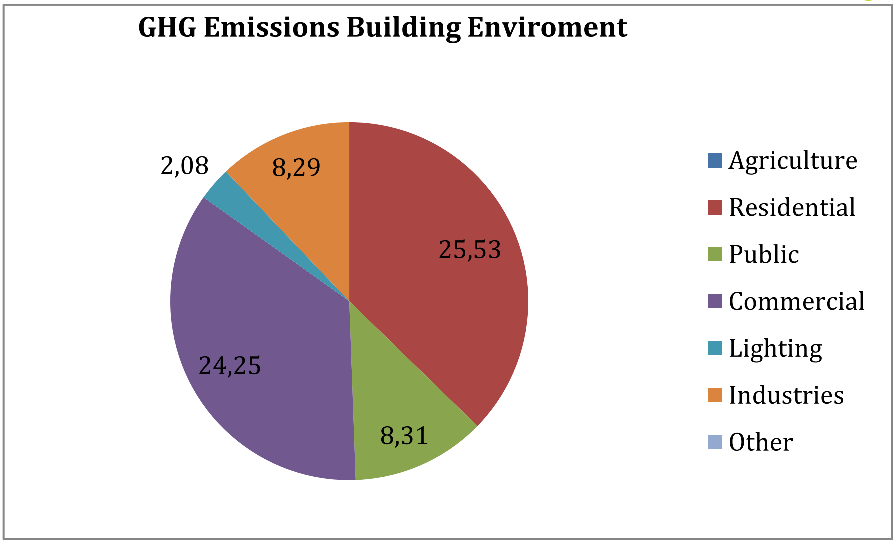

Figure 28- GHG Emissions per subsector of Building Environment

It is noticeable that the Commercial Buildings and Residential Houses are responsible for the majority of the GHG emissions. Most buildings in this subsector are recreational buildings for hotels, bars, restaurant, for tourism and most of the Residential buildings are holiday houses. A lot can be gained by this subsector.

The sector Industry is very small on Lampedusa. In 2019 the sector in total produced 8% of CO_2 emissions. With regard to the island's labour market, commerce and the hotel sector present the greatest number of commercial activities while, for manufacturing activities, the sectors that present the highest number of local units are related to the production of food, concentrated especially in typical productions and fishing.

4.1.3.1 Traffic and Transport

The traffic and transport sector on Lampedusa emits 31.54% of CO_2 emissions per year in 2018. The sector is divided in three subsectors, namely: Local Car Fleet; Public Transport; Private and commercial Transport.

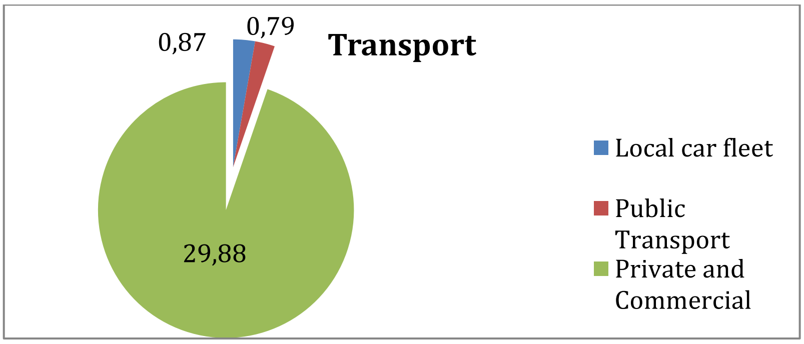

Figure 29- GHG Transport Emissions.

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It is noticeable that the Private and Commercial transports, are responsible for the majority of the CO_2 emissions per year especially during summer period. According to the Municipality, the car fleet of Lampedusa, especially in the tourist period, consists mainly of motorbikes. It is worth to consider the emission values of the Dock source active as well from 9:00 to 15:00 that considers only an average distance of 300 meters made by vehicles, forklifts, heavy and light vehicles (in different quantities) that constitute the traffic related to the handling of goods. traffic related to the movement of goods to and from the ferry.

4.1.4 Characterisation of the Energy Sector

The supply of energy, since there is no direct connection with the mainland, is provided through a diesel thermoelectric power plant managed by the company S.EL.IS. Lampedusa S.p.A. The company has a power plant located close to the town centre, in the district of Pisana and consists of 8 generators coupled to equal number of diesel engines of a total power of 22.5 MVA. The generators work with different scheduling according to the hourly electrical load and the engines work alternating between the primary energy production system and the storage system. As expected, the minimum peak is when neither heating nor cooling is needed, and the tourist season has not yet begun. Differently the maximum peak is in the evening of August in which the island has the greatest number of tourists and the demand for air conditioning is at its peak. Between the winter period and the summer period the monthly value doubles, thus it is possible to affirm that the electric energy in summer is 4 times higher compared to the spring period.

Table 6- Vector consumer/Electricity demand per year MWh.

Vector Energy Consumers	Electricity Demand (MWh)	%
Public Lighting	855	3%
Residents	9438	29%
Non-residents	1403	4%
Tourist Establishments	3302	10%
Tertiary Activities	3084	9%
Tertiary Activities such as Bars, Pizzerias and Restaurants	1596	5%
Industries	1975	6%
Municipal Users	322	1%

Water Plant and Sewage Plant	366	1%
Desalination Plant	3509	11%
Hospital	313	1%
Airport	1865	6%
Military Areas and Barracks	2453	7%
Self-consumption Power Plant	2389	7%

The processing of the data of the individual vectors is showing the greatest weight to the residential load, which accounts for 29% of the total load. The second highest weight is that of hotels, which, if added to that of residences intended for tourist accommodation, affects about 15% of the total load. The desalinization plant has a fairly significant weight being 10% of consumption. The consumption of municipal utilities, including those such as the hospital and the water plant and sewage system, are considered with overall cover 3% of global consumption. The very high value of the percentage of self-consumption, equal to 7% of the total, has been a value imposed at the time of data processing in order to take into account within it all those vectors that despite being good absorbers of electricity have been excluded from the research. It is confirmed that in Lampedusa that not all energy consumption is reported within the 12 vectors of consumption identified. In particular, it is important to consider that some users have not been considered because are not belonging to any of the identified categories, the energy requested by them has not been taking into account. Therefore, to include also these small deficiencies it has been decided to increase the value relative to the auto-consumption up to 7%.

A lot of effort on Lampedusa is set to produce (renewable) energy locally. Based on the evaluations previously made regarding the demand for electricity to 2025, the objective of this first scenario is to produce approximately 12,300 MWh/year of electricity from renewable energy sources. The first scenario of the project assumes its development in the period between 2016 and 2025 envisaging a mix of renewable energy sources, consisting exclusively of solar and wind energy to which is associated an electrical storage system. In particular, the installation of:

- Single integrated photovoltaic systems on the roofs of buildings,
- Photovoltaic systems on the ground in areas already identified, environmentally altered.
- A wind farm composed of wind turbines with rated power less than 200 kW

In addition, it has been assumed that from 2020 the individual photovoltaic systems on the roofs of buildings will be integrated by as many storage systems with lithium batteries able to dampen even more the peaks of demand and stabilize more demand peaks and stabilize more the island's electricity grid. Regarding the storage system, it has been assumed to use pre-combined modules sodium nickel chloride batteries, salt batteries are in fact increasingly chosen for applications such as the power supply frequently for applications such as the power supply of electric vehicles and storage of energy from renewable sources such as energy from renewable sources such as solar or wind energy as they guarantee safety, reliability, and flexibility of installation. Their most important characteristic is that, thanks to the internal operating temperature of 270° C, they guarantee performance and service life independent of the environmental temperature.

Based on the evaluations previously made regarding the demand for electricity in 2035, the objective of this second scenario is to produce at least 29,000 MWh/year of electricity from renewable energy sources. The plants installed during the period of the first scenario (2025) will be maintained active and integrated with similar plants. They will be complemented by a large offshore wind farm, a wave power plant, and a fuel cell and electrolyser system for the production of electricity from hydrogen.

The 2035 fossil free scenario will consider:

- An additional 1 MW of photovoltaic systems will be installed on the roofs of buildings.
- The installation of a 1 MW Tidal energy plant (it is assumed that this will be placed near the west coast of the island).
- The installation of the 1.5 MW offshore wind energy and hydrogen storage system, Lampedusa has to wait until these technologies can be found on the market with competitive prices and production reliability. It is important to mention that in 2035 an offshore wind plant can be realized, maybe with floating technology, composed by 3 wind turbines of 1.5 MWp.
- A hydrogen storage system will be installed to serve the entire electrical system of the island.

Besides the continuous effort of AEC to help companies, farmers, and residents to install solar panels, a number of larger projects are underway, planned or envisioned. A large part of that is done within the IANOS project, through the application of the Virtual Power Plant (VPP) as a cloud-based cluster of intermittent energy generators of wind turbines, solar panels, and sea wave energy in the case of Lampedusa, controlled from a central point. Lampedusa will for sure take advantages by IANOS applications especially for the energy and balance demand and supply of energy on the islands. The policy program of the municipality of Lampedusa sets the goals for a further reduction of CO_2 emissions and adopting more renewable resources in the energy mix. In general, the goal is to meet its own energy needs as much as possible while working on this together with inhabitants and tourists.

4.2 Bora-Bora

4.2.1 Overview of the current situation and future scenarios

Information to be included in the next version.

4.3 Nisyros

4.3.1 Overview of the current situation and future scenarios

The GHG Emissions originated from the power consumption of the Island, are related to the Oil Engines that exist in Kos, the Island that supplies energy to Nisyros through an interconnection cable. Apart from that, the Emissions are related to the Mobility at the Island during the years, as the cars, motorcycles, and trucks are using oil and diesel from the local gas station.

One of the major sources of Emissions is the Desalination Plant, that is the biggest energy consumer (1,500 MWh per year) and uses Diesel.

According to the National statistics for the GHG Emissions [22] that are produced in Greece, it is obvious that 6,39 tons of CO2e are produced every year per citizen. Nisyros island has 1,008 habitants so the yearly produced CO2 GHG emissions are 6.441,12 tons of Emissions per year (2016 statistics). These emissions are becoming from the following sectors:

- Demand and Consumption of Electricity: The production of the electricity is being in Kos from Diesel Engines
- Local Economy
- Transportation and Mobility with Diesel fuel.

If we consider the increasing number of habitants on the tourism period (April to October), the above emissions number can be increased in double.

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From the above analysis and data, it is obvious the Energy plays crucial role on the GHG creations. So Nisyros the last year has designed the Energy transition to RES using friendly methods as a result to achieve the ZERO Status (Zero Waste and Zero Emissions). This transitional plan is being worked from great engineers and Nisyros has structured a well known plan for the Decarbonisation as below

4.3.2 Overview of the Decarbonisation plan of Nisyros

The Decarbonisation Plan of Nisyros is based on the Master Plan for the Energy transition of the Island where the Municipality is going to develop Renewable Energy sources through Photovoltaics, Small Wind Turbines as well as Geothermal power with low enthalpy. To be more specific the plan of Nisyros is the following:

- Delivering and installing photovoltaics in the Public Buildings;
- Working with local Universities, European Union authorities as well as the Greek authorities as a result to design and install photovoltaics on the Households buildings apart from others. With this goal Nisyros aims to eliminate the Energy poverty and from the other side to create all the necessity initiatives as a result the citizens to participate in an Energy community;
- Making the Desalination and Wastewater treatment facility to be powered by Energy systems with Smart PV systems with sufficient storage as a result the system to work with self-sufficiency and the facilities to work with Solar Energy. The photovoltaics will be installed in Public areas with total coverage 8,900 m^2;
- Apart from that, according to the energy transitions plan of Nisyros, it is going to be installed two small wind power turbines with 250 kW capacity per one, as a result to create sufficient energy that will supply the energy needs;
- About the mobility on the Island, the Municipality with Scientific authorities has designed the transition to Electric mobility, installing 15 Electric Vehicle Chargers in all the Island regions including the four (4) villagers. In addition, initiatives are going to be established to encourage citizens to substitute their vehicles with electric ones.

4.3.3 Energy Transition Results

With the above plan, Nisyros is going to be ZERO EMISSIONS place, and the Island will be self-sustained in the Energy production and needs. Apart from that according to the Local decisions and action plan, the Island will achieve ZERO Carbons (GHG Emissions) after that implementation of the installations of the facilities apart from others.

5 Conclusions and Next Steps

According to the information presented in this document, the energy sector is the biggest contribution to GHG emissions. This sector includes both electricity production, transport, and the building environment.

In the case of Terceira Island, the energy sector, namely the subsectors of electricity production and transport, and the agriculture sector, are the most relevant in the emission of GHG. Thus, the reduction of emissions goes through the use of renewable energy combined with electric vehicles.

The Ameland Island presents a different reality from Terceira since it has a connection to the continental electrical grid and has a population of about 3,700 inhabitants, receiving 600,000 tourists per year. Therefore, the sectors that contribute more to the emission of GHG are the Built Environment, the Traffic and Transport. In order to reduce emissions, the municipality has invested in the more efficient use of energy and in renewables, in order to produce its own electricity and not have to import it.

The distribution of Lampedusa's emissions is similar to the previous ones due to tourism. Thus, the Building Environment sector is responsible for 70% of the emissions, namely the Residential (25.53%) and the Commercial (24.25%) subsectors, while the remaining 30% corresponds to the Transport sector.

Once again, the majority of emissions are related to the energy sector, i.e. electricity generation and transport. This island is electrically connected to the islands of Kos and Tilos through a subsea cable, and they use conventional diesel generators. The main consumer of electricity on Nisyros is the desalination plant, which runs on diesel. Thus, to change this situation, they will invest in the installation of renewable resources and in the installation of chargers to encourage the use of electric vehicles.

There is a clear commitment by Governments to renewable resources production Thus, with the expectation of increasing the installed capacity of renewable origin year after year, decarbonisation will be achieved through an increase in efficiency and with the electrification of consumption.

After the description of the GHG emissions of the islands, the next steps are to understand better the various solutions of this project in order to present the potential for replication and update the information provided in this deliverable.

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