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IANOS

SUSTAINABLE SOLUTIONS
for islands' decarbonisation

IANOS Replication across EU and cooperation with relevant project/initiatives

Authors: Denisa Ziu (ENG), Vincenzo Croce (ENG)

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Executive Summary

This deliverable D9.5 describes the activities of T9.3 "Replication potential across EU and cooperation with relevant projects/initiatives". The deliverable intends to provide the first steps for the replicability assessment of IANOS solution in additional EU islands. Starting from the outputs of T9.1 and T9.2, the formal description of the demonstrators and replicators, will be used to identify additional potential replication capacities on EU islands (either mainland grid connected (Ameland) or isolated (Terceira).

Deliverable D9.5 is the first version of two reports which will identify additional potential replication capacities on EU islands. The current version defines the methodology to follow for replicability assessment in additional EU islands. The initial steps concern: the replicability analysis of the IANOS islands, i.e., the definition of Master Use Cases; the definition of additional EU island clusters that represent island characteristics from different point of views, e.g., size, grid interconnection, seasonality, geographical features, economic development, and resource availability.

Table of Contents

List of Figures....5

List of Tables....5

Notations, abbreviations, and acronyms....6

1 Introduction....7

1.1 Objectives and Scope....7

1.2 Relation to other activities....7

1.3 Structure of the deliverable....7

2 Methodology....9

3 IANOS islands Master Use Cases....10

3.1 Replication concept developed in IANOS....10

3.2 Terceira Master Use Case....12

3.3 Ameland Master Use Case....13

3.4 BORA BORA Master Use Case....15

3.5 Lampedusa Master Use Case....15

3.6 Nisyros Master Use Case....17

4 Definition of EU island clusters....18

4.1 The NESOI project....18

4.2 Island clusters from NESOI....19

4.2.1 Clusters by size and grid interconnection....19

4.2.2 Clusters by Geographical Features....21

4.2.3 Cluster by Economic Development....22

5 Conclusions and next steps....24

References....25

List of Figures

Figure 1 Methodology adopted 9

List of Tables

Table 1 IANOS use cases overview...10

Notations, abbreviations, and acronyms

BESS	Battery Energy Storage System
EV	Electric Vehicle
FI	Fellow Island
iVPP	Intelligent Virtual Power Plant
LEC	Local Energy Community
LH	Lighthouse Island
MUC	Master Use Case
RES	Renewable Energy Source
TT	Transition Track
UC	Use Case

1 Introduction

1.1 Objectives and Scope

IANOS project aims to promote the wide replication and upscaling of innovative solutions in EU islands. D9.5 is the first report on the IANOS Replication across EU and cooperation with relevant project/initiatives of Task 9.3. The goal of this deliverable is to identify additional potential replication capacities on EU islands.

As a first step, the methodology for replicability assessment in additional EU islands is defined. The methodology consists in the analysis of IANOS replication activities performed in the two Lighthouse islands (Ameland and Terceira) and three Fellow islands (Bora Bora, Lampedusa, Nisyros). Moreover, the methodology includes the analysis of the characteristics of other islands in the EU.

1.2 Relation to other activities

D9.5 is the first report on the IANOS Replication across EU of task T9.3. T9.3 follows the work of tasks T9.1 "Lighthouse Islands Replication and Scalability Plan" and T9.2 "Fellow Islands Replication and Scalability Plan". The output of these two tasks is used to identify additional potential replication capacities on EU islands, either mainland grid connected (Ameland) or isolated (Terceira). In addition, a strong connection is made with the activities of task T9.4 for the collaboration with other projects like NESOI to define the set of islands across EU for the replication of IANOS technology.

1.3 Structure of the deliverable

Chapter 2 – Methodology

The methodology for IANOS replication assessment has been defined. The methodology adopted for this scope involves the analysis of IANOS replication activities performed in the two Lighthouse islands and three Fellow islands and the definition of EU clusters. The goal of the defined methodology is to prepare a guidebook of best practices and lessons learnt for the stimulation of replication towards other islands.

Chapter 3 – IANOS islands Master Use Cases

The first step of methodology includes the replicability analysis of the IANOS islands, i.e., the definition of Master Use Cases (MUC). A Master Use Case has been defined and presented for each island as a result of tasks 9.1 and 9.2.

Chapter 4 – Definition of EU island clusters

Chapter 4 presents the criteria for grouping EU islands into clusters, based on their characteristics from different point of views, e.g., size, grid interconnection, seasonality, geographical features, economic development, and resource availability. The resulting clusters are those defined in NESOI project.

Chapter 5 – Conclusions and next steps

Chapter 5 concludes the document and reports the steps for the next deliverables related to T9.3.

2 Methodology

The first report on the IANOS Replication across EU and cooperation with relevant project/initiatives of Task 9.3. The aim of the deliverable is to identify additional potential replication capacities on EU islands.

The methodology adopted for this scope (Figure 1) involves the analysis of IANOS replication activities performed in the two Lighthouse islands and three Fellow islands. To this end, a Master Use Case (MUC) has been defined and presented for each island as a result of tasks 9.1 and 9.2, summarising the main actions to be taken to decarbonise the islands' energy system, a procedure that can then be replicated in other geographical islands in the EU. Moreover, with the scope of preparing a guidebook of best practices and lessons learnt for the stimulation of replication towards other islands, we report in this deliverable also the definition of EU island clusters. The clusters represent island characteristics from different point of views, e.g., size, grid interconnection, seasonality, geographical features, economic development, and resource availability.

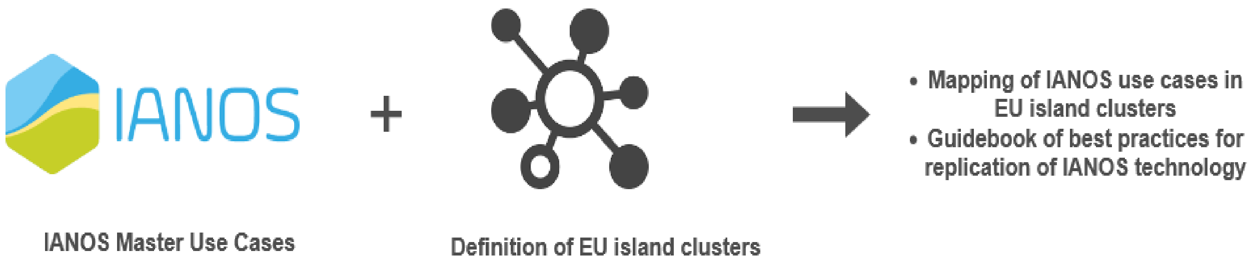

Figure 1 Methodology adopted

3 IANOS islands Master Use Cases

3.1 Replication concept developed in IANOS

In IANOS the term replication addresses use cases and innovative solutions demonstrated in the 2 Lighthouse Islands (LHs) Ameland and Terceira, which are of interest to be replicated or even implemented on a large scale in the island context, both in Lighthouse (LHs) and Fellow Islands (FIs). Table 1 shows the set of IANOS Use-Cases (UCs), as defined in the Grant Agreement, clustered into 3 Energy Transition Tracks (TT) according to the challenges addressed and exploited opportunities. The Energy Transition Tracks are the following:

-TT#1 - Energy efficiency and grid support for extremely high-RES penetration – which comprises UC1, UC2, UC3, UC4. This TT utilizes the intelligent Virtual Power Plant (iVPP) logic to reduce energy curtailment and enabling a high-RES penetration in the energy system.

-TT#2 - Decarbonization through electrification and support from non-emitting fuels – which comprises UC5, UC6, UC7, UC8. This TT demonstrates the potential of electrification as a mean to decarbonize relevant sectors along with non-emitting fuels utilization for cross-resource integration and circular economy.

-TT#3: Empowered Local Energy Communities – that includes only UC9 and aims to engage and involve citizens into the decarbonization transition of the islands.

Table 1 IANOS use cases overview

Island Energy Transition Tracks	IANOS Use Cases (UC)		LH Islands				FI Islands		
			AME		TERC		LAMP	BORA	NIS
#TT1: Energy efficiency and grid support for extremely high-RES penetration	UC1	Community demand-side driven self-consumption maximization	D	R	D	R	-	-	R
	UC2	Community supply-side optimal dispatch and intra-day services provision	D	R	D	R	-	R	-
	UC3	Island-wide, any-scale storage utilization for fast response	D	R	D	R	R	R	-

TT#2: Decarbonization through electrification and support from non-emitting fuels		ancillary services							
	UC4	Demand Side Management and Smart Grid methods to support Power quality and congestion management services	D	R	D	R	-	-	R
	UC5	Decarbonisation of transport and the role of electric mobility in stabilizing the energy system	D	R	D	R	R	R	R
	UC6	Decarbonizing large industrial continuous loads through electrification and locally induced generation	D	R	-	R	-	-	R
	UC7	Circular economy, utilization of waste streams and gas grid decarbonization	D	R	-	R	R	R	R
	UC8	Decarbonisation of heating network	D	R	-	R	R	R	R
TT#3: Empowered LECs	UC9	Active Citizen and LEC Engagement into Decarbonization Transition	D	R	D	R	R	R	R

In order to fully address the defined TTs, IANOS aims to enable and demonstrate the implementation of 9 CUs, as well as to explore the potential for replication and large-scale implementation of some of these UCs (including the innovative solutions offered by IANOS) by defining a **Master Use Case** for each island that will bundle all the different UC-level interventions into a single UC, called MUC, and based on the specific needs of the island and aspects of the energy transition. The MUC will include innovative as well as conventional IANOS solutions, mixed together to achieve the islands' energy sustainability goals. The specific capacities and areas for each of the selected technologies should be defined, as well as the grid topology in which the innovative IANOS technologies will be included. The economics of MUCs, including CAPEX and OPEX for each operating unit, system and technology, should also be provided.

In the following paragraphs, the first versions of the master use cases for each island are reported. The definition of master use cases is the result of the activities of tasks T9.1 and T9.2.

3.2 Terceira Master Use Case

Terceira LH Island aims to implement energy efficiency, grid flexibility and e-mobility measures in the context of the island's decarbonisation. The main objectives of the Azorean Island are the optimization of the behind-the-meter assets towards maximizing the RES self-consumption of households, the provision of ancillary energy flexibility services for the grid by the deployed energy storage systems, and the electrification of the transport sector. Terceira will examine further replication or large-scale deployment of the UCs demonstrated in IANOS in order to deliver a detailed replication plan for achieving carbon neutrality in the long run. The Master Use Case will consider the set of UCs 1, 3, 4 and 5 in order to investigate their replication potential and feasibility, based on the foreseen decarbonisation scenarios. The following conventional and innovative technologies will be deployed and tested in these UCs:

- Battery energy storage system (BESS) of 15 MW/3 MWh
- 2 V2G charging stations with a rated power of 10 kVA (EFAEM)
- Electrochemical Batteries (16 batteries with a total capacity of 3.3 kWh)
- PV panels with embedded microinverters with a total capacity of 1.5 kWp (5x300Wp) (BeON).
- Heat Batteries with a total heat storage capacity of 3.5 kWh (SunAmp)
- 5 Electric Water Heaters with a capacity of 150L (UNINOVA)
- 2 Smart Energy Routers with a battery of 5 kWh each deployed (UNINOVA)
- A Flywheel (100kW) (Terraloop)
- Hybrid Transformers (400kVA) (EFACEC)

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3.3 Ameland Master Use Case

The entire set of IANOS UCs that will be implemented by the LH Island of Ameland, focusing both on energy efficiency and decarbonisation aspects, will be examined also in terms of replication and upscaling potential. The Master Use Case will consider the aggregation of all interventions included in the UCs in order to investigate their replication potential and feasibility, based on the defined decarbonisation scenarios. A detailed description regarding the included technologies per transition track (TT#1 and TT#2) and their specific characteristics is presented.

Energy efficiency

The technologies involved to create more RES, energy storage, promotion of self-consumption and smart energy services are:

- Solar Farm: 6 MWp Solar Farm at the airport of Ameland.
- Solar Farm & Battery Storage: 3 MWp Solar Farm & BESS with DC-connections at Ballumerbocht Ameland.
- BioBased Saline Battery: 120 kWh biobased saline SuWoTec battery
- Electrolyser: In the proposal a 2 MW Electrolyser was planned in combination with a water taxi which would be realised by Wagenborg (ship owner) and would use the hydrogen from the electrolyser. Wagenborg decided to not run that project. This not only means that there is no water taxi within the IANOS project but also that there is no use for a large scale electrolyser. A small scale electrolyser will be installed and tested in the Ballumerbocht. With this a combination will be made with the wastewater treatment plan to use the oxygen and a hydrogen fuelled cleaning truck.
- Households with battery packs, PV and µCHP's: 3 houses with battery pack (3.5kWh), solar panels and micro-CHP (1kWe, 5.5kWth)
- Hybrid Heat Pumps: 135 Hybrid Heat-Pumps (20kWth gas boiler + 1.1kWe/5kWth Heat Pump)

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- Methane Fuel Cells: 35 privately owned CH4 Fuel Cells. These are already being in operation and funded by the National Project Slimme Stroom.
- Virtual Power Plant: Platform to connect all assets and regulate energy flow

Decarbonisation

The technologies involved to decarbonise transport, decarbonise large industrial load, decarbonise heating networks and to utilize waste streams to create methane are:

- Digester: A digester to use restaurant waste (swill, fat) and sludge from the water treatment plant as a source for methane production.
- Charging Infrastructure: 10 new public charging stations, privately owned charging stations, municipality owned charging stations
- CHP Plants
- Electric Bikes: All Bike rental companies offer electric bikes for tourists.
- Electric Buses: All buses are electric.
- Electric Cars available for tourists: Available at taxi rental company.
- Electric Cars of the municipality: 3 electric cars of the municipality of Ameland.
- Sea Water Heat Pumps
- Heating Grid Nes/ Heating Grid Buren: the development of two new heating grids in Nes and Buren
- Heating Grid Klein Vaarwater/ Large Fuel Cell/CHP Plants: an extension of the current heating grid with a fuel cell and CHP's as heat source.
- Tidal Kite: 500kWe Tidal Kite to be installed between Ameland and Terschelling
- AWG Natural Gas Platform: Replace gas-driven compressor by electrical compressor
- Hydrogen fuelled transport: a cleaning truck which is planned to rent from another municipality

- Wind Turbines: There are some small-scale wind turbines installed on Ameland. Municipality promoted installing turbines. There are now 3 permit requests (2 regular turbines, 1 vertical axis). Hydrogen storage

3.4 BORA BORA Master Use Case

The main objective of Bora-Bora Island is to increase its energy self-sufficiency for both the supply and demand side by local resources and the proposed replicated solutions by the project. By 2030, Bora-Bora wants to accomplish essential decarbonisation setting the goal of generating 75% of its electricity from RES. IANOS will assist in the deployment of 2 MW_p PV agricultural greenhouses and 2 MW_p PV shading structures integrated with an energy storage system. The creation of a desalination unit, the installation of solar panels and onshore maritime thermal energy (2 MWth) to support the renovation of the airport's air conditioning, and the building of an electric boat charging station are also in the plan. Relevant UCs to be replicated are UCs 2,3,5 and 8. The Master Use Case, supported by a more detailed dimensioning of envisioned interventions, on the level of systems, will be defined in the 2nd version.

3.5 Lampedusa Master Use Case

Despite Lampedusa and Linosa programmed several actions to foster RES in the framework of the Sustainable Energy and Climate Action Plan (SECAP), the situation has changed due to the implementation of a new plan to use the funds provided for the Green Island project promoted in the framework of Italian PNRR. In fact, through the PNRR, Lampedusa and Linosa have received funding in the order of 41 million euros to be spent on the island's green transition no later than 2026. The municipality of Lampedusa is currently analysing solutions to be implemented with these funds. In addition, solutions are being studied to use these funds as leverage for potential private investments that can exponentially increase RES production on the two islands.

Therefore, an overview of potential solutions to be implemented through Italian PNRR funds include for Lampedusa the:

- installation of 300 photovoltaic modules on public rooftops on the island of Lampedusa for a total of 92.4 kW_p with an estimated production of 153.2 MWh/year;
- installation of a floating wind system for a total of 1500/3000 kW_p and a production of more than 5150 MWh/year at a distance of about 10km from the north coast of the island of Lampedusa;
- installation of a photovoltaic system on the island of Lampedusa for a total of about 2.3 MW_p with an estimated production of 3800.0 MWh/year;
- installation of a 2300kWh electrochemical storage system;
- installation of 15 electric vehicle charging infrastructure on the island of Lampedusa;

The foreseen interventions for Linosa, are respectively:

- installation of 78 photovoltaic modules on public roofs on the island of Linosa for an overall total of 40 kW_p with an estimated production of 72.1 MWh/year;
- installation of a photovoltaic system on the island of Linosa for an overall total of 450 kW_p and a production of 765 MWh/year;
- purchase of 1 electric-powered bus, 3 electric-powered mini-buses and 3 electric-powered vans to be divided in the two islands;
- installation of 5 electric vehicle charging infrastructures on the island of Linosa.

The municipality aims to conduct techno-economic and feasibility studies with the aim to provide better grid stability through defining effective RES penetration models into the island's grid and addressing critical grid challenges as of congestion, curtailment, and voltage variations, facilitating the island energy transition. IANOS will assist Lampedusa during those studies and the potential implementation of those solutions. The goal for Lampedusa and Linosa is to figure out how to replicate the results achieved by UC 3, 5, 8 and 9. The Master Use Case will be defined in the second version.

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3.6 Nisyros Master Use Case

Nisyros envisions to benefit from the grid stability provided by the Kos electricity network, which is expected to be interconnected to the mainland grid with DC underwater cables by 2027. It is also necessary to conduct feasibility and techno-economic studies to determine the optimal decarbonisation and flexibility measures to the electric grid e.g., the installation of PV and wind parks accompanied by grid scale storage systems that will make it easier to operate the regional electrical grid in the South Aegean. Nisyros has 200 residential and 11 public buildings. Nisyros aims to boost RES penetration and decarbonize its energy grid via the construction of both a PV park and a wind farm with a total capacity of 570kW and 1.7MW respectively. The existing municipal fleet (32 vehicles) will be replaced by electric vehicles (EVs) powered by 12 PV-based charging stations that will be coupled with innovative grid scale storage systems. The Master Use Case will include the innovative technologies of Saline Battery (SuWoTec) and Flywheel (Terraloop) that are demonstrated in IANOS project. UCs 1, 4, and 8 are expected to be taken into account for the formulation of the MUC. The following interventions will be considered:

- PV park (570kW)
- Wind farm (1.7MW)
- 12 EV charging stations: (AC 22kW each)
- Energy storage systems (240kWh)
  (2 bio-based saline batteries in the 120-kWh variant, developed by SuWoTec)
- A Flywheel (with a capacity of 250 kW) (developed by Terraloop)

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4 Definition of EU island clusters

4.1 The NESOI project

The EU Island Facility NESOI (New Energy Solutions Optimised for Islands) [1] is a four-year Horizon 2020 project funded under call topic LC-SC3-ES8-2019 (European Islands Facility–Unlock financing for energy transitions and supporting islands to develop investment concepts). It began on 1 October 2019 and will finish on 30 September 2023 and is made up of a multi-disciplinary consortium consisting of 10 partners from seven EU member states. It has a total budget of €10 million of which approximately €3 million is dedicated to a cascade funding mechanism to provide direct financial support to EU Islands.

The NESOI project has three key objectives:

- Promote investments for energy transition in the islands
- Facilitate the decentralization of energy systems
- Contribute to EU policies and the achievement of 2030 targets

The NESOI Facility works in close contact with the Clean Energy for EU Islands Secretariat created to facilitate the clean energy transition on EU islands from the bottom up, and bringing it one step forward by providing to islands training, technical support, cooperation opportunities and robust funding opportunities to concretely convert Island Sustainable Energy Action Plans into Renewable Energy Sources plants, building and energy infrastructure retrofitting, energy bills reduction, local job creation and more.

Thanks to the common partner RINA, IANOS will collaborate with NESOI in assessing the replicability potential of IANOS technology solutions.

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4.2 Island clusters from NESOI

This section presents the criteria for grouping islands into clusters, based on their characteristics from different point of views, e.g., size, grid interconnection, seasonality, geographical features, economic development, and resource availability. The resulting clusters are those defined in NESOI [2] starting from survey findings and analysis of ASSET database of European islands.

4.2.1 Clusters by size and grid interconnection

Large islands

These islands are very populated like Sicily or Sardinia and count more than 500,000 inhabitants. Large islands are advanced in terms of transition status, mainly in renewable energy and public lighting projects and have plans to fulfil their goals. Their main drivers are the national regulation/objectives they must comply with and the environmental benefits of the actions, while their most perceived limitations are economical barriers and funds, also with problems encountered in the definition of roles between public entities. The need for an energy transition in this case can be less severe, as these islands have high efficiency processes, being able to count on the electricity grid of the continent.

Medium sized islands

These islands count from about 150,000 to 500,000 inhabitants. Medium-sized islands have also developed energy transition projects, with renewable energy integration as the most advanced aspects, and have plans to further these efforts. Their main driver is the reduction of the environmental impact of their activities, and the limitations and needs are similar to the ones for the large islands (economical and organizational).

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Small Non-Connected Islands with High Seasonality

Small islands count no more than 150,000 inhabitants; these ones are not electrically connected to the mainland, and present a high seasonality, which means that the number of inhabitants increase in specific times of the year. The reason is that they are generally a tourist destination, such as some islands of Greece or Croatia. Small non-connected islands with high seasonality still have a long way to go in their energy transition, with renewable energy as the most developed aspect, but are developing concrete plans to advance. Their main driver is the reduction of living costs in the island because they use energy systems with low efficiencies that have difficulty in supporting the variation of energy demand linked to seasonality. The energy transition should aim at the implementation of systems that generate electricity in a flexible manner considering the seasonality.

Small Interconnected Islands with High Seasonality

These islands have the same characteristics as the previous ones, except that they are electrically connected to the mainland. Small interconnected islands with high seasonality are behind the average in their energy transition besides public lighting projects and still do not have concrete plans to advance. Their main driver is the reduction of living costs in the island, considering that, being able to count on the electricity grid of the continent can support the variable energy demand due to seasonality.

Small Non-Connected Islands without Seasonality

Contrary to the previous islands, these ones are not affected by seasonality, which means that the number of inhabitants may not vary. Small non-connected islands without seasonality are room for improvement in their energy transition status and mainly do not have transition plans to advance. Their main driver is the reduction of environmental impact as it happens in Small Non-Connected Islands with High Seasonality.

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Small Interconnected Islands without Seasonality

Small, interconnected islands without seasonality have potential to advance their energy transition but do not have concrete plans to do so. Their main driver is the reduction of environmental impact. Small islands coincide with the lack of a skilled workforce, legal complexity and location of funds are their most common barriers. They share similar criticalities with Small interconnected islands with high seasonality.

4.2.2 Clusters by Geographical Features

Clusters by Latitude

This classification helps to identify the energy needs of islands related to their geographical location and therefore to their climate; this can result, for example, in a greater efficiency of one technology rather than another.

- Mediterranean Europe Islands (between 30° and 45° of Latitude). These islands have a Mediterranean climate, characterized by hot summers and mild and rainy winters.
- Northern/Central Europe Islands (between 45° and 70° of Latitude). Here we can distinguish two types of climates: temperate oceanic climate and cold continental climate. The first one interests the UK and the northern part of France and features cool summers (relative to their latitude) and cool but not cold winters, with a relatively narrow annual temperature range and few extremes of temperature. The second one interests the northern part of Germany and Scandinavia and features long and cold winters, while summers are short and cool.

Clusters by Orography

This classification helps to understand the feasibility of implementing a certain technology based on the orographic characteristics of the island.

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- Mountainous Islands. Mostly located in the Aegean Sea and in the Atlantic Ocean.
- Flat Islands. They are located in front of Croatia, near the UK and in the Baltic Sea.

Clusters by Population Distribution

This classification helps to understand the energy demand of the islands in relation to the lifestyle of the inhabitants.

- Concentrated in towns/cities.
- Distributed in villages over the territory.

4.2.3 Cluster by Economic Development

Clusters by Economic Activities

This classification helps to understand the demand for resources (for example water) and energy of the islands in relation to the economic activities they carry out.

- Mainly Tourism. These islands are mainly identifiable in clusters affected by seasonality and located mostly in the Greek archipelago and in Croatia.
- Mainly Primary Sector. These are mainly flat islands where it is possible to practice agricultural activities, or in any case with lush soils that can allow activities such as livestock.
- Presence of Industries. These are large or medium-sized islands belonging to Large Islands and Medium-Sized Islands mentioned above, which are therefore more industrialized than the smaller ones.

Clusters by Availability of Resources

The islands can finally be classified according to their availability of resources for their activities, or for the possible development of energy transition processes. For example, the presence of water, biomass, mineral deposits or fossil fuels, etc. can be evaluated.

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5 Conclusions and next steps

In this deliverable we reported the initial steps for IANOS replication across EU islands. First of all, the methodology for replicability assessment in additional EU islands has been defined. The methodology consists in the analysis of IANOS replication activities performed in the two Lighthouse islands (Ameland and Terceira) and three Fellow islands (Bora Bora, Lampedusa, Nisyros). Moreover, the methodology includes the analysis of the characteristics of other islands in the EU. As the number of islands to be considered is very high, a set of clusters was defined. The clusters are based on island characteristics from different point of views: size and grid interconnection, geographical features, economic development. The result of the proposed methodology is the mapping of IANOS use cases in EU island clusters, and a guidebook of best practices for replication of IANOS solution.

This deliverable is the first version of IANOS replication across Europe. In the next version of the deliverable – D9.6 to be submitted on month 48 - we will complete the analysis of the IANOS islands (the final version of the Master Use Cases) and give the results of the mapping between IANOS islands with the clusters of islands across Europe. For each cluster, we will list the islands that represent it, so that any island that is interested in replicating the IANOS technology can read the document and follow the replicability guidelines reported.

References

[1] "The NESOI project," [Online]. Available: https://www.nesoi.eu/.

[2] G. Bonvicini, S. Vela and F. Peccianti, "D3.2 Technology Pairing – Inputs to NESOI Platform," 2020. [Online]. Available: https://www.nesoi.eu/content/d32-technology-pairing-%E2%80%93-inputs-nesoi-platform.

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