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IANOS
SUSTAINABLE SOLUTIONS
for islands' decarbonisation

IANOS KPIs and evaluation metrics report

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Executive Summary

The present deliverable D2.9 "IANOS KPIs and evaluation metrics report", which is the 3rd version of D2.7, sets the foundation for the monitoring and the evaluation of IANOS interventions in the two Lighthouse and three Fellow islands by defining appropriate Key Performance Indicators (KPIs). The work in this document has been conducted in the context of Task 2.3 of the Work Package 2 (WP2) Requirements Engineering & Decarbonization Road-mapping.

The methodology followed as well as the indicators selected were based on a variety of existing assessment frameworks on on-going projects (POCITYF, SMILE etc.) and smart-grid initiatives (SCIS, BRIDGE etc.). The scope of this deliverable is to combine the information provided by the literature and introduce new indicators in order to form a KPI list that serves IANOS requirements and objectives.

The approach for the assessment indicated by BRIDGE initiative and Smart Grid Model Architecture (SGAM) assisted in defining and mapping the Key Exploitable Results (KERs) that could be derived from IANOS implementations, which were the basis for selecting the KPIs domains. The definition of the KPI domains is very important for the identification of representative indicators, which should be aligned with the three Energy Transition Tracks (TTs) and the general islands' decarbonization plan, and be in accordance with the stakeholders' perspective. Taking into consideration all the parameters that affect the project progress, seven domains (Technical, Environmental, Economic, 'Information Communication Technology (ICT), Social, Governance and Propagation) have been defined, in which each KPI is categorized. Apart from the definition of the KPI domains, the relevant stakeholders were also identified with the coordination of the project manager (EDP): Energy Utilities/ Distribution System Operators (DSOs), Transmission System Operators (TSOs), Consumers (end-users)/Prosumers, Technology and Services Providers, Policy-making Bodies and Governance, Representative Citizen Groups/Citizens. In addition, in the 2nd version of the deliverable the districts of each lighthouse (LH) island have been defined in collaboration with the LH managers.

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As the preliminary assessment and the extensive literature review led to a large amount of KPIs, the latter was iteratively reviewed by relevant partners in order to be shortened and be more manageable. For the transparency of the evaluation procedure, the two Lighthouse managers, leveraging from IANOS management structure inside each ecosystem, assessed each KPI according to five predefined criteria (Relevance, Availability, Measurability, Reliability, Familiarity) using a three-score system. Afterwards, regarding the partners' comments on the KPI selection, the finalized list along with the associated KPI cards are determined. The formation of the KPI cards is a demanding procedure as it requires the provision of all the details for each KPI, its calculation methods (formulas), the aggregation/clustering levels (temporal, spatial, Transition Track-linked, Use Case-linked) and initial recommendations for data collection and measurement methodologies as well as in which fellow islands (FI) the KPI will be estimated as part of the replication studies (WP9)

Lastly, in order to estimate the overall success of the project and its impact towards smart and green islands, a set of indicators that has been already defined during the Grant Agreement stage (Project Success Indicators (PSIs)) should be evaluated. The evaluation is achieved either with the selection of similar KPIs or with monitoring the PSIs separately. It is presented the correspondence of the PSIs with the already defined KPIs together with the calculation guidelines required for the assessment. In addition, five (5) new PSIs, not contained in the 2nd version, have been added in this version of the deliverable, pertaining to the key project success goals for specific use cases.

There is a strong relation of the work on this deliverable with other IANOS tasks. Indicatively, the KPIs defined in this deliverable will be deployed by Task 7.1 and 7.2 in order to have the technical, social and environmental assessment of the project. Moreover, through the monitoring platform to be developed in the frame of the Tasks 5.4 and 6.4, the measurements from the connected devices will be utilized for the quantifiable calculation of the KPIs.

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1 Introduction

1.1 Objectives and Scope

IANOS project aims at offering a multitude of solutions that will accelerate the energy transition of its Lighthouse (LH) islands (Ameland and Terceira) and all the necessary replication activities in its Fellow Islands (FIs). During this project, a lot of effort is given in order to turn the LH islands into smart grids reaching high levels of Renewable Energy Sources penetration and facing in an efficient way the specific energy-related challenges.

KPIs, in general, measure the effectiveness of a project towards the achievement of specific key objectives. Key Performance Indicators (KPIs) can assess (a) characteristics of a technology solution; (b) the impact of a technology on its environmental surrounding; (c) its economic feasibility; (d) its social approval either by the policy-making bodies or by the local society; and, (e) the advances and/or the relevant legal framework requirements that need to be met, before being implemented in a large scale [1]. Through the KPIs the various strategies and the implementation of innovative technologies can be adequately assessed in a holistic way. The key difference between the KPIs and the other indicators is that KPIs are always tied to a goal, a target or an objective.

The scope of this deliverable is to set the foundation for the evaluation process of the activities in the two LH islands through the definition of appropriate KPIs. A complete and well organized KPI framework is able to measure suitably the project impact towards the energy transition procedure. The outcome by the analysis conducted can be really helpful not only for IANOS but also for other smart-grid-oriented projects which all together target at the realization of the European goals for smart and green energy systems.

1.2 Relation to other IANOS activities

This deliverable is strongly related with other tasks of IANOS project. The results and the data obtained during this task will inform and provide a foundation for the evaluation framework in WP 7 and especially for the Task 7.1

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(Technical and Social Impact Assessment) and Task 7.2 (Environmental Impact Assessment). Through the monitoring platform, which will be implemented in the frame of Tasks 5.4 (Use case operation, optimization and performance monitoring for Ameland) and 6.4 (Use case operation, optimization and performance monitoring for Terceira), the measurements collected by the installed sensors (and in general by the connected devices) will be the base for the quantitative calculation of the defined KPIs. The selection of the appropriate KPIs will indicate which parameters should be measured and in which frequency should occur the real time data collection. In this way, the road for reaching the objectives of Tasks 5.4 and 6.4 will be more solid. Moreover, in order to provide a holistic tool in Task 3.3 (Energy Planning & Transition Decision Support Toolset) and in Task 3.1 (LCA/LCC tool for Transition Support) able to evaluate the overall benefits expected from smart grid interventions, regarding the viewpoints of each stakeholder, respective KPIs will be initially defined and later calculated to assist in setting the strategic priorities, aligning horizontally in all cases with the priorities set by the Green Deal. There is also a link of this deliverable with the activities of WP 8 (Energy Cooperatives and Stakeholders Engagement Participant), where a first evaluation of potential systemic effects of interventions will be made with identification of interactions between intervention-specific indicators and indicators for assessing scalability and replicability of Use Cases (UCs) in terms of the environmental and business-related aspects. Lastly, the development of the UI Dashboard in the Task 4.6 (Virtual Energy Console) will allow the Virtual Power Plant (VPP) operator to easily access different dataset and important information in line with IANOS KPIs, such as the generation mix of the VPP portfolio, the penetration of Renewable Energy Sources (RES) in the system and historical data being of extreme importance in the capitalization of the algorithms developed in WP4 (IANOS Multi-Layer VPP Operational Framework) and the monitoring performed in both WP5 and WP6 (Deployment, Use Cases Realization and Monitoring in LHs). Finally, the KPIs that will be part of the replication studies of WP9 are defined with feedback from each FI.

1.3 Structure of the deliverable

The structure of the deliverable is briefly presented in this chapter:

- Section 2: The methodology followed towards the definition of the KPIs is presented
- Section 3: The KPI definition and selection process is shown in this chapter. The section contains: a) a brief overview of the intervention activities in IANOS (Sec. 3.1), b) the review of several existing KPI frameworks that have been used as foundation for building the initial pool for the KPI selection (Sec. 3.2), c) the definition of the Key Exploitable Results (KERs) of IANOS based on the methodology proposed by BRIDGE initiative (sec. 0), d) the definition of relevant domains and their connection to stakeholders' perspectives (Sec. 3.4), e) the evaluation of the initial KPI pool towards the finalized KPI list (Sec. 3.5), and, e) the clustering and granularity evaluation levels (Sec. 3.6)
- Section 4: The complete finalized list of KPI cards is cited in this section. Sections 4.1-4.7 include the KPI cards per domain, section 4.8 briefly describes the potential risks during the measurement of the KPIs, and, finally, the Project Success Indicators (PSIs) are defined in section 4.9.
- Section 5 – Conclusions: A conclusive summary is included in this section.

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2 Methodology, Approach and Implementation

The methodology approach applied in IANOS, being adopted and aiming at defining an appropriate KPIs list which will satisfy the needs of the project, includes seven steps and has been achieved with the collaboration of the key partners from the two LH islands. In addition, as the Task 2.3 description indicates, in later versions of this deliverable, the contribution of the three Fellow islands will be included. This should be added when the Fellow islands will have sufficiently developed their decarbonization plan by defining explicitly their activities.

The methodological framework gives emphasis on satisfying the relevant stakeholders' points of view considering the demonstration of the solutions and tries to be aligned with the Smart Grid Architecture Model (SGAM) architecture, when linked with the various KERs mapped to the SGAM layers. To meet these objectives, an extensive KPI pool was initially prepared by CERTH following other KPI frameworks from relevant projects and open-access relevant publications, whereas the finalization of the KPIs list was achieved with the collaboration among the LH managers to have a clear and transparent evaluation procedure. The seven steps for the collection and the final selection of the KPIs are further described below.

<u>Step 1: *Analysing the solutions from Grant Agreement Form*</u>

Before proceeding to the KPIs selection there is a need to understand and clarify all the actions that will be demonstrated in the two LH islands as they have been presented during the proposal stage. Therefore, a better interconnection of IANOS solutions and selected KPIs will be achieved and the needs of the two islands will be served.

<u>Step 2: *Collecting background information on existing KPIs framework – Review and assess*</u>

A long survey on existing KPIs framework relevant to smart islands and cities is done in order to derive valuable ideas and suggestions that can be applied in IANOS. As a result, an extensive pool of potential KPIs will be developed building upon the recommendations of these frameworks. IANOS also capitalizes on the outcomes from similar completed or ongoing Smart Cities and

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Community (SCC) Lighthouse projects, as well from International and European standards (e.g., ISO 37120:2018, ISO 37123:2019, ETSI) 37120:2018, ISO 37123:2019, ETSI) and strategic plans and initiatives (e.g., UN's Sustainable Development Goals, U4SSC). Of course, the literature review of assessment frameworks in scientific journals that try to evaluate smart community performance and operation, completes the second step.

Step 3: *Correspondence with SGAM architecture and KERs definition.*

During this step, we tried to understand profoundly the procedure proposed by SGAM architecture and all the adaptions of our approach that should be made in order to fit with IANOS objectives. SGAM architecture offers a holistic and complete methodology for defining the KERs and the KPIs, used to quantify their advantages before and after their advancement, in a universal way for an easy comparison of the outcome of smart-grid-oriented projects. It is of outmost importance to derive the soonest possible the KERs considering all the demonstrated interventions during this project to build the fundamentals for the KPIs selection. The usage of the SGAM architecture for mapping the exploitable results of IANOS is part of the scalability and replicability analysis suggested by BRIDGE initiative. This deliverable attempts to cover the scalability and replicability aspects of the defined Use Cases, as IANOS aims at demonstrating sets of solutions that can be implemented also in other islands that share the vision for energy transition.

Step 4: *Preliminary KPIs selection and categorization according to the pre-defined KPIs domains (in relation with stakeholders' perspectives).*

In step 4 a preliminary selection of KPIs is being made by CERTH regarding the activities that will take place in the LH islands and the analysis of step 3. This will lead to an extensive KPI list including various KPIs that could potentially serve IANOS needs but it is an excellent basis for initiating the discussions with IANOS partners. In parallel, the definition of the KPI domains considering the objectives of IANOS and the efficient assessing and monitoring of the demonstrated solutions, is being completed. The selection of the KPIs domains takes into the stakeholders' perspectives for having an outcome very close to the market needs. Afterwards, the selected KPIs will be categorized to the appropriate domains.

Step 5: *Iteration with partners for evaluating the KPIs*

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As step 4 will lead to a vast amount of KPIs (in the order of some hundreds) there is a need for eliminating the list by identifying the most important of them. To achieve this, an assessment will take place by the partners based on five preselected evaluation criteria (relevance, availability, measurability, reliability, familiarity) proposed by the CIVITAS framework. Through the iteration of the KPIs pool among partners and their assessment, not only a limited KPI list will be achieved but also the selected KPIs will be tied to the real needs of each ecosystem. A continuous iteration process (through e-mails and teleconferences) is being performed to develop the finalized KPI list during this step.

Step 6: *Before the finalization of the list the various specifications will be explicitly defined*

It is really important to form the specifications of each KPI before ending up to the final KPI list in order to facilitate the partners' effort. Most of the times, to obtain the data for quantifying each KPI requires a lot of effort and it is complex enough and thus, deaccelerates the progress of the project. To avoid this, it is needed to define explicitly all the information that partners need (responsible partner, units of measurements, monitoring time interval etc.).

Step 7: *Finalize deliverable*

The implementation of the above steps leads to the finalized list of IANOS KPIs including all necessary information for their assessment (evaluation metrics and guidelines, formulas, potential thresholds of performance, grouping in categories) in the form of KPI cards. Furthermore, a set of indicators related to broad IANOS impact are also cited (Success Indicators – SIs) exactly as they were proposed during the proposal stage. These indicators are needed to be assessed towards some specific Impact Objectives of IANOS. Despite the fact that some of these SIs can be directly linked to the defined KPIs, a large set need to be defined separately. In contrast to other impact related KPIs, this set of indicators (SIs) do not fit into the defined domains and/or are too simplified and case specific and as a result they were excluded from the KPI selection methodology and process.

3 KPI definition and Selection Process

3.1 Brief overview of intervention activities in LHs

Every smart-grid-oriented project like IANOS is considered successful when its implementations serve the islands (and respectively the citizens' needs) more adequately than before. Monitoring this procession of reaching the project objectives, can be performed according to various hierarchical levels of evaluation, but the definition of proper metrics must always comply with the envisaged islands framework and intervention activities therein. These intervention actions form the innovative background on which the islands will build their greener and smarter grids. So, it is very important for every indicator defined to be able to monitor the progress and the effectiveness of the demonstrated solutions in order to have an overall view about the plan of the energy transition. For this reason, it is also important to identify and assess the baseline scenario, i.e., the state of each island before the project's interventions, in order to compare it with its state after the implementations. The metrics and the indicators show not only the success of each solution separately, but also the correlation between the interventions, and how a set of technologies together can optimize more efficient the energy system of an island.

For that reason, IANOS energy transition strategy is built around three multidisciplinary and complementary Energy Transition Tracks (ETT), aiming at increasing the integration of both commercialized and innovative energy systems, towards rendering current islands block self-sustainable and more environmentally friendly for their citizens. Within these ETTs, IANOS tries to demonstrate, replicate and accelerate the roll out of a set of 9 UCs built on top of both mature and innovative technologies. At this point, the importance of the insightful selection of KPIs is being revealed again, as they will monitor the performance of these UCs through the provision of the required evaluation output data. Error! Reference source not found. presents the main points of each E nergy Transition Track.

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The first four UCs are grouped under TT#1 (Energy efficiency and grid support for extremely high RES penetration). UC1 addresses community demand-side driven self-consumption maximization while UC2 community supply-side optimal dispatch and intra-day provision. UC3 aims to make use of any-scale storage infrastructures for fast response ancillary services (batteries, flywheel) and UC4 aims to offer Demand Side Management solutions, Smart Grid methods and congestion management services to support Power Quality.

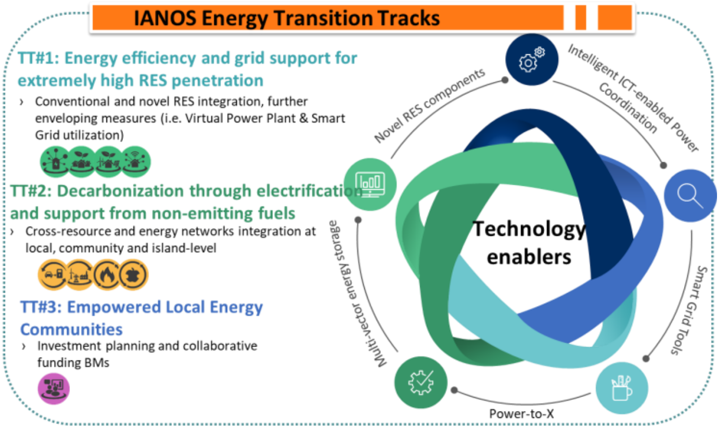

Figure 1 IANOS Energy Transition Tracks

Under the umbrella of TT#2 (Decarbonization through electrification and support from non-emitting fuels) are met the next four UCs. UC5 deals with the decarbonization of transport and the role of electric mobility in stabilizing the energy system. Within UC6 emphasis is given for decarbonizing large industrial continuous loads, mainly through electrification and locally induced generation. UC 7 refers to the utilization of waste streams along with the decarbonization of the gas grid for gaining from the benefits of the circular economy. Lastly, UC8 includes all the plans for decarbonizing the heating network.

Within the TT#3 (empowered Local Energy Communities (LECs)) only the broad UC9 is included, which encompasses all the actions that should be done for active citizen and LECs engagement into decarbonization transition.

Table 1 summarizes all the aforementioned categorization of the UCs under the three TTs.

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Table 1 IANOS Energy Transition Tracks

Island Energy Transition Tracks (IETT)	UC	IANOS Use Cases (UC)
#TT1: Energy efficiency and grid support for extremely high-RES penetration	UC1	Community demand-side driven self-consumption maximization
	UC2	Community supply-side optimal dispatch and intra-day services provision
	UC3	Island-wide, any-scale storage utilization for fast response ancillary services
	UC4	Demand Side Management and Smart Grid methods to support Power quality and congestion management services
TT#2: Decarbonization through electrification and support from non-emitting fuels	UC5	Decarbonisation of transport and the role of electric mobility in stabilizing the energy system
	UC6	Decarbonizing large industrial continuous loads through electrification and locally induced generation
	UC7	Circular economy, utilization of waste streams and gas grid decarbonization
	UC8	Decarbonisation of heating network
TT#3: Empowered LECs	UC9	Active Citizen and LEC Engagement into Decarbonization Transition

The innovative elements that will be demonstrated in LHs under each UC (and TT) are technologies with highly innovative components, which will contribute towards IANOS objectives and envisaged impact. By monitoring and assessing their progress and performance, IANOS impact can be also assessed via proper aggregation methods. If very detailed indicators are collected to assess every aspect of the technological performance (e.g., durability, integrability, operability), a very large number of indicators would be required rendering the monitoring process impossible.

The following three Tables (Table 2-4) describe for each UC its focus area, the related innovative technologies (elements) to be implemented during IANOS, as described in the grant agreement of the project (GAF), as well as the main evaluation focal points, on which the solutions should be globally assessed and monitored. Evaluation focal points represent the characteristics of measurement and/or assessment, which need to be taken into consideration during the assessment procedure in order to evaluate the results of the implemented technologies.

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Table 2 Focus area, related technologies and evaluation focal points of the UCs within the TT #1: Energy efficiency and grid support for extremely high RES penetration

	Focus area	Related IANOS Technologies	Evaluation focal points
UC 1.1 (Terceira) UC 1.2 (Ameland)	Optimal dispatch and control of LEC demand-side assets and peer to peer energy transactive framework	iVPP intelligent aggregation and clustering // iVPP behind-the-meter assets scheduler // DLT-based transactive intelligence // non-intrusive characterization and use of energy flexibility in water heating systems // PCM thermal storage (heat batteries) // Vehicle-to-Grid (V2G) charging stations // FEID-PLUS // hybrid heat pumps // water heaters // intelligent home appliances plug control // Fuel Cells // PVs and microinverters // biobased (saline) battery	Accurate energy consumption forecasts// Accurate energy production forecasts
UC 2.1 (Terceira) UC 2.2 (Ameland)	iVPP actions for performing dispatch and provide intra-day balancing services to the power system using the available energy flexibility on the generation side	iVPP Utility-scale assets scheduler for optimal dispatch in multiple time-scales (considering grid balancing reserve) // Dispatchable sources flexibility forecast // DC hybrid PV plant with different storage options// GOPACS	Increase penetration of non-dispatchable RES
UC 3.1 (Terceira) UC 3.2 (Ameland)	Provision of fast ancillary services provided by distributed storage technologies	iVPP Utility-scale assets scheduler // iVPP behind-the-meter assets scheduler // Locally implemented actuators // innovative flywheel and control // DC hybrid PV plant	Reliable system operation Ancillary services to DSO/TSO (DSM, load shifting, peak shaving)
UC 4.1 (Terceira) UC 4.2 (Ameland)	Provision of power quality services to the grid using available energy flexibility from demand resources	iVPP Aggregation & Classification // iVPP behind-the-meter assets scheduler // Smart energy routers // Hybrid heat pumps	Reduction of RE curtailment

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Table 3 Focus area, related technologies and evaluation focal points of the UCs within the TT #2: Decarbonization through electrification and support from non-emitting fuels

	Focus area	Related IANOS Technologies	Evaluation focal points
UC 5.1 (Terceira) UC 5.2 (Ameland)	Intervention actions for decarbonizing LHs transport sector through the RES available sources and by installing of EV chargers	Grid services from V2G, Smart Charging of Electric Vehicle (EV) batteries	Offering balancing to the grid through V2G charging schemes (e.g., voltage support of grid nodes with heavy RES penetration)
UC 6	Electrification of large and constant industrial loads	local iVPP framework integration for must-run consumer energy provision // Pilot testing of innovative 500 kWe underwater Tidal Kite	Increase of RES penetration by increasing the base load of Ameland
UC 7	Utilization of waste streams for generating electrical and/or thermal energy	Separate collection increasing value of waste streams	Searching novel and efficient technologies for using the remaining waste streams
UC 8	Decarbonization of heating network using hybrid heat pumps, creating an integrated design of fuel cell etc.	Hybrid heat-pumps // iVPP integration with community heating grids // integrated design of fuel cell, H2 storage and additional heat pump for peak demand // Innovative heating concept from multiple sources (heat from the ocean) and multi-vector storage (thermal and electricity	Utilization energy from local RES through the iVPP platform // storing the excess energy into the hybrid heat pumps and/or alternative fuels

Table 4 Focus area, related technologies and evaluation focal points of the UCs within the TT #3: Empowered LECs

	Focus area	Related IANOS Technologies	Evaluation focal points
UC 9.1 (Terceira) UC 9.2 (Ameland)	Raising customer's environmental and energy efficiency awareness and fostering their	An energy cooperative that serves both as an energy supplier and a project developer // A local cooperative with an organization degree of 40% of the households // A	Increase of local generation (PV, wind) // increase of the number of members participating in DSM programs // Capacity

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	participation in DSM programs	cooperatively owned DC PV-park	building // installation of a DC solar farm combined with storage

3.2 Review of existing KPIs frameworks

An extensive literature review on on-running projects and initiatives for smart cities has followed the analysis of IANOS UCs. The initiatives of Smart Cities Information System (SCIS) and CITYkeys as well as LH projects (IRIS [1], POCITYF, SMILE, INSULAE etc.) have provided a foundation for the definition of IANOS KPI framework. In the following sections a detailed description of the literature review is given. It should be noted that the sources for KPIs relative to SCCs is vast and although the following list is not exhaustive, the most relevant and global frameworks (in relation to smart cities focusing on islands) and studies have been thoroughly analysed. We describe below the most relevant frameworks, SCC projects and scientific publications that have been reviewed.

3.2.1 Smart Cities Information System (SCIS)

The updated SCIS Monitoring KPI Guide[2] was studied to provide useful information about KPIs in general, their application to the different objects of assessment and the methodology for their calculation (citation). It focuses also on the development of indicators to measure technical and economic aspects of energy, mobility and ICT related measures applicable in projects such as SCC, Energy efficient Buildings (EeB) and designated projects funded under the calls for Energy Efficiency (EE). Many similarities can be met between the energetic needs and the smart grid transition difficulties of cities and islands, hence, SCIS offers an excellent framework for KPIs selection to be utilized in IANOS.

In particular, the assessment framework proposed by SCIS is based on the clustering of the selected KPIs (36) into two groups: Core KPIs: technical (3 KPIs), environmental (3 KPIs), economic (5 KPIs), ICT (7 KPIs), mobility (8 KPIs). Those KPIs identified as the most relevant for SCIS and which should be implemented by the projects in scope of SCIS. Some of these KPIs may not apply to all projects. 2) Supporting KPIs (10 KPIs): relevant for SCIS, their use is recommended.

3.2.2 CityKeys

The CITYkeys evaluation framework[3] is primarily performance oriented and supports Smart Cities in strengthening their strategic planning, evaluating the success of smart city projects and the possibility to replicate the (successful) projects in other contexts. It focuses on the city as well as the project level while establishing a link between the two. Thus, the CITYkeys framework, although it supports the identification of indicators in various areas in smart cities i.e., health, education etc. it also provides an excellent framework for IANOS KPIs selection. The CITYkeys evaluation framework:

1. Evaluates the impact of a smart city project, comparing before and after situations or comparing expected impacts with a reference situation. As such they can also serve to benchmark projects against each other. It should be noted that a complete project assessment includes an extensive description of the context of the project, the activities and technologies in the project, financing and the business model, and the implementation process.
2. Monitors the progress of the city as a whole towards smart city goals. The time component – "development over the years" – is an important feature. The city indicators may be used to show to what extent overall policy goals have been reached, or are within reach. In addition, city-level indicators may be used to compare cities with each other, although such a comparison should be done with care.
3. Assess how the project has contributed to the objectives at city level. This requires connecting outcomes of a project evaluation with corresponding indicators on the city level.

3.2.3 Other smart grid projects

In this chapter other relevant projects from which we derived possible KPIs are presented. Specifically, Table 5 presents some indicative smart-grid-oriented projects as it is impossible to present all the frameworks reviewed.

Table 5 Assessment frameworks by smart-grid-oriented projects

Project Name	Description
POCITYF:	POCITYF focuses on demonstrating solutions at building and district level that enable the increase of energy self-consumption, energy savings and high

A POsitive Energy CITY Transformation Framework [4]	share of locally produced renewable energy. As a smart-grid-oriented project, POCITYF tries not only to intervene technically in the LHs but also to stimulate the citizens' participation in co-creation, decision making, planning and problem solving.
Assessment Framework	
POCITYF adopts eight (8) domains (Energy, Environmental, Economic, Mobility, ICT, Governance, Social, Propagation) towards setting a holistic performance framework, corresponding not only with the type of solutions and actions to be implemented, but also with the key objectives that have been set. The final POCITYF KPIs list includes 15 indicators in Energy domain, 8 in Environmental domain, 11 in the Economic domain, 7 in ICT domain, 8 in Mobility domain, 5 in Social domain, 5 in Governance domain, and 4 in Propagation domain. POCITYF intervention actions are very similar to IANOS ones, in terms of the energy transition of the community, and as a result POCITYF evaluation process can provide a foundation to IANOS assessment framework.	
Reference: **[4]**	

Project Name	Description
SMILE Smart IsLands Energy systems	The general idea of SMILE project is to test and optimize the operation of smart grids, mainly islandic ones, whose outcome could also be extrapolated to the case of non-islandic conditions when operating with a high degree of RES. Technologies for energy storage such as Battery Energy Storage System (BESS), including electric vehicles and electric storage on boats, and thermal energy storage systems are to be integrated, thus allowing to set current grids more sustainable in terms of efficiency, especially when compared with their current status of operation. Towards this aim, many solutions are proposed in order to make smart grids fed primarily by clean energy more promising for investors, more efficiently sustainable for TSOs and DSOs, and more practical and cheap for consumers, who might as well be RES producers (i.e. prosumers).
Assessment Framework	
The categorization of SMILE innovations into five (5) thematic pillars (Demand Response (DR), Smartening the Distribution Grid, Energy storage, Smart Integration of grid users from Transportation, Domestic heating/cooling systems) sets the first methodological layer for KPI analysis. These pillars represent the main categorization of the solutions tested, so that the evaluation of a pilot/demonstrator can be done according to them. The other basic axis of SMILE KPI framework lies on the definition of SMILE five (5) domains, namely technical, economic, environmental, social and legal. The final list of SMILE KPIs consist of: 18 Technical, 5 Environmental, 11 Economic, 7 Social and 4 Legal. SMILE main objective is to integrate successfully state-of-the-art technologies in small islandic grids, thus it fits perfectly with IANOS vision.	
Reference: **[5]**	

Project Name	Description
INSULAE Maximizing the impact of innovative energy approaches in the EU islands [6]	The main goal of INSULAE is to foster the deployment of innovative solutions aiming to the EU islands decarbonization by developing and demonstrating at three Lighthouse Islands a set of interventions linked to seven replicable use cases, whose results will validate an Investment Planning Tool that will be then demonstrated at four Follower Islands for the development of four associated Action Plans.
Assessment Framework	
The KPI list considered and reviewed in this work refer to the reduced KPI list as stated in D2.2 of INSULATE project. In this task, the authors identified a reduced list of KPIs grouped into six (6) vectors – Generation (4 KPIs), Demand (3 KPIs), Network (4 KPIs), Resource Capacity (2 KPIs), Societal (3 KPIs) and Environmental (3 KPIs) based in the completion of INSULAE objectives and the data availability that was necessary for the EU stock of islands data gathering. In total 19 KPIs have been selected during this process. Each KPI in each vector has been given a weighting factor in order to ponder their importance in the objectives searched by the project. IANOS can largely	

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leverage from this KPI short-list which emphasizes on the essential aspects of island transition monitoring and consequent evaluation.	
Reference: **[7]**	
Project Name	**Description**
inteGRIDy integrated Smart GRID Cross-Functional Solutions for Optimized Synergetic Energy Distribution, Utilization & Storage Technologies	InteGRIDy aims at integrating cutting-edge technologies, solutions and mechanisms in a Framework of replicable tools to connect existing energy networks with diverse stakeholders, facilitating optimal and dynamic operation of the Distribution Grid (DG), fostering the stability and coordination of distributed energy resources and enabling collaborative storage schemes within an increasing share of renewables.
Assessment Framework	
In this project a global framework for the inteGRIDy evaluation and impact assessment in technical, economic, environmental and social terms is defined. According to inteGRIDy, KPIs are categorized into global and local in order to address the main parameters that affect the project performance: the global KPIs are applicable to different demonstration sites while local KPIs correspond to individual pilot sites, addressing that way technology or location specific particularities (site specific KPI framework). In total 59 KPIs are identified, from which 16 set the Global KPI framework and 43 set the Local (pilot-specific) KPIs framework. Although this framework is structured to the specificities of the pilot sites, it can provide valuable information for IANOS evaluation procedure. Moreover, it is similar to IANOS approach the fact that an orientation of the KPI domains to the stakeholders' perspective is adopted.	
Reference:**[8]**	
Project Name	**Description**
New Energy Solutions Optimized for Islands (NESOI) – European islands facility	The NESOI European Islands Facility's goal is to unlock the potential of EU islands to become the locomotives of European Energy Transition by mobilising more than 100 M€ of investment in sustainable energy projects to an audience of 2.400 inhabited EU islands and give the opportunity to test innovative energy technologies and approaches in a cost-competitive way.
Assessment Framework	
NESOI success is strongly dependent on the projects that will receive technical assistance. In this respect, a bottom–up approach was developed, that examines 63 KPIs (5 domains) at a supported project level (bottom) and then through a simple process, these KPIs will become representative for the whole NESOI project (up). Additionally, 42 KPIs, that can be derived from the various proposals and supported projects metadata have been developed.	
Reference:**[9]**	

3.2.4 Scientific publications

Apart from relevant projects, available scientific studies on smart grids can provide important information and assessment frameworks for this project. In Table 6 representative assessment frameworks from recent scientific publications are cited.

Table 6 Assessment frameworks from scientific sources

Source	Assessment Framework
Angelakoglou et al. (2019) [10]	The framework proposed in this study includes six (6) steps ((a) Clustering of the technology/service solutions into groups called Transition Tracks; (b) definition of the main groups of stakeholders; (c) definition of KPIs domains; (d) definition of KPIs repository per domain; (e) definition of the scope of

	evaluation per KPI; and (f) threshold definition per KPI) for determining the preferred list of KPIs. A repository of 75 KPIs categorized in six (6) domains (technical, environmental, economic, social, ICT and legal) with the corresponding levels of assessment and stakeholders' group of interest. Specific emphasis is given on integrating all relevant stakeholder perspective, something that is absolutely in accordance with IANOS approach.
Pramangioulis et al. (2019) [11]	In this study a three-axis framework is proposed that includes: (a) the technology pillars; (b) the stakeholders' perspectives; and, (c) the domains of interest. The final list consists of 45 KPIs clustered under five (5) domains (technical, environmental, economic, social and legal). The KPI framework is based on SMILE project and it can be used as typical sample for project like IANOS (smart grids, autonomous power systems), of course by adapting it in IANOS needs and by enriching it according to IANOS proposition value.
De Urtasun et al. (2020) [12]	The reduced set of KPIs in this assessment framework includes nineteen 19 KPIs in 6 vectors (Generation, Demand, Network, Resource capacity, Society and Environmental). This scientific study has been conducted for the needs of project INSULAE, through which the islands try to find locally produced, sustainable and low-cost sources of energy and thus, IANOS can derive fundamental information and KPIs for its assessing procedure
Li et al. (2017) [13]	The specific study proposes a systematic approach, utilizing a bi-index method, to identify stakeholders and KPIs for multi-level (from building to district) energy performance analysis. KPIs are analyzed into three (3) levels – strategic, tactical and operational. The strategic KPI is aggregated and designed for the district level. The tactical KPI can be associated with the building and system level. The operational KPIs represent the operational performance of basic energy units. It offers 35 specific performance indicators that can serve the goals of smart grid solutions focusing on energy performance which is highly relevant to IANOS objectives.

3.3 From KERs to KPIs

In this chapter we describe the procedure followed for defining the Key Exploitable Results of IANOS based on the methodology proposed by BRIDGE initiative. Particularly, IANOS takes part in the Task Force on Scalability and Replicability (SR) of BRIDGE initiative [14] in order to perform SR analysis of the demonstrated Use Cases bases in a common framework. This will be the foundation for the comparative assessment between the projects funded by the European Commission (EC) which implement smart grid solutions.

Therefore, the suggested methodology serves two main objectives of every smart-grid-oriented project: a) the possibility of the project or some of its interventions to be replicable and scalable and b) the ability of comparing in a universal way the outcome and the impact that smart grid projects have on communities/energy systems/ societies etc.

SGAM architecture grounds a methodology for organizing and defining the Key Exploitable Results of smart-grid-oriented projects. The punctual determination of the KERs is the base for defining the appropriate KPIs domains, the involved stakeholders and in the end the KPIs that evaluate adequately IANOS progress. Thus, it will be very helpful to move towards the SGAM directions for the evaluation procedure conducted in this deliverable.

3.3.1 SGAM overview

The SGAM is a reference model to analyse and visualize smart grid use cases in a technology-neutral manner. Furthermore, it offers a tool for comparison of Smart Grid solutions so that differences and commonalities between various paradigms, roadmaps, and viewpoints can be identified. By supporting the principles of universality, localization, consistency, flexibility and interoperability, it also provides a systematic approach to cope with the complexity of smart grids, allowing a representation of the current state of implementations in the electrical grid as well as the evolution to future smart grid scenarios [15].

The basis for building the structure of SGAM is the Smart Grid Plane, where power system management is distinguished between electrical process and information management. The Smart Grid Plane extends in one dimension to the complete electrical energy conversion chain, partitioned into five domains: (Bulk) Generation, Transmission, Distribution, Distributed Energy Sources (DERs) and Customer Premises and in the other dimension to the hierarchical levels of power system management, partitioned into six zones: Process, Field, Station, Operation, Enterprise and Market as illustrated in Figure 2.

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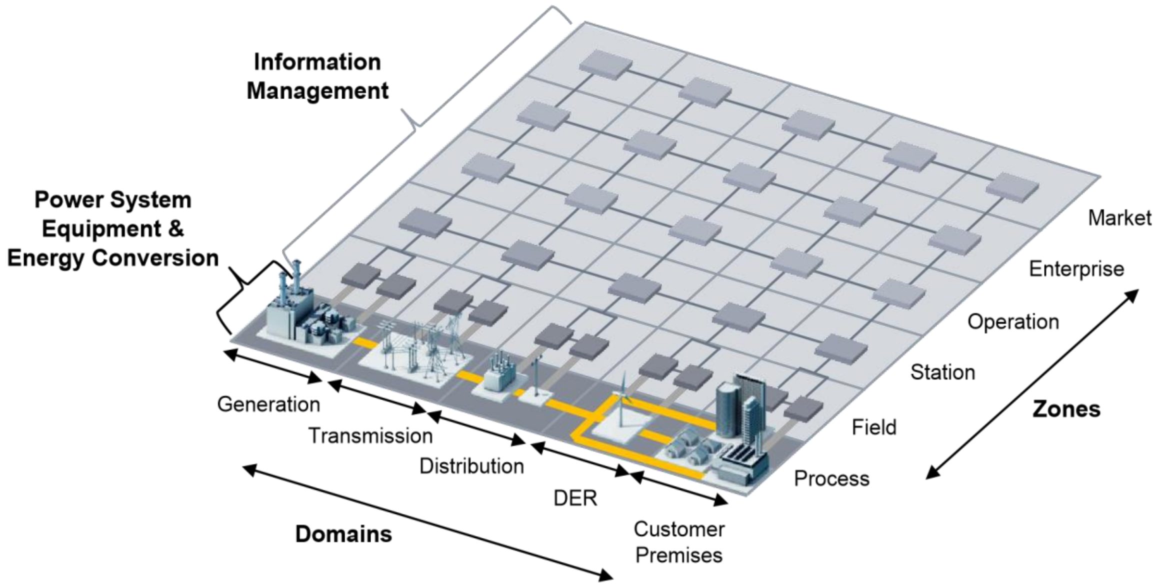

Figure 2 SGAM Smart Grid Plane

The completion of this architecture is achieved through the 'vertical' expansion of the Smart Grid Plane to five discrete layers. These five layers i.e., business objectives and processes, functions, information exchange and models, communication protocols and components represent in an abstract way the interoperability between the different stages in the operation of a smart grid.

Figure 3 shows how the SGAM framework is established by merging the concept of the interoperability layers with the previous introduced Smart Grid Plane. It is important to profoundly understand the context of each layer as well as the interactions between them, as they are the key for the categorization of the Key Exploitable Results, which will be presented in next sections.

Business layer: This layer represents the business view on the activities related to smart grids. SGAM can be used to map regulatory and economic (market) structures and policies, business models and use cases, business portfolios (products & services) of market parties involved. It is strongly related with the perspectives of the stakeholders who participate in IANOS interventions.

Function layer: The function layer describes system use cases, functions and services. The functions are represented independent from actors and physical implementations in applications, systems and components. The functions are derived by extracting the use case functionality that is independent from actors.

<u>Information layer:</u> The information that is being used and exchanged between functions, services and components is included in this layer. It contains also the information objects and the underlying canonical data models.

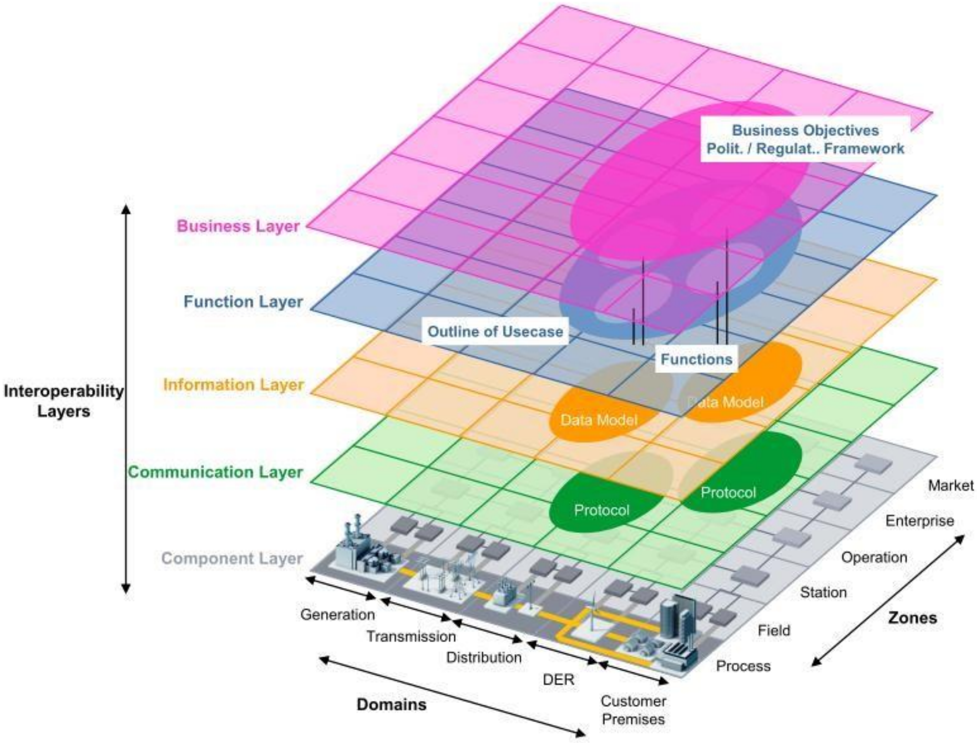

Figure 3 SGAM Interoperability Layers

<u>Communication layer:</u> The communication layer describes the protocols and mechanisms for the interoperable exchange of information between components, functions and services. The connection of this layer and the information layer is necessary for the deployment of the available information.

<u>Component layer:</u> The emphasis of the component layer is given to the physical distribution of all participating components in the smart grid context. This includes system & device actors, power system equipment, protection and control devices, network infrastructure (wired / wireless communication connections, routers, switches, servers) and any kind of computers.

More information about SGAM can be found in SGAM manual [15].

3.3.2 Scalability and Replicability analysis

BRIDGE initiative and specifically the Scalability and Replicability Analysis (SRA) Task Force (TF) (Working group: Data Management) proposes the adoption of methodological guidelines to perform a scalability and replicability analysis which would benefit from being illustrated by more examples of SRA application in ongoing and ending/ended BRIDGE projects. Despite that the SRA is the main activity of Tasks 9.1 and 9.2, it is very important to taking it into consideration in this deliverable for the evaluation of the project whose great outcome is a set of technologies and services that can be replicable and scalable.

For having a clear and transparent procedure, the SRA process is broken down and is partitioned into four (4) subroutines. These subroutines have been identified in the following logical process (Figure 4), taking into account the project's maturity (i.e. early stage / on-going / ending project). Below a brief description of the aforementioned subroutines is given.

Subroutine 1: Mapping of project objectives into the SGAM architectures. In this subroutine the following four steps are included.

1. The objectives in the component layer (details of the physical system) should be mapped
2. The communication and information layers are generated
3. The physical link of the various layers with all connectivity details (use case) is developed
4. The roles and responsibilities of the relevant actors are defined

Subroutine 2: KERs Identification. Subroutine 2 consists of four steps. These steps are briefly described below.

1. The innovation areas of the project are explicitly defined. Especially the role of innovation areas in building and operating wider systems should be identified
2. An exhaustive list of use cases that the innovations areas of the project can serve should be built and ranked according to the available quantitative needs of the system.
3. In order to avoid duplication and complexity the use cases should be merged to the highest degree possible.

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4. After naming the use cases rank list as the KERs of the project, it is important to qualify the most value use case as the most important KER of the project together with a more detailed description of it.

Subroutine 3: Identifying quantifiable KPIs (related to KERs). This subroutine is fundamental for this deliverable and in general for the evaluation procedure. The following steps summarize the activities included in this routine.

1. Using the detailed description of the primary KER, a list of possible Key Performance Indicators that can validate the achievable results of the primary KER is developed. Moreover, the source of the used data is identified in this step.
2. Alternative sources of data or alternative quantifiable KPIs that can be used for tracking progress should be evaluated.
3. For each chosen KPI, the base case scenario that will be compared to for validating the performance of the primary KER is identified.
4. For each base case scenario, the sourcing of the required data to be automated in the evaluation process is established.

Subroutine 4: Results analysis, identification of limitation factors and alternative solutions. At the last stage of this procedure, the steps below are followed.

1. The continuous flow of results and contact continuous analysis are monitored.
2. Through the analysis, other critical parameters (limiting factors) affecting scalability / replicability are defined.
3. A project quality loop for developing the solutions that will minimize the limiting factors for achieving seamless scalable and replicable solutions is generated.
4. Possible future work that will surpass any remaining limitation factors is evaluated.

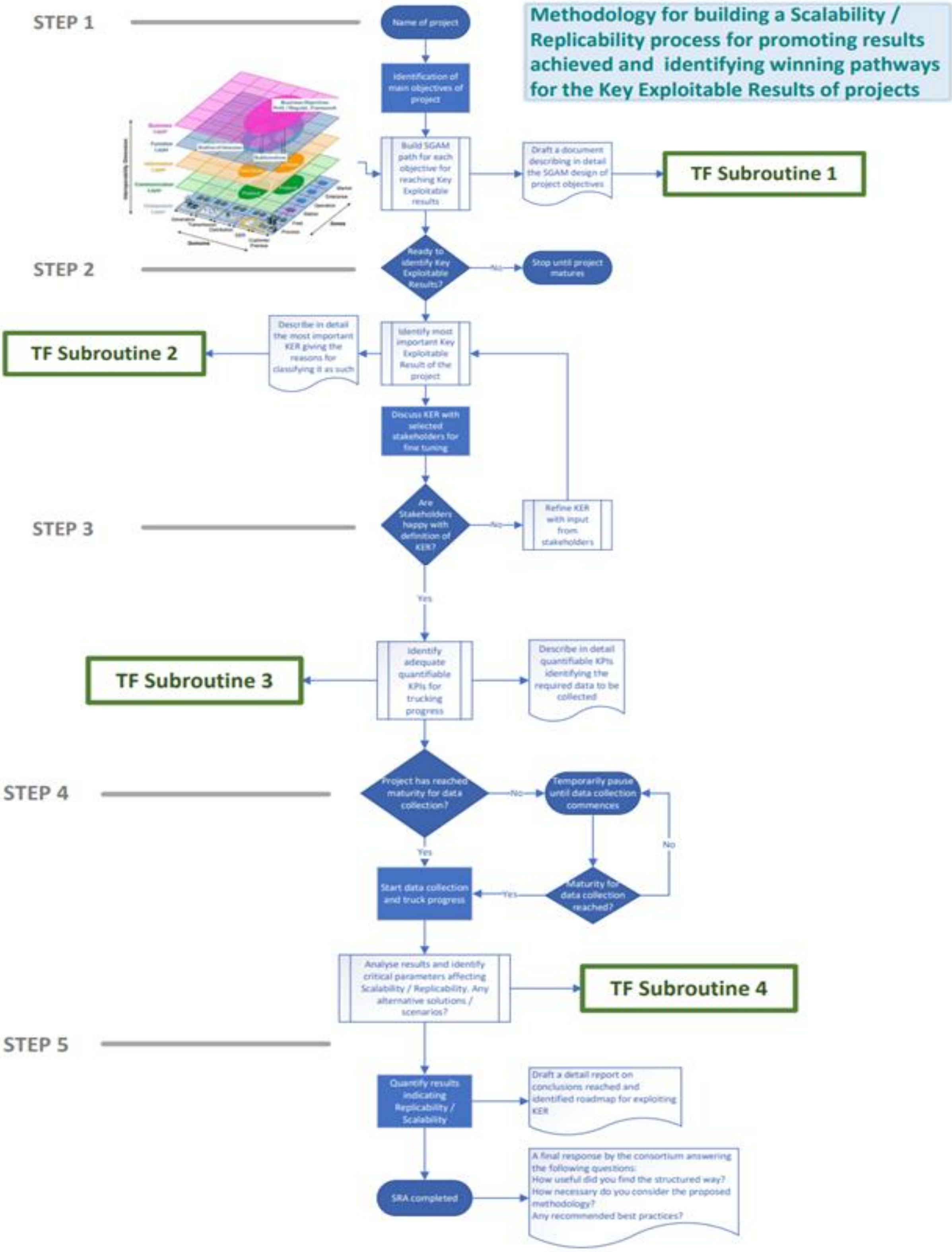

Figure 4 SRA process

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3.3.3 IANOS layers and KERs

The first step in the procedure of KERs definition as it has been described in the previous section, is to adapt IANOS objectives into the SGAM architectures. Therefore, a correspondence between SGAM layers and IANOS objectives was mapped as Table 7 shows.

Table 7 IANOS interoperability layers

Layer	KER Name
Business	Energy initiatives for community owned and individual prosumers investments
Function	Services for system and local flexibility
Information	Various modules integrated in the VPP platform
Communication	Communication protocols for the exploitation of the data
Component	Demand and Supply Hardware

In the business layer (Energy initiatives for community owned and individual prosumers investments) are included all the actions that enhance the creation of Local Energy Communities with strong citizens' participation. Taking into consideration the various IANOS activities, this layer was segmented in two main categories, i.e.: a) the Energy cooperatives and b) the Individual prosumers driven communities. The first category refers to activities such as the i) community owned solar farm (in parallel with developing crowdfunding-based business models) to be installed in Ameland (for example), ii) the development of an exploitable business concept for community owned hybrid solar – fuel cell solutions, iii) large scale cooperative (DC)-RES projects, iv) individual PV-systems through combining purchase power etc. Under the umbrella of the second category are included the actions for the reinforcement of individual prosumers engagement in the energy transition plan such as the Demand Side Management programs for grid support or for increasing self-consumption, individual RE investments (net-metering) etc.

The function layer (Services for system and local flexibility) is divided in the services for system flexibility and in the services for local flexibility. System flexibility refers both to services that can help the TSO to provide reliable frequency/voltage control, voltage management control during emergency states and congestion management as well as to general services (wholesale) for the energy system such as load shifting, peak shaving and portfolio balancing. In the local flexibility are included the ancillary services offered to DSOs (voltage control, Home and Building Management Energy Systems (HEMS and BEMS) and the services provided to/by the individual prosumers (increase self-consumption, peer to peer etc.)

Between the information and communication layer there is a strong link, as these two layers constitute the Information Technology (IT) implementation of IANOS, mostly reflected in the iVPP (WP4) development and operation. The information layer contains the various modules to be integrated in the VPP platform, from the energy console and the forecasting engine to the centralized dispatcher and the Distributed-Ledger based energy Transactions. Apparently, all the data and their format required for the operation of all the modules are included in the information layer.

The communication layer complements the information layer as for the operation of the VPP platform or the IEPT toolkit, data should be delivered in many time-frames (from second to days) from many points of the energy system. The interaction between the various platforms and the sensors that are distributed all over the system should be based on specific communication protocols, that will be exploitable by the end of the project.

The component layer consists of all the innovative and mature elements that will be installed during IANOS and can be replicated in other islandic systems. The elements have been classified considering the side (Demand and Supply side) where they operate and be established. Indicatively, for the demand side are regarded technologies such as the hybrid heat pump and the smart equipment control (FEID PLUS) and for the supply side elements such as the tidal kite, the flywheel and the hybrid transformer.

The most important technologies (software, hardware, communication means) that can be exploitable for future projects can be regarded as IANOS Key Exploitable Results. In this deliverable, an extra effort is given for orienting the KPIs, which will monitor and evaluate IANOS progress, to the KERs derived by the smart grid interventions (Table 10). Table 8 presents some indicative sub-KERs (related to IANOS) per KER (SGAM).

Table 8 Indicative sub-KERs in each SGAM KER

KER	Indicative sub-KERs	
Energy initiatives for community owned and individual prosumers investments	Energy cooperatives Community owned solar farms, in parallel with developing crowdfunding-based business models// Business concept for community owned hybrid solar – fuel cell solutions// Large scale cooperative (DC)-RES projects// Individual PV-systems through combining purchase power	Individual prosumers Self-efficiency// DSM programs// Individual RE investments/ net-metering
Services for system and local flexibility	System flexibility Frequency control// Voltage Control// Ancillary Services (e.g., voltage management during emergency states frequency control)// Congestion Management Peak Shaving// Portfolio balancing// load shifting	Local flexibility Voltage Control// Ancillary Services (e.g., voltage control during emergency states)// Congestion and Capacity Management// HEMS/BEMS Increasing the rate of Renewable Energy self-consumption// Peer to Peer// Back up power
Various modules integrated in the VPP platform	Intelligent aggregation clustering// behind the meter assets scheduler// management of the storage systems// DLT-based transactive platform// Centralized dispatcher// Virtual Energy Console	
Communication protocols for the exploitation of the data	For hardware: IEC 61850 (energy router)// proprietary IoT protocol (Interactive plugin microinverter)// OCPP, Modbus TCP, IEC 60870-5-104 (V2G EV Charger)// customized API, IEC 61850 or IEC 60870 (hybrid transformer)// TCP/IP, enhanced with multiple possible software protocols (flywheel)// DLMS, Modbus TCP, Proprietary APIs (HEMS)// RS-232, Modbus (heat batteries) For software: TCP/IP, web-based HTTP, MQTT, AMQP, data models such as openADR2.0, S2 (Def-Pi), REST APIs, wired protocols: Ethernet, RS-232/UART, RS-485/Modbus RTU, wireless protocols: WiFi, Bluetooth, LoRa, NB-Iot, EnOcean	
Demand and Supply Hardware	Demand side Smart equipment control (FEIDs)// Hybrid heat pumps// Heat batteries// EV charging stations// Smart Energy Router// Water Heating Systems	Supply side Flywheel// Tidal Kite// Electrolyser for Hydrogen production// Hybrid Transformer// PVs with microinverter// Biobased saline batteries// Fuel Cell// Large scale BESS// Small wind turbines// V2G

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After the KERs definition, it is needed to determine the basic domains into which the KPIs will be classified and to seek for the correspondence between the stakeholders and the defined KERs (and the KPIs).

3.4 KPIs domains and stakeholders' point of view

The procedure described in the previous section gives the directions for defining the KPIs domains and the relevant stakeholders. Particularly, KERs derived from the demonstrated solutions can indicate which are the domains for categorizing efficiently the KPIs. Furthermore, as it is easier to find the relation between the KERs and the involved stakeholders, we can have a preliminary selection of the relevant stakeholders, whose perspectives should the KPIs take into account.

3.4.1 IANOS KPI domains

Before proceeding to the selection of the KPIs which serve the needs and evaluate the progress of the project, the domains under which all the KPIs fall, should be identified. The right and punctual choice of the KPIs domains can ensure that all the aspects of the project are adequately covered and all the necessary actions are monitored. Based on the literature review conducted in the previous sections together with the analysis of IANOS solutions, seven (7) domains are most frequently presented and are considered to fit appropriately the project performance. These are: technical, environmental, economic, ICT, social, governance and propagation (Table 9), which are also aligned with the environmental, social and governance (ESG) topics generally considered in the sustainable finance field. At this point, we should mention that this nomenclature and this discretization scheme has been adopted by the SRA Task Force proposed by BRIDGE initiative.

At this point, it should become understood that each of the above domains play a significant role in the assessment of IANOS, even if it is not obvious at first sight. Of course, the technical, and economic domains are strongly related with the successful envisioned energy transition of the island but if the environmental impact is not into the desired levels, a rearrangement of the demonstrated solutions is required. ICT is not so frequently presented but this is mostly due to the fact that ICT KPIs are embedded within other domains (mainly in technical domain). However, in this deliverable the ICT domain is a separate domain as there is a plethora of solutions in the content of information and communication technologies (e.g., VPP platform and all the embedded units).

Apart of these four domains, there are two factors that affect intensively the progress and finally the success of the project: the social acceptance of the activities during the project and the governmental strategies related to smart grid interventions. Additionally, smart community projects aim at forming conducive condition for higher citizens' participation in the energy transition vision. Governance is connected to the current EU legislative framework that is not uniform but fragmented across the various EU countries reflecting the capacity of the local governments to manage and valorise energy transition opportunities.

In the end, IANOS adopt one more domain (propagation) in order to cover the aspects of wider replicability and scalability of IANOS solutions.

Table 9 KPI domains

KPI domain	Brief Description	KPI Examples
Technical	Technical domain focuses on the interventions towards energy transition.	RES generation, Energy savings
Environmental	In the Environmental domain all the potential environmental risks, factors and the impact of the demonstrated solutions upon the life quality and the natural resources are identified.	Reduced Greenhouse gas emissions, Air quality
Economic	Economic domain refers to the business efficiency, revenues, costs of each technology and utilization scenario from a market perspective.	Return on Investment, Payback period
ICT	ICT domain takes into account technological advancements in smart grids, the usage of Information and Communication technologies enabling secure data management.	Increased Cybersecurity, ICT response time
Social	Social domain attempts to estimate the extent to which the project and its designed implementations are aligned with citizens' preferences and how various actions can facilitate the involvement of social stakeholders in the planning and decision making.	Increased citizen awareness of the potential of smart islands projects, people reached
Governance	Governance domain focuses on the actions (planning and evaluation) from the side of the municipality that assist the innovative technologies to be applied in the island. It also examines the extent to which the legal and regulatory framework is in the direction of the planned energy transition.	Involvement of the island administration, smart grid policy

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Propagation	The propagation domain evaluates the scalability and replicability potential of the implemented solutions and actions.	Social compatibility, Technical compatibility

In the next sections, the aforementioned seven domains are described in detail.

3.4.1.1 Technical

In this domain, the KPIs for measuring the effectiveness of the demonstrated solutions are included. They evaluate also the efficiency of the technologies applied with respect to the technical constraints and the operating parameters. The main sectors of this domain are met to activities on the electrical and thermal grid in any possible scales. The indicators are able to assess the energetic performance of a single residential dwelling as well as the performance of entire districts. Moreover, they identify and quantify the benefits gained by IANOS architecture on existing assets, the higher local RES generation, the increase of self-consumption etc. The continuous monitoring of the various actions during IANOS demands the installation of sensors in appropriate places into the grid in order to gather the electrical and thermal metrics of the network (e.g. voltages/currents/frequency collected along feeders, active/reactive power exchanged in crucial buses, PV generation, current capacity of available storage systems etc.). In many cases where the procedure of obtaining real time data is characterized by extremely high complexity, the support by numerical simulations on the basis of precise electrical and thermal models (representing with accuracy the operation of a building, district, island), is highly recommended. The interest in technical KPIs is too broad and depends on the diverse expectations of all stakeholder parties participating in the energy network/market, e.g., DSOs, TSOs, end-users, enterprises in the sector of energy etc.

3.4.1.2 Environmental

The KPIs in the environmental domain are elementary for evaluating the impact of the interventions on different areas such as energy production/consumption, energy storage systems and mobility. The main scope of these KPIs is to preserve the sustainability of the energy transition and to keep the consequences aligned with EU environmental strategies (climate change, air quality, people's health and safety, and waste management regulation). In this respect, Environmental KPIs will estimate the reduction of greenhouse gases emissions, the air and noise pollution levels in the pilot sites, while also recycling parameters representing the effectiveness of waste management solutions. Another point, at which this domain focuses, is the Life Cycle Analysis (LCA) methodology which is applied for the determination of environmental aspects of a technology or a product from the first stages of production until the final use and disposal.

3.4.1.3 Economic

In this category, the indicators measuring and analysing the financial and economic performance of IANOS are proposed, based on the investment concepts of stakeholders and the profitable business model that can be created. Among the objectives of the project is to provide market viable solutions, defining business oriented KPIs to evaluate the tools and applications performance. The economic analysis of the demonstrated solutions is pivotal for the expansion and replication of the applied technologies not only in other islands that share the same topology but also in islands with totally different energy status and spatial parameters. Apparently, the economic growth of a region should be achieved towards the strategies for green and sustainable economy. As it is really challenging to approach a low carbon economy, the definition of KPIs which measures the economic benefits derived by innovative elements is of utmost importance. Expenditures by the municipality for the transition towards a smart island, investments for final users in favour of low carbon measures are some examples of the KPIs cited in this domain. This domain is related to the Life Cycle Cost (LCC) analysis, which evaluates the economic performance of an asset or a combination of solutions over their entire lifetime.

3.4.1.4 Information and Communication Technology (ICT)

The ICT domain is considered as a key pillar for the incorporation of the various innovative technologies into each LH island and with respect to its specificities. As a smart grid demands the permanent elaboration of huge amount of data and accuracy in the decision making to ensure the robust operation with the least possible interruptions, it is fundamental to evaluate the performance of new installed applications. Furthermore, during IANOS an

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intelligent Virtual Power Plant platform will be developed in order to manage the decentralized energy resources as a single power plant and enable higher levels of RES penetration. ICT performance evaluation will also help the project in the direction of anticipating risks and developing the capacity of the whole ecosystem to absorb, recover promptly and adapt to new or changing conditions. The integration of the latest generation of ICT solutions will enable data management, privacy and security and data monitoring for the development of new innovative services while also resilience of whole energy management systems. The ICT domain touches almost all the TTs and UCs of IANOS, from the demand side management and the decarbonization of the transport till the creation of LECs.

3.4.1.5 Social

This domain is the base for estimating the extent to which the project and its designed collaborative action model facilitates the involvement of citizens and social actors in the planning, decision-making and implementation activities through social citizen-driven innovation mechanisms. It is important, to have an overall view on the acceptance that smart grids projects have among the citizens and the definition of such KPIs lead us in this direction. Afterwards, presenting the results from this evaluation to other citizens during future projects, it will further help to have a more active participation and involvement. Because sometimes the quantification of these KPIs is hard, IANOS expresses them in a Likert scale to interpret them.

3.4.1.6 Governance

This domain includes a set of indicators which corresponds to many aspects that can be considered on the governance involvement towards the energy transition. The KPIs in this category refer to the municipality administration (mainly for planning and evaluation) and the compatibility of the legislative framework considering the smart grid interventions. Hence, this domain includes KPIs from the Legal domain, which is broadly used by other Lighthouse projects (e.g., SMILE). As it is difficult to assess quantifiably the KPIs in this domain due to the nature of the indicators, a five-point Likert scale is adopted. The importance of the Governance domain is high, as it identifies possible regulatory barriers or legal flexibilities for the demonstrated innovative implementations.

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3.4.1.7 Propagation

This domain consists of KPIs that measure the potential of the demonstrated activities to be scalable and replicable. This domain aims at concluding to a set of KPIs that are able to evaluate the suitability of the solutions (in general the Use Cases) to be applied in other islands of different size but with the same energetic characteristics (e.g., autonomous power systems, seasonality of the load due to the tourism, connection with the mainland). Scalability and replicability touch multiple sectors of the activities such as the technical/social compatibility, ICT modularity etc. and is strongly relevant with IANOS energy transition strategies from the point of view that serve the European vision for greener and smarter islands.

3.4.2 Stakeholders' perspectives

Various stakeholders affect and are being affected by the IANOS project, while they often possess and/or control information, resources and expertise needed for its implementation. In addition, their participation is necessary for the successful implementation of the solutions as well as the propagation of the results. For this reason, potential stakeholder groups related to the IANOS project are identified by: a) extraction of relevant information from other Smart City projects as well as by identifying successful examples of stakeholders' involvement; b) analysis of LH and FI special needs and respective integrated solutions in order to identify stakeholders that can actively participate/be represented during the implementation/evaluation of the solutions; c) internal communication of IANOS experts. The defined set of stakeholders is in accordance with the work performed in T2.1 - Islands requirements engineering and use case definitions. The main stakeholder groups identified are:

(a) Energy Utilities/DSOs/TSOs;

(b) Consumers (end-users)/Prosumers;

(c) Technology and services providers (TSPs);

(d) Policy-making bodies and Governance;

(e) Representative Citizen Groups

The stakeholder groups are analysed below along with their potential relation to the IASNOS UCs and TTs. Each stakeholder can potentially affect or being affected by several KPI domains, as presented in section 4, which presents for each KPI the relevant stakeholders.

3.4.2.1 Energy Utilities/DSOs/TSOs

This stakeholder group as defined in IANOS incorporates DSOs, TSOs, energy suppliers (providers) and producers. DSOs' role is to operate, maintain and develop the distribution network to ensure that electricity is delivered to end-users in a secure, reliable and efficient manner. Nowadays, the role of the DSO is broader and varies among countries due to their heterogeneity and differences in national regulation. Most often the distribution of electricity is controlled centrally by the regulating authorities. DSOs are nowadays asked to cope up with the big technological and socio-economic changes that are emerging in the electricity sector (e.g., the increasing production from intermittent renewable energy sources, the effective integration of electric vehicles and of demand side flexibility, the changing role of future consumers and the need to provide affordable energy to all). It is thence, of high interest for smart city projects to include the DSO's perspective related to the integrated solutions to be implemented. Similar to the DSOs, are the distributors of heating/cooling or other types of energy vectors (e.g., natural gas).

As such with the term Energy Utilities, IANOS refers to either the electricity or the heating/cooling distributors, related to UC#8 of IANOS, which includes both energy suppliers and producers. Energy producers might be centralized (power plants, wind farms etc) or local (UC#1) (local wind/solar energy generation), public (public utilities) or private (Independent Power Producer – IPP) and their perspective is also crucial for Smart City projects as they produce the energy that meets the market demand. Energy suppliers (providers) act as middleman between the energy producers and the consumers, setting rates, buying energy and thus creating a competitive electric market. Their role enables customers to pursue energy savings plans and thus are directly linked to the energy market and needs of a smart city. Energy Utilities are considered as utilizers of IANOS solutions valued for improving products and processes, profitability and skills in the field while acting as catalysts for their delivery.

Finally, this stakeholder group includes the TSOs, which are entities entrusted with transporting energy in the form of electrical power or natural on a

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national or regional level, using fixed infrastructure. Their role of the System Operator in a wholesale electricity market is to manage the security of the power system in real time and co-ordinate the supply of and demand for electricity, in a manner that avoids fluctuations in frequency or interruptions of supply. The System Operator service is normally specified in rules or codes established as part of the electricity market. A gas TSO works for the functioning of the internal market and cross-border trade for gas and to ensure the optimal management, coordinated operation and sound technical evolution of the natural gas transmission network. In some islands, which have smaller networks and voltage levels, there is an absence of TSOs leading to the DSOs also assuming the role of system operators managing the security of supply at all times.

It is therefore clear that Energy Utilities/DSOs/TSOs play an important role in IANOS solutions (UC#1-UC#8).

3.4.2.2 Consumers (end-users)/Prosumers

Consumers (End-Users)/prosumers are taking the centre stage in future energy systems. Consumers are considered as the end-users who can provide feedback and improvement loops and can act as data providers/testers. Prosumers are households or organisations which at times produce surplus energy and feed it into a national (or local) distribution network; whilst at other times (when their energy requirements outstrip their own production of it) they consume that same energy from that grid. A common example are households that by means of PV panels on their roofs they generate electricity. Such households may additionally make use of battery storage (UC#3) to increase their share of self-consumed PV electricity. Other example are businesses which produce biogas and feed it into a gas network while using gas from the same network at other times or in other places.

In smart city projects consumers'/prosumers' participation is increasingly valued as they can: a) contribute to the city energy transition as data providers, motivated to contribute to services they can use themselves, b) participate in the smart city planning and provide input supporting decision making, c) participate in the development and co-creation of smart city services that enable the smart cities, while in parallel facilitate the end-user adoption and d) contribute to the power or fuel production.

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Consumers can be classified as residential and non-residential. Both of them are mainly interested in optimising their energy consumption for economic reasons.

In residential consumers affordability and complexity are seen as the main barriers to adopting new technologies and cleaner energy sources. Millennials, however, seem to be more willing to try innovative solutions and are willing to pay more for cleaner energy sources.

Non-residential consumers are increasingly motivated by climate change and sustainability, while they're paying attention to environmental issues. More and more businesses have formal resource management plans in place and they're increasingly linking them to employee compensation. Non-residential consumers include factories, such as the large industrial plants of UC#6, facilities, offices and generally non-residential buildings, municipal or private, with high energy demands.

Mobility related consumers, which are related to UC#5 of IANOS, can be grouped in those who use electro-mobility and car-sharing solutions, those who use e-mobility i.e. individual drivers or in the form of public transportation services (e.g., electric buses) enjoying less travel time and reduced pollution, and finally public transport operators, whose interest is mainly on upgrading their fleet of vehicles to electric ones in order to reduce operational costs and reduce CO2 emissions.

Other consumers include educational, health, social, and commercial organization and companies.

3.4.2.3 Technology and services providers (TSPs)

Technology and Service Providers (TSPs) are private or public sector industries, technological companies, research labs, universities (knowledge institutes), research institutes and service providers, including Small and Mid-size Enterprises (SMES) and start-ups offering leading solutions for setting up intelligent and sustainable cities. Energy Service Companies (ESCOs, aggregators and utilities are interested in connecting basic energy infrastructure with novel technologies in order to synergistically improve operational excellence, revenue potential and foster sustainable lifestyles. Towards this direction, it is essential for

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smart city projects to evaluate the impact of the different solutions (demand response, storage and EV management) of the different providers.

Furthermore, due to the fact that today transmission and distribution constitute a serious cost factor in the formula for the provision of electricity and fossil fuels are a scarce resource, the traditional model of centralised electricity is gradually transitioning to distributed energy generation that comes in several forms: city-scale CHP plants or micro, and off-grid generators for individual households, which produce electricity where it is consumed. While large grids produce failures and inefficiencies, decentralised energy and smaller grids appear to be a more reliable and cheaper alternative. The growth of small and medium-sized agents using solar photovoltaic panels (UC#1), smart meters, vehicle-to-grid electric vehicles and EV chargers (UC#5), home batteries (UC#3) and other 'smart' devices, induces an increase in flexibility of the electricity networks. These agents complemented with investors, consultants and designers or housing associations can provide useful insights, beginning from the ones that own the largest share in the electricity mixture in each city, to small prosumers.

In IANOS, the TSPs are responsible for developing, executing and supervising the implementation of the solutions. In some cases, their role is also to promote citizen engagement (UC#9) in order to reach the envisioned adoption rates for the new technologies. At the district level there are various types of market operators, such as housing corporations, who have experience in testing combined energy efficient solutions in buildings and companies manufacturing and supplying smart energy management systems for automating and controlling devices. They are responsible for both the development and the commercial exploitation of the solutions in the market. They range from traffic management providers and vehicle manufacturers (usually large companies) dealing with the priority service and the electric vehicles (UC#5), respectively, to service providers (usually SMEs) able to provide car-sharing services. TSPs can be utilizers of IANOS solutions (i.e., local business, tourism operators, construction demolition industry, Local Authorities etc), facilitators (i.e., investors, financial institutions, banks) or providers (i.e., Associations/ Non-Governmental Organization (NGOs)/umbrella organizations, Knowledge institutes and universities, Waste collection and recycling industry (UC#7), Housing Association).

3.4.2.4 Policy-making bodies and Governance

Policy-making bodies and multilevel governance represent end-users, but also an important stakeholder group which can foster and ensure an efficient and rational decarbonization process. They are responsible for ensuring a connected infrastructure, a normal and steady operation of the energy market and a regulatory framework that determines the quality standards adapting quickly to opportunities offered by novel validated technologies that increase energy efficiency and grid stability. In IANOS UC#1-UC#8, the policy making and municipal authorities are responsible for providing the necessary infrastructure and services that facilitate the implementation of energy efficient solutions giving the opportunity for socio-economic development of the district or city while resulting in the reduction of carbon emissions. In UC#9, the municipality acts as an enabler for the increase of grid flexibility and for increasing citizen awareness for the new services provided by the energy providers. In UC#5, the policy making and governance authorities are responsible for providing mobility services to the citizens trying to reduce pollution and increase air quality. Policy-making bodies should also make sure that the vast amount of data generated during the implementation and monitoring of smart city solutions are organized and utilized in such a way that enhances their decision-making capacity (TT#3) while the governance should increase its ability to get in touch and motivate a considerable number of end-users, mainly domestic and SMEs, in order to increase adoption rates.

3.4.2.5 Representative Citizen Groups

Citizens as end users i.e., residents, visitors/tourists, building owners/tenants, commuters, drivers, are all seeking ways to elevate quality of life. Encouraged by the revised Energy Performance of Buildings Directive (EPBD) and the recast of Electricity Markets Directive they are becoming more and more involved in the energy system. They are beginning to act both individually and collectively (in Citizen Energy and Renewable Energy Communities (LECs)), but certainly much more decisively, also on climate mitigation initiatives. Citizen engagement in the development of innovative services towards a healthy and sustainable urban environment nurtures open innovation and accelerates the adoption of energy efficiency measures and solutions.

Representative Citizen groups represent groups of citizens with various activities related to IANOS actions and objectives. They include actors such as residents, non-residential agents with high interest, citizen associations, professional associations (e.g., Engineers, taxi drivers etc), neighbouring cities/towns as well as citizen ambassadors. Their perspective is of utmost importance towards the citizen-centric approach of IANOS. Citizen ambassadors are specifically important as individuals who have the willingness and the capacity in creating global fluency, building relationships at local, national and global level and driving social change. They are recognized by IANOS as a catalysing human asset in communicating the benefits of deploying the Integrated Solutions and driving citizen adoption towards new technological paradigms that brings energy efficiency, environmental neutrality and socioeconomic prosperity. These citizen groups are characterised by a high level of engagement with the initiatives and/or with an active steering role in communicating to the wider public intervention in IANOS target areas (UC#9).

3.5 Towards the IANOS tailored KPIs

3.5.1 KPIs assessment procedure

This section describes in more detail the procedure followed during the stage of step 5 (Iteration with partners for evaluating the KPIs). The extensive literature review on existing KPI assessment frameworks along with their classification in predefined domains conducted in steps 1 – 4, led to a large amount of KPIs included in IANOS KPI pool. A first evaluation was made directly to reduce the number of KPIs initially selected. Indicatively, indicators whose definition was not clear or available and indicators which were too technology or site-specific (e.g., efficiency of a specific type of battery) were excluded from the analysis. Moreover, two or more indicators that shared the similar content (e.g., using different terminology, utilizing different units etc.) were included obviously only once in the repository.

The procedure mentioned above reduced significantly the number of indicators but adopting such a big amount of KPIs – even if they would potentially be utilized in smart grid projects efficiently – would make the monitoring process quite overwhelming and almost impossible to be practically applied. To overcome

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this issue with transparency among the consortium, IANOS built upon the methodology proposed by the CIVITAS framework a modified (based on IANOS needs) selection criteria procedure to achieve having a shorter list of indicators.

More specifically, the iterative evaluation procedure presented below was followed among the partners and relevant stakeholders.

1. For the assessment of every KPI in the list, five criteria were selected, which are described below.

- Relevance: Indicator should be important for the evaluation of the project impact. That means that the indicators should serve as much as possible the objectives of the project and LH and FI islands, to support their planned strategies. Additionally, the indicators should be selected and defined in such a way that the implementation of the project provides a clear signal in the change of the indicator value.
- Availability: The data that a KPI needs for being calculated should be available easily and the time required for obtaining them should be short. Indicators should be ideally based on data that are available from the technology providers that are responsible for the specific innovation, or can be easily gathered from interviews. Of course, if a large number of interviews are requested for KPI measurement, then this KPI is not preferred, and it will receive a lower score.
- Measurability: For each indicator we should be able to quantify it and measure it as objectively as possible. In cases, where the quantification is difficult a Likert scale can be utilized for the evaluation.
- Reliability: The indicators should be unambiguously defined. The same holds for their calculation methods.
- Familiarity: The indicators should be easily understood by end users and in general by non-experts.

2. A 3-point scoring system per criterion is adopted to evaluate the KPIs (0: The indicator does not satisfy this criterion, 1: The indicator satisfies this criterion adequately, 2: The indicator fully satisfies this criterion).
3. The KPI repository was diffused by the Lighthouse managers of each pilot site, who leveraged the local ecosystem (TT leaders, UCs leaders), to the relevant stakeholders (TSOs, DSOs, Energy Utilities, Technology and services

providers etc.). The latter are the only ones who are adequately informed for the particularities of the technologies demonstrated and the island specific needs. Therefore, the procedure for the final KPI list definition was absolutely transparent and aligned with stakeholders' perspectives.

4. After the fulfilment of the assessment, the selection of the indicators with the highest indicators took place. A cut-off rule of a minimum score of 7 points in total was set for all indicators.
5. Lastly, the finalized list was iterated again among the responsible partners for adding any desired comments/changes on the KPIs parameters (e.g., units of measurement modification, description change)

The finalized list is presented in Section 3.5.2. We should note at this point, that this list is subject to updates/changes as the project goes on. Various difficulties in the collection of data or in the implementation of the demonstrated solutions may arise and thus this would immensely affect respectively the evaluation project.

3.5.2 The finalized KPI list

KPI Name	KPI Sources	KPI Definition
T-1. RES Generation	SMILE; INSULAE;	This KPI calculates the energy production from renewable energy sources.
T-2. Energy savings	SCIS; Angelakoglou et al. (2019); Li et al. (2017); mySMARTLIFE [16]; ITU-T [17]	This KPI calculates the reduction of the energy consumption to reach the same services (e.g., comfort levels) after the interventions, taking into consideration the energy consumption from the reference period.
T-3. System Average Interruption Frequency Index (SAIFI)	SCIS [2]; U4SCC [18]; Angelakoglou et al. (2019); ITU-T;	This KPI calculates the annual average number of power interruptions encountered by each end-user.
T-4. System Average Interruption Duration Index (SAIDI)	SCIS; U4SCC; Angelakoglou et al. (2019); ITU-T;	This KPI calculates the average time duration of the power interruptions encountered by the end-users each year.
T-5. Degree of energetic self-supply by RES	SCIS; Angelakoglou et al. (2019); Li et al. (2017); Lombardi et al. (2012); POCITYF	The degree of energetic self-supply by RES is defined as ratio of locally produced energy from RES and the final energy consumption over a period of time (e.g. month, year).

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T-6. Percentage of total amount of waste that is used to generate energy	ISO/FDIS 37122: 2019 [19]	This KPI calculates the percentage of the total amount of waste in the island or district, which is used to generate thermal or electrical energy (this KPI should be applied in the islands that have system for utilizing waste to generate energy).
T-7. Storage capacity of the energy grid per total island energy consumption	ISO/FDIS 37122: 2019	This KPI compares the storage capacity with the total energy consumption (electricity storage such as batteries or fuel cells, electrical storage of electrical vehicles, thermal storage such as PCM).
T-8. Reduced energy curtailment of RES and DER	SCIS; Angelakoglou et al. (2019); +CityxChange [20]; SMILE	This KPI calculates the reduction of energy curtailment due to technical/operational problems.
T-9. Peak load reduction	SMILE; INSULAE; POCITYF;	This KPI calculates the peak load reduction in a daily basis mainly due to DSM programs and storage system management.
T-10. Accuracy of energy supply and demand prediction	Li et al. (2017)	This KPI measures the gap between predicted and actual energy demand/supply at a given time. It might refer not only to electrical energy but also to thermal energy depending on the solutions demonstrated in each island.
T-11. Unbalance of the three-phase voltage system	SMILE; Douglass et al. (2016) [21]	This KPI examines the quality of the power supplied by measuring the supply voltage gap between the three phases which should be 120 deg. Under normal operating conditions, during each one-week period, 95% of the 10-minute average (RMS) values of the inverse component of the supply voltage shall be within the range of 0% to 2% of the corresponding direct component.
T-12. Peak photovoltaic power installed per 100 inhabitants	POCITYF; Dall'O et al. (2017)	This KPI measures the installed capacity of photovoltaic interpolated to 100 inhabitants. To be assessed per sector (residential, tertiary, industrial and public).
EN-1. Reduced Greenhouse Gas Emissions	SCIS; Hara et al. (2016); Lombardi et al. (2012); MATCHUP [22]; U4SCC; ITU-T; +CityxChange	This KPI calculates the reduction of the Greenhouse Gas Emissions.
EN-2. Reduced Fossil Fuels consumption	SMILE	This KPI measures the amount of fossil fuels which is now not consumed because of IANOS demonstrated solutions (e.g., electrification of transport, RES penetration).
EN-3. Electrical and thermal energy produced from solid waste or other liquid waste treatment per capita per year	ISO/FDIS 37122: 2019	This KPI computes the percentage of electrical and thermal energy that is produced by the waste exploitation. Solid waste presents an opportunity to recover energy, using new and possibly cleaner technologies.

EN-4. Air quality index (Air pollution)	CITYkeys; MATCHUP; U4SCC; UnaLab [23]; INSULAE	This KPI calculates the concentration levels of various pollutants (PM10, PM2,5, NO2 etc.).
EN-5. Reduction in the amount of unsorted waste collected	CITYkeys	This KPI calculates the percentage reduction in the amount of unsorted waste collected due to the project.
EN-6. Primary Energy Demand and Consumption	POCITYF; SCIS; MATCHUP; mySMARTLIFE	This KPI calculates the primary energy demand/consumption of a system of all the energy that is consumed in the supply chain of the used energy carriers.
EC-1. Total investments	SCIS; Angelakoglou et al. (2019); +CityxChange ; SMILE; POCITYF	This KPI calculates the ratio of the total energy-related investments to the total installed power.
EC-2. ROI	SCIS; Angelakoglou et al. (2019); +CityxChange ; SMILE; POCITYF	The return on investment (ROI) is an economic variable that enables the evaluation of the feasibility of an investment or the comparison between different possible investments. This parameter is defined as the ratio between the total incomes/net profit and the total investment of the project, usually expressed in %.
EC-3. Total annual costs	SCIS; Angelakoglou et al. (2019); POCITYF	The total annual costs are defined as the sum of capital-related annual costs (e.g. interests), requirement-related costs (e.g. power costs), operation related costs (e.g. costs of using the installation, i.e. maintenance) and other costs (e.g. insurance).
EC-4. Payback period	SCIS; Angelakoglou et al. (2019); +CityxChange ; SMILE; POCITYF	The payback period is the time it takes to cover investment costs and is calculated as the ratio between the total investment and the annual margin (revenues minus costs).
EC-5. Total annual revenues	SmartEnCity ;	The total annual revenues are defined as sum of capital-related revenues, requirement-related revenues, operation-related revenues and other revenues.
EC-6. Financial benefit for the end- user	CITYkeys; Angelakoglou et al. (2019)	This KPI evaluates the total cost savings in euros for end-users per household per year.
EC-7. Minimum electricity price for companies and consumers	TRIANGULUM [24]	The indicator represents the minimum price at which electricity must be sold in order to balance costs and profits.
EC-8. Internal Rate of Return (IRR)	CITYkeys; mySMARTLIFE; Smile	This KPI assesses the Internal Rate of Return of the investments implemented during IANOS.
EC-9. Cost of Fossil Fuel purchased from mainland	SMILE	This KPI examines the amount and cost of fossil fuels that have to be purchased by the mainland for electrical and thermal energy and for the transportation sector.
EC-10. Cost of electricity purchased from mainland	SMILE	This KPI measures the cost of electricity purchased from mainland.

EC-11. Energy poverty	POCITYF	This KPI assesses the change in percentage points of (gross) household income spent on energy bills.
I-1. Increased system flexibility for energy players	SCIS; Angelakoglou et al. (2019); POCITYF	This KPI is an indication of the ability of the system to respond to – as well as stabilize and balance – supply and demand in real time, as a measure of the demand side participation in energy markets and in energy efficiency intervention.
I-2. Data privacy - Data Safety & Level of Improvement (Improved Data Privacy)	CITYkeys; Angelakoglou et al. (2019); ETSI [25]; POCITYF	This KPI refers to data privacy, or information privacy. Specifically, it is the privacy of personal information and usually relates to personal data stored on computer systems. This indicator analyses the extent to which regulations on data protection are followed and to which proper procedures to protect personal or private data are implemented.
I-3. ICT Response time	SmartEnCity; mySMARTLIFE	The response time of ICT infrastructure is related to the services developed and the payload (information exchanged) between them. The indicator is applicable to the various platforms and ICT deployment actions and services in the project.
I-4. Increased hosting capacity for RES, electric vehicles and other new loads	SCIS; Angelakoglou et al. (2019); POCITYF	This KPI gives a statement about the additional loads and RES that can be installed in the system, when innovative solutions and energy management techniques are applied (e.g. VPP platform).
I-5. Increased reliability	SCIS; Angelakoglou et al. (2019)	This KPI measures the avoiding failures revert on higher reliability, meaning fewer stops on the normal operation of the building and associated systems.
I-6. Number of sensors integrated/devices connected	MATCHUP; mySMARTLIFE	This KPI measures the number of sensors and devices that are connected to the iVPP platform and to the IEPT toolkit.
I-7. Improved cyber security	CITYkeys; MATCHUP; POCITYF	The indicator refers to the extent to which the project ensures cybersecurity of its systems. This indicator analyses the effort made in the project to ensure and/or improve cybersecurity, for instance the extent to which the project is prepared to handle risks in cybersecurity (i.e. has made a risk assessment), is prepared to manage possible disturbances (has a contingency plan and means to implement it) and use secure information systems (certified and accredited prior to deployment).
I-8. Integrated Building Management Systems in Buildings	U4SCC; ITU-T	This KPI measures the percentage area of public buildings using integrated ICT systems to automate building management. It also includes the buildings that are equipped with smart sensors
S-1. People reached	POCITYF;	This KPI calculates the number and percentage of people in the target group that

	CITYkeys; Angelakoglou et al. (2019); mySMARTLIFE	have been reached and/or are activated by the project.
S-2. Thermal Comfort	SMILE; Angelakoglou et al. (2019)	This indicator estimates the quality of the delivered heating/cooling service.
S-3. Job creation	CITYkeys; MATCHUP; mySMARTLIFE; Angelakoglou et al. (2019); +CityxChange	This KPI calculates the number of jobs created by the project without specifying the location.
S-4. Percentage of citizens' participation in decision-making	POCITYF; MATCHUP	This KPI examines the number and percentage of citizens that participate in decision-making concerning the islands energy transition.
S-5. Number of interactive social media initiatives	MATCHUP; SmartEnCity	This KPI measures the number of accounts in social media created by the municipality for sharing information about the city (e.g. news, cultural agenda, etc).
S-6. Increased citizen awareness of the potential of smart islands projects	Angelakoglou et al. (2019)	This KPI measures the increased citizen awareness of the socio-cultural potential of smart city projects.
G-1. Involvement of the island administration	CITYkeys	This KPI examines the extent to which the local authority is involved in the development of the project, other than financial, and how many departments are contributing.
G-2. Smart island policy	CITYkeys; MATCHUP; ETSI	This KPI refers to the extent to which the project has benefitted from a governmental smart grid/island policy.
G-3. Micro-grids legal framework	SMILE	This KPIs assess the extent to which microgrids regulation is suitable at EU level and at the partners' islands level.
G-4. Suitable Energy Storage Regulation	SMILE	This KPI refers to the extent to which energy storage regulation is suitable at EU level and at the partners' islands level.
P-1. Social compatibility	POCITYF; CITYkeys; Angelakoglou et al. (2019)	This KPI refers to the extent to which the project's solution fits with people's 'frame of mind' and does not negatively challenge people's values or the ways they are used to do things.
P-2. Technical compatibility	POCITYF; CITYkeys;	This KPI examines the extent to which the smart grid solutions fit with the current existing technological standards/infrastructures.
P-3. Ease of use for end users of the solution	CITYkeys;	This KPI examines the extent to which the solution is perceived as difficult to understand and use for potential end-users

In addition, Table 10 presents the corresponding KERs and sub-KERs from SGAM (Table 8) to the selected KPIs (the KPIs of the social, governance and

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propagation domain do not correspond to any KERs therefore they are not presented in the table).

Table 10 IANOS KPIs and the corresponding KERs and sub-KERs from SGAM

KPI Name	KERs	Sub-KERs
T-1. RES Generation	Demand and Supply Hardware	Tidal Kite, Electrolyser for Hydrogen production, PVs with microinverter, Small wind turbines
T-2. Energy savings	Demand and Supply Hardware, Services for system and local flexibility	Large scale BESS, Biobased Saline Batteries, Fuel Cell, Heat batteries, Increasing the rate of Renewable Energy self-consumption, Peer to Peer
T-3. System Average Interruption Frequency Index (SAIFI)	Demand and Supply Hardware, Services for system and local flexibility	Frequency control, Flywheel
T-4. System Average Interruption Duration Index (SAIDI)	Demand and Supply Hardware, Services for system and local flexibility	Ancillary Services (e.g., voltage control during emergency states), Voltage control, Hybrid Transformer
T-5. Degree of energetic self-supply by RES	Services for system and local flexibility	Increasing the rate of Renewable Energy self-consumption
T-6. Percentage of total amount of waste in the island that is used to generate energy	Demand and Supply Hardware	Digester solution
T-7. Storage capacity of the energy grid per total energy consumption	Demand and Supply Hardware	Flywheel, Biobased saline batteries, large scale BESS
T-8. Reduced energy curtailment of RES and DER	Demand and Supply Hardware, The various modules integrated in the VPP platform, Services for system and local flexibility	Large scale BESS, Biobased Saline Batteries, Fuel Cell, Heat batteries, hybrid heat pumps, KIPLO, IT implementation, HEMS/BEMS, Increasing the rate of Renewable Energy self-consumption
T-9. Peak load reduction	Demand and Supply Hardware, the various modules integrated in the VPP platform	Peak shaving, HEMS/BEMS, Biobased saline batteries
T-10. Accuracy of energy supply and demand prediction	Demand and Supply Hardware, the various modules integrated in the VPP platform, Services for system and local flexibility	IT implementation, KIPLO, HEMS/BEMS, Congestion management
T-11. Unbalance of the three-phase voltage system	Demand and Supply Hardware, Services for system and local flexibility	V2G, HEMS/BEMS, EV charging stations, Hybrid Transformer, Voltage Control
T-12. Peak photovoltaic power installed per 100 inhabitants	Demand and Supply Hardware	PVs, PVs with microinverter

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EN-1. Reduced Greenhouse Gas Emissions	Demand and Supply Hardware, The various modules integrated in the VPP platform	Hybrid heat pumps, Heat batteries, HEMS/BEMS, Water Heating Systems, Tidal Kite, Electrolyser for Hydrogen production, PVs with microinverter, Biobased saline batteries, Fuel Cell, Large scale BESS, Small wind turbines, IT implementation
EN-2. Reduced Fossil Fuels consumption	Demand and Supply Hardware, The various modules integrated in the VPP platform	Hybrid heat pumps, Heat batteries, HEMS/BEMS, Water Heating Systems, Tidal Kite, Electrolyser for Hydrogen production, PVs with microinverter, Biobased saline batteries, Fuel Cell, Large scale BESS, Small wind turbines, IT implementation
EN-3. Electrical and thermal energy produced from solid waste or other liquid waste treatment per capita per year	Demand and Supply Hardware	Digester solution
EN-4. Air quality index (Air pollution)	Demand and Supply Hardware, The various modules integrated in the VPP platform	Hybrid heat pumps, Heat batteries, HEMS/BEMS, Water Heating Systems, Tidal Kite, PVs with microinverter, Biobased saline batteries, Fuel Cell, Large scale BESS, Small wind turbines, IT implementation
EN-5. Reduction in the amount of unsorted waste collected	Demand and Supply Hardware	Digester solution
EN-6. Primary Energy Demand and Consumption	Demand and Supply Hardware The various modules integrated in the VPP platform, Services for system and local flexibility	IT implementation, KIPLO, HEMS/BEMS, Congestion management
EC-1. Total investments	Demand and Supply Hardware, The various modules integrated in the VPP platform, Energy initiatives for community owned and individual prosumers investments	Community owned solar farms, in parallel with developing crowdfunding-based business models, DSM programs, Tidal Kite, Electrolyser for Hydrogen production, PVs with microinverter
EC-2. ROI	Demand and Supply Hardware, The various modules integrated in the VPP platform, Energy initiatives for community owned and individual prosumers investments	Community owned solar farms, in parallel with developing crowdfunding-based business models, DSM programs, Tidal Kite, Electrolyser for Hydrogen production, PVs with microinverter
EC-3. Total annual costs	Demand and Supply Hardware, The various modules integrated in the VPP platform, Energy initiatives for community	Community owned solar farms, in parallel with developing crowdfunding-based business models, DSM programs, Tidal Kite, Electrolyser for Hydrogen

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	owned and individual prosumers investments	production, PVs with microinverter
EC-4. Payback period	Energy initiatives for community owned and individual prosumers investments	Community owned solar farms, in parallel with developing crowdfunding-based business models, DSM programs
EC-5. Total annual revenues	Energy initiatives for community owned and individual prosumers investments	Community owned solar farms, in parallel with developing crowdfunding-based business models, DSM programs, Business concept for community owned hybrid solar – fuel cell solutions, Individual RE investments/ net-metering
EC-6. Financial benefit for the end- user	Energy initiatives for community owned and individual prosumers investments	Community owned solar farms, in parallel with developing crowdfunding-based business models, DSM programs, Business concept for community owned hybrid solar – fuel cell solutions, Individual RE investments/ net-metering
EC-7. Minimum electricity price for companies and consumers	Services for system and local flexibility, Energy initiatives for community owned and individual prosumers investments	DSM programs, Increasing the rate of Renewable Energy self-consumption
EC-8. Internal Rate of Return (IRR)	Demand and Supply Hardware, The various modules integrated in the VPP platform, Energy initiatives for community owned and individual prosumers investments	Community owned solar farms, in parallel with developing crowdfunding-based business models, DSM programs, Electrolyser for Hydrogen production, PVs with microinverter, Biobased saline batteries, V2G
EC-9. Cost of Fossil Fuel purchased from mainland	Demand and Supply Hardware, Energy initiatives for community owned and individual prosumers investments	Hybrid heat pumps, Heat batteries, EV charging stations, V2G, Business concept for community owned hybrid solar – fuel cell solutions, Community owned solar farms, in parallel with developing crowdfunding-based business models
EC-10. Cost of Electricity purchased from mainland	Demand and Supply Hardware, Services for system and local flexibility, KER #5: Energy initiatives for community owned and individual prosumers investments	Hybrid heat pumps, Heat batteries, EV charging stations, V2G, Business concept for community owned hybrid solar – fuel cell solutions, Community owned solar farms, in parallel with developing crowdfunding-based business models, Increasing the rate of Renewable Energy self-consumption

EC-11. Energy poverty	Services for system and local flexibility, Energy initiatives for community owned and individual prosumers investments	DSM programs, Increasing the rate of Renewable Energy self-consumption
I-1. Increased system flexibility for energy players	The various modules integrated in the VPP platform, Communication protocols for the exploitation of the data	Management of the storage systems, DLT-based transactive platform, Virtual Energy Console, Grid optimizer
I-2. Data privacy - Data Safety & Level of Improvement (Improved Data Privacy)	The various modules integrated in the VPP platform, Communication protocols for the exploitation of the data	Management of the storage systems, DLT-based transactive platform, Virtual Energy Console, Grid oriented optimizer
I-3. ICT Response time	The various modules integrated in the VPP platform, Communication protocols for the exploitation of the data	Management of the storage systems, DLT-based transactive platform, Virtual Energy Console, Grid oriented optimizer
I-4. Increased hosting capacity for RES, electric vehicles and other new loads	The various modules integrated in the VPP platform, Communication protocols for the exploitation of the data	Management of the storage systems, DLT-based transactive platform, Virtual Energy Console, Grid oriented optimizer, System Modeler, Forecasting Engine
I-5. Increased reliability	The various modules integrated in the VPP platform, Communication protocols for the exploitation of the data	Management of the storage systems, DLT-based transactive platform, Virtual Energy Console, Grid oriented optimizer, System Modeler, Forecasting Engine
I-6. Number of sensors integrated/devices connected	Demand and Supply Hardware, The various modules integrated in the VPP platform, Communication protocols for the exploitation of the data	Management of the storage systems, DLT-based transactive platform, Virtual Energy Console, Grid oriented optimizer, System Modeler, Forecasting Engine, KIPLO, FEID-PLUS
I-7. Improved cybersecurity	The various modules integrated in the VPP platform, Communication protocols for the exploitation of the data	Management of the storage systems, DLT-based transactive platform, Virtual Energy Console, Grid optimizer, Crowdequity Platform, LCA/LCC toolkit
I-8. Integrated Building Management Systems in Buildings	Demand and Supply Hardware, The various modules integrated in the VPP platform, Communication protocols for the exploitation of the data	Management of the storage systems, DLT-based transactive platform, Virtual Energy Console, Grid oriented optimizer, System Modeler, Forecasting Engine, KIPLO, FEID-PLUS

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3.6 KPIs clustering and granularity evaluation levels

This section describes the KPIs clustering and defines granularity evaluation levels. The aggregation performed facilitates the monitoring procedure.

3.6.1 Output oriented and impact-oriented clustering

KPIs chosen and assessed during the stages described in previous sections, target both the technologies to be implemented as well as the core objectives of IANOS. Hence, there are two categories into the selected KPIs can be grouped: the output-oriented KPIs and the impact-oriented KPIs.

The output oriented KPIs are concrete indicators for monitoring the progress and the success of implementation (e.g., number of houses with installed smart meters, reduce to the degradation rate of the storage systems) whereas the impact oriented KPIs evaluate the benefits of the multiple interventions as well as the general goals to which each project will contribute (Energy Savings, CO2 emissions).

Despite the distinction of the KPIs according to their evaluation of the impact in the project or in the solutions, there is a strong correlation between them. Multiple output-oriented KPIs are related to one impact target as it is shown in Figure 5.

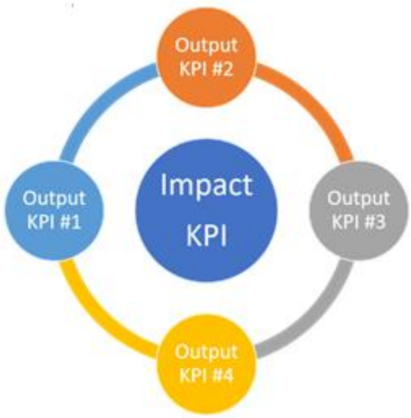

Figure 5 Relation between Output oriented and Impact oriented KPIs

3.6.2 From Use Cases to Transition Tracks

The individual technologies to be deployed and implemented in the two LH islands form the objectives of the Use Cases, which are interlinked with IANOS Energy Transition Tracks. Therefore, the selected KPIs should monitor and evaluate both the performance of each UC (sometimes they monitor the advancement of a specific technology, but generally it is not preferred to have such an orientation in the KPIs) as well as the progress of the ETTs, which are even closer to the higher level goals of IANOS. To achieve this, KPIs relevant to these specific ETT objectives are selected. In Table 11 IANOS TTs along with the linked objectives are presented.

Table 11 IANOS TTs and their objectives

TT #1	**Objective 1**
Energy efficiency and grid support for extremely high-RES penetration	Demonstration of solutions related to conventional and novel RES deployment together with their integration to the VPP platform for reducing RES curtailment
TT #2	**Objective 2**
Decarbonization through electrification and support from non-emitting fuels	Demonstration of solutions about the electrification of the transport sector and the large industrial loads along with other interventions to the energy network to reduce the CO2 emissions
TT #3	**Objective 3**
Empowered Local Energy Communities (LECs)	Implementation of actions for the creation of high quality LECs characterized by self-sustainability

3.6.3 From the building level to the entire island (spatial scale)

The individual solutions to be developed in IANOS need to be not only replicated (which is very important for the reaching the European goal for energy transition in islands) but also gradually scaled up to island level. Scalability constitutes a key requirement for the wide rollout of the innovative technologies. It refers to the possibility of implementing a technology in a bigger scale without compromising its efficiency and effectiveness. The attractiveness of an island, in terms of demonstrating other novel energy investments with the benefits of contributing in the potential business models, living conditions, and eventually more local jobs creation, increases with the capability of adopting IANOS scale up innovative solutions. In this light, it is important to assess the interventions in different spatial granularity levels in order to comply with the aforementioned requirement. The selected KPIs should include a spatial scaling component and taking into consideration their expanding character.

In IANOS three spatial levels have been defined (Building level, District level, Island level) considering the nature of the solutions provided. There are

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technologies in IANOS that will be installed in residential buildings but with high potential of being scaled up in the future (e.g., hybrid heat pumps, PVs with integrated micro-inverters, FEID PLUS, heat batteries). Furthermore, some more mature and commercialized solutions such as the fuel cells with the electrolyser, the V2G services, the AHDP, the hybrid transformer etc. are for the moment implemented in district level but their scaling up in island level are being searched. Lastly, there is a set of implementations that refer to the entire island (large BESS, tidal kite), taking into account the size of island (the power peak, the annual generation/consumption).

In the three following paragraphs a small reference is presented about the aforementioned levels.

Building level: The assessment boundary in the building level integrates the energy needs per area of application (heating, cooling, DHW, etc.), energy technologies supplying these energy needs, energy storage units, delivered energy to each energy supply unit per energy carrier and the data collected /shared by ICTs at the building level.

District level: The level of district is composed by the aggregation of different entities. In practice, indicators can be calculated for the sum of these entities along with district specific KPIs relevant to mobility, ICT measures, socioeconomic and environmental aspects. Due to the complexity of these calculations, indicators can only be calculated if a full set of data is available. Sometimes, approximations can be chosen for the missing data and parameters in order to aggregate the outcome in a district level. Of course, this would offer an approach but the tendency of the results will be sufficiently monitored. The boundaries of the districts and the corresponding energy flows must be defined properly.

Before proceeding to the definition of the districts in each island, first a brief description of the electrical network of each island is presented below:

3.6.3.1 Brief description of the electrical network in Terceira

The following figure (Figure 6) shows a map of Terceira with its electrical network, including the reach of each distribution substation and the connection points of the demonstration sites. The network supports the following groups: i) small-scale flexible consumers/distributed prosumers, residential end-users from

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Terra Chã neighbourhood, ii) medium/large-scale flexible consumers/distributed prosumers, Pronicol dairy factory, site 2 (tbd), site 3 (tbd), and iii) other, e-mobility flexibility, EDA's headquarters in Angra do Heroísmo and EDA's geothermal power plant in Pico Alto.

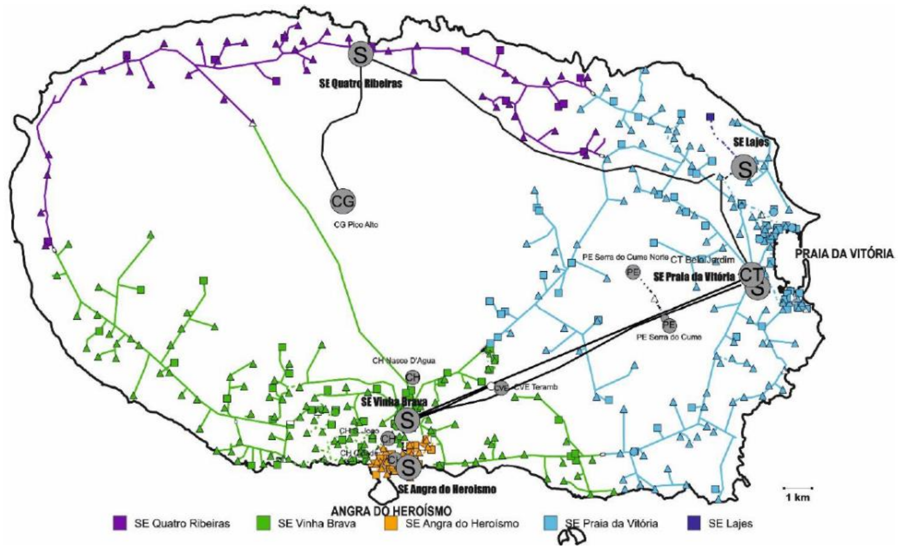

Figure 6 Terceira's grid, including the reach of each distribution substation.

The substations that support each group are described below:

1. Small-scale flexible consumers/distributed prosumers, residential end-users from Terra Chã neighbourhood:
   - Public Secondary substation No. 3PT0144, powered by a 15kV Medium Voltage (MV) feeder, Vinha Brava – São Mateus, departing from Vinha Brava substation (Figure 7).

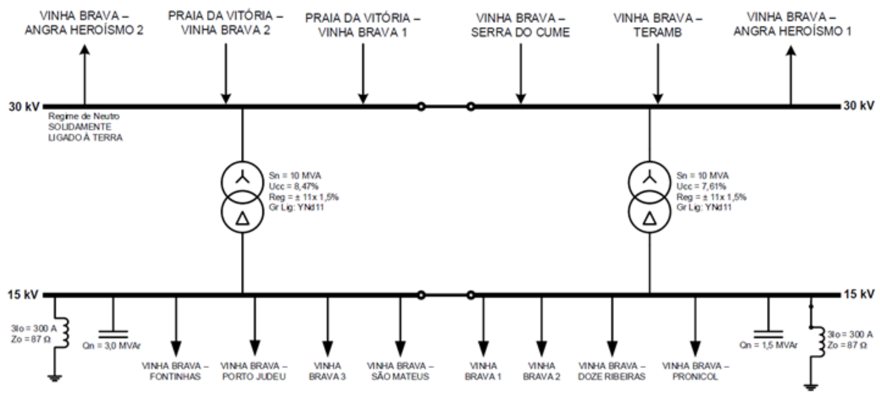

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Figure 7 Electrical scheme of Vinha Brava substation, including the 15kV connections powering Pronicol dairy factory and the secondary substation No. 114 – Vinha Brava-São Mateus – (Terra Chã neighbourhood).

2. Medium/ large-scale flexible consumers/distributed prosumers, Pronicol dairy factory, site 2 (tbd), site 3 (tbd):
    - Pronicol dairy factory: powered by privately owned secondary substation 3PT1030 supplied by a dedicated 15kV MV feeder, Vinha Brava – Pronicol, departing from Vinha Brava substation.
    - Site 2 – generation unit for self-consumption No. 1
    - Site 3 – generation unit for self-consumption No. 2
3. Other, e-mobility flexibility, EDA's headquarters in Angra do Heroísmo and EDA's geothermal power plant in Pico Alto:

Secondary substation No. 3PT0001, powered by a 15kV MV feeder, Angra do Heroísmo 04, departing from Angra do Heroísmo substation (

- *Figure 8*).
- Pico Alto geothermal power plant, connected to the network by a 30kV MV feeder, Quatro Ribeiras – Pico Alto, that links the power plant to the substation of Quatro Ribeiras (Figure 9).

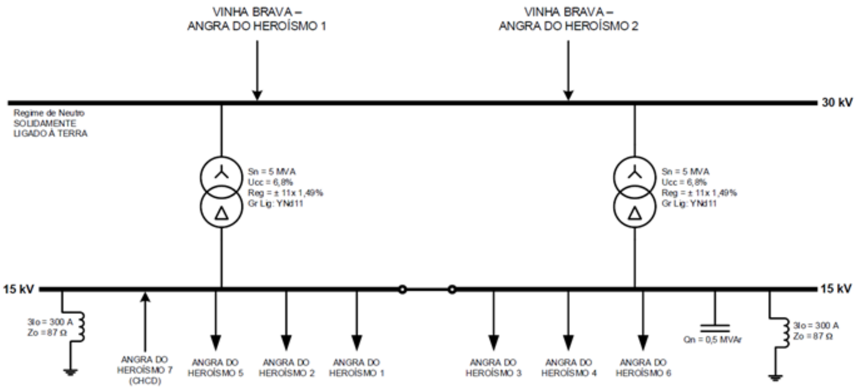

Figure 8 Electrical scheme of Angra do Heroísmo substation, including the 15kV connection powering secondary substation No. 3PT0001 – Central – (EDA's headquarters).

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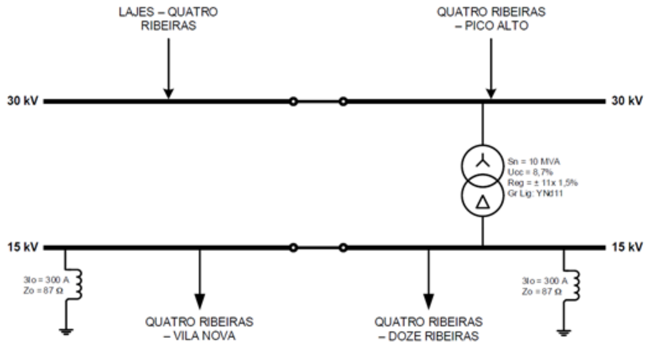

Figure 9 Electrical scheme of Quatro Ribeiras substation, including the 30kV connection connecting Pico Alto geothermal power plant.

3.6.3.2 Brief description of the electrical network in Ameland

Figure 10 shows the electrical network on Ameland and the assets that are installed or are ready to be installed on a single location: tidal kite, solar parks, NAM platform and heating grid and CHPs. Other assets like Charging Stations, Residential PV, Smart Lighting, Hybrid Heat Pumps, Small Methane Fuel Cells are spread out over the Island. The red lines show the low voltage grid (240/400V) and the black lines the medium voltage grid (10k/20k). Green symbols are the medium to low voltage transformers (called MSRs).

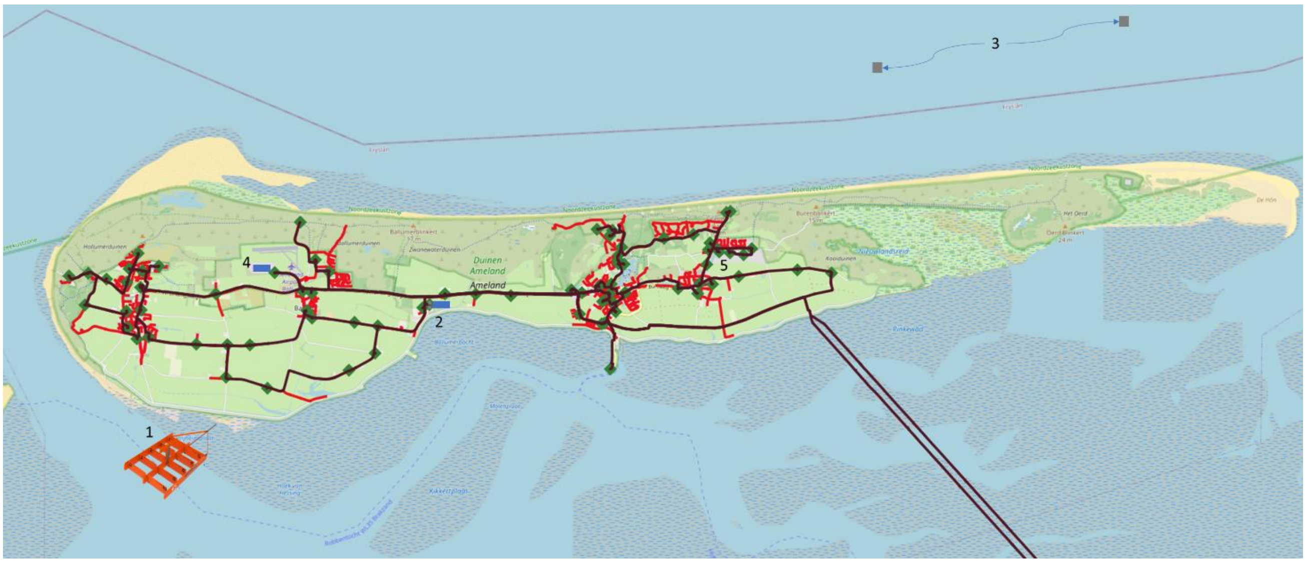

Figure 10 Ameland's grid and assets that are installed or ready to be installed. 1: Tidal Kite, 2: Solar Park Ballumerbocht 3 MW, Battery pack, Electrolyzer, 3: NAM platform, 4: Solar Park Airport 6 MW, 5: Heating Grid Klein Vaarwater, CHP's Klein Vaarwater

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3.6.3.3 Definition of Terceira districts and characterisation of the different monitoring levels

To understand the definition proposed it is necessary to understand that some of the KPIs proposed will evaluate local impacts, e.g., self-supplied renewable-based energy or peak-load reduction, while other KPIs target more global impacts, e.g., curtailment reduction and emissions avoided.

Considering the description presented, namely the location and reach of each demo site, the following districts are proposed, as shown in Figure 11:

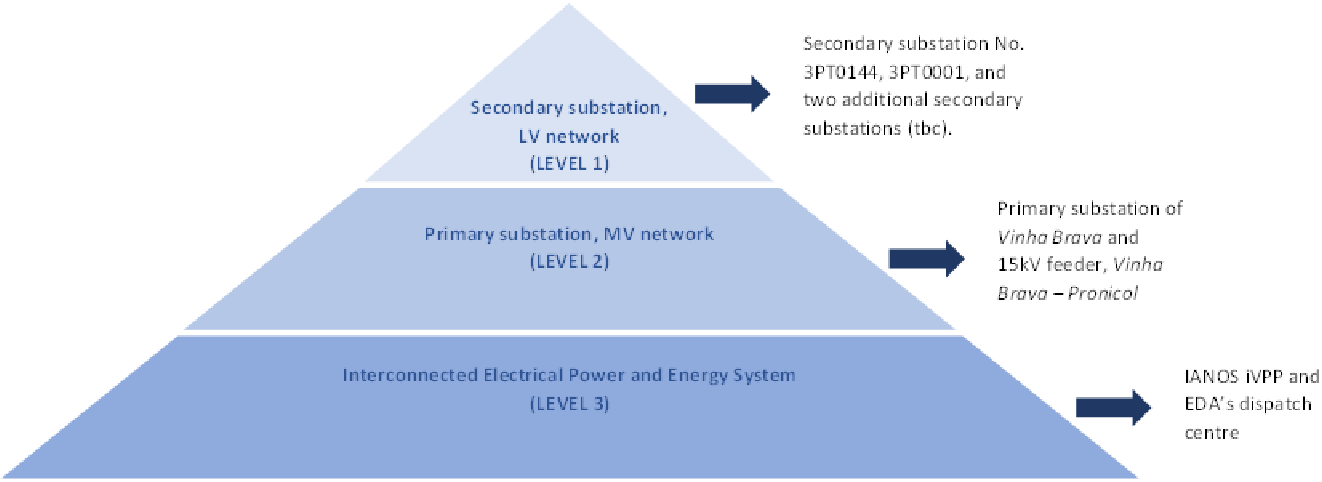

Figure 11 District levels proposed for the Terceira LHI.

1. Level 1: secondary substation level and downstream Low Voltage (LV) feeders.
   - This level represents a distribution grid area comprised by a secondary substation and one or more LV circuits departing from the secondary substation.
   - The use cases validated within the customer premises domain, involving small and medium-scale flexible consumers/distributed prosumers and other DERs, e.g., EV charging infrastructures, are linked to KPIs that will be measured based on pilot data monitored directly at the field level.
2. Level 2: primary substation level and downstream MV feeders.
   - This level represents a wider distribution grid area, including a substation and one or more of its MV feeders, powering one or more secondary substations where pilot sites are connected.
   - Within this context there are some use cases targeting validation scenarios that must be monitored based on data collected across

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different domains, such as customer premises, DER and distribution. Moreover, since at this level it's being mainly considered medium to large-scale flexible consumers/distributed prosumers and DER assets, relevant measurements must be accomplished at field but also station and operation levels.

3. Level 3: all interconnected system level.
   - This level consists of a large-scale grid area, involving a wider range of primary substations and the transmission system connecting them.
   - At island scale this level represents the entire interconnected electrical power and energy system, thus including generation, transmission, distribution, and customer premises domains.
   - As stated, the use cases proposed have an extended impact that must be assessed under a more global perspective, thus the calculation of linked performance indicators must rely on data processed by a high-level system, such as an iVPP or a central dispatch.

3.6.3.4 Definition of Ameland districts

For the case of Ameland three districts have been defined: i) large producers (solar parks, tidal kite etc), ii) large consumer: natural gas extraction platform (NAM), and, iii) the 'rest', which includes all residential areas, holiday homes, local businesses, public lighting, etc. Therefore, it also includes the 4 villages of the island: Buren, Nes, Ballum and Hollum.

Island level: The scaling to an island level is a complicated procedure as IANOS solutions target building and districts. Nevertheless, a generalized evaluation on island level can be performed by focusing on the previous granularity levels. Similar to the description for the district level, the boundary must be defined properly including all dimensional indicators. Aggregation and averaging methods can be used towards this evaluation.

For every KPI in the list, its possible relation with the three spatial levels will be mentioned (on the KPI cards in section 4), in order the outcome to be easily utilized in future projects towards islands of different size.

3.6.4 From short term to long term analysis (temporal scale)

Each island is a dynamic ecosystem, where a continuous development occurs mainly due to external factors (global technology advancement). As IANOS lasts for only four years, the assessment of the novel solutions performance and the impact in the local communities cannot be exclusively determined during its duration, thus, there is a need of observing IANOS impact after the official end of the project, when the solution will have been perfectly adapted. KPIs should take into account this time dependency of the impact when assessing the implemented technologies. From an economic perspective, evaluating the performance of solutions in different timeframes is also very important as it lowers financial risk and gives motivation for long term investments.

Based on the aforementioned reasons, indicators should provide the required temporal perspective to lead the islands to the optimal implementations and to offer an overview for the future progress of their energy systems. IANOS temporal granulation adopts three temporal frames:

In-project (short-term): The majority of the solutions has a strong impact in the islands during the project because the innovation that characterizes the solutions leads to prompt results in the ecosystems. Many of IANOS Key Objectives are to be achieved during the four years (project lifetime). This temporal level of evaluation provides information on the progress of a solution during the project. The time period of one year is suggested as a reasonable timeframe for the critical evaluation of the KPIs, however, the exact timeframe will be decided in the context of the monitoring WPs (T5.4 and T6.4).

End of project (2024) (mid-term): The assessment of the solutions implemented till the end of the project provides important information on the projects impact. In some cases, the aggregation of the short-term level can be used to calculate the indicators by summation/ averaging etc. The observation intervals depend on each KPI nature.

Post-project (2025 - 2050) (long-term): This temporal level assesses the impact of the solutions after the project lifetime. To achieve this, islands should continue monitoring the performance of the already demonstrated solutions. The implemented solutions are not static and their interaction with other island solutions should be evaluated in such temporal scale to assess their success and provide feedback for similar future projects. One reasonable timeframe for the long-term evaluation of the project is 5 years after its end, however, similar to the short-term evaluation this will be decided in the context of T5.4 and T6.4.

3.6.5 Analytics on clustering and evaluation levels

The following pie chart (

Figure 12) shows the number and percentage of KPIs in each domain. The most populated domain is the technical domain with 12 KPIs (24%), followed by the economic with 11 (22%), the ICT with 8 (16%), the social and environmental with 6 each (12%), the governance with 4 (8%) and, finally, the propagation with 3 (6%).

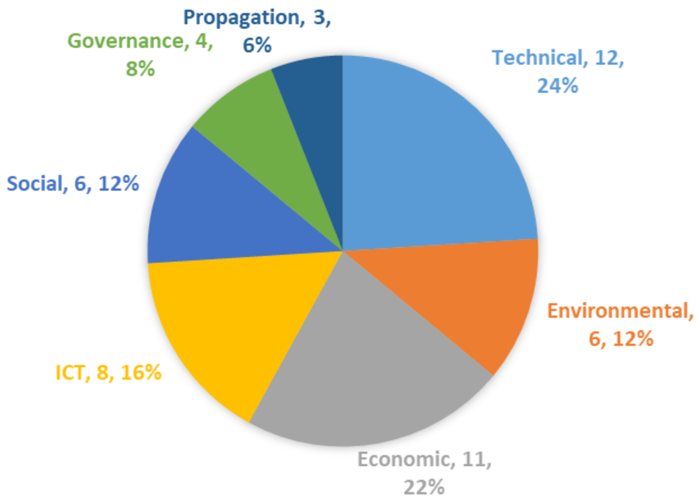

Figure 12 Number and percentage of KPIs in each domain.

The following two figures, show the analytics of the KPIs regarding the spatial scale, recommended measurement period, output/impact (Figure 13) as well as the stakeholders' engagement (Figure 14), based on the information on the KPI cards (section 4). The majority of the KPIs refer to the island level, are project outputs and will be measured both in project timeframe and at its the end. The stakeholder group energy utilities/DSOs/TSOs shows the relation with the most KPIs, while the group Representative Citizens group/Citizens shows the least.

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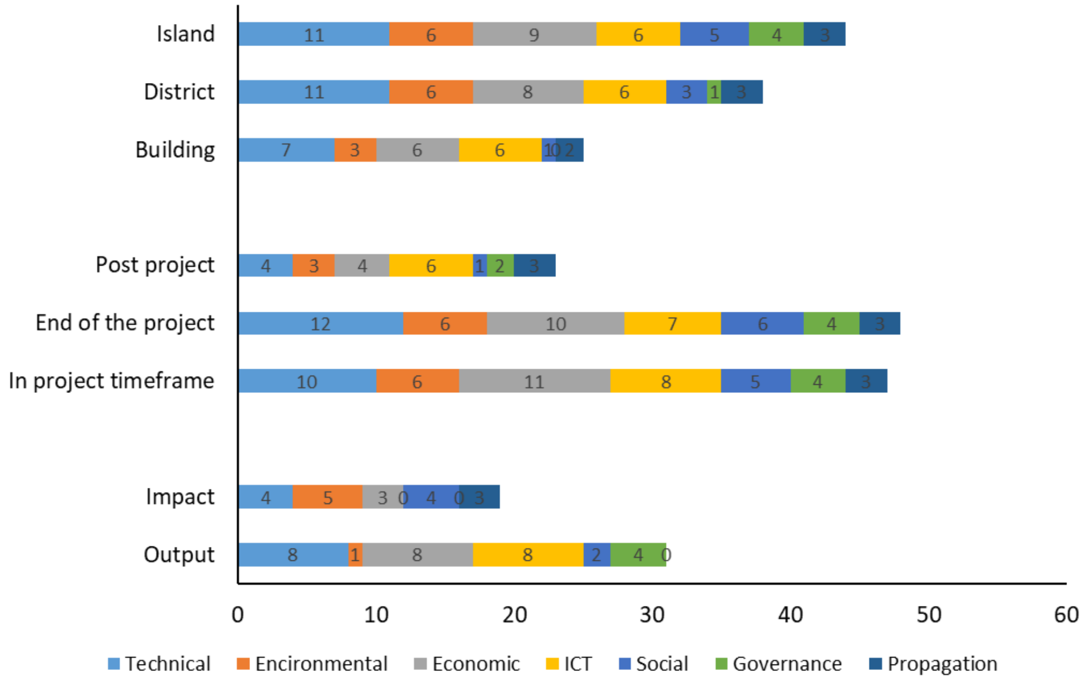

Figure 13 Analytics of spatial scale, measurement period and output/impact of KPIs.

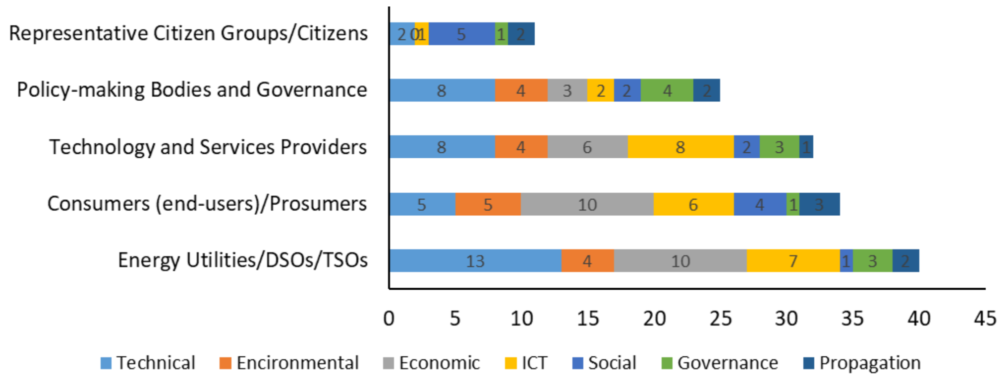

Figure 14 Analytics on stakeholders' engagement in the KPIs

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4 IANOS KPI cards

In the following sub-sections, the KPI cards per domain are presented. Each KPI card includes: a short description of the KPI, its calculation method (formula) and unit, the aggregation/clustering levels (temporal, spatial, Transition Track-linked, Use Case-linked), initial recommendations for data collection and measurement methodologies, the relevant stakeholders, the target value and, finally, the KPI owner. The latter is a single partner from each LH island who will ensure that the specific KPI is measured and calculated according to the methodology provided in the KPI Card for the particular action. If this KPI Owner needs technical support, a complementary "Supporting" partner next to the KPI Owner should be assigned too. If a specific KPI is to be measured in different sectors (energy, ICT, mobility) and/or aggregated in different levels (Building, district, island), the KPI Owner will need to assign necessary "Supporting" partners to support the overall management of the KPI. The overall KPI Owner will be used as a contact point for further actions in IANOS such as data analytics, impact assessment, SCIS inputs, etc.

In the 2nd version of the deliverable the KPIs have been revisited by both LH islands. In addition, the KPIs that will be estimated as part of the replication studies in each fellow island have been marked in the KPI cards with feedback from each FI. An iteration process with feedback from both the LH islands was performed for the refinement and finalization of the KPIs in the 3rd version. Any updates regarding the KPIs, the KPI description, the measurement process, the KPI owner, and the temporal and spatial levels of evaluation have been considered in the current (3rd) version.

4.1 KPIs in Technical Domain

4.1.1 RES Generation

RES Generation				
KPI Description	This KPI calculates the energy production from renewable energy sources. All DERs and centralized RES should be included in this KPI. It can be expressed either in energy units or in % of the energy mix.			
KPI Owner	Terceira: EDA, Ameland: Repowered			
KPI Formula	$G_{res} = G_{th} + G_{el}$ $or\ in\ \%\ G_{res} = \frac{G_{th} + G_{el}}{EG_{total}}$ • G_{res}= total energy generated by RES (GWh/year; %) • G_{th} = thermal energy generated by RES (GWh/year) • G_{el} = electrical energy generated by RES(GWh/year) • EG_{total} = total energy consumed (both renewable and conventional energy sources) (GWh/year)			
Recommended Measurement Process and Data Sources	1. Data collection for G_{th}, G_{el} and EG_{total} (from TSO/DSO of each island)			
Recommended Monitoring Interval	Monthly, yearly;			
Unit of Measurement	GWh/year; %	**Threshold Target Value**	• Increase of 83.6 GWh/year for both islands (Terceira: 69.2 GWh/y, Ameland: 14.4 GWh/y) • Terceira: 70%, Ameland: 19.8% (excluding the platform)	
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers			Island Level	x
	Policy-making Bodies and Governance	x			
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	

TT-reference	TT#1	x		TT#2	x		TT#3			
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	

	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2		
	UC 6	x	UC 7		UC 8	x	UC 9.1				
							UC 9.2				
Replication in fellow islands	Nisyros			x	Bora-Bora				Lampedusa		x

4.1.2 Energy savings

<table>
<tr><th colspan="6">Energy savings</th></tr>
<tr><td>KPI Description</td><td colspan="5">This KPI calculates the reduction of the energy consumption to reach the same services (e.g. comfort levels) after the interventions, taking into consideration the energy consumption from the reference period. Energy Savings may be calculated separately for thermal (heating or cooling) energy and electricity.</td></tr>
<tr><td>KPI Owner</td><td colspan="5">Terceira: EDA (plus external stakeholders, if necessary, for the monitoring of thermal energy), Ameland: Repowered</td></tr>
<tr><td>KPI Formula</td><td colspan="5"><u>Thermal Energy</u>
$$ES_T = ER_T - TE_C$$
$$or\ in\ \%: ES_T = 1 - \frac{TE_C}{ER_T}$$
• ES_T = Thermal energy savings
• ER_T = Thermal energy reference demand or consumption (simulated or monitored) of demonstration-site [kWh/(m^2 year) ; MWh/(year)]].
• TEC = Thermal energy consumption of the demonstration-site [kWh/(m^2 year) ; MWh/(year)]]

<u>Electrical Energy</u>
$$ES_E = ER_E - EE_C$$
$$or\ in\ \%: ES_E = 1 - \frac{EE_C}{ER_E}$$
• ES_E = Electric energy savings
• EE_C = Electric energy consumption of the demonstration-site [kWh/(m^2 year) ; MWh/(year)]
• ER_E = Electric energy reference demand or consumption (simulated or monitored) of demonstration-site [kWh/(m^2 year) ; MWh/(year)]].</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="5">1. Data collection: Data for consumption (as well as reference values) can be provided by energy utilities from energy meters. The reference values ideally should be measured before the IANOS implementations or at least accessed through historical data.
2. KPI calculation
3. Comparison with threshold target value</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="5">Monthly; yearly

Monthly values must be available.</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">kWh/ (m^2·year); MWh/(year); %</td><td>Threshold Target Value</td><td colspan="2">TBD</td></tr>
<tr><td rowspan="4">Relevant Stakeholders</td><td>Energy Utilities/DSOs/TSOs</td><td>x</td><td rowspan="4">Spatial Scale of Evaluation</td><td>Building Level</td><td>x</td></tr>
<tr><td>Consumers (end-users)/Prosumers</td><td>x</td><td>District Level</td><td>x</td></tr>
<tr><td>Technology and Services Providers</td><td>x</td><td>Island Level</td><td></td></tr>
<tr><td>Policy-making Bodies and Governance</td><td>x</td><td></td><td></td></tr>
</table>

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	Representative Citizen Groups/Citizens				
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact	x		End of project	x
				Post-project	x

TT-reference	TT#1	x	TT#2	x	TT#3					
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1		UC 4.1	x	UC 5.1	x
	UC 1.2	x	UC 2.2	x	UC 3.2		UC 4.2	x	UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1			
							UC 9.2			
Replication in fellow islands	Nisyros	x	Bora-Bora		Lampedusa	x				

4.1.3 System Average Interruption Frequency Index

System Average Interruption Frequency Index										
KPI Description	This KPI calculates the annual average number of power interruptions encountered by each end-user.									
KPI Owner	Terceira: EDA, Ameland: Liander									
KPI Formula	$SAIFI = \frac{ST}{CUS}$ $SAIFI$= system's average interruption frequency index ST= number of power interruptions annually in the grid to all end-users CUS= number of end-users									
Recommended Measurement Process and Data Sources	1. The island TSO/DSO can provide the data for ST									
Recommended Monitoring Interval	Annually									
Unit of Measurement	Interruptions/customer·year		**Threshold Target Value**	<1.5 interruptions /customer·year						
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x					
	Consumers (end-users)/Prosumers	x		District Level	x					
	Technology and Services Providers			Island Level	x					
	Policy-making Bodies and Governance									
	Representative Citizen Groups/Citizens									
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x					
	Impact			End of project	x					
				Post-project	x					
TT-reference	TT#1	x	TT#2		TT#3					
UC-reference	UC 1.1		UC 2.1		UC 3.1		UC 4.1	x	UC 5.1	
	UC 1.2		UC 2.2		UC 3.2		UC 4.2	x	UC 5.2	
	UC 6		UC 7		UC 8		UC 9.1			
							UC 9.2			
Replication in fellow islands	Nisyros		Bora-Bora		Lampedusa	x				

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 957810

4.1.4 System Average Interruption Duration Index

System Average Interruption Duration Index	
KPI Description	This KPI calculates the average time duration of the power interruptions encountered by the end-users each year.
KPI Owner	Terceira: EDA, Ameland: Liander
KPI Formula	$$SAIDI = \frac{DCI_{tot}}{ST}$$ SAIDI = Average length of electrical interruptions in hours DCI_{tot} = Sum of the duration of all customer interruptions in hours ST= number of power interruptions to all end-users in the grid annually
Recommended Measurement Process and Data Sources	1. The island TSO can provide the data for DCItot and ST
Recommended Monitoring Interval	Annually

Unit of Measurement	hours/year		**Threshold Target Value**	<2.5 hours per year	
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers			Island Level	x
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	x

TT-reference	TT#1	x		TT#2				TT#3	
UC-reference	UC 1.1		UC 2.1		UC 3.1		UC 4.1	x	UC 5.1	
	UC 1.2		UC 2.2		UC 3.2		UC 4.2	x	UC 5.2	
	UC 6		UC 7		UC 8		UC 9.1			
							UC 9.2			

Replication in fellow islands	Nisyros		Bora-Bora		Lampedusa	x

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 957810

4.1.5 Degree of energetic self-supply by RES

Degree of energetic self-supply by RES	
KPI Description	The degree of energetic self-supply by RES is defined as ratio of locally produced energy from RES and the final energy consumption over a period of time (e.g. month, year). The degree of energetic self-supply (DE) is determined separately for thermal (heating or cooling) and electrical energy as well as for the total. The energy produced locally refers to the energy provided by renewable energy sources (RES).
KPI Owner	Terceira: EDA (plus external stakeholders, if necessary, for the monitoring of thermal energy), Ameland: Liander
KPI Formula	**Thermal energy** $$DE_T = \frac{LPE_T}{TE_C}$$ • DE_T = Degree of thermal energy self-supply based on RES (%) • LPE_T = Locally produced thermal energy [kWh/month; kWh/year] • TE_C = Final thermal energy consumption (monitored) [kWh/(month); kWh/(year)] **Electrical Energy** $$DE_E = \frac{LPE_E}{EE_C}$$ • DE_E = Degree of electrical energy self-supply based on RES • LPE_E = Locally produced electrical energy [kWh/month; kWh/year] • EE_C = Electrical energy consumption (monitored) [kWh/(month); kWh/(year)] **Total Energy** $$DE_{tot} = \frac{LPE_E + LPE_T}{TE_C + EE_C}$$ • DE_E = Degree of total energy self-supply based on RES
Recommended Measurement Process and Data Sources	1. Data collection for LPE_T, TE_C, LPE_E and EE_C (from energy meters or/and simulations or/and database (TSO/DSO)) 2. KPI calculation
Recommended Monitoring Interval	The monitoring interval should depend on the system and on the granularity of the data collected. It can be hourly; monthly; yearly

Unit of Measurement	%		**Threshold Target Value**	Increase of 5%	
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers	x		Island Level	x

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	Policy-making Bodies and Governance									
	Representative Citizen Groups/Citizens									
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	x					
	Impact	x		End of project	x					
				Post-project	x					
TT-reference	TT#1	x	TT#2		TT#3					
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	
	UC 6	x	UC 7	x	UC 8	x	UC 9.1			
							UC 9.2			
Replication in fellow islands	Nisyros		Bora-Bora		Lampedusa	x				

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4.1.6 Percentage of total amount of waste that is used to generate energy

Percentage of total amount of waste that is used to generate energy	
KPI Description	This KPI calculates the percentage of the total amount of waste in the island or district which is used to generate thermal or electrical energy. This KPI should be applied in the islands that have system for utilizing waste to generate energy.
KPI Owner	Municipality of Ameland
KPI Formula	$$WE = \frac{W_{el} + W_{th}}{W_{total}}$$ • W_{el} = waste that is used to produce electricity (tones/year) • W_{th}= waste that is used to produce heat (tones/year) • W_{total} = total waste of the island/district (tones/year)
Recommended Measurement Process and Data Sources	1. Data for waste in the island can be derived from ISO 37120 indicator "collected municipal solid waste per capita" multiplied by the population of the island/district. 2. Data on the total amount of waste in the island/district that is used to generate energy should be sourced from local utilities, or relevant island departments that oversee waste treatment and related energy generation.
Recommended Monitoring Interval	yearly

Unit of Measurement			**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	
	Consumers (end-users)/Prosumers			District Level	x
	Technology and Services Providers	x		Island Level	x
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	
	Impact			End of project	x
				Post-project	x

TT-reference	TT#1				TT#2		x		TT#3	
UC-reference	UC 1.1		UC 2.1		UC 3.1		UC 4.1		UC 5.1	
	UC 1.2		UC 2.2		UC 3.2		UC 4.2		UC 5.2	
	UC 6		UC 7	x	UC 8	x	UC 9.1			

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							UC 9.2		
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa

4.1.7 Storage capacity in the energy grid per total energy consumption

<table>
<tr><th colspan="6">Storage capacity in the energy grid per total energy consumption</th></tr>
<tr><td>KPI Description</td><td colspan="5">Smart grids accommodate energy storage (typically electrical and thermal storage, but also “clean” fuels such as hydrogen and V2G storage) to reduce demand peaks and transfer energy usage to periods of intermittent renewable energy production. This KPI compares the storage capacity with the total energy consumption of the island/district. It should take into consideration all the sectors of the storage systems
i) electricity storage such as batteries, fuel cells or electrical vehicles
ii) thermal storage such as PCM
iii) fuel storage, such as hydrogen or CH4</td></tr>
<tr><td>KPI Owner</td><td colspan="5">Terceira: EDA, Ameland: Repowered</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$ES = \frac{E_{el,stored} + E_{th,stored} + E_{fuel,stored}}{E_{total}}$$
• ES =energy storage per island/district energy consumption
• $E_{el,stored}$ = the annual amount of electricity storage in gigajoules (GWh)
• $E_{th,stored}$ = the annual amount of thermal energy storage in gigajoules (GWh)
• $E_{fuel,stored}$=the annual amount of energy stored in “clean” fuels (GWh)
• E_{total} = island/district total energy consumption (GWh)</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="5">1. Data for storage capacity should be sourced from relevant departments or ministries.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="5">yearly</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">GWh/GWh</td><td>Threshold Target Value</td><td colspan="2"></td></tr>
<tr><td rowspan="5">Relevant Stakeholders</td><td>Energy Utilities/DSOs/TSOs</td><td>x</td><td rowspan="5">Spatial Scale of Evaluation</td><td>Building Level</td><td></td></tr>
<tr><td>Consumers (end-users)/Prosumers</td><td></td><td>District Level</td><td>x</td></tr>
<tr><td>Technology and Services Providers</td><td>x</td><td>Island Level</td><td>x</td></tr>
<tr><td>Policy-making Bodies and Governance</td><td></td><td></td><td></td></tr>
<tr><td>Representative Citizen Groups/Citizens</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Type of Indicator</td><td>Output</td><td>x</td><td rowspan="2"></td><td>In-project timeframe</td><td>x</td></tr>
<tr><td>Impact</td><td></td><td>End of project</td><td>x</td></tr>
</table>

				Temporal Scale of Evaluation		Post-project					x
TT-reference	TT#1	x		TT#2				TT#3			
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1		UC 5.1	x	
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2		UC 5.2	x	
	UC 6		UC 7		UC 8		UC 9.1				
							UC 9.2				
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa		

4.1.8 Reduced energy curtailment of RES and DER

<table>
<tr><th colspan="11">Reduced energy curtailment of RES and DER</th></tr>
<tr><td>KPI Description</td><td colspan="10">This KPI calculates the reduction of energy curtailment due to technical/operational problems.</td></tr>
<tr><td>KPI Owner</td><td colspan="10">Terceira: EDA, Ameland: Neroa</td></tr>
<tr><td>KPI Formula</td><td colspan="10">Reduction of
$$EnI = \frac{EnI_{base} - EnI_{IANOS}}{EnI_{base}}$$
• EnI = Energy not Injected (%)
• EnI_{base}= Energy that was curtailed before IANOS interventions (GWh/y)
• En_{IANOS} = Energy that is curtailed after IANOS interventions (GWh/y)</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="10">1. Data collection from TSO/DSOs. The reference values ideally should be measured before the IANOS implementations or at least accessed through historical data.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="10">Annually</td></tr>
<tr><td>Unit of Measurement</td><td colspan="3">%</td><td colspan="2">Threshold Target Value</td><td colspan="5">Reduce by 10%</td></tr>
<tr><td rowspan="5">Relevant Stakeholders</td><td colspan="2">Energy Utilities/DSOs/TSOs</td><td>x</td><td rowspan="5" colspan="2">Spatial Scale of Evaluation</td><td colspan="4">Building Level</td><td></td></tr>
<tr><td colspan="2">Consumers (end-users)/Prosumers</td><td></td><td colspan="4">District Level</td><td></td></tr>
<tr><td colspan="2">Technology and Services Providers</td><td></td><td colspan="4">Island Level</td><td>x</td></tr>
<tr><td colspan="2">Policy-making Bodies and Governance</td><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="2">Representative Citizen Groups/Citizens</td><td></td><td colspan="4"></td><td></td></tr>
<tr><td rowspan="3">Type of Indicator</td><td colspan="2">Output</td><td>x</td><td rowspan="3" colspan="2">Temporal Scale of Evaluation</td><td colspan="4">In-project timeframe</td><td></td></tr>
<tr><td colspan="2">Impact</td><td></td><td colspan="4">End of project</td><td>x</td></tr>
<tr><td colspan="2"></td><td></td><td colspan="4">Post-project</td><td>x</td></tr>
<tr><td colspan="11"></td></tr>
<tr><td>TT-reference</td><td>TT#1</td><td colspan="2">x</td><td colspan="2">TT#2</td><td colspan="2">x</td><td colspan="2">TT#3</td><td></td></tr>
<tr><td rowspan="4">UC-reference</td><td>UC 1.1</td><td>x</td><td>UC 2.1</td><td>x</td><td>UC 3.1</td><td>x</td><td>UC 4.1</td><td>x</td><td>UC 5.1</td><td>x</td></tr>
<tr><td>UC 1.2</td><td>x</td><td>UC 2.2</td><td>x</td><td>UC 3.2</td><td>x</td><td>UC 4.2</td><td>x</td><td>UC 5.2</td><td>x</td></tr>
<tr><td>UC 6</td><td>x</td><td>UC 7</td><td></td><td>UC 8</td><td></td><td>UC 9.1</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>UC 9.2</td><td></td><td></td><td></td></tr>
</table>

Replication in fellow islands	Nisyros		Bora-Bora		Lampedusa	

4.1.9 Peak Load Reduction

Peak Load Reduction	
KPI Description	This KPI calculates the peak load reduction after the IANOS implementation (DSM programs and storage system management) compared to the baseline scenario (before the implementation) For example, the peak load can be the maximum power consumption of a building or a group of buildings to provide certain comfort levels. With the correct application of ICT systems, the peak load can be reduced and therefore reduce the dimensioning of the supply system.
KPI Owner	Terceira: EDA, Ameland: Repowered
KPI Formula	$$PL_{REDUCTION}(\%) = \left(1 - \frac{P_{peak,IANOS}}{P_{base}}\right)$$ $P_{peak,IANOS}$: Peak load during/after the implementation P_{base}: Peak load before the implementation (baseline)
Recommended Measurement Process and Data Sources	1. Data collection from TSO. The reference values ideally should be measured before the IANOS implementations or at least accessed through historical data. The peak load can be measured as the maximum power consumption of a group of buildings.
Recommended Monitoring Interval	Hourly

Unit of Measurement	%		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers	x		Island Level	
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	
	Impact			End of project	x
				Post-project	x

TT-reference	TT#1	x		TT#2				TT#3		
UC-reference	UC 1.1	x	UC 2.1		UC 3.1	x	UC 4.1	x	UC 5.1	
	UC 1.2	x	UC 2.2		UC 3.2	x	UC 4.2	x	UC 5.2	
	UC 6		UC 7		UC 8		UC 9.1			
							UC 9.2			

Replication in fellow islands	Nisyros		Bora-Bora		Lampedusa	x

4.1.10 Accuracy of energy supply and demand prediction

<table>
<tr><th colspan="7">Accuracy of energy supply and demand prediction</th></tr>
<tr><td>KPI Description</td><td colspan="6">This KPI measures the gap between predicted and actual energy demand/supply at a given time. It might refer not only to electrical energy but also to thermal energy depending on the solutions demonstrated in each island. This KPI should also be monitored separately for vRES related solutions.</td></tr>
<tr><td>KPI Owner</td><td colspan="6">Terceira: CERTH, Ameland: CERTH</td></tr>
<tr><td>KPI Formula</td><td colspan="6"><u>Supply side</u>
$$A_s = \frac{E_{el,pred,s} + E_{th,pred,s}}{E_{el,act,s} + E_{th,act,s}}$$
• A_s = accuracy of energy supply prediction (kWh/kWh; MWh/MWh)
• $E_{el,pred,s}$ = predicted generated electrical energy (kWh;MWh)
• $E_{th,pred,s}$ = predicted generated thermal energy (kWh;MWh)
• $E_{el,act,s}$ = actual generated electrical energy (kWh;MWh)
• $E_{th,act,s}$ = actual generated thermal energy (kWh;MWh)

<u>Demand side</u>
$$A_d = \frac{E_{el,pred,d} + E_{th,pred,d}}{E_{el,act,d} + E_{th,act,d}}$$
• A_d = accuracy of energy demand prediction (kWh/kWh; MWh/MWh)
• $E_{el,pred,d}$ = predicted consumed electrical energy (kWh;MWh)
• $E_{th,pred,d}$ = predicted consumed thermal energy (kWh;MWh)
• $E_{el,act,d}$ = actual consumed electrical energy (kWh;MWh)
• $E_{th,act,d}$ = actual consumed thermal energy (kWh;MWh)

<u>vRES Supply</u>
$$A_{s,RES} = \frac{E_{el,pred,s,RES} + E_{th,pred,s,RES}}{E_{el,act,s,RES} + E_{th,act,s,RES}}$$
• $A_{s,RES}$ = accuracy of vRES energy supply prediction (kWh/kWh; MWh/MWh)
• $E_{el,pred,s,RES}$ = predicted generated electrical energy from vRES (kWh;MWh)
• $E_{th,pred,s,RES}$ = predicted generated thermal energy from vRES (kWh;MWh)
• $E_{el,act,s,RES}$ = actual generated electrical energy from vRES (kWh;MWh)
• $E_{th,act,s,RES}$ = actual generated thermal energy from vRES (kWh;MWh)</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="6">Data can be obtained by the energy utilities that are involved in the installation of RES and the monitoring of their operation.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="6">Weekly; monthly; yearly</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">kWh/kWh; MWh/MWh</td><td>Threshold Target Value</td><td colspan="3"></td></tr>
<tr><td>Relevant Stakeholders</td><td>Energy Utilities/DSOs/TSOs</td><td>x</td><td></td><td>Building Level</td><td>x</td><td></td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 957810

	Consumers (end-users)/Prosumers		**Spatial Scale of Evaluation**	District Level	x
	Technology and Services Providers			Island Level	x
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	x

TT-reference	TT#1	x		TT#2				TT#3		
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1		UC 4.1	x	UC 5.1	x
	UC 1.2	x	UC 2.2	x	UC 3.2		UC 4.2	x	UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1			
							UC 9.2			
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa	x

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4.1.11 Unbalance of the 3-phase voltage system

<table>
<tr><th colspan="6">Unbalance of the 3-phase voltage system</th></tr>
<tr><td>KPI Description</td><td colspan="5">This KPI examines the quality of the power supplied by measuring the supply voltage gap between the three phases which should be 120 deg. Under normal operating conditions, during each one-week period, 95% of the 10-minute average (RMS) values of the inverse component of the supply voltage shall be within the range of 0% to 2% of the corresponding direct component.</td></tr>
<tr><td>KPI Owner</td><td colspan="5">Terceira: EDA, Ameland: Liander</td></tr>
<tr><td>KPI Formula</td><td colspan="5">

$$PVUR = \frac{V_{mon} - V_{avg}}{V_{avg}}$$

- PVUR = phase voltage unbalance rate (%).
- V_{mon} = monitored voltage of each phase (RMS value, average from 10 or more-minutes in a week period) (kV)
- V_{avg} = Average voltage of the three phases (they can be assumed ideal values or t) ($V_{avg} = \frac{V_1+V_2+V_3}{3}$) (kV).

Can be measured also using the current (I) instead of the voltage:

$$PCUR = \frac{I_{mon} - I_{avg}}{I_{avg}}$$

- PCUR = phase current unbalance rate (%).
- I_{mon} = monitored current of each phase (RMS value, average from 10 or more-minutes in a week period) (kV)
- I_{avg} = Average current of the three phases (they can be assumed ideal values or t) ($V_{avg} = \frac{I_1+I_2+I_3}{3}$) (kV).

</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="5">1. Data collection from sensors on some MV transformers or by the TSO</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="5">10-minute average values (weekly basis) or the most frequent possible</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">%</td><td>Threshold Target Value</td><td colspan="2"></td></tr>
<tr><td rowspan="5">Relevant Stakeholders</td><td>Energy Utilities/DSOs/TSOs</td><td>x</td><td rowspan="5">Spatial Scale of Evaluation</td><td>Building Level</td><td></td></tr>
<tr><td>Consumers (end-users)/Prosumers</td><td>x</td><td>District Level</td><td>x</td></tr>
<tr><td>Technology and Services Providers</td><td></td><td>Island Level</td><td>x</td></tr>
<tr><td>Policy-making Bodies and Governance</td><td></td><td></td><td></td></tr>
<tr><td>Representative Citizen Groups/Citizens</td><td></td><td></td><td></td></tr>
</table>

Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	
	Impact	x		End of project	x
				Post-project	x

TT-reference	TT#1	x		TT#2			TT#3			
UC-reference	UC 1.1		UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x
	UC 1.2		UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x
	UC 6		UC 7		UC 8		UC 9.1			
							UC 9.2			
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa	

4.1.12 Peak photovoltaic power installed per 100 inhabitants

Peak photovoltaic power installed per 100 inhabitants	
KPI Description	This KPI measures the installed capacity of photovoltaic interpolated to 100 inhabitants. To be assessed per sector (residential, tertiary, industrial and public).
KPI Owner	Terceira: RGA/ Municipality of Angra do Heroísmo – external stakeholder to be engaged –, Ameland: AEC
KPI Formula	$$PVInt = \frac{PV_{installed} * 100}{N_{inh}}$$ $PVInt$ = Interpolated value of kWp of photovoltaic installed per 100 inhabitants $PV_{installed}$ = kWp of photovoltaic installed in area/sector N_{inh} = Number of inhabitants in area/sector
Recommended Measurement Process and Data Sources	Data collection (e.g., provided by municipalities along with energy utilities and providers)
Recommended Monitoring Interval	Once in the end of the project

Unit of Measurement	kWp/100 inhabitants	**Threshold Target Value**	

Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers	x		Island Level	x
	Policy-making Bodies and Governance	x			
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	
	Impact			End of project	x
				Post-project	

TT-reference	TT#1	x	TT#2		TT#3	x

UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1		UC 4.1		UC 5.1	
	UC 1.2	x	UC 2.2	x	UC 3.2		UC 4.2		UC 5.2	
	UC 6	x	UC 7		UC 8		UC 9.1	x		
							UC 9.2	x		

Replication in fellow islands	Nisyros	x	Bora-Bora	x	Lampedusa	

4.2 KPIs in Environmental Domain

4.2.1 Reduced Greenhouse Gas Emissions

<table>
<tr><th colspan="7">Reduced Greenhouse Gas Emissions</th></tr>
<tr><td>KPI Description</td><td colspan="6">The greenhouse gas emissions of a system correspond to the emissions that are caused by different areas of application. In different variants of this indicator the emissions caused by the production of the system components are included or excluded. To enable the comparability between systems, the emissions can be related to the size of the system (e.g. gross floor area or net floor area, heated floor area) and the considered interval of time (e.g. month, year). The greenhouse gases are considered as unit of mass (tones, kg.) of CO2 or CO2 equivalents.</td></tr>
<tr><td>KPI Owner</td><td colspan="6">Terceira: EDA/RGA, Ameland: municipality of Ameland</td></tr>
<tr><td>KPI Formula</td><td colspan="6">$$GGE = TE_C \times GEF_T + EE_C \times GEF_E$$
GGE = Greenhouse gas emissions,
TE_C = Thermal energy consumption (monitored) of the demonstration site [kWh/(month); kWh/ (year)]
EE_C = Electrical energy consumption (monitored) of the demonstration site [kWh/(month); kWh/ (year)]
GEF_T = Greenhouse gas emission factor for thermal energy (weighted average based on thermal energy production source/fuel mix) (kg CO2eq/kWh consumed)
GEF_E = Greenhouse gas emission factor for electrical energy (weighted average based on electricity production source/fuel mix) (kg CO2eq/kWh consumed)
Different spatial scales of evaluation (Building, District, Island level) can be assessed by adding up the energy carriers per respective level. To enable the comparability between systems, the emissions can be related to the size of the system (e.g. gross floor area or net floor area, heated floor area) and the considered interval of time (e.g. month, year). A breakdown of buildings and transportation emissions is also highly suggested.
Results should also be compared to a baseline to extract the respective reduction (%) of energy consumption related GHG emissions emitted.</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="6">1. Data collection→2. KPI calculation. The reference values ideally should be measured before the IANOS implementations or at least accessed through historical data.
Relevant data can be extracted from LHs SEAP/SECAP. The updated default emission factors for fossil fuel combustion, RES, electricity by country as described in ANNEX I of the Covenant of Mayors for Climate and Energy Reporting Guidelines can be applied:
https://www.covenantofmayors.eu/IMG/pdf/Covenant_ReportingGuidelines.pdf</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="6">Yearly</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">tCO2eq/year</td><td>Threshold Target Value</td><td colspan="3">Terceira: 41,325 tCO2eq/year
Ameland: 58,152 tCO2eq/year</td></tr>
<tr><td rowspan="3">Relevant Stakeholders</td><td>Energy Utilities/DSOs/TSOs</td><td>x</td><td rowspan="3">Spatial Scale of Evaluation</td><td>Building Level</td><td>x</td></tr>
<tr><td>Consumers (end-users)/Prosumers</td><td>x</td><td>District Level</td><td>x</td></tr>
<tr><td>Technology and Services Providers</td><td>x</td><td>Island Level</td><td>x</td></tr>
</table>

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	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact	x		End of project	x
				Post-project	x

TT-reference	TT#1	x		TT#2	x		TT#3			
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1			
							UC 9.2			

Replication in fellow islands	Nisyros		Bora-Bora	x	Lampedusa	x

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4.2.2 Reduced fossil fuel consumption

Reduced fossil fuel consumption	
KPI Description	This KPI measures the amount of fossil fuels which is not consumed because of IANOS demonstrated solutions (e.g., electrification of transport, RES penetration).
KPI Owner	Terceira: EDA/RGA, Ameland: municipality of Ameland
KPI Formula	$$RFFC\ (\%) = \frac{FFC_{base} - FFC_{IANOS}}{FFC_{base}}$$ FFC_{base} = the primary energy corresponding to fossils fuels before the implementation of IANOS solutions (MWh, MJ). FFC_{IANOS} = the primary energy corresponding to fossil fuels after the implementation of IANOS solutions (GWh, GJ).
Recommended Measurement Process and Data Sources	1. Fossils fuels consumed per 100km in conventional fuel-based vehicles (average). The reference values ideally should be measured before the IANOS implementations or accessed through historical data. 2. Fossil fuels needed for the thermal and electric energy produced 3. Calculation of the KPI
Recommended Monitoring Interval	Yearly average

Unit of Measurement	%	**Threshold Target Value**	For Terceira: 36.5% of the energy mix (57GWh/y) For Ameland: 14.7% of the energy mix (80.9GWh/y)

Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers	x		Island Level	x
	Policy-making Bodies and Governance	x			
	Representative Citizen Groups/Citizens				
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact	x		End of project	x
				Post-project	

TT-reference	TT#1	x	TT#2	x	TT#3					
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1			
							UC 9.2			

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Replication in fellow islands	Nisyros	x	Bora-Bora	x	Lampedusa	x

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4.2.3 Electrical and thermal energy produced from solid waste or other liquid waste treatment per capita per year

Electrical and thermal energy produced from solid waste or other liquid waste treatment per capita per year					
KPI Description	This KPI computes the amount of electrical and thermal energy that is produced by the waste exploitation. Solid waste presents an opportunity to recover energy, using new and possibly cleaner technologies. Other liquid waste such as fats, oils and grease are also a source of energy. It might also be reported separately for the thermal and electrical energy.				
KPI Owner	municipality of Ameland				
KPI Formula	$$E_w = \frac{EW_{th} + EW_{el}}{CUS}$$ E_w = total energy produced by waste per capita (GWh/capita) EW_{th} = total thermal energy produced by waste (GWh) EW_{el} = total electrical energy produced by waste (GWh) CUS = number of end-users (total population)				
Recommended Measurement Process and Data Sources	1. Data on the amount of electrical and thermal energy produced from solid waste and other liquid waste treatment should be sourced from island departments or ministries that oversee such matters, as well as from regulators and local utility providers. 2. KPI calculation.				
Recommended Monitoring Interval	Yearly				
Unit of Measurement	GWh/capita		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers	x		Island Level	x
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	

TT-reference	TT#1			TT#2		x		TT#3		
UC-reference	UC 1.1		UC 2.1		UC 3.1		UC 4.1		UC 5.1	

	UC 1.2		UC 2.2		UC 3.2		UC 4.2		UC 5.2	
	UC 6		UC 7	x	UC 8		UC 9.1			
							UC 9.2			
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa	

4.2.4

4.2.5 Air quality index (Air pollution)

<table>
<tr><th colspan="4">Air quality index (Air pollution)</th></tr>
<tr><td>KPI Description</td><td colspan="3">Air quality is expressed in the concentration of major air pollutants. At this moment from a human health perspective most important are particulates (PM10, PM2,5), NO2 (as indicator of traffic related air pollution), ozone and SO2. The concentration levels of these pollutants together define the air quality. For the EU, the CiteAir project has defined hourly, daily and yearly indices to express in one figure air quality. (http://www.airqualitynow.eu/index.php) For this indicator we use the year average air quality index. It is a distance to target indicator that provides a relative measure of the annual average air quality in relation to the European limit values (annual air quality standards and objectives from EU directives). If the index is higher than 1: for one or more pollutants the limit values are not met. If the index is below 1: on average the limit values are met</td></tr>
<tr><td>KPI Owner</td><td colspan="3">Terceira: RGA, Ameland: municipality of Ameland</td></tr>
<tr><td>KPI Formula</td><td colspan="3">For each pollutant a sub-index is calculated according to the scheme below:
<table>
<tr><td>Pollutant</td><td>Target value / limit value</td><td>Subindex calculation</td></tr>
<tr><td>NO2</td><td>Year average is 40 µg/m3</td><td>Year average / 40</td></tr>
<tr><td>PM10</td><td>Year average is 40 µg/m3</td><td>Year average / 40</td></tr>
<tr><td>PM10daily</td><td>Max. number of daily averages above 50 µg/m3 is 35 days</td><td>Log(number of days+1) / Log(36)</td></tr>
<tr><td>Ozone</td><td>25 days with an 8-hour average value ≥ 120 µg/m3</td><td># days with 8-hour average ≥ 120 / 25</td></tr>
<tr><td>SO2</td><td>Year average is 20 µg/m3</td><td>Year average / 20</td></tr>
<tr><td>Benzene</td><td>Year average is 5 µg/m3</td><td>Year average / 5</td></tr>
</table>
The overall index is the average of the sub-indices for NO2, PM10 (both year average and the number of days ≥50 µg/m3 sub-index) and ozone for the island background index. For the traffic year average index, the averages of the sub-indices for NO2 and PM10 (both) are being used. The other pollutants (including PM2.5) are used in the presentation of the city index if data are available, but do not enter the calculation of the city average index. They are treated as additional pollutants like in the hourly and daily indices. The main reason is that not every city is monitoring this full range of pollutants.</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="3">Concentrations are measured by monitoring equipment and reported to air quality monitoring authority (i.e., City Environment Office, National Environment Office, etc.). Many cities/islands use a local or national variant of an air quality index, which can replace this indicator (but loosing EU comparability). Most pollutants are measured continuously in EU member states.
See: http://www.airqualitynow.eu/comparing_home.php
https://aqicn.org/map/europe/
For the case of Terceira the data will be gathered from the following source: http://qualidadedoar.azores.gov.pt/indice</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="3">Annually</td></tr>
<tr><td>Unit of Measurement</td><td>Index (no unit)</td><td>Threshold Target Value</td><td></td></tr>
</table>

Relevant Stakeholders	Energy Utilities/DSOs/TSOs		**Spatial Scale of Evaluation**	Building Level	
	Consumers (end-users)/Prosumers			District Level	x
	Technology and Services Providers			Island Level	x
	Policy-making Bodies and Governance	x			
	Representative Citizen Groups/Citizens				
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact	x		End of project	x
				Post-project	x

TT-reference	TT#1		TT#2	x	TT#3					
UC-reference	UC 1.1	x	UC 2.1		UC 3.1		UC 4.1		UC 5.1	x
	UC 1.2	x	UC 2.2		UC 3.2		UC 4.2		UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1			
							UC 9.2			

Replication in fellow islands	Nisyros	x	Bora-Bora	x	Lampedusa	x

4.2.6 Reduction in the amount of unsorted waste collected

Reduction in the amount of unsorted waste collected	
KPI Description	This KPI calculates the percentage reduction in the amount of unsorted waste collected due to the project. Higher levels of municipal waste contribute to greater environmental problems. Collection of municipal waste is also an indicator of city management with regard to cleanliness, health and quality of life. A proper system can foster recycling practices that maximize the life cycle of landfills and create recycling micro-economies; and it provides alternative sources of energy that help reduce the consumption of electricity and/or petroleum-based fuels. This KPI refers separately to both solid and liquid waste. Municipal waste should include waste originating from households, commerce and trade, small businesses, office buildings and institutions (e.g., schools, hospitals, government buildings). The definition should also include bulky waste (e.g., white goods, old furniture, mattresses), garden waste, leaves, grass clippings, street sweepings, the content of litter containers, and market cleansing waste, if managed as waste, waste from selected municipal services, i.e. waste from park and garden maintenance, waste from street cleaning services (e.g. street sweepings, the content of litter containers, market cleansing waste), if managed as waste. Finally, it includes wastewater from municipal sewage network and treatment (sewage sludge).
KPI Owner	Ameland: municipality of Ameland
KPI Formula	The reduction can be accounted for when looking at the levels before and after the project. And the reduction is calculated by: **Solid waste** $$PSSW = \frac{SW_{base}/t_{mon1} - SW_{IANOS}/t_{mon2}}{SW_{base}/t_{mon1}}$$ $PSSW$ = percentage reduction of collected unsorted solid waste (%) SW_{IANOS} (tones)= unsorted solid waste collected after the project during the time period t_{mon2} (days) SW_{base} (tones)= unsorted solid waste collected before the project during the period t_{mon1} (days) **Liquid waste** $$PSLW = \frac{LW_{base}/t_{mon1} - LW_{IANOS}/t_{mon2}}{LW_{base}/t_{mon1}}$$ $PSLW$ = percentage reduction of collected liquid waste (%) LW_{IANOS} (tones)= liquid waste collected after the project during the period t_{mon2} (days) LW_{base} (tones)= liquid waste collected before the project during the period t_{mon1} (days)
Recommended Measurement Process and Data Sources	1. Data collection from waste management companies. 2. Data collection from the municipality. 3. Data from potentially installed smart containers. The reference values ideally should be measured before the IANOS implementations or at least accessed through historical data.

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Recommended Monitoring Interval	Once in the beginning of the project and once after the end of the project.										
Unit of Measurement	%			**Threshold Target Value**							
Relevant Stakeholders	Energy Utilities/DSOs/TSOs			**Spatial Scale of Evaluation**	Building Level						
	Consumers (end-users)/Prosumers		x		District Level						x
	Technology and Services Providers				Island Level						x
	Policy-making Bodies and Governance		x								
	Representative Citizen Groups/Citizens										
Type of Indicator	Output		x	**Temporal Scale of Evaluation**	In-project timeframe						
	Impact				End of project						x
					Post-project						
TT-reference	TT#1			TT#2		x		TT#3			
UC-reference	UC 1.1		UC 2.1		UC 3.1		UC 4.1		UC 5.1		
	UC 1.2		UC 2.2		UC 3.2		UC 4.2		UC 5.2		
	UC 6		UC 7	x	UC 8		UC 9.1				
							UC 9.2				
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa		x

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4.2.7 Primary Energy Demand and Consumption

Primary Energy Demand and Consumption	
KPI Description	The primary energy demand/consumption of a system encompasses all the energy that is consumed in the supply chain of the used energy carriers. It includes consumption of the energy sector itself, losses during transformation (for example, from oil or gas into electricity) and distribution of energy, and the final consumption by end users. To enable the comparability between systems, the total primary energy demand/consumption can be related to the size of the system (e.g., conditioned area) and the considered time interval (e.g., month, year). Demand is defined here as "designed consumption" (simulation). Consumption is actual/monitored energy consumption.
KPI Owner	Terceira: RGA, Ameland: municipality of Ameland
KPI Formula	Building Level: $$PE_d = \frac{TE_d \times PEF_T + EE_d \times PEF_E}{A_b}$$ PE_d = Primary energy demand (simulated) TE_d = Thermal energy demand (simulated) [kWh/(month); kWh/(year)] EE_d = Electrical energy demand (simulated) [kWh/(month); kWh/(year)] PEF_T = Primary energy factor for thermal energy (weighted average based on source/fuel mix in production) PEF_E = Primary energy factor for electrical energy (weighted average based on source/fuel mix in production) Ab = Floor area of the building [m2] $$PE_c = \frac{TE_c \times PEF_T + EE_c \times PEF_E}{A_b}$$ PE_c = Primary energy consumption (monitored) TE_c = Thermal energy consumption (monitored) [kWh/(month); kWh/(year)] EE_c = Electrical energy consumption (monitored) [kWh/(month); kWh/(year)] PEF_T = Primary energy factor for thermal energy (weighted average based on source/fuel mix in production) PEF_E = Primary energy factor for electrical energy (weighted average based on source/fuel mix in production) Ab = Floor area of the building [m2] District/Island Level: $$PE_{district-island/\ primary\ demand} = \sum PE_d$$ $$PE_{district-island/\ primary\ consumption} = \sum PE_c$$
Recommended Measurement Process and Data Sources	1. Simulation→2. Data collection→3. KPI calculation. The calculation of the respective primary energy demand/consumption can be estimated with the application of default primary energy factors. According to Annex IV of the Directive 2012/27/EU a default coefficient of 2.5 can be applied for savings in kWh of electricity, whereas the respective value for fossil fuels can be taken as 1.1. The Customs Department of Terceira will be involved in the measurement process.
Recommended Monitoring Interval	Monthly, Yearly

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Unit of Measurement	kWh/(m²*month; year)		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers	x		Island Level	x
	Policy-making Bodies and Governance	x			
	Representative Citizen Groups/Citizens				
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact	x		End of project	x
				Post-project	x

TT-reference	TT#1	x			TT#2		x		TT#3	
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1		UC 4.1	x	UC 5.1	
	UC 1.2	x	UC 2.2	x	UC 3.2		UC 4.2	x	UC 5.2	
	UC 6	x	UC 7		UC 8	X	UC 9.1			
							UC 9.2			

Replication in fellow islands	Nisyros		Bora-Bora		Lampedusa	x

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4.3 KPIs in Economic Domain

4.3.1 Total investments

<table>
<tr><th colspan="6">Total Investments</th></tr>
<tr><td>KPI Description</td><td colspan="5">An investment is defined as an asset or item that is purchased or implemented with the aim to generate payments or savings over time. The investment in a newly constructed system is defined as cumulated payments until the initial operation of the system. The investment in the refurbishment of an existing system is defined as cumulated payments until the initial operation of the system after the refurbishment. (grants are not subtracted). As investments are considered only the energy-oriented (exclude investments non energy related - e.g., refurbishment of bathrooms).</td></tr>
<tr><td>KPI Owner</td><td colspan="5">Terceira: EDA/RGA/ Municipality of Angra do Heroísmo – external stakeholder to be engaged –, (plus various stakeholders depending of the final ownership/promoter of each investment), Ameland: municipality of Ameland</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$AI_{ER} = \frac{I_{ER}}{P_{ins}}$$
AI_{ER} = Average investment of the interventions related to energy retrofitting (in the district) per unit of installed power [€/kW]
I_{ER} = Total investment for all interventions related to energy retrofitting [€]
P_{ins} = Total installed power [kW]</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="5">This information can be obtained from municipal bodies, public services, owners of the demo buildings, energy utilities and major technology providers related to energy aspects/retrofitting. Data may be obtained from specific studies carried out for other projects.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="5">Annually</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">(€/kW, € in total)</td><td>Threshold Target Value</td><td colspan="2"></td></tr>
<tr><td rowspan="5">Relevant Stakeholders</td><td>Energy Utilities/DSOs/TSOs</td><td>x</td><td rowspan="5">Spatial Scale of Evaluation</td><td>Building Level</td><td></td></tr>
<tr><td>Consumers (end-users)/Prosumers</td><td>x</td><td>District Level</td><td>x</td></tr>
<tr><td>Technology and Services Providers</td><td>x</td><td>Island Level</td><td>x</td></tr>
<tr><td>Policy-making Bodies and Governance</td><td></td><td></td><td></td></tr>
<tr><td>Representative Citizen Groups/Citizens</td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Type of Indicator</td><td>Output</td><td></td><td rowspan="3">Temporal Scale of Evaluation</td><td>In-project timeframe</td><td>x</td></tr>
<tr><td>Impact</td><td></td><td>End of project</td><td></td></tr>
<tr><td></td><td></td><td>Post-project</td><td></td></tr>
<tr><td colspan="6"></td></tr>
</table>

TT-reference	TT#1	x	TT#2	x	TT#3	x

UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x	
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x	
	UC 6	x	UC 7	x	UC 8	x	UC 9.1	x			
							UC 9.2	x			
Replication in fellow islands	Nisyros			x	Bora-Bora				Lampedusa		x

4.3.2 Return on Investment (ROI)

Return on Investment (ROI)												
KPI Description	The return on investment (ROI) is an economic variable that enables the evaluation of the feasibility of an investment or the comparison between different possible investments. This parameter is defined as the ratio between the total incomes/net profit and the total investment of the project, usually expressed in %.											
KPI Owner	Terceira: EDA/RGA/ Municipality of Angra do Heroísmo – external stakeholder to be engaged –, (plus various stakeholders depending on the final ownership/promoter of each investment), Ameland: municipality of Ameland											
KPI Formula	$ROI_T = \frac{\sum_{t=1}^{T}(In_t - TAC_{after_t}) - (I_{BR} + I_{ER})}{I_{BR} + I_{ER}}$ ROI_T = Return on Investment [%] In_t = Income in year t T = Duration of the economic analysis period: T=10, 15 and 20 Years, depending on the common practice area											
Recommended Measurement Process and Data Sources	1. Data collection→2. Simulation (if needed) →3. KPI calculation. This information can be obtained from municipal bodies, public services, owners of the demo buildings, energy utilities and major technology providers participating in the project. Data may be obtained from specific studies carried out for other projects.											
Recommended Monitoring Interval	Once (during project implementation)											
Unit of Measurement	%			**Threshold Target Value**	TBD							
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x		**Spatial Scale of Evaluation**	Building Level				x			
	Consumers (end-users)/Prosumers	x			District Level				x			
	Technology and Services Providers	x			Island Level				x			
	Policy-making Bodies and Governance											
	Representative Citizen Groups/Citizens											
Type of Indicator	Output	x		**Temporal Scale of Evaluation**	In-project timeframe				x			
	Impact				End of project							
					Post-project							
TT-reference	TT#1	x		TT#2		x		TT#3		x		
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x		
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x		
	UC 6	x	UC 7	x	UC 8	x	UC 9.1	x				

							UC 9.2	x		
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa	x

4.3.3 Total Annual Costs

Total Annual Costs					
KPI Description	The total annual costs are defined as the sum of capital-related annual costs (e.g., interests), requirement-related costs (e.g., power costs), operation related costs (e.g., costs of using the installation, i.e., maintenance) and other costs (e.g. insurance). These costs (can) vary for each year. - Capital related costs encompass depreciation, interests and repairs caused by the investment; - Requirement-related costs include power costs, auxiliary power costs, fuel costs, and costs for operating resources and in some cases external costs; - Operation-related costs include among other things the costs of using the installation and costs of servicing and inspection; - Other costs include costs of insurance, general output, uncollected taxes etc. The total annual costs are related to the considered interval of time (year). To make different objects comparable the same types of costs have to be included in the calculation.				
KPI Owner	Terceira: EDA/RGA/ Municipality of Angra do Heroísmo – external stakeholder to be engaged –, (plus various stakeholders depending of the final ownership/promoter of each investment), Ameland: municipality of Ameland				
KPI Formula	$$TAC_i = C_E + C_{O\&M} + C_F$$ TAC_i = Total annual cost of the system after the intervention (i.e., energy, operation & maintenance, financial) for year i [€/year] CE = Total annual cost of the system supply [€/year] $CO\&M$ = Total annual cost of the operation and maintenance of the facility [€/year] CF = Total annual financing cost, if applies [€/year]				
Recommended Measurement Process and Data Sources	1. Data collection→2. Simulation (if needed) →3. KPI calculation. This information can be obtained from municipal bodies, public services, owners of the demo buildings, energy utilities and major technology providers participating in the project. Data may be obtained from specific studies carried out for other projects.				
Recommended Monitoring Interval	Yearly				
Unit of Measurement	€/year		**Threshold Target Value**	TBD	
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers	x		Island Level	x
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x		In-project timeframe	x
	Impact			End of project	x

					Temporal Scale of Evaluation		Post-project				x
TT-reference	TT#1		x		TT#2		x		TT#3		x
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x	
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x	
	UC 6	x	UC 7	x	UC 8	x	UC 9.1	x			
							UC 9.2	x			
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa		x

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4.3.4 Payback Period

Payback Period	
KPI Description	The payback period is the time it takes to cover investment costs. It can be calculated from the number of years elapsed between the initial investment and the time at which cumulative savings offset the investment. Simple payback takes real (non-discounted) values for future moneys. Discounted payback uses present values. Payback in general ignores all costs and savings that occur after payback has been reached. Payback period is usually considered as an additional criterion to assess the investment, especially to assess the risks. Investments with a short payback period are considered safer than those with a longer payback period. As the invested capital flows back slower, the risk that the market changes and the invested capital can only be recovered later or not at all increases. On the other hand, costs and savings that occur after the investment has paid back are not considered. Therefore, sometimes decisions that are based on payback periods are not optimal and it is recommended to also consult other indicators.
KPI Owner	Terceira: EDA/RGA/ Municipality of Angra do Heroísmo – external stakeholder to be engaged –, (plus various stakeholders depending on the final ownership/promoter of each investment), Ameland: municipality of Ameland
KPI Formula	Economic payback, EPP, type A static: $$EPP = \frac{EPI_{BR}}{m}$$ m can be calculated as average total annual costs (TAC) in use savings (€/year) $$m = TAC_{base} - TAC_{IANOS}$$ Type B dynamic: $$EPP = \frac{ln\big(m \cdot (1+i)\big) - ln(EPI_{BR} - EPI_{BR} \cdot (1+i) + m)}{ln(1+i)} - 1$$ Type C dynamic with energy price increase rate: $$EPP = \frac{ln\big(m \cdot (1+i)\big) - ln(EPI_{BR}(1+p) - EPI_{BR} \cdot (1+i) + (1+p)m)}{ln(1+i) - ln(1+p)} - 1$$ $EPIBR$ (€) = Energy-related investment i (%) = Discount rate p (%) = Energy price increase rate i should be unequal to p
Recommended Measurement Process and Data Sources	1. Data collection→2. Simulation (if needed) →3. KPI calculation. This information can be obtained from municipal bodies, public services, owners of the demo buildings, energy utilities and major technology providers participating in the project. Data may be obtained from specific studies carried out for other projects.
Recommended Monitoring Interval	Once (during project implementation)

<table>
<tr><td>Unit of Measurement</td><td colspan="2">years</td><td>Threshold Target Value</td><td colspan="2"><9 years, many of the solutions have even <7</td></tr>
<tr><td rowspan="5">Relevant Stakeholders</td><td>Energy Utilities/DSOs/TSOs</td><td>x</td><td rowspan="5">Spatial Scale of Evaluation</td><td>Building Level</td><td>x</td></tr>
<tr><td>Consumers (end-users)/Prosumers</td><td>x</td><td>District Level</td><td>x</td></tr>
<tr><td>Technology and Services Providers</td><td>x</td><td>Island Level</td><td>x</td></tr>
<tr><td>Policy-making Bodies and Governance</td><td>x</td><td></td><td></td></tr>
<tr><td>Representative Citizen Groups/Citizens</td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Type of Indicator</td><td>Output</td><td>x</td><td rowspan="3">Temporal Scale of Evaluation</td><td>In-project timeframe</td><td>x</td></tr>
<tr><td>Impact</td><td></td><td>End of project</td><td></td></tr>
<tr><td></td><td></td><td>Post-project</td><td></td></tr>
</table>

<table>
<tr><td>TT-reference</td><td>TT#1</td><td colspan="2">x</td><td>TT#2</td><td colspan="2">x</td><td>TT#3</td><td colspan="2">x</td></tr>
<tr><td rowspan="4">UC-reference</td><td>UC 1.1</td><td>x</td><td>UC 2.1</td><td>x</td><td>UC 3.1</td><td>x</td><td>UC 4.1</td><td>x</td><td>UC 5.1</td><td>x</td></tr>
<tr><td>UC 1.2</td><td>x</td><td>UC 2.2</td><td>x</td><td>UC 3.2</td><td>x</td><td>UC 4.2</td><td>x</td><td>UC 5.2</td><td>x</td></tr>
<tr><td>UC 6</td><td>x</td><td>UC 7</td><td>x</td><td>UC 8</td><td>x</td><td>UC 9.1</td><td>x</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>UC 9.2</td><td>x</td><td></td><td></td></tr>
<tr><td>Replication in fellow islands</td><td colspan="2">Nisyros</td><td>x</td><td colspan="2">Bora-Bora</td><td></td><td>Lampedusa</td><td>x</td><td></td></tr>
</table>

4.3.5 Total Annual Revenues

Total Annual Revenues											
KPI Description	The total annual revenues are defined as sum of capital-related revenues, requirement-related revenues, operation-related revenues and other revenues. These revenues can vary for each year. Capital-related revenues encompass temporally distributed investment-related grants. Requirement-related revenues include sales revenues and grants for electricity, heat, cold and other. Operation-related revenues and other revenues are in this context of minor importance. The total annual revenues are related to the considered interval of time (year).										
KPI Owner	Terceira: EDA/RGA/ Municipality of Angra do Heroísmo – external stakeholder to be engaged –, (plus various stakeholders depending on the final ownership/promoter of each investment), Ameland: municipality of Ameland										
KPI Formula	$$TAR = \sum_i REV_i$$ TAR= total annual revenues [€] REV= revenue from the ith investment over a year [€]										
Recommended Measurement Process and Data Sources	Data can be obtained from the companies/energy utilities that are involved in IANOS solutions.										
Recommended Monitoring Interval	Annually										
Unit of Measurement	€/year			Threshold Target Value							
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x		Spatial Scale of Evaluation	Building Level						
	Consumers (end-users)/Prosumers	x			District Level	x					
	Technology and Services Providers	x			Island Level	x					
	Policy-making Bodies and Governance	x									
	Representative Citizen Groups/Citizens										
Type of Indicator	Output	x		Temporal Scale of Evaluation	In-project timeframe	x					
	Impact				End of project	x					
					Post-project						
TT-reference	TT#1	x		TT#2	x		TT#3	x			
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x	
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x	
	UC 6	x	UC 7	x	UC 8	x	UC 9.1	x			
							UC 9.2	x			

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Replication in fellow islands	Nisyros		Bora-Bora		Lampedusa	x

4.3.6 Financial benefit for the end user

Financial benefit for the end user						
KPI Description	This KPI evaluates the total cost savings in euros for end-users per household due to the project interventions. One dimension of value creation by the smart grid project is the extent to which the project generated cost savings for end-users. End-users are seen as those people who will be adopting the project and using the techniques or concepts applied in the project. Financial benefit can be an important trigger for the user acceptance and the market uptake of these solutions. Cost savings, can be generated, for example, through a reduction in energy/water use, the generation of renewable energy on site, or reduction in housing costs. To achieve costs savings, initial investments or other costs might be required, e.g., when purchasing a more efficient heating installation. These costs have to be expressed as yearly costs to be able to determine the real annual cost savings due to the project. Direct revenue created by the project is included in this calculation as avoided costs.					
KPI Owner	Terceira: RGA, Ameland: Repowered					
KPI Formula	$CS = (TDC_{base} - TDC_{IANOS})/NH$ CS = Cost savings [€] TDC_{base} = Total (direct) costs before the project [€] TDC_{IANOS} =Total (direct) costs after the project [€]. NH = Number of households affected by the project [-]					
Recommended Measurement Process and Data Sources	1. Project documentation, interviews with project leader and/or with end-users.					
Recommended Monitoring Interval	Once before the implementation of the solutions and once after the end of the project					
Unit of Measurement	€/household		**Threshold Target Value**			
Relevant Stakeholders	Energy Utilities/DSOs/TSOs		**Spatial Scale of Evaluation**	Building Level	x	
	Consumers (end-users)/Prosumers	x		District Level	x	
	Technology and Services Providers			Island Level		
	Policy-making Bodies and Governance					
	Representative Citizen Groups/Citizens					
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe		
	Impact			End of project		
				Post-project		
TT-reference	TT#1	x	TT#2		TT#3	x

UC-reference	UC 1.1	x	UC 2.1		UC 3.1		UC 4.1	x	UC 5.1	
	UC 1.2	x	UC 2.2		UC 3.2		UC 4.2	x	UC 5.2	
	UC 6		UC 7	x	UC 8	x	UC 9.1	x		
							UC 9.2	x		
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa	x

4.3.7 Minimum Electricity Price for Companies and Consumers

Minimum Electricity Price for Companies and Consumers	
KPI Description	The indicator represents the minimum cost at which electricity must be sold in order to balance costs and profits. All DSOs' costs for network losses should be considered in the calculation. Providing customers with price forecasts in several grades of accuracy, potentially with price guarantees for short periods of time could be a new revenue stream. The customers have some security by knowing the electricity prices enabling the optimal scheduling of energy consuming equipment.
KPI Owner	Terceira: EDA, Ameland: Liander
KPI Formula	Measured two times: one for residential sector and one for non-residential. $$MEP = \frac{MC}{EP}$$ MEP = minimum electricity price within a year [€/kWh] MC = minimum cost of electricity for the whole year [€] EP = electricity produced within the examined year [kWh]
Recommended Measurement Process and Data Sources	Data should be sourced from the energy providers of the city ecosystems.
Recommended Monitoring Interval	Annually

Unit of Measurement	€/kWh		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	
	Consumers (end-users)/Prosumers	x		District Level	
	Technology and Services Providers			Island Level	x
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	

TT-reference	TT#1				TT#2				TT#3	
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	
	UC 6		UC 7		UC 8		UC 9.1			
							UC 9.2			

Replication in fellow islands	Nisyros		Bora-Bora		Lampedusa	x

4.3.8 Internal Rate of Return (IRR)

Internal Rate of Return (IRR)						
KPI Description	This KPI assesses the Internal Rate of Return of the investments implemented during IANOS. It expresses the interest rate at which the net present value of the investment is zero. Simply stated, the Internal rate of return (IRR) for an investment is the percentage rate earned on each euro invested for each period it is invested. IRR is also another term people use for interest. Ultimately, IRR gives an investor the means to compare alternative investments based on their yield. This KPI can be calculated for the most important investments.					
KPI Owner	Terceira: EDA/RGA/ Municipality of Angra do Heroísmo – external stakeholder to be engaged –, (plus various stakeholders depending on the final ownership/promoter of each investment), Ameland: municipality of Ameland					
KPI Formula	IRR (r) is computed iteratively from the following equation for NPV: $$NPV = \sum_{t=1}^{T} \frac{E_t - A_t}{(1+r)^t} - I_0 = 0$$ r=Internal Rate of Return (IRR) I_0 = Initial investment in t_0 [€] E_t = Cash inflow in t [€] A_t = Cash outflow in t [€] T = Reference study period [years] NPV = Net Present Value					
Recommended Measurement Process and Data Sources	1. Data collection from the actors involved in the investments					
Recommended Monitoring Interval	Once at the end of the project					
Unit of Measurement	%		**Threshold Target Value**			
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x	
	Consumers (end-users)/Prosumers	x		District Level	x	
	Technology and Services Providers	x		Island Level	x	
	Policy-making Bodies and Governance					
	Representative Citizen Groups/Citizens					
Type of Indicator	Output		Scale of Evaluation Temporal	In-project timeframe		
	Impact			End of project	x	
				Post-project		
TT-reference	TT#1	x	TT#2	x	TT#3	x

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UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x	
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x	
	UC 6	x	UC 7	x	UC 8	x	UC 9.1	x			
							UC 9.2	x			
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa		x

4.3.9 Cost of Fossil Fuel purchased from mainland

Cost of Fossil Fuel purchased from mainland					
KPI Description	This KPI examines the amount and cost of fossil fuels that have to be purchased by the mainland for electrical and thermal energy and for the transportation sector.				
KPI Owner	Terceira: EDA/RGA, Ameland: municipality of Ameland				
KPI Formula	$FFP = FF_{el} * p_{el} + FF_{tr} * p_{tr} + FF_{th} * p_{th}$ FFP = total money spent for fossil fuels (€) FF_{el} = total amount of fossil fuels used for electrical energy production (tons) FF_{tr} = total amount of fossil fuels used for transportation (tons) FF_{th} = total amount of fossil fuels used for thermal energy production (tons) p_{el} = price per ton for the type of fossil fuels used for electricity production p_{tr} = price per ton for the type of fossil fuels used for transportation sector p_{th} = price per ton for the type of fossil fuels used for thermal energy production				
Recommended Measurement Process and Data Sources	Data request by statistic organizations				
Recommended Monitoring Interval	Annually				
Unit of Measurement	€/year		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	
	Consumers (end-users)/Prosumers	x		District Level	
	Technology and Services Providers			Island Level	x
	Policy-making Bodies and Governance	x			
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	x

TT-reference	TT#1			TT#2		x		TT#3		
UC-reference	UC 1.1		UC 2.1		UC 3.1		UC 4.1		UC 5.1	x
	UC 1.2		UC 2.2		UC 3.2		UC 4.2		UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1			
							UC 9.2			

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Replication in fellow islands	Nisyros		Bora-Bora	x	Lampedusa	x

4.3.10 Cost of Electricity Purchased from Mainland

Cost of Electricity Purchased from Mainland	
KPI Description	This KPI measures the cost of electricity purchased from mainland. It can only be applicable for interconnected power systems.
KPI Owner	Ameland: Liander
KPI Formula	$$CEPM = \sum_{i} (EP \cdot P_{el})$$ CEPM = cost of electricity purchased from mainland within a year [€/year] i=number of energy purchases within a year [-] EPi = amount of electrical energy purchased [kWh] P_i = price of electricity of the ith EP [€] Alternatively, this KPI can be computed directly from the amount of money spent for purchasing electricity over the examined year.
Recommended Measurement Process and Data Sources	1. Data can be requested by the local TSO/DSOs
Recommended Monitoring Interval	Annually

Unit of Measurement	€/year		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	
	Consumers (end-users)/Prosumers			District Level	
	Technology and Services Providers			Island Level	x
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	

TT-reference	TT#1	x		TT#2				TT#3		
UC-reference	UC 1.1		UC 2.1		UC 3.1		UC 4.1		UC 5.1	
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	
	UC 6	x	UC 7		UC 8	x	UC 9.1			
							UC 9.2			

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Replication in fellow islands	Nisyros		Bora-Bora		Lampedusa	

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4.3.11 Energy Poverty

Energy Poverty					
KPI Description	This KPI assesses the change in percentage points of (gross) household income spent on energy bills. A significant part of a household's income is consumed by housing costs and related expenditures. As such, both are determinants of the extent to which households are at risk of poverty or deprivation. As a large share of the European housing stock consists of buildings in need of refurbishment, particularly in lower income low-energy-efficiency buildings with residents living in fuel poverty, the key to alleviate fuel poverty is to renovate the stock into more energy efficient buildings. Avoiding energy poverty has therefore become an important policy aim in many European countries. The assessor may need to determine a hypothetical baseline in case of a new construction development.				
KPI Owner	Terceira: RGA, Ameland: municipality of Ameland				
KPI Formula	$percentage\ \%\ point\ change\ in\ income\ spent\ on\ energy = \left(\frac{Energy\ costs\ before\ project}{Gross\ household\ income} - \frac{Energy\ costs\ after\ project}{Gross\ household\ income}\right)$ Note: The energy costs include all building related energy, i.e. for heating/cooling, warm water and electricity.				
Recommended Measurement Process and Data Sources	Data on the average household income may be obtained from the island statistical office if not available for the immediate context of the project. If the project had as an aim to decrease energy consumption or CO2 emissions, the numbers on the reference situation and after completion of the project can serve as the basis for calculating the change in energy costs. Energy prices (metered prices) can be obtained from the local energy provider(s). Note that baseline estimations are needed				
Recommended Monitoring Interval	Twice (before and after project implementation)				
Unit of Measurement	%		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers			Island Level	
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact	x		End of project	x
				Post-project	
TT-reference	TT#1	x	TT#2	x	TT#3

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UC-reference	UC 1.1	x	UC 2.1		UC 3.1		UC 4.1	x	UC 5.1		
	UC 1.2	x	UC 2.2		UC 3.2		UC 4.2	x	UC 5.2		
	UC 6		UC 7	x	UC 8	x	UC 9.1	x			
							UC 9.2	x			
Replication in fellow islands	Nisyros			x	Bora-Bora				Lampedusa		x

4.4 KPIs in ICT Domain

4.4.1 Increased system flexibility for energy players

<table>
<tr><th colspan="6">Increased system flexibility for energy players</th></tr>
<tr><td>KPI Description</td><td colspan="5">This KPI is an indication of the ability of the system to respond to – as well as stabilize and balance – supply and demand in real time, as a measure of the demand side participation in energy markets and in energy efficiency intervention. Stability refers to the maintaining of voltage and frequency of a given power system within acceptable levels.</td></tr>
<tr><td>KPI Owner</td><td colspan="5">Terceira: EDA/Cleanwatts/EDP, Ameland: NEROA</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$\Delta SF = \frac{SF_{IANOS} - SF_{base}}{P_{peak}}$$
ΔSF = energy flexibility (%)
SF_{IANOS} = the amount of load capacity participating in demand side management after the IANOS activities, taken as the total capacity in all UCs [kW].
SF_{base} = the amount of load capacity participating in demand side management in the baseline scenario [kW]
SFbase depends on the existing technologies and potential targets on the islands and would not be always zero e.g., in the case of home-based BESS to support load shifting in off-peak hours.
P_{peak} = the consumption peak
It can also be expressed related to cost as:
$$SF_{AC} = \frac{\Delta SF}{AC}$$
Where SF_{AC} refers to the system flexibility pertinent to average costs (AC) stemming from grid operations of increased load and/or new/additional installations.</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="5">1. Data should be gathered from the department of energy of the municipality or the energy provider.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="5">daily/monthly/yearly</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">(%, W/€)</td><td>Threshold Target Value</td><td colspan="2"></td></tr>
<tr><td rowspan="4">Relevant Stakeholders</td><td>Energy Utilities/DSOs/TSOs</td><td>x</td><td rowspan="4">Spatial Scale of Evaluation</td><td>Building Level</td><td></td></tr>
<tr><td>Consumers (end-users)/Prosumers</td><td></td><td>District Level</td><td>x</td></tr>
<tr><td>Technology and Services Providers</td><td>x</td><td>Island Level</td><td>x</td></tr>
<tr><td>Policy-making Bodies and Governance</td><td></td><td></td><td></td></tr>
</table>

	Representative Citizen Groups/Citizens										
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x						
	Impact			End of project	x						
				Post-project	x						
TT-reference	TT#1		x		TT#2				TT#3		
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x	
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x	
	UC 6	x	UC 7		UC 8	x	UC 9.1				
							UC 9.2				
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa		

4.4.2 Data privacy - Data Safety & Level of Improvement (Improved Data Privacy)

<table>
<tr><th colspan="6">Data privacy - Data Safety & Level of Improvement (Improved Data Privacy)</th></tr>
<tr><td>KPI Description</td><td colspan="5">This KPI refers to data privacy, or information privacy. Specifically, it is the privacy of personal information and usually relates to personal data stored on computer systems. This indicator analyses the extent to which regulations on data protection are followed and to which proper procedures to protect personal or private data are implemented. It is strongly related with the activities in Task 1.4 (Data, Ethics and Cyber Security Management). If personal data is being collected, the purpose of data collection should be known and the collected data shouldn't be used for any other purpose. The owner of the data i.e., the administrator of the register should be defined and the authorisation from the end-users need to be always acquired.</td></tr>
<tr><td>KPI Owner</td><td colspan="5">Terceira: EDP, Ameland: NEROA</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Not at all –– 1 — 2 — 3 — 4 — 5 — Very high level of data privacy

1. Project involves use of personal or private data but national regulations/laws on its protection are not followed.
2. National regulations/laws on protection of personal data are followed.
3. National regulations on protection of personal data and EU Directive on the Protection of Personal Data (95/46/EG), EU General Data Protection Regulation 679/2017 (GDPR) are followed.
4. Relevant national and European regulations on data protection are followed and written agreements are made for use of end-users' private/personal data.
5. Relevant national and European regulations on data protection are followed and written agreements are made for use of end-users' private/personal data. Possibly collected personal/private data is accessed only by agreed persons and is heavily protected from others (e.g., locked or database on internal server with firewalls and restricted access).</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="5">Data should be gathered from island IT department.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="5">Twice (in the middle and in the end)</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">5-point Likert scale</td><td>Threshold Target Value</td><td colspan="2"></td></tr>
<tr><td rowspan="5">Relevant Stakeholders</td><td>Energy Utilities/DSOs/TSOs</td><td>x</td><td rowspan="5">Spatial Scale of Evaluation</td><td>Building Level</td><td></td></tr>
<tr><td>Consumers (end-users)/Prosumers</td><td>x</td><td>District Level</td><td></td></tr>
<tr><td>Technology and Services Providers</td><td>x</td><td>Island Level</td><td>x</td></tr>
<tr><td>Policy-making Bodies and Governance</td><td>x</td><td></td><td></td></tr>
<tr><td>Representative Citizen Groups/Citizens</td><td>x</td><td></td><td></td></tr>
<tr><td></td><td>Output</td><td>x</td><td></td><td>In-project timeframe</td><td>x</td></tr>
</table>

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Type of Indicator	Impact				**Temporal Scale of Evaluation**	End of project				x
						Post-project				x
TT-reference	TT#1	x			TT#2		x	TT#3	x	
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1	x		
							UC 9.2	x		
Replication in fellow islands	Nisyros				Bora-Bora			Lampedusa		

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4.4.3 ICT Response Time

ICT Response Time					
KPI Description	The response time of ICT infrastructure is related to the services developed and the payload (information exchanged) between them. The indicator is applicable to the various platforms and ICT deployment actions and services in the project. For some ICT services response times need to be in milliseconds while for other services seconds or minutes are perfectly acceptable.				
KPI Owner	Terceira: CERTH/Cleanwatts, Ameland: NEROA				
KPI Formula	$$RT_{ICT} = \frac{t_{trans}}{PL}$$ RT_{ICT} = ICT response time [sec/byte] t_{trans}=transaction time [sec] Pl=payload [byte]				
Recommended Measurement Process and Data Sources					
Recommended Monitoring Interval					
Unit of Measurement	ms/byte; sec/byte; min/byte (Depends on the system)		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers	x		Island Level	x
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	x
TT-reference	TT#1	x	TT#2	x	TT#3

UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1			
							UC 9.2			
Replication in fellow islands	Nisyros		Bora-Bora		Lampedusa					

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4.4.4 Increased hosting capacity for RES, electric vehicles and other new loads

Increased hosting capacity for RES, electric vehicles and other new loads					
KPI Description	This KPI gives a statement about the additional loads and RES that can be installed in the system, when innovative solutions and energy management techniques are applied (e.g., VPP platform). The calculation is realized by comparing the network capacity before and after IANOS implementation.				
KPI Owner	Terceira: EDA/RGA, Ameland: NEROA				
KPI Formula	$$EHC_{\%} = \frac{HC_{IANOS} - HC_{base}}{HC_{base}}$$ EHC = the enhanced hosting capacity of new loads when IANOS solutions are applied with respect to the baseline scenario (before demonstrating IANOS activities) (%). HC = the additional hosting capacity of new loads applied with respect to currently connected generation (GW or MW).				
Recommended Measurement Process and Data Sources	1. Data should be gathered from the department of energy of the municipality or the energy provider. 2. Data to be collected at all levels where RES are implemented and aggregated to island level.				
Recommended Monitoring Interval					
Unit of Measurement	%		**Threshold Target Value**	>29%	
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers			District Level	x
	Technology and Services Providers	x		Island Level	x
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	x

TT-reference	TT#1	x		TT#2	x		TT#3			
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1			

							UC 9.2			
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa	

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4.4.5 Increased Reliability

Increased Reliability	
KPI Description	This KPI measures the avoiding failures revert on higher reliability, meaning fewer stops on the normal operation of the building and associated systems. With the application of ICT it is possible to correct a potential misbehaviour of the system and avoid unexpected stops. The indicator will be measured as the relative improvement in the number of interruptions.
KPI Owner	Terceira: EDA, Ameland: NEROA
KPI Formula	$$Reliability_{\%} = \frac{NF_{avoided}}{NF_{base}} = \left(1 - \frac{NF_{IANOS}}{NF_{base}}\right) = \left(1 - \frac{SAIFI_{IANOS}}{SAIFI_{base}}\right)$$ NF stands for the number of failures, while the subscripts base and IANOS refer, respectively, to the baseline scenario (before the IANOS implementations) and to the situation after the IANOS solutions are implemented. *SAIFI* is the system's average interruption frequency index.
Recommended Measurement Process and Data Sources	Data collection from TSO/DSOs
Recommended Monitoring Interval	yearly

Unit of Measurement	%		**Threshold Target Value**	6-12%	
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers	x		Island Level	
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	
	Impact			End of project	x
				Post-project	x

TT-reference	TT#1	x	TT#2		TT#3	x				
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1	x		

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							UC 9.2	x		
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa	

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4.4.6 Number of sensors integrated/devices connected

Number of sensors integrated/devices connected					
KPI Description	This KPI measures the number of sensors and devices that are connected to the iVPP platform and to the IEPT toolkit.				
KPI Owner	Terceira: EDA/EDP, Ameland: NEROA				
KPI Formula	$N_{s+d} = n_s + n_d$ N_{s+d}= number of sensors and devices that are connected to the iVPP platform and to the IEPT toolkit [-] N_s=number of sensors [-] N_d= number of devices [-]				
Recommended Measurement Process and Data Sources	Data to be provided by the project manager				
Recommended Monitoring Interval	Once in the end of the project				
Unit of Measurement	#		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers	x		Island Level	
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	

TT-reference	TT#1	x		TT#2				TT#3		
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	
	UC 6		UC 7		UC 8		UC 9.1			
							UC 9.2			
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa	

4.4.7 Improved Cybersecurity

Improved Cybersecurity					
KPI Description	The indicator refers to the extent to which the project ensures cybersecurity of its systems. This indicator analyses the effort made in the project to ensure and/or improve cybersecurity, for instance the extent to which the project is prepared to handle risks in cybersecurity (i.e., has made a risk assessment), is prepared to manage possible disturbances (has a contingency plan and means to implement it) and use secure information systems (certified and accredited prior to deployment). The indicator gives an overview of the contribution of the project to the preparedness of the city to risks of cybersecurity (use of proper security procedures) and its ability to manage and mitigate possible disturbances, e.g., cyberattacks.				
KPI Owner	Terceira: EDA/Cleanwatts/EDP, Ameland: NEROA				
KPI Formula	Not at all –– 1 — 2 — 3 — 4 — 5 — Very high level of Cybersecurity 1. Not at all: Cybersecurity hasn't received any attention in the project planning, even though the project involves the use of ICT. 2. Low: A risk assessment on cybersecurity has been made for the project but there is either no contingency plan or high risks remain present. 3. Moderate: A risk assessment on cybersecurity has been made for the project and there is contingency plan for it. 4. High: A risk assessment on cybersecurity has been made for the project and there is a contingency plan for it. Risks on cybersecurity are low. 5. Very high: A risk assessment on cybersecurity has been made for the project and there is a contingency plan for it. Risks on cyber security are low. The project uses only information systems with security assessment approvals (certified and accredited prior to deployment).				
Recommended Measurement Process and Data Sources	Data to be derived from project documentation or interviews with project leader and LH managers.				
Recommended Monitoring Interval	Once (in the end of the project)				
Unit of Measurement	5-point Likert scale		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers	x		Island Level	x
	Policy-making Bodies and Governance	x			
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	x

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TT-reference	TT#1		x		TT#2				TT#3	x
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1	x		
							UC 9.2	x		
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa	

4.4.8 Integrated Building Management Systems in Buildings

Integrated Building Management Systems in Buildings					
KPI Description	This KPI measures the percentage area of buildings using integrated ICT systems to automate building management. It also includes the buildings that are equipped with smart sensors				
KPI Owner	Terceira: RGA and Municipality of Angra do Heroísmo– external stakeholder to be engaged – (not yet final), Ameland: NEROA				
KPI Formula	$$BMS\ (\%) = \frac{PB_{in}}{F_{total}}$$ • PB_{in} = Floor area of buildings using ICT-based systems for integrated management or smart sensors in the island (m^2) • F_{total} = Total floor number of buildings (m^2)				
Recommended Measurement Process and Data Sources	1. The data can be gathered from: (i) buildings registry of the island; and (ii) smart buildings programs				
Recommended Monitoring Interval	yearly				
Unit of Measurement	%		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs		**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	
	Technology and Services Providers	x		Island Level	
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	

TT-reference	TT#1		x		TT#2				TT#3	
UC-reference	UC 1.1		UC 2.1		UC 3.1		UC 4.1	x	UC 5.1	
	UC 1.2		UC 2.2		UC 3.2		UC 4.2	x	UC 5.2	
	UC 6		UC 7		UC 8		UC 9.1			
							UC 9.2			
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa	

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4.5 KPIs in Social Domain

4.5.1 People Reached

<table>
<tr><th colspan="6">People Reached</th></tr>
<tr><td>KPI Description</td><td colspan="5">Percentage of people in the target group that have been reached and/or are activated by the project. A project is usually most successful if the entire target group of a service participates. For example, if all electrical car owners join in optimizing their battery use to improve the energy system efficiency of the district. In addition, a high score on people reached can be seen as a signal of increased community engagement due to the project. The effort the project will make towards reaching the full extent of its target group can vary and with it the size of the target audience. Therefore, this effort and target audience for each integrated solution have to be clearly defined before assessing the indicator.</td></tr>
<tr><td>KPI Owner</td><td colspan="5">Terceira: RGA, UniNova, Municipality of Angra do Heroísmo– external stakeholder to be engaged – and EDA, Ameland: Hanze, AEC (supporting)</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$PR = \frac{N_{citizens,reached}}{N_{citizens,considered}}$$
PR = percentage of people reached (%)
$N_{citizens,reached}$=number of people reached/activated by the project
$N_{citizens,considered}$= number of citizens considered as the total target group of the project</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="5">1. The LH managers create a log file to record people reached through: a) communication campaigns (press, social media), b) events organized by IANOS, c) participation in third party events, and d) an estimation of people reached through social media and press is recorded;
2. Calculate the number of people in the project implementation area but also expand this to other scale of evaluation i.e., city if relevant</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="5">Once in the end of the project</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">%, number of people</td><td>Threshold Target Value</td><td colspan="2"></td></tr>
<tr><td rowspan="5">Relevant Stakeholders</td><td>Energy Utilities/DSOs/TSOs</td><td>x</td><td rowspan="5">Spatial Scale of Evaluation</td><td>Building Level</td><td></td></tr>
<tr><td>Consumers (end-users)/Prosumers</td><td>x</td><td>District Level</td><td>x</td></tr>
<tr><td>Technology and Services Providers</td><td>x</td><td>Island Level</td><td>x</td></tr>
<tr><td>Policy-making Bodies and Governance</td><td>x</td><td></td><td></td></tr>
<tr><td>Representative Citizen Groups/Citizens</td><td>x</td><td></td><td></td></tr>
<tr><td rowspan="3">Type of Indicator</td><td>Output</td><td></td><td rowspan="3">Temporal Scale of Evaluation</td><td>In-project timeframe</td><td>x</td></tr>
<tr><td>Impact</td><td>x</td><td>End of project</td><td>x</td></tr>
<tr><td></td><td></td><td>Post-project</td><td></td></tr>
</table>

TT-reference	TT#1	x		TT#2		x		TT#3		x	
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1		
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2		
	UC 6	x	UC 7	x	UC 8	x	UC 9.1	x			
							UC 9.2	x			
Replication in fellow islands	Nisyros			x	Bora-Bora			x	Lampedusa		x

4.5.2 Thermal comfort

Thermal comfort												
KPI Description	This indicator estimates the quality of the delivered heating/cooling service. It is certainly a matter of technical aspects that can be measured with quantified technical indicators, but also a matter of the opinion of the service receivers.											
KPI Owner	Ameland: Hanze, AEC (supporting)											
KPI Formula	Not at all –– 1 — 2 — 3 — 4 — 5 — Very high level of thermal comfort											
Recommended Measurement Process and Data Sources	Survey on representative citizens' group via questionnaire.											
Recommended Monitoring Interval	Once in the end of the project											
Unit of Measurement	5-point Likert scale		**Threshold Target Value**									
Relevant Stakeholders	Energy Utilities/DSOs/TSOs		**Spatial Scale of Evaluation**	Building Level	x							
	Consumers (end-users)/Prosumers	x		District Level								
	Technology and Services Providers			Island Level								
	Policy-making Bodies and Governance											
	Representative Citizen Groups/Citizens	x										
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe								
	Impact	x		End of project	x							
				Post-project								
TT-reference	TT#1			TT#2	x	TT#3						
UC-reference	UC 1.1		UC 2.1		UC 3.1		UC 4.1		UC 5.1			
	UC 1.2		UC 2.2		UC 3.2		UC 4.2		UC 5.2			
	UC 6		UC 7	x	UC 8	x	UC 9.1					
							UC 9.2					
Replication in fellow islands	Nisyros		Bora-Bora	x	Lampedusa							

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4.5.3 Job creation

<table>
<tr><th colspan="11">Job creation</th></tr>
<tr><td>KPI Description</td><td colspan="10">This KPI calculates the number of jobs created by the project activities, such as the installation of solutions, without specifying the location.</td></tr>
<tr><td>KPI Owner</td><td colspan="10">Terceira: RGA, Municipality of Angra do Heroísmo – external stakeholder to be engaged – and EDA , Ameland: Hanze, AEC (supporting)</td></tr>
<tr><td>KPI Formula</td><td colspan="10">Nj=number of jobs created [-]</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="10">1. Project documentation or interviews with the project leader.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="10"></td></tr>
<tr><td>Unit of Measurement</td><td colspan="3">number</td><td>Threshold Target Value</td><td colspan="6">>482</td></tr>
<tr><td rowspan="5">Relevant Stakeholders</td><td colspan="2">Energy Utilities/DSOs/TSOs</td><td></td><td rowspan="5">Spatial Scale of Evaluation</td><td colspan="5">Building Level</td><td></td></tr>
<tr><td colspan="2">Consumers (end-users)/Prosumers</td><td>x</td><td colspan="5">District Level</td><td>x</td></tr>
<tr><td colspan="2">Technology and Services Providers</td><td></td><td colspan="5">Island Level</td><td>x</td></tr>
<tr><td colspan="2">Policy-making Bodies and Governance</td><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="2">Representative Citizen Groups/Citizens</td><td>x</td><td colspan="5"></td><td></td></tr>
<tr><td rowspan="3">Type of Indicator</td><td colspan="2">Output</td><td></td><td rowspan="3">Temporal Scale of Evaluation</td><td colspan="5">In-project timeframe</td><td>x</td></tr>
<tr><td colspan="2">Impact</td><td>x</td><td colspan="5">End of project</td><td>x</td></tr>
<tr><td colspan="2"></td><td></td><td colspan="5">Post-project</td><td>x</td></tr>
<tr><td colspan="11"></td></tr>
<tr><td>TT-reference</td><td>TT#1</td><td colspan="2">x</td><td>TT#2</td><td colspan="2">x</td><td>TT#3</td><td colspan="3">x</td></tr>
<tr><td rowspan="4">UC-reference</td><td>UC 1.1</td><td>x</td><td>UC 2.1</td><td>x</td><td>UC 3.1</td><td>x</td><td>UC 4.1</td><td>x</td><td>UC 5.1</td><td>x</td></tr>
<tr><td>UC 1.2</td><td>x</td><td>UC 2.2</td><td>x</td><td>UC 3.2</td><td>x</td><td>UC 4.2</td><td>x</td><td>UC 5.2</td><td>x</td></tr>
<tr><td>UC 6</td><td>x</td><td>UC 7</td><td>x</td><td>UC 8</td><td>x</td><td>UC 9.1</td><td>x</td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>UC 9.2</td><td>x</td><td colspan="2"></td></tr>
<tr><td>Replication in fellow islands</td><td colspan="3">Nisyros</td><td>x</td><td colspan="2">Bora-Bora</td><td>x</td><td colspan="2">Lampedusa</td><td></td></tr>
</table>

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4.5.4 Percentage of citizens' participation in decision-making

Percentage of citizens' participation in decision-making	
KPI Description	This KPI examines the absolute number and the percentage of citizens that participate in decision-making concerning the islands energy transition.
KPI Owner	Terceira: RGA, Municipality of Angra do Heroísmo – external stakeholder to be engaged –, Ameland: Hanze, AEC (supporting)
KPI Formula	$$n_{citizens} = \frac{N_{citizens}}{POP}$$ $n_{citizens}$ = percentage of citizens that participates in decision-making [%] $N_{citizens}$=number of citizens that participates in decision-making [-] POP=island population [-]
Recommended Measurement Process and Data Sources	Data collection of open processes i.e., written suggestions, complains and comments
Recommended Monitoring Interval	Annually

Unit of Measurement	(%, number of citizens)	**Threshold Target Value**	25% increase in both LH islands

Relevant Stakeholders			**Spatial Scale of Evaluation**		
	Energy Utilities/DSOs/TSOs			Building Level	
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers			Island Level	x
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens	x			

Type of Indicator			**Temporal Scale of Evaluation**		
	Output	x		In-project timeframe	x
	Impact			End of project	x
				Post-project	

TT-reference	TT#1		TT#2		TT#3	x

UC-reference										
	UC 1.1		UC 2.1		UC 3.1		UC 4.1		UC 5.1	
	UC 1.2		UC 2.2		UC 3.2		UC 4.2		UC 5.2	
	UC 6		UC 7	x	UC 8		UC 9.1	x		
							UC 9.2	x		

Replication in fellow islands	Nisyros	x	Bora-Bora	x	Lampedusa	

4.5.5 Number of interactive social media initiatives

Number of interactive social media initiatives					
KPI Description	This KPI measures the number of *posts* in social media *and news items* in traditional media created by the municipality for sharing information about the *project.*				
KPI Owner	Terceira: EDP, Ameland: Hanze, AEC (supporting)				
KPI Formula	$$N_{init} = \frac{N_{posts}}{POP}$$ N_{init}=number of interactive social media initiatives per 1000 citizens [-] N_{posts}=number of posts about the project in already existing accounts created in the island [-] POP=island population in 1000s [-]				
Recommended Measurement Process and Data Sources	Data collection from the project leader				
Recommended Monitoring Interval	Once in the end of the project				
Unit of Measurement	#/cap		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs		**Spatial Scale of Evaluation**	Building Level	
	Consumers (end-users)/Prosumers			District Level	
	Technology and Services Providers	x		Island Level	x
	Policy-making Bodies and Governance	x			
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	
	Impact			End of project	x
				Post-project	

TT-reference	TT#1			TT#2			TT#3		x	
UC-reference	UC 1.1		UC 2.1		UC 3.1		UC 4.1		UC 5.1	
	UC 1.2		UC 2.2		UC 3.2		UC 4.2		UC 5.2	
	UC 6		UC 7		UC 8		UC 9.1	x		
							UC 9.2	x		
Replication in fellow islands	Nisyros				Bora-Bora				Lampedusa	x

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4.5.6 Increased citizen awareness of the potential of smart grid projects

Increased citizen awareness of the potential of smart grid projects					
KPI Description	This KPI measures the increased citizen awareness of the socio-cultural potential of smart city projects.				
KPI Owner	Terceira: RGA, Ameland: Hanze, AEC (supporting)				
KPI Formula	Five-point Likert scale (Not at all 1 – 2 – 3 – 4 – 5 High level of citizen awareness)				
Recommended Measurement Process and Data Sources	Data collection from interviews through questionnaires. In Terceira, the Municipality of Angra do Heroísmo will be involved in order to facilitate the contact with local stakeholders.				
Recommended Monitoring Interval	Once in the end of the project				
Unit of Measurement	Five-point Likert scale		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs		**Spatial Scale of Evaluation**	Building Level	
	Consumers (end-users)/Prosumers			District Level	
	Technology and Services Providers			Island Level	x
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens	x			
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	
	Impact	x		End of project	x
				Post-project	

TT-reference	TT#1	x		TT#2		x		TT#3	x	
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1	x		
							UC 9.2	x		
Replication in fellow islands	Nisyros			Bora-Bora				Lampedusa	x	

4.6 KPIs in Governance Domain

4.6.1 Involvement of the island administration

Involvement of the island administration										
KPI Description	This KPI examines the extent to which the local authority is involved in the development of the project, other than financial, and how many departments are contributing.									
KPI Owner	Terceira: RGA/ Municipality of Angra do Heroísmo – external stakeholder to be engaged –, Ameland: municipality of Ameland									
KPI Formula	Likert scale Not involved – 1 – 2 – 3 – 4 – 5 Very much involved									
Recommended Measurement Process and Data Sources	Data to be derived from project documentation and/or interviews with project leader and other team members									
Recommended Monitoring Interval	Once in the end of the project									
Unit of Measurement	5-point Likert scale		**Threshold Target Value**							
Relevant Stakeholders	Energy Utilities/DSOs/TSOs		**Spatial Scale of Evaluation**	Building Level						
	Consumers (end-users)/Prosumers			District Level	x					
	Technology and Services Providers			Island Level	x					
	Policy-making Bodies and Governance	x								
	Representative Citizen Groups/Citizens									
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x					
	Impact			End of project	x					
				Post-project						
TT-reference	TT#1		TT#2	x	TT#3	x				
UC-reference	UC 1.1		UC 2.1		UC 3.1		UC 4.1		UC 5.1	x
	UC 1.2		UC 2.2		UC 3.2		UC 4.2		UC 5.2	x
	UC 6		UC 7	x	UC 8	x	UC 9.1	x		
							UC 9.2	x		
Replication in fellow islands	Nisyros	x	Bora-Bora	x	Lampedusa	x				

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4.6.2 Smart island policy

Smart island policy	
KPI Description	This KPI refers to the extent to which the project has benefitted from a governmental smart grid/island policy.
KPI Owner	Terceira: RGA/ Municipality of Angra do Heroísmo – external stakeholder to be engaged –, Ameland: municipality of Ameland
KPI Formula	Likert scale (Very much hampered – 1 — 2 — 3 — 4 — 5 — Very much benefitted)
Recommended Measurement Process and Data Sources	Data to be derived from project documentation, policy documents and/or interviews with project leader.
Recommended Monitoring Interval	Once in the end of the project

Unit of Measurement	5 point Likert scale		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs	x	**Spatial Scale of Evaluation**	Building Level	
	Consumers (end-users)/Prosumers			District Level	
	Technology and Services Providers	x		Island Level	x
	Policy-making Bodies and Governance	x			
	Representative Citizen Groups/Citizens				
Type of Indicator	Output	x	**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact			End of project	x
				Post-project	

TT-reference	TT#1	x		TT#2	x		TT#3	x		
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x
	UC 6	x	UC 7	x	UC 8	x	UC 9.1	x		
							UC 9.2	x		

Replication in fellow islands	Nisyros		Bora-Bora	x	Lampedusa	x

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4.6.3 Micro-grids legal framework

<table>
<tr><th colspan="6">Micro-grids legal framework</th></tr>
<tr><td>KPI Description</td><td colspan="5">This KPIs assess the extent to which microgrids regulation is suitable at EU level and at the partners' islands level.</td></tr>
<tr><td>KPI Owner</td><td colspan="5">Terceira: EDP, Ameland: municipality of Ameland</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Likert scale (it is not suitable – 1 — 2 — 3 — 4 — 5 — It fits perfectly with smart grid development)</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="5">Data to be derived from review on the national/ European laws.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="5">Annually; Every two years</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">5 point Likert scale</td><td>Threshold Target Value</td><td colspan="2"></td></tr>
<tr><td rowspan="5">Relevant Stakeholders</td><td>Energy Utilities/DSOs/TSOs</td><td>x</td><td rowspan="5">Spatial Scale of Evaluation</td><td>Building Level</td><td></td></tr>
<tr><td>Consumers (end-users)/Prosumers</td><td>x</td><td>District Level</td><td></td></tr>
<tr><td>Technology and Services Providers</td><td>x</td><td>Island Level</td><td>x</td></tr>
<tr><td>Policy-making Bodies and Governance</td><td>x</td><td></td><td></td></tr>
<tr><td>Representative Citizen Groups/Citizens</td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Type of Indicator</td><td>Output</td><td>x</td><td rowspan="3">Temporal Scale of Evaluation</td><td>In-project timeframe</td><td>x</td></tr>
<tr><td>Impact</td><td></td><td>End of project</td><td>x</td></tr>
<tr><td></td><td></td><td>Post-project</td><td></td></tr>
</table>

<table>
<tr><td colspan="11"></td></tr>
<tr><td>TT-reference</td><td>TT#1</td><td colspan="2">x</td><td>TT#2</td><td colspan="2">x</td><td>TT#3</td><td colspan="3"></td></tr>
<tr><td rowspan="4">UC-reference</td><td>UC 1.1</td><td>x</td><td>UC 2.1</td><td>x</td><td>UC 3.1</td><td>x</td><td>UC 4.1</td><td>x</td><td>UC 5.1</td><td>x</td></tr>
<tr><td>UC 1.2</td><td>x</td><td>UC 2.2</td><td>x</td><td>UC 3.2</td><td>x</td><td>UC 4.2</td><td>x</td><td>UC 5.2</td><td>x</td></tr>
<tr><td>UC 6</td><td>x</td><td>UC 7</td><td>x</td><td>UC 8</td><td>x</td><td>UC 9.1</td><td>x</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>UC 9.2</td><td>x</td><td></td><td></td></tr>
<tr><td>Replication in fellow islands</td><td colspan="3">Nisyros</td><td></td><td colspan="2">Bora-Bora</td><td></td><td colspan="2">Lampedusa</td><td></td></tr>
</table>

4.6.4 Suitable Energy Storage Regulation

<table>
<tr><th colspan="11">Suitable Energy Storage Regulation</th></tr>
<tr><td>KPI Description</td><td colspan="10">This KPI refers to the extent to which energy storage regulation is suitable at EU level and at the partners' islands level.</td></tr>
<tr><td>KPI Owner</td><td colspan="10">Terceira: EDP, Ameland: municipality of Ameland</td></tr>
<tr><td>KPI Formula</td><td colspan="10">Likert scale (it is not suitable – 1 — 2 — 3 — 4 — 5 — It fits perfectly with smart grid development)</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="10">Data to be derived from review on the national/ European laws.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="10">Annually; Every two years;</td></tr>
<tr><td>Unit of Measurement</td><td colspan="4">5 point Likert scale</td><td colspan="2">Threshold Target Value</td><td colspan="4"></td></tr>
<tr><td rowspan="5">Relevant Stakeholders</td><td colspan="3">Energy Utilities/DSOs/TSOs</td><td>x</td><td colspan="2" rowspan="5">Spatial Scale of Evaluation</td><td colspan="3">Building Level</td><td></td></tr>
<tr><td colspan="3">Consumers (end-users)/Prosumers</td><td>x</td><td colspan="3">District Level</td><td></td></tr>
<tr><td colspan="3">Technology and Services Providers</td><td>x</td><td colspan="3">Island Level</td><td>x</td></tr>
<tr><td colspan="3">Policy-making Bodies and Governance</td><td>x</td><td colspan="3"></td><td></td></tr>
<tr><td colspan="3">Representative Citizen Groups/Citizens</td><td></td><td colspan="3"></td><td></td></tr>
<tr><td rowspan="3">Type of Indicator</td><td colspan="3">Output</td><td>x</td><td colspan="2" rowspan="3">Temporal Scale of Evaluation</td><td colspan="3">In-project timeframe</td><td>x</td></tr>
<tr><td colspan="3">Impact</td><td></td><td colspan="3">End of project</td><td>x</td></tr>
<tr><td colspan="3"></td><td></td><td colspan="3">Post-project</td><td></td></tr>
<tr><td colspan="11"></td></tr>
<tr><td>TT-reference</td><td>TT#1</td><td colspan="2">x</td><td colspan="2">TT#2</td><td colspan="2">x</td><td>TT#3</td><td colspan="2">x</td></tr>
<tr><td rowspan="4">UC-reference</td><td>UC 1.1</td><td>x</td><td>UC 2.1</td><td>x</td><td>UC 3.1</td><td>x</td><td>UC 4.1</td><td>x</td><td>UC 5.1</td><td>x</td></tr>
<tr><td>UC 1.2</td><td>x</td><td>UC 2.2</td><td>x</td><td>UC 3.2</td><td>x</td><td>UC 4.2</td><td>x</td><td>UC 5.2</td><td>x</td></tr>
<tr><td>UC 6</td><td>x</td><td>UC 7</td><td>x</td><td>UC 8</td><td>x</td><td>UC 9.1</td><td>x</td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>UC 9.2</td><td></td><td colspan="2"></td></tr>
<tr><td>Replication in fellow islands</td><td colspan="3">Nisyros</td><td>x</td><td colspan="2">Bora-Bora</td><td></td><td colspan="2">Lampedusa</td><td>x</td></tr>
</table>

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4.7 KPIs in Propagation Domain

4.7.1 Social Compatibility

Social Compatibility	
KPI Description	This KPI refers to the extent to which the project's solution fits with people's 'frame of mind' and does not negatively challenge people's values or the ways they are used to do things. The indicator 'social compatibility' aims to provide an indication of the extent to which a solution fits with people's current "frame of mind", that is influenced by values and past experiences. If an innovation requires people to significantly think differently, and challenges assumptions or the ways how we normally are accustomed to do things, its implementation in society will be more difficult. Abdalla (2012) has shown that the gains from environmental measures in sustainable residential districts that go beyond the building codes, may be offset by residents' behaviour if these measures do not match residents' beliefs and expectations. For example, an innovation has a higher compatibility when it does not require an extremely different 'frame of mind' or 'ways of doing things'. Moreover, social compatibility is affected by socio-cultural values and beliefs or past collective experiences that influence the general opinion about the innovation or similar innovations. The 'frame of mind', therefore, can differ between countries.
KPI Owner	Terceira: RGA, Ameland: Hanze
KPI Formula	The indicator provides a qualitative measure and is rated on a five-point Likert scale: Not at all – 1 — 2 — 3 — 4 — 5 — Very much 1. Not at all: the solution differs to such a degree from the usual way of doing things and/or from existing norms and values, that it is almost impossible for people to accept the solution. 2. Low: the solution requires considerable changes in the current way of doing things, and/or requires a change in norms and values. 3. Moderate: the solution has certain aspects that differ from the usual way of doing things which users (or others involved) will need to get accustomed to, but requires no major changes in norms or values. 4. High: the solution is largely compatible with the current way of doing things, or with existing norms and values. Only slight adjustments are needed. 5. Very high: the solution does not differ from the usual way of doing things in operational sense and is fully consistent with existing norms and values Two examples and nuances between required changes to people's values or ways of doing things: A car sharing system with membership and a per km payments requires a completely different mindset compared to a privately owned car and a change in travel habits, and thus would score with 1. A public transport paying card requires some changes in habits (not buying paper tickets, ensuring that you always have the card with you when travelling, etc.), but not a major change in norms and values and thus gets a score of 3.
Recommended Measurement Process and Data Sources	Data to be derived from project documentation and/or interviews with the project leader and/or end-users and stakeholders.
Recommended Monitoring Interval	Once in the end of the project

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Unit of Measurement	5 point Likert scale				**Threshold Target Value**							
Relevant Stakeholders	Energy Utilities/DSOs/TSOs			x	**Spatial Scale of Evaluation**	Building Level						
	Consumers (end-users)/Prosumers			x		District Level					x	
	Technology and Services Providers					Island Level					x	
	Policy-making Bodies and Governance			x								
	Representative Citizen Groups/Citizens			x								
Type of Indicator	Output				**Temporal Scale of Evaluation**	In-project timeframe					x	
	Impact			x		End of project					x	
						Post-project					x	
TT-reference	TT#1	x			TT#2		x		TT#3		x	
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x		
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x		
	UC 6	x	UC 7	x	UC 8	x	UC 9.1	x				
							UC 9.2	x				
Replication in fellow islands	Nisyros				Bora-Bora			x	Lampedusa			x

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4.7.2 Technical compatibility

<table>
<tr><th colspan="6">Technical Compatibility</th></tr>
<tr><td>KPI Description</td><td colspan="5">This KPI examines the extent to which the smart grid solutions fit with the current existing technological standards/infrastructures. This indicator aims to provide an indication of the technical compatibility of the solutions, meaning the extent to which the solution fits with current practices, administrative and existing technological standards/infrastructures.</td></tr>
<tr><td>KPI Owner</td><td colspan="5">Terceira: Cleanwatts , Ameland: NEROA</td></tr>
<tr><td>KPI Formula</td><td colspan="5">The indicator provides a qualitative measure and is rated on a five- point Likert scale:

No technical compatibility – 1 — 2 — 3 — 4 — 5 — Very high

1. No technical compatibility: the solution needs many and major adjustments to current (infra)structures and/or practices for its implementation.
2. Low compatibility: the solution requires some major adjustments to current (infra)structures and/or practices for its implementation.
3. Moderate: some adjustments to current (infra)structures and/or practices are necessary to implement the solution.
4. High: only minor adjustments (think of a different type of plug, a specific internet connection, etc.) are needed to implement the solution.
5. Very high: no adjustments to current (infra)structures and/or practices are needed, the solution can immediately be implemented.</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="5">Data to be derived from interviews with the project leader and/or stakeholders and based on expert judgement</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="5">Once in the end of the project</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">5 point Likert scale</td><td>Threshold Target Value</td><td colspan="2"></td></tr>
<tr><td rowspan="5">Relevant Stakeholders</td><td>Energy Utilities/DSOs/TSOs</td><td>x</td><td rowspan="5">Spatial Scale of Evaluation</td><td>Building Level</td><td>x</td></tr>
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<tr><td>Technology and Services Providers</td><td>x</td><td>Island Level</td><td>x</td></tr>
<tr><td>Policy-making Bodies and Governance</td><td>x</td><td></td><td></td></tr>
<tr><td>Representative Citizen Groups/Citizens</td><td>x</td><td></td><td></td></tr>
<tr><td rowspan="3">Type of Indicator</td><td>Output</td><td></td><td rowspan="3">Temporal Scale of Evaluation</td><td>In-project timeframe</td><td>x</td></tr>
<tr><td>Impact</td><td>x</td><td>End of project</td><td>x</td></tr>
<tr><td></td><td></td><td>Post-project</td><td>x</td></tr>
<tr><td colspan="6"></td></tr>
</table>

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TT-reference	TT#1	x		TT#2	x		TT#3				
UC-reference	UC 1.1	x	UC 2.1	x	UC 3.1	x	UC 4.1	x	UC 5.1	x	
	UC 1.2	x	UC 2.2	x	UC 3.2	x	UC 4.2	x	UC 5.2	x	
	UC 6	x	UC 7	x	UC 8	x	UC 9.1				
							UC 9.2				
Replication in fellow islands	Nisyros			x	Bora-Bora			x	Lampedusa		x

4.7.3 Ease of use for end users of the solution

Ease of use for end users of the solution					
KPI Description	This KPI provides an indication of the complexity of the implemented solution within the IANOS project for the end-users. End-users are conceptualised as those individuals who will be using/working with the solution. Some solutions or innovations are perceived as relatively difficult to understand and use while others are clear and easy to the adopters. It is presumed that a smart solution that is easy to use and understand will be more likely adopted compared to a difficult solution.				
KPI Owner	Terceira: EDA/RGA, Ameland: Hanze				
KPI Formula	The indicator provides a qualitative measure and is rated on a five- point Likert scale: Very difficult – 1 — 2 — 3 — 4 — 5 — Very easy 1. Very difficult: users need extensive and sustained instructions to understand the solution and without these the solution cannot be understood or used. 2. Fairly difficult: users need to be well instructed to be able to understand and use the solution properly. Considerable time is required to familiarize themselves with the solution. 3. Slightly difficult: users have to invest some time to understand the solution and get accustomed to working with it. Some time is needed before the solution has become fully familiar to end users 4. Fairly easy: a small investment in time is required of the end users to understand the solution and get accustomed to it, but they are fairly quickly familiar to work with it. 5. Very easy: the solution is as easy to understand and use.				
Recommended Measurement Process and Data Sources	To be derived from interviews with the project leader and end-users, and based on expert judgement.				
Recommended Monitoring Interval	Once in the end of the project				
Unit of Measurement	5 point Likert scale		**Threshold Target Value**		
Relevant Stakeholders	Energy Utilities/DSOs/TSOs		**Spatial Scale of Evaluation**	Building Level	x
	Consumers (end-users)/Prosumers	x		District Level	x
	Technology and Services Providers			Island Level	x
	Policy-making Bodies and Governance				
	Representative Citizen Groups/Citizens				
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	x
	Impact	x		End of project	x
				Post-project	x

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TT-reference	TT#1		x		TT#2		x		TT#3		x
UC-reference	UC 1.1	x	UC 2.1		UC 3.1	x	UC 4.1	x	UC 5.1	x	
	UC 1.2	x	UC 2.2		UC 3.2	x	UC 4.2	x	UC 5.2	x	
	UC 6		UC 7	x	UC 8	x	UC 9.1	x			
							UC 9.2	x			
Replication in fellow islands	Nisyros				Bora-Bora			x	Lampedusa		x

4.8 Potential risks in the measurements of the KPIs

In the 2nd version of the deliverable, some potential risks impacting the measurement process and/or the overall performance assessment of the KPIs have been identified. These risks were further examined in the 3rd version and will be further explored in the following months of the project, and if mitigation actions cannot be established, some KPIs might be subject to change (might be reflected in an updated version). These risks and mitigation actions are presented in the following table:

Table 12 Potential risks in the measurement of specific KPIs

KPI name	Potential risks	Mitigation actions
Air quality index (Air pollution)	The KPI cannot be measured// The data won't be accessible with the required detail.	•Abundance of KPIs have been defined that cover similar aspects of the project, therefore if one cannot be measured it will be covered by a different one. •Constant communication with the various partners of each LH ecosystem. •KPI owners have been defined for most of the KPIs and those that haven't will be defined in the near future in communication with the technology providers and the IVPP module.
Increased system flexibility for energy players	The amount of load capacity participating in demand side management (SF) might not be accessible through the retailer.	
Increased hosting capacity for RES, electric vehicles and other new loads	The additional hosting capacity of new loads (HC) might not be accessible through the retailer.	
Job creation	The number of jobs created due to the project interventions is not easily accessible. Recommended measurements process and possible data sources are not so clear at this stage. We will need to check what will be the relevant stakeholders to involve.	

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4.9 Project Success Indicators (PSIs) and correspondence with the selected KPIs

As IANOS has already set goals in the Grant Agreement Form (GAF), they need to comply with the KPIs presented above in order to be able to evaluate the general impact of the project. These goals are expressed basically through the Project Success Indicators (PSIs) described in GAF with well-defined target values. The important difference between the KPIs and the PSIs is that the latter express the general desired outcome from IANOS implementations, which are oriented to the energy transition and to graduated change of the energy network into a smart grid. Reaching the quantifiable objectives, set by the aforementioned PSIs, means that the project has been successfully implemented and its overall goals have been accomplished.

Although the evaluation of the PSIs is easier by selecting similar KPIs, many difficulties appear in the assessment procedure when the KPIs list is large. For facilitating the evaluation process, we defined some of the PSIs separately (their definition and the target value) and for the rest we determined the correspondence with the KPIs. In addition, 5 new PSIs concerning certain Use Case objectives and dealing with the success of the project itself, have been added in this 3rd version.

Table 13 summarizes the entire set of the PSIs, along with specific target values. There are two main categories of PSIs. First, the PSIs that directly correspond to relevant KPIs are presented. In addition, the PSIs that are not directly linked to the selected KPIs are presented. These PSIs should be monitored separately from the KPIs.

Table 13 Project Success Indicators (PSIs)

IANOS PSIs			
IANOS PSI	**Reduced Fossil Fuels consumption**	**Linked KPI**	Fossil Fuels consumption savings
Target value	379.7 GWh/y (in total for both LH islands)		
IANOS PSI	**Total GHG emissions savings**	**Linked KPI**	Reduced Greenhouse Gas Emissions
Target value	88.4 ktons CO2eq/y (in total for both LH islands)		

IANOS PSI	**RES Utilization**	**Linked KPI**	KPI 4.1.1 RES Generation
Target value	83.6 GWh/y (in total for both LH islands)		
IANOS PSI	**System Average Interruption Frequency Index (SAIFI)**	**Linked KPI**	System Average Interruption Frequency Index (SAIFI)
Target value	<1.5 interruptions/year		
IANOS PSI	**System Average Interruption Duration Index (SAIDI)**	**Linked KPI**	System Average Interruption Duration Index (SAIDI)
Target value	<2.5 hours/year		
IANOS PSI	• **Batteries storage** • **Thermal storage** • **V2G storage** • **Electrolyser/hydrogen storage**	**Linked KPI**	Storage capacity of the island's energy grid per total island energy consumption
Target value	• Batteries storage (Terceira 15MW;10.5MWh// Ameland: 2.8MW; 3.13MWh) • Thermal storage (Terceira: 0.2MW, 0.1MWh// Ameland: 0.1MW, 0.3MWh) • V2G storage (Terceira 0.1MW;0.1MWh// Ameland: 0.3MW) • Electrolyser/hydrogen storage (Terceira 0// Ameland: 2MW;80MWh)		
IANOS PSI	**Reduced energy curtailment of vRES**	**Linked KPI**	Reduced energy curtailment of RES and DER
Target value	<2%		
IANOS PSI	**Total net energy needs covered by RES**	**Linked KPI**	RES Generation
Target value	Terceira: 70%, Ameland: 11.8%		
IANOS PSI	**Increase self-consumption**	**Linked KPI**	Increase of degree of energetic self-supply by RES
Target value	5%		
IANOS PSI	**Pay-back period of IANOS solutions**	**Linked KPI**	Payback period
Target value	<9 years, many of the solutions have a PB period even <7 years		
IANOS PSI	**Reduce energy bills of end users**	**Linked KPI**	Reduction of average electricity price for companies and consumers
Target value	>15%		

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IANOS PSI	**Increased hosting capacity for vRES without affecting overall system stability**	**Linked KPI**	Increased hosting capacity for RES, electric vehicles and other new loads
Target value	>29%		
IANOS PSI	**Increase accuracy of vRES forecasts**	**Linked KPI**	Accuracy of energy supply and demand prediction
Target value	10%		
IANOS PSI	**•Reduction of residual waste (of hospitality businesses) using reverse collection (40%) •Decrease the amount of household sewage by feeding it into the digester (60%)**	**Linked KPI**	Reduction in the amount of solid waste collected
Target value	40% and 60% respectively		
IANOS PSI	**Total investments by the end of the project**	**Linked KPI**	Total investments
Target value	182M€ (121.6M€ (LHs)+60.4M€ (FIs))		
IANOS PSI	**Increased system flexibility from the demand side**	**Linked KPI**	Increase system flexibility for energy players
Target value	>9%		
IANOS PSI	**Increased system stability**	**Linked KPI**	Increased reliability
Target value	6-12%		
IANOS PSI	**New jobs generated by IANOS**	**Linked KPI**	Increase of Local job creation
Target value	>482		
IANOS PSI	**Increase accuracy of vRES forecasts**	**Linked KPI**	Accuracy of energy supply and demand prediction
Target value	>10%		
IANOS PSI	**Number of ancillary and other energy services offered**	**Linked KPI**	-

Target value	>2		
IANOS PSI	**Social compatibility - number of end-users that are positive about how energy systems are controlled**	**Linked KPI**	-
Target value	>90%		
IANOS PSI	**Potential of IANOS solutions to be scaled and replicated**	**Linked KPI**	-
Target value	Likert Scale 4.0/5.0 (No replication potential – 1 — 2 — 3 — 4 — 5 — Very high potential/the solutions can easily be replicated)		
IANOS PSI	**Performance on processing complex energy system**	**Linked KPI**	-
Target value	Likert Scale 4.5/5.0 (Very low – 1 – 2 – 3 – 4 – 5 Very high performance)		
IANOS PSI	**Reduce the need for fertilizer using digestate produced by the anaerobic digester**	**Linked KPI**	-
Target value	10%		
IANOS PSI	**Smart solutions can improve some key quality-of-life indicators**	**Linked KPI**	-
Target value	10-30%		
IANOS PSI	**Increase membership of the local cooperatives in the two LH islands**	**Linked KPI**	-
Target value	25%		
IANOS PSI	**Enabling a community of prosumers to be fully autonomous and dynamic in terms of formation and transactions**	**Linked KPI**	-
Target value	Terceira: 40, Ameland: 335		
IANOS PSI	**Participants (prosumers/consumers) involved in LECs by the end of IANOS**	**Linked KPI**	-

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Target value	Terceira: 300, Ameland: 600		
IANOS PSI	**Increase on energy self-consumption from behind-the-meter assets**	**Linked KPI**	-
Target value	>12%		
IANOS PSI	**Existence of a decarbonization roadmap for the transport sector**	**Linked KPI**	-
Target value	Likert Scale, 4.0/5.0 (No decarbonization plan – 1 – 2 – 3 – 4 – 5 – A clear roadmap defines the decarbonization pathways for the transport sector)		
IANOS PSI	**Analysis of decarbonization options for transport sector**	**Linked KPI**	-
Target value	Likert Scale, 4.0/5.0 (Very limited analysis on e-mobility and alternative fuels options – 1 – 2 – 3 – 4 – 5 – Detailed analysis and feasibility/viability assessment of all decarbonization options)		
IANOS PSI	**Assessment of the potential of other waste streams**	**Linked KPI**	-
Target value	Likert Scale, 4.0/5.0 (No utilisation of remaining waste streams – 1 – 2 – 3 – 4 – 5 - Very high level of remaining waste streams' valorisation for green energy production)		
IANOS PSI	**Participation in DSM programs**	**Linked KPI**	-
Target value	Likert Scale, 3.0/5.0 (Communities not involved – 1 – 2 – 3 – 4 – 5 – Very much involved: Involvement of energy community members in local DSM programs via provision of power consumption monitoring services and KPIs feedback)		

5 Conclusions

The aim of this deliverable was to define a KPI list that serves the requirements and objectives of the IANOS project, both for the LH islands as well as the fellow ones. Towards this scope, eight steps were followed:

1. Literature review was performed for on-going projects (e.g., SMILE, INSULAE, POCITYF), smart-grid initiatives (SCIS, BRIDGE etc.) as well as relevant publications that led to an extensive initial pool of relevant KPIs.
2. Following the SGAM architecture of BRIDGE, five KERs (Key Exploitable Results) were defined considering the IANOS objectives and needs, which correspond to the five layers of SGAM (business, function, information, communication and component): i) Energy initiatives for community owned and individual prosumers investments, ii) Services for system and local flexibility, iii) Various modules integrated in the VPP platform, iv) Communication protocols for the exploitation of the data and v) Demand and Supply Hardware.
3. These KERs were the basis for selecting the seven KPI domains (taking feedback also from other projects): Technical, Environmental, Economic, ICT, Social, Governance and Propagation, in which each KPI is categorized.
4. Apart from the definition of the KPI domains, the relevant stakeholders were also identified with the coordination of the project manager (EDP): Energy Utilities/DSOs/TSOs, Consumers (end-users)/Prosumers, Technology and Services Providers, Policy-making Bodies and Governance, Representative Citizen Groups/Citizens.
5. In the 2nd version of the deliverable the districts of each LH island have been defined with feedback from both LH managers.
6. The KPI pool was sent to the LH managers and TT Leaders and was assessed based on five (5) criteria: relevance, availability, measurability, reliability, familiarity (proposed by the CIVITAS framework). The KPIs with a score higher than 7 form the final KPI list.
7. Formation of the KPI cards for each KPI, which includes information about its calculation methods (formulas), the aggregation/clustering levels (temporal, spatial, Transition Track-linked, Use Case-linked), initial

recommendations for data collection and measurement methodologies, the relevant stakeholders, the KPI owner and the target value as well as in which FIs they will be estimated as part of the replication studies (WP9).

8. Finally, the PSIs that were defined during the Grant Agreement stage are presented. Several PSIs are linked with relevant KPIs. Also, the PSIs that are not linked with any KPIs are presented as well along with their target values. In the 3rd version, 5 new PSIs were defined and included in the IANOS framework.

The KPIs defined in this deliverable are related to many tasks of the project, such as: Task 7.1 and 7.2 regarding the technical, social and environmental assessment of the project. In addition, through the monitoring platform that will be developed in the context of Tasks 5.4 and 6.4, the measurements from the connected devices will be utilized for the calculation of the KPIs. Moreover, the defined KPIs will be utilized by Task 3.1 and 3.3 to develop a tool that evaluates the overall benefits expected from smart grid interventions. Finally, there is a link of this deliverable with the activities of WP 8 (Energy Cooperatives and Stakeholders Engagement Participant) and the Task 4.6 (Virtual Energy Console).

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