ReDREAM
change your energy

D1.2

Report on buildings performance aligned with the SRI and KPIs

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[1] PU = Public
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Review

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Summary

ReDREAM Project

The energy transition is one of the key challenges of our time but along with its complexities brings opportunities for all stakeholders and opens the door for the participation of new ones. Fostered by the EU and National regulations, the European energy sector is changing at a dramatic speed. The decentralization of generation along with the digitalization of grids and assets are opening a new scenario in which customers play a central and active role; be it directly, as prosumers or energy communities or indirectly, through aggregators, customers can participate in the electricity markets, providing flexibility and energy while optimizing the use of their assets.

The activation of the Demand Side Flexibility (DSF) potential of buildings is of crucial importance to support the decarbonization of the energy system. Thanks to smart appliances and proper control of the installed Decentralized Energy Resources (DERs), buildings are able to adjust their consumption, generation, or storage capabilities responding to the needs of the customers and the energy system, thereby enhancing their energy efficiency, reducing their carbon emissions and positively impacting on system efficiency. As an additional benefit, the smart flexible buildings represent an important mechanism to drive customers' engagement in the energy transition.

The EU-funded ReDREAM project aims to enable this effective participation of consumers and prosumers in the energy market developing a user-centred energy ecosystem based on a new service-dominant logic, where energy and non-energy services are provided. This will lead to the establishment of a new concept: a connected user-centred energy ecosystem.

Summary of Deliverable

How effective will ReDREAM be?
How can we measure the project's actual impact and assess its benefits?
How well is ReDREAM aligned with the EU regulation, the SRI in particular?

These are the core questions that drove the work conducted in Task 1.2 and whose results are presented in this deliverable. Indeed**, this document represents a cornerstone for assessing the ReDREAM success,** as its main goal is the definition of the project's Key Performance Indicators (KPIs), its alignment with EU regulation and particularly with Smart Readiness Indicators (SRI). For a complete overview, D1.2 shall be read along with D1.1 and D1.3 for the social and the legal KPIs, respectively.
As for consolidated best practice, the project's results will be measured through Key Performance Indicators. KPIs are a crucial tool to monitor the projects' performances and provide knowledge of the benefits that decentralization and digitalization can bring to both customers and the energy system, thanks to the proper use of smart technologies in buildings through the action of ReDREAM.

The analysis of the ecosystem characteristics led to the identification of the key features and impact areas of the project, guiding the following research on the indicators. KPIs have been defined taking inputs from a literature review and the analysis of the relevant European regulations and Directives and adapting them to the characteristics of ReDREAM.

First of all, using smart technologies, the ecosystem developed in the project directly impacts buildings enhancing their interactions with the grid and their efficiency, while informing and improving the comfort level of occupants. Therefore, from the very beginning it was clear that a specific regulated

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parameter was suitable to be exploited as KPI for the project: the Smart Readiness Indicator, introduced in the revised Energy Performance of Buildings Directive (EPBD)[1].

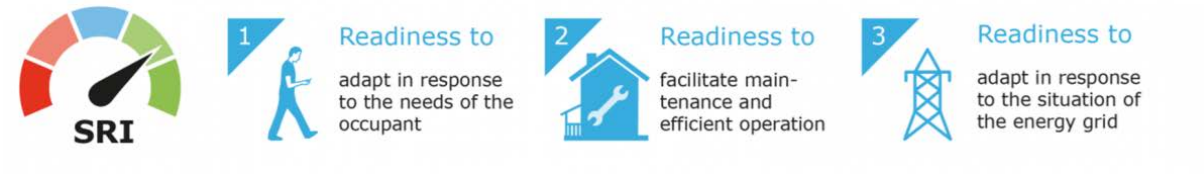

Figure 1: SRI Key Functionalities. Source: VITO

Despite its suitability, the SRI presented some criticalities since, during the development of this study, the indicator was not yet fully translated into national regulations. To overcome the issue, the SRI regulatory framework has been studied, and the relevant developments have been followed throughout the duration of the Task. The outcome of this study has been the creation of a first Excel tool to be integrated into the platform for carrying out basic SRI self-assessments in all buildings and building units of the project and studying the impact of the ecosystem on them and on the indicator itself.

The methodology followed to develop this tool follows the EPBD delegated[2] and implementing[3] acts and is completed by the indications and results of the technical study[4] on which these acts were based. The SRI tool is a starting point and will be evolved during the project, to both align it to any national methodologies that could be defined in the coming months, and to propose an alternative calculation method based on actual performance metrics. Nevertheless, the Excel tool allows to obtain results for each building and predict or assess the influence of ReDREAM on this indicator. As a consequence, two SRI-related KPIs have been designed to properly monitor the impact, namely:

Code	Name
SRI1	SRI Increase / decrease - Building
SRI2	SRI Variation - Building

Table 1: SRI-related KPIs

In addition to the SRI, and to complement it, a series of existing and new KPIs have been identified and developed to cover in detail all the relevant impact areas of the project. These KPIs have been grouped into seven different categories, namely:

[1] Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018.
[2] COMMISSION DELEGATED REGULATION (EU) 2020/2155 of 14 October 2020
[3] COMMISSION IMPLEMENTING REGULATION (EU) 2020/2156 of 14 October 2020
[4] FINAL REPORT ON THE TECHNICAL SUPPORT TO THE DEVELOPMENT OF A SMART READINESS INDICATOR FOR BUILDINGS, June 2020

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Once defined the first draft list of KPIs according to the project's needs and characteristics, each KPI category has been developed by the contributors of the Task, according to the specific area of expertise. As a final step, all KPIs have been reviewed and selected throughout a poll circulated among all the contributors, to obtain a final list that has been incorporated in a dedicated Excel file (named *ReDREAM Tech KPIs Library*) for better usability.

A selection of KPIs for each category is shown in Table 1 on the next page. The complete list of KPIs can be found in the Excel *ReDREAM Tech KPIs Library* accompanying the document.

Category	Code	Name
Flexibility	F1	Energy mobilized through DR
	F2	Flexible energy despatched
	F3	Flexible energy offered
	F4	Maximum flexible capacity offered
	F5	Flexible capacity contracted
	F6	Precision for flexibility capacity analysis
	F8	Available flexible capacity
	F9	Decrease in failure rate in flexibility capacity of the grid
	F10	Distribution grid investments avoidance or deferral due to the use of flexibility
	F11	Increased RES and DER's hosting capacity
	F12	DSF despatched/contracted in each market
	F14	Mean DSF revenue (energy)
	F18	Growth of assets used for DSF
	F20	Most obedient equipment typology for flexibility provision
Renewables	R1	Energy activated coming from RES in DEMOs
	R2	RES generation
	R3	Self-consumption rate
	R4	RES energy export
	R5	Energy export/import ratio
	R6	Connected RES
	R8	Share of renewable electricity on the final consumption
Environmental Impact	EI1	GHG emissions
	EI2	GHG emissions savings
	EI4	GHG emissions per square meter
	EI5	Avoided emissions thanks to RES self-consumption
Energy Efficiency and Performances	EP1	Electricity use intensity
	EP2	Primary Energy Use of electricity
	EP3	Load factor
	EP4	Electricity cost index (bill)
	EP6	TD Electricity Consumption
Comfort and Health	CH1	Predictive Mean Vote (PMV)
	CH2	Predicted Percentage of Dissatisfied (PPD)
	CH4	Comfort zone
	CH6	Frequency of Visual Comfort (FVC)
	CH7	CO2 Concentration
	CH8	PM Concentration
Economic	EC1	Estimated ROI –Return on Investment- for the REDREAM ecosystem
	EC2	PBT - Pay Back Time
	EC3	IRR - Internal Rate of Return
	EC7	WACC - Weighted Average Cost Capital
	EC8	SRoI - Social Return on Investment
	EC12	Life-cycle cost of electrical energy generation
Technology and Services	T1	N. of services combining EE with other energy services, technologies and non-energy benefits
	T2	N. of services developed to predict energy patterns
	T3	Decrease of error in predictability of consumption
	T5	Accessibility of third parties

Table 2: Selection of KPIs - All categories

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In parallel to the aforementioned detailed KPIs, a shortlist of indicators with a broader scope has been designed. These so-called "High-Level KPIs" are defined mirroring the expected "Impacts" of the project identified in the GA and are calculated combining a selection of the aforementioned detailed KPIs and the SRI, through appropriate weighting factors. Thereby, they allow to grasp in a summarized way the effect of the whole project on the key areas targeted, comparing results in a developed scenario (Research and Innovation) with respect to a reference scenario (or Business as Usual). For the calculation of some High-Level KPIs, also Social KPIs identified in Deliverable 1.1 are included. Table 2 offers a summary of the KPIs.

Code	High-Level KPI Name	Associated KPIs
HL1	Increased use of demand response across the European energy system	F1
		F5
		F8
		F18
HL2	Demonstrated and improved viability of innovative energy services, best practices and effective incentives that can be replicated at large scale	EC1
		S.2.10
		EC2
HL3	Increased uptake of services that combine energy efficiency with other energy services, technologies and non-energy benefits	T1
		S.2.11
		CH2
		CH6
		CH7
		CH8
HL4	Increased reliability of innovative energy services and accessibility to them	F6
		F18
		T5
HL5	Increased predictability of consumption patterns and consumer behavior	T2
		T3
HL6	Improved modelling of the flexibility levers from the new energy services	F9
		F10
HL7	Increased share of energy or power that can be mobilized to provide flexibility to the grid and increase the hosting capacity of RES	F11
		R1
		F8
HL8	Environmental Impacts	EI2
		R8
		EP2
HL9	Average Smart Readiness Indicator variation – High Level	SRI2 (of each building)

Table 3: High-level KPIs and associated detailed KPIs

To sum up, this document is **the baseline reference for assessing ReDREAM's achievements** and it will evolve with project development. Indeed, in the following steps of the project, all the KPIs and the SRI calculation methodology will be tested, thanks to continuous progress monitoring in the SRI national legal framework and through a proper testing process. This will allow adjusting and further developing ReDREAM KPIs and SRI calculation methodology, where necessary to guarantee the best possible evaluation system.

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Table of acronyms

Acronyms	Description
BAU	Business As Usual
CIVI	CIVIEsco
Del.Reg.	Delegated Regulation
DER(s)	Distributed Energy Resource(s)
DR	Demand Response
DSF	Demand Side Flexibility
ED	Electricity Directive
EED	Energy Efficiency Directive
EPBD	Energy Performance of Buildings Directive
GA	Grant Agreement
HL KPI	High-Level Key Performance Indicator
Imp.Reg.	Implementing Regulation
KPI(s)	Key Performance Indicator(s)
MS	Member State
NTUA	National Technical University of Athens
PD	Project Description
RED	Renewable Energy Directive
R&I	Research and Innovation
RES	Renewable Energy Sources
SRI	Smart Readiness Indicator
T1.2	Task 1.2
TD	Technical Domain
VITO	Vlaamse Instelling voor Technologisch Onderzoek
WP	Work Package

Table 4: Table of Acronyms

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Table of Contents

Index

Technical References **2**

Review 3

Document history 4

Summary **6**

ReDREAM Project 6

Summary of Deliverable 6

Table of Contents **11**

List of tables **13**

List of figures **14**

1 Introduction **15**

1.1 ReDREAM 15

1.2 Work Package 1 15

1.3 Objectives of the report 15

1.4 KPIs and SRI in the context of ReDREAM 16

2 Methodology **17**

2.1 Work Process 17

2.2 Guiding principles for the indicators' definition 18

Research and alignment 19

3 Smart Readiness Indicator **20**

3.1 Introduction and regulatory background 20

3.2 Calculation methodology 23

3.2.1 Explanation 23

3.2.2 Weighting factors and smart ready services catalogue 25

3.3 Integrating the SRI in ReDREAM 26

3.3.1 Calculation of the SRI and use as a KPI 26

4 Other technical Key Performance Indicators **29**

4.1 KPIs classification and selection 29

4.2 Excel file structure 30

4.3 KPIs list 31

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°957837

4.3.1 Flexibility KPIs 31
4.3.2 Renewables KPIs 34
4.3.3 Environmental Impact KPIs 37
4.3.4 Energy Efficiency and Performance KPIs 38
4.3.5 Comfort and Health KPIs 40
4.3.6 Economic KPIs 41
4.3.7 Technology and Services KPIs 42
4.4 Final remarks 43
4.4.1 Notes on definitions and conventions 43
4.4.2 Notes on results' interpretation 44
5 High-Level KPIs 45
5.1 Introduction 45
5.2 Calculation methodology 46
5.3 High Level KPIs tables 47
6 Conclusions and next steps 52
7 Bibliography 54
ANNEX I: KPIs 56
KPIs related to HL KPIs: 56
Other detailed KPIs: 66

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°957837

List of tables

Table 1: SRI-related KPIs 7
Table 2: Selection of KPIs - All categories 8
Table 3: High-level KPIs and associated detailed KPIs 9
Table 4: Table of Acronyms 10
Table 5: SRI-related KPIs - Building 27
Table 6: Selection of Flexibility KPIs 34
Table 7: Selection of Renewables KPIs 36
Table 8: Selection of Environmental Impact KPIs 38
Table 9: Selection of Energy Efficiency and Performances KPIs 40
Table 10: Selection of Comfort and Health KPIs 41
Table 11: Selection of Economic KPIs 42
Table 12: Selection of Technology and Services KPIs 43
Table 13: High-Level KPIs 46
Table 14: HL KPI calculation methodology - Steps 46
Table 15: HL1 47
Table 16: HL2 48
Table 17: HL3 48
Table 18: HL4 49
Table 19: HL5 49
Table 20: HL6 49
Table 21: HL7 50
Table 22: HL8 50
Table 23: HL9 51

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°957837

List of figures

Figure 1: SRI Key Functionalities. Source: VITO 7
Figure 2: Scheme of the work process 17
Figure 3: SRI Key Functionalities. Source: VITO final technical study 21
Figure 4: SRI calculation methods. Source: VITO final technical study 22
Figure 5: SRI Technical domains. Source: VITO final technical study 23
Figure 6: SRI Impact criteria. Source: VITO final technical study 23
Figure 7: Detail of an example of non-official simplified Catalogue. Source: own elaboration 24
Figure 8: SRI calculation methodology scheme. Source: own elaboration 24
Figure 9: Smart readiness rating determination. Source: own elaboration 25
Figure 10: Scheme of required steps for SRI calculation using the Excel tool 27
Figure 11: Example of ReDREAM Tech KPIs Library table - Details: Generalities 30
Figure 12: Example of ReDREAM Tech KPIs Library table - Details: Scale and Overlaps 30
Figure 13: HL KPI calculation methodology - Flowchart 47

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°957837

1 Introduction

1.1 ReDREAM

The ReDREAM project aims to effectively move the participation of consumers (residential, commercial, and industrial) to the centre of the energy system, thanks to an open and co-creative ecosystem where all stakeholders will actively interact. This ambitious challenge will require the collection of demand response tools and services (energy and non-energy) capable of enabling the capacity for the consumers of participating in the energy market through an improvement of predictability of consumption patterns and consumer behaviour. A new solution based on an open co-creative energy ecosystem built upon a new paradigm where the user gives the value will centralise the portfolio of innovations to develop this new paradigm.

1.2 Work Package 1

The project foresees a structure of nine work packages, all closely related to each other. The basics of the work are laid down in Work Package 1 (WP1), named "Boundaries and definition of a customer-centric model".

This WP aims to create the ground for the development of the customer engagement methodology, based on a consumer-centric approach, and define the framework of the ecosystem. Specifically, WP1 analyses the alignment between the consumer-centric model and the proposed SDL paradigm, along with the consumer engagement strategies and EU policy. In addition, it includes the study of IT and energy requirements for the development of the embedded tools and services. To achieve these goals, WP1 is divided into six Tasks.

Task 1.2 (T1.2), whose deliverable is here presented, focuses on the definition of the projects' Key Performance Indicators (KPIs) - excluding the social KPIs (Task 1.1) and regulatory KPIs (Task 1.3) - and the alignment with the Smart Readiness Indicator (SRI).

1.3 Objectives of the report

This report intends to present the results and justify the principles followed during the analysis conducted in T1.2 to define the most appropriate Key Performance Indicators for ReDREAM and to align and prepare the ecosystem for the integration of a new regulated certification, the Smart Readiness Indicator.

Specifically, Chapter 2 will explain the methodology followed for the research, identification, development and final integration of the indicators in the ecosystem. Chapter 3 will be fully dedicated to the SRI, from the regulatory background to the calculation methodology and the proposed integration path into the ecosystem. Chapter 4 will present all the other KPIs defined and Chapter 5 the next steps and possible ways forward.

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1.4 KPIs and SRI in the context of ReDREAM

Key Performance Indicators need to be designed mirroring the project's goals in order to keep under control the status, gather information and bring new knowledge useful for research progress.

Therefore, the KPIs are a crucial tool to monitor the impact of ReDREAM on buildings, but also customers and entire communities, from the energy, economic, environmental and comfort point of view. Moreover, they allow showing the positive effect of engaging final customers in the electricity system making them active participants of the energy transition, through the smart use of their distributed energy resources (self-generation, energy storage, loads for Demand Response, EV charging infrastructures, etc.) and their buildings as a whole.

Buildings and customers' assets represent an important resource thanks to their Demand Side Flexibility (DSF) potential that, if exploited, can provide services to the grid participating in the electricity markets. The ReDREAM ecosystem, thanks to its smart technologies and the energy and non-energy services offered, aims to unlock this hidden potential and to make the best of what is available in every DEMO, creating a positive impact not only for the single customer or building but also for the entire system.

As a result, from the beginning of the Task, it has been clear that the KPIs needed to have a broader scope than buildings' performances and describe the interactions with the grid along with the ecosystem's influence on customers. Consequently, the goal of the Deliverable, even if always kept in line with what presented in the Grant Agreement (GA), had to be redirected to the definition of a wider list of KPIs that could embrace all the relevant impact areas of the ReDREAM ecosystem (excluding the social and regulatory areas covered by other Tasks) and provide a comprehensive set of information that could be useful for a large number of stakeholders.

At the basis of the work, there has been a selection of mandatory KPIs defined in the project description, which has been useful to define the impact areas under which to classify and develop the KPIs. Starting from this first shortlist, thorough literature research has been conducted to identify existing parameters and gather inputs for the creation of new ones. Among the provisions of the EU regulations and directives, particular importance has been given to the Smart Readiness Indicator a parameter introduced in the revised Energy Performance of Buildings Directive (EPBD)[1]. Covering not only energy savings but also flexibility and response to user needs, this indicator promised from the start to be an ideal tool to rate the effects of an ecosystem such as the one of ReDREAM.

As a consequence of all the above, two parallel activities that will be thoroughly described in the next Chapter 3 and Chapter 4 have been carried out:

1. The study of the Smart Readiness Indicator and the identification of the best option for its integration into the ecosystem to use it as a detailed and specific KPI;
2. The research and development of all the other most relevant technical Key Performance Indicators, adapting the ideas coming from the literature to the characteristics of the ecosystem.

The combination of the results obtained from all these KPIs will allow to properly monitor the developments of the ecosystem and to assess its positive impact on the customers and the entire energy system.

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2 Methodology

2.1 Work Process

The process applied to obtain the results of this deliverable followed a workflow that can be schematized in the graphic of Figure 2:

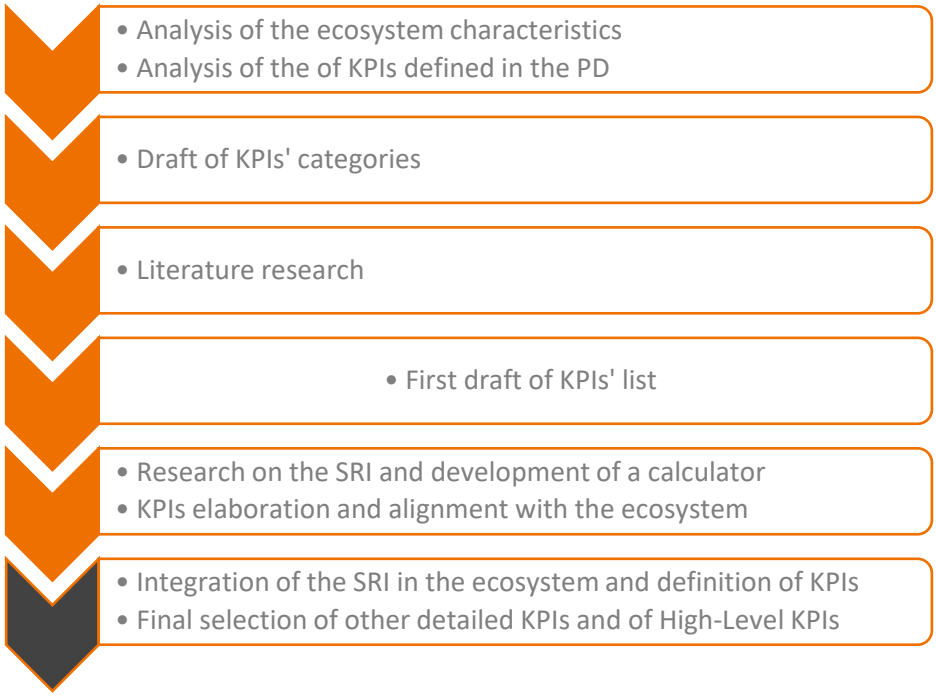

Figure 2: Scheme of the work process

The first step has been the analysis of the ecosystem characteristics and the mandatory KPIs and relative targets identified in the project description. These KPIs highlight the key areas of impact of the ecosystem, spanning from flexibility to renewable generation, environmental, and economics.

As a result of this activity, it has been possible to lay the foundation of the work identifying the general categories in which to divide the KPIs and the key areas of impact of the project, namely: Flexibility, Renewables, Environmental Impact, Energy Efficiency and Performances, Comfort & Health, Economics, and Technology & Services.

In this second step, it came out the necessity for the indicators to have a wider scope than the single buildings or their performances -despite their importance remains central in the project- since the effects of the ecosystem go beyond this horizon.

The third step that followed this initial classification has been a thorough literature research. Starting from a selection of European regulations and Directives, the most appropriate sources of information have been selected for each of the identified categories and key areas of impact. This process, combined with the analysis of the ecosystem characteristics, led to the creation of a first draft list of Key Performance Indicators and to the confirmation of the relevance of the SRI as a regulated parameter to be included in the ecosystem, taking it as a separate top-level KPI.

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Consequently, two parallel work streams were created. On one hand, deeper research on the SRI regulatory framework and calculation methodology has been conducted. This led to the creation of an Excel tool that can be used as a basic SRI calculator. This tool aims to integrate the SRI in the ecosystem from the start and allows the calculation of two SRI-related KPIs; furthermore, the tool is a basic framework that will be evolve during the following steps of the project. This evolution will be explained in more detail in the chapter dedicated to the SRI (Chapter 3).

On the other hand, it has been conducted a thorough analysis aimed to elaborate and adapt the identified KPIs, assessing their applicability to -and consistency with- the ecosystem characteristics. This activity included the definition of the most appropriate calculation methodology for each KPI, considering the input data available. Once all the KPIs have been designed, a selection process has been carried out, creating a poll through which experts could provide their feedback and select the most valuable KPIs. In addition, a selection of these detailed KPIs can be combined into High-Level KPIs that give a broader vision of the performances of the ecosystem on a selection of key impact areas.

2.2 Guiding principles for the indicators' definition

During the KPIs research and definition, some key principles have been followed:

- Alignment: each KPI needs to be aligned with the goals of the project and its characteristics, enclosing the areas on which the project has a clear impact;
- Attainability of the data: each KPI needs to be calculated with input data that is easily accessible or is provided by the ecosystem;
- Flexibility: KPIs need to be as flexible and adaptable as possible;
- Simplicity: KPIs need to be, when possible, simple to calculate, present and use;
- Evolution: the indicators can evolve with the development of the project. The eventuality of future changes and adaptations always needs to be considered;
- Multiple targets: KPIs should, when possible, provide information on the project results that are useful for different stakeholders and at different levels.

The purpose of all the indicators, being either KPIs developed independently, adapted to ReDREAM, or directly inspired from the regulation such as the SRI, has always been twofold. On one hand, indicators need to show the performances of ReDREAM, providing proof of the efficacy of the ecosystem and direct feedback on the progress. On the other hand, they need to issue useful information, consistent with the purpose of the project, for a broad spectrum of stakeholders, from policymakers to final customers.

Especially for the latter category, indicators can be a useful tool to improve their engagement. Consequently, a small selection of KPIs have been designed having this parallel goal in mind and labelled as *Customers' KPIs*. Even if all KPIs can be shared with customers, this particular selection has been proposed following, in turn, some basic guidelines:

- Be easily understandable;
- Be in line with the goals and principles of the energy transition;
- Cover the aspects of greatest interest to customers.

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2.3 Research and alignment

During the research phase, the most relevant sources, from European regulations and directives to European projects and scientific papers and reports, have been identified and analysed. Regarding the European Regulations and Directives, a specific focus has been given to:

- The Energy Performance of Buildings Directive (EPBD): 2018/844/EU[1] and 2010/31/EU[5]
- The Energy Efficiency Directive (EED): 2018/2002[6] and 2012/27/EU[7]
- The Renewable Energy Directive (RED II): 2018/2001[8]
- The Electricity Directive (ED): 2019/944[9]

Once completed the research phase, the direct applicability of regulations, standards, certifications, or pre-determined KPIs has always been assessed considering the ecosystem characteristics, the input data available and the KPIs guiding principles followed. This project-alignment check has led to the exclusion of parameters or standards -for instance, the Energy Performance Certificate (EPC)- due to the non-overlap between ReDREAM impact areas and the scope of these certificates. Conversely, the Smart Readiness Indicator has been confirmed as a suitable parameter to be integrated with the ecosystem, for the aforementioned reasons.

This alignment check occurred for the definition of all indicators. Following the research process, during which inputs have been taken to define the first draft of KPIs, an assessment has been carried out to understand if direct applicability was possible or an elaboration of the KPI was necessary. For instance, it has proved necessary to avoid or adapt all those KPIs that include gas consumption, since ReDREAM can monitor and has an effect only on electricity.

As a last note, the development of specific KPIs categories, such as the Economic and Comfort & Health, has been entrusted to experts of the project Consortium, respectively CIVIEsco (CIVI) and the National Technical University of Athens (NTUA).

5 DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings (recast)
6 DIRECTIVE (EU) 2018/2002 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018
7 DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012
8 DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018
9 DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast)

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3 Smart Readiness Indicator

3.1 Introduction and regulatory background

The use of smart technologies in buildings represents an effective solution to allow their active integration into the energy system and improve at the same time their energy performances and the comfort level of occupants. This is why in recent years the European Union has increased its interest in smart buildings and the Commission included dedicated provisions in the Clean Energy Package[10].

Specifically, the EPBD[1] recognizes smart buildings as a key solution to guarantee the success of an energy system with a large share of renewables and DERs. Moreover, the Directive introduces provisions for the creation of an 'optional Common Union scheme' to rate the smart readiness of the buildings, to give a clear and simple indicator that can raise awareness and be understood by all stakeholders, from tenants to building owners and investors. This parameter is the Smart Readiness Indicator.

To define the technical details of its calculation methodology and implementation pathways, the Directorate-General for Energy (DG ENER) of the Commission instructed a consortium of VITO[11] and Waide Strategic Efficiency Europe to produce technical support studies on the establishment of the SRI. The final study[4] has been released in summer 2020 and provided inputs for the drafting of a Delegated Regulation[2] (Del. Reg.) and Implementing Regulation[3] (Imp. Reg.), published in fall 2020, completing the EPBD provisions regarding the SRI.

In the Delegated Regulation, the SRI definition and the general purposes are presented:

- Definition - **Art. 2(1):**

  'Smart readiness indicator' means an indicator that informs on the rating of smart readiness of a building or building unit […].

- Purpose – **Art. 3(1,2):**

  'The smart readiness indicator shall allow for the assessment of the capabilities of a building or building unit to adapt its operation to the needs of the occupant and of the grid and to improve its energy efficiency and overall in-use performance […]'

  and:

  '[…] shall cover features for increased energy savings, benchmarking and flexibility, and enhanced functionalities and capabilities provided by more interconnected and intelligent devices.'

The buildings' key smart readiness functionalities at the base of the SRI calculation methodology, are the following[1]:

- *The ability to maintain energy performance and operation of the building through the adaptation of energy consumption for example through use of energy from renewable sources;*

[10] https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en

[11] Vlaamse Instelling voor Technologisch Onderzoek, Flemish institute for technological research

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- *The ability to adapt its operation mode in response to the needs of the occupant while paying due attention to the availability of user-friendliness, maintaining healthy indoor climate conditions and the ability to report on energy use; and*
- *The flexibility of a building's overall electricity demand, including its ability to enable participation in active and passive as well as implicit and explicit demand response, in relation to the grid, for example through flexibility and load shifting capacities.*

Figure 3: SRI Key Functionalities. Source: VITO final technical study

It is then clear that the SRI focuses on the potential performances and interactions between buildings, occupants, and energy system. This is consistent with the declared aim of the indicator to drive towards buildings with high energy performances, flexible and fully integrated into the grid and the energy system, while reaching high levels of comfort and air quality, along with significant use of renewables. These characteristics show a clear alignment between the purpose of the SRI and the scope and goals of the ReDREAM project.

To complete the regulatory analysis and outline the characteristics and scope of this parameter, we present here a schematic summary of excerpts from the regulations considered relevant for the project and its use within it.

- The SRI is an optional scheme (Del.Reg.[2] Art. 6): each EU Member State (MS) can decide if and how to implement it or not. At the time this report is written, no MS has translated the European provisions into national law yet. Moreover, the calculation methodology defined in the implementing acts may be complemented with details defined at the national level; consequently, the complete methodologies cannot be foreseen upfront and it will be necessary to wait for the relative national legislations.

- The SRI should not be an indicator of the building's energy performances and it should complement, not substitute, existing certifications (for instance the EPC, Del.Reg.[2] recitals (8) and (9)).

- The assessment of the SRI and the issuance of the certificate should be carried out by experts (Imp.Reg.[3] recital (4). Nevertheless, a self-assessment should be possible for all interested stakeholders, even if this does not lead to an official certificate. The self-assessment can be done also through an online tool provided by the Commission.

To conclude, it is worth mentioning that the SRI will be revised in the next few years. The current version of the SRI has a checklist approach; this encountered the critics of some stakeholders, claiming the need for a more dynamic approach based on measured data and actual performances. In the VITO final technical study[4], three potential assessment procedures have been proposed, with a growing level of complexity and detail (see Figure 3 below). A simplified method (Method A), a detailed method (Method B, requiring more input data and evaluation time), and a final version (Method C) based on

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measured or metered data. This last method, despite being potentially the most accurate, has been considered only a possible evolution of the SRI and not a solution for the scope of the study, therefore for the implementing acts that followed.

A Simplified method	B Expert SRI assessment	C *In-use smart building performance*
Checklist approach with limited, simplified services list	Checklist approach, covering full catalogue of smart services	*Measured / metered data (potentially restricted set of domains)*
Online self-assessment by end-user (no certification) OR On-site inspection by third-party qualified expert (formal certification)	Online self-assessment by technical expert (no certification) OR On-site inspection by third-party qualified expert (formal certification)	*In-use buildings, metered data* *Part of the commissioning?* *TBS self-reporting their actual performance*
Up to one hour	½ day to 1 day, depending on the complexity	*Gather data over a long period (e.g. 1 year)*
Residential buildings and small non-residential building (net surface floor area < 500m²)	Non-residential buildings (and residential buildings if desired)	*Residential and non-residential* *Restricted to occupied buildings (not in design phase)*

Figure 4: SRI calculation methods. Source: VITO final technical study

In order to develop proposals for the improvements of the SRI calculation methodology and give it a more dynamic approach, a final working group of experts -called Topical group C- has been added to the study at the end of 2019. At the time of writing this report, the working group is still developing its conclusions that will feed into the discussions about the SRI evolution. The activities of the workgroup will be followed during the ReDREAM project since the ReDREAM partners have immediately identified the lack of a connection with actual performances and real data as an issue of the indicator.

Anyhow, all of the above has guided the decisions on the SRI implementation and its evolution within the project.

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3.2 Calculation methodology

3.2.1 Explanation

As anticipated, following either the simplified Method A or the detailed Method B, the proposed methodology to calculate the indicator is based on a simple evaluation procedure through a checklist process.

The methodology groups all the buildings appliances or “smart ready services” into nine “Technical domains”, shown in Figure 5:

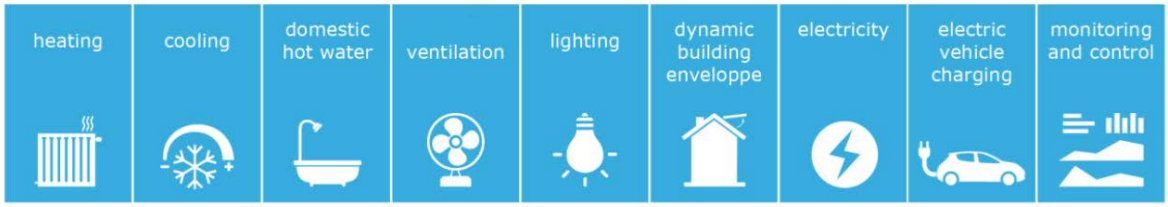

Figure 5: SRI Technical domains. Source: VITO final technical study

Each smart ready service, hence each Technical domain in which they are grouped, is considered to have an “impact” on seven sectors, called “Impact criteria”: energy efficiency, maintenance and fault prediction, comfort, convenience, health well-being and accessibility, information to occupants and energy flexibility and storage (see Figure 6).

Figure 6: SRI Impact criteria. Source: VITO final technical study

As a first step, the certifier must verify which appliances and related “smart-ready services” are present in the building. Then, using a dedicated Catalogue (see the Figure below), the certifier can determine what the “functionality level” of each service is; clearly, a higher level reflects a "smarter" implementation of the service, meaning a more beneficial impact for the building users.

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Domain	Theme	Code	Service group	Smart ready service	Functionality level 0 (as non-smart default)	Functionality level 1	Functionality level 2	Functionality level 3	Functionality level 4	part of the proposed simplified indicator	Preconditions / Dependency on other services or building types	Degree to which the functionality can be determined by inspection
Cooling	Controllability of Performance: Emission	Cooling-S1	Cooling control - demand side	Cooling emission control	No automatic control	Central automatic control (e.g. central thermostat)	Individual room control (e.g. thermostatic valves, or electronic controller)	Individual room control with communication between controllers and to BACS	Individual room control with communication and occupancy detection	1	Always to be assessed (if domain is relevant)	High but levels 3 and 4 are harder to assess
Cooling	Controllability of Performance: Production	Cooling-S2	Control cooling production facilities	Generator control for cooling	On/Off-control of cooling production	Multi-stage control of cooling production capacity depending on the load or demand (e.g. on/off of several compressors)	Variable control of cooling production capacity depending on the load or demand (e.g. hot gas bypass, inverter frequency control)	Variable control of cooling production capacity depending on the load AND external signals from grid		1	Always to be assessed (if domain is relevant)	Low
Cooling	Storage & Connectivity	Cooling-S3	Flexibility and grid interaction	Flexibility and grid interaction	No automatic control	Scheduled operation of cooling system	Self-learning optimal control of cooling system	Cooling system capable of flexible control through grid signals (e.g. DSM)	Optimized control of cooling system based on local predictions and grid signals (e.g. through model predictive control)	1	Only applicable if storage is present	
Cooling	Reporting functionalities	Cooling-S4	Information to occupants and facility managers	Report information regarding cooling system performance	None	Central or remote reporting of current performance KPIs (e.g. temperatures, submetering energy usage)	Central or remote reporting of current performance KPIs and historical data	Central or remote reporting of performance evaluation including forecasting and/or benchmarking	Central or remote reporting of performance evaluation including forecasting and/or benchmarking; also including predictive	1	Always to be assessed (if domain is relevant)	

Figure 7: Detail of an example of non-official simplified Catalogue. Source: own elaboration from https://smartreadinessindicator.eu/milestones-and-documents

For each functionality level, the catalogue provides related "scores" for each of the defined Impact Criteria. The score of each service is then aggregated at the domain level, obtaining a score for each Technical domain in relation to each Impact criteria. Then, through appropriate coefficients and weighting factors, it is possible to calculate a single score for each Impact criteria.

The Impact criteria, in turn, are grouped into three macro-categories called Key functionalities: Energy performances and operations, Response to user needs and Energy Flexibility. Hence, the methodology calculates the scores of the three Key functionalities and, finally, aggregates them in a single overall index of the SRI associated with each building.

The entire process can be summarized with the scheme of Figure 8:

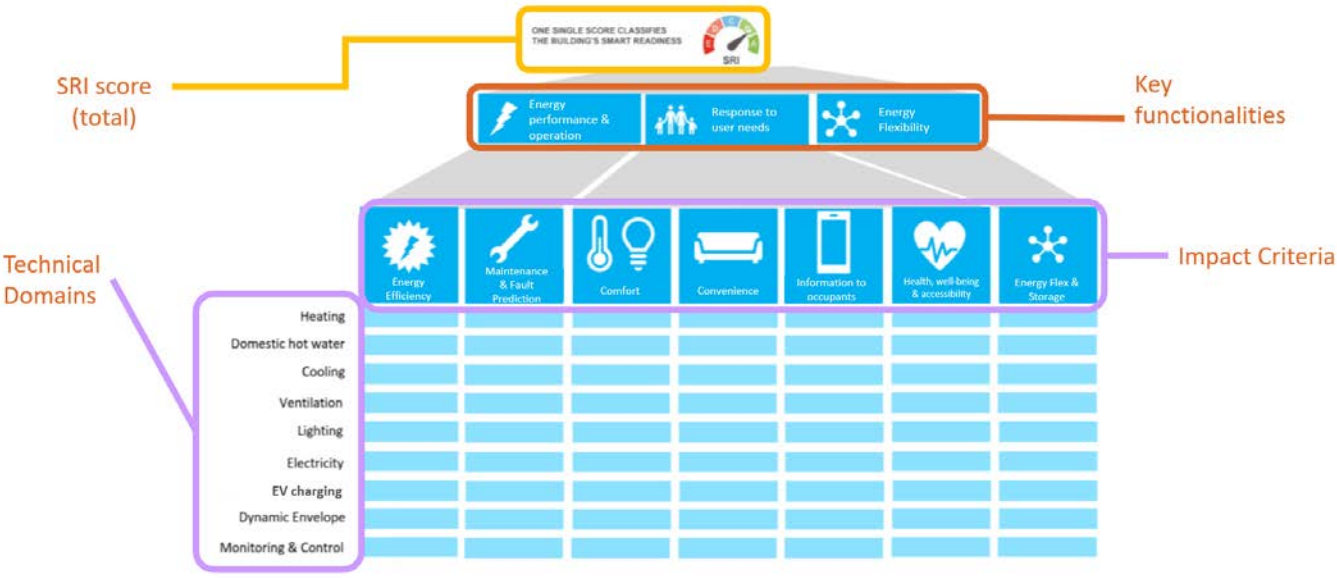

Figure 8: SRI calculation methodology scheme. Source: own elaboration from VITO final technical study

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The smart readiness of a building then is expressed by a rating that derives from a total smart readiness score which is expressed as a percentage, representing the ratio between the smart readiness of the building and the maximum smart readiness that it could reach[12] (Figure 9).

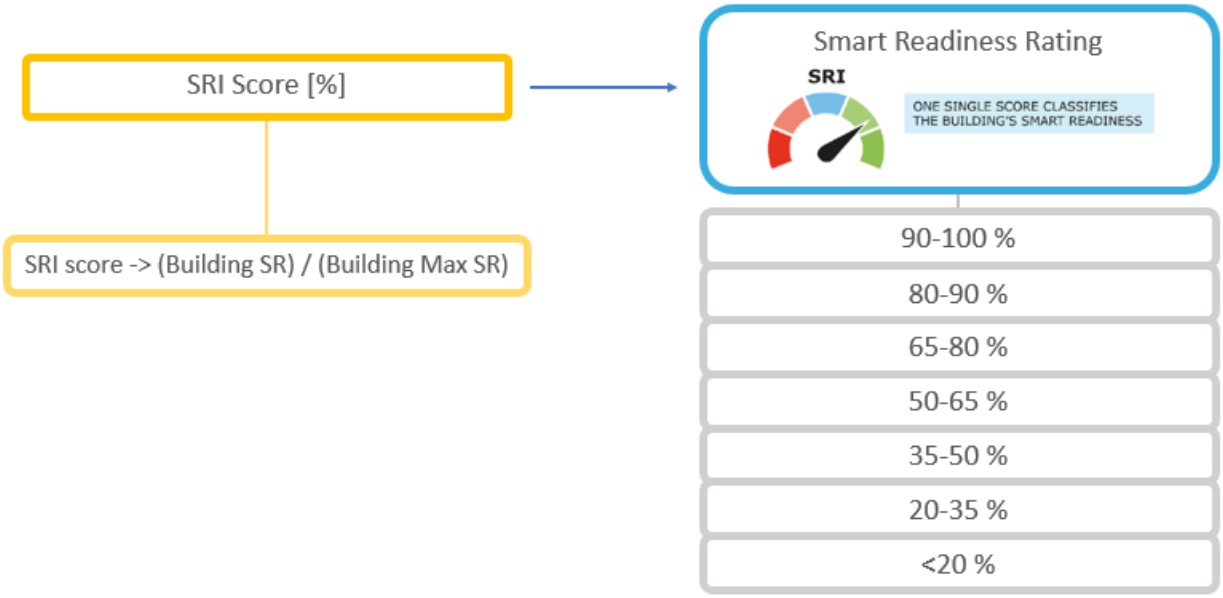

Figure 9: Smart readiness rating determination. Source: own elaboration

3.2.2 Weighting factors and smart ready services catalogue

All the final steps rely again on appropriate coefficients and weighting factors. It is then clear that the definition of these coefficients and weighting factors has a relevant impact on the final score.
Each Key functionality has an equivalent weight on the evaluation of the building's smartness index (1/3 each). However, the weighting of Impact criteria in the related Key functionalities has to be determined at the national level, hence there is a level of freedom in this regard. The VITO final technical study proposes that the weight is divided equally between the individual impact categories of which each Key functionality is composed, but this is still not official. In any case, it is interesting to note that the weight of the Flexibility Impact criteria on the final SRI is relatively high.

The other element that has an important influence on the final result and is not fully regulated at the EU level, is the smart ready services catalogue. Each MS has to prepare and make available its own catalogue, in line with the provisions of the relevant regulation, and this is an additional reason why we can foresee that the SRI will not be harmonized between the MS in which it will be implemented.

[12] Del.Reg. Annex I (3). The ranges in which the SRI score can land are defined in the Del.Reg. Annex VIII.

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3.3 Integrating the SRI in ReDREAM

Following the regulatory analysis, it has been clear that the ReDREAM ecosystem is aligned with the scope and purpose of the indicator. The SRI's "Impact criteria" reflect the declared impact areas and the key goals of the project. Moreover, the SRI gives the unique possibility from a regulated indicator to take into account the assets' flexibility, one of the cornerstones of the ReDREAM ecosystem. Consequently, it has been decided to use this indicator as defined in the regulation and focus on its proper integration in the project to exploit it as a meaningful KPI.

The regulatory and literature analysis that has been carried out, guided the decisions for the modalities and the path of the SRI integration in ReDREAM. As anticipated, at the time of writing this report the SRI has not been implemented at the national level yet. This has excluded the possibility to integrate with the ecosystem the real calculation methodology applied in each of the MS where the project DEMOs are located, at least in the first stage of the project, since it has also not been possible to base a calculation methodology or do assessments using official smart ready service catalogues or weighting factors.

As a result, the partners decided to follow a two-phase approach:

- First phase: Design a basic self-made version of the SRI to be used as a separate metric in all the DEMOs, following the European regulation available and the guidelines of the VITO final technical study. This first phase has been carried out within this Task 1.2 and is described in the following subsection 3.3.1.

- The second phase will be divided into two parallel workstreams and will be carried out in the next Work Packages of the project:
    - Update the SRI applied methodology when (and if) national legislations will be released during the prosecution of the project. This activity entails following the national implementation process.
    - Develop the SRI proposing a more dynamic methodology making the most of the capabilities of the ReDREAM ecosystem. In this phase, inputs will be taken following any eventual indication of the Topical group C or evolution of the European legislation.

3.3.1 Calculation of the SRI and use as a KPI

An SRI Excel tool has been created to allow the ecosystem and its users to conduct a self-assessments of the smart readiness of the buildings and building units.

The tool is based on the official calculation methodology presented in the Del.Reg.[2] (Annex I) and relies on the simplified catalogue accompanying the technical study[13] and the weighting factors there proposed. The simplicity of this first calculator allows an agile use and a fast assessment.

All the actions needed to for the assessment of the SRI can be easily undertaken in the Excel since the catalogue, complete with the list of weighting factors (that vary according to the buildings' type and location), is included.

[13] https://smartreadinessindicator.eu/milestones-and-documents

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The following chart schematizes the steps that are required to the user for the SRI calculation:

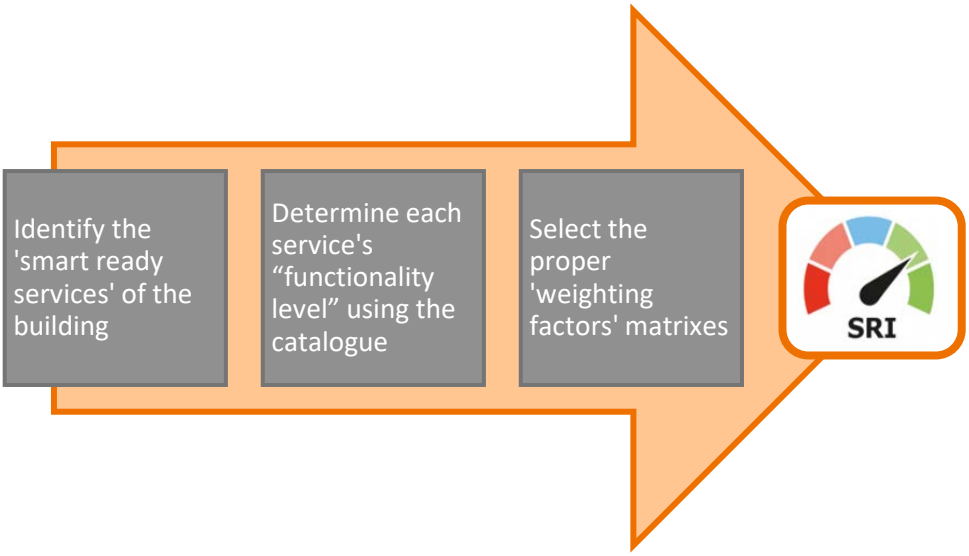

Figure 10: Scheme of required steps for SRI calculation using the Excel tool

The SRI, calculated for each building site through the Excel tool, represents an indicator of the impact of ReDREAM and its smart services on each single building.

Comparing the values of the SRI ahead of the implementation of the ecosystem (reference scenario, SRI_{ref}) and after (final scenario, SRI_{end}), it is possible to assess or predict the effect of ReDREAM technology on the potential buildings' performances and smartness, monitoring its variation. Consequently, two specific KPIs have been introduced with this purpose:

Code	Name	Description	Unit of measure	Calculation / Formula
SRI1	**SRI Increase / decrease - Building**	Difference between the final value of the SRI (after the implementation of the ecosystem and its smart technologies) and the initial value of the SRI of the building (reference, before the implementation of the ecosystem). A positive value shows an SRI increase thanks to ReDREAM.	[%]	$\Delta_{SRI} = SRI_{end} - SRI_{ref}$ Where: $SRI_{ref/end}$: initial and final values of SRI of the building / site
SRI2	**SRI Variation - Building**	Percentage variation of the SRI from the initial value (reference, before the implementation of the ecosystem) to the final value of the building (after the implementation of the ecosystem and its smart technologies). A positive value shows an SRI increase thanks to ReDREAM.	[%]	$SRI_{var} = \left(\frac{SRI_{end} - SRI_{ref}}{SRI_{ref}}\right) x100$ Where: $SRI_{ref/end}$: initial and final values of SRI of the building / site

Table 5: SRI-related KPIs - Building

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The use of the SRI in the project has also the additional benefit to introduce to the customers this new parameter, which can be beneficial to improve their awareness and engagement since the indicator can prove the positive effects of the project on buildings and building units even before the actual installations of the assets, predicting what assets will change and how.

In any case, the SRI Excel calculator will be the base on which to build up the more sophisticated versions of the SRI methodology foreseen for the second phase. The other technical KPIs presented in the next Chapter 4 can be used to provide the actual performance data that are needed to develop a more dynamic version of the indicator.

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4 Other technical Key Performance Indicators

In this chapter, we present all the other KPIs that have been defined in the second workstream of the Task and that will be used to monitor the development of the progress and its results along with the SRI. The results have been reported, along with the SRI-related KPIs, in an Excel file named *ReDREAM Tech KPIs Library* that contains all the information on each KPI, from its definition to the calculation methodology and the scope. In this report, only a selection of the most relevant KPIs per category will be presented, while the complete list of KPIs is the accompanying *ReDREAM Tech KPIs Library*.

4.1 KPIs classification and selection

For better usability, the KPIs list has been divided into seven different categories that mirror the key impact areas of the ecosystem, which fall within the scope of this Task, namely:

- **Flexibility:** this category groups all KPIs that have a direct relation with the provision, market participation, effects, and potential of Demand Side Flexibility.
- **Renewables:** the Renewables category contains all the KPIs useful to monitor the performances of renewables self-generation and consumption and the effects of the ecosystem actions on them.
- **Environmental Impact:** indicators to monitor the Environmental Impact in terms of greenhouse gas emissions related to electricity consumption and their improvement due to the ecosystem.
- **Energy Efficiency and Performances:** in this category, fall the typical KPIs that assess the energy performances and related costs (savings included) related to electricity consumption.
- **Comfort & Health:** customers' comfort indicators and parameters to monitor pollutants concentration.
- **Economics:** selection of typical parameters to monitor economic performances of the project; indirectly, it contains all the economic-related KPIs classified in the other categories.
- **Technology & Services:** category focused on technical aspects of the ReDREAM ecosystem, services offered and prediction precision.

Since several indicators could be classified under more than one category, in the *ReDREAM Tech KPIs Library* a dedicated column keeps track of which categories every single KPI can be related to. This is particularly noticeable for the Economic category since several 'Economic-related' KPIs are spread in the other categories as well.

Once the final list has been presented to the project partners, a selection process has been carried out in order to exclude indicators of lesser practical use, due to their high complexity or low relevance for customers' engagement. A poll has been set up to collect the feedback of the projects' experts, who rated each KPI. This process led to the exclusion of the lower-scoring ones and the adaptation and

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modification of others. The final KPIs list turned out more agile, usable and aligned with the goals of the project.

As introduced in the subchapter dedicated to the guiding principles followed for the definition of the indicators (2.2), some KPIs have been either in parallel dedicated or purposely designed to be directed to customers as well. They have been labelled *Customers' KPIs*. These KPIs needed to be in line with the goals and principles of the energy transition and the project itself but at the same time easily understandable, bringing new knowledge and catching the interest of customers. To avoid an overload of information that could have an effect opposite to that desired, only a few KPIs have been considered *Customers' KPIs* (six in total).

4.2 Excel file structure

The *ReDREAM Tech KPIs Library* includes all the KPIs and is subdivided into one sheet per KPI category. Within each sheet, a table shows all the relevant information of the indicators. An example can be seen the Figures below:

Generalities							
Code	**Name**	**Description**	**Unit of measure**	**Calculation / Formula**	**Notes**	**Polarity**	**Targets (if mandatory KPI)**
F1	**Energy mobilized through DR**	Sum of all DR activations through the available mechanisms (consumption matching with RES self-generation, peak load reduction, flex provision in balancing services and congestion management services, etc.). It corresponds to the "real flexible energy" activated in the project.	[kWh/ day (month,quarter, year)]	Measurements	Mandatory KPI (KPII)	An increase in time is desired	Local targets (+ household/non-res) | Total 324610 kWh/y | Beyond project: 32000 MWh/y

Figure 11: Example of ReDREAM Tech KPIs Library table - Details: Generalities

Scale				Overlaps with other categories						
Project	**DEMO / Community**	**Customer / Building**	**Asset**	**Flex**	**RES**	**Environ**	**Energy Eff**	**Comf& Health**	**Econo mic**	**Tech & Services**
x	x			x						

Figure 12: Example of ReDREAM Tech KPIs Library table - Details: Scale and Overlaps

The tables offer a comprehensive list of information for each of the KPIs:

- **Code**: the internal code associated with each indicator.
- **Name**: name of the indicator.
- **Description**: explanation of the purpose and scope of the KPI.
- **Unit of measure**.
- **Calculation / Formula**: details on the modalities of calculation or determination of the parameter.
- **Notes**: any noteworthy details.
- **Polarity**: indications on the desired value, where necessary.

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- **Targets**: if the KPI is a mandatory one (meaning among the KPIs determined in the GA), expected results for the KPI.
- **Scale**: defines what is the scale of the KPI, if it monitors the whole project, the single DEMO or Community, the single Customer or Building or a specific asset.
- **Overlaps with other categories**: what of the identified categories does the KPI belong to.

4.3 KPIs list

We present here a selection of the 'highest scoring' KPIs for each category, with some introductory notes to guide the interpretation of the indicators. The description of each KPI is reported in the related column of each table. More information on each indicator can be found in the ANNEX I.

4.3.1 Flexibility KPIs

The flexibility KPIs have a central role for the project since the demand response and the market participation tools are one of the main features of the ReDREAM ecosystem and even the majority of the KPIs predefined in the GA were related to flexibility. As a consequence, this category is the most numerous in terms of indicators.

Since the provision of flexibility has effects not only for the customers but for the system and the markets as well, the indicators proposed here cover a broad range of different "impact areas", that can be generally subcategorised as: flexibility provision and potential, revenues from market participation, ecosystem DSF capabilities, benefits for the grids and distributed assets for DSF provision.

It is worth mentioning that to monitor flexibility provision and potential, the list includes flexibility KPIs proposed by the association smartEn[14] (F2-F4), in addition to the general indicator that encompasses all energy mobilised through DSF mechanisms (F1). These KPIs take into account both potential and real flexibility provision and are considered as a meaningful indicator of the flexibility performances of a building.

KPIs to monitor benefits for the grid have the important goal to show the positive impact of flexibility to the whole electricity system. The proper activation of flexible resources can lead, for instance, to reduce congestions in local distribution grids, allowing Distribution System Operators (DSOs) to postpone or completely avoid investments in grid reinforcements (KPI F10). Other positive effects, such as an increased Renewable Energy Resources (RES) hosting capacity, are also monitored through KPI F11.

KPIs that cover revenues from DSF market participation, such as F12, are useful to keep track of the opportunities that the market offers in each of the MS where the DEMOs are located and to monitor flexibility profitability, which is still unclear for many stakeholders, especially communities and customers.

Even the performances of the ecosystem platform are controlled (KPI F6) and the number and capabilities of the distributed assets used to provide DSF (F20).

[14] smartEn position paper, "Towards a Quantification of the Demand-side Flexibility of Buildings", October 2020

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The KPIs F2 (*Flexible energy despatched*) has been chosen as a *Customer KPI* (if calculated for the single customer or community) since it allows to provide indications of actual DSF market participation, which is still an unusual feature for the majority of end customers.

Code	Name	Description	Unit of measure	Calculation / Formula
F1	**Energy mobilized through DR**	Sum of all Demand Response activations through the available mechanisms (consumption matching with RES self-generation, peak load reduction, flex provision in balancing services and congestion management services, etc.). It corresponds to the "real flexible energy" activated in the project.	[kWh/ day (month,quarter, year)]	$E_{DSF,loadshift} + E_{DSF,markets} + E_{DSF,peakload}$ Where: $E_{DSF,loadshift\,/\,markets\,/\,peakload}$ real flex energy activated for load shifting, market participation, peak shaving
F2	**Flexible energy despatched**	Flexible energy contracted and despatched among all the markets.	[kWh/day (month, quarter, year)]	$E_{DSF,markets} = \sum_{m=1}^{M} E^{m}{}_{DSF,market}$ Where: $E^{m}{}_{DSF,market}$: real flex energy activated (despatched) in the market "m"
F3	**Flexible energy offered**	Flexible energy offered in all the markets.	[kWh/day (month,quarter, year)]	$E_{DSF,offered} = \sum_{m=1}^{M} E^{m}{}_{DSF,offered}$ Where: $E^{m}{}_{DSF,offered}$: daily flex energy offered in the market "m"
F4	**Maximum flexible capacity offered**	Maximum flexible capacity offered in the markets, maximum capacity bid.	[kW]	$P^{max}_{DSF,offered} = MAX(P^{max,m}_{DSF,offered}\,;\,\forall m)$ Where: $P^{max,m}_{DSF,offered}$: daily flex capacity offered in the market "m"
F5	**Flexible capacity contracted**	The KPI shows how much flexible capacity is actually contracted throughout all the markets/mechanisms remunerating capacity, by the ecosystem as a whole, a DEMO or a single customer, in a day (or summed in a month, quarter, year). If the market has a capacity auction, it corresponds to the capacity actually contracted in such market	[kW[	$P_{DSF,contracted} = \sum_{m=1}^{M} P^{m}{}_{DSF,contracted}$ Where: $P^{m}{}_{DSF,contracted}$: DSF capacity contracted each day in market/mechanism m
F6	**Precision for flexibility capacity analysis**	Measure related to the ecosystem capability of connecting with electricity markets and analysing in real-time the available DSF with precision. Calculated as function of the kWh of flexible energy forecasted to be activated divided by the kWh of flexible energy actually activated in the markets by the platform.	[%]	$Precision = 100 - \left\lvert \frac{P_{DSF,forecasted}}{P_{DSF,activated}} - 1 \right\rvert \times 100$ Where: $P_{DSF,forecasted}$: forecasted flex capacity to be activated $P_{DSF,activated}$: flex capacity actually activated.

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F8	**Available flexible capacity**	Parameter to monitor the amount of a DEMO or prosumer's available capacity that can be used to provide flexibility. With the development of the ecosystem, an improvement should be expected, also taking into account that it will drive customers to engage more with flexibility and install/allow more of their loads to the platform for flex purposes. The calculation is done adding up the capacity of each appliances available for DSF.	[kW]	$AFC = \sum_{i=1}^{N} P_{flex,j}$ Where: j: applicance j $P_{flex,j}$: capacity of appliance j that can be exploited for DSF purposes
F9	**Decrease in failure rate in flex capacity of the grid**	The failure rate (FLR) is calculated as the deviation between the requested flexible energy - or "market activated energy"- to lower or increase and the flexible energy actually activated. This deviation should decrease during the development of the project.	[%]	$Var = \left(\frac{FLR_{end}}{FLR_{ref}} - 1\right) \times 100$ Where: $FLR = \left\lvert 1 - \frac{E_{el,DSF,activated}}{E_{el,DSF,requested}} \right\rvert \times 100$ And: $E_{el,DSF,activated/requested}$: flex energy actually activated/requested.
F10	**Distribution grid investments avoidance or deferral due to the use of flex**	Investment avoidance can be obtained from the profits in local flexibility markets when these are present. A hypothesis is made for such markets: DSOs remunerate with prices close to distribution grid savings. Therefore, revenues from local flexibility markets (€/year) for each DEMO can be taken as the amount that DSOs are avoiding in distribution grid investments. In countries where local flex markets run by DSOs are not present, to give an indication, the ecosystem will run the simulations using data from countries where local flexibility markets are established (i.e. the UK).	[€/year]	$\sum_{d=1}^{365} E^{d}{}_{DSF,LocalFlex} \times Price^{d}{}_{DSF,LocalFlex}$ Where: $E^{d}{}_{DSF,LocalFlex}$: energy despatched in the local flex market in the day "d" $Price^{d}{}_{DSF,LocalFlex}$: average price of the local flex market (UK)
F11	**Increased RES and DER's hosting capacity**	The hosting capacity is defined as the amount of new production or consumption that can be connected to the grid without endangering the reliability or voltage quality of other customers[15]. To determine if the grid's RES hosting capacity is improved, a hypothesis is made. First of all, the ratio between the spillages (renewable energy generated and fed into the grid) and the total renewable energy generation is calculated. Thanks to the better consumption / self-generation matching of the ecosystem (self-consumption maximisation), this ratio is expected to be reduced. This, in turn, can be taken as an increased hosting capacity of the grid since the impact of the DEMOs' DERs on it will be lower. Therefore, if the ratio lowers in time the result is a YES (increased hosting capacity); if the ratio increases in time, the result will be a NO.	YES / NO	$If: Sp\%_{end} < Sp\%_{beg} \rightarrow YES$ $If: Sp\%_{end} > Sp\%_{beg} \rightarrow NO$ Where: $Sp\% = \left(E^{spilled}_{RES,selfgen} / E^{tot}_{RES,selfgen} \right)$ And: $E^{spilled}_{RES,selfgen}, E^{tot}_{RES,selfgen}$: Measurements

[15] Hosting Capacity of the Power Grid for Renewable Electricity Production and New Large Consumption Equipment, Math H. J. Bollen ID and Sarah K. Rönnberg, Energies 2017, 10, 1325

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F12	**DSF despatched / contracted in each market**	Volume of DSF (in terms of energy, 1, or capacity 2) accepted in markets, separated per specific market.	1. [kWh/year] 2. [kW/year]	$E\|P_{DSF,market,m} = \sum_{d=1}^{365} E\|P^{d}{}_{DSF,market,m}$ Where: $E\|P^{d}{}_{DSF,market,m}$: real flex energy | power despatched or contracted in the market "m" the day "d"
F14	**Mean DSF revenue (energy)**	Mean income per kWh coming from DSF market participation. This parameter can monitor also the platform improved ability in playing in the markets and the increased business opportunities coming from flexibility while markets open in the different countries. Is calculated as the ratio between the total income from activated DSF in a year [€] and the total flexible energy despatched in a year [kWh/year].	[€/kWh]	$MeanRev = \frac{Rev_{E,DSF}}{E_{DSF,despatched}}$ Where: $Rev_{E,DSF}$: total revenue from activated DSF in a year [€]; $E_{DSF,despatched}$: total flexible energy despatched in a year [kWh/year].
F18	**Growth of assets used for DSF**	Increase of n° of DSF assets (decentralised loads, batteries and generation) available from the beginning of the project.	[%]	$Increase_{N,ast} = \frac{(N_{ast,DSF,end} - N_{ast,DSF,beg})}{N_{ast,DSF,beg}} \times 100$ Where: $N_{ast,DSF}$: number of assets used for DSF
F20	**Most obedient asset typology for flexibility provision**	Classification of the DSF assets based on their obedience. Note: the obedience of an asset is its accuracy to follow a given command.	Classification	-

Table 6: Selection of Flexibility KPIs

4.3.2 Renewables KPIs

Communities and prosumers in the project have distributed generation installed (generally PV panels). The action of the ecosystem allows making the best of them, maximising self-consumption (KPI R3) thanks to a proper matching of consumption with self-generation (KPI R1). This consequently limits spillages to the grid, releasing pressure from it and improving the hosting capacity (monitored through KPI F11 of the Flexibility category).

Since renewable generation is of high interest for customers, other KPIs are dedicated to keeping track of the renewable capacity installed (R6), the renewable generation (R2), the related energy export, and the import-export balance (R4, R5).

KPI R2 (*RES generation*) calculated for a single customer or a community, has been taken as a *Customer KPI*. Renewable self-generation is an obvious key parameter to be shown to active customers.

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Code	Name	Description	Unit of measure	Calculation / Formula
R1	**Energy activated coming from RES in DEMOs**	Renewable energy self-generated and consumed. The maximisation of this parameter is possible matching the known RES generation and consumption patterns[16]. It is calculated for each DEMO and, adding the single contributions, for the whole project.	[kWh/day (month,year)]	$E^{cons}_{RES,selfgen} = E^{tot}_{RES,selfgen} - E^{spilled}_{RES,selfgen}$
R2	**RES generation**	Parameter useful to monitor the amount of renewable energy generated and stored/consumed/sold within each DEMO.	[kWh/day (month,year)]	$E^{tot}_{RES,selfgen} = \sum_{i=1}^{N} E^{i}_{RES,selfgen}$ Where: $E^{i}_{RES,selfgen}$: daily renewable energy generated by asset "i"
R3	**Self-consumption rate**	Weight of self-consumption on total energy consumption, obtained by dividing KPI R1 by the total yearly electricity consumption (KPI EP1).	[%]	$SCR = \left(E^{cons}_{RES,selfgen} / E^{cons}_{el,tot} \right) \times 100$ Where: $E^{cons}_{RES,selfgen}$: Energy activated coming from RES in DEMOs; $E^{cons}_{el,tot}$: total electricity consumption.
R4	**RES energy export**	Renewable energy self-generated and fed into the grid (spillages), calculated as 1. kWh/year and 2. percentage of energy exported (spilled) with respect to the total energy self-generated.	1. [kWh/year] 2. [%]	1. $E^{spilled}_{RES,selfgen} = \sum_{d=1}^{365} E^{spilled,d}_{RES,selfgen}$ Where: $E^{spilled,d}_{RES,selfgen}$: renewable energy self-generated and spilled on the day "d" 2. $Sp\% = \left(E^{spilled}_{RES,selfgen} / E^{tot}_{RES,selfgen} \right) \times 100$
R5	**Energy export / import ratio**	Comparison between renewable energy self-generated and exported and the total electricity imported from the grid on a daily basis. Notes: if exports exceed the imports, a community can be considered a "Positive Energy Community". This parameter can experience a decrease in time due to the better generation-consumption matching.	[%]	$EIR = \left(E^{spilled}_{RES,selfgen} / E_{el,grid} \right) \times 100$ Where: $E^{spilled}_{RES,selfgen}$: renewable energy self-generated and exported; $E_{el,grid}$: electricity imported from the grid.
R6	**Connected RES**	Amount of RES installed power. Note: this parameter is interesting also to keep monitoring in time the total capacity of a collective since several national regulations put a maximum power limit for the RES installed in a collective self-consumption configuration.	[kW]	$P_{RES,selfgen} = \sum_{i=1}^{N} P^{i}_{RES,selfgen}$ Where: $P^{i}_{RES,selfgen}$: power of installed asset "i"
R8	**Share of renewable electricity on**	Percentage of the electricity consumed that can be traced back to renewable generation. Calculated as the ratio between KPI R1 and KPI EE1.	[%]	*R7/EEI1*

[16] The maximisation of this parameter can bring even economic benefits since the incentives for self-consumption (including collective self-consumption, promoted by the RED II Directive 2018/2001) are usually related to the MWh self-consumed.

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	the final consumption			

Table 7: Selection of Renewables KPIs

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4.3.3 Environmental Impact KPIs

The reduction of emissions, specifically of Greenhouse Gas (GHG), is the key goal of the European policy and the driver of the energy transition. For the Environmental impact category, it has been decided to focus on GHG emissions, since the main focus of EU regulation is on greenhouse gases and the input data available for other pollutants are less precise and time-dependant.

Buildings' GHG contribution can be considered mainly related to the energy performances, given buildings' lifespan (a carbon component is also related to renovations but it falls out of the scope of this project). In fact, building performances are usually linked to their GHG emissions: in the EPBD Annex I (2a) we find that: *For the purpose of expressing the energy performance of a building, Member States may define additional numeric indicators […] of greenhouse gas emission produced in kgCO2eq/(m2.y)*".

Several parameters are typically used to perform calculations to monitor emissions and the regulatory and standards analysis carried out gave useful indications for the definition of these KPIs. However, since ReDREAM has neither influence nor monitors gas consumption, the defined KPIs only take into account the indirect emissions coming from the electricity consumed. The action of the ecosystem can improve the related performances thanks to the maximisation of self-generation, the energy efficiency services and better matching with hours in which RES generation is higher in the grid.

Conventionally, GHG emissions are reported as kilograms (or tonnes) of CO_2 equivalent [$kg_{CO2,eq}$], so this is the unit of measure adopted for the KPIs.

The table below shows the main environmental impact parameters that have been defined, following the concepts presented above. Both emissions (EI1, EI4) and emissions savings or avoided emissions (EI2, EI5) are monitored. In this category, both EI2 (*GHG emissions savings*) and EI4 (*GHG emissions per square meter*) have been chosen as *Customers' KPIs*. The former has been selected since emissions' savings is a core principle of the energy transition and a sensitive parameter for active customers and energy communities' members. The latter is a typical indicator of buildings' performances that can be easily compared among different customers.

Code	Name	Description	Unit of measure	Calculation / Formula
EI1	**GHG emissions**	GHG emissions (indirect) due to the consumption of grid electricity, having a carbon content related to the specific electricity generation mix of the country at the time of consumption. The action of the ecosystem will reduce this parameter thanks to the maximisation of self-generation, the energy efficiency measures and the better matching with hours in which RES generation is higher in the grid. In order to catch these effects, real-time grid electricity emission factors will be used, GHG emissions will be calculated and then summed. The result will be expressed as a total yearly (monthly and daily) value. Calculated as the product of the grid imported electricity and the grid electricity emission factor ([kgCO2eq/kWh]). Note: An improvement in time has to be expected also due to the decarbonization of the countries' electricity generation mix.	[kgCO2eq/year (month,day)]	$Emissions_{GHG} = E_{el,grid}^{cons} \times ef_{el,grid}$ Where: $E_{el,grid}^{cons}$: electricity imported from the grid ; $ef_{el,grid}$: emission factor of the grid electricity.

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EI2	**GHG emissions savings**	Savings in kilograms of CO2 equivalent. The calculation is performed with an approximation: at the end of each day, the average emission factor of the grid electricity generation mix ($ef_{grid,elec}^{average}$) is calculated. From it, it is possible to calculate the approximate daily emissions that would have occurred if all electricity consumed would have been imported from the grid ($e_{GHG,NR}$) without the action of the ecosystem and the self-generation, creating a baseline. To obtain the savings ($savings_{GHG}$), the KPI EI1 for the site is then subtracted. The daily value of the savings can be aggregated into monthly and yearly values.	[kgCO2eq/day (month/year)]	$savings_{GHG} = e_{GHG,NR} - e_{GHG,tot}$ Where: $e_{GHG,NR} = ef_{grid,elec}^{average} \times E_{el,cons}$ $e_{GHG,tot} = KPI\ F1$
EI4	**GHG emissions per square meter**	Emissions per square meter, real-time (hour) and aggregated monthly and yearly, calculated as the ratio of the customer GHG emissions and the area of the site/dwelling. This KPI is easily comparable and shows each customer's environmental impact and combines the positive effects of energy efficiency and DSF. Note: Yearly GHG emissions per square meter for each consumer/site are indicated in the EU regulation to monitor the energy performances of a building/site.	[kgCO2eq/m²/h (month,year)]	$m2Emissions_{GHG} = Emissions_{GHG}/Area$ Where: $Emissions_{GHG}$: KPI EI1; Area: area of the site/dwelling.
EI5	**Avoided emissions thanks to RES self-consumption**	GHG emissions that would be produced without self-consumption. Product of the consumed self-generated renewable electricity and the CO2eq emission factor at the time of consumption.	[kgCO2eq/h (month/year)]	$AvoidedEm_{GHG,RES} = E_{RES,selfgen}^{cons} \times ef_{el,grid}$ Where: $E_{RES,selfgen}^{cons}$: self-generated renewable electricity consumed. $ef_{el,grid}$: GHG emission factor of the grid electricity.

Table 8: Selection of Environmental Impact KPIs

4.3.4 Energy Efficiency and Performance KPIs

For the Energy efficiency and performances, we can repeat similar considerations to the ones made for the Environmental impact category: only performances related to electricity use and consumption can be influenced and monitored by the platform.

Therefore, typical parameters for energy performances and efficiency are used but have been modified to include only electricity consumptions: Electricity use intensity (EP1) and Primary energy consumption (EP2). The latter is considered a key metric in European regulation[17].

A series of KPIs is focused on the economics connected to electricity consumption (such as EP4): the action of the ecosystem can reduce the electric bills, thanks to the optimal management of the electric appliances, the maximisation of self-generation, shifting consumptions to match the less expensive hours of the day, relying on buildings' inertia and learning customers habits.

[17] Directive (EU) 2018/844 (EPBD) Annex I (1): The energy performance of a building shall be expressed by a numeric indicator of primary energy use in kWh/(m 2 .y) for the purpose of both energy performance certification and compliance with minimum energy performance requirements […].

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Finally, some KPIs are dedicated to tracking the performances of single appliances or Technical Domains (EP6), which have been defined from the EPBD[18] and the SRI domains.

The KPIs EP2 (*Primary Energy Use of electricity*) and EP4 (*Electricity cost index*) are the *Customers' KPIs* of this category. The primary energy use intensity has been selected since it is a known parameter used to report energy performances; EP4 corresponds to the electric bill costs, hence is of key importance for all customers to have it always available and updated.

Code	Name	Description	Unit of measure	Calculation / Formula
EP1	**Electricity use intensity**	Electricity consumption of the site, per square meter (1) and total for building/ dwelling /site (2). Note: (1) is a common metric to monitor consumptions and their reduction, hence an energy efficiency growth. Always better to make distinctions in the results between residential and non-residential buildings. It can be calculated also for a DEMO/Community, as a sum of the single contributions.	1. [kWh/m²/month (year)] 2. [kWh/site/day (month, year)]	1. $EUI_m2 = EUI/Area$ 2. $EUI = E_{el,tot}^{cons}$ Where: $E_{el,tot}^{cons}$: total electricity consumption of the site; Area: area of the site/dwelling.
EP2	**Primary Energy Use of electricity**	Yearly primary energy consumption (or Primary Energy Use, PEU) related to the electricity consumption, per square meter. Is calculated by multiplying the electricity consumed imported (coming from the grid) and the primary energy factor of grid electricity, then subtracting the positive contribution given by the renewable electricity exported. Allows quantifying losses in generation, transmission and distribution of the electricity, the characteristics of the grid electricity mix and the positive effects of the self-generation. It can be also calculated as an average of the whole DEMO or project. Note: The losses are null in the case of self-consumption, therefore this parameter should be effective in taking into account both the better electricity use intensity and the maximisation of self-consumption. The calculation is derived from the methodology followed in the SAP[19].	[kWh/ m²/year]	$PEU_{el}_m2 = PEU_{el}/Area$ $PEU_{el} = (E_{el,grid}^{cons} \times PEF_{el,grid}) - (E_{RES,selfgen}^{spilled} \times PEF_{el,RES})$ Where: $E_{el,grid}^{cons}$: electricity imported from the grid and consumed; $PEF_{el,grid}$: primary energy factor of grid electricity; $E_{RES,selfgen}^{spilled}$: renewable electricity self- generated and exported; $PEF_{el,RES}$: primary energy factor of renewable electricity.
EP3	**Load factor**	Parameter obtained as the ratio of average demand (capacity) and peak demand of a site. A low value suggests that only in some cases a high demand is set: since network charges are higher with higher peaks, to service rather infrequent peaks the kWh for the customer is highly charged. The peak shaving effect of the ecosystem should have a positive effect on this parameter.	[%]	$LF = (P_{el}^{average}/P_{el}^{peak}) \times 100$ Where: $P_{el}^{average}$: average demand of the site (capacity); P_{el}^{peak}: peak demand of the site (capacity).
EP4	**Electricity cost index (bill)**	Total annual electricity cost (1) and its percentage variation in time (2). A decrease (negative value) is to be expected thanks to the action of the ecosystem.	1. [€/year)] 2. [%]	2. $Var_{Cost,year\,j} = \frac{Cost_{year,j} - Cost_{ref}}{Cost_{ref}} \times 100$ Where: $Cost_{year,j/ref}$: Total annual electricity cost of year j / of reference year (before beginning of project).

[18] Directive (EU) 2018/844 (EPBD) Annex I (1): The energy performance of a building shall be determined on the basis of calculated or actual energy use and shall reflect typical energy use for space heating, space cooling, domestic hot water, ventilation, built-in lighting and other technical building systems.

[19] Briefing Note – Derivation and use of Primary Energy factors in SAP; BRE. Version 1.3 – 01/10/2019.

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EP6	**TD Electricity Consumption**	KPI to be calculated for each Technical Domain (TD). Consumption of the single technical domain (1) in absolute value, (2) per square meter and (3) in percentage of the total Electricity use intensity of the whole site.	1. [kWh/day (month,year)] 2. [kWh/m²/day(month,year); 3. [%]	2. $E^{cons}_{el,TD}_m2 = E^{cons}_{el,TD}/Area$ 3. $E^{cons}_{el,TD_{\%}} = E^{cons}_{el,TD}/EUI$ Where: *Area*: area of the site/dwelling; *EUI*: KPI EP1 of the site/dwelling

Table 9: Selection of Energy Efficiency and Performances KPIs

4.3.5 Comfort and Health KPIs

People tend to spend a growing share of their time inside buildings and the importance of comfort levels and air quality is increasing. Therefore, mentions of the need to optimize energy performances taking into account health and comfort levels can be found even in recent European regulations[20].

The ReDREAM ecosystem monitors comfort and health parameters and seeks to improve them. To this end, typical indicators have been selected. Some KPIs are dedicated to thermal comfort, such as CH1 and CH2[21], and CH4. Other KPIs are related to visual comfort instead (CH6[22]). Finally, indoor air quality is covered in estimating or measuring both CO_2 and Particulate Matter (PM) concentrations (CH7, CH8).

This category of KPIs has been developed thanks to the expertise of NTUA.

Code	Name	Description	Unit of measure	Calculation / Formula
CH1	**Predictive Mean Vote (PMV)**	An Index that predicts the mean value of the votes of a large group of persons on the seven-point thermal sensation scale.	Dimensionless	$PMV = (0.303e^{-0.36 \cdot MET} + 0.028) \times L$ T_a: Air temperature [°C] RH: Relative humidity [%] T_r: Radiant mean temperature [°C] U_a: Relative air velocity [m/s] Clo: Clothing level [clo] MET: Metabolic rate [1-8, MET = 60 W/m²] L: Heat loss from human body
CH2	**Predicted Percentage of Dissatisfied (PPD)**	Quantitative prediction of the percentage of thermally dissatisfied occupants, determined from PMV.	[%]	$PD = 100 - 95\, e^{-(0.03353PVM^4 + 0.2179PVM^2)}$
CH4	**Comfort zone**	Represents the combinations of conditions for the same metabolic rate and clothing level for which the PMV is between -0.5 and +0.5.	[°C, %]	Assessment
CH6	**Frequency of Visual Comfort (FVC)**	The percentage of the time within a given period during which daylight alone delivers appropriate values of illuminance. The assumption is that if the average illuminance is within the range between two threshold values (below E_{Under} or above E_{Over}), visual comfort is guaranteed	[%]	$FVC = \frac{\sum_i wf_i \cdot t_i}{\sum_i t_i}$ $wf_i = \begin{cases} 1 & E_{under} < E_{daylight} < E_{over} \\ 0 & E_{light} < E_{under} \vee E_{dlight} > E_{over} \end{cases}$

[20] Directive (EU) 2018/844 (EPBD) Annex I (2): The energy needs […] shall be calculated in order to optimise health, indoor air quality and comfort levels defined by Member States at national or regional level.

[21] ISO 7730 Ergonomics of the thermal environment analytical determination and interpretation of thermal comfort using calculation of the pmv and ppd indices and local thermal comfort criteria 2005

[22] Sicurella, F., G. Evola, and E. Wurtz, A statistical approach for the evaluation of thermal and visual comfort in free-running buildings. Energy and Buildings, 2012. 47: p. 402-410

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		thanks to daylight only. Note: a reference value can be FVC>80%[23].		
CH7	**CO2 Concentration**	CO2 Concentration in indoor air, in 1 ppb and 2 percentage. Note: if an estimation is necessary, standard CO2 emissions of 20 l/h per person can be assumed.	1. [ppb] 2. [%]	Estimation from the number of occupants
CH8	**PM Concentration**	Concentration of Particulate Matter (PM) of various diameters.	1. [µg/m^3] 2. [#/m^3]	Assessment

Table 10: Selection of Comfort and Health KPIs

4.3.6 Economic KPIs

Economic-relate parameters are present in several of the KPIs categories. The KPIs here collected are more specifically related to general economic performances.

First of all, the ecosystem performances at the project or community level are monitored, giving indications closer to a financial statement through KPIs EC1, EC2, and EC3.

Narrowing the scope, other KPIs focus at a smaller level of detail and cover performances of DEMOs and customers (EC12).

It has been decided to include also a KPI whose assessment methodology is not uniquely defined in the literature yet: this is KPI EC8, The Social Return of Investment. This indicator would be of high value and can provide relevant indications and information in the context of ReDREAM. This parameter has been included with the aim to develop it in the next steps of the project.

This category of KPIs has been defined thanks to the expertise of CIVI.

Code	Name	Description	Unit of measure	Calculation / Formula
EC1	**Estimated ROI for the REDREAM ecosystem**	Return on Investment, measuring the return on invested capital and therefore the ability to obtain returns on investments. Indicates the ability to remunerate both risk capital and debt capital.	-	$ROI = \frac{OperInc}{NetOperInvestCap}$ Where: $OperInc$: Operative Income $NetOperInvestCap$: Net Operating Invested Capital
EC2	**Pay Back Time (PBT)**	Pay Back Time, a corporate finance indicator to assess the attractiveness of an investment, assessing the recovery of the investment. A shorter PBT is desired to reach the breakeven; it is useful to determine the cost savings of energy efficiency technology. Calculated as the ratio of the Acquisition cost and the difference between Average financial flows and Average operating costs. Notes: Classical Payback: 5-20 years.	[years]	$PBT = \frac{AcquisCost}{AFF - AOC}$ Where: $AcquisCost$: Acquisition cost AFF: Average financial flows AOC: Average operating costs

[23] "A review of indices for assessing visual comfort with a view to their use in optimization processes to support building integrated design"; Salvatore Carlucci a,*, Francesco Causone , Francesco De Rosa and Lorenzo Pagliano. Renewable and Sustainable Energy Reviews.

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EC3	**Internal Rate Return (IRR)**	Internal Rate Return, establishing the profitability of potential investments, showing the annual growth rate. Using the formula, one would set NPV equal to zero and solve for the discount rate, which is the IRR. Notes: expected range of IRR > cut-off rate.	-	$0 = NPV = \sum_{t=1}^{T} \frac{C_t}{(1+IRR)^t} - C_0$ Where: C_0: total initial investment cost; C_t: net cash inflow during the time period t; NPV: Net present value.
EC7	**Weighted Average Cost of Capital (WACC)**	Weighted Average Cost of Capital, a useful parameter to assess investor's returns on an investment and a bankability practical tool. Allows investors to establish the cost of capital, by analysing all its components.	[%]	$WACC = \left(\frac{E}{V} \times Re\right) + \left(\frac{D}{V} \times Rd \times (1 - Tc)\right)$ Where: *E*=Market value of the firm's equity *D*=Market value of the firm's debt *V=E+D* *Re*=Cost of equity *Rd*=Cost of debt *Tc*=Corporate tax rate
EC8	**Social Return on Investment (SRoI)**	Social Return on Investment, measures non-financial values such as social, economic, and environmental factors. It is useful to quantify the value chain created for the local community. It enables the planning and evaluation quantifying the monetization of the social impact in financial terms. Notes: this parameter is not uniquely defined yet and will be developed in the next steps of the project.	-	-
EC12	**Life-cycle cost of electrical energy generation**	Sum of all the costs throughout the lifetime of the energy investment, normalized to the energy generated.	[€/MWh]	$LCCeg = \frac{(OPEX_{el,gen} + CAPEX_{el,gen})}{E^{tot}_{RES,selfgen}}$ Where: $OPEX/CAPEX_{el,gen}$= OPEX and CAPEX for the electricity self-generation $E^{tot}_{RES,selfgen}$: overall electric self-generation, in the technical/useful lifetime of the project (or 20 years).

Table 11: Selection of Economic KPIs

4.3.7 Technology and Services KPIs

This last category includes indicators to monitor the ReDREAM ecosystem services that will be developed (T1, T2), their accessibility (T5) and their performances (T3).

Code	Name	Description	Unit of measure	Calculation / Formula
T1	**Number of services combining EE with other energy services,**	KPI to monitor the implementation of ReDREAM's energy and non-energy services, to provide a holistic set of solutions.	[#]	Assessment

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	technologies and non-energy benefits			
T2	**Number of services developed to predict energy patterns**	Services to predict energy patterns, such as the open digital twins developed in WP2, will increase the precision of consumptions' prediction. The more services will be developed, the better the predictability will be (monitored in KPI T3).	[#]	Assessment
T3	**Decrease of error in predictability of consumption**	KPI to monitor improvements in the precision of consumption patterns and consumers behaviours through digital twins and other software services.	[%]	$ErrVar = \left(\frac{Perr_{beg} - Perr_{end}}{Perr_{beg}}\right) \times 100$ Where: ErrVar: Error variation Beg: beginning of the project; End: end of the project; $Perr = \left\lvert\frac{Vmeasured - Vpredicted}{Vmeasured}\right\rvert \times 100$ $Vmeasured; predicted$: measured/predicted electricity consumption values
T5	**Accessibility of third parties**	Total number of third parties able to connect to the platform. Accessibility to the platform is necessary to guarantee a future replicability, with third parties that are able to profit from the EE services.	[#]	Assessment

Table 12: Selection of Technology and Services KPIs

4.4 Final remarks

4.4.1 Notes on definitions and conventions

Dimensions (square meters): for dwelling dimensions (especially floor area) the conventions of the Standard Assessment Procedure for Energy Rating of Dwellings are followed[24], *"Dimensions refer to the inner surfaces of the elements bounding the dwelling. Thus floor dimensions are obtained by measuring between the inner surfaces of the external or party walls, disregarding the presence of any internal walls."*

Primary energy: Energy from renewable and non-renewable sources, which has not undergone any conversion or transformation process[1]**.**

GHG emissions: According to Regulation 2018/842[25], GHG emission "*[…] means emissions in terms of tonnes of CO2 equivalent of carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), nitrogen trifluoride (NF3) and sulphur hexafluoride (SF6) […]*".

[24] SAP 2012, version 9.92

[25] Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013

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DSF: for Demand Side Flexibility, we apply the following definition[26] *"Decentralised behind-the-meter sources of flexibility are collectively termed Demand Side Flexibility (DSF). DSF is technology agnostic and refers to the turning on / off, up / down, or shifting of, decentralised loads, batteries and generation across any value stream or customer segment. Assets can be aggregated or utilised individually".*

Time granularity: Time granularity of the measurements (hence KPIs calculated from them) depends on the specific KPI. Even when not specified, monthly, seasonal (quarterly) and yearly measurements should always be in place.

Time reference in percentage variations: When a percentage variation is calculated as a KPI, yearly values should be compared to avoid seasonality effects or random variations. Since the measurements will start only 2-3 months ahead of the ecosystem implementation, when a percentage variation is foreseen the reference value will be calculated taking those 2-3 months only and the comparison will be made with the values obtained the same months of the year(s) after. The results will lack some accuracy but will show a trend, otherwise not possible to obtain with real measured data.

4.4.2 Notes on results' interpretation

A thorough analysis of the results and their interpretation will be carried out in the Tasks of Work Package 5. Nevertheless, some initial considerations and suggestions have been included. Any specific note regarding the single KPI can be found in the Description row of the tables or the *ReDREAM Tech KPIs Library*. Here, general indications are given:

Building/Customer: The performances or relevant results relative to a building are influenced by its utilization. To make comparisons or identify benchmarks using the KPIs for a single building/customer, a distinction should be made according to its purpose and utilization (e.g. clear distinctions between residential, commercial and industrial sites).

DEMO: Comparisons between the different DEMOs will give indications on the peculiarities of each country. Differences in weather, regulatory and markets conditions, kind of customers participating in each DEMO will greatly influence the results.

Seasonality: seasonality can significantly impact buildings' performances -being this flexibility, energy performances or environmental impact- and renewables' generation. This is why quarterly timeframes are suggested to be monitored.

[26] smartEn EU Market Monitor for Demand Side Flexibility, 2020

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5 High-Level KPIs

5.1 Introduction

The KPIs presented in the previous chapter have the purpose to monitor the most relevant technical parameters and variables, useful to track the developments and produce relevant results to be shared. However, in order to have a vision of the overall impact of the ecosystem, broader Key Performance Indicators -named High-Level KPIs (HL KPIs)- have been designed in parallel, mirroring the overall objectives and goals that the project aims for, i.e. the 'IMPACTS' as indicated in the GA.

These KPIs are determined through the combination of a selection of the most appropriate detailed KPIs, depending on the case. In some cases, even non-technical KPIs that are covered in other deliverables of WP1 are included, namely the following Social KPIs covered in Deliverable 1.1[27]:

- **S.2.10**: No. of interactions to share best practices through the energy social network.
- **S.2.11**: No. of users up taking previous services.

The following table shows the list of High-Level KPIs and the detailed KPIs included in their calculation:

Code	High-Level KPI Name	Associated KPIs
HL1	Increased use of demand response across the European energy system	F1
		F5
		F8
		F18
HL2	Demonstrated and improved viability of innovative energy services, best practices and effective incentives that can be replicated at large scale	EC1
		S.2.10
		EC2
HL3	Increased uptake of services that combine energy efficiency with other energy services, technologies and non-energy benefits	T1
		S.2.11
		CH2
		CH6
		CH7
		CH8
HL4	Increased reliability of innovative energy services and accessibility to them	F6
		F18
		T5
HL5	Increased predictability of consumption patterns and consumer behavior	T2
		T3
HL6	Improved modelling of the flexibility levers from the new energy services	F9
		F10
HL7	Increased share of energy or power that can be mobilized to provide flexibility to the grid and increase the hosting capacity of RES	F11
		R1
		F8
HL8	Environmental Impacts	EI2
		R8
		EP2

[27] Report on social requirements, use cases and functionalities for ecosystem layers and social KPIs

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HL9	Average Smart Readiness Indicator variation – High Level	**SRI2** (of each building)

Table 13: High-Level KPIs

5.2 Calculation methodology

For each IMPACT, the selected detailed KPIs are evaluated at the project scale through measurements, calculations or estimations, both in the reference scenario (beginning of the project or Business As Usual -BAU-) and in the developed scenario (end of the project or Research and Innovation -R&I-). Then, their percentage variation is calculated. Afterwards, the percentage variation of each selected KPI is combined through a weight sum to give the HL KPI; the weights chosen depend on the relevance of the detailed KPI but not on the location since it has been decided to use the same weights for each DEMO. Moreover, the HL KPI is accompanied by the values of the variation of each KPI combining them.

In summary, the calculation follows the steps:

1	Calculation of the relevant "detailed" KPIs at the beginning of the project ("ref" or "BAU") and at the end of the project ("end" or "R&I").
2	Calculation of the variation to accompany the HL KPI result[28], e.g.: $\Delta_{\boldsymbol{KPI}} = KPI_{R\&I} - KPI_{BAU}$ | Unit of measure: depending on the KPI
3	Calculation of the percentage variation of each KPI[29] (if not already in this form), e.g.: $\boldsymbol{Var}_{\%,\boldsymbol{KPI}} = \left(\frac{KPI_{R\&I} - KPI_{BAU}}{KPI_{BAU}}\right) * 100$ | Unit of measure: [%]
4	Calculation of the high level KPI as a weighted average of the percentage variation of all the detailed KPIs "I" ($Var_{\%,KPI,i}$), using the appropriate weight for each KPI (w_i). $\boldsymbol{HL} = \sum_{i=1}^{N} Var_{\%,KPI,i} \times w_i$ | Unit of measure: [%]

Table 14: HL KPI calculation methodology - Steps

[28] The formula is different when a reduction between BAU and R&I has to be expected or desired, e.g. $KPI_{BAU} - KPI_{R\&I}$

[29] The formula is different when a reduction between BAU and R&I has to be expected, e.g. $\left(\frac{KPI_{BAU} - KPI_{R\&I}}{KPI_{BAU}}\right) * 100$

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The schematization of the process is shown in the flowchart below:

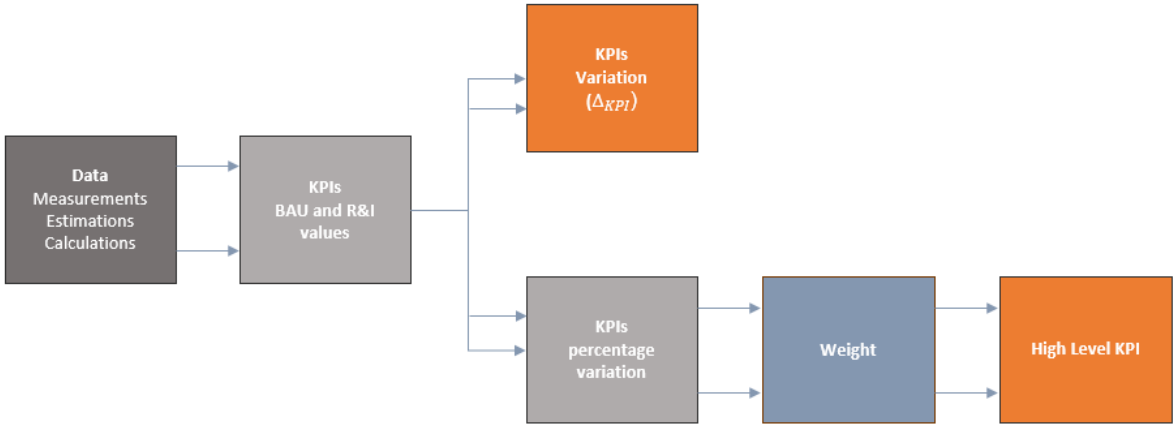

Figure 13: HL KPI calculation methodology - Flowchart

5.3 High Level KPIs tables

The tables that follow show the calculation process for each High-Level KPI and the weighting factors chosen for each associated detailed KPI. For the weights, a higher value has always been assigned to the KPI indicated in the GA as key to monitor the related IMPACT.

HL1 combines the overall KPI F1, tracking the total amount of DR activation calculated for the whole project, with KPI F5 that shows how much flexibility is contracted in markets with a capacity payment. Moreover, KPIs F8 and F18 take into account the variation of flexibility available assets and capacity thanks to the implementation of the ecosystem. All of the above monitors to the markets' uptake of flexibility in the European electricity system.

HL1	Increased use of demand response across the European energy system		
Associated detailed KPIs		Weight	
F1	Energy mobilized through DR	w1	0,75
F5	Flexible capacity contracted	w2	0,1
F8	Available flexible capacity	w3	0,075
F18	Growth of assets used for DSF	w4	0,075
HL1 [%] = $\sum_{i=1}^{4} Var_{\%,KPI,i} \times w_i$			

Table 15: HL1

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The viability of the proposed energy services is shown through HL2: both economic (the ROI and the PBT) and social parameters compose this KPI that allows assessing also the replicability of the concept proposed.

HL2	Demonstrated and improved viability of innovative energy services, best practices and effective incentives that can be replicated at large scale		
Associated detailed KPIs		Weight	
EC1	Estimated ROI for the REDREAM ecosystem	w1	0,35
S.2.10	N. of interactions to share best practices through the energy social network	w2	0,35
EC2	Pay Back Time (PBT)	w3	0,3
HL2 [%] = $\sum_{i=1}^{3} Var_{\%,KPI,i} \times w_i$			

Table 16: HL2

HL3 embodies KPIs of different areas to show the ability of the ecosystem to offer a holistic set of solutions and benefits for the consumers. KPI T1 gives the indication of how many transversal services the platform offers, including non-energy ones related also to health and comfort whose effects are here taken into account through the detailed Comfort&Health KPIs CH2, CH6, CH7, CH8. The combination of energy and non-energy services is expected to increase the take-up by consumers, which is covered by social KPI S.2.11.

HL3	Increased uptake of services that combine energy efficiency with other energy services, technologies and non-energy benefits		
Associated detailed KPIs		Weight	
T1	N. of services combining EE with other energy services, technologies and non-energy benefits	w1	0,35
S.2.11	N. of users up taking previous services	w2	0,35
CH2	Predicted Percentage of Dissatisfied (PPD)	w3	0,1
CH6	Frequency of Visual Comfort (FVC)	w4	0,05
CH7	CO2 Concentration	w5	0,075
CH8	PM Concentration	w6	0,075
HL3 [%] = $\sum_{i=1}^{6} Var_{\%,KPI,i} \times w_i$			

Table 17: HL3

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HL4 is dedicated to assess both the quality of the new innovative energy services proposed -such as DR and energy efficiency, whose increase is monitored by KPI T6- and their accessibility for third parties (covered with KPI T5), key to guarantee a future replicability. The quality of the services is also shown by the way the ecosystem connects the user with the electricity markets and analyses the flexibility of demand with high precision: this is taken into account through KPI F6.

HL4	Increased reliability of innovative energy services and accessibility to them		
Associated detailed KPIs		Weight	
F6	Precision for flexibility capacity analysis	w1	0,7
T5	Accessibility of third parties	w2	0,2
T6	N. of energy services deployed	w3	0,1
HL4 [%] = $\sum_{i=1}^{3} Var_{\%,KPI,i} \times w_i$			

Table 18: HL4

HL5 relates to the ability of the ecosystem to predict consumption patterns and consumers' behaviour, key for its proper operation. New energy services will be developed with this goal (KPI T2) and the error of predictability should decrease in time (KPI T3). HL5 shows their combined effect.

HL5	Increased predictability of consumption patterns and consumer behaviour		
Associated detailed KPIs		Weight	
T2	N. of services developed to predict energy patterns	w1	0,25
T3	Decrease of error in predictability of consumption	w2	0,75
HL5 [%] = $\sum_{i=1}^{2} Var_{\%,KPI,i} \times w_i$			

Table 19: HL5

HL6 combines the capability of the ecosystem to provide a reliable service to the grid and the impact that this can have on the management of the distribution grids, allowing DSOs to avoid expensive investments in reinforcements. The quality of the DR tools can lead to a decrease in failure rate of the grid's flexibility capacity (KPI F9). The investments avoidance or deferral is covered by KPI F10.

HL6	Improved modelling of the flexibility levers from the new energy services		
Associated detailed KPIs		Weight	
F9	Decrease in failure rate in flex capacity of the grid	w1	0,4
F10	Distribution grid investments avoidance or deferral due to the use of flex	w2	0,6
HL6 [%] = $\sum_{i=1}^{2} Var_{\%,KPI,i} \times w_i$			

Table 20: HL6

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Similarly, HL7 is dedicated to the impact that the increased use and availability of demand side flexibility driven by the ecosystem implementation (KPI F8) can have to increase the grids' hosting capacity (KPI F11)[30]. The maximisation of self-consumption guaranteed by ReDREAM, should decrease the RES spillage that cannot be absorbed by the grid.

HL7	Increased share of energy or power that can be mobilized to provide flexibility to the grid and increase the hosting capacity of RES		
Associated detailed KPIs		Weight	
F11	Increased RES and DER's hosting capacity	w1	0,4
R1	Energy activated coming from RES in DEMOs	w2	0,4
F8	Available flexible capacity	w3	0,2
HL7 [%] = $\sum_{i=1}^{4} Var_{\%,KPI,i} \times w_i$			

Table 21: HL7

Positive Environmental impacts (HL8) are a crucial goal for the project since they are the main drivers of the energy transition. HL8 is consequently mainly related to monitoring the savings of GHG emissions (KPI EI2), which are also guaranteed by all the combined actions of the ecosystem to maximise the consumption of renewable electricity self-generated and not (KPI R8) and increase energy efficiency (both effects impacting KPI EP2).

HL8	Environmental Impacts		
Associated detailed KPIs		Weight	
EI2	GHG emissions savings	w1	0,65
R8	Share of renewable electricity on the final consumption	w2	0,175
EP2	Primary Energy Use of electricity	w3	0,175
HL8 [%] = $\sum_{i=1}^{3} Var_{\%,KPI,i} \times w_i$			

Table 22: HL8

[30] Since KPI F11 is represented only by a binary result (YES/NO), in the calculations the values assigned to it are YES=100% ; NO=0%. Hence, the related $Var_{\%,KPI}$ coincides with the variation between R&I and BAU scenarios.

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Finally, even for the Smart Readiness Indicator an associated High Level KPI has been defined to provide a vision of the global impact of the ecosystem, combining the SRI-related KPI (SRI2) of each building participating in the project. Due to the nature of the indicator's calculation methodology, a simplified procedure is followed, assigning the same weight for each building's SRI. Again, the HL KPI related to the SRI is accompanied by the variation of the indicator between beginning ("ref") and end of the project ("end").

HL9	Smart Readiness Indicator – High Level	
Relevant detailed KPIs		
SRI2	SRI Variation – Building	SRI2 of each building of the project
$$\overline{SRI}_{var,tot} = \left(\frac{\overline{SRI}_{end} - \overline{SRI}_{ref}}{\overline{SRI}_{ref}}\right) x100$$ Where: $\overline{SRI}_{ref/end}$ is the average SRI of the initial and final values of SRI of all the buildings / sites		
$$\Delta_{SRI,tot} = \overline{SRI}_{end} - \overline{SRI}_{ref}$$ Where: $\overline{SRI}_{ref/end}$ is the average SRI of the initial and final values of SRI of all the buildings / sites		

Table 23: HL9

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6 Conclusions and next steps

This report presents the process followed to define the indicators that will be applied to monitor performances in the ReDREAM project for the most important features. European regulations and Directives have been analysed for the definition of these indicators and used, or adapted, in line with the characteristics of the ecosystem.

A regulated parameter, the Smart Readiness Indicator, has been proposed to be included in the ecosystem since it allows to encompass key impact areas of the ReDREAM ecosystem. Its calculation methodology, despite not being defined at a national level yet, has been studied and translated into a calculator, to be used as a first self-assessment tool. The assessment of the buildings' SRI allow then the calculation of two specific KPIs that monitor the influence of the ReDREAM ecosystem on this indicator, hence on the buildings' potential performances.

The SRI and its KPIs are complemented with a series of other technical parameters, which have been defined to cover all the relevant features of the project starting from a list of mandatory KPIs grouped into seven domains, or categories:

This set of KPIs represents a useful tool to monitor the main variables showing on a detailed way the performances of the ecosystem in the DEMOs and of its implementation as a whole. To have an overall reference of the project performances, the set of High-Level KPIs allows an immediate understanding of the ecosystem's impact on a selection of key impact areas.

Starting from these basics, further work will be carried out during the prosecution of the project - namely in Work Packages 2, 5, and 6- and adjustments can be expected once the testing phase will begin. All KPIs, High-level and non, will have to be verified and validated with input data coming from the DEMOs. In this process, evolutions and adjustments can be envisaged.

The Smart Readiness Indicator calculator will, in turn, be evolved and modified in two potential parallel workstreams:

1. Follow the national implementation of the European regulation and adjust the calculator to the specific calculation methodologies proposed in each of the four Member States where the project DEMOs are located (Spain, Italy, UK, and Croatia).
2. Evolve the calculator proposing a more dynamic methodology, based on actual performances and using the results from the KPIs defined.

The results of this second activity can feed into the work of the Topical group C, which will be thoroughly followed, and have the potential to produce an indicator capable of showing the real

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benefits and impact of an ecosystem offering to prosumers a large set of services such as ReDREAM, improving customers' engagement.

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ANNEX I: KPIs

This annex presents more detailed information about the KPIs introduced in the subchapters 3.1.1 and 4.3, indicating description, unit of measure, formula, scale and any other relevant notes. First of all, the KPIs that are associated to the HL KPIs will be presented, then all the others covered in this document.

KPIs related to HL KPIs:

Flexibility category:

KPI Name	Energy mobilized through DR			Code	F1
Description	Sum of all DR activations through the available mechanisms (consumption matching with RES self-generation, peak load reduction, flex provision in balancing services and congestion management services, etc.). It corresponds to the "real flexible energy" activated in the project.				
Unit of measure	[kWh/ day (month, quarter, year)]				
Formula | $Var_{\%,KPI}$	$E_{DSF,loadshift} + E_{DSF,markets} + E_{DSF,peakload}$ Where: $E_{DSF,loadshift\ /\ markets\ /\ peakload}$ real flex energy activated for load shifting, market participation, peak shaving	$Var_{\%,KPI} = \left(\frac{F1_{R\&I} - F1_{BAU}}{F1_{BAU}}\right) * 100$			
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x			

KPI Name	Flexible capacity contracted			Code	F5
Description	The KPI shows how much flexible capacity is actually contracted throughout all the markets/mechanisms remunerating capacity, by the ecosystem as a whole, a DEMO or a single customer. If the market has a capacity auction, it corresponds to the capacity actually contracted in such market. The KPI can be monitored taking the preferred time granularity, namely; year, quarter, month, week, day, real-time (preferred: year).				
Unit of measure	[kW]				
Formula	$P_{DSF,contracted} = \sum_{m=1}^{M} P^m{}_{DSF,contracted}$ Where: $P^m{}_{DSF,contracted}$: DSF capacity contracted each day in market/mechanism m	$Var_{\%,KPI} = \left(\frac{F5_{R\&I} - F5_{BAU}}{F5_{BAU}}\right) * 100$			
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x			

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KPI Name	Precision for flexibility capacity analysis			Code	F6
Description	Measure related to the ecosystem capability of connecting with electricity markets and analysing in real-time the available DSF with precision. Calculated as function of the kWh of flexible energy forecasted to be activated divided by the kWh of flexible energy actually activated in the markets by the platform. A target for the project has been set: >99%				
Unit of measure	[%]				
Formula	$Precision = 100 - \left\lvert \frac{P_{DSF,forecasted}}{P_{DSF,activated}} - 1 \right\rvert \times 100$ Where: $P_{,DSF,forecasted}$: forecasted flex capacity to be activated $P_{DSF,activated}$: flex capacity actually activated.		$Var_{\%,KPI} = \left(\frac{F6_{R\&I} - F6_{BAU}}{F6_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x			

KPI Name	Available flexible capacity			Code	F8
Description	Parameter to monitor the amount of a DEMO or prosumer's available capacity that can be used to provide flexibility. With the development of the ecosystem, an improvement should be expected, also taking into account that it will drive customers to engage more with flexibility and install/allow more of their loads to the platform for flex purposes. The calculation is done adding up the capacity of each appliances available for DSF.				
Unit of measure	[kW]				
Formula	$AFC = \sum_{i=1}^{N} P_{flex,j}$ Where: j: applicance j $P_{flex,j}$: capacity of appliance j that can be exploited for DSF purposes		$Var_{\%,KPI} = \left(\frac{F8_{R\&I} - F8_{BAU}}{F8_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

KPI Name	Decrease in failure rate in flex capacity of the grid	Code	F9
Description	The failure rate (FLR) is calculated as the deviation between the requested flexible energy - or "market activated energy"- to lower or increase and the flexible energy actually activated. This deviation should decrease during the development of the project.		
Unit of measure	[%]		

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Formula	$Var = \left(\frac{FLR_{end}}{FLR_{ref}} - 1\right) \times 100$ Where: $FLR = \left\lvert 1 - \frac{E_{el,DSF,activated}}{E_{el,DSF,requested}} \right\rvert \times 100$ And: $E_{el,DSF,activated/requested}$: flex energy actually activated/requested.		$Var_{\%,KPI} = \left(\frac{F9_{BAU} - F9_{R\&I}}{F9_{BAU}}\right) * 100$	
Scale	Project	DEMO/Community	Customer/Building	Asset
	x	x		

KPI Name	**Distribution grid investments avoidance or deferral due to the use of flex**		**Code**	**F10**
Description	Investment avoidance can be obtained from the profits in local flexibility markets when these are present. A hypothesis is made for such markets: DSOs remunerate with prices close to distribution grid savings. Therefore, revenues from local flexibility markets (€/year) for each DEMO can be taken as the amount that DSOs are avoiding in distribution grid investments. In countries where local flex markets run by DSOs are not present, to give an indication, the ecosystem will run the simulations using data from countries where local flexibility markets are established (i.e. the UK).			
Unit of measure	[€/year]			
Formula	$\sum_{d=1}^{365} E^{d}{}_{DSF,LocalFlex} \times Price^{d}{}_{DSF,LocalFlex}$ Where: $E^{d}{}_{DSF,LocalFlex}$: energy despatched in the local flex market in the day "d" $Price^{d}{}_{DSF,LocalFlex}$: average price of the local flex market (UK)		$Var_{\%,KPI} = \left(\frac{F10_{R\&I} - F10_{BAU}}{F10_{BAU}}\right) * 100$	
Scale	Project	DEMO/Community	Customer/Building	Asset
	x	x		

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KPI Name	Increased RES and DER's hosting capacity			Code	F11
Description	The hosting capacity is defined as the amount of new production or consumption that can be connected to the grid without endangering the reliability or voltage quality of other customers31. To determine if the grid's RES hosting capacity is improved, a hypothesis is made. First of all, the ratio between the spillages (renewable energy generated and fed into the grid) and the total renewable energy generation is calculated. Thanks to the better consumption / self-generation matching of the ecosystem (self-consumption maximisation), this ratio is expected to be reduced. This, in turn, can be taken as an increased hosting capacity of the grid since the impact of the DEMOs' DERs on it will be lower. Therefore, if the ratio lowers in time the result is a YES (increased hosting capacity); if the ratio increases in time, the result will be a NO.				
Unit of measure	YES / NO				
Formula	$If: Sp\%_{end} < Sp\%_{beg} \rightarrow YES$ $If: Sp\%_{end} > Sp\%_{beg} \rightarrow NO$ Where: $Sp\% = \left(E^{spilled}_{RES,selfgen} / E^{tot}_{RES,selfgen} \right)$ And: $E^{spilled}_{RES,selfgen}, E^{tot}_{RES,selfgen}$: Measurements		$Var_{\%,KPI} = F11_{R\&I} - F11_{BAU}$ Where: F11 expressed as Yes: 100% NO: 0%		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x			

KPI Name	Growth of assets used for DSF			Code	F18
Description	Increase of n° of DSF assets (decentralised loads, batteries and generation) available from the beginning of the project.				
Unit of measure	[%]				
Formula	$Increase_{N,ast} = \frac{(N_{ast,DSF,end} - N_{ast,DSF,beg})}{N_{ast,DSF,beg}} \times 100$ Where: $N_{ast,DSF}$: number of assets used for DSF		$Var_{\%,KPI} = F18$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

31 Hosting Capacity of the Power Grid for Renewable Electricity Production and New Large Consumption Equipment, Math H. J. Bollen ID and Sarah K. Rönnberg, Energies 2017, 10, 1325

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Renewables category:

KPI Name	Energy activated coming from RES in DEMOs			Code	R1
Description	Renewable energy self-generated and consumed. The maximisation of this parameter is possible matching the known RES generation and consumption patterns. It is calculated for each DEMO and, adding the single contributions, for the whole project.				
Unit of measure	[kWh/day(month, year)]				
Formula	$E^{cons}_{RES,selfgen} = E^{tot}_{RES,selfgen} - E^{spilled}_{RES,selfgen}$		$Var_{\%,KPI} = \left(\frac{R1_{R\&I} - R1_{BAU}}{R1_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

KPI Name	Share of renewable electricity on the final consumption			Code	R8
Description	Percentage of the electricity consumed that can be traced back to renewable generation. Calculated as the ratio between KPI R7 and KPI EE1.				
Unit of measure	[%]				
Formula	$R7/EE1$		$Var_{\%,KPI} = \left(\frac{R2_{R\&I} - R2_{BAU}}{R2_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x			

Environmental Impact category:

KPI Name	GHG emissions			Code	EI1
Description	GHG emissions (indirect) due to the consumption of grid electricity, having a carbon content related to the specific electricity generation mix of the country at the time of consumption. The action of the ecosystem will reduce this parameter thanks to the maximisation of self-generation, the energy efficiency measures and the better matching with hours in which RES generation is higher in the grid. In order to catch these effects, real-time grid electricity emission factors will be used, GHG emissions will be calculated and then summed. The result will be expressed as a total yearly (monthly and daily) value. Calculated as the product of the grid imported electricity and the grid electricity emission factor ([kgCO2eq/kWh]). Note: An improvement in time has to be expected also due to the decarbonization of the countries' electricity generation mix.				
Unit of measure	[kgCO2eq/year (month,day)]				
Formula	$Emissions_{GHG} = E^{cons}_{el,grid} \times ef_{el,grid}$ Where: $E^{cons}_{el,grid}$: electricity imported from the grid ; $ef_{el,grid}$: emission factor of the grid electricity.		$Var_{\%,KPI} = \left(\frac{EI1_{R\&I} - EI1_{BAU}}{EI1_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

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Energy Performances and Efficiency category:

KPI Name	Primary Energy Use of electricity			Code	EP2
Description	Yearly primary energy consumption (or Primary Energy Use, PEU) related to the electricity consumption, per square meter. Is calculated by multiplying the electricity consumed imported (coming from the grid) and the primary energy factor of grid electricity, then subtracting the positive contribution given by the renewable electricity exported. Allows quantifying losses in generation, transmission and distribution of the electricity, the characteristics of the grid electricity mix and the positive effects of the self-generation. It can be also calculated as an average of the whole DEMO or project. Note: The losses are null in the case of self-consumption, therefore this parameter should be effective in taking into account both the better electricity use intensity and the maximisation of self-consumption. The calculation is derived from the methodology followed in the SAP32.				
Unit of measure	[kWh/m2/year]				
Formula	$PEU_{el}_m2 = PEU_{el}/Area$ $PEU_{el} = (E^{cons}_{el,grid} \times PEF_{el,grid}) - (E^{spilled}_{RES,selfgen} \times PEF_{el,RES})$	Where: $E^{cons}_{el,grid}$: electricity imported from the grid and consumed; $PEF_{el,grid}$: primary energy factor of grid electricity; $E^{spilled}_{RES,selfgen}$: renewable electricity self- generated and exported; $PEF_{el,RES}$: primary energy factor of renewable electricity.	$Var_{\%,KPI} = \left(\frac{EP2_{BAU} - EP2_{R\&I}}{EP2_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

Comfort and Health category:

KPI Name	Predicted Percentage of Dissatisfied (PPD)			Code	CH2
Description	Quantitative prediction of the percentage of thermally dissatisfied occupants, determined from PMV. To calculate the values per DEMO and project, a simple average of the buildings values can be made.				
Unit of measure	[%]				
Formula	$PD = 100 - 95\, e^{-(0.03353PVM^4 + 0.2179PVM^2)}$		$Var_{\%,KPI} = \left(\frac{CH2_{BAU} - CH2_{R\&I}}{CH2_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

[32] Briefing Note – Derivation and use of Primary Energy factors in SAP; BRE. Version 1.3 – 01/10/2019.

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KPI Name	Frequency of Visual Comfort (FVC)			Code	CH6
Description	The percentage of the time within a given period during which daylight alone delivers appropriate values of illuminance. The assumption is that if the average illuminance is within the range between two threshold values (below E_{Under} or above E_{Over}), visual comfort is guaranteed thanks to daylight only. Note: a reference value can be FVC>80%33. To calculate the values per DEMO and project, a simple average of the buildings values can be made.				
Unit of measure	[%]				
Formula	$FVC = \frac{\sum_i wf_i \cdot t_i}{\sum_i t_i}$ $wf_i = \begin{cases} 1 & E_{under} < E_{daylight} < E_{over} \\ 0 & E_{light} < E_{under} \vee E_{dlight} > E_{over} \end{cases}$		$Var_{\%,KPI} = \left(\frac{EP3_{R\&I} - EP3_{BAU}}{EP3_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

KPI Name	CO2 Concentration			Code	CH7
Description	CO2 Concentration in indoor air, in 1 ppb and 2 percentage. Note: if an estimation is necessary, standard CO2 emissions of 20 l/h per person can be assumed. To calculate the values per DEMO and project, a simple average of the buildings values can be made.				
Unit of measure	1. [ppb] | 2. [%]				
Formula	Estimation from the number of occupants		$Var_{\%,KPI} = \left(\frac{CH7_{BAU} - CH7_{R\&I}}{CH7_{BAU}}\right) * 100$ Where: $CH7_{BAU/R\&I}$: average values for the projects' buildings		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

KPI Name	PM Concentration			Code	CH8
Description	Concentration of Particulate Matter (PM) of various diameters. To calculate the values per DEMO and project, a simple average of the buildings values can be made.				
Unit of measure	1. [µg/m3] | 2. [#/m3]				
Formula	Assessment		$Var_{\%,KPI} = \left(\frac{CH8_{BAU} - CH8_{R\&I}}{CH8_{BAU}}\right) * 100$ Where: $CH8_{BAU/R\&I}$: average values for the projects' buildings		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

[33] "A review of indices for assessing visual comfort with a view to their use in optimization processes to support building integrated design"; Salvatore Carlucci a,*, Francesco Causone , Francesco De Rosa and Lorenzo Pagliano. Renewable and Sustainable Energy Reviews.

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Economic category:

KPI Name	Estimated ROI for the REDREAM ecosystem			Code	EC1
Description	Return on Investment, measuring the return on invested capital and therefore the ability to obtain returns on investments. Indicates the ability to remunerate both risk capital and debt capital.				
Unit of measure	[%]				
Formula	$ROI = \frac{OperInc}{NetOperInvestCap}$ Where: $OperInc$: Operative Income $NetOperInvestCap$: Net Operating Invested Capital		$Var_{\%,KPI} = \left(\frac{EC1_{R\&I} - EC1_{BAU}}{EC1_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x			

KPI Name	Pay Back Time (PBT)			Code	EC2
Description	Pay Back Time, a corporate finance indicator to assess the attractiveness of an investment, assessing the recovery of the investment. A shorter PBT is desired to reach the breakeven; it is useful to determine the cost savings of energy efficiency technology. Calculated as the ratio of the Acquisition cost and the difference between Average financial flows and Average operating costs. Notes: Classical Payback: 5-20 years.				
Unit of measure	[years] or [months]				
Formula	$PBT = \frac{AcquisCost}{AFF - AOC}$ Where: $AcquisCost$: Acquisition cost AFF: Average financial flows AOC: Average operating costs		$Var_{\%,KPI} = \left(\frac{EC2_{R\&I} - EC2_{BAU}}{EC2_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x			

Technology and Services category:

KPI Name	Number of services combining EE with other energy services, technologies and non-energy benefits			Code	T1
Description	KPI to monitor the implementation of ReDREAM's energy and non-energy services, to provide a holistic set of solutions.				
Unit of measure	[#]				
Formula	Assessment		$Var_{\%,KPI} = \left(\frac{T1_{R\&I} - T1_{BAU}}{T1_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x				

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KPI Name	Number of services developed to predict energy patterns			Code	T2
Description	Services to predict energy patterns, such as the open digital twins developed in WP2, will increase the precision of consumptions' prediction. The more services will be developed, the better the predictability will be (monitored in KPI T3).				
Unit of measure	[#]				
Formula	Assessment		$Var_{\%,KPI} = \left(\frac{T2_{R\&I} - T2_{BAU}}{T2_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x				

KPI Name	Decrease of error in predictability of consumption			Code	T3
Description	KPI to monitor improvements in the precision of consumption patterns and consumers behaviours through digital twins and other software services.				
Unit of measure	[%]				
Formula	$ErrVar = \left(\frac{Perr_{beg} - Perr_{end}}{Perr_{beg}}\right) \times 100$ Where: ErrVar: Error variation Beg: beginning of the project; End: end of the project; $Perr = \left\lvert\frac{Vmeasured - Vpredicted}{Vmeasured}\right\rvert \times 100$ $Vmeasured; predicted$: measured/predicted electricity consumption values		$Var_{\%,KPI} = T3$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x				

KPI Name	Accessibility of third parties			Code	T5
Description	Total number of third parties able to connect to the platform. Accessibility to the platform is necessary to guarantee a future replicability, with third parties that are able to profit from the EE services.				
Unit of measure	[#]				
Formula	Assessment		$Var_{\%,KPI} = \left(\frac{T5_{R\&I} - T5_{BAU}}{T5_{BAU}}\right) * 100$		
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x				

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SRI-related KPIs:

KPI Name	SRI Increase / decrease - Building			Code	SRI1
Description	Difference between the final value of the SRI (after the implementation of the ecosystem and its smart technologies) and the initial value of the SRI of the building (reference, before the implementation of the ecosystem). A positive value shows an SRI increase thanks to ReDREAM.				
Unit of measure	[%]				
Formula	$\Delta_{SRI} = SRI_{end} - SRI_{ref}$ Where: $SRI_{ref/end}$: initial and final values of SRI of the building / site				
Scale	Project	DEMO/Community	Customer/Building	Asset	
			x		

KPI Name	SRI Variation - Building			Code	SRI2
Description	Percentage variation of the SRI from the initial value (reference, before the implementation of the ecosystem) to the final value of the building (after the implementation of the ecosystem and its smart technologies). A positive value shows an SRI increase thanks to ReDREAM.				
Unit of measure	[%]				
Formula	$SRI_{var} = \left(\frac{SRI_{end} - SRI_{ref}}{SRI_{ref}}\right) x100$ Where: $SRI_{ref/end}$: initial and final values of SRI of the building / site				
Scale	Project	DEMO/Community	Customer/Building	Asset	
			x		

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Other detailed KPIs:

Flexibility category:

KPI Name	Flexible energy despatched			Code	F2
Description	The KPI shows how much flexible energy is actually contracted and despatched - throughout all the markets/mechanisms available- by the ecosystem as a whole, a DEMO or a single customer. Variations with time: time can be chosen as preferred. Seasonality can significantly impacts buildings' DSF, interesting to be monitored: a quarterly timeframe should be considered. Variations with location: comparisons between the different DEMOs will give indication on the possibilities that each country offers (weather, typical assets, markets open, etc.). Variations with customers: separate residential and non-residential: utilization of a building impacts DSF capability. Customer KPI.				
Unit of measure	[kWh/ day (month, quarter, year)]				
Formula	$E_{DSF,markets} = \sum_{m=1}^{M} E^{m}{}_{DSF,market}$ Where: $E^{m}{}_{DSF,market}$: real flex energy activated (despatched) in the market "m"				
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

KPI Name	Flexible energy offered			Code	F3
Description	KPI monitoring the amount of flexible energy offered throughout all the markets/mechanisms available by the ecosystem as a whole, a DEMO or a single customer. As for KPI F2, interesting to monitor the variations with time, location and type of customer.				
Unit of measure	[kWh/ day (month, quarter, year)]				
Formula	$E_{DSF,offered} = \sum_{m=1}^{M} E^{m}{}_{DSF,offered}$ Where: $E^{m}{}_{DSF,offered}$: daily flex energy offered in the market "m"				
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

KPI Name	Maximum flexible capacity offered	Code	F4
Description	Maximum capacity offered in the markets -throughout all the markets/mechanisms available remunerating capacity- by the ecosystem as a whole, a DEMO or a single customer. The KPI can be monitored taking the preferred time granularity, namely; year, quarter, month, week, day, real-time (preferred: year).		

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Unit of measure	[kW]			
Formula	$P^{max}_{DSF,offered} = MAX(P^{max,m}_{DSF,offered}\ ;\ \forall m)$ Where: $P^{max,m}_{DSF,offered}$: daily flex capacity offered in the market "m"			
Scale	Project	DEMO/Community	Customer/Building	Asset
	x	x	x	

KPI Name	DSF despatched / contracted in each market	**Code**	**F12**
Description	Volume of DSF (in terms of energy, 1, or capacity 2) accepted in markets, separated per specific market.		
Unit of measure	1. [kWh/year] | 2. [kW/year]		
Formula	$E\|P_{DSF,market,m} = \sum_{d=1}^{365} E\|P^{d}{}_{DSF,market,m}$ Where: $E\|P^{d}{}_{DSF,market,m}$: real flex energy | power despatched or contracted in the market "m" the day "d"		

Scale	Project	DEMO/Community	Customer/Building	Asset
		x		

KPI Name	Mean DSF revenue (energy)	**Code**	**F14**
Description	Mean income per kWh coming from DSF market participation. This parameter can monitor also the platform improved ability in playing in the markets and the increased business opportunities coming from flexibility while markets open in the different countries. Is calculated as the ratio between the total income from activated DSF in a year [€] and the total flexible energy despatched in a year [kWh/year].		
Unit of measure	[€/kWh]		
Formula	$MeanRev = \frac{Rev_{E,DSF}}{E_{DSF,despatched}}$ Where: $Rev_{E,DSF}$: total revenue from activated DSF in a year [€]; $E_{DSF,despatched}$: total flexible energy despatched in a year [kWh/year].		

Scale	Project	DEMO/Community	Customer/Building	Asset
	x	x	x	

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KPI Name	Most obedient asset typology for flexibility provision			Code	F20
Description	Classification of the DSF assets based on their obedience. Note: the obedience of an asset is its accuracy to follow a given command.				
Unit of measure	Classification				
Formula	Assessment				
Notes					
Scale	Project	DEMO/Community	Customer/Building	Asset	

Renewables category:

KPI Name	RES generation			Code	R2
Description	Parameter useful to monitor the amount of renewable energy generated and stored/consumed/sold within each DEMO.				
Unit of measure	[kWh/day(month, year)]				
Formula	$E^{tot}_{RES,selfgen} = \sum_{i=1}^{N} E^{i}_{RES,selfgen}$ Where: $E^{i}_{RES,selfgen}$: daily renewable energy generated by asset "i"				
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

KPI Name	Self-consumption rate			Code	R3
Description	Weight of self-consumption on total energy consumption, obtained by dividing KPI R1 by the total yearly electricity consumption (KPI EP1).				
Unit of measure	[%]				
Formula	$SCR = \left(E^{cons}_{RES,selfgen} / E^{cons}_{el,tot} \right) \times 100$ Where: $E^{cons}_{RES,selfgen}$: Energy activated coming from RES in DEMOs; $E^{cons}_{el,tot}$: total electricity consumption.				
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

KPI Name	RES energy export			Code	R4
Description	Renewable energy self-generated and fed into the grid (spillages), calculated as 1. kWh/year and 2. percentage of energy exported (spilled) with respect to the total energy self-generated.				
Unit of measure	1. [kWh/year] | 2. [%]				

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Formula	1. $E_{RES,selfgen}^{spilled} = \sum_{d=1}^{365} E_{RES,selfgen}^{spilled,d}$ Where: $E_{RES,selfgen}^{spilled,d}$: renewable energy self-generated and spilled on the day "d" 2. $Sp\% = \left(E_{RES,selfgen}^{spilled} / E_{RES,selfgen}^{tot} \right) \times 100$			
Scale	Project	DEMO/Community	Customer/Building	Asset
	x	x	x	

KPI Name	Energy export / import ratio	**Code**	**R5**
Description	Comparison between renewable energy self-generated and exported and the total electricity imported from the grid on a daily basis. Notes: if exports exceed the imports, a community can be considered a "Positive Energy Community". This parameter can experience a decrease in time due to the better generation-consumption matching.		
Unit of measure	[%]		
Formula	$EIR = \left(E_{RES,selfgen}^{spilled} / E_{el,grid} \right) \times 100$ Where: $E_{RES,selfgen}^{spilled}$: renewable energy self-generated and exported; $E_{el,grid}$: electricity imported from the grid.		

Scale	Project	DEMO/Community	Customer/Building	Asset
		x	x	

KPI Name	Connected RES	**Code**	**R6**
Description	Amount of RES installed power. Note: this parameter is interesting also to keep monitoring in time the total capacity of a collective since several national regulations put a maximum power limit for the RES installed in a collective self-consumption configuration.		
Unit of measure	[kW]		
Formula	$P_{RES,selfgen} = \sum_{i=1}^{N} P^{i}_{RES,selfgen}$ Where: $P^{i}_{RES,selfgen}$: power of installed asset "i"		

Scale	Project	DEMO/Community	Customer/Building	Asset
	x	x		

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KPI Name	Total renewable electricity consumption			Code	R7
Description	Total RES consumption, sum of RES self-consumption (R1) and the share of renewable electricity imported from the grid and consumed. The latter is calculated hourly (then summed in a daily value) multiplying the electricity imported from the grid by the percentage of renewable energy of the electricity mix (hydro, solar, wind, biomass, geothermal, etc.).				
Unit of measure	[kW]				
Formula	$E_{el,RES}^{cons,tot} = R1 + E_{el,grid}^{cons} \times share_{RES}^{el,grid}$				
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x			

Environmental Impact category:

KPI Name	GHG emissions savings			Code	EI2
Description	Savings in kilograms of CO2 equivalent. The calculation is performed with an approximation: at the end of each day, the average emission factor of the grid electricity generation mix ($ef_{grid,elec}^{average}$) is calculated. From it, it is possible to calculate the approximate daily emissions that would have occurred if all electricity consumed would have been imported from the grid ($e_{GHG,NR}$) without the action of the ecosystem and the self-generation, creating a baseline. To obtain the savings ($savings_{GHG}$), the KPI EI1 for the site is then subtracted. The daily value of the savings can be aggregated into monthly and yearly values.				
Unit of measure	[kgCO2eq/day (month/year)]				
Formula	$savings_{GHG} = e_{GHG,NR} - e_{GHG,tot}$ Where: $e_{GHG,NR} = ef_{grid,elec}^{average} \times E_{el,cons}$ $e_{GHG,tot} = KPI\ F1$				
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x			

KPI Name	GHG emissions per square meter			Code	EI4
Description	Emissions per square meter, real-time (hour) and aggregated monthly and yearly, calculated as the ratio of the customer GHG emissions and the area of the site/dwelling. This KPI is easily comparable and shows each customer's environmental impact and combines the positive effects of energy efficiency and DSF. Note: Yearly GHG emissions per square meter for each consumer/site are indicated in the EU regulation to monitor the energy performances of a building/site.				
Unit of measure	[kgCO2eq/m2/h (month,year)]				

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Formula	$m2Emissions_{GHG} = Emissions_{GHG}/Area$ Where: $Emissions_{GHG}$: KPI EI1; Area: area of the site/dwelling.			
Notes				
Scale	Project	DEMO/Community	Customer/Building	Asset
			x	

KPI Name	**Avoided emissions thanks to RES self-consumption**	**Code**	**EI5**
Description	GHG emissions that would be produced without self-consumption. Product of the consumed self-generated renewable electricity and the CO2eq emission factor at the time of consumption.		
Unit of measure	[kgCO2eq/h (month/year)]		
Formula	$AvoidedEm_{GHG,RES} = E^{cons}_{RES,selfgen} \times ef_{el,grid}$ Where: $E^{cons}_{RES,selfgen}$: self-generated renewable electricity consumed. $ef_{el,gria}$: GHG emission factor of the grid electricity.		

Scale	Project	DEMO/Community	Customer/Building	Asset
	x	x	x	

Energy Performances and Efficiency category:

KPI Name	**Electricity use intensity**	**Code**	**EP1**
Description	Electricity consumption of the site, per square meter (1) and total for building/ dwelling /site (2). Note: (1) is a common metric to monitor consumptions and their reduction, hence an energy efficiency growth. Always better to make distinctions in the results between residential and non-residential buildings. It can be calculated also for a DEMO/Community, as a sum of the single contributions.		
Unit of measure	1. [kWh/m2/month (year)] | 2. [kWh/site/day (month, year)]		
Formula	1. $EUI_m2 = EUI/Area$ 2. $EUI = E^{cons}_{el,tot}$ Where: $E^{cons}_{el,tot}$: total electricity consumption of the site; Area: area of the site/dwelling.		

Scale	Project	DEMO/Community	Customer/Building	Asset
		x	x	

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KPI Name	Load factor			Code	EP3
Description	Parameter obtained as the ratio of average demand (capacity) and peak demand of a site. A low value suggests that only in some cases a high demand is set: since network charges are higher with higher peaks, to service rather infrequent peaks the kWh for the customer is highly charged. The peak shaving effect of the ecosystem should have a positive effect on this parameter.				
Unit of measure	[%]				
Formula	$LF = (P_{el}^{average} / P_{el}^{peak}) \times 100$ Where: $P_{el}^{average}$: average demand of the site (capacity); P_{el}^{peak}: peak demand of the site (capacity).				
Scale	Project	DEMO/Community	Customer/Building	Asset	
			x		

KPI Name	Electricity cost index (bill)			Code	EP4
Description	Total annual electricity cost (1) and its percentage variation in time (2). A decrease (negative value) is to be expected thanks to the action of the ecosystem.				
Unit of measure	1. [€/year)] | 2. [%]				
Formula	2. $Var_{Cost,year\,j} = \frac{Cost_{year,j} - Cost_{ref}}{Cost_{ref}} \times 100$ Where: $Cost_{year,j/ref}$: Total annual electricity cost of year j / of reference year (before beginning of project).				
Scale	Project	DEMO/Community	Customer/Building	Asset	
			x		

KPI Name	TD Electricity Consumption			Code	EP6
Description	KPI to be calculated for each Technical Domain (TD). Consumption of the single technical domain (1) in absolute value, (2) per square meter and (3) in percentage of the total Electricity use intensity of the whole site.				
Unit of measure	1. [kWh/day (month,year)] | 2. [kWh/m2/day(month,year)] | 3. [%]				
Formula	2. $E_{el,TD_m2}^{cons} = E_{el,TD}^{cons} / Area$ 3. $E_{el,TD_{\%}}^{cons} = E_{el,TD}^{cons} / EUI$ Where: *Area*: area of the site/dwelling; *EUI*: KPI EP1 of the site/dwelling				
Scale	Project	DEMO/Community	Customer/Building	Asset	
			x	x	

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Comfort and Health category:

KPI Name	Predictive Mean Vote (PMV)			Code	CH1
Description	An Index that predicts the mean value of the votes of a large group of persons on the seven-point thermal sensation scale. To calculate the values per DEMO and project, a simple average of the buildings values can be made.				
Unit of measure	Dimensionless				
Formula	$PMV = (0.303e^{-0.36 \cdot MET} + 0.028) \times L$ T_a: Air temperature [°C] RH: Relative humidity [%] T_r: Radiant mean temperature [°C] U_a: Relative air velocity [m/s] Clo: Clothing level [clo] MET: Metabolic rate [1-8, MET = 60 W/m²] L: Heat loss from human body				
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

KPI Name	Comfort zone			Code	CH4
Description	Represents the combinations of conditions for the sa me metabolic rate and clothing level for which the PMV is between -0.5 and +0.5. To calculate the values per DEMO and project, a simple average of the buildings values can be made.				
Unit of measure	[°C, %]				
Formula	Assessment				
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x	x		

Economic category:

KPI Name	Internal Rate Return (IRR)			Code	EC3
Description	Internal Rate Return, establishing the profitability of potential investments, showing the annual growth rate. Using the formula, one would set NPV equal to zero and solve for the discount rate, which is the IRR. Notes: expected range of IRR > cut-off rate.				
Unit of measure	-				
Formula	$0 = NPV = \sum_{t=1}^{T} \frac{C_t}{(1+IRR)^t} - C_0$ Where: C_0: total initial investment cost; C_t: net cash inflow during the time period t; NPV: Net present value.				
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x			

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KPI Name	Weighted Average Cost of Capital (WACC)			Code	EC7
Description	Weighted Average Cost of Capital, a useful parameter to assess investor's returns on an investment and a bankability practical tool. Allows investors to establish the cost of capital, by analysing all its components.				
Unit of measure	[%]				
Formula	$WACC = \left(\frac{E}{V} \times Re\right) + \left(\frac{D}{V} \times Rd \times (1 - Tc)\right)$ Where: E=Market value of the firm's equity D=Market value of the firm's debt V=E+D Re=Cost of equity Rd=Cost of debt Tc=Corporate tax rate				
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x			

KPI Name	Social Return on Investment (SRoI)			Code	EC8
Description	Social Return on Investment, measures non-financial values such as social, economic, and environmental factors. It is useful to quantify the value chain created for the local community. It enables the planning and evaluation quantifying the monetization of the social impact in financial terms. Notes: this parameter is not uniquely defined yet and will be developed in the next steps of the project.				
Unit of measure	-				
Formula	TBD				
Scale	Project	DEMO/Community	Customer/Building	Asset	
	x	x			

KPI Name	Life-cycle cost of electrical energy generation			Code	EC12
Description	Sum of all the costs throughout the lifetime of the energy investment, normalized to the energy generated.				
Unit of measure	[€/MWh]				
Formula	$LCCeg = \frac{(OPEX_{el,gen} + CAPEX_{el,gen})}{E^{tot}_{RES,selfgen}}$ Where: $OPEX/CAPEX_{el,gen}$= OPEX and CAPEX for the electricity self-generation $E^{tot}_{RES,selfgen}$: overall electric self-generation, in the technical/useful lifetime of the project (or 20 years).				
Scale	Project	DEMO/Community	Customer/Building	Asset	
		x	x		

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ReDREAM Tech KPIs Library

VERSION
V3

GENERAL NOTES ON THE DRAFT FILE
The following Excel sheets present the list of the technical detailed KPIs developed, divided under different categories: Flexibility, Renewables, Environmental Impact, Energy Efficiency and Performances, Comfort and Health, Technology and Services. Finally, the SRI-related KPIs can be found in the last sheet. Some of the KPIs presented can be further developed or adjusted in the next steps of the project. Additional details on the KPIs categories are presented in the Word document of the deliverable.

RESULTS INTERPRETATION, CONVENTIONS, CALCULATION PROCEDURES
Dimensions (square meters): Afor dwelling dimensions (especially floor area) the conventions of the Standard Assessment Procedure for Energy Rating of Dwellings are followed , "Dimensions refer to the inner surfaces of the elements bounding the dwelling. Thus floor dimensions are obtained by measuring between the inner surfaces of the external or party walls, disregarding the presence of any internal walls." **Building/Customer:** The performances or relevant results relative to a building are influenced by its utilization. To make comparisons or identify benchmarks using the KPIs for a single building/customer, a distinction should be made according to its purpose and utilization (e.g. clear distinctions between residential, commercial and industrial sites). **DEMO:** Comparisons between the different DEMOs will give indications on the peculiarities of each country. Differences in weather, regulatory and markets conditions, kind of customers participating in each DEMO will greatly influence the results. **Time granularity:** Time granularity of the measurements (hence KPIs calculated from them) depends on the specific KPI. Even when not specified, monthly, seasonal (quarterly) and yearly measurements should always be in place. **'Customer KPI':** KPIs labelled as Customer KPI in the Notes. are a selection of KPIs considered significant to be directly shown to the final customer. **Time reference in percentual variations:** WWhen a percentage variation is calculated as a KPI, yearly values should be compared to avoid seasonality effects or random variations. Since the measurements will start only 2-3 months ahead of the ecosystem implementation, when a percentage variation is foreseen the reference value will be calculated taking those 2-3 months only and the comparison will be made with the values obtained the same months of the year(s) after. The results will lack some accuracy but will show a trend, otherwise not possible to obtain with real measured data. **Primary energy:** Energy from renewable and non-renewable sources, which has not undergone any conversion or transformation process[1]. **GHG emissions:** According to Regulation 2018/842, GHG emission "[…] means emissions in terms of tonnes of CO2 equivalent of carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), nitrogen trifluoride (NF3) and sulphur hexafluoride (SF6) […]". **DSF:** for Demand Side Flexibility, we apply the following definition "Decentralised behind-the-meter sources of flexibility are collectively termed Demand Side Flexibility (DSF). DSF is technology agnostic and refers to the turning on / off, up / down, or shifting of, decentralised loads, batteries and generation across any value stream or customer segment. Assets can be aggregated or utilised individually". **Seasonality:** seasonality can significantly impact buildings' performances -being this flexibility, energy performances or environmental impact- and renewables' generation. This is why quarterly timeframes are suggested to be monitored.

A workable Excel version is available upon request

Flexibility KPIs

Generalities								Scale				Overlaps with other categories					
Code	Name	Description	Unit of measure	Calculation / Formula	Notes	Polarity	Targets (if mandatory KPI)	Project	DEMO / Community	Customer / Building	Asset	Flex	RES	Environ	Energy Eff	Comfort&Health	Economic	Tech & Services
F1	**Energy mobilized through DR**	Sum of all DR activations through the available mechanisms (consumption matching with RES self-generation, peak load reduction, flex provision in balancing services and congestion management services, etc.). It corresponds to the "real flexible energy" activated in the project. The KPI is obtained as a sum of the values of KPIs F2, F22 and F23.	[kWh/ day (month,quarter, year)]	Measurements	Mandatory KPI (KPI1)	An increase in time is desired	Local targets (+ household/non-res) ; Total 32-66.10 kWh/y ; Beyond project: 10000 MWh/y	X	X			X						
F2	**Flexible energy despatched**	Flexible energy contracted and despatched throughout all the markets. The value can be obtained as a sum of the values for each market of KPI F12 (for the energy).	[kWh/day (month,quarter, year)]	Measurements	**Customer KPI.** Variations with time: time can be chosen as preferred: year, quarter, month, week, day, real-time (preferred: year) . Seasonality can significantly impacts buildings' DSF, interesting to be monitored: a quarterly timeframe should be considered. Variations with DEMO: comparisons between the different DEMOs will give indication on the possibilities that each country offers (weather, typical assets, markets open, etc.). Variations with customers: separate residential and non-residential: utilization of a building impacts DSF capability.	An increase in time is desired		X	X	X		X						
F3	**Flexible energy offered**	Flexible energy offered in all the markets.	[kWh/day (month,quarter, year)]	Measurements	See notes above			X	X	X		X						
F4	**Maximum flex capacity offered**	Maximum flexible capacity offered in the markets, maximum capacity bid.	[kW]	Measurements	See notes above			X	X	X		X						
F5	**Flexible capacity contracted**	DSF capacity contracted in the markets. If the market has a capacity auction, it corresponds to the capacity actually contracted in such market.	[kW]	Measurements	See notes above			X	X	X		X						
F6	**Precision for flexibility capacity analysis**	Measure related to the ecosystem capability of connecting with electricity markets and analyzing in real-time the available DSF with precision. Calculated as function of the kW of flexible capacity forecasted to be activated divided by the kW of flexible capacity actually activated in the markets by the platform.	[%]	Precision =100-(P_(el,DSF,forecasted)/P_(el,DSF,activated)) -1)*100	Mandatory KPI (KPI9)	A high value is desired	>99%	X	X			X						X
F7	**Weight of DR activation**	Ratio between yearly kWh of DR actually activated and kWh of consumption. Parameter that shows the 'impact' of DR on each prosumer/DEMO.	[%]	100 * (kWh,DR,activated) / (kWh,consumption)					X	X		X						
F8	**Available flexible capacity**	Parameter to monitor the amount of a DEMO or prosumer's available capacity that can be used to provide flexibility. With the development of the ecosystem, an improvement should be expected, also taking into account that it will drive customers to engage more with flexibility and install/allow more of their loads to the platform for flex purposes. The calculation is done adding up the capacity of each appliances available for DSF.	[kW]	Sum,j [(appliance power,j)]				X	X	X		X						
F9	**Decrease in failure rate in flex capacity of the grid**	The failure rate (FLR) is calculated as the deviation between the requested flexible energy -or "market activated energy"- to lower or increase and the actual flexible energy delivered -or "real activated energy"-. This deviation should improve during the development of the project. Possible to use the Storey "Real non-served energy" KPI in the calculation of FLR (nominator).	[%]	(FLRend-FLRbeginning) / FLRbeginning x 100; where: FLR = 1 - ((Eat,DSF,activated / kWh,DSF,requested)) * 100	Mandatory KPI (KPI13)	A negative value shows an error reduction in time.	Total decreas of 9.8% (plus local targets)	X	X			X						X
F10	**Distribution grid investments avoidance or deferral due to the use of flex**	Investment avoidance can be obtained from the profits in local flexibility markets when these are present. A hypothesis is made for such markets: DSOs remunerate with prices close to distribution grid savings. Therefore, revenues from local flexibility markets (€/year) for each DEMO can be taken as the amount that DSOs are avoiding in distribution grid investments. In countries where local flex markets run by DSOs are not present, to give an indication, the ecosystem will run the simulations using data from countries where local flexibility markets are established (UK).	[€/year]	Measurements	Mandatory KPI (KPI14)		Total: 10,241.67 €/y ; Total beyond life: 9.6 M€/y (plus ocal targets)	X	X			X				X		
F11	**Increased RES and DER's hosting capacity**	The hosting capacity is defined as the amount of new production (or consumption) that can be connected to the grid without endangering the reliability or voltage quality of other customers . To determine if the grid's RES hosting capacity is improved, a hypothesis is made. First of all, the ratio between the spillages (renewable energy generated and fed into the grid) and the total renewable energy generation is calculated. Thanks to the better consumption / self-generation matching of the ecosystem (self-consumption maximisation), this ratio is expected to be reduced. This, in turn, can be taken as an increased hosting capacity of the grid since the impact of the DEMOs' DERs on it will be lower. Therefore, if the ratio lowers in time the result is a YES (increased hosting capacity); if the ratio increases in time, the result will be a NO.	YES / NO	If: (Spills ,j,end)< (Spills ,j,beg) →YES If: Spills ,end> Spils ,beg →NO Where: Spills=((E_(RES,selfgen)*spilled)/(E_(RES,selfgen)*Int)). And: E_(RES,selfgen)*spilled,E_(RES,selfgen)*Int: Measurements	Mandatory KPI (KPI15)		YES	X	X			X	X					
F12	**DSF despatched / contracted in each market**	Volume of DSF (in terms of energy, 1, or capacity 2) accepted in markets, separated per specific market.	1. [kWh/year] 2. [kW/year]	Measurements					X			X						
F13	**Revenues from DSF market participation**	Revenues thanks to DSF participation in the electricity markets (also separated for each market), to monitor variations from beginning to end of the project. It can be related to Spider's "Real flexibility revenue", expanded to take into account revenues from capacity payments as well. Related to kWh,despatched/time and kW,contracted, multiplied by the related specific market price.	[€,tot/year] and [€/market/year]	Measurements				X	X	X		X				X		
F14	**Mean DSF revenue (energy)**	Mean income per kWh coming from DSF market participation. This parameter can monitor also the platform improved ability in playing in the markets and the increased business opportunities coming from flexibility while markets open in the different countries. Is calculated as the ratio between the total income from activated DSF in a year [€] and the total flexible energy despatched in a year [kWh/year].	[€/kWh]	[ ] MeanRev= Rev _((E,DSF)/E_(DSF,despatched))				X	X	X		X				X		
F15	**Mean DSF revenue (capacity)**	Mean income per kW coming from DSF market participation. Could be taken as a parameter to monitor the platform improved ability in playing in the markets and the opening of more market opportunities for DSF in the several countries.	[€/kW]	(Total income from contracted DSF capacity in a year [€/year]) / (Total DSF capacity contracted in a year [kW/year])				X	X	X		X				X		
F16	**Impact of DSF revenues**	Impact of DSF on the revenues/savings of the Community	[%]	(Revenues from DSF market participation [€/ea,year])/(DEMO total revenues/savings [€/year]) *100				X	X			X				X		
F17	**DSF assets**	N° of DSF assets (decentralised loads, batteries and generation) available.	[#]	Assessment				X	X	X		X						
F18	**Growth of assets used for DSF**	Increase in the n° of DSF assets (decentralised loads, batteries and generation) available from the beginning of the project.	[%]	(1 - N,assets,dsf , end / N,assets,dsf ,beginning)*100	With the ReCREAM ecosystem implementation, a growth of the assets used for DSF should be seen. Moreover, the ecosystem should drive electrification, hence to install more assets capable of offering	A positive value is desired		X	X	X		X						
F19	**Most used equipment typology for DSF provision**	Classified by real DSF capacity [kW] and DSF delivered [kWh]	Classification	Assessment at the end of the project				X	X			X						X
F20	**Most obedient asset typology for flexibility provision**	Classification of the DSF assets based on their obedience.	Classification	Assessment	The obedience of an asset is its accuracy to follow a given command							X						X
F21	**System Peak reduction**	Maximum kW reduction achieved. The value can be monitored daily, monthly and yearly.	[kW]	Measurements				X	X			X						
F22	**DR activated for load shifting**	Demand Response activation to shift consumption on different times of the day, e.g. to match renewable generation.	[kWh/day (month, quarter, year)]	Measurements				X	X	X		X						
F23	**DR activated for peak reduction**	Demand Response activation to reduce peaks during the day. The values are then aggregated, as usual, in monthly, quarterly and yearly values.	[kWh/day (month, quarter, year)]	Measurements														

Renewables KPIs

Generalities								Scale				Overlaps with other categories						
Code	Name	Description	Unit of measure	Calculation / Formula	Notes	Polarity	Targets (if mandatory KPI)	Project	DEMO / Community	Customer / Building	Asset	Flex	RES	Environ	Energy Eff	Comfort&Health	Economic	Tech & Services
R1	Energy activated coming from RES in DEMOs	Renewable energy self-generated and consumed. The maximization of this parameter is possible matching the known RES generation and consumption patterns . It is calculated for each DEMO and, adding the single contributions, for the whole project.	[kWh/day(month/year)]	Measurements	Mandatory KPI (KPI16)		527.724 kWh/year	x	x			x	x					
R2	RES generation	Parameter useful to monitor the amount of renewable energy generated and stored/consumed/sold within each DEMO.	[kWh/day(month,year]	Measurements	**Customer KPI**			x	x				x					
R3	Self-consumption rate	Weight of self-consumption on total energy consumption, obtained by dividing KPI R1 by the total yearly electricity consumption (KPI EP1).	[%]	SCR=((E_j9ES,selfgen)*conv)/(E_j#,tot)*cons ()=100				x	x	x			x					
R4	RES energy export	Renewable energy self-generated and fed into the grid (spillages), calculated as 1. kWh/year and 2. percentage of energy exported (spilled) with respect to the total energy self-generated.	1. [kWh/year] 2. [%]	1. Measurements; 2. Spl=((E_j9ES,selfgen)*spilled)/(E_j9ES,selfgen)*tot)]=100				x	x	x			x					
R5	Energy export/import ratio	Comparison between renewable energy self-generated and exported and the total electricity imported from the grid on a daily basis.	[%]	100 * RES energy export [day] / Total electricity import [day]	If exports exceed the imports, a community can be considered a "Positive Energy Community". This parameter should be interpreted as a decrease in time due to the better generation-consumption matching.				x	x			x					
R6	Connected RES	Additional amount of RES installed capacity. Note: this parameter is interesting also to keep monitoring in time the total capacity of a collective since several national regulations put a maximum power limit for the RES installed in a collective self-consumption configuration.	[kW]	Measurements				x	x				x					
R7	Total renewable electricity consumption	Total RES consumption, sum of RES self-consumption (R1) and the share of renewable electricity imported from the grid and consumed. The latter is calculated hourly (then summed in a daily value) multiplying the electricity imported from the grid by the percentage of renewable energy of the electricity mix (hydro, solar, wind, biomass, geothermal, etc.).	[kWh/day(month,year]	R1 + [E_j#,grid)*cons x percentageRES_j#,grid)]					x	x			x					
R8	Share of renewable electricity on the final consumption	Percentage of the electricity consumed that can be traced back to renewable generation. Calculated as the ratio between KPI R7 and KPI EE1.	[%]	R7/EE1					x	x			x					
R9	RES spillages	Renewable energy self-generated and spilled to the grid. Maximising the generation–consumption matching, this parameter will be reduced by the platform (and, in turn, KPI R1 will grow)	[kWh/day(month/year)]	Measurements					x	x			x					

Environmental impact KPIs

Generalities								Scale				Overlaps with other categories						
Code	Name	Description	Unit of measure	Calculation / Formula	Notes	Polarity	Targets (if mandatory KPI)	Project	DEMO / Community	Customer / Building	Asset	Flex	RES	Environ	Energy Eff	Comfort&Health	Economic	Tech & Services
E11	**GHG emissions**	GHG emissions (indirect) due to the consumption of grid electricity, having a carbon content related to the specific electricity generation mix of the country at the time of consumption. The action of the ecosystem will reduce this parameter thanks to the maximization of self-generation, energy efficiency measures and better matching with hours in which RES generation is higher in the grid. In order to catch these effects, real-time or hourly grid electricity emission factors will be used, GHG emissions will be calculated and then summed; part of the positive effect could be also ascribed to the decarbonization of the EU electricity generation. This is more clearly showed by the following KPI "GHG emissions reduction". The result will be expressed as a total yearly (monthly and daily) value for REGBEAM and each DEMO and calculated also for each customer as an input to the KPI GHG emissions per square meter.	[kgCO2eq/year (month,day)]	[ ] Emissions _GHG=E_bl,grid*conv ef _ [ ] e_bl,grid	An improvement in time has to be expected also due to the decarbonization of the countries electricity generation mix.			x	x	x				x				
E12	**GHG emissions savings**	Savings in kilograms of CO2 equivalent. The calculation is performed with an approximation: at the end of each day, the average emission factor of the grid electricity generation mix (ef _,grid,elec)*average) is calculated. From it, it is possible to calculate the approximate daily emissions that would have occurred if all electricity consumed would have been imported from the grid (e_GHG,NR)) without the action of the ecosystem and the self-generation, creating a baseline. To obtain the savings (savings _GHG), the KPI E11 for the site is then subtracted. The daily value of the savings can be aggregated into monthly and yearly values.	[kgCO2eq/day(month/year)]	[ ] savings _GHG =e_(GHG,NR)-e_(GHG,tot) [ ] Where: e_(GHG,NR)= ef _,grid,elec)*average E_bl,cons) e_(GHG,tot)= KPI E1	**Customer KPI.** For better precision, it is possible to calculate the mean grid electricity emission factor as a weighted average of the hourly consumptions since at night-time there is usually a lower consumption but higher emission factors that can raise the average value.			x	x					x				
E13	**GHG emissions reduction**	Percentual GHG emissions variation from the "beginning" to the "end" of the project. The variation will be calculated comparing the KPI E11 before the implementation of the ecosystem (taking as a timeframe the 2/3 months during which data from the customers without the action of the ecosystem will be gathered) and after (using the value for the same 2/3 months of the year but in the last year of the project), to minimize effects related to the seasonality or random variations in consumption due to external factors. This parameter should show an improvement as explained for the KPI E11.	[%]	100 * (GHGemission,end - GHGemission,beginning) / (GHGemission,beginning)	A negative value shows an emissions reduction.			x	x					x				
E14	**GHG emissions per square meter**	Emissions per square meter, real-time (hour) and aggregated monthly and yearly, calculated as the ratio of the customer GHG emissions and the area of the site/dwelling. This KPI is easily comparable and shows each customer's environmental impact and combines the positive effects of energy efficiency and DSF. Note: Yearly GHG emissions per square meter for each consumer/site are indicated in the EU regulation to monitor the energy performances of a building/site.	[kgCO2eq/m2/h (month,year)]	[ ] m2Emissions _GHG= [ ] Emissions _GHG /Area	**Customer KPI**	A lower value is desired				x				x	x			
E15	**Avoided emissions thanks to RES self consumption**	GHG emissions that would be produced without self-consumption. Product of the consumed self-generated renewable electricity and the CO2eq emission factor at the time of consumption.	[tCO2eq/hour(/month/year)]	[ ] AvoidedEm _[(GHG,RES)=E_(RES,self fgen)*conv ef _,el,grid]				x	x	x			x	x				

Energy Efficiency and Performances KPIs

Generalities								Scale				Overlaps with other categories						
Code	Name	Description	Unit of measure	Calculation / Formula	Notes	Polarity	Targets (if mandatory KPI)	Project	DEMO / Community	Customer / Building	Asset / Technical domain	Flex	RES	Environ	Energy Eff	Comfort&Health	Economic	Tech & Services
EP1	Electricity use intensity	Electricity consumption of the site, per square meter (1) and total for building/ dwelling /site (2). (1) is a common metric to monitor consumptions and their reduction, hence an energy efficiency growth. It can be calculated also for a DEMO/Community, as a sum of the single contributions.	1. [kWh/m2/month (year)] 2. [kWh/site/day (month,year)]	1. EUi_m2=EUi/Area 2. EUi=E_ist,tot/*Cons	Always suggested to make distinctions in the results between residential and non-residential buildings.				x	x					x			
EP2	Primary Energy Use of electricity	Yearly primary energy consumption (or Primary Energy Use, PEU) related to the electricity consumption, per square meter. It calculated by multiplying the electricity consumed imported (coming from the grid) and the primary energy factor of grid electricity, then subtracting the positive contribution given by the renewable electricity exported. Allows quantifying losses in generation, transmission and distribution of the electricity, the characteristics of the grid electricity mix and the positive effects of the self-generation. Note: The losses are null in the case of self-consumption, therefore this parameter should be effective in taking into account both the better electricity use intensity and the maximisation of self-consumption. It can be also calculated as an average of the whole DEMO or project. The calculation is derived from the methodology followed in the SAP .	[kWh/m2/year]	[ ] PEU _el=E_ist,grid*cons+ PEF _ist,grid - [ ] PEU _el=E_ist,grid*cons+ PEF _ist,grid - E_RES,selfgen*epilon+ PEF _ist,RES)/Area	Customer KPI			x	x	x				x			
EP3	Load factor	Parameter obtained as the ratio of average demand (capacity) and peak demand of a site. A low value suggests that only in some cases a high demand is set: since network charges are higher with higher peaks, to service rather infrequent peaks the kWh for the customer is highly charged. The peak shaving effect of the ecosystem should have a positive effect on this parameter.	[%]	LF=(P_el*average/P_el*peak)*100 Where: P_el*average, P_el*peak: measurements	This KPI should be calculated with monthly values.	A lower value is desired				x		x		x			
EP4	Electricity cost index (bill)	Total annual electricity cost (1) and its percentage variation in time (2). A decrease (negative value) is to be expected thanks to the action of the ecosystem.	1. [K/day (month,year)] 2. [%]	Measurements	Customer KPI	2. A negative value shows a decrease in electricity costs				X					x		x	
EP5	Electricity cost savings	Total economic savings due to the optimal management of the electric appliances, the optimal use of self-generation, the matching with hours in which electricity is less expensive, the smart exploitation of buildings' inertia and customers habits' learning.	[K/day (month,year)]	Measurements						X					x		x	
EP6	TD Electricity Consumption	KPI to be calculated for each Technical Domain (TD). Consumption of the single technical domain (1) in absolute value, (2) per square meter and (3) in percentage of the total Electricity use intensity of the whole site.	1. [kWh/day (month,year)] 2. [kWh/m2/day(month,year); 3. [%]	Measurements	TD: Heating, Cooling, DHW+water pumps, Ventilation, Lighting, Interia loads, Evs charging					X	X				x			
EP7	TD Primary Energy Consumption	Primary energy consumed related to the electricity consumption of the single technical domain, per square meter of the site. It is calculated as a product of the share of grid electricity consumed by the technical domain (calculated as TDElectricity Consumption in percentage times the Electricity Imported from the grid) multiplied by the Primary Energy Factor of the grid electricity. The value will be overestimated since following this methodology, the capability of the ecosystem of matching with high-RES generation hours is lost.	[kWh/m2/day(month,year)]	(TDElectricityConsumption [%] * Electricity,imported [kWh/day(month,year)]) * PEFgrid,electricity / (area of the site [m2])	TD: Heating, Cooling, DHW+water pumps, Ventilation, Lighting, Interia loads, Evs charging					X	X				x		x	
EP8	TD Electricity consumption cost (bill)	Cost of the energy supplied for the single technical domain. The cost can be calculated multiplying the Electricity Cost Index and the percentual value of the daily TD Electric consumption [%], in order to take into account the share of self-consumption on the total.	[K/day(month,year)];	TDElecCostCost = Electricity cost index [K/day] * TDElectricityConsumption [%]	TD: Heating, Cooling, DHW+water pumps, Ventilation, Lighting, Interia loads, Evs charging					x	x				x			
EP9	Contracted Power Load factor	This parameter is a variation of the typical Load factor (EP3) and is obtained as the ratio of the site demand (in kW) and its contracted power. The parameter allows for a clear visualisation of the demand status and how much is the maximum power growth still available in each moment. Again, the peak shaving effect of the ecosystem should have a positive effect on this parameter. The demand (kW), can be measured real time or can be calculated as a hourly and daily average (consequently the KPI can be calculated in the same timeframes).	[%]	(P_el / Pcontracted)*100 Where: P_el: Measurements (real-time, average per hour/day)						X					x			

Comfort & Health KPIs

Generalities								Scale				Overlaps with other categories						
Code	Name	Description	Unit of measure	Calculation / Formula	Notes	Polarity	Targets (if mandatory KPI)	Project	DEMO / Community	Customer / Building	Asset	Flex	RES	Environ	Energy Eff	Comfort & Hlth	Economic	Tech & Services
CH1	**Predictive Mean Vote (PMV)**	An Index that predicts the mean value of the votes of a large group of persons on the seven-point thermal sensation scale	Dimensionless	PMV = (0.303e^(-0.36 MET)+0.028)×L Ta: Air temperature [oC] RH: Relative humidity [%] Tr: Radiant mean temperature [oC] Va: Relative air velocity [m/s] Clo: Clothing level [clo] MET: Metabolic rate [1-8, MET = 60 W/m2] L: Heat loss from human body	The ASHRAE thermal sensation scale is defined as follows: 3 (hot) 2 (warm) 1 (slightly warm) 0 (neutral), -1 (slightly cool), -2 (cool), -3 (cold). It was developed for use in qualifying people's thermal sensation. It is assumed that is symmetric around zero.	0 is the desired outcome				x						x		
CH2	**Predicted Percentage of Dissatisfied (PPD)**	Quantitative prediction of the percentage of thermally dissatisfied occupants, determined from PMV.	[%]	PPD = 100 -95exp(-0.03353PMV^4 - 0.2179PMV^2)		A low value is desired				x						x		
CH3	**Discomfort index**	Physiological thermal stress indicator for people based on dry-bulb and wet-bulb temperature (or air temperature and relative humidity)	Dimensionless	"DI = Ta-0.55(1-0.01Rh)(Ta-14.5) Rh: Relative Humidity [%] Ta: Air temperature [oC] DI interpretation Uncomfortable DI < 14.9 Comfortable 15.0 <= DI <= 19.9 Partially comfortable 20.0 <= DI <= 26.4 Uncomfortable DI => 26.5	Additional index to PMV and PPD. DI interpretation Uncomfortable DI < 14.9 Comfortable 15.0 <= DI <= 19.9 Partially comfortable 20.0 <= DI <= 26.4 Uncomfortable DI => 26.5					x						x		
CH4	**Comfort zone**	Represents the combinations of conditions for the same metabolic rate and clothing level for which the PMV is between -0.5 and +0.5.	[C, %]	Assessment	Air Temperature > Radiant Temperature [C] Relative Humidity [%]					x						x		
CH5	**Standard effective temperature (SET)**	The temperature of an imaginary environment at 50% RH, max air speed < 0.1 m/s and radiant temperature equal to air temperature in which the total heat loss from the skin of an imaginary occupant with an activity level of 1.0 met and a clothing level of 0.6 is the same as that from a person in the actual environment, with actual clothing and activity level.	[C]	Assessment	-					X						x		
CH6	**Frequency of Visual Comfort (FVC)**	The percentage of the time within a given period during which daylight alone delivers appropriate values of illuminance. The assumption is that if the average illuminance is within the range between two threshold values (below lEUnder or above lEOver), visual comfort is guaranteed thanks to daylight only.	[%]	FVC=∑_(i=1^n)▒〖w_i (H_i)〗 H_i=〖{〗 ^ 1 if E_under<E_daylight<E_over@ E_light<E_under E_daylight>E_over 〗	Reference value: FVC>80%. A modified formula is proposed with one-tailed acceptability criterion where daylight is sufficient or insufficient. No need to measure daylight luminance, but it requires the amount of time artificial lighting is used.	A high value is desired				X						x		
CH7	**CO2 Concentration**	CO2 Concentration in indoor air, in 1 ppb and 2 percentage. If an estimation will be necessary, standard CO2 emissions of 20 lth per person can be assumed.	1. [ppb]; 2. [%].	Measurements / Estimation from the number of occupants	If an estimation is necessary, standard CO2 emissions of 20 l/h per person can be assumed.	A low value is desired				X						x		
CH8	**PM Concentration**	Concentration of Particulate Matter (PM) of various diameters	1. [µg/m3] 2. [#/m3]	Assessment	Indicates the need of ventilation.	A low value is desired				X						x		

Economic KPIs

Generalities								Scale				Overlaps with other categories						
Code	Name	Description	Unit of measure	Calculation / Formula	Notes	Polarity	Targets (if mandatory KPI)	Project	DEMO / Community	Customer / Building	Asset	Flex	RES	Environ	Energy Eff	Comfort&Health	Economic	Tech & Services
EC1	**Estimated ROI for the REDREAM ecosystem**	Return on investment, measuring the return on invested capital and therefore the ability to obtain returns on investments. Indicates the ability to remunerate both risk capital and debt capital.	[€] | [%]	ROI=OperatingIncome/NetOperatingInvestedCapital Where NetOperatingInvestedCapital is: Net Total Assets - ExtraCharacteristic Investments	M andatory KPI (KPI6). Tthe benchmark for ROI is given by the WACC and it is lower than the ROI (Return on Equity, it does only indicate the ability to remunerate risk capital, despite of the RoE). Range 7-to-16%.	-		X	X								X	
EC2	**Pay Back Time (PBT)**	Pay Back Time, a corporate finance indicator to assess the attractiveness of an investment, assessing the recovery of the investment. A shorter PBT is desired to reach the breakeven; it is useful to determine the cost savings of energy efficiency technology. Calculated as the ratio of the Acquisition cost (AcquisCost) and the difference between Average financial flows (AFF) and Average operating costs (AOC).	[years]	PBT=AcquisCost/(AFF-AOC)	Typical PBT: 5-20 years.	-	24 months	X	X								X	
EC3	**Internal Rate Return (IRR)**	Internal Rate Return, establishing the profitability of potential investments, showing the annual growth rate. Using the formula, one would set NPV equal to zero and solve for the discount rate, which is the IRR.	-	[ ] 0=NPV=∑_(t=1)^(T)▒ C_t/(1+IRR)^t -C_0 Where: C_0: total initial invest. cost C_t: net cash inflow during the time period t	IRR > cut-off rate.	-		X	X								X	
EC4	**Debt Service Coverage Ratio (DSCR)**	Is the most suitable indicator to show the ability to service debt given a level of income; in essence, it shows operational cash flows able to repay the loan.	[%]	Debt servicing cash flow/[Annual debt capital share + Financial charges]		-		X	X								X	
EC5	**Discounted Pay Back Period (DPBP)**	The Discounted PBP tells "how long" it will take to recoup an investment compared to cash flows, when investors use to repay not only the capital but also the cost of equity, in this case the Equity range should be added to the PBP. The result is a value in years. Compared to the PBP, the values (flows) at the denominator have to be discounted by the cost of equity (expressed in interest rate %).	[years]	Acquisition cost/[Average financial flows - Average operating costs]	RANGE: slightly higher than the PBP range			X	X								X	
EC6	**Loan Life Coverage Ratio (LLCR)**	Fundamental indicator assessing the bankability analysis especially as a guarantee for financing. It is the bankability indicator throughout the period of existence of the debt and is calculated as a ratio between 1. the sum (cumulated and discounted) of the cash flows to service the debt assessed at the beginning of the project up to the last year of repayment of the debt, increased by the cash reserve that can be used for the debt itself, and 2. the residual debt calculated at the initial moment in which the evaluation is carried out.	[%]	SUM(t)[(CFt(1+i)^t)/(t-DR)]/Dt) Where t goes from s to (s+n) and: CFt = Cash flow to the service the debt of year t; t = instant of evaluation s = years of debt repayment i = WACC DR = cash reserve for debt service as denominator Dt = Outstanding debt at the initial assessment moment	RANGE: 1.25 to 1.85% (better if >1.8%)	-		X	X								X	
EC7	**Weighted Average Cost of Capital (WACC)**	Weighted Average Cost of Capital, a useful parameter to asses investor's returns on an investment and a bankability practical tool. Allows investors to establish the cost of capital, by analysing all its components.	[%]	WACC=(E/V)*Re+(D/V)*Rd*(1-Tc)] Where: E=Market value of the firm's equity D=Market value of the firm's debt V=E+D Re=Cost of equity Rd=Cost of debt Tc=Corporate tax rate	RANGE: 10% to 15%	-		X	X								X	
EC8	**Social Return on Investment (SRoI)**	Social Return on Investment, measures non-financial values such as social, economic, and environmental factors. It is useful to quantify the value chain created for the local community. It enables the planning and evaluation quantifying the monetization of the social impact in financial terms.	[#]	-	This parameter's assessment methodology will be developed in the next steps of the project	-		X	X								X	
EC9	**Social Economic / prosperity Indicator**	The amount of value globaly produced by the project: quantity of euros procuded by each euro invested to build the project.	[€/€] adimensional	SEI=[(DirSav+IndSav+OPEX+CAPEX)]/CAPEX Where: DirSav= Direct Savings IndSav= Indirect Savings		-			X	X							X	
EC10	**Annuity Gain**	Measures the annual profits of an investment throughout its lifetime. Calculated as the total EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization) of the project lifetime, divided by the project lifetime itself.	[€/year]	(Total EBITDA) / (Lifetime)		-			X								X	
EC11	**Subventions**	KPI useful to monitor and keep track of any public subvention or mechanism providing a guaranteed financing for RES generation, per kWh. Cumulated sum of all forecasted incentives for each RES generation typology and volume at community level (Feed-In-Tariffs and any others) divided by the total RES generation volume (KPI R2).	[€/kWh]	(Total yearly Subventions) / (Total yearly RES generation)		-			X	X							X	
EC12	**Life-cycle cost of electrical energy generation**	Sum of all the costs throughout the lifetime of the energy investment, normalized to the energy generated. Calculated as total CAPEX & OPEX per electric generation, divided by the overall electric generation in the technical/useful lifetime of the overall project (or 20years).	(€/MWhel or €/MWhth)	[ ] [ ] LCOeg=[(OPEX _(el,gen)+ CAPEX _(el,gen))]/[(E_(RES,selfgen)*Yus) [ ] Where: OPEX/CAPEX _(el,gen)= OPEX and CAPEX for the electricity self-generation E_(RES,selfgen)*Yus: overall electric self-generation, in the technical/useful lifetime of the project (or 20 years).		-			X	X								X	

Technology & Services KPIs

Generalities								Scale				Overlaps with other categories						
Code	Name	Description	Unit of measure	Calculation / Formula	Notes	Polarity	Targets (if mandatory KPI)	Project	DEMO / Community	Customer / Building	Asset	Flex	RES	Environ	Energy Eff	Comfort&Health	Economic	Tech & Services
T1	**N. of services combining EE with other energy services, technologies and non-energy benefits**	KPI to monitor the implementation of ReDREAM's energy and non-energy services, to provide a holistic set of solutions.	[#]	Assessment	Mandatory KPI (KPI7)	-	Total: 22	x										x
T2	**N. of services developed to predict energy patterns**	Services to predict energy patterns, such as the open digital twins developed in WP2, will increase the precision of consumptions' prediction. The more services will be developed, the better the predictability will be (monitored in KPI T2).	[#]	Assessment	Mandatory KPI (KPI10)	-	Total: 8	x										x
T3	**Decrease of error in predictability of consumption**	KPI to monitor improvements in the precision of consumption patterns and consumers behaviours through digital twins and other software services.	[%]	$ErrVar=\left\lvert \sum_{t=1}^{T} Perr_beg - Perr_end \right\rvert / Perr_beg \times 100$ Where: ErrVar: Error variation Beg: beginning of the project; End: end of the project; $Perr=\left\lvert \sum Vmeasured - Vpredicted \right\rvert / Vmeasured \times 100$ Vmeaured,predicted: measured/predicted electricity consumption values	Mandatory KPI (KPI12)	A positive value shows a decrease of the error.	Decrease of the error (Total): 22%	x										x
T4	**Number of charging points present**	Number of charging points available in the DEMO buildings for the customers' EVs, 1. in total and 2. per EV.	1. [#CP]; 2. [#CP/#Evs]	Assessment		-		x	x									x
T5	**Accessibility of third parties**	Number of third parties able to connect to the platform. Accessibility to the platform is necessary to guarantee a future replicability, with third parties that are able to profit from the EE services.	[#]	Sum,(Tpaccess,i)				x										
T6	**No. of energy services deployed**	Number of services developed to provide energyefficiency and DSF	[#]	Assessment				x										

Smart Readiness Indicator KPIs

Generalities								Scale				Overlaps with other categories						
Code	Name	Description	Unit of measure	Calculation / Formula	Notes	Polarity	Targets (if mandatory KPI)	Project	DEMO / Community	Customer / Building	Asset	Flex	RES	Environ	Energy Eff	Comfort&Health	Economic	Tech & Services
SRI1	**SRI Increase / decrease - Building**	Difference between the final value of the SRI (after the implementation of the ecosystem and its smart technologies) and the initial value of the SRI of the building (reference, before the implementation of the ecosystem).	[%]	$\Delta_{SRI} = SRI_{end} - SRI_{ref}$ Where: $SRI_{ref,end}$: initial and final values of SRI of the building /t site	Each SRI is calculated through the SRI Excel tool	A positive value shows an SRI increase thanks to ReDREAM.				x								
SRI2	**SRI Variation - Building**	Percentage variation of the SRI from the initial value (reference, before the implementation of the ecosystem) to the final value of the building (after the implementation of the ecosystem and its smart technologies).	[%]	$SRI_{var} = \left(\frac{SRI_{end} - SRI_{ref}}{SRI_{ref}}\right) x100$ Where: $SRI_{ref,end}$: initial and final values of SRI of the building / site	Each SRI is calculated through the SRI Excel tool	A positive value shows an SRI increase thanks to ReDREAM.				x								