Deliverable 5.3

Guidelines for the design of effective P4P rate structures

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Smart Energy Services to Improve the Energy Efficiency of the European Building Stock

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Abbreviations and Acronyms:

Acronym	Description
EEM	Energy Efficiency Measures
EEP	Energy Efficiency Plan
EEOS	Energy Efficiency Obligation Scheme
SRI	Smart Readiness Indicator
GENCAT	Generalitat de Catalunya
TL	Task Leader
WP	Work Package
WPL	Work Package Leader

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1 Executive summary

The present report, aims to examine the relationship between the Potential Energy Efficiency Measures (EEM) for a group of buildings with the P4P rates structure within a P4P program framework. in the present deliverable, is expected to analyse the main elements that must be considered in the Incentive structure to foster different kind of EEM implementation according to the scope of the designed P4P

The main outcomes that have been found throughout the work developed are:

1. The scope of the P4P Program has to mark the line of type of EEM to be implemented and rewarded. This does not mean limiting to specific measures, but rather defines whether these measures should be focused particular policies as decarbonisation, increasing digitalisation and energy management in accordance with specific strategies for each country or region.
2. The need for the Aggregator or Portfolio Manager to have tools and indicators like the SRI that allow them to group the different kinds of buildings (regardless of their activity or use) by the EEM needs and qualification. This means the availability of a complete and detailed catalogue of EEM's linked with a list of compensation rates. This also should allow them to study case by case (building energy efficiency needs), and also in an aggregated way in order to be able to construct the Energy Efficiency Plan, in order to handle with Energy Savings and Compensation Rates.
3. The importance of taking in account different factors related with activities of the buildings that are not directly linked with the Energy savings or EEM's, such as energy purchase contracts or maintenance contracts commitments, legislative restrictions, incompatibilities.

The key findings on P4P compensating energy efficiency as an energy resource depend on the importance to combine Deep Energy Efficiency Measures that need to be performed during long term with "low Handing fruit" measures which present short terms wins. The labour of the Aggregator is to design the standards and expected depth of renovation that ESCOs should provide with some performance guarantee. To compensate the energy efficiency as an energy resource means to treat it as a continuous source that could provide not only energy efficiency benefits, but also social and environmental ones for a huge number of users.

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2 Introduction

This deliverable outlines the interplay between the compensation structure of a P4P scheme and its effect on the pursued EEMs. In other words:

- **How different compensation rates for energy savings affect the choice of the Energy Efficiency Measures (hereinafter "EEM's")**
- **How a P4P scheme influences the design of an appropriate Energy Efficiency Plan (hereinafter "EEP") for an agreement or contract within a fixed time frame.**

Taking as a reference the GENCAT Building results as starting point, the aim of this deliverable is to find out reasonable and solid conclusions to portrait them to different guidelines for the **design of effective P4P rate structures.** Those guidelines could help the building owners or different actors involved in a P4P scheme to benefit from incentives for energy savings or demand management, while ensuring that the improvement of energy efficiency remains the primary goal.

For thus, the current study is based on the selected GENCAT buildings characteristics according to the results of SRI analysis done in Deliverable Selected buildings, SRI and comfort assessments[1], as well as the EEM classification developed in deliverable The Boundary Cases for the P4P Rates[2].

From now on, it is also wanted to find out all these other aspects or factors directly related with buildings and its facilities not the ones only based on energy consumption or on energy efficiency, neither the user's comfort only, but which could influence on the P4P Scheme selection and its later deployment. Such as prior energy purchase or facilities management contracts, the property sort, the information accessibility, legal framework among others. Some of these aspects are already considered the report: *Selected buildings, SRI and comfort assessments*.

In the Section 2, all of the factors that involve Pilot buildings are combined with the purpose of creating different indicators to allow the aggregator or Portfolio to decide what EEM or what EEP are more appropriate for a P4P Scheme application. These indicators are based on some of the variables of the report *The Boundary Cases for the P4P rates and SRI*. A general overview for each building has been done to make a preliminary

[2] D4.3 The Boundary Cases for the P4P Rates https://zenodo.org/record/4320758#.X-sGm470mUl

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evaluation about the most appropriate EEM for a P4P Program in order to determine 2 or 3 Pilot Buildings.

On the other hand, in **Section 3**, the compensation rates will be defined and studied more extensively and in detail also taking as a reference some of the conclusions and results of internal shared information with all partners. In this section are treated various topics such as the different sort of compensation rates according each measure, or how the legal framework could affect the EEP and consequently the incentive. It will also be talked about how and when compensation rates will be applied.

Finally, in **Section 4** the definition of compensation rates indicators including the SRI and the P4P schemes for the pilot buildings will be identified. For this reason, it is important to define in previous sections (Section 1 and 2) the necessary tools to be able to make realistic EEP's. For now, in the current state of the project, a definitive scheme for the P4P model within SENSEI has not yet been determined. This is a work that will be developed throughout the Guidelines for the design of a P4P Scheme.

Section 2 Energy Efficiency Measures and Pilot GENCAT Building Selection

Selection of EEM's Classification- Catalogue
Indicators definition
Pilot Buildings Selection

Section 3 Compensation Rate Structures

Identification of main elements for compensation rate structures

Section 4 P4P Indicators definition and Pilots selection

Definition of Compensation rates indicators including SRI
GENCAT Pilot Selection

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3 Selection of the EEM's – scenarios: selection of the pursued EEM's for the pilot buildings

3.1 European Green Deal Context

In December 2019 the European Commission presented the ***European Green Deal***[3] as a roadmap for making EU's economy sustainable with the first goal of being climate neutral by 2050. In order to achieve this environmental challenge, the Green Deal Plan has been grouped by 9 different policy areas or topics, each one has to reach its own objectives and establishes directives and plans to achieve them.

Among these policies there is one aimed to improve **energy performance of buildings** and their renovation. It is well known that the buildings need an important amount of energy and resources to be constructed or renewed, and not only for that, but even more for their daily use. The Commission is also promoting the development of innovative and financing opportunities in the energy efficiency in buildings. In October 2020 the European commission also published the strategy called ***Renovation Wave***[4] with the purpose of doubling the energy renovation rate per year.

Hence, it is very crucial for the design of the appropriate EEP to take into account these above specific goals. It implies to not just consider the facilities and appliances renovation but also consider long term and passive measures and deeper retrofits, that can provide the building the highest value and extend its useful life. Furthermore, the long term plans regarding the decarbonisation and electrification lead us to decide on measures that avoid the use of fossil fuels, including the perspective to consider the energy efficiency as an energy resource since it is able to manage the energy demand by reducing the consumption and increasing energy savings.

[3] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1603122220757&uri=CELEX:52020DC0662

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On the other hand, according the Directive 2010/31/EU5 European state members have the obligation to stablish a **Long-Term Building Renovation Strategy**[6] in order to update the building stock introducing EEM's. It means that each member has to prioritize the retrofit objectives according to the current situation and needs, and how to mitigate the energy poverty as well.

Once defined the European and Governmental public policies context, the role of public administrations, utilities and other institutions or actors like TSO/DSO enters to participate in that field. One of their tasks will be to be in charge of promoting in first instance those strategies. Understanding to promote the act of encouraging and achieving commitments. Therefore, they have to provide and offer different kind of mechanisms to incentivize the implementation of EEM's individually (single project) or in an integral way through the EEP's or through a global project portfolio.

Hence, we have to link these three branches: public policies, energy efficiency initiatives promoters and EEM's. This means that the **EEM selection** will be conditioned in part by the goals of public strategies, such as the decarbonisation, which implies the electrification or the use of renewal energy or by the different financial methods and tools offered by public institutions or energy providers, such as grants or in our case of study, **the P4P rates per each real kWh saved.**

3.2 Considering the Energy Efficiency as an Energy resource in P4P Scheme. Key findings.

We cannot deny that the best energy is that which is not consumed, and that the definition of efficiency means doing more with less. So what makes it so interesting to consider Energy Efficiency as another energy resource, as fossil or nuclear fuels have been so far, or how renewable energies are intended to be now and in the future? The answer is very easy, energy efficiency allows us to play with the savings obtained from the implementation of different measures, whether they are active measures, passive measures or even those based on user behaviour and good practices, in order to add it

[5] Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en

[6] https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/long-term-renovation-strategies_en

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as another input when managing global energy demand. That is, it should be another element of the energy system as renewable energies are.

In addition, energy efficiency has become the top priority of all energy policies for all Governments, in particular for the European Union[7], as it has just been explained, not only to help reduce energy consumption in each country, but also as a tool to combat climate change and promote the environment and the comfort for users.

Given that energy efficiency can be considered as one of the most cost-effective resources, it makes it more attractive when making large investments.

On the other hand, energy efficiency has a lot of room for improvement in all sectors, especially for buildings (residential and non-residential) and industry. Not only that, but it is also a continuous resource, as there will always be opportunities for improvement as equipment ages and also every time the devices, equipment or building materials will offer better performances. Therefore, both its profitability and its field of improvement make Energy Efficiency a key element in all sectors and for the **Energy Transition.**

To date, public authorities or utilities have encouraged the implementation of these measures through various grants and subsidies. Financing models have also been created, for example ESCOs that allow the user to pay for investments based on the savings obtained, among others. In this sense, the SENSEI wants to add to this whole structure based on P4P by encouraging investors through two key concepts.

1) Incentivise for each kWh saved, by creating compensation structures based on the implementation of long-term EEMs that have a direct impact on the power system and in demand response.

2) And on the other hand, the aggregation of different refurbishment projects instead of consider the individual ones in order to attract more capital.

Hence, it can be said that in order to achieve a model where the Energy Efficiency is treated as energy resource in relation to a P4P scheme is to link it with the compensation rate structure, in which long-term measures that present greater savings be greater rewarded. This will mean permanent and long-term savings. However, short-term measures, and continuous improvement as well as an annual rethinking and redesigning of each program or portfolio to adapt to needs and uncertainties, will also need to be taken into account. In short, if we want to treat energy efficiency as a resource, we must

[7] https://ec.europa.eu/info/news/energy-efficiency-first-accelerating-towards-2030-objective-2019-sep-25_en

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also take into account all the aspects that define a resource such as availability, unit cost, infrastructure, maintenance and operability, among others. And in case of P4P consider them when designing the compensation structure.

3.3 Energy Efficiency Measures

3.3.1 General analysis of EEM and EEP

The labour of the ***Aggregators or P4P Promoters/Facilitator*** is to work with a wide portfolio of Energy Efficiency Projects attractive enough for all actors involved like ESCO companies, Building Owners, Investors or financial institutions, System Operators as well as Public Administrations with the ultimate goal of formalizing a P4P agreement, the duration of which must be assessed according to the measures and the economic capacity of each of the parties. Moreover, it is wanted to work with as many projects as possible in order to group them and make the investment more secure and engaging.

However, the question is to know how ***Aggregators/P4P Promoters*** build their Portfolio or what information or decision tools are necessary to design it. For thus, apart from the targeted buildings or customers, one of the first steps that must be considered is the assessment and draw up of a list of EEM's for each project, as well as a list of compensation rates linked with each of those measures. This allows not only to calculate the energy savings potentials, but also to calculate the compensation rate potential, that will make the project more or less cost-effective at the end. Apart from that the project should not be considered as an isolated case or as a single project, as it has been done to date, but it should include a group of buildings or potential customers as a whole to make the P4P program more robust. By grouping different projects, the compensation rates could increase and therefore improve investment cost.

Generally, the identification of the EEM's is usually studied during previous energy audits reports, in a renovation project of the building or through other tools and methods like SRI which helps the **Aggregator** or the **Energy Manager** to find out these opportunities that can be included in the project portfolio or not. Once done, the EEM's are classified and prioritized according the energy efficiency savings potentials close to the necessary investment and its RO.

What we are seeking now is to introduce the **compensation rate** as a new parameter of decision making when measures must be selected seeing their interrelation. And how it can determine the EEM implementation.

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In order to analyse all aspects commented above and take them into the practice, the current chapter will use the list of 12 GENCAT buildings, which are earlier. It will be seen **step by step** which of these buildings are more susceptible to be included in a P4P scheme than others and why, depending on the value of their Energy Measures and different parameters. The aim is to be the most realistic as possible.

The classification analysis done in D.4.3 has been used to score each of the GENCAT building measures. Nevertheless, some other aspects that could influence the EEM selection will also be treated, such as prior energy purchase contracts, legal aspects or other variables that make the implementation of this EEM in that building impossible, and force the Aggregator to look for alternatives or even discard it for the P4P scheme specifically.

In order to get more accurate information, the Building Managers of Justice, Culture and Agriculture Department has been interviewed. They provide us information about the current status of planned SHERPA EEM, the maintenance and energy purchase contracts.

In the following diagram shows the steps that have been followed up to determine the appropriate EEM's of GENCAT BUILDINGS in the P4P scheme:

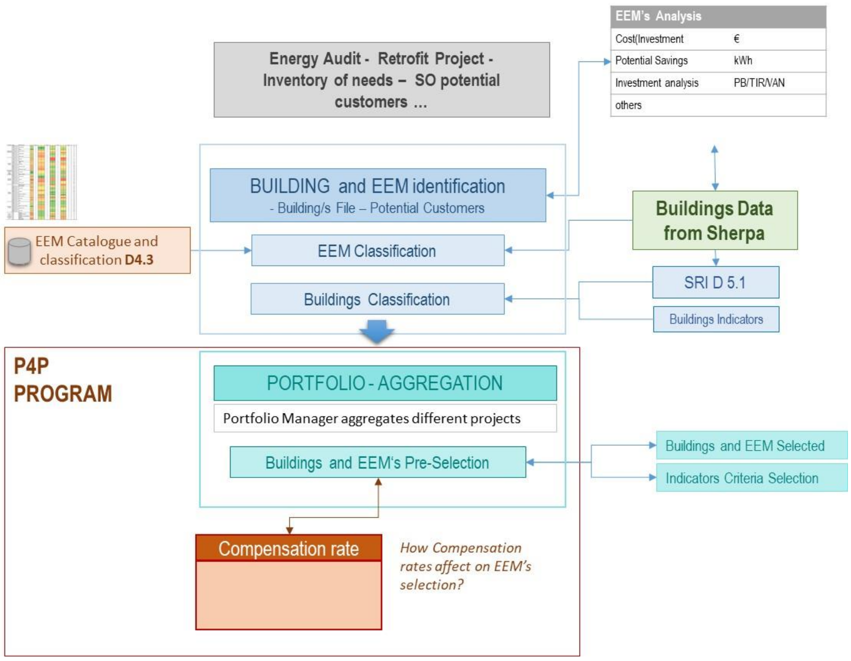

Diagram 1: Building Selection and EEM P4P Scheme

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3.3.2 EEM Catalogue and Classification in SENSEI

The prior step to determine the energy efficiency potential consists of defining or unifying a unique catalogue of the available EEM's which will help on one hand the **Portfolio Manager / Aggregator** to define the EEP for each project. And on the other hand, to design the Compensation rates by the Program owner. Further, all of these measures are classified according to their energy efficiency potential as well as its effect on the power grid. Apart from that, using this kind of catalogues or EEM data base the **P4P FACILITATOR** or **PROMOTER** have it easier to link them with the P4P rates or compensation rates schemes, and therefore it is possible to have a global idea of the investment impact.

In Deliverable The Boundary Cases for the P4P Rates [8], the EEM's have been classified based on NREL's building component library Building Sync Standard[9].

	CATEGORY	N (4.3)	EEM	kWhe saved	kWht saved	Residential	Industrial	Commercial
PASSIVE MEASURES	BUILDING ENVELOPE	14	Thermal coat		x	X	X	X
		15	Fixtures		x	X	X	X
		16	Solar screens		x	X	X	X
ACTIVE MEASURES	DISTRIBUTED GENERATION	1	Photovoltaics	x		X	X	X
		2	Wind	x			X	
		3	Solar collectors		x	X		X
		4	Cogeneration		x	X	X	X
		5	trigeneration		x		X	X
	THERMAL SYSTEMS	17	District heating		x	X	X	X
		18	Heat recovery		x			X
		19	Heat pump	x		X	X	X
		20	Speakers		x	X	X	X
		21	Hydronic appliances		x	X		X
		22	DHW recovery		x	X		X
		23	Circulators	x		X		X
		24	Fans	x			X	X
	ELECTRICAL SYSTEMS	25	LED	x		X	X	X
		26	Electric engines	x			X	X
		27	Capacitor bank	x			X	X
		28	Optimizers	x		X	X	X
ACTIVE MEASURES	STORAGE SYSTEMS	6	Batteries	x		X	X	X
		7	Hydroelectric	x			X	
		8	Compressed air	x			X	
		9	Hydrogen	x			X	X
		10	Thermal storage		x	X	X	X
		11	Refrigerator storage		x		X	X
	BUILDING and AUTOMATION CONTROL SYSTEMS	29	Heating		x	X	X	X
		30	Domestic hot water		x	X	X	X
		31	Cooling		x	X	X	X
		32	Ventilation and Conditioning	x		X	X	X
		33	Lighting	x		X	X	X
		34	Solar screens		x	X	X	X
		35	TBM systems	x	x	X	X	X
	CONVERSION OF THE ENERGY CARRIER	12	Heat pump		x	X	X	X
		13	Electric vehicles		x		X	

Table 1: EEM Measures Classification. Source Deliverable the Boundary Cases for the P4P Rates. Table adapted.

First, the EEM's are classified according to 7 different categories: Building Envelope, Distributed Generation, Thermal systems, Electrical Systems, Storage System, Building

[8] The Boundary Cases for the P4P Rates https://zenodo.org/record/4320758#.X-sGm470mUI

[9] https://bcl.nrel.gov/nrel/types/measure

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and automation control systems, conversion of the energy carrier. It is also possible to divide them by passive measures or active measures. Furthermore, the classification also includes the sector or customer segment (residential, commercial, industrial) Each EEM value has a different scoring depending on its aspects.

In a second stage the EEM's are classified and scored according 3 new categories:

- **Classification Table A:** Qualitative analysis of the effects on the network, on the two parameters: energy and network. (Grid effects)
- **Classification Table B:** Qualitative Building benefits.
- **Classification Table C:** Quantitative analysis Value of Measures taking into consideration the financial and economic aspects of the energy efficiency measures.

According the results of the above categories, the EEM are scored from 1 to 10 (or from A to J) depending on their impact in the energy efficiency savings as it is detailed in *Table 2.*

CATEGORY	ID	ID	INTERVENTION	TO	Class A	B	Class B	C	Class C	X	Class X	ID
DISTRIBUTED GENERATION	1a	RESIDENTIAL	photovoltaics	8	C	7	D	8	C	7	D	1a
	1b	INDUSTRIAL		8	C	10	A	8	C	8	C	1b
	1c	COMMERCIAL		8	C	10	A	8	C	8	C	1c
	2b	INDUSTRIAL	Wind	10	A	9	B	9	B	9	B	2b
	3a	RESIDENTIAL	Solar collectors	6	E	5	F	7	D	6	E	3a
	3c	COMMERCIAL		6	E	7	D	8	C	7	D	3c
	4a	RESIDENTIAL	Cogeneration	6	E	5	F	5	F	4	G	4a
	4b	INDUSTRIAL		8	C	5	F	9	B	8	C	4b
	4c	COMMERCIAL		8	C	5	F	9	B	8	C	4c
	5b	INDUSTRIAL	trigeneration	8	C	4	G	8	C	7	D	5b
	5c	COMMERCIAL		8	C	4	G	8	C	7	D	5c
STORAGE SYSTEMS	6a	RESIDENTIAL	Batteries	5	F	6	E	2	I	3	H	6a
	6b	INDUSTRIAL		5	F	6	E	2	I	4	G	6b
	6c	COMMERCIAL		5	F	6	E	2	I	4	G	6c
	7b	INDUSTRIAL	Hydroelectric	6	E	7	D	9	B	8	C	7b
	8b	INDUSTRIAL	CAES	6	E	5	F	9	B	8	C	8b
	9b	INDUSTRIAL	Hydrogen	6	E	6	E	6	E	5	F	9b
	9c	COMMERCIAL		6	E	6	E	6	E	5	F	9c
	10a	RESIDENTIAL	Thermal storage	5	F	6	E	8	C	6	E	10a
	10b	INDUSTRIAL		5	F	5	F	9	B	7	D	10b
	10c	COMMERCIAL		5	F	5	F	9	B	7	D	10c
	11b	INDUSTRIAL	Refrigerator storage	5	F	4	G	8	C	6	E	11b
	11c	COMMERCIAL		5	F	4	G	8	C	6	E	11c
CONVERSION OF THE ENERGY CARRIER	12a	RESIDENTIAL	Heat pump	9	B	7	D	9	B	9	B	12a
	12b	INDUSTRIAL		10	A	7	D	9	B	9	B	12b
	12c	COMMERCIAL		10	A	7	D	9	B	9	B	12c
	13b	INDUSTRIAL	Electric vehicles	8	C	8	C	5	F	5	F	13b
BUILDING ENVELOPE	14a	RESIDENTIAL	Thermal coat	6	E	8	C	9	B	8	C	14a
	14b	INDUSTRIAL		4	G	10	A	9	B	9	B	14b
	14c	COMMERCIAL		8	C	10	A	9	B	9	B	14c
	15a	RESIDENTIAL	Fixtures	6	E	4	G	4	G	4	G	15a
	15b	INDUSTRIAL		2	I	4	G	4	G	3	H	15b
	15c	COMMERCIAL		4	G	4	G	4	G	4	G	15c
	16a	RESIDENTIAL	Solar screens	6	E	3	H	9	B	7	D	16a
	16b	INDUSTRIAL		4	G	6	E	9	B	7	D	16b
	16c	COMMERCIAL		8	C	6	E	9	B	8	C	16c
THERMAL SYSTEMS	17		District heating	8	C	5	F	3	H	4	G	17
	18c	COMMERCIAL	Heat recovery	6	E	8	C	7	D	6	E	18c
	19a	RESIDENTIAL	Heat pump	4	G	7	D	8	C	6	E	19a
	19b	INDUSTRIAL		6	E	7	D	9	B	8	C	19b
	19c	COMMERCIAL		6	E	7	D	9	B	8	C	19c
	20a	RESIDENTIAL	Speakers	4	G	4	G	6	E	5	F	20a
	20b	INDUSTRIAL		6	E	6	E	9	B	8	C	20b
	20c	COMMERCIAL		6	E	7	D	10	A	9	B	20c
	21a	RESIDENTIAL	Hydronic appliances	6	E	7	D	9	B	8	C	21a
	21c	COMMERCIAL		6	E	9	B	10	A	10	A	21c
	22a	RESIDENTIAL	DHW recovery	6	E	4	G	6	E	5	F	22a
	22c	COMMERCIAL		6	E	5	F	9	B	7	D	22c
	23a	RESIDENTIAL	Circulators	4	G	4	G	3	H	3	H	23a
	23c	COMMERCIAL		6	E	6	E	8	C	7	D	23c
	24b	INDUSTRIAL	Fans	4	G	6	E	8	C	6	E	24b
	24c	COMMERCIAL		6	E	6	E	10	A	9	B	24c
ELECTRICAL SYSTEMS	25a	RESIDENTIAL	LED	6	E	9	B	9	B	9	B	25a
	25b	INDUSTRIAL		8	C	8	C	9	B	9	B	25b
	25c	COMMERCIAL		8	C	9	B	9	B	9	B	25c
	26b	INDUSTRIAL	Efficient electric motors	8	C	5	F	9	B	8	C	26b
	26c	COMMERCIAL		10	A	5	F	9	B	9	B	26c
	27b	INDUSTRIAL	Capacitor bank	6	E	5	F	8	C	6	E	27b
	27c	COMMERCIAL		8	C	5	F	8	C	7	D	27c
	28a	RESIDENTIAL	Optimizers	6	E	6	E	9	B	7	D	28a
	28b	INDUSTRIAL		8	C	9	B	9	B	9	B	28b
	28c	COMMERCIAL		8	C	9	B	9	B	9	B	28c
BUILDING AND AUTOMATIO N CONTROL SYSTEMS	29		Heating	4	G	9	B	7	D	6	E	29
	30		Domestic hot water	4	G	9	B	4	G	5	F	30
	31		Cooling	4	G	9	B	6	E	6	E	31
	32		Ventilation and Conditioning	6	E	9	B	10	A	9	B	32
	33		Lighting	6	E	8	C	5	F	5	F	33
	34		Solar screens	4	G	8	C	5	F	5	F	34
	35		TBM systems	4	G	8	C	5	F	5	F	35

Table 2: EEM Classification by Categories (A, B, and C) and the Score levels

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3.3.2.1 SENSEI and SHERPA EEM classification differences

As it is commented before, SENSEI Project takes as a reference the GENCAT Buildings which have already studied in SHERPA and END-edit projects10. The classification of Energy Measures as well as the variables taken in account are slightly different between two projects and from these ones described in *The Boundary Cases for the P4P rates* or SRI method. For that reason and in order to unify the different definitions and criteria all the measures considered in SHERPA Project has been adapted to the language used in SENSEI.

3.1 SENSEI Pilot Buildings and their EEM.

3.1.1 Case of Study: 12 GENCAT buildings and SRI results

This section is focused on the 12 Pilot GENCAT Buildings previously classified with Smart Readiness Indicator (SRI), which scores the overall potential of all services that regulate and interact with present technologies. The building details and information have been taken from the SHERPA PROJECT and END-edit Platform. The used typologies of them are Education (1), Office-Courthouses (3), Cultural (2), Healthcare and Nursing Home (3) and Penitentiary (3). It is very important to highlight that all these particular cases are focused only in **buildings for public use.** Although penitentiary centres could be associated with the residential sector, no specific or residential examples as such, or any examples from the industrial sector, would be studied. This Fact it may involve differences in case the management is public or private.

For the Aggregator, will be also important to be clear about the type of building, it is considered in each case, and especially in the commercial sector, which is broader in terms of activities and uses (offices, shops, restaurants, hotels, leisure centres, etc.).

In the case of our study, we will add it in a broader and more generic way, but in future studies it will have to define in much more detail the sector in which we are going to work on, especially when we want to relate it to the compensation structure. The Segment or customer sector is important when defining the compensation structure.

[10] https://sherpa.interreg-med.eu/

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In the following table are summarized the building typology for Generalitat de Catalonia (GENCAT) buildings.

Id.	Building name	Typology and Category	Surface (m2)	energy consumption (kWh/year) -2017*
CU01	Centre for the Restoration of Art of Catalonia	Cultural - Commercial	5.090	1.656.735
CU02	Museum of Science and Technology of Catalonia	Cultural - Commercial	22.000	1.387.460
ED60	Oficina Comarcal Terra Alta i Escola Agrària Gandesa	Education - Commercial	1.223	99.616
OF27	Courthouse of Gavà*	Offices -Commercial	4.815	607.237
OF39	Palace of Justice*	Offices - Commercial	22.497	2.164.580
OF40	Courthouse of Sabadell*	Offices - Commercial	10.535	1.748.010
OT36	CP Ponent + CO (prision)	Residential	26.479	9.467.815
OT37	CP Quatre Camins* (prison)	Residential	97.329	12.772.313
OT38	CP Brians 1 (+ Can Duran) (prison)	Residential	53.559	12.625.453
OT48	Res i Centre de dia -Gracia (Nursing Home)	Residential	4.120	845.410
OT50	Res i Centre de dia Mossèn Homs (Nursing Home)	Residential	10.074	1.355.364
SN32	CAP Manso	Sanitary Commercial		1.709.595

Table 3: GENCAT Pilot Buildings list. Data 2017*

Despite the fact the conclusions of the SRI assessments didn't achieve the results expected due to the impact of COVID-19. It is assumed the following results are valid enough to carry on with the global assessment. At a later stage, the results could be updated once the pandemic situation improves and more accurate results could be obtained.

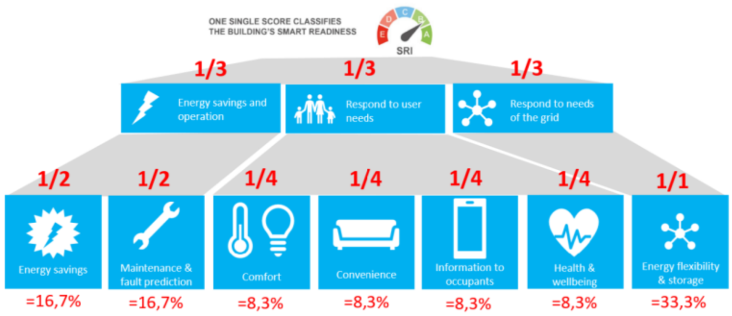

Image1: 1 SRI methodology. Impact Criteria and Categories

Code	Building Name	Basic SRI Score	Advanced SRI Score	Energy Savings And Operation	Respond To Users' Needs	Respond To Needs Of The Grid
CU01	CRBMC	D (26%)	D (24%)	39%	37%	3%
CU02	mNACTEC	C (51%)	C (44%)	38%	27%	89%
ED60	Terra Alta School i Escola Agrària Gandesa	C (43%)	C (39%)	41%	39%	51%
OF27	Court house of Gavà*	D (26%)	D (27%)	38%	37%	4%
OF39	Palace of Justice*	C (42%)	C (45%)	34%	32%	61%
OF40	Courthouse of Sabadell*	C (41%)	C (39%)	59%	48%	16%
OT36	CP Ponent + CO	D (25%)	D (24%)	34%	32%	9%
OT37	CP Quatre Camins*	D (22%)	D (23%)	33%	27%	7%
OT38	CP Brians 1 (+ Can Duran)	E (10%)	E (13%)	16%	14%	0%
OT48	Day care center Barcelona-Gracia	D (34%)		48%	41%	13%
OT50	Day care center Terrassa-Mossèn Homs	E (11%)		21%	7%	5%
ESN32	Primary care center Manso	E (19%)		28%	17%	11%

Table 4: SRI index for GENCAT Pilot Buildings.

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- ***Energy Savings and operation:*** relates to the financial aspects most directly and also covers maintenance and fault prediction.
- ***Respond to user needs:*** relates to “Comfort”, “Convenience”, “Information to occupants” as well as “Health and wellbeing”.
- ***Respond to needs of the grid***: concerns the energy environment of the building. It consists solely of the impact criterion “Energy flexibility and storage” and prominently emphasizes demand response related services.

In the following table are summarized the energy consumption (kWh) of 2017 distributed by use (Heating, DHW, Cooling, Ventilation, Lighting, Generation). The rest of particular equipment (1) for each building are not considered in this study neither in SRI Calculation. In the last column are indicated the amount of the rest of equipment’s consumption vs the total of Consumption.

Code	Heating	DHW	Cooling	Ventilation	Lighting	Generation	Total	Total Consumption	Rest of equipment’s (*)
CU01	818,01	6,81	210,27		80,32		1.115,40	1.656,74	49%
CU02	717,56	10,05	80,39		172,46	29,86	1.010,31	1.387,46	37%
ED60	65,00	0,28	8,92		3,29		77,48	99,62	29%
OF27	58,15	13,73	178,45		183,94		434,28	607,24	40%
OF39	615,23	61,97	511,29	30,99	443,27		1.662,75	2.164,58	30%
OF40	411,11	33,42	434,49		398,40		1.277,42	1.748,01	37%
OT36	5.376,52	2.261,14	138,55		721,31		8.497,52	9.467,82	11%
OT37	5.687,54	2.314,91	379,63		848,58		9.230,66	12.772,31	38%
OT38	5.809,06	1.505,58	277,66		1.009,66		8.601,96	12.625,45	47%
OT48	311,98	39,06	195,59		59,13		605,75	845,41	40%
OT50	547,50	210,58	191,68		132,73		1.082,48	1.355,36	25%
ESN32	433,07	100,26	360,81	64,37	602,54		1.561,05	1.709,60	10%

Table 5: GENCAT Pilot Buildings Yearly Consumption/Production by Domain (in MWh/y) 2017. Source Sherpa Project.

In SRI, the consumption for heating, cooling and lighting is most significant. However, in a future analysis of a P4P scheme the singularities of each building typology could be studied to look for energy efficiency improvement for those equipment’s that are used in a specific way (e.g. computers, sanitary equipment, etc.). This other point of view opens the possibility to create specific P4P schemes aimed towards the activity carried out in each building if that is the case.

The weights of each of the different uses are represented in the following Figure.

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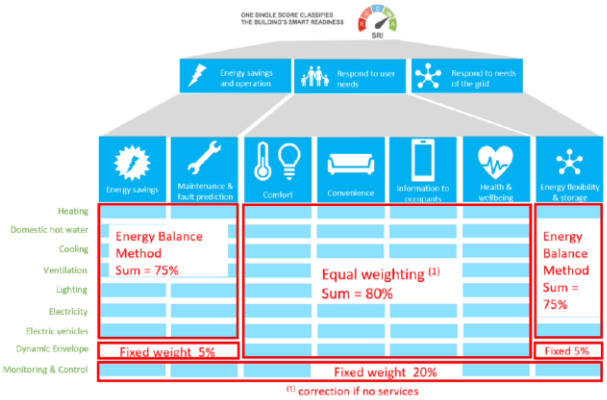

Image: 2 SRI Weights

Throughout this chapter, 2 of these 12 buildings are selected as Pilot Buildings and they will be used to examine the P4P model. In order to achieve this selection different indicators will be defined and compared. These indicators have to provide enough information to have a first idea how to decide which building is more suitable than other to be considered for a P4P scheme.

According the first results of SRI assessment the potential measures to be implemented in GENCAT buildings are summarized in the following table.

TYPOLOGY		BUILDINGS	BEST INTERVENTIONS FOR AN EE IMPROVEMENT
Equipment	Education	ED60 - **Agricultural School of Gandesa**	**1. Maintenance & Fault prediction for heating and cooling**
	Office - Courthouses	OF27 - **Courthouse of Gavà**	**2. Readiness of the DHW related services readiness**
		OF39 - **Palace Of Justice**	**3. Functional improvement** in all domains
		OF40 - **Courthouse of Sabadell**	**4.** Improve the **responsiveness to the grid**
	Cultural	CU01 - **Centre Restoration of Artefacts of Catalonia**	**5. The Monitoring & Control**: SAUTER System could be improved to synergies between the building's technologies for additional efficiency
		CU02 - **Museum of Science and Technology of Catalonia**	**6.** The readiness in this building cannot be improved much further without **significant technological modernizations.**
	Healthcare	SN32 - **CAP Manso**	The smart readiness of Comfort and Convenience **7. The lighting** **5. The Monitoring & Control** (the rudimentary network analysers would have to be interconnected by a more sophisticated management System)
	Residential/ Others	OT48 - **Nursing Home Barcelona-Gràcia**	**1. The heating domain** shows potential for improvement
		OT50 – **Nursing Home Mossen Homs**	None of the functionality requirements for smart readiness in the Wellbeing & Health impact criterion **1. The management system for heating and cooling.**
		OT36 - **Penitentiary Centre Ponent**	**4.** Improve the responsiveness to the grid
		OT37 - **Penitentiary Centre Quatre Camins**	**8.** Improve the **Maintenance & Fault prediction** **9. Improve the automation in lighting.**
		OT38 - **Penitentiary Centre Brians 1**	**4. Improve the responsiveness to the grid.**

Table 6: Potential measures detected with the SRI methodology

In this section summarize the EEM's per each building that are from the combination of the SHERPA[11] data, as it is explained in section 3.3.2.1 and the report on *The Boundary Cases for the P4P rates* EEM classification. As a first overview, we can conclude that

11 See section 3.3.2.1

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the majority of them are based on passive measures (mainly in the replacement of windows and solar films), active measures (LED-lighting and replacement of Heating or Cooling System) and the implementation of Energy Management or HVAC. Although some consider the PV or Solar Thermal Panels installation on the roof, it is important to emphasize that in none of these cases consider the switch from fossil fuels to electricity. Only the change from LPG to Natural Gas (NG).

The following is a brief summary and description of the EEM’s adopted and analysed in the SHERPA – EDI Net for each building.

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ESLP0RECU01: Centre for the Restoration of Artefacts of Catalonia (CRBMC)		
EEM Name	**Description**	
Building and automation control systems		
Heating and cooling	Replacement of the current boiler for a condensation boiler compatible with a solar thermal plant. + Improving the management and control system so it can control all the different areas of the building independently	Electricity and natural gas savings
Building envelope		
Solar Screens	Installation of solar film in the windows to reject significantly the solar radiation and to improve the thermal performance of the current windows.	Electricity savings. Comfort
Distributed generation		
Photovoltaics	Photovoltaic energy on the roof – 72kWp	Electricity savings
Solar collectors	Thermal solar energy facility for helping the heating system.	Electricity savings

Table 7: EEM Description CU01 CRBMC. Source Sherpa Project

ESLP0RECU02: Museum of Science and Industry of Catalonia (mNACTEC)		
EEM Name	**Description**	
Building and automation control systems		
Heating and cooling Ventilation and Conditioning	Implement software capable of controlling the basics elements of the heating and cooling production system remotely. Implement an automatic system to open and close the roof windows	Electricity and gas savings + comfort.
Lighting	Implementation of presence sensors and photocells Installation of programmable automatic clocks Lighting management and control system.	Electricity savings
Building envelope		
Fixtures	Replacement of the windows that had lost their air chamber, and consequently their thermal.	Gas-oil savings
Solar Screens	Solar Film in SW and SE windows	Electricity savings + comfort.
Electrical Systems		
Led	Replacement of the existing luminaires with LEDs.	Electricity savings
Heating and cooling		
Heat Pump/boiler	Replacement of the current boilers with natural gas boilers	Electricity and gas savings + comfort.

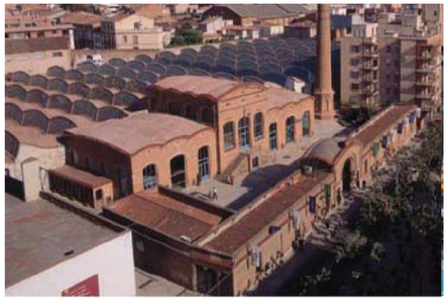

Table 8: EEM Description CU02 mNACTEC. Source Sherpa Project

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ESLP0REED60: Regional Office and Agricultural School - Gandesa		
EEM Name	**Description**	
Building and automation control systems		
Heating and cooling	Improving the management and control system of the whole equipment. Automatization of the current valves.	Gas-oil and electricity savings
Building envelope		
Fixtures	Replacement of the current windows	Gas-oil and electricity savings
Thermal Coat	Improvement of the exterior walls insolation	Gas-oil and electricity savings
Distributed generation		
Photovoltaics	Photovoltaic energy	Electricity savings

Table 9: EEM Description ED60 Regional Office and Agricultural School. Source Sherpa Project

ESLP0REOF27: Courthouse of Gavà		
EEM Name	**Description**	
Building and automation control systems		
Cooling	Replacement of the two chillers for ones with better technical benefits.	Savings electric energy
Heating	Replacement of a boiler for condensation and leave the other one for booster.	Gas Savings
Heating and cooling	Integrate these network analysers into a system that can be access remotely	Electricity and gas savings + comfort.
Lighting	Implementation of presence sensors and photocells Installation of programmable automatic clocks Lighting management and control system.	Savings electric energy
Building envelope		
Solar Screens	Installation of solar film on the windows to reject significantly the solar radiation and to improve the thermal performance of the current windows	Electricity and natural gas savings
Distributed generation		
Photovoltaics	Photovoltaic energy situated in the roof	Savings electric energy
Solar collectors	Thermal solar energy	Savings calorific energy
Electrical Systems		
Led	Replacement of the existing luminaires by LEDs.	Savings electric energy

Table 10: EEM Description OF Court House Gavà. Source Sherpa Project

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ESLP0REOF39: Palace of Justice		
EEM Name	**Description**	
Building and automation control systems		
Heating and cooling	Engineering study and thermal simulations. Implementation of a management and control software for the HVAC system that can be accessed remotely.	Electricity and gas natural savings
Lighting	Implementation of presence sensors and photocells Installation of programmable automatic clocks Lighting management and control system.	
Building envelope		
Fixtures	Replacement of the current windows with others of better thermal performance	Natural gas savings
Solar Screens	Solar Film in SW and SE windows	Electricity savings. Comfort
Distributed generation		
Photovoltaics	Photovoltaic energy situated on the roof	Electricity savings
Electrical Systems		
Led	Replacement of the existing luminaires with LEDs.	Electricity savings

Table 11: EEM Description OF39 Palace of Justice. Source Sherpa Project

ESLP0REOF40: Courthouse of Sabadell		
EEM Name	**Description**	
Building and automation control systems		
BACS	Implementation of an energy management and control solution capable of managing and controlling the lighting system and the heating and cooling production systems, accessible remotely and flexible to integrate more energy consumers in the future	Electricity and natural gas savings
Heating and cooling	Replacement and integration of the existing devices with a new management and control system accessible remotely Replacement of the cooling and the heating production equipment with others of better thermal performance	Electricity and natural gas savings
Lighting	Implementation of presence sensors and photocells Installation of programmable automatic clocks Lighting management and control system.	Electricity savings
Building envelope		
Solar Screens	Installation of solar film on the windows to reject significantly the solar radiation and to improve the thermal performance of the current windows.	Electricity and natural gas savings
Electrical Systems		
Led	Replacement of the existing luminaires with LEDs	Electricity savings

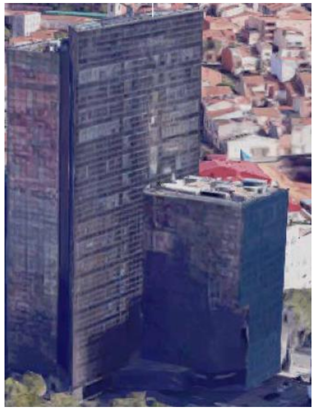

Table 12: EEM Description OF40 Courthouse of Sabadell. Source Sherpa Project

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ESLP0REOT36: PENITENTIARY PONENT			
EEM Name	**Description**		
Building and automation control systems			
Heating and cooling	Integrate network analysers into a system that can be accessed remotely to control the production. Improving heating efficiency technology thanks to replacing the existent old boilers with others of better performance.	Electricity and natural gas savings	
Lighting	Implementation of presence sensors and photocells Installation of programmable automatic clocks Lighting management and control system.	Electricity savings	
Building envelope			
Fixtures	Replacement of the current windows with ones of PVC with double glass in order to insulate the building better.	Saving energy. Comfort.	
Solar sceens	Solar film on SW and SE windows	Saving energy. Comfort.	
Distributed generation			
Photovoltaics	Photovoltaic energy situated on the roof	Savings electric energy	
Solar collector	Thermal solar energy	Savings calorific energy	
Electrical Systems			
Led	Replacement of the existing luminaires with LEDs.		

Table 13: EEM Description OT36 Penitentiary Center Ponent. Source Sherpa Project

ESLP0REOT37: Penitentiary 4 Camins			
EEM Name	**Description**		
Building and automation control systems			
Heating and cooling	Replacement with highly efficient condensation gas boilers. Integrate these network analysers into a system that can be accessed remotely.	Electricity and natural gas savings	
Lighting	Implementation of presence sensors and photocells Installation of programmable automatic clocks Lighting management and control system.	Electricity savings	
Building envelope			
Solar Screens	Solar Film on SW and SE windows	Saving energy. Comfort.	
Distributed generation			
Photovoltaics	Photovoltaic energy situated on the roof	Electricity savings	
Electrical Systems			
Led	Replacement of the existing luminaires in the cells and corridors with LEDs.	Electricity savings	
Heating and cooling			
Heating	Replacement with biomass heating boilers. Renewable energy	Savings thermal energy	

Table 14: EEM Description OT37 Penitentiary Center 4 Camins . Source Sherpa Project

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 847066.

ESLP0REOT38: Penitentiary Brians 1		
EEM Name	**Description**	
Building and automation control systems		
Cooling and Heating	Replacement of the old boilers with highly efficient condensing boilers/Distribution system/ Integrate these network analysers into a system that can be accessed remotely.	Electricity and natural gas savings
Lighting	Implementation of presence sensors and photocells Installation of programmable automatic clocks Lighting management and control system.	Electricity savings
Building envelope		
Fixtures	Replacement of the actual windows with ones with double glass and air chamber	Thermal energy savings
Solar Screens	Solar Film on SW and SE windows	Electricity savings. Comfort.
Distributed generation		
Photovoltaics	Photovoltaic energy situated on the roof	Electricity savings
Solar collectors	Thermal solar energy	Thermal energy savings
Electrical Systems		
Led	Replacement of the existing luminaires with LEDs.	Electricity savings

Table 15: EEM Description OT38 Penitentiary Center Brians 1. Source Sherpa Project

ESLP0REOT48: Nursing home Barcelona - Gràcia		
EEM Name	**Description**	
Building and automation control systems		
Lighting	Implementation of presence sensors and photocells Installation of programmable automatic clocks Lighting management and control system	Electricity savings
Cooling and Heating	Improving the management and control system of the whole equipment	Electricity and natural gas savings
Building envelope		
Fixtures	Replacement of the windows for others with better thermal performance	Thermal energy savings
Distributed generation		
Sollar collectors	Improve of the performance of the solar thermal system thanks of the modification the angle of the solar modules.	Thermal energy savings
Electrical Systems		
Led	Replacement of the existing luminaires with LEDs.	Electricity savings

Table 16: EEM Description OT48 Nursing home Gràcia. Source Sherpa Project

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 847066.

ESLP0REOT50 Nursing Home – Mossèn Homs		
EEM Name	**Description**	
Building and automation control systems		
Lighting	Implementation of presence sensors and photocells Installation of programmable automatic clocks Lighting management and control system	Electricity savings
Cooling and Heating	Improving acclimatization efficiency technology	Electricity savings
Building envelope		
Fixtures	Replacement of the current windows with others with better thermal performance	Thermal energy savings
Solar Screens	Installation of solar film in the windows to reject significantly the solar radiation and to improve the thermal performance of the current windows	Energy savings. Comfort.
Distributed generation		
Photovoltaics	Photovoltaic energy in the roof	Electricity savings
Solar collectors	Thermal solar energy in the roof	Savings natural gas energy
Electrical Systems		
Led	Replacement of the existing luminaires with LEDs.	Electricity savings

Table 17: EEM Description OT50 Nursing Home. Source Sherpa Project

ESLP0RESN32: PRIMARY HEALTH CARE - CAP MANSO		
EEM Name	**Description**	
Building and automation control systems		
Heating and cooling	Improving acclimatization efficiency technology Integrate network analysers into a system that can be access remotely.	Electricity savings
Lighting	Implementation of presence sensors and photocells Installation of programmable automatic clocks Lighting management and control system	Electricity savings
Building envelope		
Fixtures	Replacement of the windows with others with better thermal performance	Thermal energy savings
Solar Screens	Installation of solar film on the windows to reject significantly the solar radiation	Energy savings. Comfort.
Distributed generation		
Photovoltaics	Photovoltaic energy plant of 24kWp installed on the rooftop	
Electrical Systems		
Led	Replacement of the existing luminaires with LEDs.	Electricity savings

Table 18: EEM Description SN32 Primary Health Care Manso. Source Sherpa Project

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3.2 Pilot Buildings EEM Classification and Selection

3.2.1 Preliminary considerations

The aim of this chapter is to determine at least 2 Buildings from a list of 12. In order to select them, different preliminary considerations have been taken into account that simplify the selection tasks.

1. **First:** the possibility or the availability of getting information: Due to the COVID-19, the buildings destined for sanitary or healthy activities have not been considered in this selection. The buildings that have been dismissed are:

Code	Building Name
OT48	Day care center Barcelona-Gracia
OT50	Day care center Terrassa-Mossèn Homs
ESN32	Primary care center Manso

Table 19: Buildings list dismissed

2. **Second:** Due to the enormous delays the COVID-19 pandemic some artificial data to calculate the SRI was used, that means that was complemented by common properties of similar buildings.

Project Name	Building name	Basic SRI score	Advanced SRI Score	Artificial Data used
CU01	Restoration Center	D (26%)	D (24%)	no
CU02	Museum	C (51%)	C (44%)	no
ED60	Public School Offices	C (43%)	C (39%)	no
OF27	Courthouse	D (26%)	D (27%)	yes
OF39		C (42%)	C (45%)	yes
OF40		C (41%)	C (39%)	yes
OT36	Penitentiary Centre	D (25%)	D (24%)	no
OT37		D (22%)	D (23%)	yes
OT38		E (10%)	E (13%)	no
OT48	Nursing Center	D (34%)		no
OT50		E (11%)		no
SN32	Primary Medical Care	E (19%)		no

Table 20: SRI Outcomes considering Artificial Data

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Therefore, after these first two considerations, a first filter of buildings has been carried out, the measurements of which will be classified below by a series of indicators. From now on, the buildings to be studied are the following:

Code	Building Name	Basic SRI Score	Advanced SRI Score	Energy Savings And Operation	Respond To Users' Needs	Respond To Needs Of The Grid
CU01	**CRBMC**	**D (26%)**	**D (24%)**	**39%**	**37%**	**3%**
CU02	**mNACTEC**	**C (51%)**	**C (44%)**	**38%**	**27%**	**89%**
ED60	**Terra Alta School i Escola Agrària Gandesa**	**C (43%)**	**C (39%)**	**41%**	**39%**	**51%**
OF27	Court house of Gavà*	D (26%)	D (27%)	38%	37%	4%
OF39	Palace of Justice*	C (42%)	C (45%)	34%	32%	61%
OF40	Courthouse of Sabadell*	C (41%)	C (39%)	59%	48%	16%
OT36	CP Ponent + CO	D (25%)	D (24%)	34%	32%	9%
OT38	CP Brians 1 (+ Can Duran)	E (10%)	E (13%)	16%	14%	0%

Table 21: Buildings to be considered as Pilot Buildings

3.2.2 Indicators Description- Selection criteria indicators

We are going to define the different indicators that let us to classify the EEM first and the buildings on the other. The Variables and classification of *The Boundary Cases for the P4P rates* are adapted to different indicators in order to express better the Measures selection and have a unique criterion to compare the measures and also the building's characteristics. Moreover, other indicators linked with the indirect maintenance cost or savings have been also involved in this criteria.

There are 2 levels of indicators: one directly with the building's characteristics and the other one directly related to the measures value and their sustainable benefits.

3.2.2.1 Energy Efficiency Measures Indicators

The Aggregator or the Portfolio Manager during the Portfolio elaboration, where the different cases and projects will be grouped, will need different tools in order to evaluate not only the needs of the potential customers, but also to evaluate the quality and the EEM potential. This means that each EEM has to be scored according to the different parameters and benefits. It could also be linked directly to the P4P rates structure.

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In the following table there have been studied some of the possible indicators that could help the Aggregator to develop this task.

EEM SELECTION CRITERIA					
Indicator code	**Topic**	**Description**	**Units**	**Relation with Classification of EEM's** [12]	**Resource**
E1	Economic	Economic direct savings potential (energy costs)	Value from 1-10	Table C	Value of generic outcomes [13]
E2	Economic	Economic indirect savings potential (i.e.: maintenance costs for each measure and for the whole buildings		-	Internal development using current data of buildings.
T1	Technical (environmental)	Decrease energy demand and/or consumption		-	Internal development using Sherpa Data
T2	Technical	Shift energy demand	Value from 1-10	TABLE A	
S1	Social	Quality and innovation	Value from 1-10	TABLE B SRI	

Table 22: EEM Indicators. Selection Criteria

The indicators have been classified into 3 different topics. **Economic, Technical and Social**. The Economic indicators are these ones related to the costs and savings of the EEM implementation. The Technical ones are these related directly with technical aspects such as the energy demand reduction or the effect of each measure on the Shift energy demand. Finally, the Social Indicators, are those that provide us qualitative information regarding the environmental and social benefits for building's users. Is also important to highlight that SRI also provides us this kind of information.

[12] The Boundary Cases for the P4P Rates

[13] The Boundary Cases for the P4P Rates

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3.2.2.1 Building Indicators

The following table describes the indicators that are going to be used to select the pilot buildings. The global evaluation of this group of buildings could give us enough information to decide which buildings could be more interesting to be included in a P4P scheme in case the Aggregator has to prioritize them. Naturally, this is a proposal for the Buildings Selection Guideline.

Building Selection criteria				
Code	**Name**	**Definition**	**units**	**Data based on:**
C1	Energy consumption	Higher consumption/m2 compared with other buildings (same use)	Scored from 1 to 5	Electricity and Gas Invoices 2017 (to be update)**
C2	Economic savings potential	Higher economic saving potential (According to Sherpa results and SRI)	kWh	The potential savings from SHERPA Building reports
C3	Accessibility / Information	Information availability (accountability, energy and maintenance costs, current contractual obligations, etc.)	Scored from 1 to 5	Interviews and questioner done by Energy and Building Managers
C4	Visibility /social impact	If the building is very recognisable or frequently visited by the public, it can through an energy renovation, have an "exemplary role", increasing public officers' and citizens' awareness on energy-efficiency. If it is a very visible building an intervention may be requested to improve the image of the building and the profile image of the building owner. The project is or can be connected with local/regional strategies about urban planning or regulation.	0-1	The P4P model is based on data from Public Buildings. This indicator has been created to prioritize between two buildings in equal conditions. It is considered a Strategic Indicator, because, it seeks to set an example to society.
C5	Rehabilitation needs	No interventions implemented in the past (max 10 years ago)	Scored from 1 to 5	Interviews and questioner done by Energy and Building Managers Building data: last refurbishments
C6	Implementation potential	Higher implementation possibilities due to: Funding possibilities, no contractual obligations, etc.	Score from 1 to 5	Interviews and questioner done by Energy and Building Managers
SRI	Smart Readiness Indicator	Global Present Status of Building	% and A-D	

Table 23: Building Selection Criteria Indicators

C1 Energy Consumption

This indicator is scored from in 3 levels depending on the range of the Energy Consumption kWh/m2. The assumptions that have been made are:

Energy Consumption (kWh/m2)	Indicator value
0-100	1
100-200	3
>200	5

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C2- Energy Savings

It indicator is scored also in 3 ranges, which depends on the percentage of the potential energy Savings. It encompasses the total potential Energy Savings of the building after the Energy audit analysis.

Energy Savings potential	Indicator value
0-20%	1
20-40%	3
>40%	5

C5 Rehabilitation needs

This indicator aims to relate the year of construction with the normative building code which have been evolving. In that case the ranges are based on the construction periods in Spain or in the SHERPA buildings framework. It is very important to highlight that since 1978 the buildings are constructed under the Basic Building Standards and Regulation, which has been updated to date. This indicator gives us information about the margin of improvement in energy efficiency, especially with regard to construction elements (facades, roofs, structure, etc.)

Year of construction	Indicator value
>1978	1
1956-1978	3
<1956	5

It is very important when defining and scoring this indicator to check if in the last 10 years partial or total refurbishment works have been carried out.

This indicator could be adapted according the construction codes or standards in different countries.

3.2.3 Pilot GENCAT Building EEM Classification

3.2.3.1 EEM Classification data collection and results

To sum up the EEM's have been selected according the report *The Boundary Cases for the P4P rates* EEM catalogue, the main EEM's analysis parameters, the Sherpa building data, and SRI results. Coming back to the EEM's selection diagram, the Indicators let us

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to create the decision matrix in 2 stages: 1st one related to the EEM classification for each Building and 2nd the Classification and ranking between the different buildings.

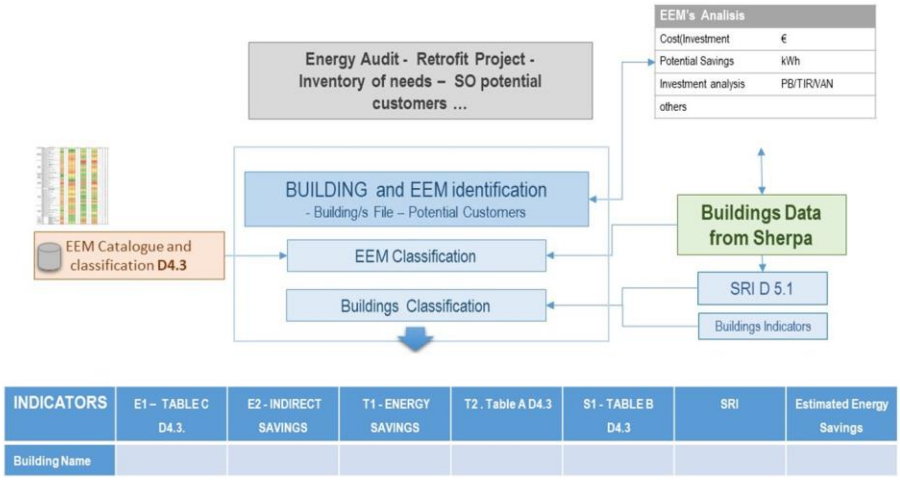

Diagram 2: Buildings Selection and indicators of EEM

3.2.3.1 Summary table of measures and their values

Once the EEM Selection indicators are described we are in a position to present the results for GENCAT Buildings. Per each EMM are scored the list of EEM indicators: Economic: E1 linked with the Table C of the Deliverable Boundary Cases for the P4P Rates EEM's classification and E2 direct with Indirect Savings (*); Technical: T1- potential Energy Savings and T2 Shift Energy Demand (linked with Table A) and Social (innovative and quality indicators) linked with Table B the same deliverable The Boundary Cases for the P4P Rates

Building EEM	E1 - TABLE C 4.3.	T1 - ENERGY SAVING	T2. Table A 4.3	S1 - TABLE B 4.3	Estimated energy saving
CU01 CRBMC	31,5	32	26	34	34,48%
Building and automation control systems	6,5	13	4	9	15,93%
Heating		10			13,33%
Heating and cooling	6,5	3	4	9	2,60%
Ventilation and Conditioning					0,00%
Building envelope	9	3	8	8	2,89%
Solar Screens	9	3	8	8	2,89%
Distributed generation	16	16	14	17	15,66%
Photovoltaics	8	9	8	10	8,49%
Solar collectors	8	7	6	7	7,17%

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Table 24: EMM Scoring and indicators for Building: CU01 CRBMC

Building EEM	E1 - TABLE C 4.3.	T1 - ENERGY SAVING	T2 . Table A 4.3	S1 - TABLE B 4.3	Estimated energy saving
CU02 mNACTEC	52,5	29	42	51,5	29,37%
Building and automation control systems	21,5	6	16	25,5	5,17%
Heating and cooling (29+31)	6,5	2	4	8,5	1,81%
Lighting	5	4	6	8	3,36%
Ventilation and Conditioning	10		6	9	
Building envelope	13	2	12	10	2,23%
Fixtures	4	2	4	4	2,16%
Solar Screens	9	0	8	6	0,07%
Electrical Systems	9	8	8	9	8,31%
Led	9	8	8	9	8,31%
Heating and cooling	9	9	6	7	9,31%
Heat Pump	9	9	6	7	9,31%

Table 25 EMM Scoring and indicators for Building: CU02 Museum NACTEC

Building EEM	E1 - TABLE C 4.3.	T1 - ENERGY SAVING	T2 . Table A 4.3	S1 - TABLE B 4.3	Estimated energy saving
ED60 Terra Alta Agrarian School	27,5	40	24	33	75,69%
Building and automation control systems	6,5	10	4	9	11,14%
Heating and cooling	6,5	10	4	9	11,14%
Building envelope	13	20	12	14	28,79%
Fixtures	4	10	4	4	11,13%
Thermal Coat	9	10	8	10	17,66%
Distributed generation	8	10	8	10	35,54%
Photovoltaics	8	10	8	10	35,54%
Storage Systems					0,00%

Table 26 EMM Scoring and indicators for Building: ED60 Terra Alta Agrarian School

Building EEM	E1 - TABLE C 4.3.	T1 - ENERGY SAVING	T2 . Table A 4.3	S1 - TABLE B 4.3	Estimated energy saving
OT36 CP Ponent + CO	49,5	23	44	53	22,86%
Building and automation control systems	11,5	1	10	17	0,98%
Heating and cooling	6,5	1	4	9	0,60%
Lighting	5	0	6	8	0,38%
Building envelope	13	1	12	10	1,10%
Fixtures	4	1	4	4	0,66%
Solar screens	9	0	8	6	0,44%
Distributed generation	16	8	14	17	8,15%
Photovoltaics	8	3	8	10	3,13%
Solar collector	8	5	6	7	5,02%
Electrical Systems	9	5	8	9	4,67%

Table 27 EMM Scoring and indicators for Building: OT36 CP Ponent + CO

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Building EEM	E1 - TABLE C 4.3.	T1 - ENERGY SAVING	T2 . Table A 4.3	S1 - TABLE B 4.3	Estimated energy saving
OT38 CP Brians 1 (+ Can Duran)	53	24	46	53	24,65%
Building and automation control systems	15	4	12	17	4,79%
Cooling and Heating		4			4,10%
Lighting	5	0	6	8	0,22%
Ventilation and Conditioning	10	0	6	9	0,47%
Building envelope	13	0	12	10	0,60%
Fixtures	4	0	4	4	0,48%
Solar Screens	9	0	8	6	0,12%
Distributed generation	16	16	14	17	15,91%
Photovoltaics	8	9	8	10	8,81%
Solar collectors	8	7	6	7	7,10%
Electrical Systems	9	3	8	9	2,57%
Led	9	3	8	9	2,57%
Heat pump		1			0,78%

Table 28 EMM Scoring and indicators for Building: OT38 CP Brians 1 (+ Can Duran)

3.2.3.2 Summary table of measures and their values

The following table summarizes the aggregate results for each of the buildings.

Building EEM	E1 - TABLE C 4.3.	T1 - ENERGY SAVING	T2 . Table A 4.3	S1 - TABLE B 4.3	Estimated energy saving
CU01 CRBMC	31,5	32	26	34	34,48%
CU02 mNACTEC	52,5	29	42	51,5	29,37%
ED60 Terra Alta Agrarian School	27,5	40	24	33	75,69%
OT36 CP Ponent + CO	49,5	23	44	53	22,86%
OT38 CP Brians 1 (+ Can Duran)	53	24	46	53	24,65%

Table 29: EEM's total selection criteria

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3.2.4 Buildings Selection

3.2.4.1 Getting a first ranking per Building and its relation with SRI

In the same way, the criteria for selecting buildings have been applied according to the indicators explained in the previous sections. The following table lists the global values for all of them.

Building selection criteria	C1	C2	C3	C5	C6		SRI
	Energy consumption (kWh/m2)	Economic savings	Accessibility	Building deterioration	Implement. possibilities	TOTAL	SRI
CU01- Restoration Center of Art of Catalonia	**5**	**3**	**10**	**1**	**10**	**32,4**	D (24%)
CU02-Museum of Science and Technology	**1**	**3**	**10**	**5**	**10**	**30,4**	C (44%)
ED60-Public Office - Agrarian School at Terra Alta	1	5	10	3	10	31	C (39%)
OT36-Penitentiary Center Ponent	**5**	**3**	**10**	**3**	**10**	**34,4**	D (24%)
OT38-CP Brians 1 (+ Can Duran)	5	3	10	3	10	34,4	E (13%)
OT37-Pennitentiary center Quatre Camins	-	-	-	-	-	-	D (23%)
OF27-Courthouse of Gavà	-	-	-	-	-	-	D (27%)
OF39-Palace of Justice	-	-	-	-	-	-	C (45%)
OF40-Courthouse of Sabadell	-	-	-	-	-	-	C (39%)
OT48-Nursing Center	-	-	-	-	-	-	D (34%)
OT50-Nursing Center	-	-	-	-	-	-	E (11%)
SN32-Primary medical Center Manso	-	-	-	-	-	-	E (19%)

3.2.5 Proposal of GENCAT scenarios

According the indicators outcomes, the most appropriate Buildings to be studied in the following chapters, and in particular in chapter 4, are:

- CU01- Restoration Center of Art of Catalonia
- ED60-Public Office - Agrarian School at Terra Alta
- OT36-Penitentiary Center Ponent

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3.3 Other Aspects: specific characteristics of Buildings of GENCAT.

There are particularities of GENCAT BUILDINGS that could affect directly and indirectly and that could take part in the decision-making at the time of realizing a measurement or another one. Here are explained some of them, and how they could be extrapolated to a more general case or situation.

The main ones are:

- Prior energy purchase contracts:
- Prior maintenance contracts
- Type of Property, involved actors
- Complexity to carry out some measures
- Legal requirements
- EEM incompatibilities

Thus, the Aggregator or the Portfolio Manager has to take into account during the portfolio development since they can condition the final results.

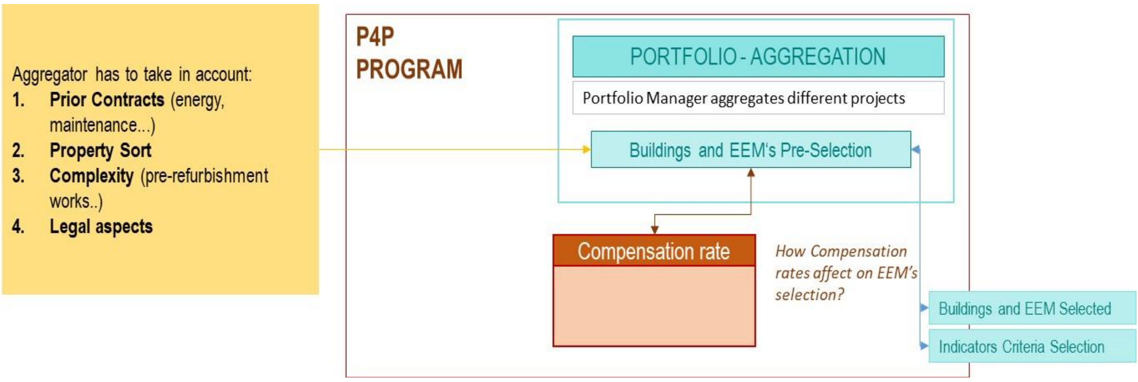

Diagram 3: External aspects that could impact on the Portfolio Manager to aggregate or not the potential buildings or customers in the P4P Program.

Prior Energy Purchase Contracts

As a public institution, Generalitat of Catalonia (GENCAT) services the general interest of society under the main principle of Efficiency and effectiveness. It means that all of its acts and works must achieve a specific goal and obtain results through the heights performances and obtain the maximum results using the minimum or appropriate resources (technical, financial and human). According this precept, the GENCAT has a framework agreement for the Energy Supply where all the department interested in can

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purchase the energy resources (Electricity, Natural Gas, LNG and Propane) in order to achieve economies of scale in prices and procurement processes. However, this acquisition has normally a commitment regarding a minimum of mandatory amount of MWh purchased. This Fact could limit part of the EEM goals because despite being able to reduce consumption, there will always be an economic minimum commitment to meet and as consequence impacts on the global EEP investment.

Hence, during the EMP design the prior Energy Supply contracts (Natural Gas, Electricity, etc.) must be taken into account and it must be studied what could be the affects between the estimated and real saving and the estimated and real consumption previously agreed in those contracts. In case that the real Energy Savings reduce substantially the Energy Consumption predicted the user or in that case, GENCAT, should consider the necessity or the obligation to take out this service of the contract. An example would be a situation where it is planned to install PV panels to produce electricity since the electricity needs from the grid could reduce more than 40%.

In conclusion, the **terms and conditions of previous energy supply contracts** must be taken into account by the Aggregator or the P4P owner in order to have a global view of each customer and design the most appropriate EEP and calculate the real costs and savings. Most probably the new EEP implies to reformulate some Energy Supply contracts.

Prior Maintenance Contracts

With regard to maintenance contracts the same or very similar happens as in the energy supply purchase. The maintenance contracts in GENCAT are also handled through a public procurement where the maintenance performances are strictly stipulated and defined in the contract specifications. The duration of these contracts may be 2 or more years, depending on the needs and stipulations of the tenders. Hence, any change or modification of these maintenance works due the implementation of an EEM could have a noticeable impact on the maintenance costs. On one hand this could effect on the hours per week needed for the building maintenance, or on the other hand more personal specialized in energy management maintenance could be required. Therefore, it implies that the maintenance contract should be also reformulated together with the EEP in order to avoid unexpected costs due to contracts terms. It could be also an opportunity to include in the maintenance requirements and protocols high energy efficiency skills and knowledge to get higher savings in operation works and get better rates.

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Type of Property, involved actors

The Building Owner (BO) is the last authority to decide what performances or works will transform or not the building to a better and more efficient one. However, in relation to the property there are involved different actors that play an important role on this transformation. For example, the BO could be a real state, could be a private owner, public administration, or others, meanwhile there could be also the role of the tenant.

In residential sector, the property variable takes on a relevant importance, since the fact of increasing the value of the building thanks to the implementation of EEM's, will immediately cause the taxes linked to that increase in value to have a considerable impact on building owner income.

In the case of the GENCAT, depending on the building, could have these two different roles. In some cases, it is a BO but in other cases GENCAT has rented the building to a different private owner.

Complexity to carry out some measures

Another aspect that could difficult the implementation of certain EEM is the complexity to carry out them in specific building due to different reasons such as the age of the building, its location, if the building is listed as historical, the sort of uses, the need for special permits.

Other examples could be the necessity to make first an integral refurbishment related to the structure of buildings where the main reforms are focused on different topics from the energy efficiency and whose costs may be much higher than those of the EEP. They are more related to the construction requirements, accessibility measures or whole electrical installation update in order to comply with the regulations codes.

Consequently, prior to making the EEP the Aggregator or the P4P owner has to investigate if the potential building to be included in the project portfolio is affected by any of the restrictions discussed above and treat it in a special way since it means additional cost.

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Legal Requirements

Apart from the Legal aspects related to the electrical market or to financial rules that could have a positive or negative impact on the SENSEIN MODEL. There are also other legal aspects directly related with the EMM at the moment when we have to decide to implement them or not.

On the one hand there are the Urbanistic compatibilities. The responsible to decide what EEM are most appropriate in each case, when he or she is designing the EEM Portfolio, has to take in consideration the **urban planning regulations** since it could make them to think of other alternatives.

On the other hand, another legal aspect to considerer is the tax regulation. Even though the building refurbishment could be beneficial increasing the Building Value, the same aspect has a direct impact on the income of the small owner. That is to say, the building Owner has to pay an extra or plus tax individually for this added value. This situation may cause the owners don't want to carry out the necessary EEM implementation.

Incompatibilities

According to Sherpa Project, there are some measures which are incompatible with others because of different reasons that are detailed below.

1. In **CU01 - Restoration Center of Art of Catalonia** solar screens measure is incompatible with the photovoltaic measure because both use the same glass area of the Building (southeast glass area). Besides, photovoltaic measure is also incompatible with the solar collector's measures because both would place on the same roof too.

2. In **CU02-Museum of Science and Technology,** the heat pump measure is incompatible with one of the measures that are in the undefined category. In the indefinite category, there is the replacement of the burner and the chiller. So the one which is incompatible with heat pump is the replacement of the current burner because the first one is based on changing the gas boiler as a unit and replace it for a new model with better performance and the second measure is based on changing this part of the gas boiler.

3. In **OT36-Penitentiary Center Ponent** the fixtures measure is incompatible with the solar screen measure because this second needs a special glass where to

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install it. Besides, photovoltaic measure is incompatible with solar collectors because both would be installed on the same place. Finally, in the SHERPA project, the lighting category is divided into different categories. On one hand, there is the lighting technology - programmed Schedule measure that consists of the installation of programmable clocks. On the other hand, there is the management and control System measure. These two measures are incompatible because the two controls the light system in different ways.

4. In **OT38-Penitentiary BRIANS** there is the lighting category which, according to SHERPA project, is divided in two measures. On one hand, there is the lighting technology - programmed Schedule measure that consists of the installation of programmable clocks. On the other hand, there is the management and control System measure. These two measures are incompatible because the two controls the light system in different ways. Besides, photovoltaic measure is incompatible with the solar collector's measures because both would place on the same space.

Summary. Other aspects that affect the EEM Selection

To sum up: When designing a plan of measures, whether through P4P or any other financing system, it will be essential to take into account all aspects related to the building.

OTHER ASPECTS TO TAKE IN ACCOUNT

1. Prior Contracts		
	Energy Supply electricity)	- Does the contract includes terms and conditions that entail penalties in case of significantly reducing consumption? - Could the EEM's provide secondary economic benefits in relation to the type of contract? (e.g. changes to a better tariff, reduction of power etc)
	Maintenance	- What are the implications of implementing measures in maintenance contracts, especially in the case of large buildings or large owners? Could be entail penalties? (e.g. reducing work-hours) - Does it require more trained and expert professionals in Energy Efficiency to keep and control the expected Energy savings? - The EEM's implantation in P4P Scheme means also creating specific maintenance plans?.
2. PROPERTY		- Decision-making capacity in small private owners? - Differences between BM vs CEOs in the case of large corporations whose decisions are not always focused on energy efficiency and sustainability.
3. COMPLEXITY TO IMPLEMENT EEM		- Is there any priority measure not related to energy efficiency that must be complied by regulation? (e.g. homologate the electrical installation to current regulations, accessibility reforms such as elevator installation.) - Is the Building considered as a Historical? - In case of difficulties for the implementation of the EEM, will it be necessary to think about more complex alternatives that imply a greater investment?

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4 Identification of P4P rates for the pilot buildings

4.1 General Analysis. Classification of compensation systems.

This section examines the interplay between the compensation structure of a P4P scheme and its effect on the pursued EEM's. The purpose of a P4P scheme and its compensation rate structure goes further than a simple subsidy or grant, it looks for the long term savings and for other benefits to the electrical grid, social and environmental. Nevertheless, this means that a deeper knowledge of the potential savings for each EEM or EEP is needed to adjust the incentives to these actual outcomes and, in addition to make the investment more attractive and secure.

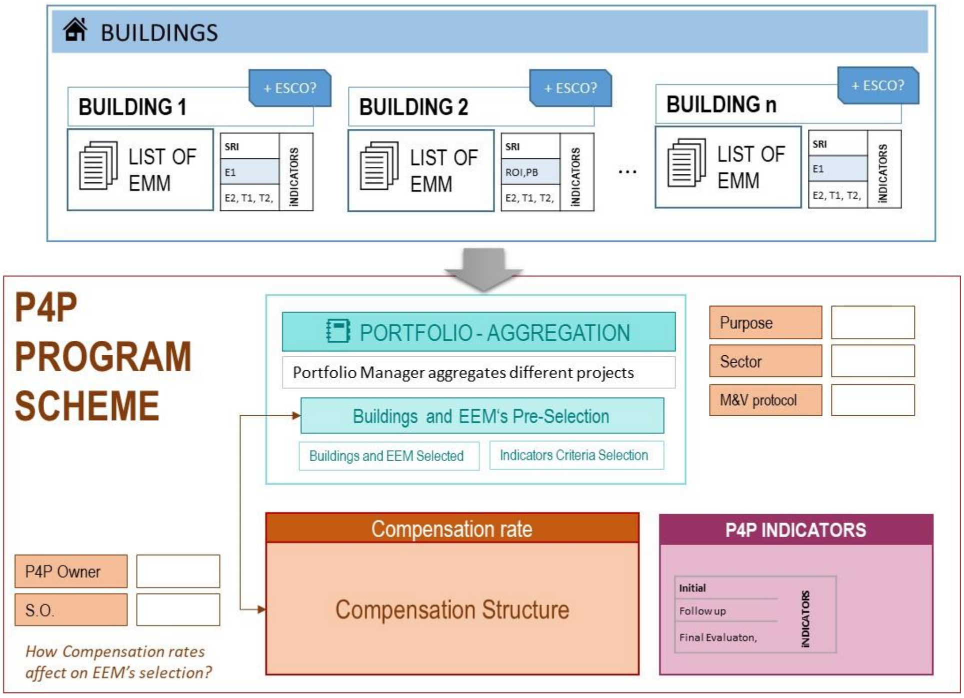

Diagram 4: Compensation Rate Structure within a P4P Scheme

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The aim of this chapter is to explain with more detail the concept of a Compensation Rate and its structure within a P4P Scheme and its relation with the EEM by answering first a series of questions that will help the reader to understand it with a major depth.

- *How the requirements and elements of a P4P program affect the value of different EEMs?*
- *How different compensation rates for energy savings affect the choice of the EEMs to pursue?*
- *How P4P rates can be structured to avoid focusing on the easiest-to-obtain and/or short-lived savings but rather incentivize deeper savings?*
- *How the compensation structure of a P4P scheme can steer energy efficiency interventions towards measures that are beneficial for both the building owners and the grid*
- *How differentiated P4P rates can be more effective that uniform ones, as well by associating indicators that describe the current state of the building, including SRI with Incentive rates and minimum saving level requirements.*
- *How the details of a P4P scheme affect the expected SRI after the implementation of the EEMs;*
- *How the EEM plans are affected when P4P rates reflect the time-dependent value of the energy saved*;

4.1.1 How the requirements and elements of a P4P program effect the value of different EEMs?

In Deliverables *D4.4 Experience and lessons learned from pay-for-performance (P4P) pilots for energy efficiency* are described the requirements and boundary elements that define a P4P Scheme. Before finding out what relation there is between the design of the **Compensation Rate Structure** and the EEM that would be finally selected, is it necessary to evaluate what elements of the P4P Scheme Design has a **direct impact** on the value of EEM's. While in the previous Chapter a group of EEM for GENCAT buildings have been selected according to SENSEI classification in the P4P scheme design phase the value of these EEM will depend on more general aspects. Depending on what the P4P Program is looking for (e.g. reduce the energy consumption at peak times, or decarbonize, etc.) each EEM's will take more or less significant importance

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regardless of its value in *D4.3 The Boundary Cases for the P4P rates.* In other words, during the P4P Scheme design phase we have to decide which eligible EEM's are wanted to be compensated or not, or otherwise which measures will be definitely dismissed. Although the P4P model is not looking for **specific technologies** it is intended to promote in the first instance those that are related to the **Energy Efficiency as an energy resource** and therefore those that also have an impact on the electrical grid, and at the same time in turn allows the figure of the aggregator or portfolio manager to group several projects.

In the following table there are summarized the different elements for the design of a P4P programme

P4P Scheme requirement / boundary elements		**Direct impact on the EE Value**
Key Drivers	Purpose	Yes.
	Regulatory drivers	
Basic design attributes	Type of approach	
	Administration	
	Roles	
	Source of funding	
	Customer Segment	Yes.
	Eligible measures	
Performance assessment	Protocol M&V	
	Baseline	
	Metering Technology	
Payment methods/ Compensation rate structure	Beneficiary of performance payment	yes
	Contract duration	
	Reward structure	
	Price per unit	

Table 30: Main Boundary elements of a P4P Scheme

4.1.1.1 The Purpose/ Regulatory drivers:

The Purpose of the P4P Program could be, in general, linked to the International Agreements, European Directives or National Energy Efficiency Strategies which mark the line to be followed in relation to the decarbonisation and the deeper renovations among others. Of course, the decision for the definitive purpose is in the hands of the owner of the P4P program, whether private or public. In addition to this, a first approach that can be done is related to the national strategies which are associated with national economic funds and part of the budgets of public administrations or utilities, so it could determine in part the cash flow of the P4P Scheme.

1. *The P4P Owner (TSO/Public institution) decides the EEM bases.*

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4.1.1.2 Sector or Customer Segment

Depending on the sector to which the program is addressed the EEM's will be of one type or another. These sectors could be differentiated or classified in a different kind of grouping. For example, depending on the location (grouping buildings of the same area independently of the use or activity), depending on the peak consumption (kWh, kWh/year), depending on the size (m2), on the use (residential, commercial, industrial), depending on the property, etc. But in all cases the measures that will have to be prioritized will be those in which there is a greater improvement path. For example, in the case of residential buildings, it is known that around 50% of the buildings are constructed prior to 1970[14] and therefore the improvement path will be focused in the envelope or electrification of the HVAC equipment. While in large buildings it will be necessary to prioritize other types of measures, for example improve ventilation system or introduce smart meters and technologies to manage the whole energy systems. This will involve the program owners and facilitators, whether they are an administration, utilities or TSO/DSO, knowing in depth the needs of their potential customers. Hence, the customer segment not only will have a direct effect on the EEM value but also on the design of the P4P rate.

> *2. The customer segment has a direct effect on EE Value and the design of P4P*

4.1.2 How different compensation rates for energy savings affect the choice of the EEMs to pursue?

This question is closely related with the previous one, but now we have to immerse in P4P program and on the **definition of the incentives structure**, that's to say, what is going to be paid for and how and what other benefits the P4P rates are looking for (comfort, environmental, behavioural and operational benefits, etc.).

4.1.2.1 What is a compensation rate structure?

In the conceptual framework of a P4P Scheme, the compensation rate is a financial/economic incentive created to promote the implantation of different EEM by paying a determined amount of money for these savings (kWh or CO2) that could be

[14] https://ec.europa.eu/energy/eu-buildings-factsheets_en

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verified through the M&V protocol. It must be delimited within the P4P payment structure. Independent of who is willing to pay for it or who is going to receive it, the design of this structure will mark the type of EEM that will be carried out or not in function of their potential and real savings and therefore the gain that will make the Investment more or less profitable. Consequently, we can not only look at the incentive itself; the whole payment structure must be analysed since it will have a direct effect on the EEM decision-making.

4.1.2.2 Elements that define the Compensation Rate Structure

The elements and parameters that define the compensation rate structure are crucial to achieve the P4P scheme goals, and thus to carry out as many EEM's as possible. For that reason, all those parameters have to be thought or designed to accommodate the different portfolios of the aggregators.

The most important ones have been highlighted in the following table:

Rate/Incentive Structure		
Scope	The Scope of the Payment Structure is related with it is designed according to a Pure P4P or Hybrid	Pure P4P Hybrid: Upfront (%) and pure P4P payments
Minimum Cost Reduction or Source Energy Savings	the Minimum cost reduction is the total amount of Energy Savings to be achieve during the contract period. It could be estimated in relation to the customer segment, the Building type (use), or the Surface. And its value could be expressed in % or specific amount.	Per Building Type Per Customer Segment Per m2
Location	The Location of the buildings to be grouped	
Payment conditions		
Periodicity	defines the periodicity when savings will have to be accounted for as well as payments made	quarterly yearly Reviewed periods ...
Incentive itself	Here the amount of €/kWh saved has to be determined, it will mark what we have to Perform and how.	Formulas must be defined in each case.
	Threshold: it must be defined a limit	
	Application, and review	
Bonus (extra-incentive)	Additional incentive if the expected savings have been overcome, to be analysed in future approaches	
Penalties	The penalties are very close with contractual terms and conditions. They have to determine the different casuistry in case that the goals are not achieve.	Pure P4P Hybrid: Upfront (%) and P4P
Contractual	Pure P4P	Linked with WP6
	Hybrid: Upfront (%) and P4P	

Table 31: Rates Structure.

Hereunder these elements are analysed one by one in order to see what connection there is between the Compensation rates and the EEM selection. In all this document have been already detected some of them.

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Scope:

Payment Structure		In which aspects do the elements of the compensation structure affect the selection of measures
Scope	Pure P4P	1. The fact that there is an initial % vs to pay everything at the end of each payment period, can it make us decide for some measures than for others? If not, why? 2. The Pure P4P could discourage the implementation of those EEM that have a higher investment level or very long Pay Backs, due to the initial disbursement necessary to implement could be really very high. Hence, we are promoting indirectly little initiative and penalizing the long-term or deep ones. 2. The Pure P4P in general the compensation rate is based on a flexible performance-dependent , in case we need to think of an inflexible part to keep the participants invested we need to design the hybrid model
	Hybrid: Upfront (%) and P4P	Instead a hybrid model, that combines an Upfront payment + periodically p4p payment could break the barrier of initial disbursement for those high investments. Apart from that, it can give the investor confidence and security when participating in the new program (remove barriers to entry).

Minimum Energy Savings Goal:

Payment Structure		In which aspects does the elements of the compensation structure affect the selection of measures
Minimum Cost Reduction or Source Energy Savings	Per Building Type, Use, Surface	1st. The Minimum Energy Saving Goal is linked with the P4P Purpose. 2nd IT must indicate the Minimum Global Savings for a set of different projects or per Portfolio. By this way the Portfolio Manager could make a final balance between the savings don't produced and those that have been produced above expectations. Depending on the Program Owner and designer the minimum could be defined according to the Building Type, use (residential, non-residential) the Size (surface), etc. It affects the EEM's selection since in case of Residential Buildings to achieve the same level of Savings it is necessary to consider a larger portfolio and deeper renovation measures, which will increase the investment and contractual period. Whereas, in the commercial sector (e.g. big Hotels or Office building), perhaps the same minimum could be achieved much before.

Payment Conditions: Periodicity

Payment Structure	In which aspects does the elements of the compensation structure affect the selection of measures
Payment conditions	
Periodicity	The payment periodicity is linked with the contract terms and conditions, but also at the same time it is linked with the data availability, due it is being paid per performance. So, the periodicity is also linked with the Energy Measures.

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Location

Payment Structure	In which aspects does the elements of the compensation structure affect the selection of measures
Location	As commented above, this variable may or may not be within the compensation structure or it only may rather be a variable of the global P4P structure. It can be a matter of discussion, but in any case should be considered. It has sense for incentivising in case of grouping within a km radius that allows to accumulate savings that have a greater incidence by a part of the distribution? Why could be the Building location a decisive element to decide what kind of measures to be promoted or implemented.? There are 2 perspectives in that sense: The first one is directly related to the Energy Demand Management, if the Portfolio Manager is able to aggregate different buildings very close to each other, the effect on the power grid in that location could be actually very significant. The second perspective is more related to the Aggregation directly, and it entail collateral financial and environmental benefits. For example, the ESCO who takes part in this Program and needs to invest and purchase material to implement the measures, could get better prices to aggregate different projects in the same geographical location. Moreover, if the local economy is also promoted, emissions caused by transport could even be reduced, etc. Regarding to Circular Economy: The Compensation rate designer should also define it considering the elements of circular economy. Even this concept is more close to recycling, reuse and reduce waste, nowadays, energy efficiency is strongly linked with it. And especially when we speak and think locally. This variable also opens the doors to the participation of Energy Communities.

The Incentive /rates

Payment Structure		In which aspects does the elements of the compensation structure affect the selection of measures
Rate	Here the amount of €/kWh saved has to be determined, it will mark what we have to Perform and how. payment formulas definition. Link with M&V Protocol	Regarding the **amount to be paid,** in this stage of the project we are not able to determine a specific amount (only by way of example). However, the incentive will address what variable of each EEM has to be measured (units, periodicity, etc.) and then include range values. Questions like these can be asked: - Should this amount be different depending on the EEM type, that is to say, if the Decarbonizing Measures should be best paid than other measures because it is encouraging the electrification instead of keeping the fossil fuels? - Otherwise, can it be settled down a fix price (€/kWh) independently of the energy source (Electricity, GN) and after step up additional amounts in case of EEM's focused on electrification?
	Threshold: it must be defined a limit.	Must there be Incentive Threshold? If yes, it cannot be higher than the expected economical savings. It could be previously examined in the Energy Audit in This should tell us by previous audits based on the mix of measures and also considering the grouping of projects Could this cap be increased in case of grouping projects?
	Application, monitoring and review	Is it necessary an annually or periodical review for the application and incentive itself? In case that the contract is formalized for more than 10 years. Should be considered the Consumer Price Index (CPI) fluctuations in that cases?

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Bonus, extra incentive.

Payment Structure	In which aspects does the elements of the compensation structure affect the selection of measures
Bonus (extra-incentive)	The Bonus or the extra-incentive is it considered in some of the United States P4P Schemes that have been studied in the SENSEI deliverable *Experience and lessons learned from pay-for-performance (P4P) pilots for energy efficiency*[15].

Penalties

Payment Structure	In which aspects does the elements of the compensation structure affect the selection of measures
Penalties	How are linked the possible penalties and the EEM decision making? There will be some EEM more susceptible to fail and to not achieve the expected Savings. They could be linked with the Scope of the Rate Structure. If we are talking about a Pure P4P it won't be necessary to return the payments received, however, in case of hybrid P4P, it could be the possibility to return part of the payments received at the end of the contract. Consideration: - it is demonstrated that the measure has not been reached due to a poor sizing of the same at the project level. Possibility of implementing other complementary measures to maintain compensation and Energy saving levels? - Non-payment of compensation or partial payment (proportional to the savings achieved). - Terminate the contract (in case of breach). These penalties could discourage the **implementation of innovative measures** due to the degree of uncertainty and make the investor prefer those known measures with direct savings (Renewable production).

To sum up, the P4P Rates designer or decision maker must consider everything explained above in order to define the incentive or payments structure, the basis of which will depend on the available public budget and the duration in years of the P4P program. Furthermore, both in the P4P definition bases and in the contracts terms and conditions, as well as the protocol used for the M&V these elements have to be well defined to avoid any discrepancies in the future.

4.1.3 How P4P rates can be structured to avoid focusing on the easiest-to-obtain and/or short-lived savings but rather incentivize deeper savings?

[15] https://zenodo.org/record/3887823#.YKS1VI77SUm

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In first place, it must be differentiated the **easiest-to-obtain savings** from the **deeper savings** concepts. The first ones, also well known as “Low Hanging Fruit” are these sort of EEM’s or renovation works with a very low investment, which are easy to implement and whose payback is in short term, such as LED lighting renovation. Moreover, in some occasions, these are offered directly by manufacturers instead of coming from a global study like an Energy Audit or an Integral Retrofit Project.

Whereas the **Deeper Retrofit or Deeper Renovation** [16] are these works related to integral building renovation, new construction or grouping of different projects. It must be said that most of the time the private building’s owners cannot afford the investment of this kind of renovation works. This implies another challenge to persuade investors by offering incentives within the compensation rates.

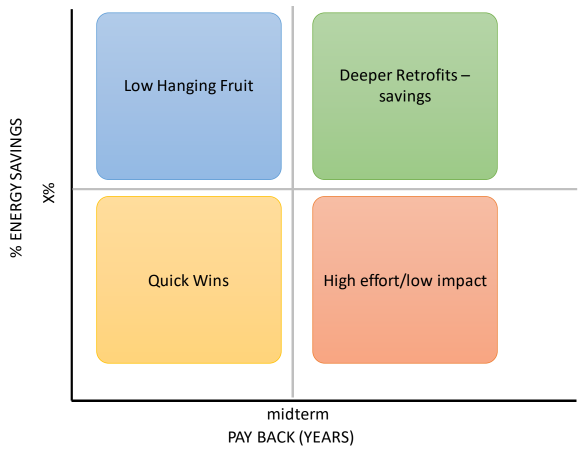

Diagram 5: Impact vs Effort Matrix.

Making the same analysis for pre-selected buildings in Section 2, If we compare for each measure the potential savings obtained and the payback of the necessary investment, it was clear how the long-term measures are mainly measures related to renewable energy and passive measures. Being the last ones, the most difficult to implement. Hence, the Aggregation and the promotion to implement deeper refurbishments are strongly linked. Aggregating different projects could increase the total Energy Savings potential, and at the same time could contribute to collateral benefits for the grid in case this aggregation considers different projects within a same small geographical area. In addition, the

[16] An energy renovation is classified as deep renovation in cases in which the primary energy demand of a building (based on calculated or measured performance) has been reduced by x > 60% compared to the primary energy demand of the building in the calendar year before the energy renovation

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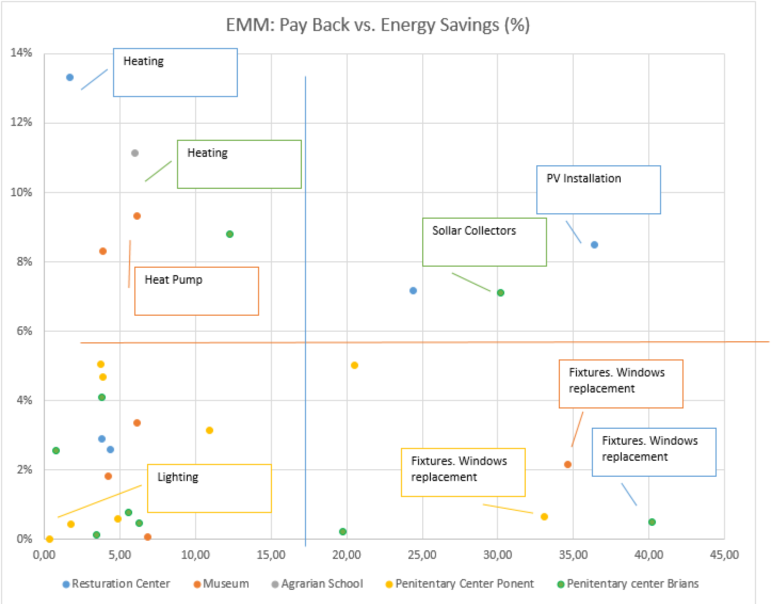
closeness of the set of buildings within the same portfolio, benefits the distribution of the materials and equipment that have to be implemented.



As an example and to understand what deep retrofits mean, there is an study done by the European Commission named "Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU"[17], where the non-renewable primary energy savings are divided in 4 types of renovation achievements:

- Below threshold (x < 3% savings)
- Light renovations (3% ≤ x ≤ 30% savings)
- Medium renovations (30% < x ≤ 60% savings)
- Deep renovations (x > 60% savings)

It is important to highlight that these renovation levels are not associated with the examples of the present deliverable. However, our case of study is based on existing buildings (residential, commercial), their trend for deep renovation would have to go in the same direction or try to achieve similar levels. For that, it is very important, and for that SENSEI is working on this model, to take in consideration the concept of Aggregation from different projects, and the aggregation of deeper renovation and easiest-to-obtain measures- Mainly for two reasons, the first one to ensure a great savings potential by balancing the underestimated and overestimated savings among all buildings. Is it to say, the aggregator or the investor could reduce the Investment risk.

[17] https://ec.europa.eu/energy/studies_main/final_studies/comprehensive-study-building-energy-renovation-activities-and-uptake-nearly-zero-energy_en

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While the second one, it can encourage private and residential customers to participate in this kind of programs.

Does it mean that we have to forget the measures that provide with easy-to-obtain savings? In general, no, but they must be considered as part of the global project. That's to say that the Global project encompasses both "low Hanging Fruit" and Deeper Savings. And for that, it is very important to consider a combination of measures during the compensation rate structure design.

According the same study, the annual amount of deep renovation in EU is only around 0.2%. and defines as Deep Renovation: "An energy renovation is classified as deep renovation in cases in which the primary energy demand of a building (based on calculated or measured performance) has been reduced by x > 60% compared to the primary energy demand of the building in the calendar year before the energy renovation"

There are a set of challenges regarding deeper Savings and P4P model Goals:

1. High knowledge of EE to innovate and to be able to calculate the effect of Deeper savings (costs, risks, etc.)
2. Relationship among the main actors involved when making long-term decisions, their effects and repercussions
3. Current energy performance: SRI, Energy Efficiency audit-project, Baseline
4. Energy Plan Strategy. How to plan the different actions and EEM implementation? where to start?
5. Commitment with legal codes, national and international legislation considering long term actions.

4.1.4 How the compensation structure of a P4P scheme can steer energy efficiency interventions towards measures that are beneficial for both the building owners and the grid.

When the P4P Owner is looking to compensate for these initiatives that produce a shared benefit for the Power grid and the Building Owner, it has to find the meeting point of the benefits expected by each of them.

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	Main Expected benefits (examples)
Building Owner	Reduce energy cost by reducing energy consumption because it reduces the energy bills
Power grid Owner	Reduce load during peak hours because it could reduce the grid maintenance cost

Measure Description	Indicators	Challenges
EEM that have an impact on the power curve	Class A D4.3 The Boundary Cases for the P4P Rates	• Aggregator or Portfolio Manager should study in depth the use/activity building profile. • Portfolio Manager or Aggregator knows in each case what is the better EEM and its impact on the demand curve to avoid peak hours.
EEM that consider the whole annual period	Energy Consumption Energy profile needs	• Consider the renovation of cooling and heating systems together in order to have a greater impact on the network for one year
Passive Measures		• The impact on power grid of a passive measures is difficult to assess in comparison to measures such as the lighting substitution to LEDs or new motors implantation. It entails a deeper Energy Efficiency knowledge by the Aggregator in order to define the projects portfolio and be provided with simulation tools that helps her or him to be more precise.

4.1.5 How differentiated P4P rates can be more effective than uniform ones, as well by associating indicators that describe the current state of the building, including SRI with Incentive rates and minimum saving level requirements?

Associating indicators to the compensation rates is most suitable for P4P programs that focus on deep retrofit savings and/or advancements that are not directly linked to the building's energy balance. The increased performance of a building that e.g. the SRI represents will take time to show its effect on the measurable efficiency, but participants will want their immediate efforts rewarded. The SRI also captures benefits to the grid (demand response) and the user (comfort). Depending on the building type and focus of the P4P program, the overall score or only a few sub scores of the SRI could factor into the calculation. The evaluation method is also more resilient to shifts in the energy environment or a poor handling of the building facilities by an operator. As a drawback, the regular re-evaluation of indicators definitely requires more effort and cooperation than measuring energy consumption. Data driven tests of the P4P compensation structure

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would be necessary to quantify which share of the rates could be reasonably differentiated.

In chapter 4, there have been described additional indicators to facilitated the continuous evaluation of the EEM Performance.

4.1.6 How the details of a P4P scheme affect the expected SRI after the implementation of the EEM's

The Aggregator or the Portfolio Manager starts from a set of indicators and parameters that define the Building current status, among them there is the SRI. It gives us a global vision of the state of the building and allows to detect points for improvement. Therefore, the Portfolio Manager can set a SRI Improvement goal. Through the different details of the P4P scheme, in particular these ones related to the EEM's typologies included, she or he can do different SRI scenarios and simulations in order to see if the goal set could be achieved or not, and what additional measures must be considered to obtain it.

4.1.7 How the EEM plans are affected when P4P rates reflect the time-dependent value of the energy saved:

The Energy Savings are a direct function of the variable time. It depends on the consumption profile of each Building during a single day and the building activity, it also depends on the period of the year which will also be influenced by climatic and geographical conditions. As it has been described before P4P rate could be defined as Pure P4P or a Hybrid P4P. In the first case, the incentives will be paid posteriori once the energy saving has been verified according to the M&V protocol that has been defined in each case. In the second case, an initial amount is paid before at the beginning in order to start with the EEP and which will be subsequently recalculated according to the future incentives obtained from the verified savings.

4.2 SRI and its contribution on the design of P4P rates

The SRI catalogue goes into great detail about services a building can provide on various functional levels. The P4P rates could be linked to level ups of a select few services; or an improvement to the overall SRI scoring with fixed energy distribution as described earlier. As the SRI rates purely the potential of the present systems, it also ignores all

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possible mistakes by a system operator. This could help settle disagreements and responsibility allocation of underperforming programs.

Effective P4P rates should lead to a steady score increase in repetitive consumption-fixed SRI assessments of the same building. The P4P rates incentivize the building improvements of the program, and if these improvements are covered by one of the SRI services from the catalogue, they raise the respective SRI sub-score. As energy savings are not taken into account directly, the SRI might be better suited to evaluate the progress towards the P4P program's long-term goals.

In order to enhance the feedback obtainable from the SRI, a P4P program's rates could be directly linked to the services and functionality levels of the catalogue. As the scope of the SRI is wider than only EE, such programs could also adopt comfort or DR related improvements, and factor them into the rates. The rates could also reward the installation of synergistic technologies which will be the content of D8.2 "Consolidated services and technical standards catalogue." One thing to keep in mind is that the SRI assessments require active communication about the program status and cannot just be passively monitored like consumption changes

4.3 Actors Involved in P4P scheme: TSO/DSO Perspective.

Different roles and actors involved in a P4P Scheme are widely defined and analysed. In that sense, the TSO and DSO play an important role in P4P Scheme both in its design and its deployment as well as for P4P rate structure definition. As explained in *D4.3 The Boundary Cases for the P4P rates Section 4*

, TSO and DSO could contribute in the P4P Scheme as part of EEOS (Energy Efficiency Obligation Scheme)

TSO/DSO Challenges			
Increasing the Knowledge of the power sector		Key words	P4P requirements
Power Grid Infrastructure update	Exist the necessity to invest on the power grid infrastructures. In particular regarding the **digitalization** at all points in the chain, from production to the end customer	Improvement and digitalization of the infrastructure	Introduce gradually mandatory elements that allow the digitization of the electrical network. Possibility to bonus or improve rates considering those improvements.
	Improve the differences between the rural areas from the urban areas. There is still big weakness in rural areas regarding the power grid infrastructure.	Improves the services offer.	The P4P promoter or owner could design specific programs for Rural areas ore isolated areas of the electrical network to in

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			order to expand energy efficiency and self-generation, to reduce fossil fuel consumption.

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TSO/DSO Challenges			
Increasing the Knowledge of the power sector		Key words	P4P requirements
Market Needs	The market constantly evolving makes a world more efficient. Energy transformation is a reality, and the System Operation has to adapt to this Market requirement. For example the electric vehicle (EV) is a key part for both the management of the demand and the need to upgrade the distribution network.	Introduce new elements on the system such as EV and alternative solution	P4P will consider the EE as an energy resource and has to be designed with a global overview of all elements that revolve around a building and its activity such as mobility, urbanism, green areas, recycling, air quality, etc.
	Due the COVID-19 pandemic the global needs are rethinking, there is undoubtedly a paradigm shift. Therefore the energy needs will be different.	energy paradigm shift	P4P could be a first step for the energy needs paradigm change, taking in account news ways of living and needs. Such as the increase in teleworking, increase in online shopping, see if these changes can be reviewed within a P4P scheme to facilitate the EEM implementation
Customers' needs / demand	1. The society is increasingly committed to the environment and the fight against climate change looks for purchase Energy from renewal resources	society committed to the environmental	The P4P owner, programmer has to take in account the values and needs of the society. For that reason, as well as the Public administration does, the society should have a relevant role during the P4P design, and people should be able to participate and be consulted for the P4P purposes
	2. Energy poverty: the contrast between people at higher risk of social exclusion and society is increasing. Making there an increase in energy poverty, both locally and globally.	Fight against the Energy poverty	On the other hand, not the whole part of society can worry about whether to install solar panels or not, but their main concern is to be able to pay the energy bills. That is why one of the lines that must be taken into account in P4P design and in which TSO and DSOs have important decision-making is the capacity to fight energy poverty.

5 Identification of P4P Scheme and rates for the Pilot Buildings

5.1 Introduction.

In previous chapters the compensation rates structure has been defined. On the one hand, in **Section 2**, it has been developed an analysis to determine which EEM will be most appropriate for a P4P scheme and which indicators describes the current state of the buildings. In other words, each building has been defined by the potential EEM and its own characteristics. On the other hand, in **section 3**, the compensation rates

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structure has been analysed in order to define the variables and elements that move towards specific measures. Now, in the present **section 4**, the idea is encompassing the conclusions of both sections through the definition of indicators that allow us to define 2 scenarios with the GENCAT Building information.

For this reason, the section has been divided into the following parts: *Part 1.* brief introduction. *Part 2*. Definition of indicators about the current state of the building. And *Part 3*. Definition of the 2 scenarios.

5.2 Definition of indicators for P4P Scheme

One of the most important points to keep in mind when defining the design of a compensation structure, is to define at the same time a set of indicators. These indicators will enable a follow-up of the evolution of the estates and the improvement of global energy efficiency. Both from the individual point of view, it means per building and by grouping them in a single Portfolio. Furthermore, it also allows to check the progress of the whole P4P Program by the Aggregator, Portfolio Manager or Program Owner. By these way, these different actors will be able to take decisions for a continuous improvement and find out the complications and correct those unexpected deviations. Depending on the Program scope, it will be necessary to define different lists of indicators, more or less extensive, which will depend on how strict the evaluation and calculation of incentives will be.

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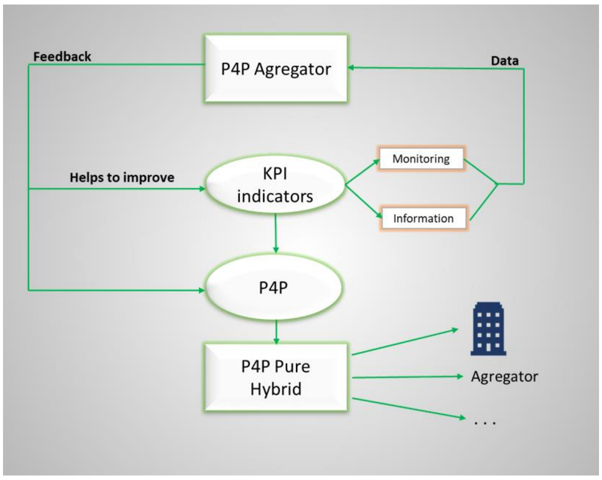
In the following scheme, the indicator role has been graphically simplified in a P4P scheme.



Indicator main axes

In the first place, it is necessary to define two types of KPI's. On the one hand, those of MONITORING, which will directly inform and impact on the evolution of the P4P and also allow us to periodically assess the states. While, on the other hand there are the INFORMATION INDICATORS (Tracking), the ones that do not participate in the scheme directly, but they do allow recollection of data for the support of future decisions, and that at the same time they might be included as monitoring indictors in a more advanced state of the Program.

Both types of indicators must give the Aggregator enough information to be able to make decisions throughout the implementation of P4P and achieve those goals that have been set from the beginning. In addition, the monitoring indicators will allow the P4P Owner to be able to verify, together with the savings achieved, the tasks carried out by the Portfolio Manager.

It is important to emphasize that in this chapter it is not planned to determine the financial flow between all actors involved in a P4P scheme and how it is linked with the compensation rate structure. This essential element to understand better this incentive structure is investigated in the following deliverable of the SENSEI project: *The ex-ante evaluation of financial benefits in the SENSEI P4P scheme*[18]. Hence the indicators

[18] https://zenodo.org/record/4771652#.YLkY04XiuMp

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definition has been treated independently of how the cash flow is distributed among the different actors, whether directly to the owner, the aggregator, the manager and through what means of payment such as the invoice or others kind of means.

Below are going to be explained the possible indicators to monitor the results and which will have an impact on the assessment and effectiveness of the incentives.

In the following table there is a proposal for this set of indicators that could be defined by the Aggregator or by the P4P Designer. These indicators are divided in three different thematic areas: Economical, Social and Environmental. Beyond paying a price for every kWh or CO2 verified, there are a group of indicators related with the impact of the EEM implantation such as these ones related to the maintenance (Indirect-Economic) or the user-end and employee's behaviour (Social), and finally the indicators related to the energy consumption or generation. The last ones consider technical variables.

In the following the indicators structure is defined by different fields: the indicators Identification, the Indicators area or main thematic focus, the Indicators Type, indicator function and description, and the Critical Success Factor as well as the Desired Range.

The Indicator Type

It provides us information about the main characteristics.

Economic	INDIRECT	the implementation of EEM has an indirect impact on the Buildings Costs : in particular Maintenance Cost for the whole Building.
	DIRECT	the implementation of EEM has a direct impact in the Buildings Cost: reduction of energy cost, bills improvements, etc.
Social	QUALITY	Means the quality of the EEM functionality and the Energy Efficiency Importance among end-users, employees behaviour.
	INNOVATION	It is related to the implementation of measures that go further than traditional ones and besides provide a social benefit.
	COMFORT	Measures the impact on comfort and health for example reduction of sick absence
Environmental	TECHNICAL	These type of indicator are directly related with the measure outcomes

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The indicator function

The function is to define the indicator as a **Monitoring** indicator and therefore necessary to be included in the P4P Scheme, otherwise as a **Tracking** or information indicators that provides us extra data to take decisions and control the EEM impact. The Monitoring indicators they can be defined for a Pure P4P program as a hybrid one.

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Indicators for the compensation rate calculation

In the following indicator board, the Aggregator could have a quick reference guide regarding the indicators, that could be monitored case by case, or by group of buildings.

indicator ID	Indicator Axys	Indicators Type	Indidcator function	Indicator description	Critical Success Factor	Desired Range		
01.00	Economic	Indirect	Tracking	Planned maintenance vs. Reactive maintenance ratio		-	-	-
01.01	Economic	Indirect	Tracking	Planned maintainance vs. Reactive maintainance ratio (for each type of equipment)		-	-	-
02.00	Economic	Indirect	Tracking	Maintenance costs per m2		-	-	-
03.00	Economic	Indirect	Tracking	Reduction of maintainance costs per m2 (%)		-	-	-
04.00	Economic	Direct	Tracking	Reduction of energy costs (%)		>10%	[5-10%]	<5%
05.00	Social	Quality	Pure P4P	Qualification of the staff				
06.00	Social	Quality	Pure P4P	Number of employees trained in EE		[71-100%]	[31-70%]	[0-30%]
07.00	Social	Quality	Pure P4P	Number of participative activities to promote EE among tenants / users		>=4%	[2-3%]	[0-1%]
08.00	Social	Quality	Pure P4P	Improvement of indoor air quality (%)		>20%	[10-20%]	<10%
09.00	Social	Innovation	Pure P4P	Number of innovative EEM implemented		>1	1	0
10.00	Social	Comfort	Tracking	Health and comfort (sick absence)		-	-	-
11.00	Environmental	Tecnic	Hybrid P4P	Energy consumption reduction (kWh / m2)		25%	[10-25%]	<10%
12.00	Environmental	Tecnic	Hybrid P4P	mWh generated		?	?	?
12.01	Environmental	Tecnic	Hybrid P4P	Autoconsumption level		?	?	?
13.00	Environmental	Tecnic	Hybrid P4P	Impact on demand shift		46	[25-46]	<46

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Indicator description or Indicator Sheet

Each of the indicators will be described below through its descriptive sheet. The idea of those sheets is to answer questions like: who? To whom? How often? How to calculate it?

INDICATOR	Planned maintenance vs. Reactive maintenance ratio			
DEFINITION	To register of the ratio planned vs. reactive maintanance in order to track the impact of the EEM to the maintainance costs			
GOAL	To identify any existing correlation between the EEM or EEP to the building maintainance costs.			
SCOPE	BUILDING			
AREA	REGIONAL DEPARTMENT			
RECIPIENTS	☐ BUILDING MANAGER	☑ P4P aggregator		☐ USERS
AXIS	☐ SOCIAL	☐ ENVIRONMENTAL		☑ ECONOMIC
SCOPE	☑ PUBLIC	☑ PRIVATE		
REQUIRED DATA				
VARIABLES	Annual maintainance working hours			
UNITS	h			
FONT	Facility manager			
MINIMUM SCALE OF INFORMATION	Working hours			
CALCULATION				
FORMULA	$\sum \text{Planned maintainance} / \sum \text{Reactive maintaince}$			
MESUREMENT UNIT	Working hours			
SEGMENTATION	Building			
FREQUENCY OF CALCULATION	To be defined			
FREQUENCY OF EVALUATION	To be defined			
CALCULATION DURING PILOT IMPLEMENTATION	YES			
CALCULATION POST PILOT IMPLEMENTATION	YES			
EVALUATION PARAMETERS				
BASELINE	Introduce current value			
MINIMUM OBJECTIVE	To be defined			
DESIRED OBJECTIVE	To be defined			
MANAGEMENT				
UPDATE RESPONSIBLE	Building manager			
EVALUATION RESPONSIBLE	P4P aggregator			
AUTOMATION	NO			
OPEN DATA	NO			
DATA ACCESSIBILITY				
REGIONAL GOVERNMENT	YES			
BUILDING MANAGERS	YES			
USERS	NO			
OTHERS	NO			
MONITORING OF RESULTS				
	febr-21	*jul-21*	*oct-21*	
RESULTS				
MINIMUM OBJECTIVE				
DESIRED OBJECTIVE				
SCORING				
OTHER INFORMATION:				

Table 32: Indicator information sheet example

More information regarding the indicators sheet is detailed in Annex 1

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ECONOMIC INDICATORS DESCRIPTION:

Planned maintenance vs. Reactive maintenance ratio.

INDICATOR	Planned maintenance vs. Reactive maintenance ratio
DEFINITION	To register of the ratio planned vs. reactive maintenance in order to track the impact of the EEM to the maintenance costs
GOAL	To identify any existing correlation between the EEM or EEP to the building maintenance costs.

Planned maintenance vs. Reactive maintenance ratio (for each type of equipment)

INDICATOR	Planned maintenance vs. Reactive maintenance ratio (for each type of equipment)
DEFINITION	To register of the ratio planned vs. reactive maintenance in order to track the impact of the EEM to each type of equipment (lighting, heating, etc.). This indicator should be defined accordingly to the EEP designed.
GOAL	To identify any existing correlation between the EEM or EEP to the building maintenance costs.

<u>Reduction of maintenance costs per m2 (%)</u>

INDICATOR	Reduction of reactive maintenance per m2 (%)
DEFINITION	Register and evaluate the impact of the EEM or EEP to the maintenance costs
GOAL	To identify any existing correlation between the EEM or EEP to the building maintenance costs.

Maintenance cost per m2

INDICATOR	Maintenance costs per m2
DEFINITION	Register and evaluate the impact of the EEM or EEP to the maintenance costs
GOAL	To identify any existing correlation between the EEM or EEP to the building maintenance costs.

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SOCIAL INDICATORS DESCRIPTION

Number of employees trained in EE

INDICATOR	Number of employees trained in EE
DEFINITION	This indicator aims to track the number of employees trained by the implementer.
GOAL	This indicator aims to measure the complementary EEM to promote energy culture among employees. This indicator will be used to evaluate the extra-bonus to be compensated by the P4P Aggregator using a Pure P4P scope.

Number of participative activities to promote EE among tenants / users

INDICATOR	Number of participative activities to promote EE
DEFINITION	This indicator aims to track the number of activities to promote EE among employees, tenants and / or users
GOAL	This indicator aims to measure the complementary EEM to promote energy culture among employees. This indicator will be used to evaluate the extra-bonus to be compensated by the P4P Aggregator using a Pure P4P scope.

Improvement of indoor air quality (%)

INDICATOR	Improvement of Indoor Air Quality (IAQ)
DEFINITION	Registration of the Indoor air quality improvement (CO2 sensors).
GOAL	This indicator aims to measure the improvement of the indoor air quality due to EEM/EEP implementation. This indicator will be used for the calculation of the extra-bonus compensation (in case it applies)

Number of innovative EEM implemented

INDICATOR	Number of innovative EEM implemented
DEFINITION	To register de number of innovative EEM implemented
GOAL	This indicator aims to evaluate the degree of innovation of the EEP implemented in the frame of the P4P programs.

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Health and comfort (sick absence)

INDICATOR	Health and comfort
DEFINITION	Registration of the impacts of the EEM to the health and comfort of employees and/or users. This indicator will be different for each building considering the concrete health and comfort issues identified by users on each building.
GOAL	This indicator aims to evaluate the impacts of the EEP implementation to the health and comfort of the users: reduction of sick absence, complaints, etc.

ENVIRONMENTAL INDICATORS DESCRIPTION:

Energy consumption reduction (kWh / m2)

INDICATOR	ENERGY CONSUMPTION REDUCTION
DEFINITION	Register de consumption variation due to EEM implementation
GOAL	The aim of this indicator is to track the consumption reduction derived from the EEM implementation. This indicator will be the reference for compensation system.

MWh generated

INDICATOR	MWh generated
DEFINITION	Register the MWh generated by the building
GOAL	Tracking the amount of MWh generated by the building.

Self-consumption level

INDICATOR	Self-consumption level
DEFINITION	Register the degree of the energy generated and consumed by the building
GOAL	Track the amount of self-consumption level. This indicator will be used as an objective to be achieved in the frame of the compensation system.

Impact on demand shift

INDICATOR	Impact on demand shift
DEFINITION	Evaluation of the impact that the EEM or EEP have on the demand consumption curve of the building.
GOAL	The goal is to evaluate the demand shifting derived from the implementation of each measure and/or the ERB projects as a whole.

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Critical Success Factor

For each Indicator should be set different **Critical Success Factors** as a necessary element to detect quickly the possible reasons of failure or possible obstacles that prevent achieving the expected results. The expected value will depend on each Building and its activity, so the Portfolio Manager has to determine the Critical Success factor according each indicator. Some examples are shown in the next table.

indicator ID	Indicator description	Critical Success Factor
01.00	Planned maintenance vs. Reactive maintenance ratio	1.has been elaborate an accurate Maintenance Plan, the timings are realistic? 2. Are Maintenance Staff well trainned?
01.01	Planned maintainance vs. Reactive	
02.00	Maintenance costs per m2	1. The unit price per h for maintenance are deviated according market reasons?
03.00	Reduction of maintainance costs per m2 (%)	
04.00	Reduction of energy costs (%)	1. Are prices and Energy pruchase well negotiated? 2. Are there any Tax variances during last months? 3. Has the production or activity (open hours) increased? 4. The needs (Heating, cooling, etc) are affected by Weather changes?
05.00	Number of employees trained in EE	1. The Building Owner/Manager encourages, promotes knowledge in Energy Efficiency among users. 2. Are posters fixed, what is their effectiveness and reception?
06.00	Number of participative activities to promote EE among tenants / users	1. the responsible has properly the training activities organizated, has facilitated the publication, information and participation? 2. the engagment of Activities is so poor.
07.00	Improvement of indoor air quality (%)	1. Has the occupation increase? 2. Are The CO2 sensors periodically checked? 3. Are the ventilation system periodically checked?
08.00	Number of innovative EEM implemented	1. Are there new regulation that allows/restrict the implementation of innovative measures?
09.00	Health and comfort (sick absence)	1. Are the sick absences or medical leaves due to building discomfort increase?
10.00	Energy consumption reduction (kWh / m2)	1. Linked directly with M&V Protocol. Where are defined all parametres to calculate stimate future energy demand and potential savings.
11.00	MWh generated	
11.01	Autoconsumption- Self-production level	
12.00	Impact on demand shift	1. Has the production or activity (open hours) increased/decrease? 2. Are different schedules made during the holiday period

Table 33: Critical Success Factor

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Desired Range

The desired Ranges should be the “Traffic lights” which alerts the aggregator or manager about the evolution of the indicators. The value for each Range must be defined at the beginning of each P4P Agreement and will depend on each Building. Then the aggregator would have to analyse the results as a whole according to his/her project portfolio.

For these Tracking indicators there is not defined a desired range because this type of indicators just provides information about other aspects affected and related to the EEM implementation such as the Maintenance ratios. However, could be the possibility in the future to convert the tracking indicators to a Pure or Hybrid P4P indicator when the outcomes could be linked with the payment rates. On the other hand, for the rest of indicators are defined different values ranges, that determine if the incentive will be awarded or not, as well as for these Bonus cases which are not directly related to the energy savings such as EE training.

indicator ID	Inidcator function	Indicator description	Desired Range		
01.00	Tracking	Planned maintenance vs. Reactive maintenance ratio	-	-	-
01.01	Tracking	Planned maintainance vs. Reactive maintainance ratio (for each type of equipment)	-	-	-
02.00	Tracking	Maintenance costs per m2	-	-	-
03.00	Tracking	Reduction of maintainance costs per m2 (%)	-	-	-
04.00	Tracking	Reduction of energy costs (%)	>10%	[5-10%]	<5%
05.00	Pure P4P	Qualification of the staff			
06.00	Pure P4P	Number of employees trained in EE	[71-100%]	[31-70%]	[0-30%]
07.00	Pure P4P	Number of participative activities to promote EE among tenants / users	>=4%	[2-3%]	[0-1%]
08.00	Pure P4P	Improvement of indoor air quality (%)	>20%	[10-20%]	<10%
09.00	Pure P4P	Number of innovative EEM implemented	>1	1	0
10.00	Tracking	Health and comfort (sick absence)	-	-	-
11.00	Hybrid P4P	Energy consumption reduction (kWh / m2)	25%	[10-25%]	<10%
12.00	Hybrid P4P	MWh generated	?	?	?
12.01	Hybrid P4P	Autoconsumption level	?	?	?
13.00	Hybrid P4P	Impact on demand shift	46	[25-46]	<46

For example, the Energy Consumption reduction ranges values are directly linked with the expected energy savings and these values will be different according each building. The same will happen with the self-generation using Renewable energy if the case.

The main purpose of the desired ranges is to provide the Portfolio Manager with an evaluation tool to allow her/him to know in each moment the current status of the EEM

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implementation and to calculate in advance the potential incentives. And therefore make run track of global investment.

5.3 Identification of P4P scheme indicators for each 3 scenarios

A summary of the indicators for three of the 12 buildings selected.

It is considered that the Economic and Social thematic indicators are common for all 3, while technical ones depend on the Energy saving potential in each case.

5.3.1 Economic indicators per 3 GENCAT scenarios.

There are two different types of economic indicators, direct and indirect. The first ones are these indicators, as it is explained in other sections above, that measure the direct reduction of energy costs, and therefore show the direct impact on the bill after the EEM implementation. Otherwise, the indirect indicators measure the economic indirect impact of the same EEM deployment not on energy bill, but on other current cost bills such as maintenance cost. The main difference between indirect and direct indicators is that the indirect ones do not have a direct impact on the calculation of incentives as they are considered only as tracking, therefore they have no desired value. On the other hand, the direct ones do have a direct impact on the calculation of the incentives, and therefore in order to be able to monitor them, 3 ranges of values have been defined. In that case the Energy cost reduction are dived in 3 ranges:

- **Green Range**: optimal outcomes. When the energy reduction by the EEM implies an energy reduction the better one (green) greater than 10%.
- **Yellow Range**: middle outcomes: When Energy reduction does not reach the optimum expected but average results are achieved.
- **Red Range**: worst outcomes. The EEM implantation doesn't achieve the outcomes expected and its value is below 5%.

					Desired Range		
01.00	Economic	Indirect	Tracking	Planned maintenance vs. Reactive maintenance ratio	-	-	-
01.01	Economic	Indirect	Tracking	Planned maintainance vs. Reactive maintainance ratio (for each type of equipment)	-	-	-
02.00	Economic	Indirect	Tracking	Maintenance costs per m2	-	-	-
03.00	Economic	Indirect	Tracking	Reduction of maintainance costs per m2 (%)	-	-	-
04.00	Economic	Direct	Tracking	Reduction of energy costs (%)	>10%	[5-10%]	<5%

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Regarding the indirect indicators, and in particular the indicators related to maintenance improvement and cost reduction, could be integrated as direct indicator in case the Aggregator or the Energy manager could have at their disposal a tool that would allow them to simulate the impact of different energy efficiency measures on maintenance costs and therefore set tangible objectives such as energy costs. There are current maintenance cost calculation tools on the market that allow the number of hours and its associated cost to be calculated for each type of maintenance action. This would also allow to establish in some way objectives or plans of action. Linking the improvement of the energy efficiency of that measure, with its impact on the operation and maintenance actions for that equipment and also for the entire building. Furthermore, the SRI could also reflect this impact.

5.3.2 Maintenance Ratio Tool

For this deliverable a tool has been developed based on the Maintenance Ratio of EEM's in order to help the Aggregator or the Energy Manager. Through this tool it can be directly calculated those ratios related to the expenses or savings that the measures chosen for each building entail. Thus, based on these indicators, the efficiency and effectiveness can be verified.

On the **first sheet** – *"Measures Reference"* – we can see a summary of each measure with its family of measures in order to have a general idea of the classification.

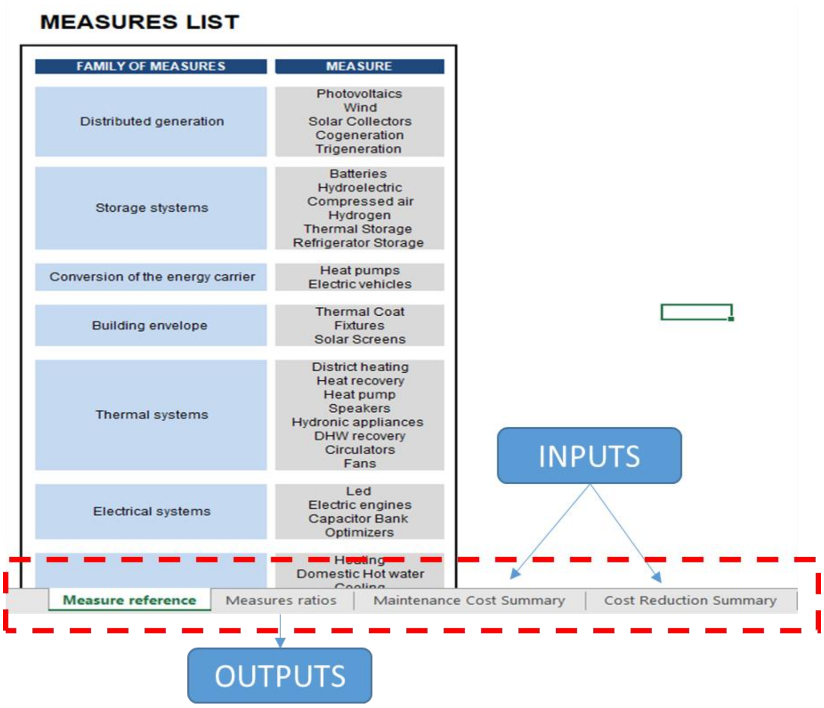

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Diagram 6: Maintenance Ratio Calculator Sheet

The **second sheet** – *"Measures Ratio"* – shows the ratios for each measure or for each group of measures. These are calculated directly once the fields on sheet three and sheet four have been filled in. Some of the ratio calculated by this tool are directly linked to the maintenance of the EEM. Otherwise there are other ratios that are based on the maintenance cost reductions obtained implementing these EEM's.

DEFINITION	Measure	Ratio
Measure maintenance costs / Family Measure costs	-	0,00%
Measure maintenance costs / Total maintenance costs		0,00%
Family measure costs / Total maintenance costs		0,00%
Total maintenance cost per measure / total built area	-	0,00%
Total maintenance cost per family /total built area	-	0,00%
Cost reduction per measure / Family measure cost reduction	-	0,00%
Cost reduction per measure / Total measures cost reduction	-	0,00%
Family measure cost reduction / Total measures cost reduction	-	0,00%

Measure dropdown
-
Photovoltaics
Wind
Solar collectors
Cogeneration
Trigeneration
Batteries
Hydroelectric

Diagram 7: Measures Ratio per Indicator and EEM

On the third sheet – "Maintenance Costs" – we can find the detail of the maintenance allowances for each measure divided between corrective maintenance and preventive maintenance. Corrective maintenance is one that locates, corrects and repairs defects in equipment or facilities. The preventive is one that helps us reduce the possible risk of damaging some equipment. Finally, on the fourth sheet – "Maintenance cost reduction" – , we find the detail of the cost savings that have occurred thanks to the efficiency of the measures. Hence the third sheet inputs are:

IINPUT 1	**the Maintenance cost** for preventive and corrective actions. The tool allows to separate the cost per each type of EEM and family.
IINPUT 2	**The Maintenance cost reduction**.

MAINTENANCE COST SUMMARY

MAINTENANCE EXPENDITURES DETAIL		
Preventive Maintenance	Family	Amount
Photovoltaics	Distributed generation	0,00 €

MAINTENANCE EXPENDITURES DETAIL		
Corrective Maintenance	Family	Amount
Photovoltaics	Distributed generation	0,00 €

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COST REDUCTION

COST REDUCTION PER MEASURE	
Maintenance Expenditure	Amount
Photovoltaics	

COST REDUCTION PER FAMILY	
Maintenance Expenditure	Amount
Distributed generation	0,00 €

The idea was to create a method with which the user could easily calculate the most important ratios to take into account to carry out a good follow-up of the Implemented measures.

On the other hand, ratios have also been proposed in which the built area is taken into account, both the total and that of below ground and above ground. The first ratios are those that try to give a vision about the maintenance costs of the measures while the following one's deal with the reduction of costs due to the implementation of these.

5.3.3 Social indicators per 3 GENCAT scenarios.

In this study, the common social indicators for all scenarios are also considered. What these indicators consist of?

In the same way that the SRI includes a sub score in relation to the needs of the users, at the social level it is also intended to assess how the involvement by the user and the workers themselves in relation to energy efficiency improves. The ranges of these indicators would be defined by the director of the center and the aggregator. The reason for these indicators is to be able to monitor the relationship between people's social behaviour and the operation of the most efficient facilities. For this, 5 indicators have been defined.

05.00	Social	Quality	Pure P4P	Number of employees trained in EE	[71-100%]	[31-70%]	[0-30%]
06.00	Social	Quality	Pure P4P	Number of participative activities to promote EE among tenants / users	>=4	[2-3%]	[0-1%]
07.00	Social	Quality	Pure P4P	Improvement of indoor air quality (%)	>20%	[10-20%]	<10%
09.00	Social	Comfort	Tracking	Health and comfort (sick absence)	-	-	-

- **<u>Number of employees trained</u>**. It measures the % of employees which have attended courses organized by the management of the center on energy efficiency, the higher the%, the greater its value and therefore it could be rewarded.

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- **Number of participating activities**: in that case in order to achieve the energy savings outcomes implies that is necessary a minimum of EE promotion activities.
- **The Improvement of Air quality:** this indicator could be also considered as technical, because it measures the quality of the different areas of the building.
- **The Number of innovative EEM** seeks to encourage improvement actions that not only imply added value due to its innovative aspect in relation to the whole of society and that can be replicated in the future, but also take into account the day-to-day aspects of users and their environment. In this case, as the project is focused on improving the energy efficiency of buildings, only one innovative measure is considered as an optimal objective.
- Finally, in the last indicator related to the **health and comfort**. What is intended to be known is the relationship between abstention from work and discomfort due to poor operation and functioning of the equipment.

Now, the specific value for technical indicators will be shown for 3 GENCAT Buildings.

5.4 Buildings Scenarios

5.4.1 ESP0RECU2- Culture: Museum of Science and Industry of Catalonia (mNACTEC)

In the previous sections the technical indicators are defined such as those that measure the technical aspects of the measures and which in turn could be monitored for the bonus of the P4P incentives. The Range values will depend on the EEP or the EEM's list of each Building.

In the analysis of the Museum of Science and Industry of Catalonia (CUO2) done in Chapter 2 regarding the EEM's value, the estimated energy savings are specified (29,37%), and the effect on the demand curve on the other (Table A-T2 = 42).

Building EEM	E1 - TABLE C 4.3.	T1 - ENERGY SAVING	T2 . Table A 4.3	S1 - TABLE B 4.3	Estimated energy saving
CU02 mNACTEC	52,5	29	42	51,5	29,37%
Building and automation control systems	21,5	6	16	25,5	5,17%
Building envelope	13	2	12	10	2,23%
Electrical Systems	9	8	8	9	8,31%
Heating and cooling	9	9	6	7	9,31%

These indicators are also used to monitor the actual impact after the EMM's implementation and during the P4P contract. The optimal value of the ranges is the

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maximum value expected outcome for the implementation of all EEM's. In that case the optimal Range value correspond to a 29% and which matches the expected value of the Energy Efficiency Study.

The same happens in the T2 Value or the impact on demand Shift, in case that the all implemented measures achieve the expected curve and outcomes, the optimal results should be 42. This value depends on the catalogue of *D4.3 The Boundary Cases for the P4P rates*. Any change on this catalogue would involve updating these values.

10.00	Environmental	Tecnic	Hybrid P4P	Energy consumption reduction (kWh / m2)	29%	[15-29%]	<15%
11.00	Environmental	Tecnic	Hybrid P4P	MWh generated	X	X	X
12.00	Environmental	Tecnic	Hybrid P4P	Autoconsumption level	X	X	X
13.00	Environmental	Tecnic	Hybrid P4P	Impact on demand shift	42	[20-42]	<20

Finally, in case that the selected EEM's List consider Renewable Energy the total MWh and Self consumption have to be also monitored in order to consistently receive the corresponding incentive or P4P rate.

5.4.2 ESP0REED60- Regional and Agriculture School- Gandesa

Making the same analysis for the Agriculture School and regional Office in Gandesa, the indicators are the following ones:

Regarding the Estimated Energy Savings the total amount is 75,69%, however the major part is due to the installation of PV panels that will reduce the energy consumption to 35,54% by providing self-electric production. While the EEM's regarding the building envelope and automation controls representing the remaining 40,15%

Building EEM	E1 - TABLE C 4.3.	T1 - ENERGY SAVING	T2 . Table A 4.3	S1 - TABLE B 4.3	Estimated energy saving
ED60 Terra Alta Agrarian School	27,5	40	24	33	75,69%
Building and automation control systems	6,5	10	4	9	11,14%
Building envelope	13	20	12	14	28,79%
Distributed generation	8	10	8	10	35,54%
Photovoltaics	8	10	8	10	35,54%

Hence, after the EEM's implementaion the technic indicators to follow up and to be able to be rewarded with P4P rates, are the following ones. And otpimal ranges values correspons to the expected value of the EEM's selection matrix.

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10.00	Environmental	Tecnic	Hybrid P4P	Energy consumption reduction (kWh / m2)	76%	[30-76%]	<30%
11.00	Environmental	Tecnic	Hybrid P4P	MWh generated			
12.00	Environmental	Tecnic	Hybrid P4P	Autoconsumption level			
13.00	Environmental	Tecnic	Hybrid P4P	Impact on demand shift	24	[10-24]	<10

However, it should be noted that in the SHERPA study no data were detailed in the production of MWh of electricity through PV Panels nor the volume of kWh self-consumed.

5.4.3 ESP0RECU2- Culture: Centre for the restoration of Arts of Catalonia

Finally, regarding the Penitentiary Center OT38 Brians 1 the selected EEM's list is:

Building EEM	E1 - TABLE C 4.3.	T1 - ENERGY SAVING	T2 . Table A 4.3	S1 - TABLE B 4.3	Estimated energy saving
OT38 CP Brians 1 (+ Can Duran)	53	24	46	53	24,65%
Building and automation control systems	15	4	12	17	4,79%
Building envelope	13	0	12	10	0,60%
Distributed generation	16	16	14	17	15,91%
Electrical Systems	9	3	8	9	2,57%
Led	9	3	8	9	2,57%

In that case the optimal energy saving ranges only represent a 25% and the impact on the shift curve is 46.

10.00	Environmental	Tecnic	Hybrid P4P	Energy consumption reduction (kWh / m2)	25%	[10-25%]	<10%
11.00	Environmental	Tecnic	Hybrid P4P	MWh generated	NA	NA	NA
12.00	Environmental	Tecnic	Hybrid P4P	Autoconsumption level	NA	NA	NA
13.00	Environmental	Tecnic	Hybrid P4P	Impact on demand shift	42	[20-42]	<20

In all these 3 cases, the M&V protocol definition is very important to define first; the Base Line and the continuous energy efficiency improvement and energy saving outcomes coming from these measures.

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6 Conclusions

Throughout this document, the aim has been to determine the key points that relate to the compensation structures of a P4P scheme, and how the selection of the first ones are conditioned according to the design of the payment model of incentives. In order to discover this relationship, a 3-step analysis was performed. First of all, and through the examples of the GENCAT buildings, a list of EEM's have been determined for each buiilding considereing which could be the most suitable when being encouraged or compensated. Their main characteristics are valued by quantitative and qualitative parameters established in a catalogue of EEM's. In this analysis had been used the outcomes of the SENSEI report "*Experience and Lessons Learned from Pay-for-Performance (P4P) pilots for Energy Efficiency*", however SRI catalogue could be used as weel. Both catalogues descrive and score the EEM's. A similar approach has been also carried out at the building level. That is, to check what characteristics of a building must be considered to assess and include it in the P4P model (e.g. year of construction, whether recent reforms have been carried out, location, etc.).

Subsequently, what has been done is to define the parametres of a compensation structure or incentive payment structure within the framework of the P4P program. They have been analysed element by element, and how they could condition and affect the implementation of one measure over another. The compensation structure it is just one more piece of the whole P4P scheme, for that reason, is will be necessary to define what other aspects and elements will give shape to the SENSEI scheme. This labor will be developed in different deliverables of the SENSEI project.

Finally, in the third and last step, a series of Indicators have been defined which, together with the SRI, must make it possible to monitor the expected results with the results obtained from each of the measures and also in a global way. It also allows all actors involved to know in advance the potential incentives to be obtained.

<u>In-depth knowledge of potential energy efficiency measures.</u>

Given this brief summary, we will continue to highlight the most important points that should be taken into account in the design of the P4P model and specifically in the design of compensation structures. Many examples of the use of a P4P model studied in the field of energy efficiency where deeply studied. On most of them the measures to be

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compensated were focused in general terms in the areas of air conditioning and lighting and mainly those that were focused on the industrial and commercial sectors.

In this sense one of first conclusions reached is the necessity to have a **Catalogue of Quantified and Qualified Measures** wide enough to be used as a decision tool. It must allow the assessment of individual cases (Building or single project) as well as different aggregated projects, and score the potential of the improvement of energy efficiency and therefore determine significant energy savings. Although in this project we do not want to link the compensation structures to specific measures, what is intended, as seen in the American examples, is to generalize by typology. Therefore this catalogue should serve as a preliminary decision tool used by Aggregator or Portfolio Manager. For that reason, in the first chapter the catalogue and classification of measures of D4.3 The Boundary Cases for the P4P rates has been used to determine the value of each of the measures of the GENCAT buildings.

However, it is important to note that the proposed catalogue in D4.3 The Boundary Cases for the P4P rates did not include specific measures to replace heating or DHW equipment that use fossil fuels such as natural gas. The majority of the measures are focused on the electrification of the demand, that is to say, to promote the replacement of equipment that uses fossil fuels by those based on electrical energy. The fact is, that despite the electrification and decarbonisation are the way to forward, it should be emphasized that today many measures used today are still based on the replacement of equipment with fossil fuels by others with higher performances and less consumption. This is the case for many SHERPA Project buildings considered in WP5. The energy efficiency measures studied are based on the combination of renewable energies and natural gas boilers. This leads to reflection, that despite wanting the electrification and taking into account that the present project project is focused on increasing energy efficiency as another energy resource, ask us if we should still consider to include or not in these catalogues any measures that involve improving energy efficiency even these ones that consumes fossil fuels. The reason for all this is that the transition from the current situation where we have a diversification of energy demand (electricity, natural gas, diesel, etc.) to a purely descarbonised situation, must be done in different stages. Among other reasons, one example is the location (e.g. rural areas) or the type and use of building, as well as the necessary investment that make this step directly difficult. Therefore, perhaps measures that consider the use of fuels such as natural gas with higher performances should still be included and quantified in the Catalogues of Measures.

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Importance of the group or aggregation of clients / users

One of the other concepts that is discussed throughout SENSEI project and that will be analysed in other deliverables is the concept of Aggregation of individual projects in order to make the investment more solid and robust. One of the other tasks corresponding to the Portfolio Manger or Aggregator is the collection or creation of a Portfolio of projects, each with their investment, implementation period, risk, etc. Hence the task consist in establishing the aggregation criteria for projects that may at the same time be conditioned by the payment structures of the rate. That is to say, the sense of grouping of the different projects can come conditioned by the typology of measures that are being promoted in the same program of the P4P, or another example could be the aggregation by a concrete geographic location or districts that includes different type of customers or users segments grouping of various types of buildings (commercial, hospitals, schools, residential buildings, etc.). One of the challenges for the aggregator today is to include the residential sector in this type of programs. In the majority of projects of USA, they were destined to the commercial and the tertiary sector, leaving in second place the residential one. Residential is a more difficult sector to enter as investments are high and are accompanied by reluctance or insecurity from homeowners. Therefore, in this sense, the Aggregator must have the knowledge to establish aggregation criteria at the same time as sufficient tools that allow him to decide and build the EEPs at the same time that she or he is able to engage new segments of customers.

The question is who has to provide the Aggregator this kind of tools, they must come as guidelines included in the same P4P program, or they can be based on other guidelines and hypotheses and their own experience?

Incentive structure: beyond subsidies.

Unlike traditional grants, P4P programs are based on the payment of savings incentives or verified returns. That is to say, after a EEM has been implmented and the energy savings could be verified in relation to the Base Line (M&V) they will be rewarded with an incentive or a compensation rate. The challenge in this case is to determine the structure and parameters that define this incentive. In this case, it will be the owner of the Program (e.g. Public administration) or the one who has to make the payment who decides **how, when and when to make this payment** as well as the formulas for determining the amounts to be paid. In the US cases studied in *D4.4 Experience and lessons learned from pay-for-performance (P4P) pilots* for energy efficiency these

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program owners were mainly Public Administrations jointly with energy companies in order to solve the congestions of the electrical networks.

In order to introduce these business models in Europe one of the most suitable ways to start would be with a public entity / building owner that has the necessary budget. The public entity determines not only the objective to be achieved and on the basis of which policy, what is to be compensated and the sector or sectors to be promoted, but also to define the amount depending on different parameters and variables. These will be closely linked to the grades or grades in the measurement catalogues defined above.

Governance model and actors involved

One of the most important conclusions reached especially when defining the compensation structure and understanding the flow of payments is the need to define the Governance model. In other words, define which actors take part in the model, and who is responsible for the functions of management, promotion, leadership, etc. Defining these roles is key to defining a compensation system aligned with the specific interests of all actors in the model.

In addition, the governance model must make it possible to identify, evaluate and respond to the main barriers such as contractual, fiscal, cultural and economic barriers that at certain times could discourage the model and slow down its deployment. For example, if the scope of action includes the residential sector, it can be benefited in the sense that living conditions have improved, improving the comfort of the home and reducing energy bills, but on the contrary it can be seen. harmed, if in case of upward revaluation of their home this can have an impact on taxes and negatively on their income. Another example, following the case of the residential sector, would be the lack of confidence in this business model due to the ignorance and insufficiency of energy culture.

The governance structure should be completed by knowing these specific restrictions / barriers on the pilots, so that their design is effective and can be implemented.

Together with the definition of the Governance Model throughout the SENSEI project, the actors who will participate and what their functions will be must be defined. During this document, special reference was made to the Aggregator or the Portfolio Manager as a figure who has to manage the different projects and set up the energy efficiency plans. On the other hand, there will be the Owner Program, which should lead this

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Governance, and the most appropriate currently would be that it be characterized by a public entity. There is also the role of TSOs and DSOs and their energy efficiency obligations.

Among all these roles, it is necessary to define where the bag of money that will be used to compensate for these savings or environmental benefits comes from, and it is necessary to define to whom it will be paid. Additionally, especially in the planning and design stage of the Program and therefore of the compensation structure, it will also be necessary to create multi-disciplinary working groups that provide different visions and knowledge in order to detect the needs of the market.

Data management and monitoring

Another important element that is also key in defining the payment structure is the type of data we need to collect in order to verify these energy savings, and how we do it. Not only that, but also the volume of data to be analysed and extracted from patterns (BIG DATA). It will be necessary to assess in each case what level of monitoring and M&V protocols are to be applied. As the case may be, it may not be necessary to monitor all uses and services, otherwise global monitoring would be enough. On the other hand, depending on the complexity of the case and the type of measure, especially the passive ones, in which monitoring, data management and its interpretation become more laborious.

Investment and risks

It must be said that, in fact, behind all this there are investments in major rehabilitation projects that aim in the first instance is to improve the energy efficiency of the building, either by applying active measures on its air conditioning systems or hot water, or by applying passive measures to improve the insulation of its facades, among others. So, in spite of everything, what a good compensation structure has to achieve is that these investments are made at the same time that it gives meaning to the energy savings they entail. And so they need to be designed with a variety of factors in mind that can lead to risky investment. The investor will be another actor to participate in this model, and together with the Aggregator (although it may be the same person) will have to make decisions.

Here's to talking about long-term investments, investments that are higher than what deeper savings should be. So if as an investor I want to participate in these incentive

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programs, that which want them is to promote profound savings reforms, I have to be clear about the risks involved and also how long I commit to achieving the goals through of the contract established between the different parties.

Indicators. As a monitoring, control and forecasting tool

Finally, as in any project or grant program, the compensation structures must be accompanied by a set of indicators (KPI's) which on the one hand must fulfil the function of monitoring the calculation of verified savings. They would be direct indicators, that if they meet and reach expected values, the incentive can be paid. But on the other hand, since P4P is still a model that encompasses energy efficiency as a whole. It is necessary to define other indicators, which allow on the one hand that the Aggregator or the Portfolio Manager can advance in the evaluation and progress of the measures and then take corrective measures if necessary, or even if it is necessary to rethink the investment.

On the other hand, to create indicators, which not only give us an answer to the direct impact of the measures that have been implemented, but also allow us to know other secondary or indirect aspects such as the impact on individual and global maintenance of the building as well as the behaviour of the workers themselves or end users. In this case, the SRI Indicator defined in 5.1 would allow on the one hand to assess the progressive evolution of the operational improvements of the building. While the other indicators defined in this deliverable, would assess the impact on maintenance and upkeep costs for each measure.

Let's not forget the Environment and Society needs

In the construction of a P4P model, we cannot forget key aspects such as the environment and social issues. It is true that the main goal of the model, as a business model, is to encourage investments that promote energy efficiency as an energy vector in order to achieve global goals such as decarbonisation and improving the energy performance of buildings. However, this model must be considered taking into account the social and environmental context in each case.

In social terms, the promotion of energy efficiency also involves an important task of raising awareness of the actors to be involved in the model. Therefore, **the promotion of energy culture and environmental education are indispensable in order for the goals set within the program.** It would not make sense to make such models without taking into account the participation of the user or the public points of view.

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P4P programs should be accompanied by training plans for building users according to different levels of needs (residents, workers, etc.). Because in order for the buildings to be efficient, they will not only be efficient on their own, but their users and workers must know how to use them. This is why there is a need for a Commitment on the part of the aggregating entity or the promoter of P4P to train and raise awareness among users in terms of energy efficiency, and that in the terms that is possible it can also be subsidized to additional incentive mode. In the same way that there should be a commitment or interest on the part of the user to be subsidized or enjoy more energy efficient spaces.

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7 ANNEX 1

Indicators sheets

Maintenance vs. Reactive maintenance ratio.

INDICATOR	Planned maintenance vs. Reactive maintenance ratio			
DEFINITION	To register of the ratio planned vs. reactive maintanance in order to track the impact of the EEM to the maintainance costs			
GOAL	To identify any existing correlation between the EEM or EEP to the building maintainance costs.			
SCOPE	BUILDING			
AREA	REGIONAL DEPARTMENT			
RECIPIENTS	☐ BUILDING MANAGER	☑ P4P aggregator		☐ USERS
AXIS	☐ SOCIAL	☐ ENVIRONMENTAL		☑ ECONOMIC
SCOPE	☑ PUBLIC	☑ PRIVATE		
REQUIRED DATA				
VARIABLES	Annual maintainance working hours			
UNITS	h			
FONT	Facility manager			
MINIMUM SCALE OF INFORMATION	Working hours			
CALCULATION				
FORMULA	$\sum Planned\ maintainance / \sum Reactive\ maintaince$			
MESUREMENT UNIT	Working hours			
SEGMENTATION	Building			
FREQUENCY OF CALCULATION	To be defined			
FREQUENCY OF EVALUATION	To be defined			
CALCULATION DURING PILOT IMPLEMENTATION	YES			
CALCULATION POST PILOT IMPLEMENTATION	YES			
EVALUATION PARAMETERS				
BASELINE	Introduce current value			
MINIMUM OBJECTIVE	To be defined			
DESIRED OBJECTIVE	To be defined			
MANAGEMENT				
UPDATE RESPONSIBLE	Building manager			
EVALUATION RESPONSIBLE	P4P aggregator			
AUTOMATION	NO			
OPEN DATA	NO			
DATA ACCESSIBILITY				
REGIONAL GOVERNMENT	YES			
BUILDING MANAGERS	YES			
USERS	NO			
OTHERS	NO			
MONITORING OF RESULTS				
	febr-21	*jul-21*	*oct-21*	
RESULTS				
MINIMUM OBJECTIVE				
DESIRED OBJECTIVE				
SCORING				
OTHER INFORMATION:				

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Planned Maintenance vs. reactive maintenance ratio (for each type of equipment)

INDICATOR	Planned maintainance vs. Reactive maintainance ratio (for each type of equipment)		
DEFINITION	To register of the ratio planned vs. reactive maintanance in order to track the impact of the EEM to each type of equipment (lighting, heating, etc.). This indicator should be defined accordingly to the EEP designed.		
GOAL	To identify any existing correlation between the EEM or EEP to the building maintainance costs.		
SCOPE	BUILDING		
AREA	REGIONAL DEPARTMENT		
RECIPIENTS	☑ BUILDING MANAGER	☑ P4P aggregator	☐ USERS
AXIS	☐ SOCIAL	☐ ENVIRONMENTAL	☑ ECONOMIC
SCOPE	☑ PUBLIC	☑ PRIVATE	

REQUIRED DATA	
VARIABLES	Annual maintainance working hours
UNITS	h
FONT	Facility manager
MINIMUM SCALE OF	Working hours
CALCULATION METHODOLOGY	
FORMULA	$\sum Planned\ maintainance / \sum Reactive\ maintaince$
MESUREMENT UNIT	Working hours
SEGMENTATION	Type of equipment (heating and cooling, lighting, etc.)
FREQUENCY OF CALCULATION	To be defined
FREQUENCY OF EVALUATION	To be defined
CALCULATION DURING PILOT IMPLEMENTATION	YES
CALCULATION POST PILOT IMPLEMENTATION	YES
EVALUATION PARAMETERS	
BASELINE	Introduce current value
MINIMUM OBJECTIVE	To be defined
DESIRED OBJECTIVE	To be defined
MANAGEMENT	
UPDATE RESPONSIBLE	Building manager
EVALUATION RESPONSIBLE	P4P aggregator
AUTOMATION	NO
OPEN DATA	NO
DATA ACCESSIBILITY	
REGIONAL GOVERNMENT	YES
BUILDING MANAGERS	YES
USERS	NO
OTHERS	NO

MONITORING OF RESULTS	*febr-21*	*jul-21*	*oct-21*			
RESULTS						
MINIMUM OBJECTIVE						
DESIRED OBJECTIVE						
SCORING						

OTHER INFORMATION:

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Maintenance cost per m²

INDICATOR	Maintenance costs per m2		
DEFINITION	Register and evaluate the impact of the EEM or EEP to the maintainance costs		
GOAL	To identify any existing correlation between the EEM or EEP to the building maintainance costs.		
SCOPE	BUILDING		
AREA	REGIONAL DEPARTMENT		
RECIPIENTS	☑ BUILDING MANAGER	☑ P4P aggregator	☐ USERS
AXIS	☐ SOCIAL	☐ ENVIRONMENTAL	☑ ECONOMIC
SCOPE	☑ PUBLIC	☑ PRIVATE	
REQUIRED DATA			
VARIABLES	Annual maintainance costs		
UNITS	€/m2		
FONT	Facility manager		
MINIMUM SCALE OF	Cost of working ours		
CALCULATION			
FORMULA	$\sum Maintenance\ costs / \sum m2$		
MESUREMENT UNIT	€/m2		
SEGMENTATION	Building		
FREQUENCY OF CALCULATION	To be defined		
FREQUENCY OF EVALUATION	To be defined		
CALCULATION DURING PILOT IMPLEMENTATION	YES		
CALCULATION POST PILOT IMPLEMENTATION	YES		
EVALUATION PARAMETERS			
BASELINE	Introduce current value		
MINIMUM OBJECTIVE	To be defined		
DESIRED OBJECTIVE	To be defined		
MANAGEMENT			
UPDATE RESPONSIBLE	Building manager		
EVALUATION RESPONSIBLE	P4P aggregator		
AUTOMATION	NO		
OPEN DATA	NO		
DATA ACCESSIBILITY			
REGIONAL GOVERNMENT	YES		
BUILDING MANAGERS	YES		
USERS	NO		
OTHERS	NO		

MONITORING OF RESULTS	*febr-21*	*jul-21*	*oct-21*			
RESULTS						
MINIMUM OBJECTIVE						
DESIRED OBJECTIVE						
SCORING						

OTHER INFORMATION:

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Reduction of reactive maintenance per m2 (%)

INDICATOR	Reduction of reactive maintainance per m2 (%)
DEFINITION	Register and evaluate the impact of the EEM or EEP to the maintainance costs
GOAL	To identify any existing correlation between the EEM or EEP to the building maintainance costs.
SCOPE	BUILDING
AREA	REGIONAL DEPARTMENT
RECIPIENTS	☑ BUILDING MANAGER ☑ P4P aggregator ☐ USERS
AXIS	☐ SOCIAL ☐ ENVIRONMENTAL ☑ ECONOMIC
SCOPE	☑ PUBLIC ☐ PRIVATE
REQUIRED DATA	
VARIABLES	Annual reactive maintainance costs
UNITS	€/m2
FONT	Facility manager
MINIMUM SCALE OF	Cost of working ours
CALCULATION	
FORMULA	$\Sigma^{Reactive\ Maintenance\ costs} / _{\Sigma m2}$
MESUREMENT UNIT	€/m2
SEGMENTATION	Building
FREQUENCY OF CALCULATION	To be defined
FREQUENCY OF EVALUATION	To be defined
CALCULATION DURING PILOT IMPLEMENTATION	YES
CALCULATION POST PILOT IMPLEMENTATION	YES
EVALUATION PARAMETERS	
BASELINE	Introduce current value
MINIMUM OBJECTIVE	To be defined
DESIRED OBJECTIVE	To be defined
MANAGEMENT	
UPDATE RESPONSIBLE	Building manager
EVALUATION RESPONSIBLE	P4P aggregator
AUTOMATION	NO
OPEN DATA	NO
DATA ACCESSIBILITY	
REGIONAL GOVERNMENT	YES
BUILDING MANAGERS	YES
USERS	NO
OTHERS	NO

MONITORING OF RESULTS	febr-21	jul-21	oct-21			
RESULTS						
MINIMUM OBJECTIVE						
DESIRED OBJECTIVE						
SCORING						

OTHER INFORMATION:

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Social Indicators

Number of employees trained in EE

INDICATOR	Number of employees trained in EE
DEFINITION	This indicator aims to track the number of employees trained by the implementor.
GOAL	This indicator aims to measure the complementary EEM to promote energy culture among employees. This indicator will be used to evaluate the extra-bonus
SCOPE	BUILDING
AREA	REGIONAL DEPARTMENT
RECIPIENTS	☑ BUILDING MANAGER ☑ P4P aggregator ☑ USERS
AXIS	☑ SOCIAL ☐ ENVIRONMENTAL ☐ ECONOMIC
SCOPE	☑ PUBLIC ☑ PRIVATE
REQUIRED DATA	
VARIABLES	Number of employees trained in EE
UNITS	Employees
FONT	Implementor
MINIMUM SCALE OF	Department
CALCULATION	
FORMULA	$\sum \textit{NUMBER OF EMPLOYEES TRAINED IN EE}$
MESUREMENT UNIT	Employees
SEGMENTATION	Building / group of buildings in case of EEP Aggregation
FREQUENCY OF CALCULATION	To be defined
FREQUENCY OF EVALUATION	To be defined
CALCULATION DURING PILOT IMPLEMENTATION	YES
CALCULATION POST PILOT IMPLEMENTATION	YES
EVALUATION PARAMETERS	
BASELINE	Introduce current value
MINIMUM OBJECTIVE	To be defined
DESIRED OBJECTIVE	To be defined
MANAGEMENT	
UPDATE RESPONSIBLE	Implementor
EVALUATION RESPONSIBLE	Building manager
AUTOMATION	NO
OPEN DATA	NO
DATA ACCESSIBILITY	
REGIONAL GOVERNMENT	YES
BUILDING MANAGERS	YES
USERS	YES
OTHERS	NO

MONITORING OF RESULTS	febr-21	jul-21	oct-21	nov-21	des-21	gen-22
RESULTS						
MINIMUM OBJECTIVE						
DESIRED OBJECTIVE						
SCORING						

OTHER INFORMATION:

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Number of participative activities to promote EE among tenants/end-users

INDICATOR	Numbe of participative activities to promote EE					
DEFINITION	This indicator aims to track the number of activities to promote EE among employees, tenants and / or users					
GOAL	This indicator aims to measure the complementary EEM to promote energy culture among employees. This indicator will be used to evaluate the extra-bonus					
SCOPE	BUILDING					
AREA	REGIONAL DEPARTMENT					
RECIPIENTS	☑ BUILDING MANAGER ☑ P4P aggregator ☑ USERS					
AXIS	☑ SOCIAL ☐ ENVIRONMENTAL ☐ ECONOMIC					
SCOPE	☑ PUBLIC ☑ PRIVATE					
REQUIRED DATA						
VARIABLES	Number of activities implemented					
UNITS	Activities					
FONT	Implementor					
MINIMUM SCALE OF	Department					
CALCULATION						
FORMULA	$\sum$ NUMBER OF ACTIVITIES IMPLEMENTED					
MESUREMENT UNIT	Number of activities					
SEGMENTATION	Building / group of buildings in case of EEP Aggregation					
FREQUENCY OF CALCULATION	To be defined					
FREQUENCY OF EVALUATION	To be defined					
CALCULATION DURING PILOT IMPLEMENTATION	YES					
CALCULATION POST PILOT IMPLEMENTATION	YES					
EVALUATION PARAMETERS						
BASELINE	Introduce current value					
MINIMUM OBJECTIVE	To be defined					
DESIRED OBJECTIVE	To be defined					
MANAGEMENT						
UPDATE RESPONSIBLE	Implementor					
EVALUATION RESPONSIBLE	Building manager					
AUTOMATION	NO					
OPEN DATA	NO					
DATA ACCESSIBILITY						
REGIONAL GOVERNMENT	YES					
BUILDING MANAGERS	YES					
USERS	YES					
OTHERS	NO					
MONITORING OF RESULTS						
	febr-21	*jul-21*	*oct-21*	*nov-21*	*des-21*	*gen-22*
RESULTS						
MINIMUM OBJECTIVE						
DESIRED OBJECTIVE						
SCORING						
OTHER INFORMATION:						

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Improvement of indoor air quality (%)

INDICATOR	Improvement of Indoor Air Quality (IAQ)					
DEFINITION	Registration of the Indoor air quality improvement (CO2 sensors).					
GOAL	This indicator aims to measure the improvement of the indoor air quality due to EEM/EEP implementation. This indicator will be used for the calculation of the					
SCOPE	BUILDING					
AREA	REGIONAL DEPARTMENT					
RECIPIENTS	☑ BUILDING MANAGER ☑ P4P aggregator			☑ USERS		
AXIS	☑ SOCIAL	☐ ENVIRONMENTAL		☐ ECONOMIC		
SCOPE	☑ PUBLIC	☑ PRIVATE				
REQUIRED DATA						
VARIABLES	Reduction of CO2					
UNITS	% of CO2 reduced					
FONT	Implementor					
MINIMUM SCALE OF	Building floor					
CALCULATION						
FORMULA	$\frac{\Delta CO_2}{CO_{2_n}}$					
MESUREMENT UNIT	% CO2 reduced					
SEGMENTATION	Building floor					
FREQUENCY OF CALCULATION	To be defined					
FREQUENCY OF EVALUATION	To be defined					
CALCULATION DURING PILOT IMPLEMENTATION	YES					
CALCULATION POST PILOT IMPLEMENTATION	YES					
EVALUATION PARAMETERS						
BASELINE	Introduce current value					
MINIMUM OBJECTIVE	To be defined					
DESIRED OBJECTIVE	To be defined					
MANAGEMENT						
UPDATE RESPONSIBLE	Implementor					
EVALUATION RESPONSIBLE	Building manager					
AUTOMATION	NO					
OPEN DATA	NO					
DATA ACCESSIBILITY						
REGIONAL GOVERNMENT	YES					
BUILDING MANAGERS	YES					
USERS	YES					
OTHERS	NO					
MONITORING OF RESULTS						
	febr-21	*jul-21*	*oct-21*	*nov-21*	*des-21*	*gen-22*
RESULTS						
MINIMUM OBJECTIVE						
DESIRED OBJECTIVE						
SCORING						
OTHER INFORMATION:						

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Number of innovative EEM implanted.

INDICATOR	Number of innovative EEM implemented					
DEFINITION	To register de number of innovative EEM implemented. understanding as Innovative Measures these kind of measure which market deployment is still in a very initial state, or the approach of which considers a combination of unusual elements. In some cases there are no regulations developed yet, but this kind of measures offers significant energy savings.					
GOAL	This indicator aims to evaluate the degree of innovation of the EEP implemented in the frame of the P4P programs.					
SCOPE	BUILDING					
AREA	REGIONAL DEPARTMENT					
RECIPIENTS	☑ BUILDING MANAGER ☑ P4P aggregator ☐ USERS					
AXIS	☑ SOCIAL ☐ ENVIRONMENTAL ☑ ECONOMIC					
SCOPE	☑ PUBLIC ☑ PRIVATE					
REQUIRED DATA						
VARIABLES	Number of innovative EEM implemented					
UNITS	Number of measures					
FONT	Implementor					
MINIMUM SCALE OF	Building floor					
CALCULATION						
FORMULA	$\sum innovative\ EEM\ implemented$					
MESUREMENT UNIT	Number of measures					
SEGMENTATION	Building					
FREQUENCY OF CALCULATION	Unique					
FREQUENCY OF EVALUATION	Unique					
CALCULATION DURING PILOT IMPLEMENTATION	YES					
CALCULATION POST PILOT IMPLEMENTATION	NO					
EVALUATION PARAMETERS						
BASELINE	Introduce current value					
MINIMUM OBJECTIVE	To be defined					
DESIRED OBJECTIVE	To be defined					
MANAGEMENT						
UPDATE RESPONSIBLE	Building manager					
EVALUATION RESPONSIBLE	Building manager					
AUTOMATION	NO					
OPEN DATA	NO					
DATA ACCESSIBILITY						
REGIONAL GOVERNMENT	YES					
BUILDING MANAGERS	YES					
USERS	YES					
OTHERS	NO					
MONITORING OF RESULTS						
	febr-21	*jul-21*	*oct-21*	*nov-21*	*des-21*	*gen-22*
RESULTS						
MINIMUM OBJECTIVE						
DESIRED OBJECTIVE						
SCORING						
OTHER INFORMATION:						

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Health and Comfort (e.g. Sick absence)

INDICATOR	Health and comfort					
DEFINITION	Registration of the impacts of the EEM to the health and comfort of employees and/or users. This indicator will be different for each buidling considering the concrete health and comfort issues identified by users on each building.					
GOAL	This indicator aims to evaluate the impacts of the EEP implementation to the health and comfort of the users: reduction of sick absence, complaints, etc.					
SCOPE	BUILDING					
AREA	REGIONAL DEPARTMENT					
RECIPIENTS	☑ BUILDING MANAGER ☑ P4P aggregator ☑ USERS					
AXIS	☑ SOCIAL ☐ ENVIRONMENTAL ☐ ECONOMIC					
SCOPE	☑ PUBLIC ☑ PRIVATE					
REQUIRED DATA						
VARIABLES	Complaints					
UNITS	% reduction of complaints					
FONT	Building manager					
MINIMUM SCALE OF	Building					
CALCULATION						
FORMULA	To be defined					
MESUREMENT UNIT	To be defined					
SEGMENTATION	Building					
FREQUENCY OF CALCULATION	Before and after implementation of measures					
FREQUENCY OF EVALUATION	Before and after implementation of measures					
CALCULATION DURING PILOT IMPLEMENTATION	YES					
CALCULATION POST PILOT IMPLEMENTATION	NO					
EVALUATION PARAMETERS						
BASELINE	Current values					
MINIMUM OBJECTIVE	To be defined					
DESIRED OBJECTIVE	To be defined					
MANAGEMENT						
UPDATE RESPONSIBLE	Building manager					
EVALUATION RESPONSIBLE	Building manager					
AUTOMATION	NO					
OPEN DATA	NO					
DATA ACCESSIBILITY						
REGIONAL GOVERNMENT	YES					
BUILDING MANAGERS	YES					
USERS	YES					
OTHERS	NO					
MONITORING OF RESULTS						
	febr-21	*jul-21*	*oct-21*	*nov-21*	*des-21*	*gen-22*
RESULTS						
MINIMUM OBJECTIVE						
DESIRED OBJECTIVE						
SCORING						
OTHER INFORMATION:						

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Environmental Indicators

Energy Consumption reduction

INDICATOR	ENERGY CONSUMPTION REDUCTION					
DEFINITION	Register de consumption variaton due to EEM implementation					
GOAL	The aim of this indicator is to track the compsumption redution derived from the EEM implementation. This indicator will be the reference for compensation					
SCOPE	BUILDING					
AREA	REGIONAL DEPARTMENT					
RECIPIENTS	☑ BUILDING MANAGER ☑ P4P aggregator ☐ USERS					
AXIS	☐ SOCIAL ☑ ENVIRONMENTAL ☐ ECONOMIC					
SCOPE	☑ PUBLIC ☑ PRIVATE					
REQUIRED DATA						
VARIABLES	kWh reduced					
UNITS	kWh					
FONT	Building manager					
MINIMUM SCALE OF	Building					
CALCULATION						
FORMULA	Variation of kWh/m2 / Initial kWh/m2 consumed					
MESUREMENT UNIT	kWh/m2					
SEGMENTATION	Building / EEM ??					
FREQUENCY OF CALCULATION	To be defined					
FREQUENCY OF EVALUATION	To be defined					
CALCULATION DURING PILOT IMPLEMENTATION	YES					
CALCULATION POST PILOT IMPLEMENTATION	NO					
EVALUATION PARAMETERS						
BASELINE	Current values					
MINIMUM OBJECTIVE	To be defined according to ERB					
DESIRED OBJECTIVE	To be defined according to ERB					
MANAGEMENT						
UPDATE RESPONSIBLE	Building manager					
EVALUATION RESPONSIBLE	Building manager					
AUTOMATION	NO					
OPEN DATA	NO					
DATA ACCESSIBILITY						
REGIONAL GOVERNMENT	YES					
BUILDING MANAGERS	YES					
USERS	YES					
OTHERS	NO					
MONITORING OF RESULTS						
	febr-21	*jul-21*	*oct-21*	*nov-21*	*des-21*	*gen-22*
RESULTS						
MINIMUM OBJECTIVE						
DESIRED OBJECTIVE						
SCORING						
OTHER INFORMATION:						

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MWh generated

INDICATOR	MWh generated					
DEFINITION	Registrte the MWh generated by the building					
GOAL	Tracking the amount of MWh generated by the building.					
SCOPE	BUILDING					
AREA	REGIONAL DEPARTMENT					
RECIPIENTS	☑ BUILDING MANAGER ☑ P4P aggregator ☐ USERS					
AXIS	☐ SOCIAL ☑ ENVIRONMENTAL ☐ ECONOMIC					
SCOPE	☑ PUBLIC ☑ PRIVATE					
REQUIRED DATA						
VARIABLES	MWh generated					
UNITS	MWh generated					
FONT	Implementor					
MINIMUM SCALE OF	Building					
CALCULATION						
FORMULA	MWh generated					
MESUREMENT UNIT	MWh					
SEGMENTATION	Building					
FREQUENCY OF CALCULATION	To be defined					
FREQUENCY OF EVALUATION	To be defined					
CALCULATION DURING PILOT IMPLEMENTATION	YES					
CALCULATION POST PILOT IMPLEMENTATION	NO					
EVALUATION PARAMETERS						
BASELINE	Current values					
MINIMUM OBJECTIVE	To be defined according to ERB					
DESIRED OBJECTIVE	To be defined according to ERB					
MANAGEMENT						
UPDATE RESPONSIBLE	Implementor					
EVALUATION RESPONSIBLE	P4P aggregator					
AUTOMATION	YES					
OPEN DATA	NO					
DATA ACCESSIBILITY						
REGIONAL GOVERNMENT	YES					
BUILDING MANAGERS	YES					
USERS	YES					
OTHERS	NO					
MONITORING OF RESULTS						
	febr-21	*jul-21*	*oct-21*	*nov-21*	*des-21*	*gen-22*
RESULTS						
MINIMUM OBJECTIVE						
DESIRED OBJECTIVE						
SCORING						
OTHER INFORMATION:						

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Self-production Level

INDICATOR	Autonsumption level					
DEFINITION	Register the degree of the energy generated and consumed by the building					
GOAL	Track the amoun tof autoconsumption level. This indicator will be used as an objective to be achieved in the frame of the compensation system.					
SCOPE	BUILDING					
AREA	REGIONAL DEPARTMENT					
RECIPIENTS	☑ BUILDING MANAGER ☑ P4P aggregator ☐ USERS					
AXIS	☐ SOCIAL ☑ ENVIRONMENTAL ☐ ECONOMIC					
SCOPE	☑ PUBLIC ☑ PRIVATE					
REQUIRED DATA						
VARIABLES	Energy generated and consumed by the building					
UNITS	kWh autoconsumed					
FONT	Implementor					
MINIMUM SCALE OF	Building					
CALCULATION						
FORMULA	$\sum kWh\ generated\ and\ consubed\ by\ the\ building$					
MESUREMENT UNIT	kWh					
SEGMENTATION	Building					
FREQUENCY OF CALCULATION	To be defined					
FREQUENCY OF EVALUATION	To be defined					
CALCULATION DURING PILOT IMPLEMENTATION	YES					
CALCULATION POST PILOT IMPLEMENTATION	NO					
EVALUATION PARAMETERS						
BASELINE	Current values					
MINIMUM OBJECTIVE	To be defined according to ERB					
DESIRED OBJECTIVE	To be defined according to ERB					
MANAGEMENT						
UPDATE RESPONSIBLE	Implementor					
EVALUATION RESPONSIBLE	P4P aggregator					
AUTOMATION	YES					
OPEN DATA	NO					
DATA ACCESSIBILITY						
REGIONAL GOVERNMENT	YES					
BUILDING MANAGERS	YES					
USERS	YES					
OTHERS	NO					
MONITORING OF RESULTS						
	febr-21	*jul-21*	*oct-21*	*nov-21*	*des-21*	*gen-22*
RESULTS						
MINIMUM OBJECTIVE						
DESIRED OBJECTIVE						
SCORING						
OTHER INFORMATION:						

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Impact on demand Shift

INDICATOR	Impact on demand shift					
DEFINITION	Evaluation of the impact that the EEM or EEP have on the demand consumption courve of the building.					
GOAL	The goal is to evaluate the demand shifting derived from the implementation of each measure and/or the ERB projects as a whole.					
SCOPE	BUILDING					
AREA	REGIONAL DEPARTMENT					
RECIPIENTS	☑ BUILDING MANAGER ☑ P4P aggregator ☐ USERS					
AXIS	☐ SOCIAL ☑ ENVIRONMENTAL ☐ ECONOMIC					
SCOPE	☑ PUBLIC ☑ PRIVATE					
REQUIRED DATA						
VARIABLES	Demand shifting					
UNITS						
FONT	Implementor					
MINIMUM SCALE OF	Building					
CALCULATION						
FORMULA						
MESUREMENT UNIT						
SEGMENTATION						
FREQUENCY OF CALCULATION	To be defined					
FREQUENCY OF EVALUATION	To be defined					
CALCULATION DURING PILOT IMPLEMENTATION	YES					
CALCULATION POST PILOT IMPLEMENTATION	NO					
EVALUATION PARAMETERS						
BASELINE	Current values					
MINIMUM OBJECTIVE	To be defined according to ERB					
DESIRED OBJECTIVE	To be defined according to ERB					
MANAGEMENT						
UPDATE RESPONSIBLE	Implementor					
EVALUATION RESPONSIBLE	P4P aggregator					
AUTOMATION	YES					
OPEN DATA	NO					
DATA ACCESSIBILITY						
REGIONAL GOVERNMENT	YES					
BUILDING MANAGERS	YES					
USERS	YES					
OTHERS	NO					
MONITORING OF RESULTS						
	febr-21	*jul-21*	*oct-21*	*nov-21*	*des-21*	*gen-22*
RESULTS						
MINIMUM OBJECTIVE						
DESIRED OBJECTIVE						
SCORING						
OTHER INFORMATION:						

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8 References and literature

1. EDI-Net PROJECT. Energy Data Innovation Network Initiative.: https://www.edi-net.eu/es/noticias/news-detail/101.html.
2. SHERPA PROJECT: https://sherpa.interreg-med.eu/
3. SENSEI WP4 D4.3 The Boundary Cases for the P4P Rates https://zenodo.org/record/4320758#.X-sGm470mUl.
4. EU Green Deal and Renovation Wave: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
5. EU Green Deal and Renovation Wave: https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en.
6. Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of Building: https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en
7. Long-term strategies: https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/long-term-renovation-strategies_en
8. Energy Efficiency first. https://ec.europa.eu/info/news/energy-efficiency-first-accelerating-towards-2030-objective-2019-sep-25_en
9. Data base from D4.3 The Boundary Cases for the P4P rates https://bcl.nrel.gov/nrel/types/measure
10. EU buildings factsheets. historical stadistics figures. https://ec.europa.eu/energy/eu-buildings-factsheets_en
11. Comprehensive Study Building energy Renovation. https://ec.europa.eu/energy/studies_main/final_studies/comprehensive-study-building-energy-renovation-activities-and-uptake-nearly-zero-energy_en

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9 Table and Diagrams List

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