Innovation Action

inteGRIDy

integrated Smart GRID Cross-Functional Solutions for Optimized Synergetic Energy Distribution, Utilization & Storage Technologies

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D3.2 – Definition of indicators and Benefits categories for CBA/CEA

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Abstract:	The indicators and benefit categories for CBA and CEA analysis of the inteGRIDy project pilots were collated from a combaintion of the activity completed to produce D1.4 and D3.1. From these sources, a complete and exhaustive list of indicators required for a thorough CBA analysis was catalogued. In order to test further the most relevant indicators and benefit categories for CEA, three pilots were surveyed, to capture all further relevant indicators and benefit categories. The methodology for the application of an NPV calculation based NPV was defined and illustrated using a worked example.
Keywords:	Cost Benefit Analysis, Cost Effectiveness Analysis, Benefit Factors, Discount Rate, Sensitivity Analysis, Horizon Value

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Executive Summary

An important aspect of the inteGRIDy project is the assessment of the pilots across the 4 key classifications; economic, environmental, social and technical.

A.T.Kearney, UCP and CERTH are three main contributing consortium members to deliverables D3.1 (Report on LCA and LCC inventory data for the use cases) [IND31], this D3.2 report and D3.3 (Report on Business cases & Financial Mechanisms) [IND33] for the purposes of defining and delivering Life Cycle Analysis (LCA), Cost Benefit Analysis (CBA) and Cost Effectiveness Analysis (CEA) for three of the pilots namely; Barcelona, Nicosia and St Jean.

Due to the lack of financial data beyond the which is used for the creation of forecasts, the analysis delivered in Work Package 3 must be considered only as a forecast, with a more tangible and reliable business case assessment being carried out later in the project via D8.4 (Report on CBA/CEA Analysis & Environmental Impact Assessment) [IND84].

With a focus on economic, this deliverable focused on an appropriate determinant of cost benefit, and in the consideration of environment, social and technical, respectively it focused on cost effectiveness.

The objective of defining the indicators and benefit categories to be used in the cost benefit analysis (CBA) and cost effectiveness analysis (CEA) of three pilot sites, is broadly three-fold. Firstly, the categories and benefit factors are consistent with those already produced in D1.4 (inteGRIDy Global Evaluation Metrics and KPIs) [IND14] and D3.1. Secondly, that they are reviewed and augmented by pilot leaders. In completed D3.1 it is accepted that most of the benefit factors that comprise the inputs to a CBA process are already defined, however, an equivalent definition of CEA-relevant factors had not been carried out, and as such, a part of D3.2 was to canvas the opinion of pilot leaders to deliver relevant CEA benefit factors.

With reference to CBA, an NPV-orientated analysis has been defined, using a nominal discount rate of 3.5%, not uncommon for this form of project. This discount rate will be tested using a sensitivity analysis approach, also defined in this deliverable. The sensitivity analysis uses a horizon value for the assets at the end of the analysis period that is approximately commensurate with the break up value of any residual assets.

The CEA analysis tool used is the Cost-Effectiveness, Effectiveness-Cost Ratio method, in recognition that there may be multiple factors effecting cost effectiveness and that a ration will need to be calculated for each factor that is relevant.

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List of Acronyms and Abbreviations

Term	Description
CBA	Cost Benefit Analysis
CEA	Cost Effectivness Analysis
EPBT	Energy Pay Back Time
IRR	Internal Rate of Return
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
NPV	Net Present Value
RES	Renewable Energy System
SAIDI	System Average Interruption Duration Index – a system index of average duration of interruption in the power supply indicated in minutes per customer.
SAIFI	System Average Interruption Frequency Index – a system index of average frequency of interruptions in power supply
VES	Virtual Energy Storage
VPP	Virtual Power Plant

1.Introduction

Scope and objectives of the deliverable

Deliverable 3.2 has the following objectives:

- To define the indicators and benefit categories required to perform a CBA.
- To define the indicators and benefit categories required to perform a CEA.
- To define a methodology to be followed in D3.3 [IND33] and D8.4 [IND84] to perform a CBA using forecast and actual pilot data respectively.
- To define a methodology to be followed in D3.3 and D8.4 to perform a CEA using forecast and actual pilot data respectively.
- To provide a worked example of a CBA calculation.

1.1.1 Need for CBA and CEA for inteGRIDy

To assess the effectiveness of the pilots in the inteGRIDy project it is essential to deploy a consistent method by which the pilots can be measured and scored. The chosen methods of assessment are CBA (Cost Benefits Analysis) and CEA (Cost Effectiveness Analysis). In the context of a renewable energy syetem and its assessment using CBA the most relevant indicators are those costs feeding into the capital cost (comprising the initial, negative cashflow position expended in the first year of the project) with revenue or 'additional benefit' related categories that comprise the enduring cashlfows.

These are typcally comprised of direct monetary benefits such as energy production, or erived benefits such as governmental or regulatory benefits ranging from feed in tariffs to tax relief or capital allowance mechanisms.

CBA is an academically and commercially accepted analysis tool which focuses on the financial aspects of an activity. Classically CBA is used to compare possible outcomes and determine the best option to achieve defined outcomes with the lowest possible costs. In the context of the inteGRIDy project it is not the objective to choose a single solution or model, but more to deliver a consistent measurement tool of costs versus outcomes for three of the pilot studies.

CEA is traditionally less concerned with fiscal measures than CBA. As an example, it is heavily employed in governmental and infrastructure environments, in particular in energy and healthcare. It is an excellent measure of the effect of activities beyond the financial outcomes. For instance, how are people, the environment or other aspects affected? Results are presented as the incremental cost per unit of effectiveness. For instance, if the measure or benefit is Carbon Savings, three trials will each return a ratio between production of a single unit (perhaps in this instance the production of a kWh of energy) and the carbon produced in the production of that unit of energy.

1.2 Structure of the deliverable

The inteGRIDy business model will be evaluated from the perspective of a 'Smart Grid Optimisation Company'. This definition will help to express the CBA in a consistent format, however, it is noted that in some countries in scope this may not be possible because such an intermediary may not exist, nor be supported by a current market legal framework. In this context this deliverbale has defined models for this purpose.

The models will provide the basis and a framework to deliver:

- The identification and evaluation of existing competitive products/services
- Comparison of organizational and technical requirements of products
- Investigation for features of existing technologies, services and integrated solutions.

These objectives will be delivered as a part of D3.3 [IND33].

In order to deliver the definition of the CBA and CEA used to assess the effectiveness of the three selected pilots, we must first define the influential indicators and benefit categories.

1.2.1 Pilot Descriptions

Descriptions of the use cases for the Barcelona and Nicosia use cases can be found in ANNEX XV to D3.1 [IND31]. A description of the use case for the St Jean pilot can be found in ANNEX I to this deliverable.

1.3 Relationships to other tasks and deliverables

1.3.1 Interaction with other Work Packages and Tasks

The inteGRIDy project has already undergone the process of defining the most relevant KPIs at a high level that are applicable to the measurement of its success. Specifically, the outputs from D1.4 [IND14] define and explain the context for the choice of these indicators.

D3.1 [IND31] defines the key economic KPIs and benefit categories to be measured and used in calculating the LCA of the pilots. These KPIs are also relevant to the calculation of the business case of the pilots. The economic indicators and benefit categories defined in D3.1 provide a definitive list of criteria for the delivery of a CBA. In addition, the high level KPIs for the inteGRIDy project also provide indicators and benefit categories for use in both CBA and CEA calculations.

Figure 1 Describes the relationship between these work packages.

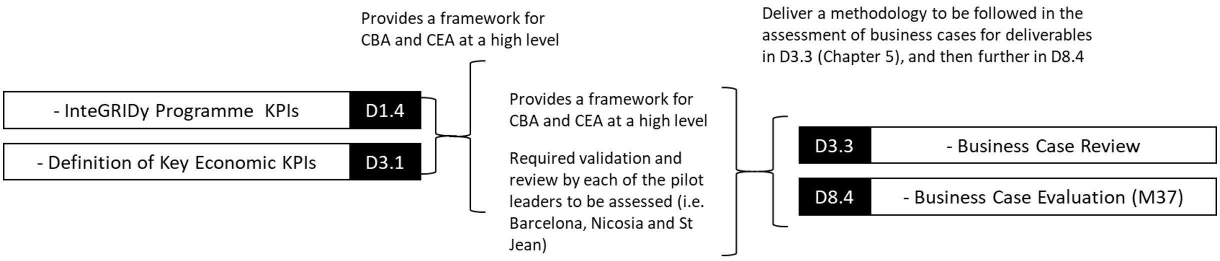

Figure 1. *Relation between deliverables in Work Packages 1, 3 and 8 related to KPIs and Benefits Categories and Indicators*

2. Assessment of indicators and benefit categories – CBA, CEA

CBA Defnition

Cost Benefit Analysis (CBA) is a systematic and consistent method or approach to the comparison of several alternative scenarios [PEA83]. It aims to standardize, costs, benefits, and their measurement to enable the like for like comparison on a 'level playing field'. The CBA often outputs a ratio of benefits to costs, and thus enables the comparison of ratios of alternative scenarios or projects. [WHE11]

CBA cannot always be regarded as a perfect solution for cost benefit comparison. It is often the case that the prediction of the future costs and benefits associated with a project is difficult. This is mitigated in CBA using an agreed and justified discount rate, however this can be considered as also less than perfect. However, the main reason for CBA producing inaccuracies is not the difficulty in predicting futures costs and benefits, but rather, is linked to the quality and the accuracy of the cost benefit estimations. These can sometimes be accurate when measurable and quantifiable, but in other cases a more subjective approach is required.

In the case of inteGRIDy, in order to remove subjectivity from the CBA process, quantitative benefit factors have been applied in the majority (but not exclusively) to the CBA, and qualitative factors have been applied in the majority (but not exclusively) to the CEA (See CEA definition).

Widely accepted, but not without some critics, the CBA process can have many derivatives, in order to increase the effectiveness of CBA in a specific environment.

CEA Definition

While CBA is wholly concerned with quantitative measures and relies on a common measurement definitions, with costs and benefits expressed financially as units of currency, this is not possible with CEA and so an alternative expression must be defined.

By way of example, if the costs and outcomes of a program are expressed in Euro, then the analysis is a cost-benefit. Conversely, cost-effectiveness analysis (CEA) is concerned with the measurement of project results in units rather than monetary figures [MUR00].

It is therefore the case that CEA is a commonly used tool for the measurement and comparison of the outcomes of a project or projects, where the benefit categories are far wider than solely fiscal. Often used in healthcare, for obvious reasons related to patient outcomes etc, in the context of inteGRIDy, CEA is deployed to record, compare and contrast the outputs of each trial that have a more social or environmental influence.

2.1.1 Indicators and Benefits categories for the CBA and CEA

A comprehensive review of the KPIs defined in D1.4 [IND14], the benefit indictaors defined in D3.1 [IND31] and a consultative review process undertaken by UCP and A.T. Kearney with each of the pilot leaders for the Barcelona, Nicosia and St. Jean pilots.

In the context of the CEA benefit indicators, a focus was placed on the qualitative benefit indicators that could be influential in the CEA process. This was because the majority of financial indicators have already been defined by D3.1.

Each indicator was classified in one of four domains, namely: Economic Environmental, Social and Technical.

In addition to this, categories were assigned to each benefit indicator. Pilot leaders were asked to apply categories to most indicators with the rest being applied by UCP where the pilot leaders were not able to assign categories. In each instance, the indicators are requested to be recorded or forecast annually for 20 years, on the basis that this is the useful life of the asset. In every case where units are expressed as MWh, these units will be converted to € based on the applicable financial tariffs or meachnisms in a particular market or geography. These categories were as follows:

i. Security of supply (MWh/year)
The supply required to fulfil the consumer's energy requirement, in order that the energy supply from conventional (grid energy) should not be available.
ii. Socio-economic welfare (€/year)
The financial benefit of the proposed solution comprised of socio-economic benefits such as reduced energy from grid sources.
iii. RES integration (MWh/year)
The quantum in grid energy replaced by energy from the relevant RES per pilot.
iv. Variation in losses (MWh/year)
The quantum of grid (DSO and TSO) losses avoided as a result of the pilot.
v. Total project expenditure of storage (€/year)
The cost of the installation of the energy storage facility.

Each of the pilot leaders was then asked to label each of the benefit indicators that was either 'relevant' or 'relevant but difficult to measure'. These can be defined in the following way:

'relevant' = a benefit indicator that is both important to the success of the pilot and is also readily measureable.

'relevant but difficult to measure' = a benefit indicator that is important to the success of the pilot, but does not have an obvious and accessible method of measurement.

The purpose of asking pilot leaders to label KPIs with these two labels where possible, was to canvas a user or operator opinion regarding criteria that would be of most importance to those most invested in a positive outcome.

This is important, because it helps to define qualitatively the cirteira that are most important to the investor in such outcomes and is a strong indicator of business thresholds being met, and thus replication occurring.

2.1.2 Benefits indicators for the CBA

The benefit categories that will be used in the CBA are summarised for each of the Barcelona, Nicosia and St Jean pilots.

The total list of benefit indicators is a consolidation of benefits sourced from D1.4 (a table of these benefit indicators can be seen in ANNEX II) and D3.1 (a table of these benefit indicators can be seen in Annex III) [IND31].

The benefit categories that will be used in the CBA are summarised for each of the Barcelona, Nicosia and St Jean pilots can be seen in Annexes IV, V and VI.

Indicators that are classified as 'Directional', meaning that they can be used to deduce whether an organisation is getting better (or worse), are marked with Δ.

Indicators that have been noted as the pilot leaders as 'relevant' or 'relevant but difficult to measure' have been listed in Table 1.

Table 1. CBA Indicators noted by pilot leaders as 'relevant' or 'relevant but difficult to measure'.

Deliverable where the KPI was defined	CBA/CEA	Domain	KPI	Units	Comments by pilots
D3.1	**CBA**	Economic	Life cycle CO2 emissions	(€/year)	Relevant but difficult to estimate
D3.1	**CBA**	Economic	Life-cycle cost of energy generation	(€/year)	Relevant but difficult to estimate
D3.1	**CBA**	Economic	Annualized life cycle cost (€/kW-yr)	(€/year)	Relevant but difficult to estimate
D3.1	**CBA**	Economic	Mitigation of operational costs by RES any relevant RES application	(€/year)	Relevant but difficult to estimate
D3.1	**CBA**	Economic	Annuity gain	(€/year)	Relevant

CBA Benefit categories, sorted by down by classification and for every (Environmental, Social, and Technical) and by category (as per catgories i-v above) are shown in Table 2, Table 3 and Table 4.

KPIs in red text were assigned a category by the pilot leaders themselves, and KPIs in black text were assigned a category by UCP. In each case the KPI refers to the overall system for each pilot. The same KPIs will also be used in the eventual assessment of the inteGRIDy platform once the project is ready to conduct this level of analysis in D8.4 [IND84].

Table 2. CBA Economic Benefit Factors.

Deliverable where the KPI was defined	CBA/CEA	Domain	KPI	Units
D1.4	**CBA**	Economic	Cost of ancillary services	(€/year)
D3.1	**CBA**	Economic	Annualized life cycle cost (€/kW-yr)	(€/year)
D3.1	**CBA**	Economic	Annuity gain	(€/year)
D1.4	**CBA**	Economic	Annuity gain	(€/year)
D1.4	**CBA**	Economic	Average Cost of Energy	(€/year)

D1.4	**CBA**	Economic	Average Cost of Energy Consumption	(€/year)
D1.4	**CBA**	Economic	Average Cost of Energy Reward	(MWh/year)
D1.4	**CBA**	Economic	Average Estimation of Cost savings	(€/year)
D1.4	**CBA**	Economic	Balancing costs	(€/year)
D1.4	**CBA**	Economic	Cost of Energy Savings	(€/year)
D1.4	**CBA**	Economic	Cost of Energy Consumption	(€/year)
D1.4	**CBA**	Economic	Cost of Energy reward	(€/year)
D1.4	**CBA**	Economic	Cost of Energy reward (based on contractual Agreement)	(MWh/year)
D1.4	**CBA**	Economic	Demand Price Elasticity (Self Elasticity)	(€/year)
D1.4	**CBA**	Economic	Discomfort against total energy reduction	(€/year)
D3.1	**CBA**	Economic	Life cycle CO2 emissions	(€/year)
D3.1	**CBA**	Economic	Life-cycle cost of energy generation	(€/year)
D3.1	**CBA**	Economic	Mitigation operational costs by RES application	(€/year)
D3.1	**CBA**	Economic	Mitigation operational costs by RES application	(€/year)
D1.4	**CBA**	Economic	Price Elasticity against Discomfort level	(€/year)
D1.4	**CBA**	Economic	Retailer Cost of Energy	(€/year)

Table 3. CBA Environmental Benefit Factors

Deliverable where the KPI was defined	CBA/CEA	Domain	KPI	Units
D1.4	**CBA**	Environmental	CO_2 emissions	(€/year)
D1.4	**CBA**	Environmental	CO_2 emissions Reduction	(€/year)
D1.4	**CBA**	Environmental	Electricity used from on-site installed units for their self-consumption	(MWh/year)
D1.4	**CBA**	Environmental	Energy payback time (EPBT)	(€/year)
D1.4	**CBA**	Environmental	Energy return on (energy) investment taking into consideration its whole life time	(€/year)
D1.4	**CBA**	Environmental	Cumulative energy demand	(€/year)

Table 4. CBA Technical Benefit Factors

Deliverable where the KPI was defined	CBA/CEA	Domain	KPI	Units
D1.4	**CBA**	Technical	Energy consumption	(MWh/year)
D1.4	**CBA**	Technical	Self-Consumption Rate	(MWh/year)
D1.4	**CBA**	Technical	Energy Losses	(MWh/year)
D1.4	**CBA**	Technical	RES generation	(MWh/year)
D1.4 Δ	**CBA**	Technical	Energy Consumption Reduction (Demand flexibility)	(MWh/year)
D1.4	**CBA**	Technical	Demand Flexibility Baseline (Potential)	(MWh/year)
D1.4	**CBA**	Technical	Energy Export	(€/year)
D1.4	**CBA**	Technical	Energy Import	(€/year)
D1.4 Δ	**CBA**	Technical	Peak load reduction	(MWh/year)

D1.4	**CBA**	Technical	RES generation	(MWh/year)
D1.4	**CBA**	Technical	Energy Consumption (Monthly, Daily...)	(€/year)
D1.4 Δ	**CBA**	Technical	Energy Consumption Reduction (Demand Flexibility)	(MWh/year)
D1.4	**CBA**	Technical	Demand Flexibility Baseline (Potential)	(MWh/year)
D1.4 Δ	**CBA**	Technical	Peak load reduction	(MWh/year)
D1.4	**CBA**	Technical	VES Demand Flexibility Baseline	(MWh/year)
D1.4	**CBA**	Technical	VES Demand Flexibility	(MWh/year)
D1.4	**CBA**	Technical	Energy Consumption (Monthly, Daily..)	(€/year)
D1.4	**CBA**	Technical	Energy Losses	(MWh/year)
D1.4	**CBA**	Technical	Active energy Consumption (Monthly, Daily..)	(€/year)
D1.4	**CBA**	Technical	Reactive energy consumption/delivery	(€/year)

2.1.3 Benefits indicators for the CEA

The benefit categories that will be used in the CEA are summarised for each of the Barcelona, Nicosia and St Jean pilots. In Annexs VII, VIII and IX to this chapter.

With regard to CEA benefit indicators, none of the pilots recognised these as ‘relevant’ or ‘relevant but difficult to measure’.

CEA benefit categories, sorted by down by classification (Environmental, Social, and Technical) and by category (as per catgories i-v above) are shown in Table 5, Table 6 and Table 7.

KPIs in red text were assigned a category by the pilot leaders themselves, and KPIs in black text were assigned a category by UCP.

Table 5. CEA Environmental Benefit Factors

Deliverable where the KPI was defined	CBA/CEA	Domain	KPI	Units
D1.4	**CEA**	Environmental	Battery degradation rate	(MWh/year)
D1.4	**CEA**	Environmental	Operative Temperature	(€/year)

D1.4 Δ	**CEA**	Environmental	Thermal Comfort Deviation	(€/year)
D1.4	**CEA**	Environmental	HR Comfort	(€/year)
D1.4	**CEA**	Environmental	Thermal Comfort	(€/year)
D1.4	**CEA**	Environmental	Visual Comfort	(€/year)
D1.4 Δ	**CEA**	Environmental	Thermal Comfort Deviation	(€/year)
D1.4 Δ	**CEA**	Environmental	Visual Comfort Deviation	(€/year)
D3.1	**CEA**	Environmental	Net Energy Ratio	(MWh/year)

Table 6. CEA Technical Benefit Factors

Deliverable where the KPI was defined	CBA/CEA	Domain	KPI	Units
D1.4	**CEA**	Technical	Average SOC	(MWh/year)
D1.4	**CEA**	Technical	Battery calendar life	(€/year)
D1.4	**CEA**	Technical	Battery cycle life	(€/year)
D1.4	**CEA**	Technical	Battery Demand Flexibility	(MWh/year)
D1.4	**CEA**	Technical	Battery Demand Flexibility Baseline	(MWh/year)
D1.4	**CEA**	Technical	Continuity of supply	(MWh/year)
D1.4	**CEA**	Technical	Demand Flexibility Ratio	(MWh/year)
D1.4	**CEA**	Technical	Demand Flexibility Request	(MWh/year)
D1.4	**CEA**	Technical	Demand Request Enrollment	(MWh/year)
D1.4	**CEA**	Technical	Demand Request Participation	(MWh/year)
D1.4	**CEA**	Technical	Depth of Discharge (DOD)	(MWh/year)
D1.4	**CEA**	Technical	Energy Losses Ratio	(MWh/year)
D1.4	**CEA**	Technical	Energy Mismatch	(MWh/year), (€/year)
D1.4	**CEA**	Technical	Energy Mismatch Ratio	(MWh/year), (€/year)

N/A	**CEA**	Technical	Hosting Capacity (HC)	(€/year), (MWh/year)
D1.4	**CEA**	Technical	Load capacity participating in DR	(MWh/year), (€/year)
D1.4 Δ	**CEA**	Technical	Peak load reduction	(MWh/year
D1.4	**CEA**	Technical	Peak to Average Ratio	(MWh/year)
D1.4 Δ	**CEA**	Technical	Reduced energy curtailment	(MWh/year)
D1.4	**CEA**	Technical	RES generation ratio	(MWh/year)
D1.4	**CEA**	Technical	SAIDI	(MWh/year)
D1.4	**CEA**	Technical	SAIFI	(MWh/year)
D1.4	**CEA**	Technical	Share of RES	(MWh/year)
D1.4	**CEA**	Technical	State of Charge (SOC)	(MWh/year)
D1.4 Δ	**CEA**	Technical	Voltage variations	(MWh/year

Table 7. CEA Social Benefit Factors

Deliverable where the KPI was defined	CBA/CEA	Domain	KPI	Units
D1.4	**CEA**	Social	Attitudes towards energy	(€/year)
D1.4 Δ	**CEA**	Social	Degree of user satisfaction from DR services	(€/year)
D1.4	**CEA**	Social	Feeling of security of supply by users	(€/year)
D1.4	**CEA**	Social	Number of people changing their behavior	(€/year)
D1.4	**CEA**	Social	Number of times social app is accessed	(€/year)
D1.4	**CEA**	Social	People understanding of the energy infrastructure installed	(€/year)
D1.4	**CEA**	Social	Social Welfare of inteGRIDy Stakeholders	(€/year)

3.CBA and CEA methodolology development

3.1.1 CBA methodology

To articulate the method by which the CBA will be delivered during the inteGRIDy project the adaptation of a standard CBA process was undertaken.

A typical CBA process may contain the following steps, against which a short commentary is provided based on the relevance and progress within an inteGRIDy context:

1. **List alternative pilot sites.**
    - In the case of inteGRIDy, this is predefined. The three alternatives within scope are already defined as the Barcelona, Nicosia and St. Jean pilots.
2. **Ensure that all affected stakeholders are identified.**
    - In the context of the CBA, the following Stakeholders have been identified:
    - User - (i.e. Sports Centre, University Campus, Prosumers, Consumers)
    - Service provider (VPP / aggregator / direct response provider)
    - Energy retailer
    - Distribution Network Operator
    - Transmission Network Operator
3. **Select measurement(s) and measure all cost/benefit elements.**
    - UCP and A.T. Kearney have consolidated outputs from D1.4 [IND14] and D3.1 [IND31], combined with the review and input from each of the pilot leaders to create a definitive list of cost and benefit elements categorised in section 2.1.2of this chapter.
4. **Predict outcome of cost and benefits over relevant time-period.**
    - The consolidated costs and benefits will be measured over 20 years, as defined by the longest practical asset life of the pilot solutions.
5. **Convert all costs and benefits into a common currency.**
    - The currency across all three pilots is Euro.
6. **The choice and application of an appropriate discount rate.**
    - A standard discount rate of 3.5% (prior to sensitivity analysis testing) will be applied in perfoming the net present value (NPV). This rate comes from the published rate from the UK HM Treasury, 2011 [UKT11].
    - Here the rate of 3.5% is calculated by using the $r = \rho + \mu g$ equation, where:
        - r is the discount rate.
        - ρ is time preference (future consumption minus present consumption on the basis of no change in expected per capita consumption).
        - μ is elasticity of marginal utility of consumption
        - g is annual growth in per capita consumption
    - The time preference in this context, comes from the principle that, generally, people prefer to receive goods and services now rather than later. Meanwhile, the latter part of the equation refers to the fact that growth means people are better off and extra consumption worth less. This reflects that future consumption will be plentiful relative to the current position and thus will generate lower marginal utility and is a widely accepted method by which government or infrastructure based NPV discount rates are formed.
7. **Calculate net present value of project options.**
    - NPV is calculated using the formula:
    - $NPV = \sum PV(B) - \sum PV(B)$
    - Where,
        - NPV = net present value
        - PV (B) = present value of the benefits
        - PV (C) = present value of the costs

8. **Perform a sensitivity analysis test.**
    - The sensitivity analysis test assures that the discount rate selected and applied in performing the NPV calculation of the project is not responsible for skewing the outcome of the assessment and thus creating an inaccurate result.
    - In the case of the inteGRIDy project is seems sensilble to perform a sensitivity test by assessing the suitability of the proposed 3.5% discount rate by calculateding the NPV using a variety of discount rates (proposed to be a range of 2-10%, in 1% increments), to determine the breakeven discount rate.
    - It is recommended that this be perfomed using a horizon value that is determined by the scrap, breakup or reuse value of any of the project assets. This method is the more relevant to projects such as the inteGRIDy pilots, and as such, preferable to simple projections, initial construction costs, depreciated value, or simple use of zero, which are other recognized methods.
    - Sensitivity analysis can be applied to NPVs using a number of different discount rates using the formula:
    - NPV = PV (B) – PV (C) + PV (H)
    - Where:
        - PV (B) = equals the net present benefits
        - PV (C) = equals the net present costs
        - PV (H) = equals the horizon value.
    - This formula is repeated using a range of discount rates (usually in 1% or 0.5% increments several steps above and below the target discount rate), to understand the breakeven discount rate. If the change in NPV is not smooth and incremental, this suggests a discount rate that has been set incorrectly.
9. **Rank each of the pilots in order of cost benefit analysis ratio.**
    - Each of the three pilots will be ranked in order of cost benefit ratio.

3.1.2 CBA worked example

To illustrate the method by which the CBA will be conducted, a flow chart of the NPV calculation that will be applied is shown in Figure 2.

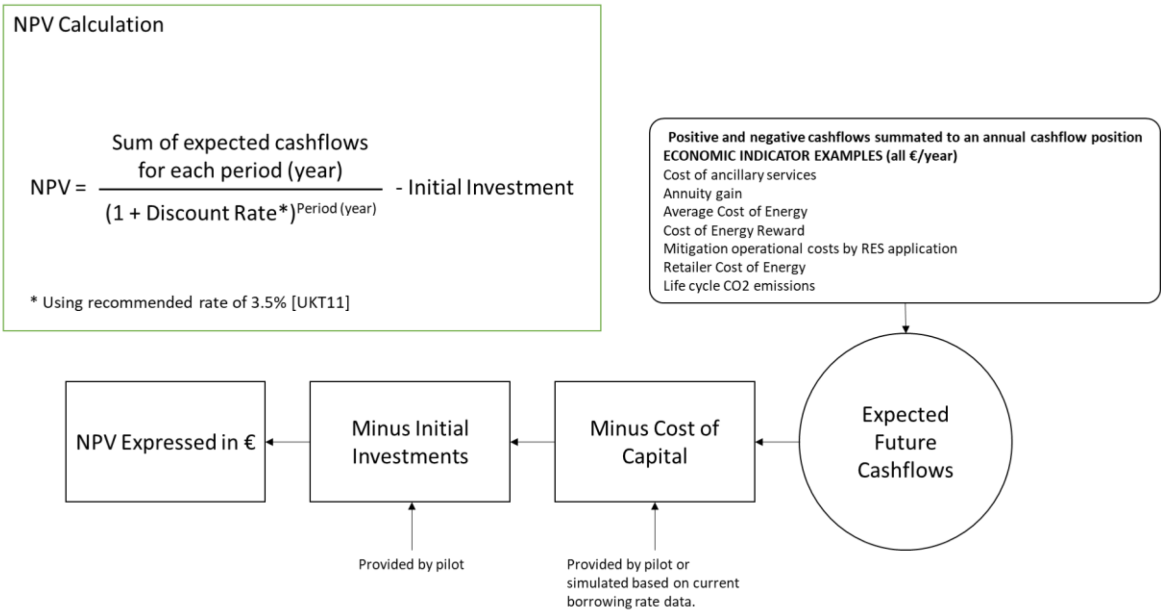

Figure 2. ***Flow chart illustrating a theorectical example of an NPV calculation using the method that will be used in the assessment of the three pilots.***

The flow chart uses a theorectical sample of costs and benefits (and assumes for the sake of simplicity that costs from year 2 onwards remain broadly consistent). The CBA is based on a basic NPV structure and will then be horizon tested. The list of economic indicators, the sum of which will comprise (but is not exlusively limited to) the yearly cashflow to be listed in the annual cashflows.

In order to illustrate the calculation, some synthesized figures have been used. This calculation can be seen as a worked example in Figure 3.

Year	Benefit	Net Cashflow	
1	150.00	-2350.00	
2	153.75	153.75	
3	157.59	157.59	
4	161.53	161.53	
5	165.57	165.57	
6	169.71	169.71	
7	173.95	173.95	
8	178.30	178.30	
9	182.76	182.76	
10	187.33	187.33	**Initial Investment**
11	192.01	192.01	2500
12	196.81	196.81	
13	201.73	201.73	**Discount Rate**
14	206.78	206.78	0.035
15	211.95	211.95	
16	217.24	217.24	**NPV**
17	222.68	222.68	£231.85
18	228.24	228.24	
19	233.95	233.95	**IRR**
20	239.80	239.80	5%

SUM of net cashflows 1331.70

NPV Calculation

$$NPV = \frac{1331.70}{(1 + 0.035)^{20}} - 2500$$

* Using recommended rate of 3.5% [UKT11]

In this context, the annual net cashflows are comprised of a combination of the ECONOMIC INDICTOR EXAMPLES a sample of which are listed in *Figure 2*.

Figure 3. ***Example Cost Benefit Analysis NPV calculation using synthesized data.***

Once the NPV has been completed the sensitivity analysis is conducted, a sensitivity analysis is used to as certain whether the correct discount rate has been applied to the NPV.

Year	Benefit	Net Cashflow	
1	150.00	-2350.00	
2	153.75	153.75	
3	157.59	157.59	
4	161.53	161.53	
5	165.57	165.57	
6	169.71	169.71	
7	173.95	173.95	
8	178.30	178.30	
9	182.76	182.76	
10	187.33	187.33	**Initial Investment**
11	192.01	192.01	2500
12	196.81	196.81	
13	201.73	201.73	**Discount Rate**
14	206.78	206.78	0.035
15	211.95	211.95	
16	217.24	217.24	**NPV**
17	222.68	222.68	£231.85
18	228.24	228.24	
19	233.95	233.95	**IRR**
20	239.80	239.80	5%

SUM of net cashflows 1331.70

Year	Benefit	Cost	
1	150.00	-2350.00	
2	153.75	0.00	
3	157.59	0.00	
4	161.53	0.00	
5	165.57	0.00	
6	169.71	0.00	
7	173.95	0.00	**Horizon Value**
8	178.30	0.00	100
9	182.76	0.00	
10	187.33	0.00	**Initial Investment**
11	192.01	0.00	2500
12	196.81	0.00	
13	201.73	0.00	**Discount Rate**
14	206.78	0.00	0.035
15	211.95	0.00	
16	217.24	0.00	**NPV**
17	222.68	0.00	
18	228.24	0.00	
19	233.95	0.00	**IRR**
20	239.80	0.00	

NPV per discount rate

Discount Rate	**0.01**	**0.02**	**0.03**	**0.035**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.09**	**0.10**
NPV	£1,053.94	£731.28	£454.95	£331.85	£217.72	£13.58	-£162.47	-£314.61	-£446.35	-£560.61	-£659.87

Figure 4. ***CBA NPV calculation with incremental discioiunt rate sensitivity analysis.***

As determined in CBA methodology, an appropriate horizon value commersurate to the breakup value of the assets. Figure 4 shows the sensitivity calculation used to text the validity of the discount rate. The discount rate uses a nominal value of 100 for the breakup value of the asset at the end of the period. In this example the calculated NPV is £231.85 with an IRR of 5%. As an institutional investment, typically IRRs of less than 10% are not considered as sensible investments, and so in this example the project would be unlikely to proceed.

3.1.3 CEA methodology

Our approach to CEA will consider the calculation of a CEA ratio that goes beyond the financial.

Two forms of ratio will be expressed:

- Cost-Effectiveness Ratio: dividing costs of an alternative by the measure of effectiveness.
- Effectiveness-Cost Ratio: dividing effectiveness measured by costs of alternative.
- Using these ratios the researcher can compare two project alternatives as follows:

$$\boldsymbol{CE_{ij}} = \frac{\boldsymbol{C_i - C_j}}{\boldsymbol{E_i - E_j}}$$

Where,

Ci = Costs of alternative i

Cj = Costs of alternative j

Ei = Effectiveness units of alternative i

Ej = Effectiveness units of alternative j

It is particularly important to apply the Cost-Effectiveness and Effectiveness-Cost ratios because only when both are considered will the mathematical significance of the non financial measures (for instance the amount of carbon saved) be determined. In this context the formula can be used to calculate incremental cost-effectiveness ratio i.e. which project has the lowest cost for each Kg of CO_2 saved for example.

In the context of the three pilots to be assessed the CEij will be calculated based on all possible combinations of the three pilots to be assessed to facikuate the 1:1 nature of the caparative ratio test that our CEA calculation delivers.

In order to assess the incremental cost-effectiveness ratios associated with non-finacial KPIs it is important to identify the key non-finacial KPIs. For each non-financial KPI a new ratio calcualtion is required.

Where benefit categorise simply cannot be measured, such as Degree of user satisfaction from DR services or Number of people changing their behaviour a questionnaire approach is recommended with a scoring sysetm that converts the qualitative consensus into a score against which a ratio can be calculated.

Notwithstanding this recommendation the following KEY CEA factors have been proposed as categories against which incremental cost effectiveness ratios are calculated.

1. Thermal Comfort Deviation
2. Peak load reduction
3. Number of people changing their behavior

Once these ratios are calculated this may lead to the calculation of other ratios if these are considered important given the new level of data available.

4.Conclusions

An important aspect of the inteGRIDy project is the assessment of the pilots across the 4 key classifications; economic, environmental, social and technical.

With a particular focus on economic, this deliverable is oriented to an appropriate determinant of cost benefit, and in the consideration of environment, social and technical, respectively it focused on cost effectiveness.

In order to forecast the relative cost benefit and cost effectiveness of the pilots in the inteGRIDy project, a sample of three pilots (Barcelona, Nicosia and St Jean) are assessed using a Cost Benefit Analysis (CBA) and Cost Effectiveness Analysis (CEA).

Prior deliverables D1.4 [IND14] and D3.1 [IND31] when some way to defining both the over-arching KPIs that would determine the indicators of performance for the inteGRIDy project, and also the key financial indicators for Life Cycle Analysis (LCA), most of which would be likely to also be the correct indicators for a CBA.

It was considered that, when addressing the benefit factors that might contribute to a CEA, a more detailed survey of these factors would be important, and so the pilot leaders of each of the aforementioned pilots were interviewed to validate the existing KPIs from D1.4 and D3.1 and as a check for completeness, with particular reference to the CEA.

With reference to CBA, an NPV-orientated analysis has been defined, using a nominal discount rate of 3.5%, not uncommon for this form of project. The NPV fornula is defined in Figure 2, with a worked example being used to illustrate the calculation in Figure 3. When the CBA is executed, a combination of the economic indicators expressed in Euro, will be consolidated and used to provide the annual cashflows required to deliver an NPV calculation. This will vary slightly by pilot depending on application and precise use case.

A common criticism of NPV as a standard analysis tool is the sensitivity of the analysis to the application of an appropriate discount rate. In practice discount rates, in particular where projects are more than 10 years in duration, are only a best guess at an average degradation rate pf the value of money, and as such should be treated with caution, in the knowledge that a peak or trough variation in such a rate could quickly cause a project to run unto cash flow issues or issues related to increased cost of capital, not previously anticipated by the less sophisticated nature of an average, rather than the use of a forecast. That said, a discount rate is a straightforward instrument, and a commonly employed tool to provide assurance of the correct discount rate is the use of a sensitivity analysis. For the CBA analysis of the inteGRIDy pilots a sensitivity analysis of discount rate will be carried out on each NPV that is calculated.

The sensitivity analysis will test every discount rate between 1% and 10%, also including the target discount rate of 3.5%. An example sensitivity analysis is illustrated in Figure 4.

The method by which CEA will be analysed for the three pilots will be by gauging at Cost Effectiveness / Effectiveness Cost Ratio.

It is particularly important to apply the Cost-Effectiveness and Effectiveness-Cost ratios because only when both are considered will the mathematical significant of the non financial measures (for instance the amount of carbon saved). In this context the formula can be used to calculate incremental cost-effectiveness ratio i.e. which project has the lowest cost for each Kg of CO2 saved for example.

In the context of the three pilots to be assessed the CEij will be calculated based on all possible combinations of the three pilots to be assessed to facikuate the 1:1 nature of the caparative ratio test that our CEA calculation delivers.

In order to assess the incremental cost-effectiveness ratios associated with non-finacial KPIs it is important to identify the key non-finacial KPIs. For each non-financial KPI a new ratio calcualtion is required.

5.References

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[IND31] inteGRIDy D3.1. Report on LCA and LCC inventory data for the use cases. 2017

[IND33] inteGRIDy D3.3. Report on Business cases & Financial Mechanisms. 2017

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[MUR00] Murray, C. J.L., Evans, D. B., Acharya, A. and Baltussen, R. M.P.M. (2000), Development of WHO guidelines on generalized cost-effectiveness analysis. Health Econ., 9: 235–251.

[PEA83] Pearce D.W. (1983) The Origins of Cost-Benefit Analysis. In: Cost-Benefit Analysis. Studies in Economics. Palgrave, London

[UKT11] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

[WHE11] Wheatley, D, 2011, CBA Builder http://www.cbabuilder.co.uk/CBA1.html, and http://www.cbabuilder.co.uk/CBA5.html

ANNEX I: St Jean Pilot Use Case Description

Template for collecting information about SOREA buildings

Building information and characteristics

Year of building construction	*2015*
Total Building Surface (m^2)	*87.4m² * 2 floors = 174.8m²*
Number of floors	*2*
Number of offices/ spaces in the building	*5 offices and a corridor (only lights, no heating in this corridor)*
Additional building facilities/spaces description	*A coffee corner at upper level*
Is there a BEMS available in the Building?	I do not know ☐ No ☒ Yes ☐ If Yes, please provide the following information: Vendor of the BEMS, types of loads controlled, types of sensors connected to the BEMS
Are there additional indoor sensing devices already installed at the building?	I do not know ☐ No ☒ Yes ☐
If yes, please specify the type	Light/Luminance ☐ Temperature ☐ Humidity ☐ Windows ☐ Motion/ Presence ☐

Other ☐

If other, please specify:

Also specify if wireless/ wired sensors and the communication protocol:

Human capital

Number of building occupants 12

Number of daily visitors in the building (if applicable) Please specify the number

Who manages the building/facilities?

In-house facility manager ☐

Building occupants ☐

External contractor ☐

Other ☒

If other, please specify: ourselves: SOREA

Energy consumption information

As a main prerequisite for the implementation of Integrity Project activities is to have electricity for heating/cooling services.

How much electricity does the building use annually for **TOTAL=offices heating + lighting + garage heating (3 * 11 KW)** 107 MWh

How much electricity does the building use annually for **lighting**? ?? MWh

Please specify the types of loads available in the building premises and their energy sources:

Load Type	Available	Energy source	Number of loads	Rated total power consumption (kW)	Energy metering[1]
Lighting	Yes	Electricity	31	1260 W	No
Heating	Yes	Electricity	6	10KW	No
Heating garage	Yes	Electricity	3	33KW	No
Cooling	No	Electricity	Please specify	Please specify	Choose an item.
Ventilation	No	Electricity	Please specify	Please specify	Choose an item.
Water heating	Yes	Electricity	1	1.2 KW	No

Heating/cooling devices

[1] Is the energy consumption of the individual specific load metered through clamp meters, plug meters or other infrastructure?

*For **heating/cooling devices** we need to know the exact model of the device (number of input/output units). Therefore, we have the list of questions about the controllability of the heating/cooling devices:*

At which level can the space heating be independently controlled?	Entire building ☐ Floor/ Business Unit ☐ Single room ☒ Other ☐ If other, please specify:
If the building has a space cooling (air-conditioning) system, at which level can it be independently controlled?	Entire building ☐ Floor/ Business Unit ☐ Single room ☐ Other ☐ If other, please specify:
Could you please provide information about the type of thermostat considered for controlling the heating/cooling system Heating device: CAMPA https://www.vitahabitat.fr/campaver-select-30-horizontal/483360-radiateur-electrique-campa-campaver-select-30-horizontal-noir-astrakan-2000w-cmsd20hsepb-3465680012465.html	Model: Wired/Wireless:

Lighting Devices

What types of lamps are used for the lighting?	Incandescent ☐ Fluorescent ☒ LED ☒ Mixed ☐ Other ☐ If mixed or other, please specify:
Are the lights dimmable?	I do not know ☐ No ☐ Yes ☐

➔LED are dimmable by nature but it is needed to install a dimmable driver. This is not the case currently. We can make the job but who will pay for the new controllable devices and which type exactly is needed?

➔Fluorescent in the garage (not measured currently)

As part of the project we will have to control lighting devices, therefore there is a need to change both the lighting devices and the controllers associated with this work→ Dimmable.

Therefore as part of the work we have to ensure that these retrofits will be performed in your *premises*

Lighting device: IDWATT

http://www.idwatt.fr/project/dalle-42w-600x600/

Water Heater Devices

Please describe the model of the electric water heater available and the typical use	Water heater device: THERMOR 241040 http://www.cedeo.fr/asset/08/24/AST2030824.pdf
Please describe the controllability of this water heater (relay switch, always on etc…)	

Metering infrastructure

Does the building have one or more smart meters for electricity metering?	I do not know ☐ No ☒ Yes ☐
At what level is electricity independently metered?	Entire building ☒ Floor/ Business Unit ☐ Single room ☐

"SOREA building technical elements" folder can be find here:

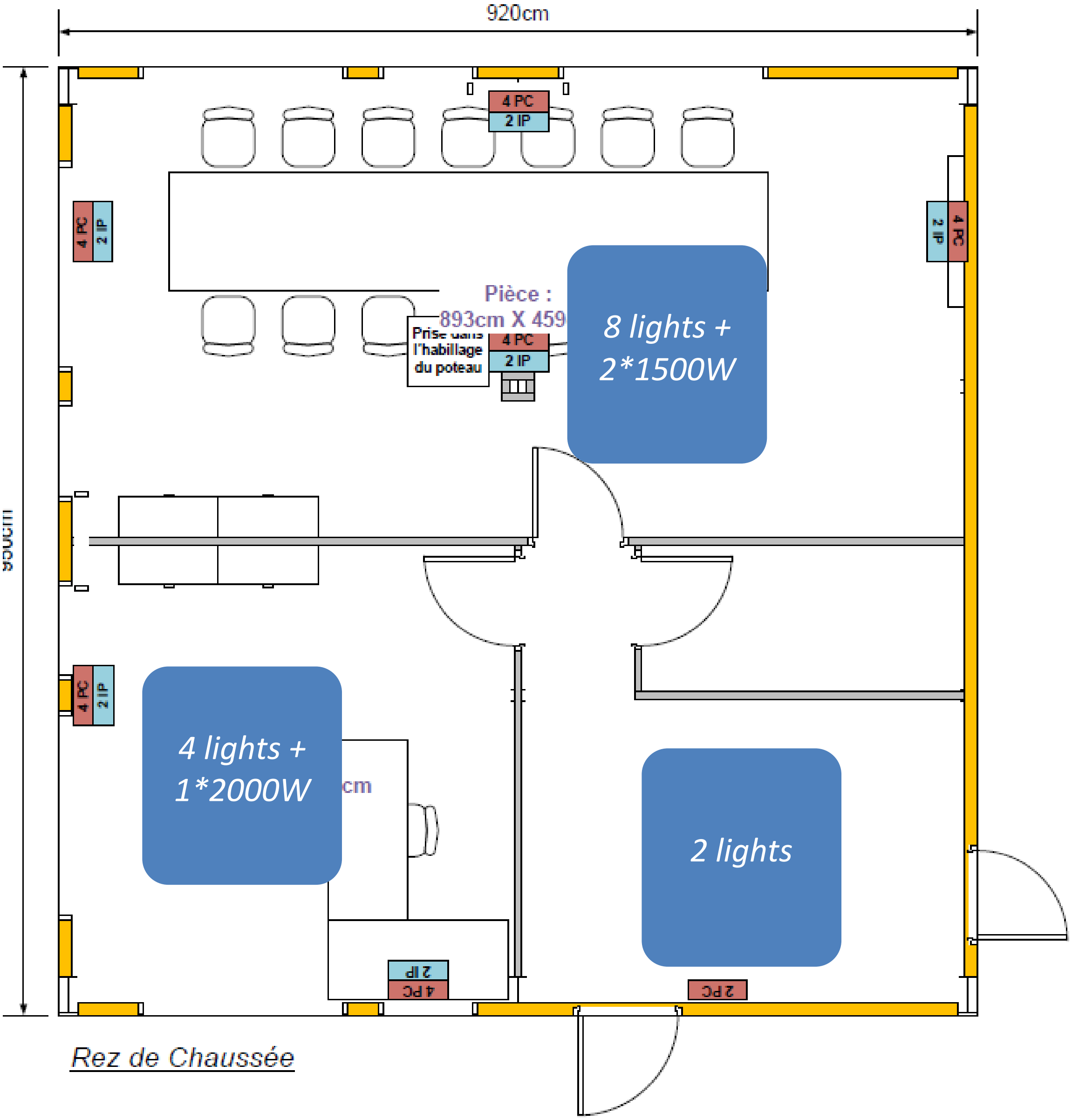
ftp://trekinned:inteGRIDy73@ftp.semsorea.fr

➔IMPORTANT TO NOTE: We can have the TOTAL annual Energy consumption (107 MWh) for all the building (heating offices + heating garage + lighting fluo garage + lighting LED offices + water heater) but it's currently not possible to dissociate them.

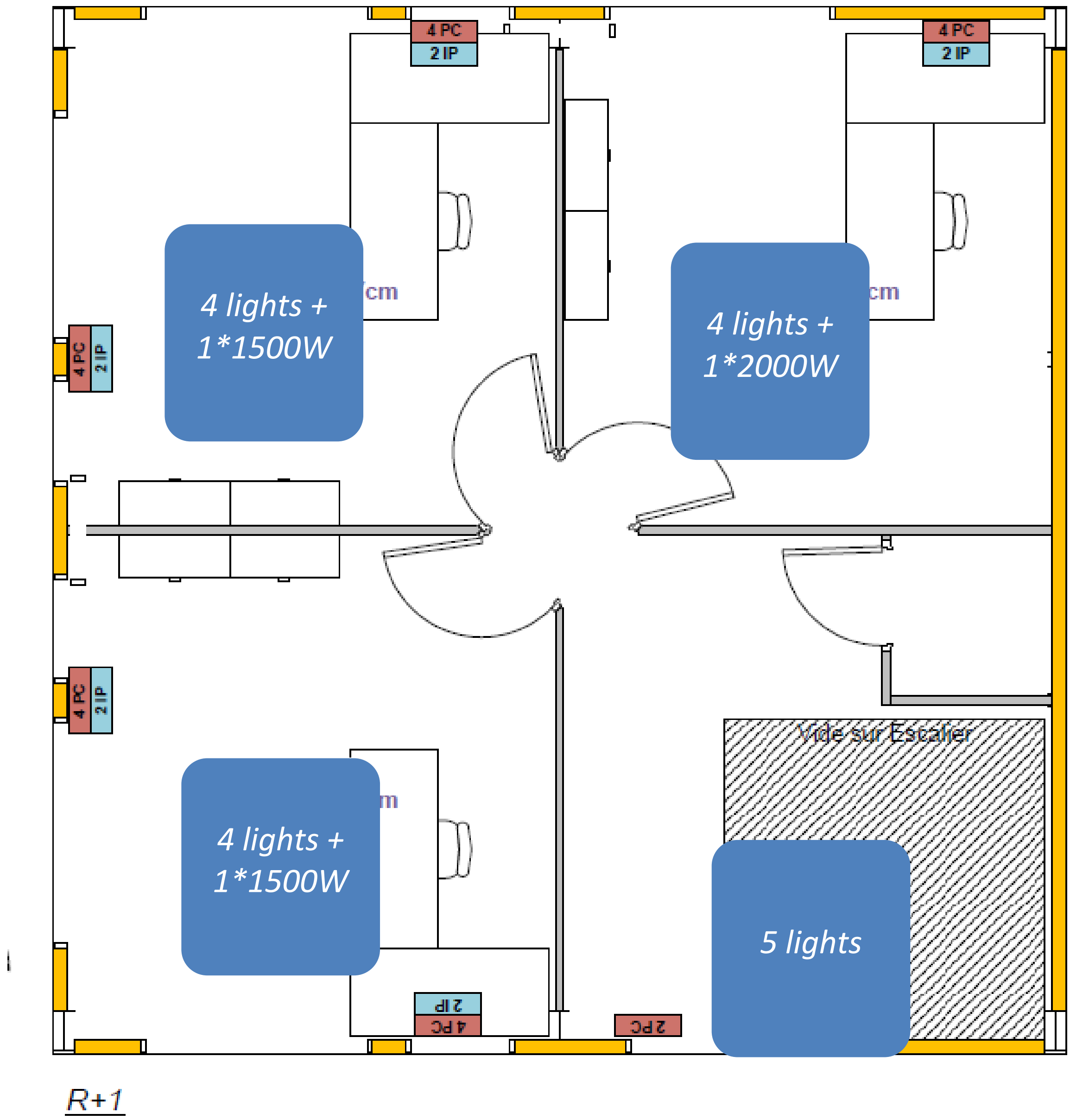
If necessary it could be done from now by installing the basic metering but it will then take one full year to know the consumption for each element out of the 107 MWh.

Building organization

Ground floor: 87.4 m²



Floor 1: 87.4m²



Building lighting organization

- ***31 LEDs panels "IDWATT" of 40W each***
- ***Total lighting = 1260 W***
    - ***31*40W = 1240 W***
    - ***2*10W in the toilets***

Building heating organization

- ***6 electrical heaters "CAMPA" :***
    - ***4 of 1500 W***
    - ***2 of 2000 W***

  Total offices heating = 10 KW

- ***1 Water heater "THERMOR" = 1200 W***

- ***Garage heating : 3 aerotherm 11 KW each = 33 KW***

ANNEX II: Table of KPIs referenced from D1.4

CBA/CEA	Domain	KPI	Units
CBA	EC	Cost of ancillary services	(€/year)
CBA	EC	Annuity gain	(€/year)
CBA	EC	Average Cost of Energy	(€/year)
CBA	EC	Average Estimation of Cost savings	(€/year)
CEA	T	Average SOC	(MWh/year)
CEA	E	Battery degradation rate	(MWh/year)
CEA	T	Battery Demand Flexibility	(MWh/year)
CEA	T	Battery Demand Flexibility Baseline	(MWh/year)
CBA	EN	CO2 emissions	(€/year)
CBA	EN	CO2 emissions Reduction	(€/year)
CBA	EC	Cost of Energy Consumption	(€/year)
CBA	EC	Cost of Energy reward	(€/year)
CEA	S	Degree of user satisfaction from DR services	(€/year)
CBA	T	Demand Flexibility Baseline (Potential)	(MWh/year)
CEA	T	Demand Flexibility Ratio	(MWh/year)
CEA	T	Demand Flexibility Request	(MWh/year)
CEA	T	Depth of Discharge (DOD)	(MWh/year)
CBA	EN	Electricity used from on-site installed units for their self-consumption	(MWh/year)
CBA	T	Energy Consumption Reduction (Demand flexibility)	(MWh/year)
CBA	T	Energy Export	(€/year)
CBA	T	Energy Import	(€/year)
CBA	T	Energy Losses	(MWh/year)
CEA	T	Energy Losses Ratio	(MWh/year)
CEA	T	Energy Mismatch Ratio	(€/year)
CEA	S	Feeling of security of supply by users	(€/year)
CEA	EN	HR Comfort	(€/year)
CBA	EC	Mitigation operational costs by RES application	(MWh/year)
CEA	EN	Operative Temperature	(€/year)
CBA	T	Peak load reduction	(MWh/year)

CEA	T	Peak to Average Ratio	(MWh/year)
CBA	T	RES generation	(MWh/year)
CEA	T	RES generation ratio	(MWh/year)
CBA	E	Retailer Cost of Energy	(€/year)
CEA	T	SAIDI	(MWh/year)
CEA	T	SAIFI	(MWh/year)
CBA	T	Self-Consumption Rate	(MWh/year)
CEA	T	State of Charge (SOC)	(MWh/year)
CEA	E	Thermal Comfort	(€/year)
CEA	E	Thermal Comfort Deviation	(€/year)

ANNEX III: Table of KPIs referenced from D3.1

CBA/CEA	Domain	KPI	Category
CBA	EC	Life cycle CO2 emissions	(€/year)
CBA	EC	Life-cycle cost of energy generation	(€/year)
CBA	EC	Annualized life cycle cost (€/kW-yr)	(€/year)
CBA	EC	Mitigation operational costs by RES application	(€/year)
CBA	EC	Annuity gain	(€/year)

ANNEX IV: CBA benefit categories used for analysis of the Barcelona Pilot

Deliverable where the KPI was defined	Domain	KPI	Units
D1.4	T	Energy consumption	(MWh/year)
D1.4	T	Self-Consumption Rate	(MWh/year)
D1.4	T	Energy Losses	(MWh/year)
D1.4	T	RES generation	(MWh/year)
D1.4	T	Energy Consumption Reduction (Demand flexibility)	(MWh/year)
D1.4	T	Demand Flexibility Baseline (Potential)	(MWh/year)
D1.4	T	Energy Export	(€/year)
D1.4	T	Energy Import	(€/year)
D1.4	T	Peak load reduction	(MWh/year)
D1.4	EN	CO2 emissions	(€/year)
D1.4	EN	CO2 emissions Reduction	(€/year)
D1.4	EN	Electricity used from on-site installed units for their self-consumption	(MWh/year)
D3.1	EC	Life cycle CO2 emissions	(€/year)
D3.1	EC	Life-cycle cost of energy generation	(€/year)
D3.1	EC	Annualized life cycle cost (€/kW-yr)	(€/year)
D3.1	EC	Mitigation operational costs by RES application	(€/year)
D3.1	EC	Annuity gain	(€/year)
D1.4	EC	Retailer Cost of Energy	(€/year)
D1.4	EC	Average Cost of Energy	(€/year)
D1.4	EC	Cost of Energy Consumption	(€/year)
D1.4	EC	Cost of Energy reward	(€/year)
D1.4	EC	Average Estimation of Cost savings	(€/year)
D1.4	EC	Cost of ancillary services	(€/year)
D1.4	EC	Mitigation operational costs by RES application	(MWh/year)
D1.4	EC	Annuity gain	(€/year)

ANNEX V: CBA benefit categories used for analysis of the Nicosia Pilot

Deliverable where the KPI was defined	Domain	KPI	Units
D1.4	T	Energy Consumption (Monthly, Daily..)	(€/year)
D1.4	T	Energy Losses	(MWh/year)
D1.4	T	Active energy Consumption (Monthly, Daily..)	(€/year)
D1.4	T	Reactive energy consumption/delivery	(€/year)
D1.4	EN	Energy payback time (EPBT)	(€/year)
D1.4	EN	Energy return on (energy) investment taking into consideration its whole life time	(€/year)
D1.4	EN	Cumulative energy demand	(€/year)
D3.1	EC	Life-cycle cost of energy generation	(€/year)
D3.1	EC	Annualized life cycle cost (€/kW-yr)	(€/year)
D3.1	EC	Mitigation operational costs by RES application	(€/year)
D3.1	EC	Annuity gain	(€/year)
D1.4	EC	Retailer Cost Of Energy (Monthly, Daily..)	(€/year)
D1.4	EC	Cost of Energy Savings	(€/year)
D1.4	EC	Average Cost of Energy Consumption	(€/year)
D1.4	EC	Average Estimation of Cost savings	(€/year)
D1.4	EC	Cost of Energy reward (based on contractual Agreement)	(MWh/year)
D1.4	EC	Average Cost of Energy Reward	(MWh/year)
D1.4	EC	Demand Price Elasticity (Self Elasticity)	(€/year)
D1.4	EC	Discomfort against total energy reduction	(€/year)
D1.4	EC	Price Elasticity against Discomfort level	(€/year)
D1.4	EC	Balancing costs	(€/year)

ANNEX VI: CBA benefit categories used for analysis of the St Jean Pilot

Deliverable where the KPI was defined	Domain	KPI	Units
D1.4	T	RES generation	(MWh/year)
D1.4	T	Energy Consumption (Monthly, Daily...)	(€/year)
D1.4	T	Energy Consumption Reduction (Demand Flexibility)	(MWh/year)
D1.4	T	Demand Flexibility Baseline (Potential)	(MWh/year)
D1.4	T	Peak load reduction	(MWh/year)
D1.4	T	VES Demand Flexibility Baseline	(MWh/year)
D1.4	T	VES Demand Flexibility	(MWh/year)
D3.1	EC	Life-cycle cost of energy generation	(€/year)
D3.1	EC	Annualized life cycle cost (€/kW-yr)	(€/year)
D3.1	EC	Mitigation operational costs by RES application	(€/year)
D3.1	EC	Annuity gain	(€/year)
D1.4	EC	Average Cost of Energy Consumption	(€/year)
D1.4	EC	Average Estimation of Cost savings	(€/year)

ANNEX VII: CEA benefit categories used for analysis of the Barcelona Pilot

Deliverable where the KPI was defined	Domain	KPI	Units
D1.4	T	Energy Losses Ratio	(MWh/year)
D1.4	T	SAIFI	(MWh/year)
D1.4	T	SAIDI	(MWh/year)
D1.4	T	State of Charge (SOC)	(MWh/year)
D1.4	T	Depth of Discharge (DOD)	(MWh/year)
D1.4	T	Average SOC	(MWh/year)
D1.4	T	Battery Demand Flexibility Baseline	(MWh/year)
D1.4	T	Battery Demand Flexibility	(MWh/year)
D1.4	T	Peak to Average Ratio	(MWh/year)
D1.4	T	RES generation ratio	(MWh/year)
D1.4	T	Demand Flexibility Ratio	(MWh/year)
D1.4	T	Demand Flexibility Request	(MWh/year)
D1.4	T	Energy Mismatch Ratio	(€/year)
D1.4	EN	Battery degradation rate	(MWh/year)
D1.4	EN	Thermal Comfort	(€/year)
D1.4	EN	Operative Temperature	(€/year)
D1.4	EN	Thermal Comfort Deviation	(€/year)
D1.4	EN	Battery degradation rate	(MWh/year)
D1.4	EN	HR Comfort	(€/year)
D1.4	S	Degree of user satisfaction from DR services	(€/year)
D1.4	S	Feeling of security of supply by users	(€/year)

ANNEX VIII: CEA benefit categories used for analysis of the Nicosia Pilot

Deliverable where the KPI was defined	Domain	KPI	Units
D1.4	T	Share of RES	(MWh/year)
D1.4	T	Battery calendar life	(€/year)
D1.4	T	Battery cycle life	(€/year)
N/A	T	Hosting Capacity (HC)	(€/year)
D1.4	T	Voltage variations	(MWh/year)
D1.4	T	Reduced energy curtailment	(MWh/year)
D1.4	T	Continuity of supply	(MWh/year)
D1.4	T	Load capacity participating in DR	(€/year)
D1.4	T	Peak load reduction	(MWh/year)
D1.4	T	Energy Mismatch	(MWh/year)
D1.4	T	Energy Mismatch Ratio	(MWh/year)
D3.1	EN	Net Energy Ratio	(MWh/year)
D1.4	EN	Battery degradation rate	(€/year)
D1.4	S	Number of people changing their behavior	(€/year)
D1.4	S	Number of times social app is accessed	(€/year)
D1.4	S	People understanding of the energy infrastructure installed	(€/year)
D1.4	S	Degree of user satisfaction from DR services	(€/year)
D1.4	S	Attitudes towards energy	(€/year)
D1.4	S	Social Welfare of inteGRIDy Stakeholders	(€/year)

ANNEX IX: CEA benefit categories used for analysis of the St Jean Pilot

Deliverable where the KPI was defined	Domain	KPI	Units
D1.4	T	RES generation ratio	(MWh/year)
D1.4	T	Peak to Average Ratio	(MWh/year)
D1.4	T	Demand Flexibility Ratio	(MWh/year)
D1.4	T	Demand Flexibility Request	(MWh/year)
D1.4	T	Demand Request Participation	(MWh/year)
D1.4	T	Demand Request Enrollment	(MWh/year)
D1.4	EN	Thermal Comfort	(€/year)
D1.4	EN	Visual Comfort	(€/year)
D1.4	EN	Thermal Comfort Deviation	(€/year)
D1.4	EN	Visual Comfort Deviation	(€/year)
D1.4	S	Number of people changing their behavior	(€/year)
D1.4	S	Degree of user satisfaction from DR services	(€/year)

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