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# CONTENTS

# 1. KPI definition and objectives

KPI (Key Performance Indicator) are a set of reference elements allowing to measure impact of a defined solution. In the framework of INCREASE project, KPI's developed have to assess BIPV solutions but also to provide a metric information allowing to follow in operation behaviour of such BIPV solutions. Six KPI's are developed in this work package and must support BIPV solution from design choices to demonstration stage. These KPI's will be used to harvest data generated by the monitoring solutions and will be able to monitor the evolution of performances over the time.

Definition of KPI's try to fit with expectations of all projects partner to promote BIPV solutions through several indicators, addressing different markets or customers. To be objective enough, KPIs are calculated based on a representative set of parameters which are directly tied, somehow, to the considered indicator. So, each KPI value comes from the calculation of the arithmetic value of the parameters of its field of application. Each parameter is evaluated over a range of values defined by a rating scale (from 0 to 5). In this way, an isobarycentre value can be determined for each parameter independently, considering only the criteria to be evaluated. Calculating the average value of all the KPIs will enable us to determine an average value for the BIPV solution evaluated, which will then enable us to rank each solution according to all the indicators.

In order to evaluate each BIPV solution as objectively as possible, six KPIs have been identified to characterize a solution application operation. Four KPIs defined in IEA PVPS T15 for BIPV solution are implemented and tailored for INCRESE needs (Energy, Economy Environment and Aesthetic). Two additional KPIs have been specially developed to meet the expectations of the project, dealing with Comfort topic and Buildability.

As a first release, the six KPIs are described with all their current parameters, but the final aim being to reduce at a set of five to six explicit parameters by KPI to enable simpler and faster use. They should also make it possible to express not only numerical values, but also actual on-site measurements.

KPIs have been developed to be applied to new-builds as well as to renovation projects, so that we can determine which solutions will be the most relevant and help decision-makers.

A set of three standards KPIs were developed in many BIPV project (BIPVBOOST) but also in the works of the T15 from IEA PVPS program, in which a new indicator dealing with the impact of aesthetical aspects was developed in.

Main aims of the development of theses parameters are to support the constant increasement of BIPV demand and to give the right guidance for decision-makers. During work sessions, in the framework of WP6, four additional parameters have emerged. “COMFORT”, “REGULATION”, “BUILDING METRICS” and” INSTALLATION FRIENDLY” were the initial additional parameters identified with strong applicability and interest potential. Work on harmonization, limiting overlap and the possibility of constructing indicators based on values measured on site meant that these indicators had to be reviewed and only the most relevant retained. As each indicator is fed by at least five parameters, it was also essential to have explicit parameters, which could be determined either by calculation, simulation, or on-site measurements. Ideally, these parameters are fed by a single feeder to ensure greater robustness.

During the first dedicated workshop a first selection of parameters and KPIs are carried out to. They have been simplified to make it easier to use, with only the most persistent elements retained.

## 2. KPI and parameter - use and construction

Based on the works carried out in BIPVBOOST project and in IEA PVPS TASK 15, on the definition of explicit KPIs to support BIPV development, here is explained the use of parameters and the calculation of final KPI value. Extended KPIs, developed in the framework of INCREASE project, keep the same working method [1].

### a. First KPI release

In order to harvest the most representative KPIs, all project partners were asked to define criteria specific to their areas of competence and expertise. The aim was to objectively collect all the differentiating criteria needed to support BIPV with contributions from all fields (apart from photovoltaic alone). The results of these meetings led to an initial series of eight KPIs, fed respectively by more than seven parameters.

The first eight KPIs are showed in the Table 1 where the common KPI are present with the addition of newly identified KPIs. The four last PKIs express the concerns of partners and networks where standard KPIs are note relevant enough and have to be completed with additional ones.

First, COMFORT KPI is a result of an achievement, measured by feedback of end-users. Even if this KPI is complex to make an objective assessment, its probably one of the best criteria to assess the right outcomes of a solution. Next, REGULATION KPI try to express the impact of national, European, or international “regulation” or “policy”, or to measure the capability to reach regulation expectations. The lack of harmonized approach even at European level and sometimes at a national level was a hindrance to work on this KPI which was considered too complex to implement and, above all, potentially subject to very rapid changes in policy.

| KPI NAME | | Number of parameters |
|---|---|---|
| ENERGY | | 11 |
| ECONOMY | | 9 |
| ENVIRONMENT | | 11 |
| AESTHETICAL | | 7 |
| COMFORT | | 9 |
| REGULATION | | 7 |
| BUILDING METRIC | | 11 |
| INSTALLATION FRIENDLY | | 8 |

*Table 1 : First set of KPIs identified.*

Next, BUILDING METRIC, is a KPI that try to express metric needs from builders or planners. It is mainly based on the gain/loss ratio between different technical situation, and how to quantify added values of BIPV solutions in replacement of standard building solutions. Last but not the least, INSTALLATION FRIENDLY, concerns specially designers and architects with parameters like the ease of installation, saving in implementation and reparability.

Every KPI is expressed by several parameters as showed in the initial ENERGY KPI (Table 2).

| KPI NAME | | Parameter | | Unit/metric |
|---|---|---|---|---|
| ENERGY | | Performance Ratio (annual) | | PR_STC / [%] or [-] |
| | | Area-specific final system yield | | Y_f_BIPV / [kWh/m2] |
| | | Specific AC Final system yield | | Y_f / [kWh/kWp] |
| | | PV array system Yield | | Ya / [kWh/kW] |
| | | Primary energy demand | | PED / [MJ oil eq. / kWh] |
| | | Final energy demand | | FED / [MJ oil eq. / kWh]] |
| | | Specific transmission | | ST / [W/m$^2$.year] |

| | | | | |
|---|---|---|---|---|
| | | Annual Energy production | | AEP / [kWh/year] |
| | | Degradation rate | | Rd / [%/year] |
| | | Energy Availability | | EA / [kWh/h] |

*Table 2: Initial table of KPI ENERGY and Parameters description.*

With so many KPI and parameters, it was becoming more and more complicated to have only outstanding elements that could then be used on demonstration sites and fed by field measurements. A revision work is carried out to simplify and to keep only the most representative parameters by KPI. A target of five to six parameters seems to be a good number of explicit parameters. We also must define parameters and KPI that could be applied for any BIPV solutions and among them IPV solutions. To have too focused on building topics parameters, will lead to an unemployment of such parameter in any photovoltaic solution. In this specific framework we intent to deal with an as broad as possible approach allowing to apply on any BIPV/IPV typology the KPIs. The Figure 1 demonstrates the work of rationalization on the most relevant parameters that will be kept for the rest of this project.

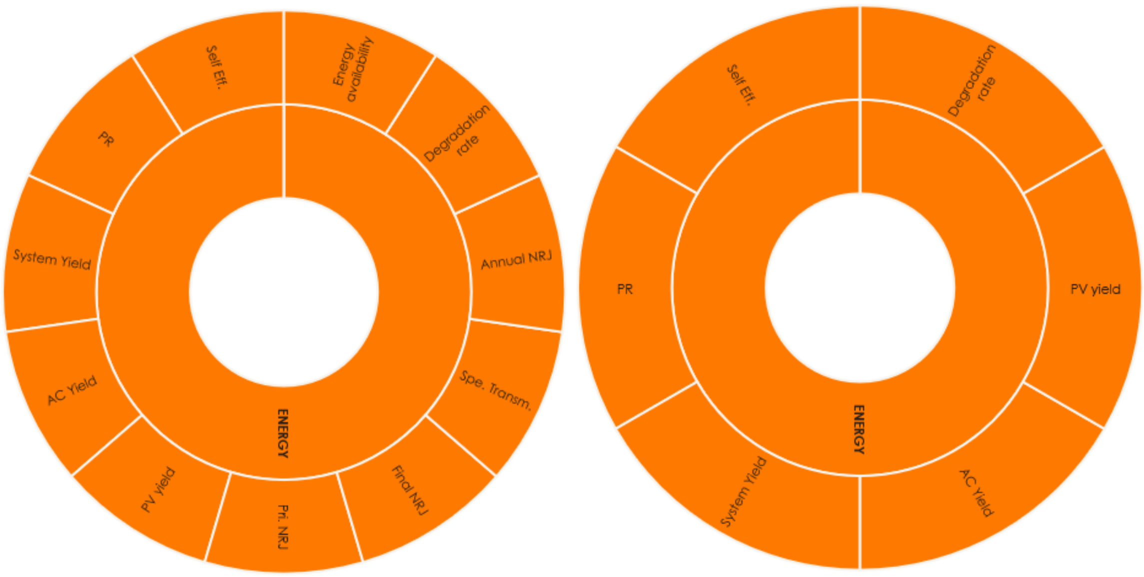


*Figure 1: Energy KPI (inner circle) and list of parameters (outer circle) BEFORE (left) and AFTER (right) rationalization.*

Number of KPI is also discussed in order to define applicability and usefulness of each one. Work done concluded on a possible reduction on only six representative KPIs, where the two erased ones were partially distributed. Only REGULATION KPI and corresponding parameters are not retained due to a too little stability over the time and probably a too large complexity to manage for the duration of this project. Before rationalization work performed, the Figure 2, presents the full distribution of KPIs and parameters to handle to express the global value of any BIPV/IPV solution.

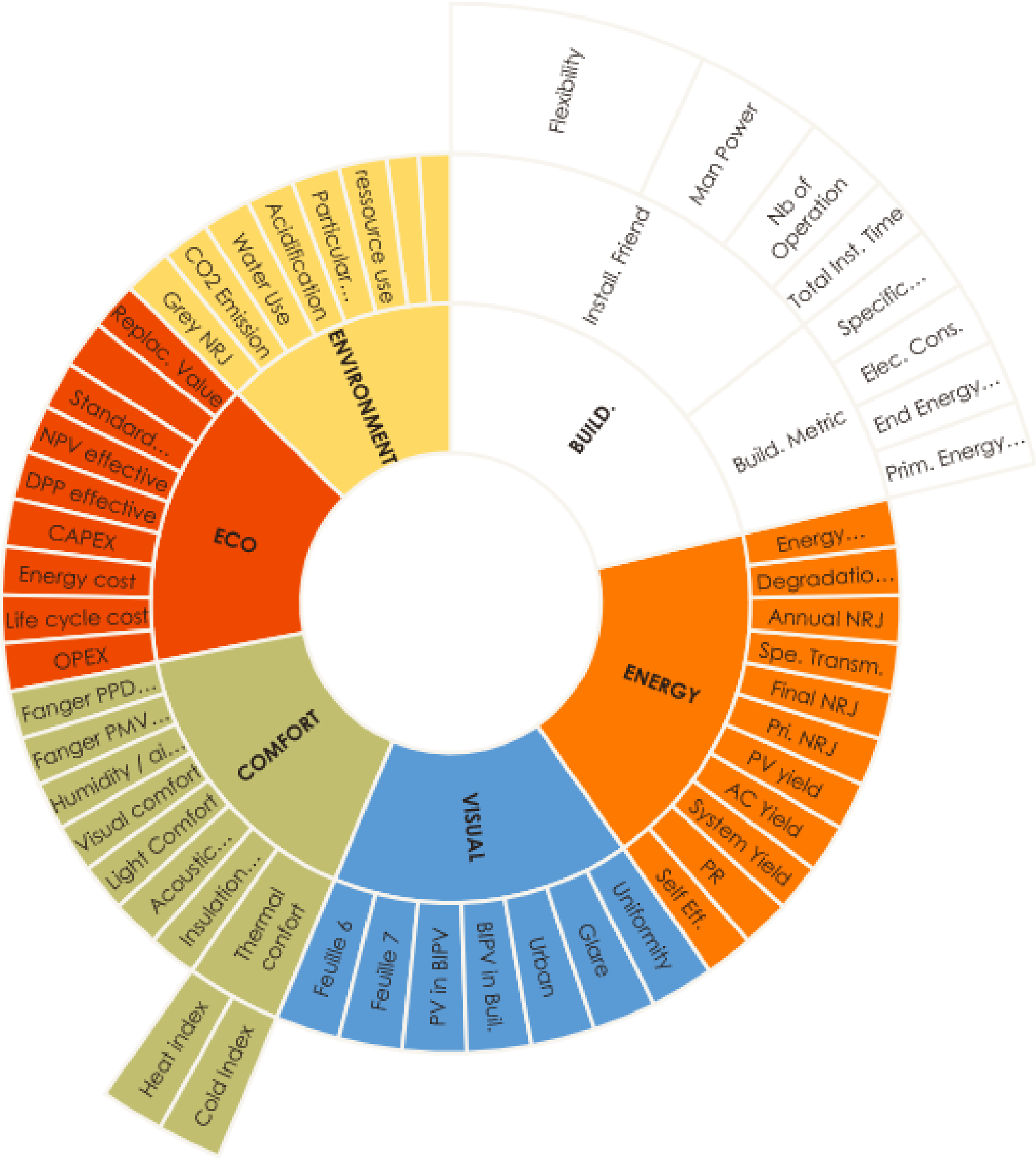


*Figure 2: Raw KPIs list and associated parameters before rationalization.*

Next step of this work is to reduce as much as possible KPIs and parameters to retain the most relevant ones, independent of location and technical specificities, and transposable to all photovoltaic solutions on which this methodology will be applied. These parameters are also defined so that, where possible, they can be consolidated by on-site measurements. the monitoring solutions that will be applied on the demonstration sites with the support of the work carried out in task 5.3.

### b. Second KPI release

Aim is to define as the most reliable and useful KPI as possible, with the selection of the most representative parameters, filled with accurate simulation or on-site measurements.  It's also a step to rationalize parameters and avoid redundancies with similar parameters used with different KPI, reducing understanding of the use of such KPIs.

In order to increase the usefulness of such KPIs, it is tempting to reduce the parameters taken onto consideration to the most useful ones. The outcome of this work is displayed in the Table 3, where the final count presents the most relevant KPIs (minus two) and the complete number of parameters associated (minus 23).

| KPI NAME | | Number of parameters |
|---|---|---|
| ENERGY | | 6 (11) |
| ECONOMY | | 5 (9) |
| ENVIRONMENT | | 6 (11) |
| AESTHETICAL | | 6 (7) |
| COMFORT | | 6 (9) |
| BUILDABILITY | | 6 (11) |

*Table 3 : Final set of KPIs selected for the INCREASE project (previous number of parameters).*

If we zoom in on the KPI ENERGY showed in the table 2, the new version of these parameters is as follows, as shown in the Table 4.

| KPI NAME | | Parameter | | Unit/metric |
|---|---|---|---|---|
| ENERGY | | Performance Ratio (annual) | | PR_STC / [%] or [-] |
| | | Area-specific final system yield | | Y_f_BIPV / [kWh/m2] |
| | | Specific AC Final system yield | | Y_f / [kWh/kWp] |
| | | PV array system Yield | | Ya / [kWh/kW] |
| | | Self-sufficiency Index | | Ssi / [%] or [-] |
| | | Degradation rate | | Rd / [%/year] |

*Table 4: Final table of KPI ENERGY and Parameters description.*

A similar work is carried out through the five other KPIs and to arrive at a new representation of the updated parameters that will be used in the INCREASE project. The final KPIs and parameters saved are displayed in Figure 3 and try to tackle the most relevant element of BIPV or IPV solutions.

After setting the parameters, it is necessary to determine how the scores are to be awarded. For standard KPI the score range is well defined, but for the new KPIs introduced in the INCREASE project, the scale (Metric or unit) must be defined and the associated score range validated. This Deliverable version present the quantitative rating basis, comes from the IEA PVPS T15 works for the following KPIs; ENERGY, ECONOMY, ENVIRONMENT and AESTHETIC. These categories were chosen based on the IEA-PVPS Task 15 Report “Compilation and Analysis of User Needs for BIPV and its Functions” [2] and internal discussions in the Task 15 expert group. For last two, COMFORT and BUILDABILITY, the definition work is at an early stage and will be consolidated for the second version of the deliverable.

Before going into detail of parameters, let’s explain how KPIs scores are calculated and the numerical weight of each parameter.

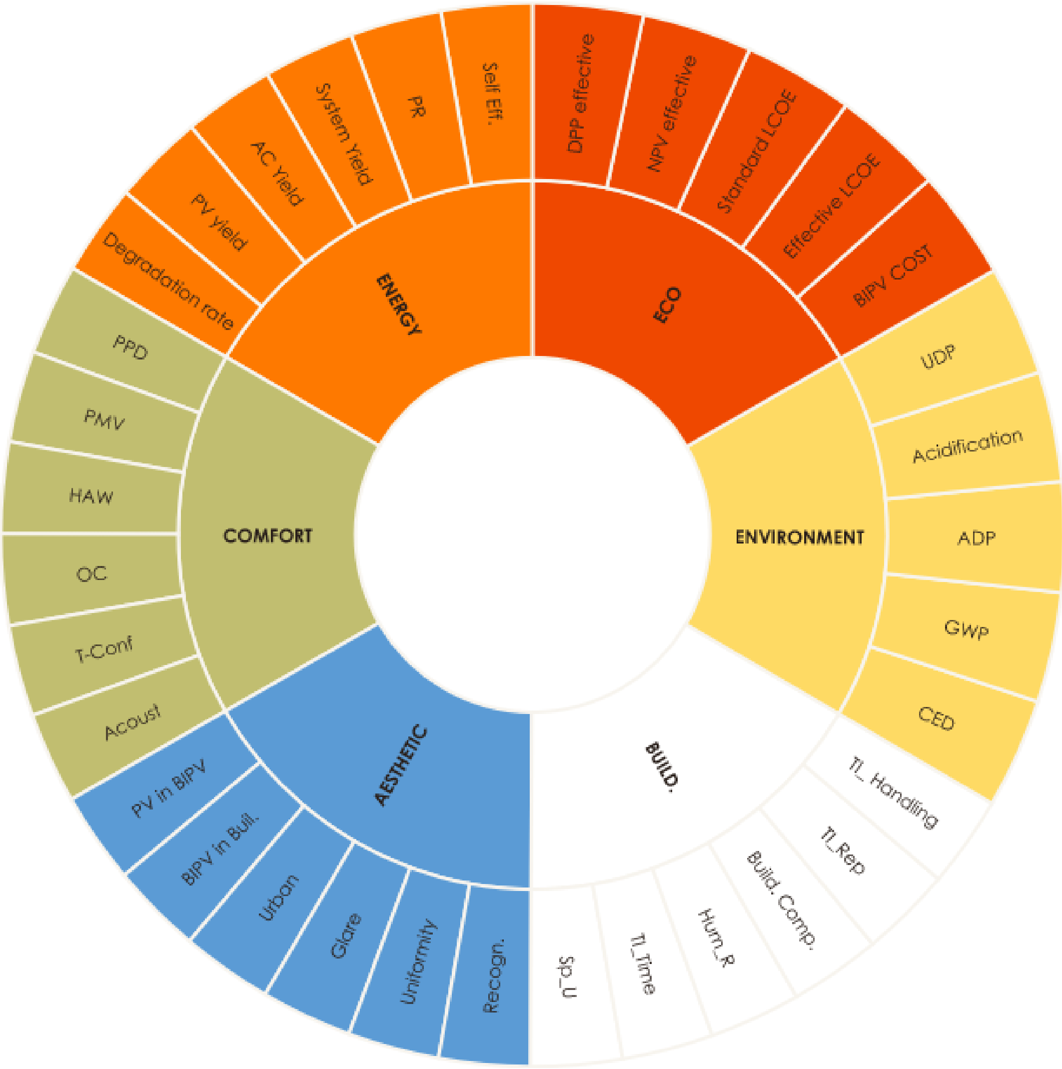


*Figure 3: Final KPIs list and associated parameters after rationalization.*

## 3. KPI score - Calculation methodology

The present work is an extension of the multi-dimensional evaluation tool developed under the framework of the IEA PVPS T15. This tool fits perfectly with the expectation of BIPV performance assessment solution to define the best solution to promote or that fits with building needs. An additional work has been done in BIPVBOOST EU project with the feedback of BIPV market and stakeholder analysis [2] ].

The approach of the tool is intended to be objective and therefore does not lead to favouring one KPI among all. Indeed, every KPI is calculated with the same calculation methodology, a mean value of all parameters embedded in the KPI. As shown in the Figure 3, every KPI is calculated using the arithmetic average with its own parameters.

The value weight of each parameter is currently the same for all parameters. although it may be possible to change the weight of each parameter at a later date, at this stage of the work, the value assigned to each parameter is identical and will provide an integer value between 1 and 5.

Each assigned value's parameter is provided from a range of value described by calculation or provided by experts from corresponding domain. Each range is divided in 5 subranges where each corresponds to a parameter value. The smallest value of subrange corresponds to the smallest value of the parameter and is therefore the worst notation; 1. On the other hand, the highest subrange value corresponds to the best rating; 5, expressing that the parameter has reached its best score.

The final KPI value is the arithmetic mean value calculated with all parameters' values. This calculated value is the corresponding score of the respective KPI, score value is between 1 and 5.

# 4. KPIs and parameters descriptions

## a) KPI ENERGY: definition and parameters

Energy key performance indicator aims to manage parameters dealing mainly with energetic values or metrics allowing to monitor or express PI. This PI refers to the electrical performance of energy systems as described in IEC reference standard [4].

The considered parameters in T15 are :

- The BIPV array DC electricity yield (YA)
- The final system AC yield (Yf)
- The area-specific AC final system yield (calculated relative to the total BIPV array area)
- The annual performance ratio (PR)
- The self-sufficiency index (SSI)

An additional parameter revealed by the work of the INCREASE project is :

- The degradation rate (Rd)

YA is the DC electricity output (kWh) directly from the photovoltaic array per unit of rated installed array power (kWc) while Yf is the net AC electricity output of the entire BIPV system (kWh) per unit of rated installed power (kWc) including the conversion efficiency. The area-specific AC final system yield implicitly includes the BIPV module efficiency, which is intrinsically dependent on the PV technology and BIPV design, and efficiency of all electrical parts (inverter, connections, cables, junction boxes, …).

While the three parameters described above are climatically dependant of the installation's location, PR is defined in IEC EN 61724 [4]. The performance ratio PR is defined as the ratio of the system's final yield Yf (kWh/kW) to its reference yield Yr (h) and represents the overall effect of losses on the BIPV. The self-sufficiency index (SSI) describes the percentage of electricity consumed by the building that is generated by the BIPV system. Finally, the Rd rate is described as a percentage of energy degradation over the time [5] and have to be checked yearly as the degradation is highly non-linear over the time. Rd could be highly dependant of integration solution due to temperature behaviour.

All these six parameters are used to calculate the mean value of ENERGY KPI according to the calculation methodology explained above.

| Energy-relevant Pis | Ref. | Unit | minimum values | maximum values |
|---|---|---|---|---|
| PV array energy yield (DC) | Ya | kWh/kWp | 0 | 1500 |
| AC final system yield | Yf | kWh/kWp | 0 | 1350 |
| Area-specific AC final system yield | AC | kWh/m$^2$ | 0 | 300 |
| Performance Ratio (annual) | PR | % | 0 | 100 |
| Self-sufficiency index | SSI | % | 0 | 100 |
| Degradation rate | Rd | %/Y | 0 | 100 |

*Table 5: Energy relevant parameters – Unit and full range.*

| rating 1 | rating 2 | rating 3 | rating 4 | rating 5 |
|---|---|---|---|---|
| <550 | 550 - 825 | 825 - 1100 | 1100 - 1375 | > 1375 |
| < 500 | 500 - 750 | 750 - 1000 | 1000 - 1250 | > 1250 |
| <100 | 100 - 150 | 150 - 200 | 200 - 250 | > 250 |
| < 50 | 50-60 | 60-70 | 70-80 | >80 |
| <5 | 5-20. | 20-50 | 50-80 | >80 |
| >5 | <5 | <2 | <1 | <0,5 |

*Table 6: Energy relevant rating score of each parameter according to the value calculated or measured.*

## b) KPI ECONOMY: definition and parameters (All)

The economic performance is determined using six PIs already well documented in the IEA T15. The performance indicators chosen for this evaluation are based on the approach described in [6]. In addition to the standard and extended calculated indicators, material replacement costs are also taken into account. The benefits from material replacement values (MPV) are also considered.

The considered parameters for economy performance indicator are:

- The BIPV building element costs (BIPV_Cost)
- The material replacement value (MRV)
- The standard LCOE (LCOE)
- The extended LCOE (eLCOE)
- The net preset value (NPV) defined as the net value of life cycle costs and life cycle income
- The extended payback period (eDPP).

The BIPV_Cost is the BIPV building element costs including all stage from conception to installation, defined in terms of cost per square metre as described in [6]. The LCOE is defined as the ratio of the total lifecycle cost over the total lifetime output electricity, with the unit as €/kWh and will be compared to grid prices. Beyond LCOE, the extended LCOE will be also introduced (eLCOE).

The MRV is the cost of equivalent building materials that are replaced by the BIPV modules [6]. The MRV for an integrated BIPV could be the cost of a reference building solution and is treated as a benefit resulting from the substitution of the conventional building material by PV. The net present value (NPV) is defined as the net value of life cycle costs and life cycle income. The extended payback period (eDPP) defines the number of years that the project needs before the full refund.

All these six parameters are used to calculate the mean value of ECONOMY KPI according to the calculation methodology explained above.

| Economic Pis | Ref. | Unit | minimum values | maximum values |
|---|---|---|---|---|
| BIPV system costs | BIPV_Cost | €/m² | 130 | 1550 |
| Material replacement value | MRV | €/m² | 0 | 460 |
| Eff. LCOE | LCOE | €/kWh | (-0,5) | 0,65 |
| Standard LCOE | eLCOE | €/kWh | -0,15 | 1,2 |
| Eff. eNPV | NVP | €/m² | (-9700) | 13700 |
| Eff. DPP | eDPP | a | 1 | 30 |

*Table 7: Economic relevant parameters – Unit and full range.*

| rating 1 | rating 2 | rating 3 | rating 4 | rating 5 |
|---|---|---|---|---|
| > 1400 | 1400 -1100 | 1100 - 700 | 700 - 300 | < 300 |
| < (-1000) | (-1000)- (-600) | (-600)- 0 | 0 - 200 | > 200 |
| > 0.4 | 0,4 - 0,24 | 0,24 - 0 | 0 - (-0,3) | < (-0,3) |
| > 0.7 | 0,7 - 0,4 | 0,4 - 0,24 | 0,24 - 0 | < 0 |
| < (-5000) | (-5000) - 0 | 0 - 5000 | 5000 - 10000 | > 10000 |
| > 25 | 25 - 15 | 15 - 10 | 10 - 2 | < 2 |

*Table 8: Economy relevant rating score of each parameter according to the value calculated or measured.*

## c) PI ENVIRONMENT: definition and parameters (CSTB)

The environmental PIs include metrics for consumption of non-renewable primary energy (mineral and metal resources, as well as water consumption, greenhouse gas emissions), particulate matter emissions and emissions contribution to acidification. The six PIs are calculated with data partially given PV datasheets but must be filled with all surrounding components used in the BIPV final solution. The first data are provided with the environmental product declaration of modules (if available) and the standard date required to perform a complete LCA analysis, such as the bill of materials and country of manufacturing of the module and components, the size and number of the elements, the power and the PV technology applied. Once again, the work carried out by IEA PVPS is used as a working base. The Report IEA-PVPS T12-19:2020 "Life Cycle Inventories and Life Cycle Assessments of Photovoltaic Systems" [7] gives the description of the indicators the PIs name and the references data for the rating.

The considered parameters for environment performance indicator are:

- Consumption of renewable primary energy resources (CED non-renewable)
- The Global Warming Potential (GWP)
- The Abiotic resource depletion (ADP)as the use or resources
- The Impact on human health (PM) with particulate matter
- The Accumulated Exceedance (Acidification: Acid.)
- The water consumption, named User Depreviation Potential (UDP)

Note that these variables are evaluated over the entire LCA of the BIPV system according to the calculation methodology described in [7]. The environmental impacts are quantified per kWh electricity generated by the BIPV system assessed. All the elements comply with the weather protection function (façade/roof/infrastructure) are assigned to the life cycle assessment (LCA) of the building and thus excluded when evaluating the environmental impacts of electricity generation.

| Environmental Pis | Ref. | Unit | minimum values | maximum values |
|---|---|---|---|---|
| CED non renewable | CED | MJ oil eq. / kWh | 0,22 | 1,25 |
| Climate Change GHG | GWP | g CO2 eq. / kWh | 15 | 88 |
| Resource Use, Minerals+Metals | ADP | mg Sb eq. / kWh | 1,06 | 6,53 |
| Particulate Matter | PM | 10-9 disease | 0,55 | 4,29 |
| Acidification | Acid. | µmol H+ eq. /kWh | 104 | 563 |
| Water use | UDP | m3 world eq. /kWh | 0,0022 | 0,0139 |

*Table 9: Environmental relevant parameters – Unit and full range.*

| rating 1 | rating 2 | rating 3 | rating 4 | rating 5 |
|---|---|---|---|---|
| > 1,25 | 1,25 -0,91 | 0,91 - 0,56 | 0,56 - 0,22 | < 0,22 |
| > 88 | 88 - 63,7 | 63,7 - 39,3 | 39,9 - 15 | < 15 |
| > 6,53 | 6,53 - 4,71 | 4,71 - 2,88 | 2,88 - 1,06 | < 1,06 |
| > 4,29 | 4,29 - 3,04 | 3,04 - 1,80 | 1,80 - 0,55 | < 0,55 |
| > 563 | 563 - 410 | 410 - 257 | 257 - 104 | < 104 |
| > 0,0139 | 0,0139 - 0,010 | 0,010 - 0,0061 | 0,0061 - 0,0022 | < 0,0022 |

*Table 10: Environmental relevant rating score of each parameter according to the value calculated or measured.*

## d) KPI COMFORT: definition and parameters (MTB/BUILDUP)

Note on interpretation of Comfort KPIs: The comfort KPIs are NOT just to be understood as “Comfort-KPI-related-to-a-BIPV-Technoloy”. But they strongly relate to the specific building and the specific way how BIPV is applied in that project.

Example 1:

- If a building **has no** cooling system, then a BIPV facade cladding can improve thermal comfort (by reducing overheating hours)
- If a building **has a** cooling system, then a BIPV facade cladding will have no impact on thermal comfort. Instead, cooling energy could become less.

Example 2:

- Shading & reflection effects of a PV system strongly depend on where and how the BIPV is installed

| Comfort PIs | Ref. | Unit | Minimum values | Miximum values |
|---|---|---|---|---|
| Fanger PPD index | PPD | % | | |
| Fanger PMV index | PMV | Index | | |
| Humidity / air / water index | HAW | % | | |
| Optical confort | OC | % | | |
| Thermal comfort / Well being | T_Comf | ΔT/Tref or % deviation h/year | | |
| Acoustic comfort | dB Att | %dB | | |

*Table 11: Comfort relevant parameters – Unit and full range.*

| rating 1 | rating 2 | rating 3 | rating 4 | rating 5 |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

*Table 12: Comfort relevant rating score of each parameter according to the value calculated or measured.*

## e) KPI AESTHETIC: DEFINITION AND PARAMETERS (EPFL/BYC)

KPI aesthetic try to handle all the visual parameters that could characterize a BIPV project. The aesthetic PIs include different aspects related to the visual rendering of the BIPV system, including the recognizability as a PV system and the colour uniformity in the surrounding building elements. These visual or aesthetical indicators are assessed with reference to the architectural intention as described in [1]. These parameters will play a significant role for historical sites or landscape protection zones which must comply with restrictive visual appearance. Coloured or textured modules are a commonly used solution to meet the aesthetical requirements. The work carried out by Babin et Al.[8] focused on the glare risk (GLARE) in close proximity with a particular attention for dense urban districts or areas with specific regulation (Highways, airports, …).

The considered parameters for aesthetic performance indicator are:

- The recognizability of PV solutions (Reco.)
- The colour uniformity of the BIPV array (Unif.)
- The glare effect of BIPV solution (GLARE)
- The identification of a building using BIPV in the urban environment (Urban)
- The identification of a BIPV system in a whole building (BIPV)
- The identification of PV modules in a BIPV system (PV)

The three last PIs are relative to the degree of visual integration into the environment on three different scales: At the module level (considering integration into the BIPV system), at the system level (considering integration into the building) and at the building level (considering integration into the urban environment), based on the hierarchical description developed by ENEA in [9] and described on three different scales the level of visual integration into the built environment.

For the colour measurement a specific protype colourimeter tool to measured colour behind transparent front-sheet will be developed by EPFL in Task 5.1. The colour variation (Delta-E) can be calculated in the CIELab color space as the distance between points in a 3-dimensional space as described in [10].

| Aesthetical PIs | Ref. |
|---|---|
| Recognizability | Reco. |
| Colour | Unif. |
| Glare | Glare |
| BIPV building <-> urban environment | Urban |
| BIPV system <-> whole building | BIPV |
| PV module <-> BIPV system | PV |

*Table 13: Aesthetic relevant parameters – Unit and full range.*

| Main parameter | rating 1 | rating 2 | rating 3 | rating 4 | rating 5 |
|---|---|---|---|---|---|
| Y/N | | | | | |
| Spatial ΔC(A) and angular<br>ΔC(θ) colour uniformity<br>(validation needed) | ΔC(A) > 10 / --*<br>ΔC(θ) > 10 / --*<br>*if desired | ΔC(A) < 10 /--*<br>ΔC(θ) < 10 / --*<br>*if desired | ΔC(A) < 7 / --*<br>ΔC(θ) < 7 / --*<br>*if desired | ΔC(A) < 4 / --*<br>ΔC(θ) < 4 / --*<br>*if desired | ΔC(A) < 1 / --*<br>ΔC(θ) < 1 / --*<br>*if desired |
| Glare risk<br>(example calculations and<br>validation needed) | Risk for<br>flash blindness<br>>10 hours annually | Risk for<br>flash blindness<br>1-10 hours | Risk for<br>discomfort glare<br>>10 hours annually | Risk for<br>discomfort glare<br>1-10 hours annually | Risk for<br>discomfort glare<br><1 hour annually |
| Y/N | | | | | |
| Y/N | | | | | |
| Y/N | | | | | |

*Table 14: Aesthetic relevant rating score of each parameter according to the value calculated or measured.*

## f) KPI BUILDABILITY: DEFINITION AND PARAMETERS (MTB/TECN/BYC)

| Buildability PIs | Ref. | Unit | Minimum values | Miximum values |
|---|---|---|---|---|
| Specific transmission (U building) | Sp-U | W/m².K | | |
| Total installation time | TI_Time | h/m² | | |
| Human ressource | Hum_R | n | | |
| ect on the surrounding area / compatibil | Build Comp | n / m² | | |
| repairability | TI_ Rep | h/m² | | |
| tal loading/transportation/unloading tim | TI_Handling | h/element or m² | | |

*Table 15: Buildability relevant parameters – Unit and full range.*

| rating 1 | rating 2 | rating 3 | rating 4 | rating 5 |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

*Table 16: Buildability relevant rating score of each parameter according to the value calculated or measured.*

## 5. Final Release

A final release of this work is expected just after the one-year project general assembly where a dedicated workshop will be allocated. The complete validation of all parameters for each performance indicator will be assessed. A final check will be carried out on the calculation methodology to validate the complete compatibility with all demo sites and capability to implement dataset for onsite measurements.

## 6. Conclusion

The first stage of this work allowed to update KPIs developed in the framework of T15 by adding some new parameters but overall to check the compatibility with the implementation of these KPIs based on measurement on site, not exclusively based on calculation or model-based approaches. Energy, Economy, Environment and Aesthetic are pretty well defined KPIs and parameters already used in some projects as BIPVBOOST project. We will have to apply them on demo-sites and experimental sites of INCREASE project and adapt them if necessary to the specific constraints of the project.

Concerning Comfort and Buildability KPIs, they have been raised by the partners as missing indicators allowing to promote and support BIPV development and to give explicit outcomes for end-users or decision-makers. These last two parameters will be addressed during the next project working meetings to define the range of each parameter and the corresponding rating. This work will have to by comply with the results of the final release.

One crucial point is to define KPI on calculation-based approach but also to integer on site measurement data according to measurement protocol developed in the Task 5.3, based on monitoring protocol given in the IEC 61724-1:2021

## 7. References

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# DELIVERABLE INFORMATION

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| **Deliverable Number:** | D6.2 |
| **Deliverable Title** | KPIs for design to demonstration and beyond: KPIs, and monitoring approaches |
| **Work Package Number** | 6 |
| **Work Package Title** | KPIs for design to demonstration and beyond |
| **Lead Organisation** | CSTB |
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| **Reviewers** | Julius Jacob (Metabuild), Maria Jimenez (Onyx) |
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| **Project Acronym** | INCREASE |
| **Grant Agreement No.** | 101136112 |
| **Project Start Date** | 01-10-2023 |
| **Project End Date** | 31-03-2028 |
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| 2 | TECNALIA | Fundacion Tecnalia Research & Innovation |
| 3 | CSTB | Centre Scientifique et Technique du Batiment |
| 4 | KU Leuven | Katholieke Universiteit Leuven |
| 5 | VITO | Vlaamse Instelling voor Technologisch Onderzoek n.v. |
| 6 | IBS | Institute of Baltic Studies |
| 7 | ONYX | Onyx Solar Energy SL |
| 8 | Soltech | Soltech |
| 9 | Sunstyle | Sunstyle International |
| 10 | BuildUp | BuildUp |
| 11 | BECSA | Becsa Sociedad Anonima |
| 12 | BYCN | Bouygues Construction |
| 13 | METABUILD | Metabuild GMBH |
| 14 | CEI | Comitato Elettrotecnico Italiano C.E.I. |
| 15 | AIE/ EuropeOn | Association Européenne de l'Installation Electrique |
| 16 | EPIA | SolarPower Europe |
| 17 | EBC | European Builders Confederation |
| 18 | ETS | Euskal Trenbide Sarea |
| 19 | PODGORICA | Glavni Grad Podgorica |
| 20 | EPFL | Ecole Polytechnique Federale de Lausanne |
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