D2.2
EU regulations and legislation for PV construction components. ETFE particularities.

ETFE-MFM

Development and demonstration of flexible multifunctional ETFE module for architectural façade lighting

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Summary

This document contents information related to the EU regulations and legislation for PV construction components, specifically for ETFE-MFM modules, aimed to the introduction of construction products in the building market, by means of the assessment of the performance and in order to obtain the CE marking.

Additionally, procedures for the life cycle costs analysis and potential contribution of ETFE-MFM products to different building sustainability certifications are examined for ETFE-MFM developments.
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Introduction

The main objective of the EU regulations and legislation for PV construction components is to remove technical barriers to trade in the field of construction products in order to enhance their free movement in the internal market. In the case of construction units based in ETFE exists a double challenger, due to the fact that there is no specific harmonized standard to assess and validate the performance of this kind of elements in order to obtain the CE marking.

Anyway, alternative procedures to achieve this target is contemplated by the current legislation, which lay down the harmonized conditions to express the performance of construction products according to their essential characteristics, not only by means of the compliance with the existing harmonized standards but also through the achievement of an specific European technical assessment that allows innovative developments to get the CE marking.

The European assessment documents elaborated to obtain the European Technical Assessment and the CE marking could be used, in turn, to generate new harmonized standards suitable for the characterization and standardization of based in ETFE construction components in order to promote the introduction of this material in the building sector. Multifunctionality of the ETFE-MFM product, with its extra capabilities of PV power generation and LED lighting, will be a relevant contribution for the achievement of this goal.

This document explains the existing options about the standardization procedure of construction products, specifying for MFM-EFTE components, in order to get the CE marking and commercialize the development item in the European market.
1 Harmonised conditions for the marketing of construction products

The European directive which regulates the marketing of construction items in the EU is the “Regulation (EU) 305/2011 of 9 March 2011”. It repeals the Council Directive 89/106/EEC, and simplifying and laying down the harmonized conditions for the marketing of construction products in the framework of the European Union.

This chapter analyse the standardized and alternative procedures to achieve the CE marking, in compliance with the current regulation, needed to commercialize the construction products in the EU’s countries.

1.1 General procedure for obtaining the CE marking

The CE marking is the manufacturer's declaration that the product meets the requirements of the applicable EC directives. To obtain the CE marking is indispensable to have drawn up a Declaration of Performance, where the essential characteristics of the construction product are detailed. The manufacturer can elaborate this document once assess and verify this performance through one of the two available ways: the compliance of the Harmonized Standards (hENs), if they exist for essential characteristics of the products; or the request of a European Technical Assessment (ETA), if there is no standard appropriated to the assessment of these features. Both measures, in turn, are inspired in the Basic Requirements, a set of essential guidelines for construction works and products.
In the following sections every document or process will be analysed, in order to detect in the next chapter the steps that ETFE-MFM products had to take for obtaining the CE marking and may be commercialized in the EU countries.

1.2 Basic requirements for construction works

The basic requirements for construction works constitute the basis for the elaboration of standardisation directives and harmonised technical specifications. In such a way that the essential characteristics of the construction products will be established through harmonized technical standards inspired in the basic requirements for construction works.

Essential characteristics are those features of the construction product which relate to the basic requirements for construction works. The performance of a construction works will be the gathering of the relevant essential characteristics expressed by level or class, or in a description. Level is the numerical value resulting from the assessment of the product’s performance according to the relevant essential characteristics. In the other hand, class is a range of levels, delimited by a minimum and a maximum value, of performance of a construction product.

Basic requirements for construction works, basis criteria for the elaboration of the Declaration of Performance

There are seven points around basic requirements for construction works are laid down: 1. Mechanical resistance and stability; 2. Safety in case of fire; 3. Hygiene, health and the environment; 4. Safety and accessibility in use; 5. Protection against noise; 6. Energy economy and heat retention; and 7. Sustainable use of natural resources.
Construction works as a whole and in their separate parts must be fit for their intended use, taking into account in particular the health and safety of persons involved throughout the life cycle of the works. Subject to normal maintenance, construction works must satisfy these basic requirements for construction works for an economically reasonable working life.

More detailed explanation of the basic requirements for construction works can be found in the Annex I of the Regulation (EU) 305/2011.

Basic requirements for construction works are applied to both procedures for obtaining the CE marking, depending on the existence of harmonized standards or the need of a European Technical Assessment which justify the declaration of performance of the products.

1.3 Harmonised technical specifications

Except in the cases laid down in the Regulation (EU) 305/2011, it is considered mandatory for every product covered by a harmonized standard to issue a Declaration of Performance and the CE marking, in relation to the essential characteristics of the construction product in accordance with such specification. This kind of construction products has to be accompanied by a Declaration of performance for being commercialize within the EU market.

In the other hand, products not covered or not fully covered by a harmonized standard need to get a European Technical Assessment for obtaining the CE marking. In any case, it has to be accompanied by a Declaration of Performance for being commercialize in the EU.

Channels available to obtain the CE marking
Both channels to access the CE marking are valid depending on the case. The concept of “harmonised technical specifications” comes to mean as well harmonised standards as European Assessment Documents, in order to unify terms.

Harmonised technical specifications are established to assess the performance of construction products, according to the before mentioned basic requirements of construction works, by means of testing of the products in lab taking into account not only technical features but also health and safety aspects related to its use during its entire life cycle.

The methods used by the Member States in their requirements for construction works, as well as other national rules relating to the essential characteristics of construction products, should be in accordance with harmonised technical specifications. It should further be taken into account different levels of basic requirements for certain construction works as well as of the differences in climate, geology and geography and other different conditions prevailing in the EU countries.

The European Committee for Standardisation (CEN) and the European Committee for Electrotechnical Standardisation (CENELEC) are recognised as the competent organisations for the adoption of harmonised standards.

Following both channels to achieve the CE marking are analysed in detail.

- **Channel 1: harmonized standards**

  Harmonized standards were conceived with the intention of removing the technical barriers in the building field and stimulate the commercialization and use of construction products within the European Union.

  They come to provide the methods and the criteria for assessing the performance of the construction products in relation to their essential characteristics, and include technical details necessary for the implementation of the system of assessment and verification of constancy of performance.

  Harmonized standards can only be adopted by one of the European standardisation bodies listed in Annex I to Directive 98/34/EC:

  - **CEN**: European Committee for Standardisation.  
    [https://www.cen.eu](https://www.cen.eu)

  - **Cenelec**: European Committee for Electrotechnical Standardisation.  
    [http://www.cenelec.eu](http://www.cenelec.eu)

  - **ETSI**: European Telecommunications Standards Institute.  
    [http://www.etsi.org](http://www.etsi.org)

- **Channel 2: European Technical Assessment**

  In order to allow a manufacturer of a construction product to draw up a Declaration of Performance for a construction product which is not covered or not fully covered by a harmonised standard, it is necessary to provide for a European Technical Assessment.

  It consists in the documented assessment of the performance of a construction product, in relation to its essential characteristics, in accordance with the respective European Assessment Document (EAD).

  To achieve a European Technical Assessment, it will be necessary the elaboration of a European Assessment Document in order to provide the methods and the criteria for assessing the performance
of the construction products in relation to their essential characteristics. The need of this document will be evaluated from the criteria contained in the Regulation (EU) 305/2011:

Following a request for a European Technical Assessment by a manufacturer, a European Assessment Document shall be drawn up and adopted by the organisation of TABs for any construction product not covered or not fully covered by a harmonised standard, for which the performance in relation to its essential characteristics cannot be entirely assessed according to an existing harmonised standard, because, inter alia:

a) The product does not fall within the scope of any existing harmonised standard;

b) For at least one essential characteristic of that product, the assessment method provided for in the harmonised standard is not appropriate; or

c) The harmonised standard does not provide for any assessment method in relation to at least one essential characteristic of that product.

These criteria will have to be carefully considered in order to evaluate the appropriate channel to obtain the CE marking of the ETFE-MFM product, its technological units or associated processes. The highly-innovative character of the ETFE-MFM developments makes think of the suitable option will be the request of a European Technical Assessment through the procedure explained.

The establishment of draft European Assessment Documents and the issuing of European Technical Assessments are entrusted to the Technical Assessment Bodies (TAB) designated by Member States together with the European Commission. There exists an organisation of TABs thought to coordinate the tasks assigned to these bodies. Among its functions, it is in charge of ensuring the transparency and the necessary confidentiality of these procedures. In the other hand, the Technical Assessment Bodies, together with the organisation of TABs, bear the full costs of the development and adoption of European Assessment Documents.

The TAB which has received a request for an ETA has to inform the manufacturer if the construction product is covered, fully or partially, by a harmonised technical specification. If there is a harmonised standard covering the product a European Technical Assessment cannot be issued. As an alternative, if the product is fully covered by a European Assessment Document, it would be used as the basis for the European Technical Assessment. In the opposite, if the product is not covered, or not fully covered, by any harmonised technical specification, the TAB would apply the procedures to issue a new European Assessment Document suitable to carry out the European Technical Assessment.

The procedure to request the European Technical Assessment by means of the adoption of a European Assessment Documents is explained in the Annex II of the Regulation (EU) 305/2011.

According to the Regulation (EU) 305/2011, a European Assessment Document must contain, at least, a general description of the construction product, the list of essential characteristics, relevant for the intended use of the product as foreseen by the manufacturer and agreed between the manufacturer and the organisation of TABs, as well as the methods and criteria for assessing the performance of the product in relation to those essential characteristics.

Legislation provided the use of the European Technical Approval Guidelines (ETAGs), established under Directive 89/106/EEC, as European Assessment Documents. In such a way that European Technical Assessments can be requested based on them. Sometimes, European Assessment Documents are
taken in turns as a basis for the development of new harmonised standards which cover new products, or families of products, with the innovative features previously not considered.

The European Technical Assessment would include the performance to be declared, by levels or classes, or in a description, of those essential characteristics; as well as technical details necessary for the assessment and verification of constancy of performance. Regulation (EU) 305/2011 also explains in detail the procedure to establish the levels or classes of performance and other considerations in relation to the essential characteristics of construction products.

1.4 Assessment and verification of constancy of performance

In order to ensure that the declaration of performance is accurate and reliable, the performance of the construction product should be assessed and the production in the factory should be controlled in accordance with an appropriate conformity system of assessment and verification of constancy of performance of the construction product. The European Commission would choose the most appropriated conformity system which fulfils all basic requirements for construction works among the following, starting with the most stringent one: conformity system 1+, conformity system 1, conformity system 2+, conformity system 3, and conformity system 4.

Assessment and Verification of Constancy of Performance (AVCP) consist in the evaluation separately by the manufacturer and, in some cases, the notified product certification body of the, among others: factory production control; samples taken at the factory; product-type on the basis of type testing, type calculation, tabulated values or descriptive documentation of the product; samples taken before placing the product on the market; etc. With respect to the function of notified bodies involved in the AVCP for construction products, distinction shall be made between: product certification body, factory production control certification body, and testing laboratory. In the other hand, there are some essential characteristics where reference to a relevant harmonised technical specification is not required: reaction to fire, resistance to fire, external fire performance, noise absorption, and missions of dangerous substances.

More details about all these subjects may be looked up in Regulation (EU) 305/2011, Annex V.
Once fulfilled the assessment and verification of constancy of performance, Declaration of Performance and CE marking can be elaborated and used.

**1.5 Declaration of performance and CE marking**

When a construction product is covered by a harmonised standard or conforms to a European Technical Assessment which has been issued for it, the manufacturer can draw up a Declaration of Performance when such a product is placed on the market.

The Declaration of Performance expresses the performance of construction products in relation to the essential characteristics of the product in accordance with the relevant harmonised technical specifications. This includes, among other, the following information: reference of the product-type; system or systems of assessment and verification of constancy of performance of the product; reference number and date of issue of the harmonised standard or the European Technical Assessment which has been used for the assessment of each essential characteristic; intended use or uses for the construction product; list of essential characteristics; where applicable, performance of the construction product by levels or classes, or in a description, especially when a European Technical Assessment has been issued.

The CE marking should be affixed to all construction products for which the manufacturer has drawn up a declaration of performance in accordance with this Regulation. If a declaration of performance has not been drawn up, the CE marking should not be affixed. Manufacturer is solely responsible of the conformity of the construction product with the declared performance, as well as the compliance with all applicable requirements laid down by the European legislation.

More details about the necessary content of the Declaration of Performance, the terms and conditions of use of the CE marking, and other related subjects are widely explained in Regulation (EU) 305/2011, Chapter II and
Annex III. In the other hand, obligations of economic operators involved in all these processes (manufactures, authorised representatives, importers and distributors) are also detailed in Chapter III.
2 Standardization and CE marking of ETFE-MFM construction products

In order to sell a construction product in the European Union (EU) the manufacturer has the obligation to issue a Declaration of Performance (DoP) and affix the CE marking showing that the product is covered by a harmonised European Standard or a European Technical Assessment (ETA).

The manufacturer, by drawing up a DoP, assumes the responsibility for the conformity of the construction product with the declared performance.

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Source: [http://www.eota.eu/en-GB/content/what-is-ce-marking/48/](http://www.eota.eu/en-GB/content/what-is-ce-marking/48/)
2.1 Standardization of ETFE-MFM products through harmonised standards

A harmonised standard is a European Standard elaborated on the basis of a request from the European Commission to a recognised European Standards Organization to develop a European standard that provides solutions for compliance with a legal provision.

The European Standards Organizations, able to publish harmonised standards, are: CEN (European Committee for Standardization), CENELEC (European Committee for Electrotechnical Standardization) and ETSI (European Telecommunications Standards Institute).

Those European Organizations have a close relation with their respective International Standards Bodies: ISO (International Organization for Standardization), IEC (International Electrotechnical Commission) and ITU (International Telecommunication Union). Although these International Bodies publish and review many standards each year, only the European Standards Organizations (CEN, CENELEC and ETSI) are able to publish harmonised standards for checking the compliance with a European Directive or Regulation.

The harmonised European standards on construction products provide a solid technical basis for manufacturers for testing the performance of their products. They have been elaborated by technical experts working in the framework of the European Standardisation Organisations.

The construction sector in CEN covers more than 3000 work items on product standards and test methods (for use in building and civil engineering). Of these, about 600 standards started to be prepared under the Construction Products Directive (CPD) and are or will be harmonized under the Construction Products Regulation (CPR), along with about 1500 supporting standards (test methods).

The summary list of the harmonised standards related to the construction products can be consulted in the following link:


The list includes some standards related to plastic products that may provide some hints about critical issues to be examined in order to validate ETFE particularities. However, this material is not covered by any of currently in force standards so a proposal of new work item should be raised to corresponding normalization CEN/CENELEC committee in case of commercialization trough harmonized standards is considered as preferred option.

Following are some standards that should be taken into account for developing ETFE pre-normative work:

- **EN EN-1013:2012 Light transmitting single skin profiled plastics sheets for internal and external roofs, walls and ceilings - Requirements and test methods.** It is applicable to single skin sheets which are used as a single layer or when assembled to form a multiple layer construction. It also specifies the test methods and provides for the evaluation of conformity and marking of the sheets.

- **EN 1873:2014 Prefabricated accessories for roofing - Individual roof lights of plastics - Product specification and test methods.** This European Standard applies to rooflights and rooflights with upstand, where a single manufacturer provides all components of the rooflight with upstand, which are bought in a single purchase. This European Standard applies to rooflights with one or several
translucent parts. Rooflights may be opened by means of opening devices in one or more parts for ventilation.

- **EN 13245-2:2008 Plastics - Unplasticized poly (vinyl chloride) (PVC-U) profiles for building applications - Part 2: PVC-U profiles and PVC-UE profiles for internal and external wall and ceiling finishes.** This European Standard specifies the health and safety requirements for unplasticized poly (vinyl chloride) (PVC-U) profiles and cellular unplasticized poly (vinyl chloride) (PVC-UE) profiles for interior and exterior wall and ceiling finishes. It also specifies methods for the evaluation of conformity of the products to the requirements, and includes requirements for their marking. The products are intended for use as wall and ceiling finishes for internal and external applications according to the manufacturer’s specifications, which may include specifications for the fixings.

- **EN 14963:2006 Roof coverings - Continuous rooflights of plastics with or without upstands - Classification, requirements and test method.** This European Standard specifies requirements for continuous rooflights made of plastic materials (e.g. GF-UP, PC, PMMA, PVC) with or without bearing profiles to be used with upstands made of e.g. GF-UP, PVC, steel, aluminium, wood or concrete, for laying in roofs, which serve the purpose of lighting by means of daylight and, possibly, of ventilating interior spaces by means of opening devices. This European Standard applies to continuous rooflights without upstand and to continuous rooflights, where a single manufacturer provides all components of the rooflight with upstand, which are bought in a single purchase.

Apart from the construction product regulation, the multifunctional module includes also Photovoltaics and LED illumination, therefore it may be needed to take into account other European Directives, as the Low Voltage Directive (LVD) 2006/95/EC or the Electromagnetic Compatibility (EMC) 2004/108/EC.

Below mentioned photovoltaics standards are the most relevant form the point of view of construction:

- **IEC 61215. Crystalline silicon terrestrial photovoltaic PV modules, design qualification, and type approval.** This European Standard covers the crystalline silicon terrestrial photovoltaic (PV) modules. Since thin-film cell will be used in ETFE-MFM developments, only the EN 61646:2008 European Standard must be taken as reference, although it would be useful to have knowledge of the legislation applicable to traditional PV modules anyway.

- **EN 61646:2008. Thin-film terrestrial photovoltaic (PV) modules, design qualification and type approval.** This International Standard lays down requirements for the design qualification and type approval of terrestrial, thin-film photovoltaic modules suitable for long-term operation in general open-air climates. This standard is intended to apply to all terrestrial flat plate module materials not covered by IEC 61215.

- **EN 61730-1:2007. Photovoltaic (PV) module safety qualification; parts 1 and 2: requirements for construction and testing, including protection class II.** These documents describe the fundamental construction and testing requirements for photovoltaic (PV) modules in order to provide safe electrical and mechanical operation during their expected lifetime.

As the market study revealed that the main market is outside the EU, international or outside of the EU standards should be considered. The following PV regulation could be useful in this way:
Grant Agreement: 322459  EU regulations and legislation for PV construction components. ETFE particularities.

- UL 1703 UL. Standard for safety flat-plate PV modules and panels; extended safety inspections for building-integrated photovoltaics (BIPV).

The Low Voltage Directive covers electrical equipment with a voltage between 75 V and 1500 V for Direct Current. Neither the photovoltaics modules nor the LED illumination systems are expected to reach those voltage values, so this Directive does not apply to the ETFE multifunctional module.

The Electromagnetic Compatibility Directive is not applicable to the PV part of the multifunctional module, because it is incapable of generating electromagnetic emissions which exceed a level allowing radio and telecommunications equipment and other equipment to operate as intended, and it will operate without unacceptable degradation in the presence of electromagnetic disturbance normally present in its intended environment.

In the case of the LED illumination system, some tests may be needed in order to verify that it complies with the requirements of the EMC Directive. The summary list of the harmonised standards related to the EMC Directive can be consulted in the following link:


Following are some standards that should be taken into account:

- EN 55015:2013. Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment.

- EN 61000-3-2:2006. Electromagnetic compatibility (EMC) -- Part 3-2: Limits - Limits for harmonic current emissions (equipment input current <= 16 A per phase).

- EN 61000-3-3:2013. Electromagnetic compatibility (EMC) -- Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <= 16 A per phase and not subject to conditional connection.


2.2 Standardization of ETFE-MFM products through European assessment document

The European Assessment Document (EAD) is a harmonised technical specification. They are developed by the European Organization of Technical Assessment (EOTA) in cases where a product is not or not fully covered by a harmonised European Standard.

The elaboration of an EAD is based on a consensus of the designated Technical Assessment Bodies (TAB) within a determined procedure. It may follow the request of a manufacturer for a European Technical Assessment (ETA).
The EAD document contains the following information:

- A general description and identification of the construction product.
- General information on the scope and use.
- The list of essential characteristics, relevant for the intended use of the products as foreseen by the manufacturer and agreed upon between the manufacturer and the TAB.
- The methods and criteria for assessing the performance of the product.
- Reference to the applicable Assessment and Verification of Constancy of Performance (AVCP).
- Reference documents such as other EADs, standards, technical reports etc.
- Product related example for a Declaration of Performance.
- Principles for the applicable factory production control to be applied

Formerly, European Technical Approval Guidelines (ETA Guidelines or ETAGs) were elaborated in order to evaluate the specific characteristics/requirements of a construction product or a family of construction

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2 Source: [http://www.eota.eu/en-GB/content/how-an-ead-is-developed/40/](http://www.eota.eu/en-GB/content/how-an-ead-is-developed/40/)
products. ETAGs were used as basis for European Technical Approvals (ETAs). As of 1st of July 2013 no new ETAGs will be developed. ETAGs remain valid and can be used as EADs according to Construction Products Regulation (CPR) for issuing European Technical Assessments (ETAs).

The list of ETAG’s (used as EAD’s) as of June 2013 is shown in next link:

http://www.eota.eu/en-GB/content/etags-used-as-ead/26/

There are 35 ETAGs (European Technical Approval Guidelines) published by now that can be used as EADs. Two of these ETAGs may have common points with ETFE products:

- **ETAG 010 Self Supporting Translucent Roof Kits.** This Guideline sets out the performance requirements, the verification methods used to examine the various aspects of performance, the assessment criteria used to judge the performance for the intended use and the presumed conditions for the design and execution of the Self Supporting Roof Kits in the works. The scope of this ETAG includes roof kits comprising the complete roof covering placed on the market as a kit. The covering itself will be mainly composed of single or multi-layer polymeric translucent elements. They may however include opaque elements.

- **ETAG 023 Prefabricated Building Units.** Prefabricated Building Units, according to this Guideline, are construction products defined as follows: industrially prepared Building Units, marketed for use as buildings (singly or in combination). The Building Units are intended for production in series and are made of pre-designed and pre-fabricated components. Minimum requirements on the contents of such Building Units are defined. Units not meeting these minimum requirements are outside the scope and shall not be CE marked on the basis of the ETAG. These minimum requirements comprise all of the following: the structural elements of the Building Units, the essential components of the external envelope including all necessary thermal insulation and the internal linings in so far as they are necessary for the satisfaction of the Essential Requirements applied to the building.

Furthermore, EOTA also produces Technical Reports (TR) to ease the application of the ETAGs. They support the EAD development. By now 45 EOTA technical Reports are publicly available.

Source: http://www.eota.eu/en-GB/content/technical-reports/28/

### 2.3 European Technical Assessment of ETFE-MFM products

The European Technical Assessment (ETA) is a document providing information on the assessment of the performance of a construction product, in relation to its essential characteristics.

The ETA provides a way for the manufacturer to get the CE marking for a product. The ETA can be issued in the following cases:

- The product is not or not fully covered by any harmonised technical specification such as European Assessment Documents (EADs) or European Standards (hENs).

- The product is covered by a European Assessment Document (EAD)
An ETA contains the following information:

- General information on the manufacturer and the product type.
- Description of the product and its intended use.
- Performances of the product and references to the methods used for its assessment.
- Assessment and Verification of Constancy of Performance systems (AVCP) applied Technical details necessary for the implementation of the AVCP.
3. Life Cycle Cost Analysis execution procedure

Life cycle costing (LCC) is a tool for evaluating the total cost performance of an asset over time, including the acquisition, operating, maintenance, and disposal costs. Its main use is in assessing different options for accomplishing the client’s objectives, where those alternatives differ not only in their initial costs, but also in their subsequent operational costs. These techniques can be equally applied to major constructed assets or to the individual components and materials from which they are constructed.

The detailed benefits to be gained from carrying out a LCC analysis will depend on the purpose of the exercise and the conditions of the project, asset and client for which it is undertaken. Typical benefits can include:

- Transparency of future operational costs.
- Ability to plan for future expenditure (e.g. through the establishment of sinking funds).
- Improved awareness of total costs.
- Ability to manipulate and optimise future costs at the design stages.
- Achieving and demonstrating better value for money in projects.
- Compliance with public sector procurement requirements.
- Evaluation of competing options, either for entire assets or parts thereof.
- Performance trade-offs against cost (e.g. environmental performance).

LCC may be applied in a wide range of situations in construction, for example in a project to invest in:

- A single complete constructed asset such as a building or civil engineering structure.
- An individual component or assembly within a constructed asset.
- A portfolio comprising a number of assets.

The purposes for which LCC may be employed can also be divided into two broad categories:

- As an absolute analysis, when used to support the processes of planning, budgeting and contracting for investment in constructed assets.
- As a comparative analysis, when used to undertake robust financial option appraisals, for example in relation to potential acquisition of assets, design approaches or alternative technologies.

3.1 Common LCC Methodology

The key stages in the LCC methodology and their broad sequence are shown in the next table and figure.
<table>
<thead>
<tr>
<th>STEP</th>
<th>OUTCOME/ACHIEVEMENT</th>
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</thead>
</table>
| 1. Identify the main purpose of the LCC analysis | - Statement of purpose of analysis  
- Understanding of appropriate application of LCC and related outcomes |
| 2. Identify the initial scope of the analysis | Understanding of:  
- Scale of application of the LCC exercise  
- Stages over which it will be applied  
- Issues and information likely to be relevant  
- Specific client reporting requirements |
| 3. Identify the extent to which sustainability analysis relates to LCC | Understanding of:  
- Relationship between sustainability assessment & LCC  
- Extent to which the outputs from a sustainability assessment will form inputs into the LCC process  
- Extent to which the outputs of the LCC exercise will feed into a sustainability assessment |
| 4. Identify the period of analysis and the methods of economic evaluation | - Identification of the period of analysis and what governs its choice  
- Identification of appropriate techniques for assessing investment options |
| 5. Identify the need for additional analyses (risk/uncertainty and sensitivity analyses) | - Completion of preliminary assessment of risks/uncertainties  
- Assessment of whether a formal risk management plan and/or register is required  
- Decision on which risk assessment procedures should be applied |
| 6. Identify project and asset requirements | - Definition of the scope of the project and the key features of the asset  
- Statement of project constraints  
- Definitions of relevant performance and quality requirements  
- Confirmation of project budget and timescales  
- Incorporation of LCC timing into overall project plan |
| 7. Identify options to be included in the LCC exercise and cost items to be considered | - Identification of those elements of an asset that are to be subject to LCC analysis  
- Selection of one or more options for each element to be analyzed  
- Identified which cost items are to be included |
| 8. Assemble cost and time (asset performance and other) data to be used in the LCC analysis | Identification of:  
- All costs relevant to the LCC exercise  
- Values of each cost  
- Any on-costs to be applied  
- Time related data (e.g. service life/maintenance data) |
9. Verify values of financial parameters and period of analysis

- Period of analysis confirmed
- Appropriate values for the financial parameters confirmed
- Taxation issues considered
- Application of financial parameters within the cost breakdown structure decided

10. Review risk strategy and carry out preliminary uncertainty/risk analysis (if required)

- Schedule of identified risks verified
- Qualitative risk analysis undertaken – risk register updated
- Scope and extent of quantitative risk assessment Confirmed

11. Perform required economic evaluation

- LCC analysis performed
- Results recorded for use at Step 14

12. Carry out detailed risk/uncertainty analysis (if required)

- Quantitative risk assessments undertaken
- Results interpreted

13. Carry out sensitivity analyses (if required)

- Sensitivity analyses undertaken
- Results interpreted

14. Interpret and present initial results in required format

- Initial results reviewed and interpreted
- Results presented using appropriate formats
- Need for further iterations of LCC exercise identified

15. Present final results in required format and prepare a final report

- Final report issued, to agreed scope and format
- Complete set of records prepared to ISO 15686 Part 3

**Table of key stages in the LCC Methodology**

In practice it will often be possible for users to combine several of the above steps in order to fit the methodology to the size of the project, the project stage and the level of detail required. For instance, Steps 1 to 6 are related with defining the goals and the analysis parameters. On smaller projects this definition exercise might typically take the form of a meeting or telephone discussion with the client and/or an exchange of correspondence. Similarly, the risk and sensitivity analyses could be incorporated into the economic evaluation exercise (Step 11) based on a small number of agreed parameters and/or the practitioner’s experience of common risk issues. Regardless of the scale or scope of the exercise, the guiding principle should always be that the key issues identified in the methodology are all considered, albeit at a level of detail appropriate to the particular exercise.

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Grant Agreement: 322459  EU regulations and legislation for PV construction components. ETFE particularities.

LCC Methodology broad sequence

3.2 LCC and sustainability analysis

Environmental sustainability is becoming a key consideration in any long term assessment of constructed assets. Practitioners recognise three fundamental and interlinked sets of issues within the ‘sustainability’ agenda:

- Environmental – relating typically to air quality, land use, use of natural resources (raw materials, energy, water, waste, etc.), transportation, biodiversity, cultural heritage, etc.
- Social – relating typically to access, amenity, user comfort and satisfaction, community health and welfare.
- Economic – relating typically to opportunities for employment, skills development, local businesses including SMEs, etc.

Some sustainability issues are difficult to measure and to incorporate into a LCC analysis. However, LCC practitioners widely accept that the environmental impact associated with constructed assets can be significant and should always be considered. Life Cycle Assessment (LCA) is one of the most versatile and widely recognised in construction and is referred to in this methodology. It addresses the environmental aspects and potential environmental impacts (e.g. use of resources and the environmental consequences of releases) throughout a product’s life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal.

Whilst LCC and LCA are two distinct and different processes that have developed and are practised as separate disciplines in the construction industry, there are many parallels and interrelationships between the two. For example, both:

- Are concerned with assessing the long term impacts of decisions.
- Require analysis of an often diverse range of inputs.
- Use similar data on inputs of materials and energy.
- Take into account operation and maintenance.
- Consider opportunities for recycling vs. disposal.
- Provide a basis for rational decision making, particularly in appraising options.

However, the two disciplines differ in the basis of the resulting decisions:

- LCC combines all relevant costs associated with an asset into outputs expressed in financial terms as a basis for making investment decisions.
- LCA enables decisions to be made on the basis of potential environmental impacts by scoring and rating on environmental criteria. Whilst costs can be firmly attributed to some environmental factors there is currently no widely agreed methodology for others and some cannot be quantified at all in cost terms.
The use and sequence of LCC and LCA will depend on the priorities of the decision-maker. The range of approaches might cover, for example:

- Use of LCC and LCA as two of the criteria in the evaluation of a single investment option (such as the decision to construct an asset), where other evaluation criteria might include functionality, aesthetics, speed of construction, future investment returns etc.

- Use of LCC and LCA as two of the criteria in the evaluation of a number of alternative investment options (either entire constructed assets or specific components, materials or assemblies within them).

- Use of LCC to provide a financial/economic evaluation of those sustainability impacts that have a widely agreed and readily calculated monetary value.

- Use of LCC to provide a financial/economic evaluation of alternative options identified in a LCA assessment.

- Use of LCA as a means of identifying alternative options with a good environmental performance and then carrying out a LCC analysis on those options only.

- Use of LCC to select cost effective options, then making a final decision in the light of a process of LCA carried out on those options only.

Thus it can be seen that LCC and LCA can either be used alongside each other in a broader evaluation process, or either process can form an input into the other.
4 Contributions of ETFE-MFM product to improving the LEED and BREEAM certifications

LEED and BREEAM certifications are systems for the design, construction, operation, and maintenance of buildings and neighbourhoods.

Some features of the ETFE-MFM product can improve the LEED and BREEAM evaluation, contributing to the environmental sustainability of the building and increasing the implementation possibilities of this technology in the market.

4.1 Improvement of LEED Green Building Certification

Leadership in Energy and Environmental Design (LEED) is a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes and neighbourhoods.

The main objective of the LEED certification is to increase the environmental responsibility of the building developers, operators and owners, in order to achieve a more sustainable building concept by means of the improvement of efficiency during the construction works and the useful life of the building.

LEED was developed and is continuously reviewed and updated by the U.S. Green Building Council (USGBC), but actually is widely used by professional all over the world.

<table>
<thead>
<tr>
<th>Identification of LEED and BREEAM credits where ETFE-MTM item can contribute to</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum contribution</strong></td>
</tr>
<tr>
<td>EA Prerequisite: Minimum energy performance</td>
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<tr>
<td>EA Credit 1: Optimize energy performance</td>
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<tr>
<td>EA Credit 2: On-site renewable energy</td>
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<tr>
<td>IEQ Credit 6: Controllability of systems of lighting &amp; thermal comfort</td>
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<tr>
<td>IEQ Credit 7: Thermal Comfort</td>
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<tr>
<td>IEQ Credit 8: Daylight and Views</td>
</tr>
<tr>
<td>ID Credit 1: Innovation in Design</td>
</tr>
</tbody>
</table>

(*) EA: Energy and Atmosphere  
IEQ: Indoor Environmental Quality  
ID: Innovation in Design

Some LEED prerequisites and credits where ETFE-MTM can contribute to
LEED is a rating system consisting in the scoring of the degree of compliance of some prerequisites and credits based on accepted energy and environmental principles. It is structured into 5 environmental categories: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR) and Indoor Environmental Quality (IEQ). Additionally, Innovation in Design (ID) and Regional Priorities (RP) bonus points, not covered under the 5 environmental categories, are also considered. Each environmental category is organized in prerequisites and credits, with a quantitative weighting according to the relative importance of the building-related impacts that it addresses. The impacts are defined as the environmental or human effect of the design, construction, operation, and maintenance of the building. A combination of approaches, including energy modelling, life-cycle assessment, and transportation analysis, is used to quantify each type of impact. Some prerequisites and credits of LEED system have been designed for being applied to specific building typologies, sectors or project scopes.

Regarding the potential contribution of the foreseen ETFE-MFM project develops to a likely LEED certification, some prerequisites and credits have been detected as more susceptible to be applied in order to increase the LEED rating. The main subjects considered make reference to the benefits coming from the photovoltaics generation capability of the ETFE-MFM, within the Energy and Atmosphere (EA) category; the thermal, transparency and acoustic properties, and lighting functionality of ETFE-MFM units, for the improvement of the comfort within the Indoor Environmental Quality (IEQ) category; the waterproof of ETFE material, within the Sustainable Sites (SS) category; and the innovative character of design of architecture in ETFE with multifunctional features, related to the Innovation in Design (ID) category:

- **Energy and Atmosphere (EA)**
  - **Prerequisite 2: Minimum Energy Performance.** Intent: to establish the minimum level of energy efficiency for the proposed building and systems to reduce environmental and economic impacts associated with excessive energy use.
  - **Credit 1: Optimize Energy Performance.** Intent: to achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.
  - **Credit 2: On-Site Renewable Energy.** Intent: to encourage and recognize increasing levels of on-site renewable energy self-supply to reduce environmental and economic impacts associated with fossil fuel energy use.

- **Indoor Environmental Quality (IEQ)**
  - **Prerequisite 3: Minimum Acoustical Performance (only apply to study centres).** Intent: to provide classrooms that are quiet so that teachers can speak to the class without straining their voices and students can effectively communicate with each other and the teacher.
  - **Credit 6.1: Controllability of Systems, Lighting.** Intent: to provide a high level of lighting system control by individual occupants or groups in multioccupant spaces (e.g., classrooms and conference areas) and promote their productivity, comfort and well-being.
• Credit 6/6.2: Controllability of Systems, Thermal Comfort. Intent: to provide a high level of thermal comfort system control by individual occupants or groups in multi-occupant spaces (e.g., classrooms or conference areas) and promote their productivity, comfort and well-being.

• Credit 7/7.1: Thermal Comfort, Design. Intent: to provide a comfortable thermal environment that promotes occupant productivity and wellbeing.

• Credit 7.2: Thermal Comfort, Verification. Intent: to provide for the assessment of building occupants’ thermal comfort over time.

• Credit 8.1: Daylight and Views, Daylight. Intent: to provide for the building occupants with a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

• Credit 8.2: Daylight and Views, Views. Intent: to provide building occupants a connection to the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

• Credit 9: Enhanced Acoustical Performance. Intent: to provide classrooms that facilitates better teacher-to-student and student-to-student communications through effective acoustical design.

• Sustainable Sites (SS)

  • Credit 6.1: Stormwater Design, Quantity Control. Intent: to limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff and eliminating contaminants.

  • Credit 6.2: Stormwater Design, Quantity Control. Intent: to limit disruption and pollution of natural water flows by managing stormwater runoff.

  • Credit 7.1: Heat Island Reduction, Non-roof. Intent: to reduce heat islands to minimize impacts on microclimates and human and wildlife habitats.

• Innovation in Design (ID)

  • Credit 1: Innovation in Design. Intent: to provide design teams and projects the opportunity to achieve exceptional performance above the requirements set by the LEED Green Building Rating System and/or innovative performance in Green Building categories not specifically addressed by the LEED Green Building Rating System.

The contribution degree of these or other prerequisites and credits are highly conditioned by the nature and characteristics of the project, although all of them require consideration.
4.2 Improvement of BREEAM Environmental Assessment Method

BREEAM (Building Research Establishment Environmental Assessment Methodology) is a method of assessing, rating, and certifying the sustainability of buildings. BREEAM works to help owners, occupiers, designers and operators to apply successfully and cost effective suitable solutions to their buildings. LEED was developed in UK, although there exist specific versions for several countries.

BREEAM uses a set of sustainability-based categories structured in credits in the same way of LEED certification. Thanks to them, buildings are valued and certified on a scale of “Pass”, “Good”, “Very Good”, “Excellent” and “Outstanding”. Different versions of BREEAM certification exist, adapted to the specifically needs of different building and project typologies.

Topics listed in the previous section, as susceptible to be applied for a LEED certification is equally valid for a BREEAM certification, due to the similarities between LEED and BREEAM technical criteria. Although some discrepancies can be detected regarding the weighting of each credit with respect to the rest, and the importance that each system gives to certain subjects, there are more similarities than differences between both certification systems.

The more significant differences lie in:

- Accuracy of the valuation method, higher for BREEAM certification. LEED is simpler, in opposite.
- Standards used as reference. LEED works with the ASHRAE standards and guidelines, while BREEAM apply the EU and UK legislations.
- BREEAM is more versatile than LEED, if a customized valuation of the project, not covered by the existing models, is needed.
- Adaptability to the local conditions. LEED are hardly influenced by USA idiosyncrasy, while BREEAM is more adjustable to the local strategies and legislations.
- Roles of participants and bodies involved in the certification process, including the methods of financing.

Both systems can be useful and recommendable in any case. The most suitable for a specific project must be decided by the parties involved in it, taking into account not only technical but also administrative, commercial and economic reasons.
Conclusions

Conclusions arrived from the work carried out during this task, based on the content included in this deliverable, are summarized in the following points:

- EU regulations and legislation of construction components in terms of assessment of performance, standardization and commercialization by means of the CE marking, are clear and have a high degree of standardization. The procedure to achieve the CE marking for a construction product is widely detailed in the “ Regulation (EU) 305/2011 of 9 March 2011”, which lay down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC.

- Due to the highly innovative character of the foreseen developments in the ETFE-MFM project and the nonexistence of a specific Harmonized Standard (hENs) or a European Assessment Document (EAD) related to ETFE construction components, it would be necessary to follow the procedure established for products not covered by the currently existing harmonized standards and request a European Technical Assessment (ETA) for ETFE-MFM products.

- Since any existing hENs or EAD covers the ETFE-MFM products, a Technical Assessment Bodies (TAB) should be required to elaborate a specific European Assessment Document (EAD), which lay down the suitable standardization requirements to achieve the ETA and the CE marking intending to commercialize the products in the EU market.

- In order to have a legislative reference for issuing a new EAD for ETFE-MFM products, some related hENs and ETAGs (European Technical Approval Guidelines) concerning plastic-based construction components and transparent building units, have been detected. The TAB involved can take these norms and guidelines as basis or supporting documents for the execution of the new EAD. Once issued a specific ETA for construction products in ETFE, a new hEN based in this can be proposed.

- It is suggested the carrying out of a Life cycle Costing analysis (LCC) to evaluate the total cost performance of an asset over time, including the acquisition, operating, maintenance, and disposal costs. This will allow property to put in practice the best management option regarding not only the initial investment but also the O&M costs to optimally accomplishing the technical and economic objectives.

- Thanks to the benefits coming from the construction, energy and lighting multifunctionality of ETFE-MFM products and systems, building projects would be able to significantly improve their LEED and BREEAM scores. An optimal evaluation of the projects through both sustainability certification systems, together with the implementation of their innovative features in architecture, would place ETFE-MFM items in a privileged position within the European and world building market.

- Finally, an additional observation is needed: since the market study contained in D2.1 revealed that the main market for ETFE-MFM product is outside the EU, the focus on EU standards is rather limited although foreseen in the DOW. Without extending the scope of the ETFE-MFM project, participants should take this issue into consideration from the design and standardization tasks to the dissemination and exploitation plans, in such a way that a good product with commercial possibilities, not only in the EU context but also in worldwide markets, can be developed.