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List of abbreviation

CEN	*European Committee for Standardization*
CENELEC	*European Committee for Standardization in the Electrical Field*
CWA	*CEN-CENELEC Workshop Agreement*
EN	*European Standard*
EOTA	*European Organization for Technical Assessment*
ESO	*European Standardization Organization*
ETAG	*European Technical Approval Guideline*
ETSI	*European Telecommunications Standards Institute*
EU	*European Union*
IEC	*International Electrotechnical Commission*
ISO	*International Organization for Standardization; International Standard*
NSB	*National Standardization Body*
SC	*Subcommittee*
TC	*Technical Committee*
UNE	*Spanish Association For Standardization*
WG	*Working Group*
WP	*Work Package*
WS	*Workshop*

Introduction

The Spanish Association for Standardization (UNE), as National Standardization Body (NSB), member of CEN-CENELEC and of ISO-IEC, is a partner in upPE-T, providing support to the consortium on standardization tasks (WP7 "Exploitation, dissemination, business plan & IPR Management").

This document has been developed within the framework of Task 7.4 "Standardization contribution" and in particular, within the Activity 7.4.2 "Contribution to the ongoing and future standardization developments", whose main objective is to facilitate the market

acceptance of the results of the project, by transferring project outcomes and findings to new standards.

With this aim, D7.14 contains the progress of upPE-T in the field of contribution to standardisation, which was presented in previous deliverables D7.11, D7.12 and D7.13, reflecting the results obtained up to the time of publication of this deliverable.

Executive summary (Abstract)

The inclusion of project outcomes in new standards, external to the consortium, that can be easily used by the European or international industry and public administrations, is useful to increase the footprint left by the project, complementing the role of scientific publications and other dissemination and communication activities.

With this aim, task T7.4 'Standardization activities' was included in the upPE-T planning from the beginning of the project. As a first step, this task consisted of carrying out a study on the existing standards of interest for the development of the different work packages, together with the identification of standardization technical bodies developing related activities.

The results of that study, in deliverables D7.11 (M6) and D7.12 "Standardization contribution" (M12) revealed the need to carry out several actions to interact with the standardization system for disseminating the project findings, as well as to contribute to ongoing standards under development or future standards. The actions to be taken in this regard were presented in deliverable D7.13, elaborated in M24, which also included an analysis of different paths to contribute to standardization and a strategic plan.

This present document, D7.14, aims to reflect the results obtained up to the time of publication of this deliverable, presenting the developments on the project's contribution to standardization activity.

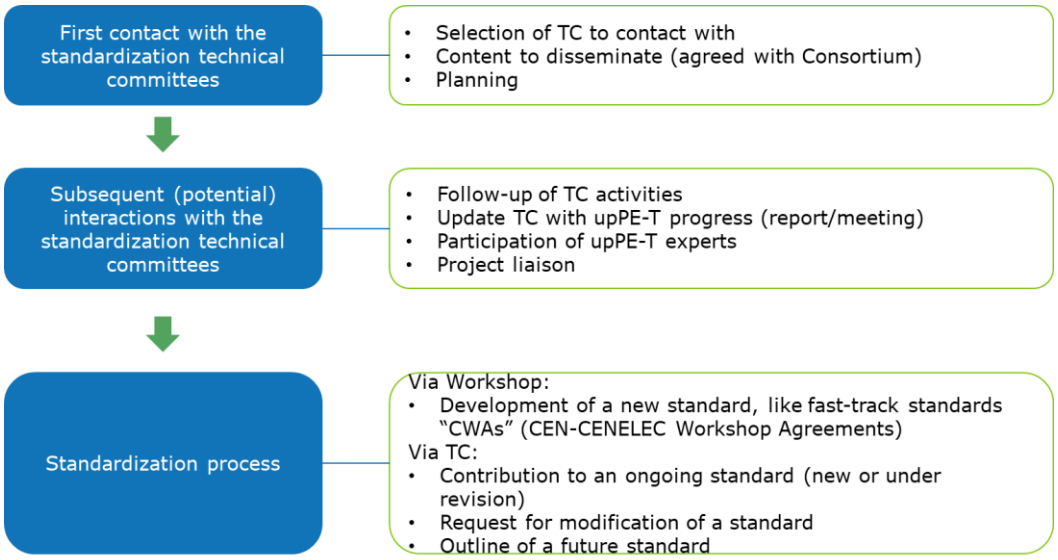
1. Report on standardization contribution in upPE-T project

1.1. Recapitulation of the strategic plan

Different actions on standardization contribution were identified and collected as a part of a strategic plan for upPE-T, which were reflected in previous deliverable D7.13 (M24).

Figure 1 shows the activities that are part of the strategy's roadmap.

Figure 1: Strategy for the contribution to standardization of upPE-T (D7.13, Clause 2)



1.1.1. First contact with the standardization technical committees

The contact with technical standardization bodies was initiated in the period M17-M20 with the objective to raise awareness about upPE-T and to ease subsequent communications, as well as to serve as a dissemination channel for all the stakeholders at European/international level that are present in the bodies contacted.

The objectives of the interaction with the relevant standardization committees included:

- To facilitate the subsequent contribution to standardization allowing the related standardization committees an advance knowledge of upPE-T and to comment about the standardization possibilities,
- To disseminate the results and objectives of the project using the network of the standardization community, and
- To gather any feedback that may come from the standardization community regarding the development of the project.

Ultimately, it was hoped that these initial contacts could be useful in determining how best to initiate a standardization process.

1.1.2. Subsequent interaction with the standardization technical committees

Several ways of interaction of the project with the standardization committees were identified, including:

- Follow-up of the activity of the relevant standardization committees.
- Further contacts with the standardization committees to update the progress of the project.
- Participation of one or more upPE-T partners in standardization technical committees.
- Establishment of a formal liaison of upPE-T with standardization committees.

In this regard, in the case of the upPE-T project, the participation of upPE-T members in the technical standardisation committees is particularly noteworthy. Evidence of this is the active participation of experts in 5 working groups of standardization committees whose activity is especially relevant for the project:

- CEN/TC 249/WG 9 Biobased and biodegradable plastics
- CEN/TC 249/WG 11 Plastics recycling
- CEN/TC 261/SC 4/WG 2 Degradability and organic recovery of packaging and packaging materials
- CEN/TC 261/SC 4/WG 10 Design for recycling for plastic packaging products
- ISO/TC 61/WG 14 Environmental aspects

In this respect, Ines Fritz (BOKU) is a key partner, participating as an expert in some of the cited working groups, acting as an excellent and appropriate source of information for the Consortium on issues related to standardization. A report on the relevant developments in this regard is annexed to this document (see Annex C).

On the other hand, responding to a specific request from the European Commission to CEN/CENELEC, regarding plastics recycling and recycled plastics in support of the European Strategy for Plastics in a Circular Economy, CETEC has joined the working groups WG9, WG11 and WG10 described above, to participate in the development of the related standards.

1.1.3. Standardization process

Based on the identification of standardizable results, the standardization landscape at the moment (result of the interaction with the standardization committees and the monitoring of their standardization works) and the progress of the project, the standardization process itself aims to consolidate the effective contribution of upPE-T to the development of new standards.

In this regard, different options were considered, distinguishing two main paths which basically differed in the participants of the drafting group, and which required further analysis:

- Via Technical Committee (TC), the traditional standardization bodies, composed by national members, that develop standards. This route offers the possibility to develop a new standard or contribute to an ongoing standard, to request the amendment of a standard that is not under development or revision, or to outline a future standard.
- Via Workshop, integrated by a group of entities with a common interest in developing a standard about a specific issue, following faster and more flexible working procedures. This route offers the possibility to develop new standards like fast-track standards "CEN Workshop Agreement", commonly abbreviated "CWA".

The decision to follow one route or another must be examined taking into account the characteristics of the project, its progress and the obtained and expected results. The work done in this respect and the conclusions of the discussion are presented and addressed in Clause 3 of this deliverable.

1.2. Progress of the standardization process

The standardization process itself was initiated in M30. As previously mentioned, the different options to contribute to standardization required an extensive analysis considering the specific characteristics of upPE-T project, the kind of the results expected, time availability, intellectual property protection strategy, etc., as well as the standardization context (the existence of closely related standards and position of the standardization committees).

As already envisaged in the strategy plan, two main lines were contemplated in the standardization process: via TC and via Workshop. Both paths were examined with the purpose to decide and justify which via would be the most appropriate for the upPE-T project.

1.2.1. Standardization via Technical Committee

Documents as European standards are generally produced in Technical Committees, with permanent members representing the National Standardization Bodies (NSB). The Technical Committees are key bodies responsible for the development and drafting of standards within their approved scopes. Some characteristics of this via, suitable for the development of EN standards, are listed below:

- Full consensus of all the member countries required.
- The elaboration of a EN standard requires around 3 years, typically.
- The revision of a EN standard must be done every 5 years.
- Their adoption is mandatory at national level in Europe.

1.2.2. Standardization via Workshop

A standardization workshop is created when there is a need for developing a precise standard in an innovative field that is not covered by the existing standardization committees, or when these committees are not interested in developing such standard (e.g. it does not fit in their work programme).

In that case, the interested parties in developing a standard about a specific issue can work together conforming a group (Workshop), that is an equivalent formula to the concept of standardization committee, but typically with a smaller number of participants, and with faster and more flexible working procedures.

The main characteristics of the Workshop via are listed below:

- Consensus limited to all the organizations involved in the process.
- Reduced elaboration time of the document (CWA), typically around 12 months.
- The revision of the CWA must be done at 3 years, with a maximum time of validity of 6 years.
- The adoption of a CWA is voluntary.

1.2.3. Conclusions of the analysis

The specific characteristics of each option were presented to the partners at a meeting of the Consortium in M32. Figure 2, shown during the meeting, collects the main differences between both options.

Figure 2: Comparison of options via TC vs. via Workshop

	Via TC (EN standard)	Via Workshop (CWA)
Consensus required:	Full (CEN/CENELEC National Members)	Limited (registered participants)
Timeframe:	3 years	12-18 months
Lifetime:	Every 5 years	At 3 years* (max 6 years)
Application:	Mandatory adoption at national level in Europe	Voluntary application

Based on the analysis performed, and according to the characteristics of upPE-T project, it seems to be clear that the most appropriate formula in this case is the elaboration of a

CWA, fundamentally because of its usual innovative nature, the limited consensus required (restricted to the participants registered in the group), and the time available for its production.

In the framework of projects like upPE-T, with a strong innovative component, the elaboration of a CWA permits the introduction of innovation in fields that are not covered by the existing standardization committees. Effectively, in case of innovative technologies, including products, processes and services, that have not yet achieved a sufficient degree of stability, a European Standard may not be the best formula, because of the nature of the standardization process and the requirement that all the national members shall adopt the resulting standard.

Taking into account that in upPE-T the duration of the whole project is 48 months, 3 years to elaborate a EN standard including outcomes of the project would not be feasible. On the contrary, the reduced time for the elaboration of a CEN Workshop Agreement (CWA) makes it a valid possibility.

On the other hand, the level of required consensus, that only involves the entities that participate in the Workshop, makes the elaboration of CWAs faster and the working procedures more flexible.

The conclusions of the analysis were also shared with all the partners of the Consortium in virtual meeting modality in M32. The meeting was a good opportunity to present and to evaluate the different options available, and to clarify any doubt regarding the standardization process. Taking the opportunity of the event, the intervention of Ines Fritz (BOKU), with extensive experience in standardisation through active participation in several standardisation bodies, was really enlightening for the rest of the partners, offering a very practical perspective of the standardization activity.

1.3. CWA development process in upPE-T

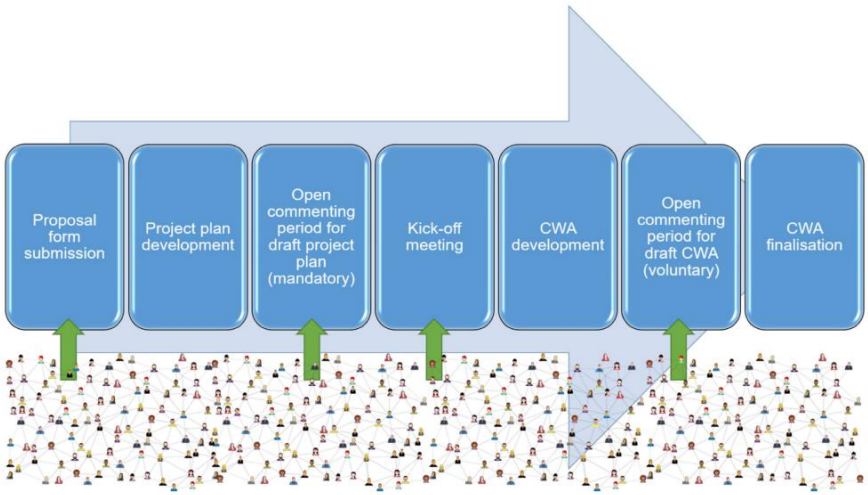
Although they are developed outside the normal CEN/CENELEC Technical Body structure, a CWA is, in any event, a CEN/CENELEC publication, and as such, the relevant provisions of the CEN/CENELEC Internal Regulations are required to be applied and it is necessary to ensure that the document will not conflict with a European Standard (and a CENELEC Harmonisation Document).

CEN Guide 29 has been elaborated to provide mechanisms and details of the characteristics and development process of the CEN/CENELEC Workshop Agreements. This guide is, therefore, an essential reference document that must be observed during the development of a CWA.

The process for initiating and developing a CWA is illustrated in Figure 3 [Source: CEN Guide 29, Introduction], which graphically describes the different steps that are part of the CWA development process from the proposal form submission to the publication of the CWA:

1. Proposal form submission
2. Project plan development
3. Open commenting period on draft project plan
4. Kick-off Meeting
5. CWA development
6. Open commenting period on draft CWA
7. CWA finalization
8. CWA publication

Figure 3: Illustration of the CWA process [Source: CEN Guide 29, Introduction]



1.3.1. Preliminary actions: identification of areas/topics to standardize

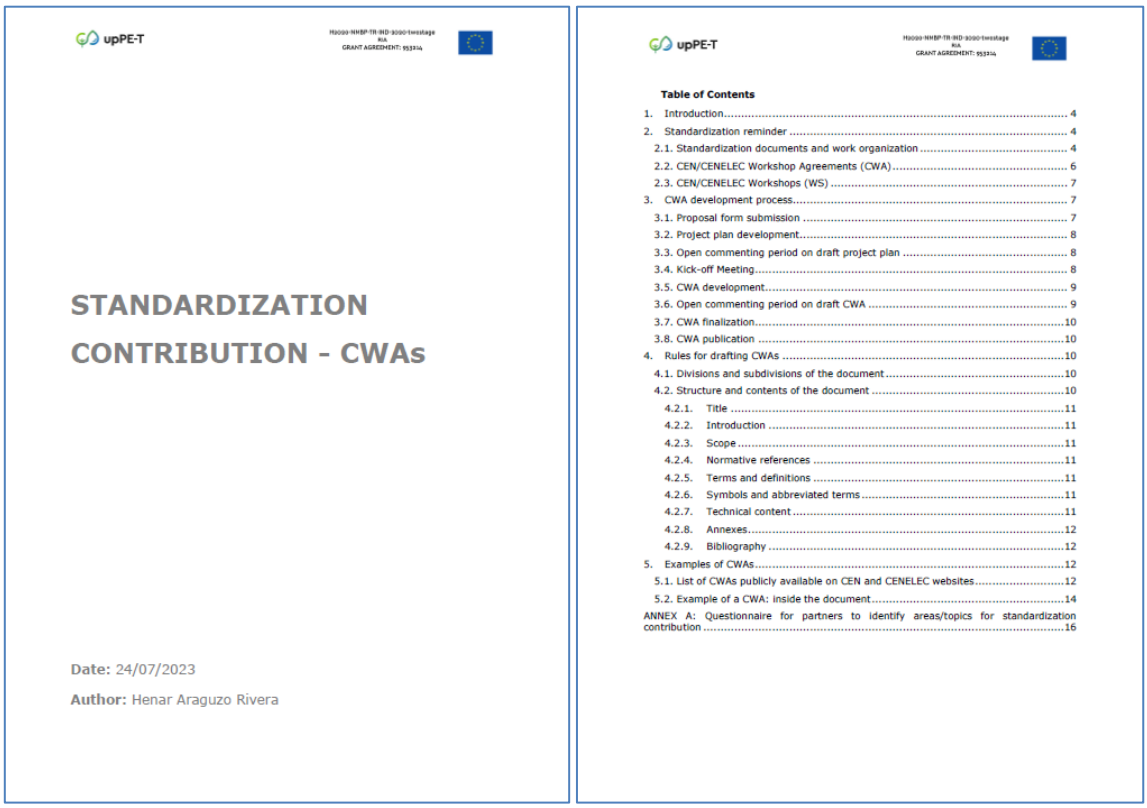
With the purpose to make the concept of a CWA and their development process more understandable for the Consortium audience, UNE prepared an explanatory brochure, which is annexed to this deliverable. It was sent by email to all the partners in M33. This document provided details and characteristics on the 'CEN/CENELEC Workshop Agreement' (CWA) and its development process.

Figure 4 illustrates the front cover and the table of contents of this explanatory brochure, whose content is annexed to this document (see Annex A to access the full document), and is structured in clauses:

1. Introduction

2. Standardization reminder
3. CWA development process
4. Rules for drafting CWAs
5. Examples of CWAs

Figure 4: Front cover and table of contents of the explanatory brochure on CWAs development process



upPE-T

STANDARDIZATION CONTRIBUTION - CWAs

Date: 24/07/2023

Author: Henar Araguzo Rivera

upPE-T

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Together with the explanatory brochure, it was elaborated and shared with all the partners a questionnaire with the purpose to facilitate the identification of possible areas/topics for standardization contribution. This 7-questions survey is annexed to this document (see Annex B).

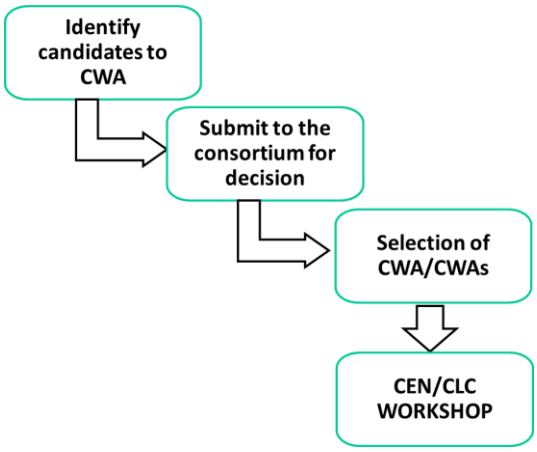
In response to this communication, different proposals of possible areas to standardize have been received for their examination:

1. CETEC proposal: Determination of hydroxy valerate monomer content in PHBV by Nuclear Resonance Spectroscopy. (Reference: task 4.3, part of deliverables D4.13, D4.14 and D4.15)
2. MOSES proposal: adaptation of contents in reference documents D6.1 "Thermoforming and injection moulding processes scaling-up" and D6.2 "Extrusion processes scaling-up".
3. CTCR proposal: adaptation of contents in reference documents D5.1 "PHBV processable compounds", D5.3 "Food packaging compounds" y D5.5 "Compounds transformation"

1.3.2. Expected actions

Figure 5 collects the actions that will precede the constitution of the CEN/CLC workshop in charge of the development of the CWAs.

Figure 5: Description of actions that precede the constitution of the CEN/CLC Workshop



Following this scheme, and as explained above, the search of the topics or areas to transfer to standards was initiated in M33 with the collaboration of all the partners.

The feedback received from the reply of partners to the questionnaire resulted in three proposals of contribution to standardization that must be examined, considering:

- The appropriateness of the contents, that should comply with some conditions:
  - It does not intend to define requirements related to safety matters
  - It does not fall within the scope of an existing CEN/TC
  - It does not intend to define requirements related to management system aspects.
  - It does not intend to define requirements related to conformity assessment aspects
- The resources available and the efforts that will be necessary. The main effort habitually consists in adapting the text of one or more documents of the project, or a part of them, according to some general principles and removing the confidential part. In this point it is important to achieve a sufficient level of participation and the commitment
- The time available for the development of the CWA. It is recommended that it does not exceed the time horizon of upPE-T.

The selection of the topics to bring to one or more standards will be agreed by the consortium. To better analyse the proposals, the necessary relevant meetings will be held with the partners directly involved.

A summary of the tentative dates for the expected key actions in the CWA development process are included in Table 2.

Table 1 Expected action with tentative dates

Action	Month
Preliminary meetings with partners directly involved in the proposal	M36-M37
Proposal form submission for the constitution of CEN/CLC Workshop	M39
Kick-off meeting	M42
Publication of CWA(s)	M47

Conclusion

Standardization is a highly valued activity as part of research and innovation projects, acting as an ally to disseminate the project results to the industry, society and public administrations. It acts facilitating the recognition, acceptance, use and future exploitation of the project solutions. It also enables interoperability and compatibility of innovative solutions with existing products, services or processes, and facilitates trade by reducing technical barriers. Standards generate trust, since they ensure that a product, service or system complies with expectations and requirements of the market or public procurement.

In the case of the upPE-T project, and with respect to the contribution to standardization, the impact and the visibility of the upPE-T project have been improved with the increased participation of experts in working groups of relevant standardization Technical Committees.

The process of contributing to standardization is expected to culminate with the elaboration and the publication of a CEN/CLC Workshop Agreement, CWA. In this regard, we are examining the proposals together with the partners directly involved, considering the relevant criteria. The final proposal(s) will be agreed by the consortium prior to the constitution of the Workshop. This way, part of the knowledge generated by the project will be transferred to industry and will revert into technical and economic benefits for Europe.

Annex A: Explanatory brochure

STANDARDIZATION CONTRIBUTION - CWAs

Date: 24/07/2023

Author: Henar Araguzo Rivera

Introduction

This document provides details and characteristics on the 'CEN/CENELEC Workshop Agreement' (CWA) and its development process. Basically, it contains the principles and rules for the structure and drafting of CWAs.

Standardization reminder

2.1. Standardization documents and work organization

Standards are voluntary technical documents that set out requirements for a specific item, material, component, system or service, or they describe in detail a particular method, procedure or best practice.

Standards are developed and defined through a process of sharing knowledge and building consensus among technical experts nominated by interested parties and other stakeholders, including businesses, consumers and environmental groups, among others. These experts are organised in Technical Committees (TC), which are subdivided in subcommittees (SC) or working groups (WG). These TCs are included in the structure of the standardisation organizations (National, European and International, with their respective 'mirror committees') and work following their internal regulations.

There are also different types of standardization documents. The most widespread is the standard, which has a different code depending on the organization under which it was developed; e.g. 'EN' for European Standards, 'ISO' or 'IEC' for International standards. Other types of documents are technical specifications (TS), technical reports (TR) and workshop agreements (CWA). Further amendments to the standards are identified by adding A1, A2, etc. at the end of the standard code.

A summary of characteristics of the different standardization documents is shown in Table 1.

Table 2 ***Standardization documents: Types and characteristics***

	International code	**European code**	**National code**	**Main characteristics**
Standard	ISO IEC	EN	UNE, NF, BS, DIN, etc. When adopting: UNE-EN, NF-EN, UNE ISO, NF-ISO, etc.	• Timeframe: 3 years • 2 steps of member approval • European adoption: mandatory • Revision: every 5 years
Technical Specification	ISO/TS IEC/TS	CEN/TS CLC/TS	When adopting: UNE-CEN/TS, NF-CEN/TS, UNE-ISO/TS, NF-ISO/TS, etc.	• Timeframe: 21 months • 1 step of member approval or internal approval in TC • European adoption: optional • Revision: at 3 years (upgrade to EN or deletion)
Technical Report	ISO/TR IEC/TR	CEN/TR CLC/TR	When adopting: UNE-CEN/TR, NF-CEN/TR, UNE-ISO/TR, NF-ISO/TR, etc.	• Timeframe: free • Internal approval in TC • European adoption: optional • Revision: not required
Workshop Agreement	IWA	CWA	Variable	• Timeframe: free timeframe (usually few months) • Internal approval in the Workshop • European adoption: optional • Revision: at 3 years (upgrade to EN or deletion)

2.2. CEN/CENELEC Workshop Agreements (CWA)

In innovative markets there is often a request for a reference document to be quickly developed as a stepping stone to standardization deliverables, to facilitate interoperability and compatibility, enhance market uptake of innovative solutions and facilitate further incremental innovations in the market. However, if innovative technologies, including products, processes and services, have not achieved a sufficient degree of stability yet, a European Standard may not be the best way of meeting this need, because of the nature of the standardization process and the requirement that all CEN/CENELEC national members shall adopt the resulting standard. [Source: CEN-CENELEC Guide 29:2020]

A CWA is a CEN/CENELEC deliverable which reflects an agreement between identified individuals and organizations responsible for its contents, and which is made available by CEN/CENELEC in at least one of the official languages.

CWA has the following characteristics that make CWA attractive for European research and innovation projects:

- It is possible to indicate the participants and their organizations in the foreword;
- It is designed to meet an immediate need;
- It can be quickly developed (within the project time frame);
- It may take various forms such as text file or computer code;
- It is developed and agreed by the participants in a temporary working group;
- The stakeholder involvement is limited to those directly interested in the subject;
- It can be used as fast track to future standardization activities;
- It is not designed to support European legislative requirements;
- Safety matters are excluded from being the subject of a CWA;
- A CWA normally includes guidelines, recommendations, best practices… and can be converted into a CEN standard in the future.

A CWA is valid for 3 years, after which the CWA shall be:

- confirmed for another 3 years
- revised
- withdrawn from the market

The maximum lifetime of the CWA is 6 years. After 6 years since the first publication, the CWA shall be transformed into another deliverable or removed.

2.3. CEN/CENELEC Workshops (WS)

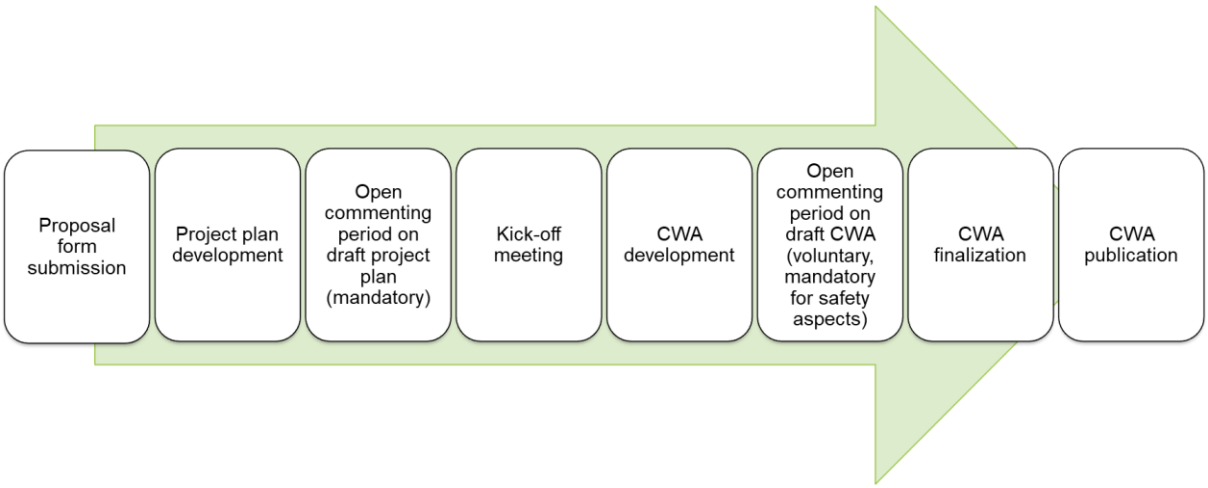
The CEN/CENELEC Workshop is the working platform open to the participation of any interested parties for elaboration of CWAs.

A CEN/CENELEC Workshop is considered as a temporary working group with a short-term task specified in its project plan and its operation is separate from Technical Committees, but it does not mean that there cannot be an interface between CEN/CENELEC Workshops and Technical Committees

CWA development process

The process for initiating the development of a CWA is illustrated in Figure 1 and is explained in subsequent subclauses.

Figure 6 ***CWA development process***



3.1. Proposal form submission

With the support of the WS Secretary, the WS Proposer prepares the CEN Workshop Proposal Form.

The Proposal Form includes, among others:

- contact information of the Proposer and the Secretary;
- the list of persons and organizations that are expected to take part in the WS;
- the scope of the proposal.

A declaration to ensure that there is no conflict with existing standards or within the domain of an existing Technical Body.

The WS Secretary submits it to the relevant Technical Committees for a 30-day consultation and to related CEN and/or CENELEC advisory and coordination groups in order to verify that there is neither any active work item covering the scope of the proposed CWS nor any other arguments against the proposed CWA.

3.2. Project plan development

The Draft Project Plan is intended to inform the public of a new Workshop to make possible that any interested party can take part in the Workshop and/or comment on this draft project plan.

All those who have applied for participation or have commented on the project plan by the deadline will be invited to the kick-off meeting of the Workshop.

3.3. Open commenting period on draft project plan

The proposal for the new CEN Workshop (CEN/WS) is announced on the CEN-CENELEC Website at least 30 days before the Kick-off Meeting.

The information posted on the website will include:

- the CEN/WS Draft Project Plan;
- initial information on the Kick-off Meeting (including Agenda and Venue);
- the WS Secretariat (and the proposed Chairperson - if known);
- how to submit comments to the Workshop Draft Project Plan.

Any comments submitted during this period shall be considered with the Workshop Secretariat and Workshop Proposer and in any case during the Kick-off Meeting at the latest.

3.4. Kick-off Meeting

The kick-off meeting shall take place at least 30 days after the publication of the draft project plan.

During the Kick-off Meeting, the Workshop Secretary gives the participants information about the Workshop and the development process of the CWA, to help them understand how the Workshop will operate.

It is important to point out that the participation at the kick-off meeting does not automatically ensure registration to the Workshop.

The participants to the kick-off meeting wishing to continue contributing to the development of the CWA will have to submit a registration form to become Workshop participants.

An example of the agenda of the kick-off meeting is shown in Table 2.

Table 3 ***Example of kick-off meeting agenda***

Kick-off meeting Agenda
1) Opening of the meeting
2) Roll call of participants
3) Adoption of the agenda
4) Introduction on CEN and on the Workshop concept
5) General presentation of the Workshop
6) Possibly other presentations
7) Election and appointment of Workshop Chair and confirmation of the Secretariat
8) Project Plan
a. Discussion and review of comments received
b. Adoption of the Project Plan (by consensus)
9) Organization of the technical work
10) Any other business
11) Next meeting, future actions and their assignment
12) Closure of the meeting

3.5. CWA development

The CEN/WS participants draft the CWA according to the specifications in the Final Workshop Project Plan.

To ensure transparency the documents of the CEN/WS should be uploaded on an electronic platform.

3.6. Open commenting period on draft CWA

It is mandatory if the CWA deals with safety aspects but it is highly recommended for all Workshops since it increases transparency.

Draft CWA text is posted at CEN website minimum 30 days (60 days for CWA dealing with safety aspects).

3.7. CWA finalization

Once there is an agreement on the final text, it is submitted to CEN.

3.8. CWA publication

After an edition process, the development of the CWA is completed with its publication.

Rules for drafting CWAs

CEN/CENELEC Internal Regulations Part 3 provides the principles and rules for the structure and drafting of CEN and CENELEC documents.

4.1. Divisions and subdivisions of the document

The terms to designate the divisions and subdivisions of subject matter are given in Table 3.

Table 4 ***Names of divisions and subdivisions***

Term	Mandatory/Optional/Conditional
Part	XXXXXXX-1
Clause	1
Subclause	1.1
Subclause	1.1.1
Annex	A

4.2. Structure and contents of the document

An example of the table of contents is shown in Table 4.

Table 5 ***Example of table of contents***

Major subdivision	Mandatory/Optional/Conditional
Title	Mandatory
Table(s) of content	Optional
Foreword	Mandatory
Introduction	Optional/Conditional
Scope	Mandatory
Normative references	Mandatory
Terms and definitions	Mandatory
Symbols and abbreviated terms	Conditional
Technical content	Mandatory/Optional/Conditional
Annexes	Optional
Bibliography	Conditional

Title

The title is a clear, concise description of the subject matter covered by the document. It is drafted to distinguish the subject matter from that of other documents, without going into unnecessary detail. Any necessary additional details are given in the Scope.

Introduction

The Introduction provides specific information or commentary about the technical content of the document, and about the reasons prompting its preparation.

Scope

The scope clearly defines the subject of the document and the aspects covered, thereby indicating the limits of applicability of the document or particular parts of it.

For the purposes of clarity, the scope can indicate other subjects that are excluded from the document, when other subjects can be implied by the wording of the scope or title.

Normative references

This clause lists, for information, those documents which are cited in the text in such a way that some or all of their content constitutes requirements of the document.

Terms and definitions

This clause provides definitions that are necessary for the understanding of certain terms used in the document.

Symbols and abbreviated terms

The Symbols and abbreviated terms clause or subclause provides a list of the symbols and abbreviated terms used in the document, along with their definitions.

Technical content

The CWA can contain guidelines, recommendations, best practices, measurement and test methods, marking, labelling…

Annexes

Annexes are used to provide additional information to the main body of the document.

Bibliography

The Bibliography lists, for information, those documents which are cited informatively in the document, as well as other information resources and background material used for the preparation of the document.

Examples of CWAs

CWAs can be made publicly available on the CEN and CENELEC websites if a pre-payment is made as compensation for the possible loss of revenue to the CEN and CENELEC members. In such cases UNE assumes those costs.

Those CWAs that are publicly available on the CEN and CENELEC websites, are sited in the CWA download area: https://www.cencenelec.eu/get-involved/research-and-innovation/cen-and-cenelec-activities/cwa-download-area/

5.1. List of CWAs publicly available on CEN and CENELEC websites

Table 5 contains a list of CWAs resulting from EU-funded projects that are made available for download.

Table 5 List of CWAs resulting from EU-funded projects that are made available for download

Link	Title
CWA 17147:2017	Guidelines for the evaluation of installed security systems, based on the STEFi dimensions (CRISP)
CWA 17145-1:2017	Ethics assessment for research and innovation - Part 1: Ethics committee (SATORI)
CWA 17145-2:2017	Ethics assessment for research and innovation - Part 2: Ethical impact assessment framework (SATORI)
CWA 17185:2017	Methodology for Improving the Resource Efficiency of Energy Intensive Industrial Processes (TOP-REF)
CWA 17284:2018	Materials modelling - Terminology, classification and metadata (MODENA)
CWA 17260:2018	Guidelines on evaluation systems and schemes for physical security products (HECTOS)
CWA 17300:2018	City Resilience Development - Operational Guidance (SMR)
CWA 17301:2018	City Resilience Development - Maturity Model (SMR)
CWA 17302:2018	City Resilience Development - Information Portal (SMR)
CWA 17335:2018	Terminologies in crisis and disaster management (DRIVER+)
CWA 17354:2018	Industrial Symbiosis: Core Elements and Implementation Approaches (SHAREBOX and EPOS)
CWA 17381:2019	The Description and Assessment of Good Practices for Smart City solutions (SMARTER TOGETHER)
CWA 17382:2020	Sustainable Energy Retrofit Process Management for Multi-Occupancy Residential Buildings with Owner Communities (SMARTER TOGETHER)
CWA 17384:2019	Articulated industrial robots - Elastostatic compliance calibration (COROMA)
CWA 17437:2019	Innovative and adaptable envelopes over existing façades in building refurbishment - Design, economic assessment, logistics and installation guidelines (BRESAER)
CWA 17453:2019	Bionic Aircraft - Optimized ALM support structures made from Al alloys
CWA 17454:2019	Bionic Aircraft - Quality control of metal ALM parts using the Ultrasonic Technique
CWA 17484:2020	Anaerobic digestion plants - Feasibility assessment methodology for integrating a Volatile Fatty Acid Platform Technology (VOLATILE)

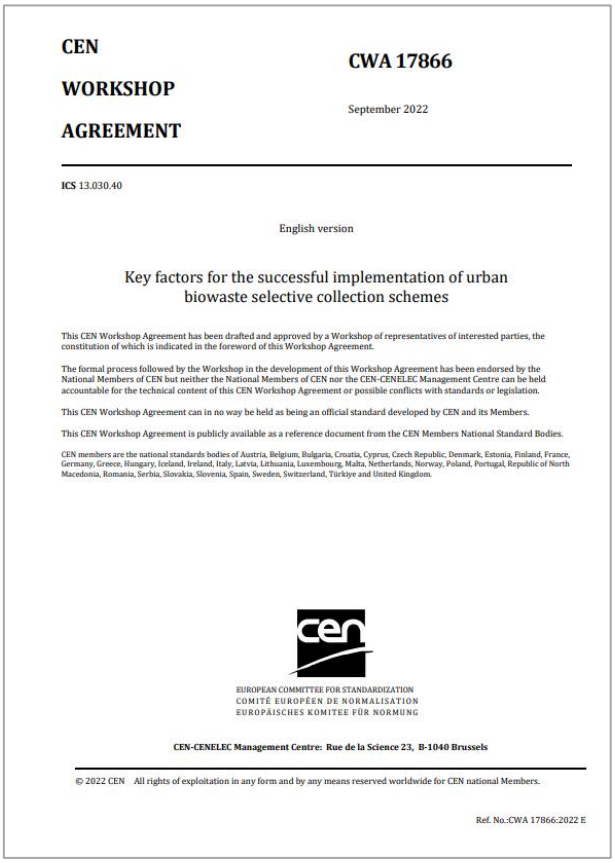
CWA 17486:2019	Verification of performance levels of Galileo Enabled mass-market receivers
CWA 17492:2020	Predictive control and maintenance of data intensive industrial processes (MONSOON)
CWA 17494:2020	Analytics Insights and Scaling Policies for Microservices (UNICORN)
CWA 17502:2020	Privacy of monitoring technology - Guidelines for introducing ambient and wearable monitoring technologies balancing privacy protection against the need for oversight and care (REACH2020)
CWA 17513:2020	Crisis and disaster management - Semantic and syntactic interoperability (DRIVER+)
CWA 17515:2020	Building a common simulation space (DRIVER+)
CWA 17553:2020	Community face coverings - Guide to minimum requirements, methods of testing and use
CWA 17514:2020	Systematic assessment of innovative solutions for crisis management - Trial guidance methodology (DRIVER+²)
CWA 17541:2020	European Criteria for Quality Internships
CWA 50714:2020	Reference model for distribution application for microgrids
CWA 17663:2021	Measurement of Worker Satisfaction in Automated Systems - Methodology CEN Workshop Agreement
CWA 50271:2021	Recommendations for a modular and cross-cutting Power Take-Off for wave energy direct drive linear solutions.
CWA 50272:2021	Methodology, procedures and equipment required for the laboratory testing of a modular and crosscutting Power Take-Off for wave energy converters
CWA 17664:2021	Lower-limb wearable devices - Performance test method for walking on uneven terrain
CWA 17726:2021	High temperature accelerated ageing of advanced ceramic specimens for solar receivers and other applications under concentrated solar radiation
CWA 17727:2022	City Resilience Development - Guide to combine disaster risk management and climate change adaptation - Historic areas
CWA 17793:2021	Test method for determination of the essential work of fracture of thin ductile metallic sheets
CWA 17794:2021	Measurement of diffusible hydrogen in metallic materials - HELIOS 4 HOT PROBE method
CWA 17806:2021	Design Circular Framework Setting - Composite recovery design solutions in the automotive industry
CWA 17807:2021	Dismantling methods and protocols in a Circular Economy Framework - Composite recovery in the automotive industry
CWA 17815:2021	Materials characterisation - Terminology, metadata and classification
CWA 17819:2021	Guidelines for the assessment of resilience of transport infrastructure to potentially disruptive events
CWA 17835:2022	Guidelines for the development and use of safety testing procedures in human-robot collaboration
CWA 17857:2022	Lens-based adaptor system for coupling fibre optic to infrared semiconductor lasers
CWA 17858:2022	Guidelines for Traditional Micro-SMEs' GDPR Compliance
CWA 17865:2022	Requirements and Guidelines for a complete end-to-end mobile forensic investigation chain
CWA 17866:2022	Key factors for the successful implementation of urban biowaste selective collection schemes
CWA 17896:2022	Test method for the evaluation of the adhesive properties of fibre reinforced polymer composite joints
CWA 17897-1:2022	Extraction, production and purification of added value products from urban wastes - Part 1: Production and purification of ectoine obtained from biogas
CWA 17898:2022	Methodology to quantify the global agricultural crop footprint including soil impacts

CWA 17907:2022	European Connected Factory Platform for Agile Manufacturing Interoperability (EFPFInterOp)
CWA 17918:2022	Zero Defects Manufacturing — Vocabulary
CWA 17933:2023	Digital health innovations - Good practice guide for obtaining consent for the use of personal health information for research and innovations
CWA 17935: 2022	Sustainable Nanomanufacturing Framework
CWA 17939: 2022	TRAIN4SUSTAIN Competence Quality Standard
CWA 17941:2022	Guidelines for an integrated approach of building retrofitting projects based on enhanced shallow geothermal technologies
CWA 17944:2022	Valorization of light hydrocarbons - One-pot method for the preparation of nanocatalysts for non-oxidative dehydrogenation (nODH) of light alkanes
CWA 17947:2022	Urban search and rescue - Guideline for the application of a test method for innovative technologies to detect victims in debris (WSCUR001)
CWA 17953:2022	Guidelines for dual-based training systems
CWA 17954:2022	Characterization of a hybrid heat pump module
CWA 17960:2022	ModGra - a Graphical representation of physical process models
CWA 17967:2023	Guidelines for design of advanced Human-Robot Collaborative cells in personalized HRC systems
CWA 17974:2023	Basic CBRN training curriculum for first responders and medical staff including first receivers
CWA 18002:2023	Best practices for hybridization and injection moulding of rigid control units on in-mould flexible devices
CWA 18006: 2023	extended Reality for Learning and Performance Augmentation - Methodology, techniques, and data formats
CWA 18011: 2023	Guidelines for the evaluation of the plane stress fracture toughness of advanced high strength sheets in the frame of fracture mechanics
CWA 18012: 2023	Test method for the determination of a cracking resistance index for advanced high strength steel sheets
CWA 18014: 2023	Mediation Grammar - A testing methodology for measuring the empowerment of users of public services for migrants

5.2. Example of a CWA: inside the document

Title, table of contents, foreword and scope of a published CWA are shown in Figure 2, as an example of a CWA once published.

Figure 2 Title, table of contents, foreword and scope of a published CWA
https://www.cencenelec.eu/media/CEN-CENELEC/CWAs/RI/cwa17866_2022.pdf



CEN

WORKSHOP

AGREEMENT

CWA 17866

September 2022

ICS 13.030.40

English version

Key factors for the successful implementation of urban biowaste selective collection schemes

This CEN Workshop Agreement has been drafted and approved by a Workshop of representatives of interested parties, the constitution of which is indicated in the foreword of this Workshop Agreement.

The formal process followed by the Workshop in the development of this Workshop Agreement has been endorsed by the National Members of CEN but neither the National Members of CEN nor the CEN-CENELEC Management Centre can be held accountable for the technical content of this CEN Workshop Agreement or possible conflicts with standards or legislation.

This CEN Workshop Agreement can in no way be held as being an official standard developed by CEN and its Members.

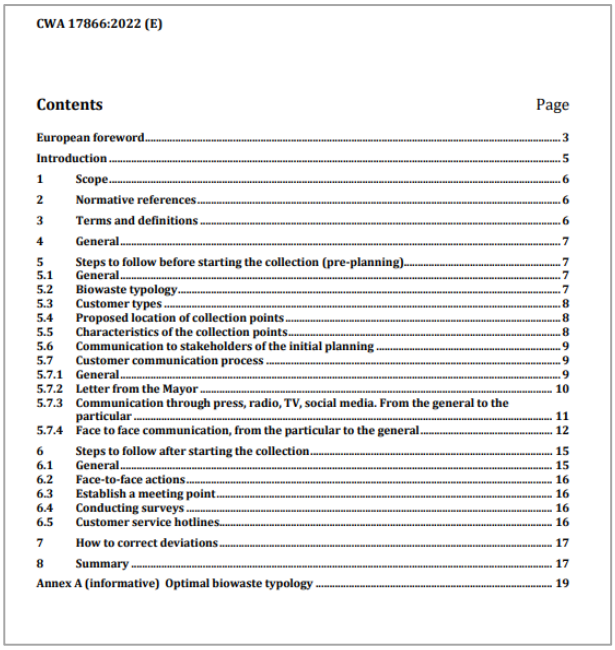
This CEN Workshop Agreement is publicly available as a reference document from the CEN Members National Standard Bodies.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No.:CWA 17866:2022 E



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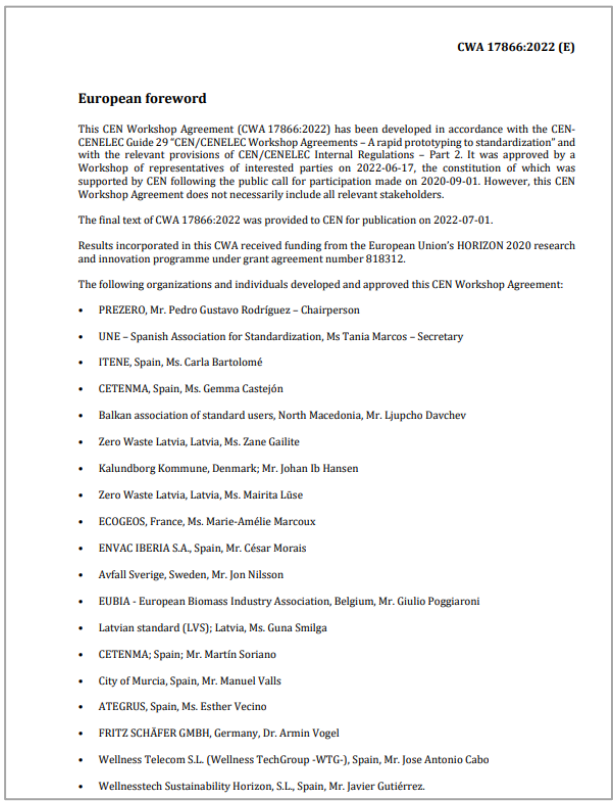


European foreword

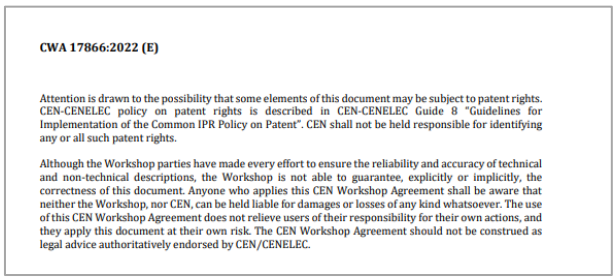
This CEN Workshop Agreement (CWA 17866:2022) has been developed in accordance with the CEN-CENELEC Guide 29 "CEN/CENELEC Workshop Agreements – A rapid prototyping to standardization" and with the relevant provisions of CEN/CENELEC Internal Regulations – Part 2. It was approved by a Workshop of representatives of interested parties on 2022-06-17, the constitution of which was supported by CEN following the public call for participation made on 2020-09-01. However, this CEN Workshop Agreement does not necessarily include all relevant stakeholders.

The final text of CWA 17866:2022 was provided to CEN for publication on 2022-07-01.

Results incorporated in this CWA received funding from the European Union's HORIZON 2020 research and innovation programme under grant agreement number 818312.

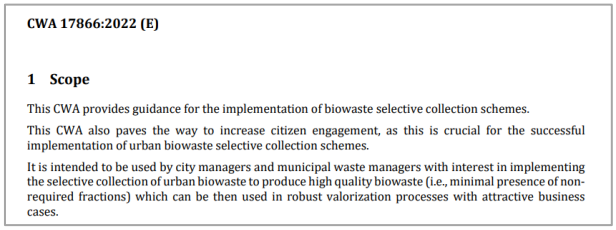
The following organizations and individuals developed and approved this CEN Workshop Agreement:

- PREZERO, Mr. Pedro Gustavo Rodríguez – Chairperson
- UNE – Spanish Association for Standardization, Ms Tania Marcos – Secretary
- ITENE, Spain, Ms. Carla Bartolomé
- CETENMA, Spain, Ms. Gemma Castejón
- Balkan association of standard users, North Macedonia, Mr. Ljupcho Davchev
- Zero Waste Latvia, Latvia, Ms. Zane Gailite
- Kalundborg Kommune, Denmark; Mr. Johan Ib Hansen
- Zero Waste Latvia, Latvia, Ms. Mairita Lūse
- ECOGEOS, France, Ms. Marie-Amélie Marcoux
- ENVAC IBERIA S.A., Spain, Mr. César Morais
- Avfall Sverige, Sweden, Mr. Jon Nilsson
- EUBIA - European Biomass Industry Association, Belgium, Mr. Giulio Poggiaroni
- Latvian standard (LVS); Latvia, Ms. Guna Smilga
- CETENMA; Spain; Mr. Martín Soriano
- City of Murcia, Spain, Mr. Manuel Valls
- ATEGRUS, Spain, Ms. Esther Vecino
- FRITZ SCHÄFER GMBH, Germany, Dr. Armin Vogel
- Wellness Telecom S.L. (Wellness TechGroup -WTG-), Spain, Mr. Jose Antonio Cabo
- Wellnesstech Sustainability Horizon, S.L., Spain, Mr. Javier Gutiérrez.



Attention is drawn to the possibility that some elements of this document may be subject to patent rights. CEN-CENELEC policy on patent rights is described in CEN-CENELEC Guide 8 "Guidelines for Implementation of the Common IPR Policy on Patent". CEN shall not be held responsible for identifying any or all such patent rights.

Although the Workshop parties have made every effort to ensure the reliability and accuracy of technical and non-technical descriptions, the Workshop is not able to guarantee, explicitly or implicitly, the correctness of this document. Anyone who applies this CEN Workshop Agreement shall be aware that neither the Workshop, nor CEN, can be held liable for damages or losses of any kind whatsoever. The use of this CEN Workshop Agreement does not relieve users of their responsibility for their own actions, and they apply this document at their own risk. The CEN Workshop Agreement should not be construed as legal advice authoritatively endorsed by CEN/CENELEC.



1 Scope

This CWA provides guidance for the implementation of biowaste selective collection schemes.

This CWA also paves the way to increase citizen engagement, as this is crucial for the successful implementation of urban biowaste selective collection schemes.

It is intended to be used by city managers and municipal waste managers with interest in implementing the selective collection of urban biowaste to produce high quality biowaste (i.e., minimal presence of non-required fractions) which can be then used in robust valorization processes with attractive business cases.

Annex B: Questionnaire for partners to identify areas/topics for standardization contribution

In order to identify possible areas/topics for contributions to standardization, UPPE-T partners are kindly asked to answer the following questions:

1. **Is your UPPE-T component/task affected by any European <u>legislation</u> (Directives, regulations…)?**

   ☐ YES (Please specify component/task and relevant legislation)

   ☐ NO

2. **Is your organisation <u>participating</u> in any European, international or national standardisation technical committee, working group or similar group related to the UPPE-T project?**

   ☐ YES, by attending meetings and by correspondence (please specify TC or group)

   ☐ YES, by correspondence (please specify TC or group)

   ☐ NO, but we are planning to participate (please specify TC or group)

   ☐ NO (Please go to 3)

   2.1. Please specify the reasons why you are participating in a TC or group (several answers are possible)

   ☐ To anticipate requirements affecting my products/services

   ☐ To influence in the content of standards according to my products/services

   ☐ To establish better levels of quality, performance, interoperability, etc...

   ☐ To make contacts with other stakeholders

   ☐ Others (please specify)

3. **Within the framework of the UPPE-T project and related to your component/tasks, is your organisation <u>using European or international standards</u> (or other European documents such as ETAG, EAD…) among those identified in previous Deliverables on Standardization Contribution?**

   ☐ YES (Please specify the most relevant standards/documents you are using)

   ☐ NO (Please go to 4)

   3.1. Please specify the reasons why you are using standards/documents related to your component/tasks (several answers are possible)

   ☐ To achieve better levels of quality, performance, interoperability, etc...

   ☐ To meet legislation or regulation requirements

☐ To guarantee in the future access to national, European or international markets

☐ To reduce production costs

☐ Others (please specify)

3.2. Please specify the degree of fulfilment with your needs of the standards/documents you are using (one answer by each standard used):

Standard/document 1

☐ The standard/document is totally useful for our purposes

☐ The standard/document could be improved in some aspects (Please specify)

☐ The standard/document should be changed in some aspects (Please specify)

☐ The standard/document is useless for our purposes (Please specify why)

Standard/document 2

[...]

4. **Do you think some aspect (technical, performance, efficiency, reliability, interoperability or quality requirements) of your component/tasks in UPPE-T (<u>for which no standard/document exists</u>) should be set and used in the industry of plastic materials, packaging and use of plastics, environmental management or others Europe-wide or world-wide to facilitate design, manufacturing, trade, safety, relation among stakeholders, etc.?**

   ☐ YES (Please specify component/task, specific aspects and possible interested sectors)

   ☐ NO

5. **In order to commercialize your component/deliverable in the future, a standard/document in common with the industry of plastic materials, packaging and use of plastics, environmental management or others Europe-wide or world-wide may be useful?**

   ☐ YES (Please specify component/deliverable and possible interested sectors)

   ☐ NO

6. **Do you think any already developed or future UPPE-T deliverable could be interesting for being applied in the future by the industry of plastic materials, packaging and use of plastics, environmental management or others Europe-wide as guidance or recommendations?**

   ☐ YES (Please specify deliverable number and possible interested sectors)

   ☐ NO

7. **An increasing number of standards based on patented technology are being successfully and widely developed. Nevertheless, to avoid patent rights problems that may arise when developing standards, CEN-CENELEC has developed a document to provide practical guidance on this subject. Do you know the IPR & Patents policies applied by CEN and ISO? (Link to CEN CENELEC IPR website: https://www.cencenelec.eu/european-standardization/ipr-and-patents/)**

   ☐ YES

   ☐ NO

Annex C: Additional actions

Information on the progress of the standardisation work through the interaction with technical bodies

C.1. Information from CETEC

Pedro López from CETEC was invited by CEN/TC 261/SC 4/WG 10 "Design for recycling for plastic packaging products working group" to a webinar titled "Boosting Plastic Packaging Recyclability: Setting the Right Standards". The webinar took place on the 27th of April 2023 and was focused on the interplay between regulation, standardization, research and innovation and how these in unity can boost plastic packaging recyclability in Europe. At the webinar, the European Commission and the European Technical Committee for standardization of packaging talked about upcoming regulations, standards and opportunities. Finally, European Horizon Projects gave examples of their work with recycling plastic packaging and Research and Innovation projects could learn more about how to get engaged via HSbooster.eu.

C.2. Information from BOKU

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Table 2: Composition of the (universal) trace element solution. The weights were dissolved for 1 liter in approx. 50-100 ml water (30-60 minutes) and dissolved completely overnight on the magnetic stirrer. 8

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Figure 2: Photographic presentation of sturmtest (OECD 301B) under mesophilic conditions at room temperature (A) and thermophilic conditions at 58°C (B). 10

Figure 3: *CO2-evolution in % of the theoretical carbon content of the test substance PLA at thermophilic and mesophilic conditions and cellulose as references over time. PLA thermo (polylactic acid at thermophilic conditions) developed after 62 days with a biodegradation rate of 16%, PLA meso (at mesophilic conditions) only 0.9%. Cellulose at thermophilic conditions reached 58.2%, while at mesophilic conditions, cellulose reached 67.1%.* 12

Figure 4: C-Balance after 62 days of biodegradation: *Fractions of carbon derived from the carbon content of the sample in percent (%) resulting in Biomass, CO2 and residual Polymer* 13

Figure 5: Biodegradability test of nanoparticle sample OLLA (Oligo-L-Lactic acid) on bacterial cellulose. PLLA and cellulose (Fluka) were used as reference. The experiment was run for 79 days. Cellulose reached a degradation rate of 84.1%, PLLA 10.1% and OLLA on BC 5.1%. 14

Figure 6: Biodegradability test of the nanoparticle sample OLLA on microcrystalline cellulose. PLLA and cellulose (Fluca)were used as reference.The experiment was run for 79 days. Cellulose reached a degradation rate of 84.1%, PLLA 10.1% and OLLA on microcrystalline cellulose 8.8%. 14

Figure 7: C-Balance after 62 days of biodegradation: *Fractions of carbon derived from the carbon content of the sample in percent (%) resulting in Biomass, CO2 and residual Polymer* 15

Figure 8: Biodegradability test of the nanoparticle sample PHB on bacterial cellulose (BC). Cellulose (Fluka) was used as reference.The experiment was run for 65 days. Cellulose reached a degradation rate of 42.2% and PHB on BC 73.9%.....15

Figure 9: Biodegradability test of nanoparticle samples SiO_2 PG-PCL (polyglycolic acid and polycaprolactone on silica), SiO_2 KS-OLLA (Oligo L-Lactic acid on silica), and SiO_2 PG-OLLA (polyglycolic acid and OLLA on silica). Cellulose (Fluka) was used as reference.The experiment was run for 65 days. Cellulose reached a degradation rate of 42.2%, SiO_2 PG-PCL 17%, SiO_2 KS-OLLA and SiO_2 PG-OLLA both 0%.....16

Figure 10: C-Balance after 62 days of biodegradation: *Fractions of carbon derived from the carbon content of the sample in percent (%) resulting in Biomass, CO2 and residual Polymer* 16

4. List of abbreviation

TOC – Total organic carbon
Th.CO_2 - Analysed theoretical carbon content
C:N – Carbon to nitrogen ratio
CO_2 – Carbon dioxide
NaOH – Sodium hydroxide
HCl – Hydrochloric acid
N – Molality
OLLA – Oligo-L-lactic acid
BC – Bacterial cellulose
PLLA – Poly-L-lactic acid
PHB - Polyhydroxybutyrate
SiO_2 & KS & KOP – Silica nanoparticles
PG – Polyglycolic acid
PCL - Polycaprolactone
PHBV - Polyhydroxybutyrate-valerate

5. Introduction

Due to the biodegradability and circularity potential, biodegradable bioplastics are of increased interest as we are having a global plastic pollution problem. The European Union is boosting the use of recycled plastics with the Circular Economy Action Plan and EU Green Deal. Organic recycling is one of the variants. Thus, an increased knowledge on bioplastics and their influence on the environment, hence biodegradability and ecotoxicity is needed.

Standardized biodegradation tests as in OECD 301B measure only the mineralized carbon and does not include the carbon that is fixed in the form of biomass or other secondary metabolites. Therefore, a carbon balance can provide a more quantitative analysis of the faith of the polymer in aqueous biodegradation tests (García-Depraect u. a. 2022; Urstadt u. a. 1995). WP7.4 aims to contribute to the generation of new standards to facilitate the acceptance and utilization by the market of the developed solutions. Other objectives are ensuring compatibility and interoperability with what already exists in the market through standards and to use standardization as a tool for dissemination of the project results and interaction with the market stakeholders. In order to provide a complete quantitative biodegradation analysis of the polymers used for food and drink packaging provided by

UpPE-T, a standardized procedure for carbon balances is needed and therefore investigated by BOKU within WP7.

Furthermore, standardized biotests are the base for measuring the properties of biodegradable materials and products. If standards are mandated in European regulations (as is the EN 13432) the methods described or cited therein may have to provide answers to scientific and to non-scientific questions. In case such standards do not exist, they are generated in pre-normative research and results are communicated to the relevant standardization working group.

6. Executive summary (Abstract)

A series of laboratory experiments had been conducted to evaluate analysis methods and calculation procedures for measuring the fate of organic carbon which was introduced into a biodegradation test. In this case the aquatic aerobic test OECD 301B (modified Sturm test) was used as it is described in literature and measurements of dissolved, evolved and non-dissolved (= suspended) carbon and protein were done. Considering a certain carbon to protein relation in bacterial cells of a defined nutrition status, the amounts of anabolized, the amount of katabolized and the amount of remaining, not metabolized carbon were calculated. By this technique, a complete carbon balance shall be made possible with the aim to know the biodegradation rate of a complex composed polymer material or product from the laboratory biodegradation test. This should avoid errors in the quantitative result for biodegradation and is intended to be presented in the standardisation working groups CEN TC261 SC4 WG2 and CEN TC249 WG9.

7. Participation in standardization bodies

Project partner member Ines Fritz continued her participation in the following National, European and International standardization groups:

Austria; FNK 068 - packaging

Austria; FNK 074 – plastics

Austria; FNK 140 WG16 – microplastic in water

EU; CEN TC261 SC4 WG2 – packaging, organic recovery

EU; CEN TC249 WG9 – plastic, biodegradable materials and products

International; ISO TC61 SC4 WG2 – plastics, environmental aspects

In the reporting period of November 1st 2022 until October 31st 2023 8 Austrian and 4 European meetings were attended. During that time the following draft documents were released: prEN TR 17910; pr EN 17427 and prEN17428 and the already existing EN 13432 was in progress of a heavy rework.

8. Pre-normative research: Providing a C-Balance for Biodegradability studies

Methods

In order to evaluate the complete carbon balance, the carbon out of CO_2 evolution and biomass are determined. The difference between the analyzed theoretical carbon content (Th. CO_2) and the measured carbon from biomass $C_{biomass}$ and evolved CO_{2out} indicates the amount of undegraded polymer. The total organic carbon content (TOC) of the polymers were analyzed external by TOC or elemental analysis.

Sturm-Test: Measurement CO_2 evolution

1) Preparation of an inoculum for aquatic biodegradation tests:

Mixed populations of microorganisms are obtained by extracting material from a composting facility or wastewater treatment plant.

- Compost:

Approximately one kilogram of fresh compost at maturation level IV-V was obtained from a composting facility and was suspended in 5 liters of hand warm tap water (approximately 30°C) and allowed to swell with repeated, vigorous stirring for about an hour. Subsequently, the coarse material was separated through sieving, starting from 4.0 down to 0.063 mm mesh size and discarded. From the liquid phase, the mineral sediment was separated and discarded three times by allowing it to settle for 20 minutes and decanting, resulting in a thick but still easily pipetteable suspension. The prepared inoculum was then stabilized for at least 72 hours at either room temperature for mesophilic biodegradation or 45°C for thermophilic conditions in an open beaker with constant stirring.

- Sewage sludge:

For an inoculum from sewage sludge, 10 liters were collected from the activated sludge tank of a wastewater treatment plant and decanted several times to obtain a concentrated but easily pipetteable consistency. This suspension was stabilized for at least 72 hours with constant stirring in an open beaker at room temperature.

2) Sturmtest - Measurement of CO_2 – evolution in aquatic conditions

The determination of aerobic biodegradability, with the measurement of oxygen consumption, was conducted according to OECD 301 B. For this purpose, 400 ml of mineral medium (table 1) was prepared in Schott glass bottles. Approximately 1000 mg of the sample was added (equivalent to about 500 mg of carbon), and approximately 5-10 ml of inoculum were pipetted in. The bottles were immediately sealed (using gas washing bottle caps) and aerated. Aeration was achieved using pre-pressurized, oil-free compressed air, mostly free of CO_2 after passing through 2 N NaOH, at a flow rate of approximately 70 ml/min. Tapped-controlled distribution valves, which alternately opened the flow to each

bottle, were used for this purpose at the IFA-Tulln (see Figure 1 and 2). All tests were conducted in duplicate or triplicate, with three parallel blank values (without the addition of biodegradable substances) and three reference tests (cellulose, Fluka No.: 22181, later Carl Roth No.: CAS:9004-34-6). The test temperature was kept constant, depending on the requirements, at either 22°C or 58°C.

The exhaust air was passed through approximately 400 ml of 0.2 N NaOH (possibly 0.5 N NaOH in the first week), and the absorbed CO_2 was periodically determined by titration with 0.5 N HCl. For this purpose, the NaOH was quantitatively transferred to a 500 ml measuring flask and filled to the mark. An aliquot of this solution was first titrated at room temperature until the phenolphthalein indicator turned colorless, and the volume of consumed HCl was noted. Simultaneously, the solution was heated and, just before boiling, further titrated, this time using a mixed indicator 5 (Merck, No.: 1.06130), and again the volume of HCl was noted. The individual determinations at different time points were continuously summed up for the calculation of the degree of degradation.

Table 1: Mineral medium for Sturm-Test, pH 7,1-7,2.

Substance	Weigh in per L
K_2HPO_4	0,50 g
KH_2PO_4	0,20 g
$MgSO_4 \cdot 7H_2O$	0,20 g
NaCl	4,5 g
$(NH_4)_2SO_4$	0,25 g
$CaCl_2 \cdot 2H_2O$	0,40 g
Trace element solution (Table 2)	1,00 ml

Table 2: Composition of the (universal) trace element solution. The weights were dissolved for 1 liter in approx. 50-100 ml water (30-60 minutes) and dissolved completely overnight on the magnetic stirrer.

Substance	Weigh in per l
H_3BO_3	500 mg
$CuSO_4 \cdot 5$ aq	150 mg
KI	180 mg
$FeCl_3 \cdot 6$ aq	300 mg
$MnSO_4 \cdot$ aq	300 mg
$Na_2MoO_4 \cdot 2$ aq	80 mg
$NiSO_4 \cdot 6$ aq	250 mg
$Co(NO_3)_2 \cdot 6$ aq	100 mg
$ZnSO_4 \cdot 7$ aq	500 mg
$KAl(SO_4)_2 \cdot 12$ aq	400 mg
$KCr(SO_4)_2 \cdot 12$ aq	450 mg
Citric acid	1000 mg

The theoretical amounts of Carbon dioxide (Th-CO_2) that can evolve after complete degradation are calculated based on the stoichiometric amounts of CO_2 (Th-CO_2) determined from the carbon content of the samples obtained by external analysis from total organic carbon analysis or elemental analysis.

mg C_{sample} = % C/100 • sample weight • 1000

% C	Carbon content of the sample (TOC analysis)
1000	Conversion factor from g to mg

mg Th. CO_2 = mg C_{sample} • (M_{CO2}/M_C) = $CO2_{in}$

M_{CO2}	Molecular weight of CO_2: 44.01 g/mol
M_C	Molecular weight of C: 12.01 g/mol

mg CO_2 = (V_M - V_{Ph} - V_{BW}) • N • 44 • A = mg $CO2_{out}$

V_M	Consumption of HCl to the endpoint of the mixed indicator in ml
V_{Ph}	Consumption of HCl to the endpoint of phenolphthalein in ml
V_{BW}	V_M - V_{Ph} of the blank value sample (inoculum without sample addition)
N	Normality of HCl (always 0.1 here)
44	Conversion factor (1 ml of 1 N HCl corresponds to 44 mg CO_2)
A	Aliquot of the NaOH absorption solution

% $Degradation_{CO2}$ (% Th CO_2) = (mg CO_2 / g Sample) • 100 / (mg TH-CO_2 / g Sample)

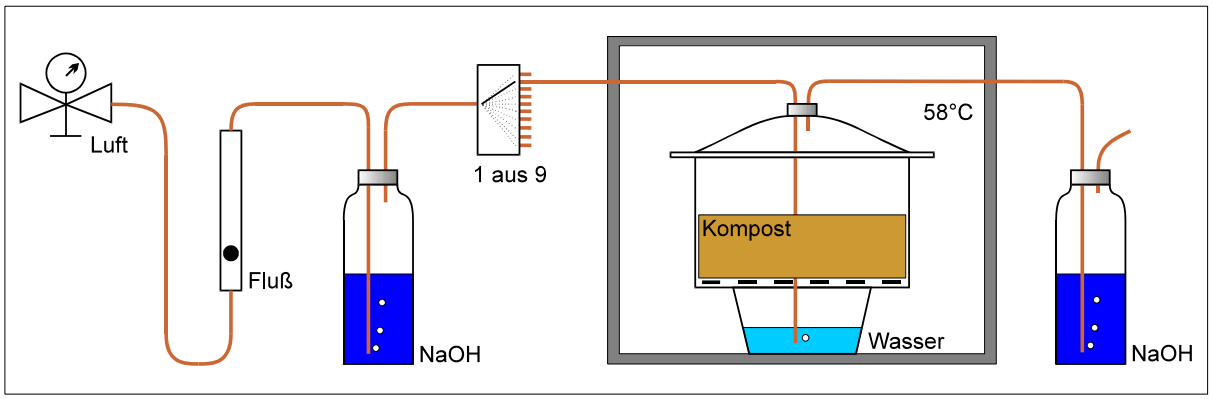

Figure 1: Scheme of the apparatus for determining biodegradability in the laboratory composting test (EN 14046). The same basic scheme is to be used for the sturmtest (OECD 301B). The distribution valve (1 of 9) serially switches on the air supply to the composting vessels. This results in pulsating aeration which, due to the periodic pauses, ultimately allows complete absorption of all carbon dioxide in the NaOH solution.

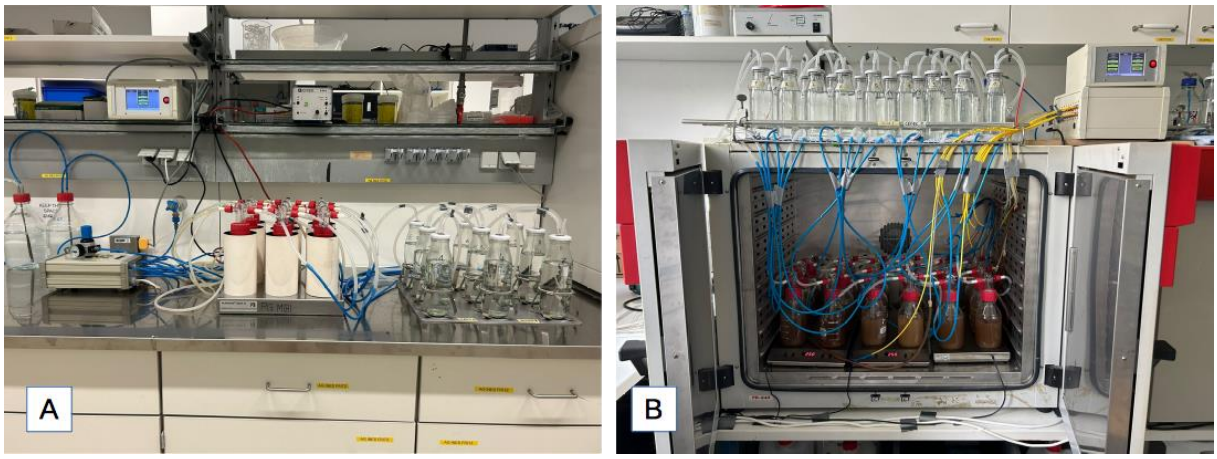

Figure 2: Photo of the laboratory setup for the Sturm test (OECD 301B) under mesophilic conditions at room temperature (A) and thermophilic conditions at 58°C (B).

Measurement of carbon derived from biomass

To evaluate the biomass of the mixed population in the cultures of the Sturm-Test, the protein content as well as the TOC content are determined in the beginning of the experiment without any addition of samples (medium + inoculum). This gives a certain carbon to nitrogen (C:N) ratio that can be used to calculate the carbon content from protein determination after the biodegradation process has been completed when the microorganisms enter a state of hunger again.

Sampling for TOC and protein determination of the test approach without any sample on day 0 of the experiment (medium+inoculum):

1. 6 x 5 mL of culture suspension were transferred to 15 mL Falcon tubes.
2. 3 tubes were frozen at -20°C for TOC determination.
3. The other 3 tubes were centrifuged for 15 minutes at 3600 rpm.
4. The supernatant was discarded and the pellet was frozen at -20°C for protein determination.

In the end of the experiment, all cultures were filled with water to the initial weight to apply afterwards the same sampling procedure as above.

- **Protein determination:**

The pellet was dissolved in 400 µL 0.25M NaOH for 15 minutes in a boiling water bath and centrifuged for 5 minutes at maximum 3600 rpm. A 20 mg/mL BSA stock solution was prepared and diluted 1:100 as a standard for photometric analysis. 50µL of the supernatant of the sample or the BSA standard was incubated with 1500µL of Bradford reagent (Sigma-Aldrich No.: SLCG1879) for 30 minutes. Measurement was then taken with a UV-Spectrophotometer (Shimadzu, UV-1800) at 595nm. To calculate the protein concentration

of the pellets, a calibration curve from BSA standard in the concentration range of 0.001 mg/ml to 1 mg/ml was prepared.

- **TOC measurement:**

For the determination of TOC from the suspensions, the tubes were thawed and afterwards 2 mL were used for the LCK380 Quick test from Hach Lange Gmbh, following the description.

- **Ratio of TOC/Protein = C:N ratio**

To obtain the biomass content of the cultures at the end of the degradation test, the calculated protein concentrations are multiplied by the C-N ratio from the test approach.

Calculations to receive the residual polymer that was not degraded:

$TOC_{Start}/Protein_{Start}$ = C:N ratio

$Protein_{End}$ [mg/L] • C:N ratio = $Biomass_{End}$ [mg/L]

$C\text{-}Biomass_{BlankEnd}$ [mg/L] • $Volume_{culture}$ [L] • 44/12 [g/mol] = $CO_2\text{-}Biomass_{BlankEnd}$

$Biomass_{End}$ [mg/L] • $Volume_{culture}$ [L] • 44/12 [g/mol] – $CO_2Biomass_{BlankEnd}$ = $CO_2\text{-}Biomass_{Endcorr.}$

CO_2 [mg] - CO_{2Blank} [mg] = $CO_{2outcorr.}$

Residual Polymer in %:

(Th. CO2 [mg] – $CO_{2outcorr.}$ [mg] – $CO_2\text{-}Biomass_{Endcorr}$ [mg].)*100/Th. CO2 [mg]

Results

PLA at mesophilic and thermophilic conditions

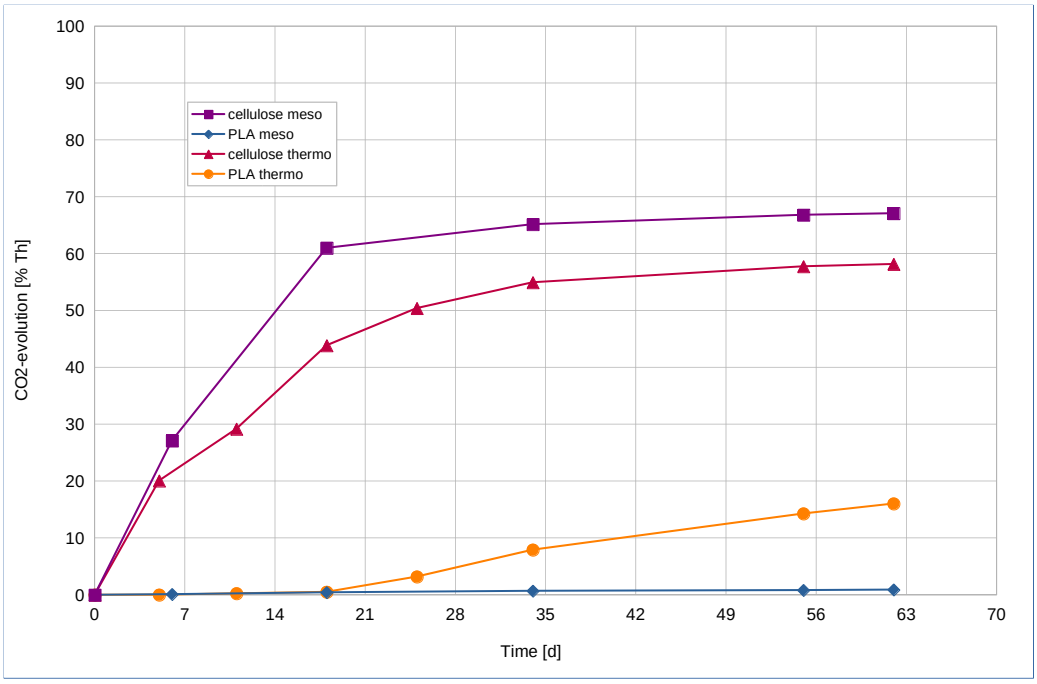

Figure 3: ***CO2-evolution in % of the theoretical carbon content of the test substance PLA at thermophilic and mesophilic conditions and cellulose as references over time. PLA thermo (polylactic acid at thermophilic conditions) developed after 62 days a biodegradation rate of 16%, PLA meso (at mesophilic conditions) only 0.9%. Cellulose at thermophilic conditions reached 58.2%, while at mesophilic conditions, cellulose reached 67.1%.***

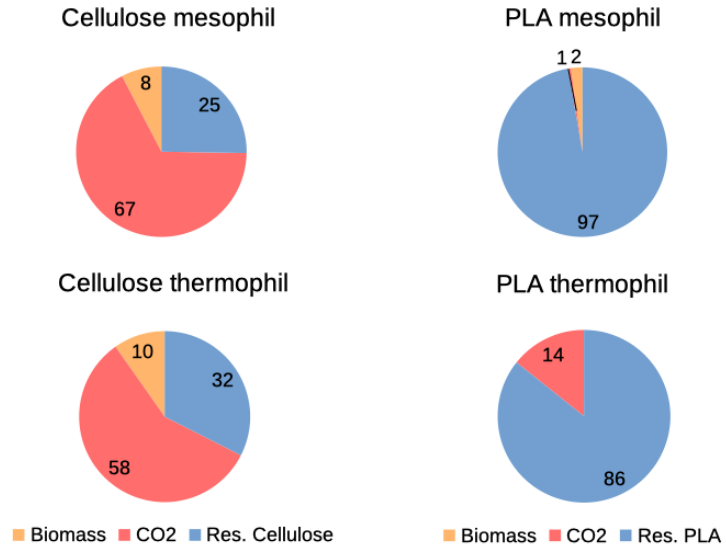

Figure 4: C-Balance after 62 days of biodegradation: ***Fractions of carbon derived from the carbon content of the sample in percent (%) resulting in Biomass, CO_2 and residual Polymer.***

Nanoparticles from WP5.4

- **Experiment 1**

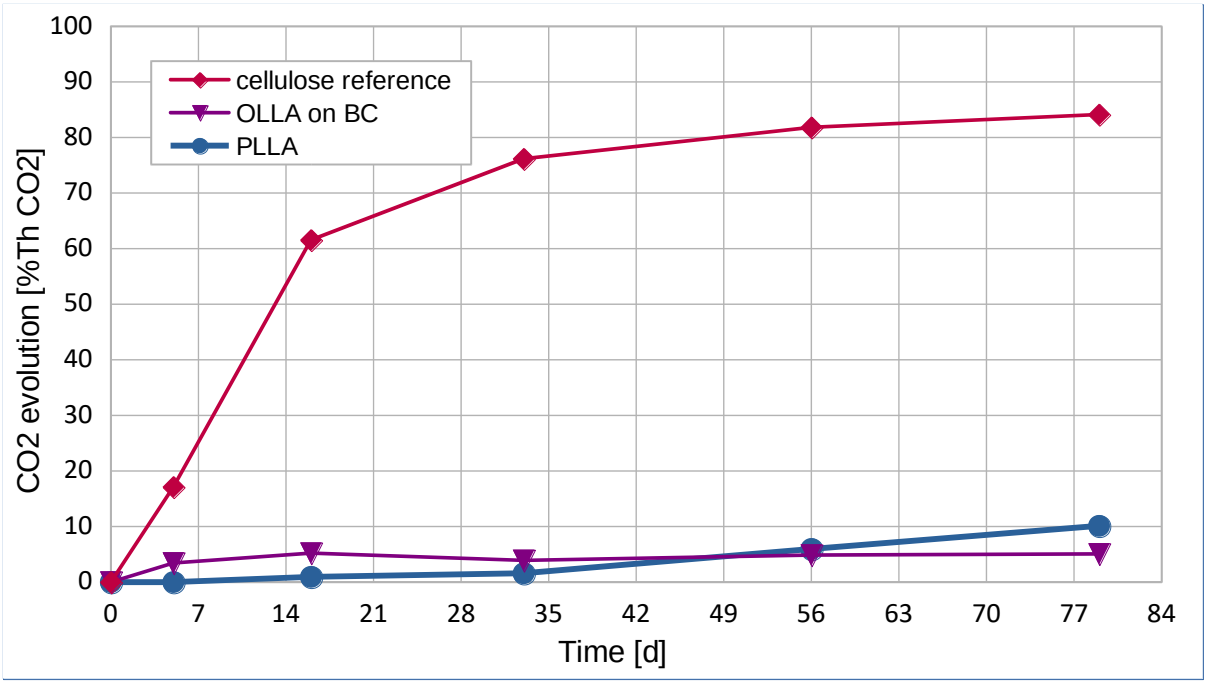

Figure 5: Biodegradability test of nanoparticle sample OLLA (Oligo-L-Lactic acid) on bacterial cellulose. PLLA and cellulose (Fluka) were used as reference. The experiment was run for 79 days. Cellulose reached a degradation rate of 84.1%, PLLA 10.1% and OLLA on BC 5.1%.

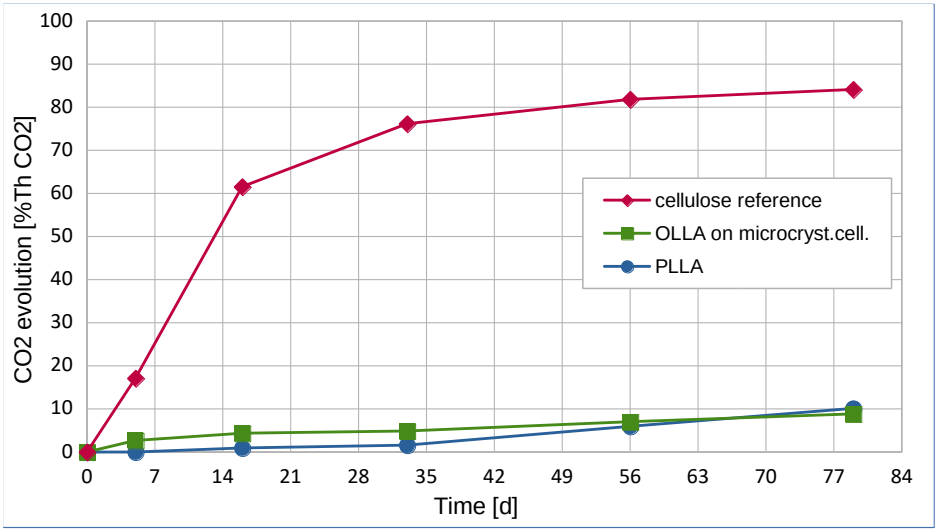

Figure 6: Biodegradability test of the nanoparticle sample OLLA on microcrystalline cellulose. PLLA and cellulose (Fluca)were used as reference.The experiment was run for 79 days. Cellulose reached a degradation rate of 84.1%, PLLA 10.1% and OLLA on microcrystalline cellulose 8.8%.

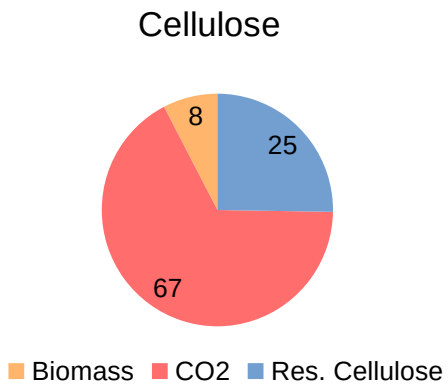

Figure 7: C-Balance after 62 days of biodegradation: *Fractions of carbon derived from the carbon content of the sample in percent (%) resulting in Biomass, CO_2 and residual Polymer.*

- **Experiment 2**

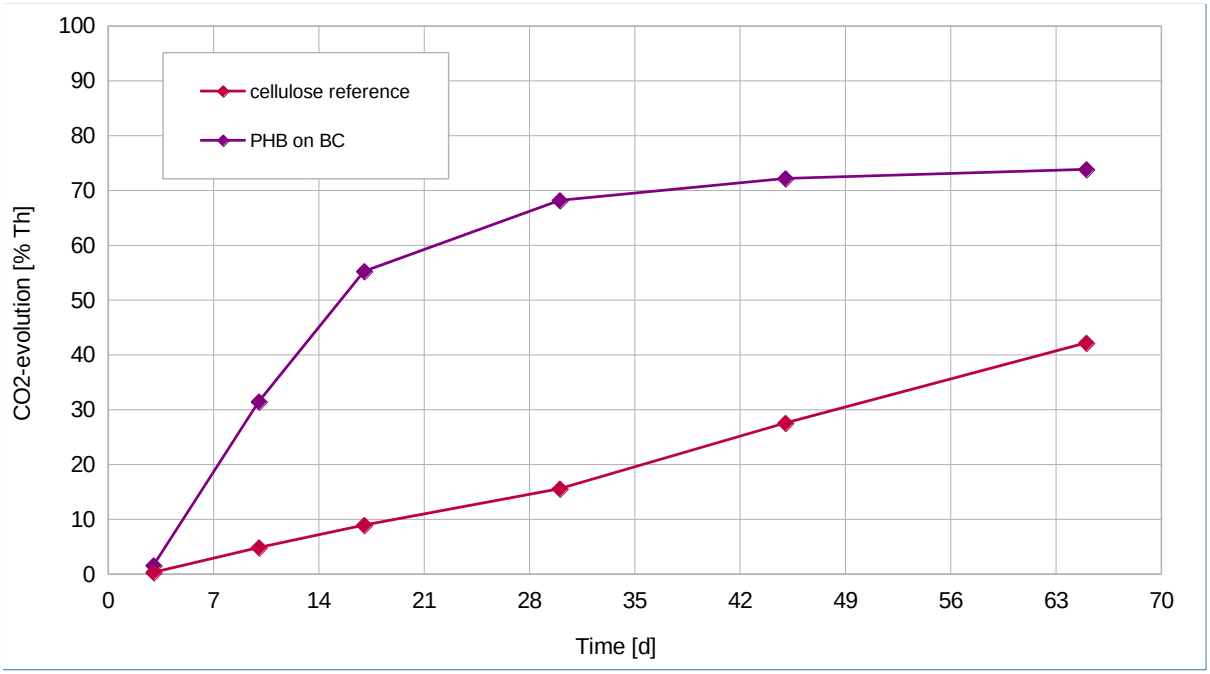

Figure 8: Biodegradability test of the nanoparticle sample PHB on bacterial cellulose (BC). Cellulose (Fluka) was used as reference. The experiment was run for 65 days. Cellulose reached a degradation rate of 42.2% and PHB on BC 73.9%.

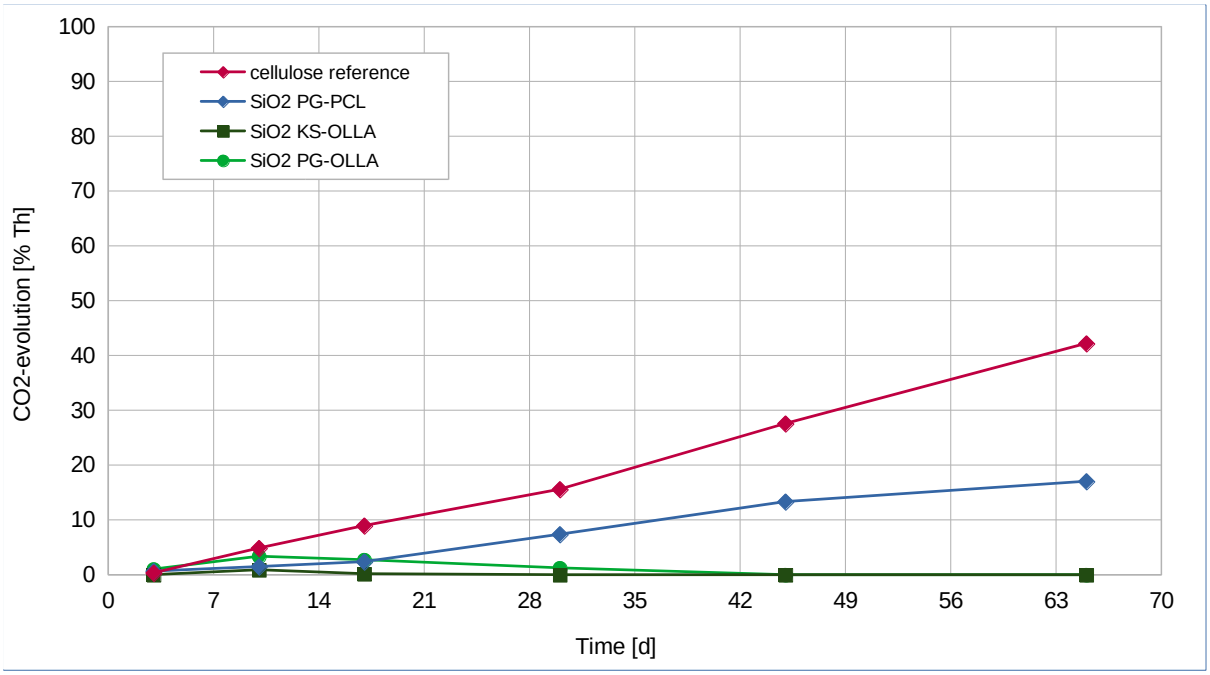

Figure 9: Biodegradability test of nanoparticle samples SiO_2 PG-PCL (polyglycolic acid and polycaprolactone on silica), SiO_2 KS-OLLA (Oligo L-Lactic acid on silica), and SiO_2 PG-OLLA (polyglycolic acid and OLLA on silica). Cellulose (Fluka) was used as reference. The experiment was run for 65 days. Cellulose reached a degradation

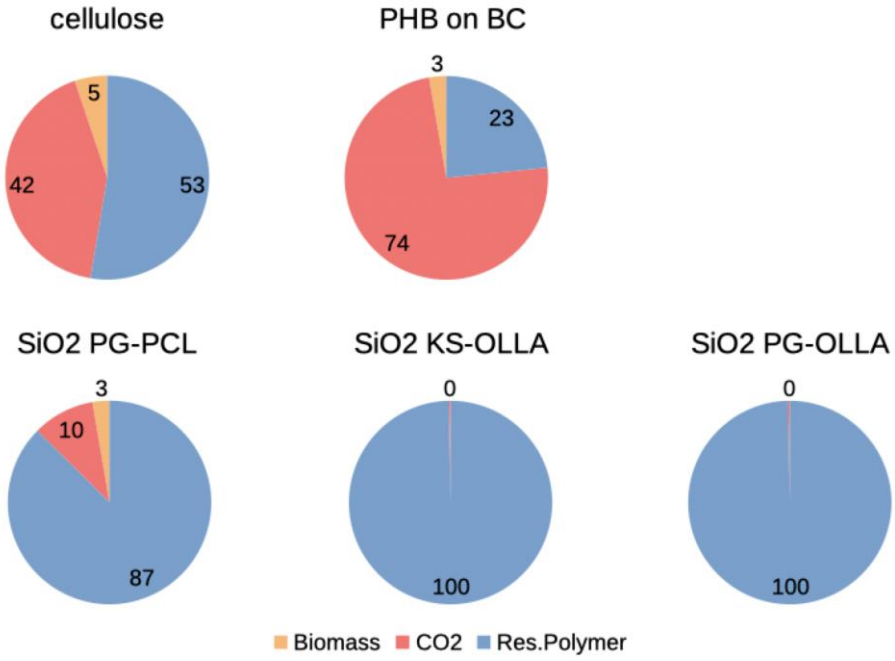

Figure 10: C-Balance after 62 days of biodegradation: *Fractions of carbon derived from the carbon content of the sample in percent (%) resulting in Biomass, CO_2 and residual Polymer.*

Conclusion

The intended test series is not completed at this time. The discussion is now based on preliminary data and should be treated with care!

Comparing evolved CO_2 with measured residual organic carbon in the forms of not biodegraded residues and newly grown biomass, shows some correlation and shows differences in the conversion rates. The mixed bacteria inocula form relatively more biomass per released CO_2 when fed on cellulose than when fed on PLA or OLLA or on PHB. While the amount of released CO_2 remains an acceptable indirect parameter for quantitative estimation of the metabolization rate (=biodegradation rate) of polymer materials and products, only a detailed carbon balance can give evidence about the fate of the organic carbon and allows an estimation of the potential of a claimed biodegradable material or product to release persistent microplastic particles.

The experiments will be continued during the last upPE-T project year.

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Standards:

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