Draft Project plan for the CEN Workshop on extraction, production and purification of added value products from urban wastes

Recipients of this project plan are kindly requested to name all patent rights known to them to be relevant to the Workshop and to make available all supporting documents.

Madrid, 2022-04-04 (Version 1.1)

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Summary

Wastewater treatment and organic fraction of municipal solid waste are responsible for the annual generation of up to 138 million tonnes of bio-waste, in the EU. It has been estimated that almost 75% of this waste is currently sent to incineration or landfilling, with an extraordinary environmental and economic cost associated. Moreover, a high percentage of this waste holds a great potential as a source of recycled materials or valuable component recovery source. Wastewater contains cellulose and nutrients that could be used as feedstock for many applications. Solid organic waste could be also an interesting source of materials for added value applications (e.g. ectoine, polyhydroxyalkanoates, biomethane, etc.), to complement their conventional valorisation routes (e.g fertilizers, biogas, etc).

Nowadays, bio-waste is usually processed by means of methods such as anaerobic digestion and composting for the production of biogas or compost to be used as fertilizer. Similarly, domestic wastewater treatment is often conducted in activated sludge systems, which present high operating costs and energy demand. These methods present a low performance, high carbon footprint and low recovery of nutrients and valuable components.

The European R&I project DEEP PURPLE has developed innovative processes of production and purification of different added value products. These processes are based on the recovery of bioproducts from the treatment of urban bio-waste as an inexpensive and sustainable carbon or/and nutrient source for biomass growth to be further transformed into high added-value products for different industrial sectors.

The planned workshop defines novel processes on production and purification of added value products.

The workshop will specify extraction production and purification processes of two added value products;

- ectoine obtained from biogas.
- polyhydroxyalkanoates (PHAs) biopolymers from wastewater.

1 Status of the project plan

Draft project plan for public commenting (Version 1.1)

This draft project plan is intended to inform the public of a new Workshop. Any interested party can take part in this Workshop and/or comment on this draft project plan. Please send any requests to participate or comments by e-mail to egayo@une.org

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 on **2022-05-17**.

2 Workshop proposer and Workshop participants

2.1 Workshop proposer

Person or organisation	Short description and interest in the subject
Víctor Pérez UVA-Institute of Sustainable Processes	"Víctor Pérez has 5 years' experience on the development of techno-economic, sensitivity and sustainability analysis regarding the industrial production of polyhydroxyalkanoates (PHA) and ectoine from biogas in waste treatment facilities. This research has been developed during his PhD thesis in the Institute of Sustainable processes of Valladolid University, which will be defended in 2022. Also, he has participated in the design, construction and operation of two demo-scale plants for the valorization of biogas into PHA and ectoine financed by the H2020 programme of the European Commission". The Institute of Sustainable Processes of Valladolid University has more than 10 years of experience in the biological production of PHA and ectoine from residual gas streams and organic waste. In the past 10 years, they have conducted 6 R&I projects in the topic and publish more than 20 papers index in the Journal Citation Reports"

2.2 Other potential participants

This CWA will be developed in a Workshop (temporary body) that is open to any interested party. The participation of other experts would be helpful and is desired. It is recommended that:

- Wastewater services companies
- Municipalities
- Urban solid waste companies
- Environmental services companies
- Environment and sustainability academic and research centres
- Natural active compounds and bio-based ingredients producers
- Plastic and bioplastic industries
- Cosmetic industries

take part in the development of this CWA.

2.3 Participants at the kick-off meeting

The following persons or organisations already signed up to the kick-off meeting prior to the publication of the draft project plan.

Person	Organisation
Workshop proposer Víctor Pérez,	Workshop proposer INSTITUTE OF SUSTAINABLE PROCESSES AT UNIVERSIDAD DE VALLADOLID – UVA (Spain)
Jose Luis Molto Marin	ACTIVATEC (UK)
Raúl Muñoz, María del Rosario Rodero	INSTITUTE OF SUSTAINABLE PROCESSES AT UNIVERSIDAD DE VALLADOLID – UVA (Spain)
Patricia Zamora	FCC AQUALIA (Spain)
Laurent Bélard Amélie Raingué	NATUREPLAST (France)
Gabriel Morales	FCC Environment (Spain)
Cristina González	TECHNOLOGICAL CENTRE IN PACKAGING, LOGISTICS, TRANSPORT- ITENE (Spain)
Daniele Turati Maurizio Tosin	NOVAMONT (Italy)
Marius-Febi Matei Bianca Maria Barozzi	GATE2GROWTH (Denmark)
Workshop secretariat Elena Gayo	Workshop secretariat SPANISH ASSOCIATION FOR STANDARDIZATION – UNE (Spain)

2.4 Registered Workshop participants

.The following persons or organisations have registered as Workshop participants at the kick-off meeting and will actively participate in the development of the CWA.

Person	Organisation
Workshop Chair	Workshop Chair
Workshop Vice-Chair	Workshop Vice-Chair
Workshop secretariat	Workshop secretariat

3 Workshop objectives and scope

3.1 Background

The workshop deals with urban waste and wastewater management, GHG emissions reduction and recycling within the concept of circular economy.

Wastewater treatment and organic fraction of municipal solid waste are responsible for the annual generation of up to 138 million tonnes of bio-waste, in the EU. It has been estimated that almost 75% of this waste is currently sent to incineration or landfilling, with an extraordinary environmental and economic cost associated. Moreover, a high percentage of this waste holds a great potential as a source of recycled materials or valuable component recovery source. Wastewater contains cellulose and nutrients that could be used as feedstock for many applications. Solid organic waste could be also an interesting source of materials for added value applications (e.g. ectoine, polyhydroxyalkanoates, biomethane, etc.), to complement their conventional valorisation routes (e.g fertilizers, biogas, etc).

On the other hand, different products of interest for the industry could be generated from the treatment of urban solid wastes and wastewaters.

This workshop faces the standardization of the methodology extraction, production and purification of two added value products from urban waste: ectoine and PHA biopolymers.

Ectoine

Europe is nowadays the region with the largest number of anaerobic digesters in the world (approx. 18000 units in 2017), followed by China (7000 units by 2015) and USA (2200 in 2015) (EBA 2018[1]; WBA 2019[2]).

[1] EBA. Statistical Report of the European Biogas Association 2018. https://www.europeanbiogas.eu/wpcontent/uploads/2019/11/EBA_report2018_abriged_A4_vers12_220519_RZweb.pdf. Accessed: 14th December 2019

[2] WBA. Global Potential of Biogas. World Biogas Association 2019. http://www.worldbiogasassociation.org/wp-content/uploads/2019/09/WBA-globalreport-56ppa4_digital-Sept-2019.pdf. Accessed: 14th December 2019.

Europe's leadership in biogas production has been triggered by the urgent need to reduce its dependence on imported natural gas and valorise the organic waste from the domestic, livestock and industrial sector. European biogas supported in 2016 a primary energy production of almost 16.1 million tonnes of oil equivalent (Mtoe), corresponding to an electricity production of 62.5 Twh and sales to heat district systems of 643.000 tonnes of oil equivalent (Eurobserv 2017[3]). The anaerobic digestion of energy crops, urban solid waste and livestock waste accounted for almost 12 Mtoe, landfill gas for 3 Mtoe and wastewater treatment for 1.5 Mtoe in Europe in 2016. The regulatory limit of 60 % in the use of energy crops in Germany (the largest producer of biogas) has slowed down the exponential growth of biogas production occurred in the past decade. However, the recent European commitment at COP25 to achieve net-zero greenhouse gas emissions by 2050, along with the increase in the price of fossil fuels and in the number of political initiatives to implement a circular economy in Europe, foresees a steady increase in biogas production. Indeed, an increase in the annual production of biogas up to 41 Mtoe by 2030 is expected according to the European Biogas Association. The rapid reduction in the cost of solar and wind energy production in the past decade is causing a gradual reduction in feed-in tariffs and fiscal incentives for the *in-situ* generation of electricity from biogas worldwide. This recent fact is triggering research in alternative uses of biogas, which would ultimately improve the final economic balance of anaerobic digestion. In this context, biogas can be used as a feedstock for the generation of products with higher added value than biogas such as biomethane via biogas purification, chemical building blocks via catalysis and commodities and fine chemicals via biotechnologies.

Currently, ectoine (1,4,5,6,tetra-2-methyl-4-pyrimidinecarboxylic acid) is one of the most profitable products produced by microorganisms. Due to its high effectiveness as stabilizer of enzymes, DNA-protein complexes and nucleic acids, ectoine has a value in the pharmaceutical industry of approximately US$1000 kg and a global consumption of 20 tones/year (Strong et al., 2016[4]). Nowadays, industrial bacterial processes for the production of ectoine only use the γ-Proteobacteria Halomonas elongata. This strain that can accumulate ~16% g ectoine/g biomass, has a broad salt tolerance and is able to rapidly synthesize and excrete ectoine to the medium (Kunte et al., 2014[5]). Industrial ectoine production, also known as bio-milking, consists of a long fed-batch fermentation (~120 h) with two steps at different salt concentrations (12 and 0%), to obtain first a high culture density (25 g/L) and subsequently induce a hypo-osmotic shock (Sauer et al., 1998[6]). The sudden decrease in media salinity results in the excretion of ectoine from the cell to the culture broth, where the product is collected for its downstream purification. The upstream processing is still inefficient due to the high amount of nutrients, oxygen and time required, besides entailing a complex and expensive downstream processing (Lang et al., 2011[7]). These limitations represent a challenge to its commercial large-scale production. In this context, the use of biogas as an inexpensive feedstock

3 Eurobserv. Biogas barometer 2017. https://www.eurobserv-er.org/biogas-barometer-2017/. Accessed: 14th December 2019.

4 Strong, P. J., Kalyuzhnaya, M., Silverman, J., & Clarke, W. P. (2016). A methanotroph-based biorefinery: potential scenarios for generating multiple products from a single fermentation. Bioresource technology, 215, 314-323. https://doi.org/10.1016/j.biortech.2016.04.099

5 Kunte, H. J., Lentzen, G., & Galinski, E. (2014). Industrial production of the cell protectant ectoine: protection mechanisms, processes, and products. Current biotechnology, 3, 10-25. https://doi.org/10.2174/2211550113026660037

6 Sauer, T., & Galinski, E. A. (1998). Bacterial milking: a novel bioprocess for production of compatible solutes. Biotechnology and bioengineering, 57(3), 306-313.

7 Lang, Y. jun, Bai, L., Ren, Y. nan, Zhang, L. hua, & Nagata, S. (2011). Production of ectoine through a combined process that uses both growing and resting cells of Halomonas salina DSM 5928T. Extremophiles, 15(2), 303–310. https://doi.org/10.1007/s00792-011-0360-9

for ectoine biosynthesis by halotolerant methanotrophs has been demonstrated (Cantera et al. 2020[8]; Carmona-Martínez et al. 2021[9]).

PHA biopolymers

Polyhydroxyalkanoates (PHAs) include a range of various length hydroxy fatty acid polyesters which are naturally produced by some types of bacteria (Anjum et al., 2016[10]). Similar to polylactic acids (PLAs), PHA polymers are both bio-based and bio-degradable and therefore have attracted much attention over the last four decades as an alternative to commonly used non-degradable plastics. PHAs possess similar physical properties to polyethylene (PE), polypropylene (PP) and polyethylene terephthalate (PET) which currently dominate in the packaging industry. Currently, new abundant substrates are sought after to avoid the high price of monosaccharides and to achieve a circular economy which necessitates utilisation of various sustainable organic wastes for the production of commercial goods. Moreover, the concept of the carbon recovery at wastewater treatment facilities has been successfully verified and anaerobically grown purple photobacteria have been shown to produce PHAs at high concentrations.

One of the key steps in the PHAs polymer extraction process is the need for the cell to be disrupted, in order to recover the PHA granules, which have accumulated in the bacterial cell cytoplasm. The nature of the cell disruption can be divided into two categories: mechanical (high-pressure homogenisation and a bead mill) and non-mechanical methods (utilising chemicals to either digest the cellular material surrounding the PHA granules or to act as a solvent).

Since extraction process represents as much as 50% of the total cost of recovery of PHAs from the biomass, it was determined that it should provide high yield and incur low cost. However, yield and cost are not the only factors to consider. Chloroform extraction is used as a benchmark for the PHAs isolation methods as it allows the process to achieve the purest product after the polymer precipitation in cold ethanol or methanol, however there is a general concern over the hazardous nature of the chlorinated organic solvents (requiring compliance with strict operational H&S and disposal regulations) and also the high costs associated with organic solvents recovery.

3.2 Scope

The purpose of this CEN/CENELEC Workshop is to agree well-defined specifications for:

- Etraction, production and purification of ectoine obtained from biogas
- Extraction and purification of PHA biopolymers

The agreement will be formalized by two CEN/CENELEC Workshop agreements (CWA) that will be develop in two parts:

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[8] Cantera S., Phandanouvong-Lozano V., Pascual C., García-Encina P., Lebrero R., Hay A., & Muñoz R. (2020) A systematic comparison of ectoine production from upgraded biogas using Methylomicrobium alcaliphilum and a mixed haloalkaliphilic consortium. Waste Management. 102: 773-781. https://doi.org/10.1016/j.wasman.2019.11.043

[9] Carmona-Martínez, A.A., Marcos-Rodrigo, E., Bordel, S., Marín, D., Herrero-Lobo, R., García-Encina, P.A., & Muñoz, R. (2021). Elucidating the key environmental parameters during the production of ectoines from biogas by mixed methanotrophic consortia. J. Environ. Manage. 298, 113462. https://doi.org/10.1016/j.jenvman.2021.113462

[10] Anjum, A., Zuber, M., Zia, K. M., Noreen, A., Anjum, M. N., & Tabasum, S. (2016). Microbial production of polyhydroxyalkanoates (PHAs) and its copolymers: A review of recent advancements. In *International Journal of Biological Macromolecules* (Vol. 89, pp. 161–174). Elsevier. https://doi.org/10.1016/j.ijbiomac.2016.04.069

- **Production and purification of ectoine obtained from biogas**

This document will define an operational guideline for biogas bioconversion into ectoine, extraction of pure ectoine from a solution and ectoine purification.

This part of the workshop agreement will be chaired by María del Rosario Rodero from UVA. The Institute of Sustainable Processes of Valladolid University is a research institute of the University of Valladolid dedicated to solving environmental problems and improving industrial processes through the development of sustainable technologies and control and automation tools.

- **Extraction and purification of PHA biopolymers**

This document will define the process for extraction and purification of PHA bio polyesters from enriched biomass

Mr Jose Luis Moltó from ACTIVATEC will chair this part of the CWA. ACTIVATEC LTD is a company focused on the evaluation and optimisation of processes to produce natural active compounds and bio-based ingredients for cosmetics and functional food from currently unused and low-value organic sources.

The processes defined in those standardization documents contribute to GHG emissions reduction and recycling within the concept of circular economy by transformation of urban bio-waste into high added-value products for different industrial sectors

The proposed CWAs will not define requirements related to safety aspects

3.3 Related activities

Throughout the DEEP PURPLE Project some different activities are being developed related to the standardization which provides the project in general and in particular to its results, the benefits of harmonization and dissemination of standards. The first activity related with standardization has been the search and analysis of the existing standards, and on-going developments, relevant to the project in order to introduce aspects that enable interoperability, dissemination of results in the standardization community and related benefits in order to ease introduction of DEEP PURPLE outputs in markets.

As result of this standardization analysis no standards or projects under development related to the CWA topic have been identified. However, there are committees, that deal with related subjects and thus need to be considered - and involved, where necessary - during this Workshop:

- CEN/TC 183 - Waste management
- CEN/TC 308 - Characterization and management of sludge
- CEN/TC 249 - Plastics
- CEN/TC 249/WG 9 Bio-based and biodegradable plastics
- CEN/TC 249/WG 24 - Environmental aspects
- CEN/TC 411 -Bio-based products
- CEN/TC 392 – Cosmetics
- CEN/TC 462 -Regulated chemicals in products

Those TCs have been informed of the outcoming WS and invited to participate.

Because of the possible overlaping of it scope, the project proposal draft was sent to CEN TC 249 Plastics, asking for comments with a 30-days period for reply. No comments have been received.

4 Workshop programme

4.1 General

The kick-off meeting is planned to take place on **2022-05-17 through TEAMS.** A draft for public commenting will be published for 30 days.

A total of two Workshop meetings (kick-off meeting and Workshop meetings) and web conferences will be held, during which the content of the CWA(s) will be presented, discussed and approved.

The CWA will be drawn up in English (language of meetings, minutes, etc.). The CWA will be written in English.

4.2 Workshop schedule

The CWA will consist of two parts, which are indicated as separate work items. Both work items will be developed at the same time and because of that there is only one schedule that covers both work items

- Work item 1: Production and purification of ectoine obtained from biogas
- Work item 2: Extraction and purification of PHA biopolymers

The estimated duration of this workshop is 9-10 months

Table 1: Workshop schedule Work item 1 (preliminary)

CEN/CENELEC Workshop	M01	M02	M03	M04	M05	M06	M07	M08	M09	M10	M11	M12	…
Initiation													
1. Proposal form submission and TC													
2. Project plan development													
3. Open commenting period on draft project													
Operation													
4. Kick-off meeting													
5. CWA(s) development													
6. Open commenting period on draft													
7. CWA(s) finalised and approved by Workshop participants													
Publication													
8. CWA(s) publication													
Dissemination (see 7)													
Milestones			K						V/A		P D		

Table 2: Workshop schedule Work item 2 (preliminary)

CEN/CENELEC Workshop	M01	M02	M03	M04	M05	M06	M07	M08	M09	M10	M11	M12	…
Initiation													
1. Proposal form submission and TC													
2. Project plan development													
3. Open commenting period on draft													
Operation													
4. Kick-off meeting													
5. CWA(s) development													
6. Open commenting period on draft CWA(s)													
7. CWA(s) finalised and approved by Workshop													
Publication													
8. CWA(s) publication													
Dissemination (see 7)													
Milestones			K						V / A		P D		

B CEN/CENELEC BT meeting deciding on establishment of a CEN/CENELEC Workshop
K Kick-off
M Workshop meeting
V Virtual Workshop meeting
A Adoption of CWA
P Publication of CWA
D Online distribution of CWA

5 Resource planning

The proposed CEN/CENELEC workshop will run in the frame of R&I project DEEP PURPLE *Conversion of diluted mixed urban bio-wastes into sustainable materials and products in flexible purple photobiorefineries* that has received funding from the Bio Based Industries Joint Undertaking (BBI JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 837998

6 Workshop structure and rules of cooperation

6.1 Participation in the Workshop

The Workshop will be constituted during the course of the kick-off meeting. By approving this project plan, the interested parties declare their willingness to participate in the Workshop and will be formally named as Workshop participants, with the associated rights and duties. Participants at the kick-off meeting who do not approve the project plan are not given the status of a Workshop participant and are thus excluded from further decisions made during the kick-off meeting and from any other decisions regarding the Workshop.

As a rule, the request to participate in the Workshop is closed once it is constituted. The current Workshop participants shall decide whether any additional members will be accepted or not.

Any new participant in the Workshop at a later date is decided on by the participants making up the Workshop at that time. It is particularly important to consider these aspects:

a. expansion would be conducive to shortening the duration of the Workshop or to avoiding or averting an impending delay in the planned duration of the Workshop;

b. the expansion would not result in the Workshop taking longer to complete;

c. the new Workshop participant would not address any new or complementary issues beyond the scope defined and approved in the project plan;

d. the new Workshop participant would bring complementary expertise into the Workshop in order to incorporate the latest scientific findings and state-of-the-art knowledge;

e. the new Workshop participant would actively participate in the drafting of the manuscript by submitting concrete, not abstract, proposals and contributions;

f. the new Workshop participant would ensure wider application of the CWA.

All Workshop participants who voted for the publication of the CWA or its draft will be named as authors in the European Foreword, including the organisations which they represent. All Workshop participants who voted against the publication of the CWA, or who have abstained, will not be named in the European Foreword.

6.2 Workshop responsibilities

The Workshop Chair is responsible for content management and any decision-making and voting procedures. The Workshop Chair is supported by the Workshop Vice-Chair and the responsible Workshop secretariat, whereby the Workshop secretariat will always remain neutral regarding the content of the CWA(s). Furthermore, the Workshop secretariat shall ensure that CEN-CENELEC's rules of procedure, rules of presentation, and the principles governing the publication of CWA(s) have been observed. Should a Workshop Chair no longer be able to carry out her/his duties, the Workshop secretariat shall initiate the election of a new Workshop Chair. The list below covers the main tasks of the Workshop Chair. It is not intended to be exhaustive.

- Content related contact point for the Workshop
- Presides at Workshop meetings
- Ensures that the development of the CWA respects the principles and content of the adopted project plan
- Manages the consensus building process, decides when the Workshop participants have reached agreement on the final CWA, on the basis of the comments received
- Ensures due information exchange with the Workshop secretariat
- Represents the Workshop and its results to exterior

The Workshop secretariat, provided by a CEN/CENELEC national member, is responsible for organising and leading the kick-off meeting, in consultation with the Workshop proposer. Further Workshop meetings and/or web conferences shall be organised by the Workshop secretariat in consultation with the Workshop Chair. The list below covers the main tasks of the Workshop secretariat. It is not intended to be exhaustive.

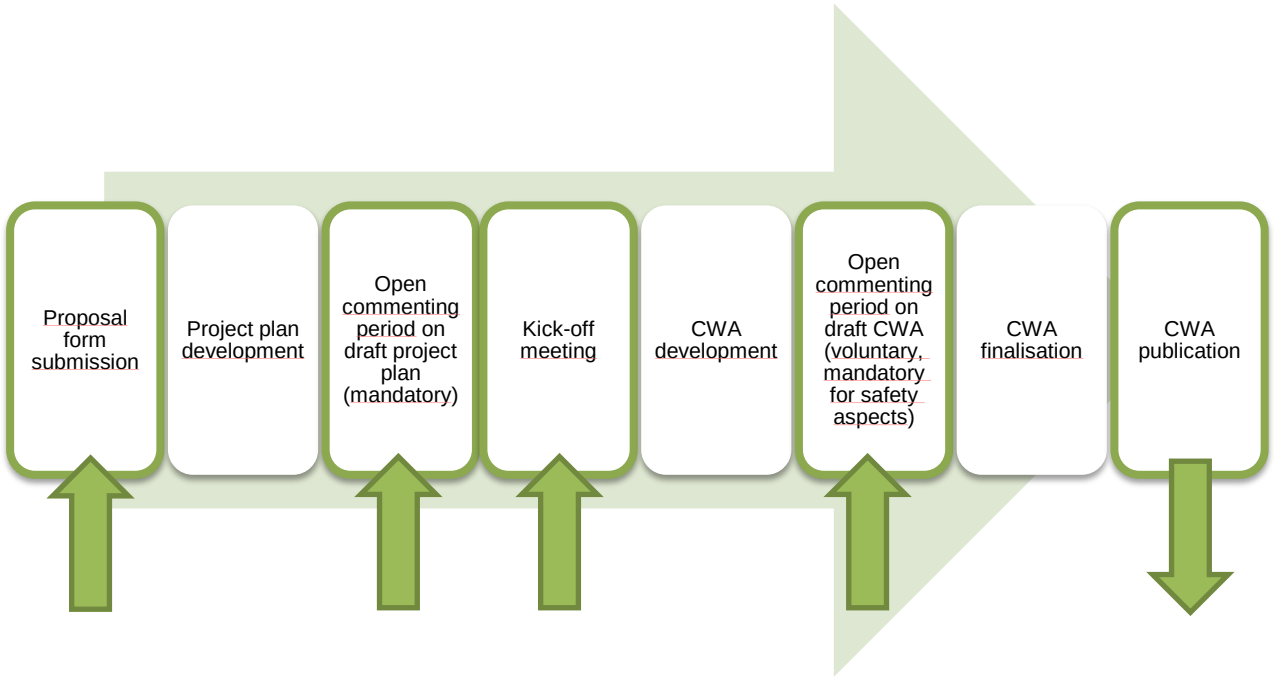
- Administrative and organisational contact point for the Workshop
- Ensures that the development of the CWA respects the principles and content of the adopted project plan and of the requirements of the CEN-CENELEC Guide 29
- Formally registers Workshop participants and maintains record of participating organisations and individuals
- Offers infrastructure and manage documents and their distribution through an electronic platform
- Prepares agenda and distribute information on meetings and meeting minutes as well as follow-up actions of the Workshop
- Initiates and manage CWA approval process upon decision by the Workshop Chair
- Interface with CEN-CENELEC Management Centre (CCMC) and Workshop Chair regarding strategic directions, problems arising, and external relationships
- Advises on CEN-CENELEC rules and bring any major problems encountered (if any) in the development of the CWA to the attention of CEN-CENELEC Management Centre (CCMC)
- Administrates the connection with relevant CEN or CENELEC/TCs

6.3 Decision making process

The final draft of the CWA, considered by the Chair to represent the best possible consensus, will be presented to the Workshop participants who will be invited to express their support for this final draft so that their names can be listed in the Foreword.

During the drafting process, in cases where opposing views are expressed, the overall level of support by the Workshop will be tested by asking the Workshop participants to express their position. These interim decisions on the direction to be taken will be decided on the basis of a simple majority among the organizations participating in the Workshop. If Workshop participants cannot be present in the meetings where such decision is taken, an alternative means of including them in the decision process may be used.

7 Dissemination and participation strategy



Proposal form submission

The Workshop proposal will be disseminated to the following relevant stakeholders and bodies for consultation:

- standards committee, working group etc.
- Specific DEEP PURPLE project dissemination channels
- Specific DEEP PURPLE partners dissemination channels

Open commenting period on draft project plan

The project plan will be disseminated to the following relevant stakeholders and bodies for commenting:

- standards committee, working group etc.
- Specific DEEP PURPLE project dissemination channels
- Specific DEEP PURPLE partners dissemination channels

In addition to the CEN and CENELEC website, the project plan and the date of the kick-off meeting will be advertised on DEEP PURPLE networks to raise awareness. Interested parties are requested to contribute either through commenting of the project plan (short term) or through Workshop participation (long term).

Open commenting period on draft CWA

The draft CWA will be disseminated to the following relevant stakeholders and bodies for commenting:

- standards committee, working group etc.
- Specific DEEP PURPLE project dissemination channels
- Specific DEEP PURPLE partners dissemination channels

In addition to the CEN and CENELEC website, the draft CWA will be advertised on social media and DEEP PURPLE project dissemination channels to raise awareness. Interested parties are requested to contribute through commenting of the draft CWA (short term).

CWA publication

The final CWA will be disseminated to the following relevant stakeholders and bodies:

- standards committee, working group etc.
- Specific DEEP PURPLE project dissemination channels
- Specific DEEP PURPLE partners dissemination channels

In addition to the CEN and CENELEC website, the final CWA will be advertised on:

- sector specific newsletter
- social media, such as
  - Facebook
  - Instagram
  - LinkedIn
  - Twitter
- Research Gate
- EC Newsroom
- others

8 Contacts

- Workshop Chair and coordinator of project 1:
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