EUROPEAN CLIMATE, INFRASTRUCTURE AND ENVIRONMENT EXECUTIVE AGENCY (CINEA)

CINEA.C – Green research and innovation
C.2 – Horizon Europe Energy

GRANT AGREEMENT

Project 101147377 — WindTwin

PREAMBLE

This **Agreement** ('the Agreement') is **between** the following parties:

on the one part,

the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and

on the other part,

1. 'the coordinator':

BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC), PIC 999655520, established in CALLE JORDI GIRONA 31, BARCELONA 08034, Spain,

and the following other beneficiaries, if they sign their 'accession form' (see Annex 3 and Article 40):

2. **FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV (FHG-IEE)**, PIC 999984059, established in HANSASTRASSE 27C, MUNCHEN 80686, Germany,

3. **WAVEC/OFFSHORE RENEWABLES - CENTRO DE ENERGIA OFFSHORE ASSOCIACAO (WAVEC)**, PIC 999543485, established in EDIFICIO DIOGO CAO, DOCA DE ALCANTA NORTE, LISBOA 1350-352, Portugal,

4. **EPRI EUROPE DAC (EPRI)**, PIC 913811393, established in 3 DUBLIN LANDINGS NORTH WALL QUAY, DUBLIN D01 C4E0, Ireland,

5. **ETULOS SOLUTE SL (SOLUTE)**, PIC 952762325, established in Av. Cerro del Aguila 3, SAN SEBASTIAN DE LOS REYES 28703, Spain,

6. **UNIVERSITAET KASSEL (UKS)**, PIC 999852624, established in MONCHEBERGSTRASSE 19, KASSEL 34125, Germany,

7. **IBERDROLA RENOVABLES ENERGIA SA (IBERDROLA)**, PIC 953093774, established in PLAZA EUSKADI 5, BILBAO 48009, Spain,

8. **SINTEF OCEAN AS (SINTEF)**, PIC 997806603, established in PAUL FJERMSTADS VEG 59, TRONDHEIM 7052, Norway,

9. **+ATLANTIC ASSOCIACAO PARA UM LABORATORIO COLABORATIVO DO ATLANTICO (+ATLANTIC)**, PIC 898055586, established in INSTITUTO POLITECNICO DE LEIRIA ESCOLA TECNOLOGIA DO MAR RUA DO CONHECIMENT 4, PENICHE 2520-614, Portugal,

10. **OPEN CASCADE (OPEN CASCADE)**, PIC 942422416, established in 1 PLACE DES FRERES MONTGOLFIER, GUYANCOURT 78280, France,

11. **CNET CENTRE FOR NEW ENERGY TECHNOLOGIES SA (EDP NEW)**, PIC 933299857, established in RUA CIDADE DE GOA 4, SACAVEM E PRIOR VELHO LISBOA 2685 039, Portugal,

12. **MARIN ENERGI TESTSENTER AS (MET Centre)**, PIC 928496902, established in HELGANESVEGEN 41, AVALDSNES 4299, Norway,

13. **BELGISCH LABORATORIUM VAN ELEKTRICITEITSINDUSTRIE (ENGIE Laborelec)**, PIC 998728200, established in RODESTRAAT 125, LINKEBEEK 1630, Belgium,

Unless otherwise specified, references to ‘beneficiary’ or ‘beneficiaries’ include the coordinator and affiliated entities (if any).

If only one beneficiary signs the grant agreement (‘mono-beneficiary grant’), all provisions referring to the ‘coordinator’ or the ‘beneficiaries’ will be considered — mutatis mutandis — as referring to the beneficiary.

The parties referred to above have agreed to enter into the Agreement.

By signing the Agreement and the accession forms, the beneficiaries accept the grant and agree to implement the action under their own responsibility and in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

The Agreement is composed of:

Preamble

Terms and Conditions (including Data Sheet)

[1] Template published on Portal Reference Documents.
[2] Template published on Portal Reference Documents.
[3] Template published on Portal Reference Documents.

TERMS AND CONDITIONS

TABLE OF CONTENTS

DATA SHEET

1. General data

Project summary:

Project summary
The expected growth of both on- and offshore wind energy is enormous and many new wind parks are planned for the coming years. Experience from the existing wind farms shows the importance of a proper micrositing of the wind turbines as well their efficient interconnection within the farm. In addition, bringing wind farms together into clusters toward a wind power plant concept might induce long distance negative interaction between the farms, reducing their expected efficiency. This might happen both on- and offshore. The high amount of connected wind power and the expected increase during the coming years, requires that this technology has to be prepared to take a more important role as of its contribution to the reliability and security of the electricity system. The present proposal, WinDTwin, targets to develop and validate an offshore wind farm digital twin (DT) for highly accurate prediction of power production and energy demand of the end user. The DT will give users tailored access to high-quality information, services, models, scenarios, forecasts, and visualisations, as a central hub for offshore wind decision-makers. And will also serve as platform, offering users access to a comprehensive array of high-quality resources, services, models, scenarios, forecasts, and visualisations. WinDTwin seeks to revolutionise the way industry professionals make informed choices. To reach WinDTwin expected impact, the ambitious innovation-led research proposed necessitates bringing together a range of skills and expertise which cannot be found within a single member country or institution. We have put together a unique team that has a broad range of expertise through the whole wind energy development process; ranging from the management of wind energy production and development of industrial codes, numerical methods, algorithms, ensuring the uptake of improved methodologies.. The WinDTwin consortium consists of 13 organizations from 7 different Member States.

Keywords:

- Renewable energy sources - general
- Wind
- Digital Twin, High-resolution wind farm modelling, Detailed wind-turbine physical modelling, Data-driven models, power production forecasting, operational wind farm optimization

Project number: 101147377

Project name: Towards a digital twin for forecasting of power production to wind energy demand

Project acronym: WindTwin

Call: HORIZON-CL5-2023-D3-02

Topic: HORIZON-CL5-2023-D3-02-14

Type of action: HORIZON Research and Innovation Actions

Granting authority: European Climate, Infrastructure and Environment Executive Agency

Grant managed through EU Funding & Tenders Portal: Yes (eGrants)

Project starting date: first day of the month following the entry into force date

Project end date: starting date + months of duration

Project duration: 36 months

Consortium agreement: Yes

2. Participants

List of participants:

N°	Role	Short name	Legal name	Ctry	PIC	Max grant amount
1	COO	BSC	BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION	ES	999655520	607 500.00
2	BEN	FHG-IEE	FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV	DE	999984059	548 075.74

N°	Role	Short name	Legal name	Ctry	PIC	Max grant amount
3	BEN	WAVEC	WAVEC/OFFSHORE RENEWABLES - CENTRO DE ENERGIA OFFSHORE ASSOCIACAO	PT	999543485	734 406.25
4	BEN	EPRI	EPRI EUROPE DAC	IE	913811393	346 875.00
5	BEN	SOLUTE	ETULOS SOLUTE SL	ES	952762325	608 859.38
6	BEN	UKS	UNIVERSITAET KASSEL	DE	999852624	613 615.00
7	BEN	IBERDROLA	IBERDROLA RENOVABLES ENERGIA SA	ES	953093774	152 500.00
8	BEN	SINTEF	SINTEF OCEAN AS	NO	997806603	607 500.00
9	BEN	+ATLANTIC	+ATLANTIC ASSOCIACAO PARA UM LABORATORIO COLABORATIVO DO ATLANTICO	PT	898055586	307 125.00
10	BEN	OPEN CASCADE	OPEN CASCADE	FR	942422416	566 500.00
11	BEN	EDP NEW	CNET CENTRE FOR NEW ENERGY TECHNOLOGIES SA	PT	933299857	447 000.00
12	BEN	MET Centre	MARIN ENERGI TESTSENTER AS	NO	928496902	200 000.00
13	BEN	ENGIE Laborelec	BELGISCH LABORATORIUM VAN ELEKTRICITEITSINDUSTRIE	BE	998728200	258 750.00
Total						5 998 706.37

Coordinator:

– BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC)

3. Grant

Maximum grant amount, total estimated eligible costs and contributions and funding rate:

Maximum grant amount (Annex 2)	Maximum grant amount (award decision)
5 998 706.37	5 998 706.37

Grant form: Lump Sum

Grant mode: Action grant

Budget categories/activity types: Lump sum contributions

Cost eligibility options: n/a

Budget flexibility: No

4. Reporting, payments and recoveries

4.1 Continuous reporting (art 21)

Deliverables: see Funding & Tenders Portal Continuous Reporting tool

4.2 Periodic reporting and payments

Reporting and payment schedule (art 21, 22):

Reporting					Payments	
Reporting periods			Type	Deadline	Type	Deadline (time to pay)
RP No	Month from	Month to				
					Initial prefinancing	30 days from entry into force/10 days before starting date – whichever is the latest
1	1	18	Periodic report	60 days after end of reporting period	Interim payment	90 days from receiving periodic report
2	19	36	Periodic report	60 days after end of reporting period	Final payment	90 days from receiving periodic report

Prefinancing payments and guarantees:

Prefinancing payment	
Type	Amount
Prefinancing 1 (initial)	4 798 965.10

Reporting and payment modalities (art 21, 22):

Mutual Insurance Mechanism (MIM): Yes

MIM contribution: 5% of the maximum grant amount (299 935.32), retained from the initial prefinancing

Restrictions on distribution of initial prefinancing: The prefinancing may be distributed only if the minimum number of beneficiaries set out in the call condititions (if any) have acceded to the Agreement and only to beneficiaries that have acceded.

Interim payment ceiling (if any): 90% of the maximum grant amount

No-profit rule: n/a

Late payment interest: ECB + 3.5%

Bank account for payments:

ES9201821797370201586936 BBVAESMM

Conversion into euros: n/a

Reporting language: Language of the Agreement

4.3 Certificates (art 24): n/a

4.4 Recoveries (art 22)

First-line liability for recoveries:

Beneficiary termination: Beneficiary concerned

Final payment: Each beneficiary for their own debt

After final payment: Beneficiary concerned

Joint and several liability for enforced recoveries (in case of non-payment):

Individual financial responsibility: Each beneficiary is liable only for its own debts (and those of its affiliated entities, if any)

Joint and several liability of affiliated entities — n/a

5. Consequences of non-compliance, applicable law & dispute settlement forum

Suspension and termination:

Additional suspension grounds (art 31)

Additional termination grounds (art 32)

Applicable law (art 43):

Standard applicable law regime: EU law + law of Belgium

Dispute settlement forum (art 43):

Standard dispute settlement forum:

EU beneficiaries: EU General Court + EU Court of Justice (on appeal)

Non-EU beneficiaries: Courts of Brussels, Belgium (unless an international agreement provides for the enforceability of EU court judgements)

6. Other

Specific rules (Annex 5): Yes

Standard time-limits after project end:

Confidentiality (for X years after final payment): 5

Record-keeping (for X years after final payment): 5 (or 3 for grants of not more than EUR 60 000)

Reviews (up to X years after final payment): 2

Audits (up to X years after final payment): 2

Extension of findings from other grants to this grant (no later than X years after final payment): 2

Impact evaluation (up to X years after final payment): 5 (or 3 for grants of not more than EUR 60 000)

CHAPTER 1 GENERAL

ARTICLE 1 — SUBJECT OF THE AGREEMENT

This Agreement sets out the rights and obligations and terms and conditions applicable to the grant awarded for the implementation of the action set out in Chapter 2.

ARTICLE 2 — DEFINITIONS

For the purpose of this Agreement, the following definitions apply:

Actions — The project which is being funded in the context of this Agreement.

Grant — The grant awarded in the context of this Agreement.

EU grants — Grants awarded by EU institutions, bodies, offices or agencies (including EU executive agencies, EU regulatory agencies, EDA, joint undertakings, etc.).

Participants — Entities participating in the action as beneficiaries, affiliated entities, associated partners, third parties giving in-kind contributions, subcontractors or recipients of financial support to third parties.

Beneficiaries (BEN) — The signatories of this Agreement (either directly or through an accession form).

Affiliated entities (AE) — Entities affiliated to a beneficiary within the meaning of Article 187 of EU Financial Regulation 2018/1046[4] which participate in the action with similar rights and obligations as the beneficiaries (obligation to implement action tasks and right to charge costs and claim contributions).

Associated partners (AP) — Entities which participate in the action, but without the right to charge costs or claim contributions.

Purchases — Contracts for goods, works or services needed to carry out the action (e.g. equipment, consumables and supplies) but which are not part of the action tasks (see Annex 1).

Subcontracting — Contracts for goods, works or services that are part of the action tasks (see Annex 1).

In-kind contributions — In-kind contributions within the meaning of Article 2(36) of EU Financial

[4] For the definition, see Article 187 Regulation (EU, Euratom) 2018/1046 of the European Parliament and of the Council of 18 July 2018 on the financial rules applicable to the general budget of the Union, amending Regulations (EU) No 1296/2013, (EU) No 1301/2013, (EU) No 1303/2013, (EU) No 1304/2013, (EU) No 1309/2013, (EU) No 1316/2013, (EU) No 223/2014, (EU) No 283/2014, and Decision No 541/2014/EU and repealing Regulation (EU, Euratom) No 966/2012 ('EU Financial Regulation') (OJ L 193, 30.7.2018, p. 1): "**affiliated entities** [are]:
(a) entities that form a sole beneficiary [(i.e. where an entity is formed of several entities that satisfy the criteria for being awarded a grant, including where the entity is specifically established for the purpose of implementing an action to be financed by a grant)];
(b) entities that satisfy the eligibility criteria and that do not fall within one of the situations referred to in Article 136(1) and 141(1) and that have a link with the beneficiary, in particular a legal or capital link, which is neither limited to the action nor established for the sole purpose of its implementation".

Regulation 2018/1046, i.e. non-financial resources made available free of charge by third parties.

Fraud — Fraud within the meaning of Article 3 of EU Directive 2017/1371[5] and Article 1 of the Convention on the protection of the European Communities' financial interests, drawn up by the Council Act of 26 July 1995[6], as well as any other wrongful or criminal deception intended to result in financial or personal gain.

Irregularities — Any type of breach (regulatory or contractual) which could impact the EU financial interests, including irregularities within the meaning of Article 1(2) of EU Regulation 2988/95[7].

Grave professional misconduct — Any type of unacceptable or improper behaviour in exercising one's profession, especially by employees, including grave professional misconduct within the meaning of Article 136(1)(c) of EU Financial Regulation 2018/1046.

Applicable EU, international and national law — Any legal acts or other (binding or non-binding) rules and guidance in the area concerned.

Portal — EU Funding & Tenders Portal; electronic portal and exchange system managed by the European Commission and used by itself and other EU institutions, bodies, offices or agencies for the management of their funding programmes (grants, procurements, prizes, etc.).

CHAPTER 2 ACTION

ARTICLE 3 — ACTION

The grant is awarded for the action **101147377** — **WindTwin** ('action'), as described in Annex 1.

ARTICLE 4 — DURATION AND STARTING DATE

The duration and the starting date of the action are set out in the Data Sheet (see Point 1).

CHAPTER 3 GRANT

ARTICLE 5 — GRANT

5.1 Form of grant

[5] Directive (EU) 2017/1371 of the European Parliament and of the Council of 5 July 2017 on the fight against fraud to the Union's financial interests by means of criminal law (OJ L 198, 28.7.2017, p. 29).
[6] OJ C 316, 27.11.1995, p. 48.
[7] Council Regulation (EC, Euratom) No 2988/95 of 18 December 1995 on the protection of the European Communities financial interests (OJ L 312, 23.12.1995, p. 1).

The grant is an action grant[8] which takes the form of a lump sum grant for the completion of work packages.

5.2 Maximum grant amount

The maximum grant amount is set out in the Data Sheet (see Point 3) and in the estimated budget (Annex 2).

5.3 Funding rate

Not applicable

5.4 Estimated budget, budget categories and forms of funding

The estimated budget for the action (lump sum breakdown) is set out in Annex 2.

It contains the estimated eligible contributions for the action (lump sum contributions), broken down by participant and work package.

Annex 2 also shows the types of contributions (forms of funding)[9] to be used for each work package.

5.5 Budget flexibility

Budget flexibility does not apply; changes to the estimated budget (lump sum breakdown) always require an amendment (see Article 39).

Amendments for transfers between *work packages* are moreover possible only if:

- the work packages concerned are not already completed (and declared in a financial statement) and
- the transfers are justified by the technical implementation of the action.

ARTICLE 6 — ELIGIBLE AND INELIGIBLE CONTRIBUTIONS

6.1 and 6.2 General and specific eligibility conditions

Lump sum contributions are eligible ('eligible contributions'), if:

(a) they are set out in Annex 2 and

(b) the work packages are completed and the work is properly implemented by the beneficiaries and/or the results are achieved, in accordance with Annex 1 and during in the period set out in Article 4 (with the exception of work/results relating to the submission of the final periodic report, which may be achieved afterwards; see Article 21)

They will be calculated on the basis of the amounts set out in Annex 2.

[8] For the definition, see Article 180(2)(a) EU Financial Regulation 2018/1046: '**action grant**' means an EU grant to finance "an action intended to help achieve a Union policy objective".

[9] See Article 125 EU Financial Regulation 2018/1046.

6.3 Ineligible contributions

'Ineligible contributions' are:

(a) lump sum contributions that do not comply with the conditions set out above (see Article 6.1 and 6.2)

(b) lump sum contributions for activities already funded under other EU grants (or grants awarded by an EU Member State, non-EU country or other body implementing the EU budget), except for the following case:

(i) Synergy actions: not applicable

(c) other:

(i) country restrictions for eligible costs: not applicable.

6.4 Consequences of non-compliance

If a beneficiary declares lump sum contributions that are ineligible, they will be rejected (see Article 27).

This may also lead to other measures described in Chapter 5.

CHAPTER 4 GRANT IMPLEMENTATION

SECTION 1 CONSORTIUM: BENEFICIARIES, AFFILIATED ENTITIES AND OTHER PARTICIPANTS

ARTICLE 7 — BENEFICIARIES

The beneficiaries, as signatories of the Agreement, are fully responsible towards the granting authority for implementing it and for complying with all its obligations.

They must implement the Agreement to their best abilities, in good faith and in accordance with all the obligations and terms and conditions it sets out.

They must have the appropriate resources to implement the action and implement the action under their own responsibility and in accordance with Article 11. If they rely on affiliated entities or other participants (see Articles 8 and 9), they retain sole responsibility towards the granting authority and the other beneficiaries.

They are jointly responsible for the *technical* implementation of the action. If one of the beneficiaries fails to implement their part of the action, the other beneficiaries must ensure that this part is implemented by someone else (without being entitled to an increase of the maximum grant amount and subject to an amendment; see Article 39). The *financial* responsibility of each beneficiary in case of recoveries is governed by Article 22.

The beneficiaries (and their action) must remain eligible under the EU programme funding the grant

for the entire duration of the action. Lump sum contributions will be eligible only as long as the beneficiary and the action are eligible.

The **internal roles and responsibilities** of the beneficiaries are divided as follows:

(a) Each beneficiary must:

(i) keep information stored in the Portal Participant Register up to date (see Article 19)

(ii) inform the granting authority (and the other beneficiaries) immediately of any events or circumstances likely to affect significantly or delay the implementation of the action (see Article 19)

(iii) submit to the coordinator in good time:

- the prefinancing guarantees (if required; see Article 23)
- the financial statements and certificates on the financial statements (CFS): not applicable
- the contribution to the deliverables and technical reports (see Article 21)
- any other documents or information required by the granting authority under the Agreement

(iv) submit via the Portal data and information related to the participation of their affiliated entities.

(b) The coordinator must:

(i) monitor that the action is implemented properly (see Article 11)

(ii) act as the intermediary for all communications between the consortium and the granting authority, unless the Agreement or granting authority specifies otherwise, and in particular:

- submit the prefinancing guarantees to the granting authority (if any)
- request and review any documents or information required and verify their quality and completeness before passing them on to the granting authority
- submit the deliverables and reports to the granting authority
- inform the granting authority about the payments made to the other beneficiaries (report on the distribution of payments; if required, see Articles 22 and 32)

(iii) distribute the payments received from the granting authority to the other beneficiaries without unjustified delay (see Article 22).

The coordinator may not delegate or subcontract the above-mentioned tasks to any other beneficiary or third party (including affiliated entities).

However, coordinators which are public bodies may delegate the tasks set out in Point (b)(ii) last

indent and (iii) above to entities with 'authorisation to administer' which they have created or which are controlled by or affiliated to them. In this case, the coordinator retains sole responsibility for the payments and for compliance with the obligations under the Agreement.

Moreover, coordinators which are 'sole beneficiaries'[10] (or similar, such as European research infrastructure consortia (ERICs)) may delegate the tasks set out in Point (b)(i) to (iii) above to one of their members. The coordinator retains sole responsibility for compliance with the obligations under the Agreement.

The beneficiaries must have **internal arrangements** regarding their operation and co-ordination, to ensure that the action is implemented properly.

If required by the granting authority (see Data Sheet, Point 1), these arrangements must be set out in a written **consortium agreement** between the beneficiaries, covering for instance:

- the internal organisation of the consortium
- the management of access to the Portal
- different distribution keys for the payments and financial responsibilities in case of recoveries (if any)
- additional rules on rights and obligations related to background and results (see Article 16)
- settlement of internal disputes
- liability, indemnification and confidentiality arrangements between the beneficiaries.

The internal arrangements must not contain any provision contrary to this Agreement.

ARTICLE 8 — AFFILIATED ENTITIES

Not applicable

ARTICLE 9 — OTHER PARTICIPANTS INVOLVED IN THE ACTION

9.1 Associated partners

Not applicable

9.2 Third parties giving in-kind contributions to the action

Other third parties may give in-kind contributions to the action (i.e. personnel, equipment, other goods, works and services, etc. which are free-of-charge) if necessary for the implementation.

Third parties giving in-kind contributions do not implement any action tasks. They may not charge contributions to the action (no lump sum contributions) and their costs are considered entirely covered by the lump sum contributions paid to the beneficiaries.

[10] For the definition, see Article 187(2) EU Financial Regulation 2018/1046: "Where several entities satisfy the criteria for being awarded a grant and together form one entity, that entity may be treated as the **sole beneficiary**, including where it is specifically established for the purpose of implementing the action financed by the grant."

The third parties and their in-kind contributions should be set out in Annex 1.

9.3 Subcontractors

Subcontractors may participate in the action, if necessary for the implementation.

Subcontractors must implement their action tasks in accordance with Article 11. The beneficiaries' costs for subcontracting are considered entirely covered by the lump sum contributions for implementing the work packages (irrespective of the actual subcontracting costs incurred, if any).

The beneficiaries must ensure that their contractual obligations under Articles 11 (proper implementation), 12 (conflict of interest), 13 (confidentiality and security), 14 (ethics), 17.2 (visibility), 18 (specific rules for carrying out action), 19 (information) and 20 (record-keeping) also apply to the subcontractors.

The beneficiaries must ensure that the bodies mentioned in Article 25 (e.g. granting authority, OLAF, Court of Auditors (ECA), etc.) can exercise their rights also towards the subcontractors.

9.4 Recipients of financial support to third parties

If the action includes providing financial support to third parties (e.g. grants, prizes or similar forms of support), the beneficiaries must ensure that their contractual obligations under Articles 12 (conflict of interest), 13 (confidentiality and security), 14 (ethics), 17.2 (visibility), 18 (specific rules for carrying out action), 19 (information) and 20 (record-keeping)also apply to the third parties receiving the support (recipients).

The beneficiaries must also ensure that the bodies mentioned in Article 25 (e.g. granting authority, OLAF, Court of Auditors (ECA), etc.) can exercise their rights also towards the recipients.

ARTICLE 10 — PARTICIPANTS WITH SPECIAL STATUS

10.1 Non-EU participants

Participants which are established in a non-EU country (if any) undertake to comply with their obligations under the Agreement and:

- to respect general principles (including fundamental rights, values and ethical principles, environmental and labour standards, rules on classified information, intellectual property rights, visibility of funding and protection of personal data)
- for the submission of certificates under Article 24: use qualified external auditors which are independent and comply with comparable standards as those set out in EU Directive 2006/43/EC[11]
- for the controls under Article 25: allow for checks, reviews, audits and investigations (including on-the-spot checks, visits and inspections) by the bodies mentioned in that Article (e.g. granting authority, OLAF, Court of Auditors (ECA), etc.).

[11] Directive 2006/43/EC of the European Parliament and of the Council of 17 May 2006 on statutory audits of annual accounts and consolidated accounts or similar national regulations (OJ L 157, 9.6.2006, p. 87).

Special rules on dispute settlement apply (see Data Sheet, Point 5).

10.2 Participants which are international organisations

Participants which are international organisations (IOs; if any) undertake to comply with their obligations under the Agreement and:

- to respect general principles (including fundamental rights, values and ethical principles, environmental and labour standards, rules on classified information, intellectual property rights, visibility of funding and protection of personal data)

- for the submission of certificates under Article 24: to use either independent public officers or external auditors which comply with comparable standards as those set out in EU Directive 2006/43/EC

- for the controls under Article 25: to allow for the checks, reviews, audits and investigations by the bodies mentioned in that Article, taking into account the specific agreements concluded by them and the EU (if any).

For such participants, nothing in the Agreement will be interpreted as a waiver of their privileges or immunities, as accorded by their constituent documents or international law.

Special rules on applicable law and dispute settlement apply (see Article 43 and Data Sheet, Point 5).

10.3 Pillar-assessed participants

Pillar-assessed participants (if any) may rely on their own systems, rules and procedures, in so far as they have been positively assessed and do not call into question the decision awarding the grant or breach the principle of equal treatment of applicants or beneficiaries.

'Pillar-assessment' means a review by the European Commission on the systems, rules and procedures which participants use for managing EU grants (in particular internal control system, accounting system, external audits, financing of third parties, rules on recovery and exclusion, information on recipients and protection of personal data; see Article 154 EU Financial Regulation 2018/1046).

Participants with a positive pillar assessment may rely on their own systems, rules and procedures, in particular for:

- record-keeping (Article 20): may be done in accordance with internal standards, rules and procedures

- currency conversion for financial statements (Article 21): may be done in accordance with usual accounting practices

- guarantees (Article 23): for public law bodies, prefinancing guarantees are not needed

- certificates (Article 24):

    - certificates on the financial statements (CFS): may be provided by their regular internal or external auditors and in accordance with their internal financial regulations and procedures

- certificates on usual accounting practices (CoMUC): are not needed if those practices are covered by an ex-ante assessment

and use the following specific rules, for:

- recoveries (Article 22): in case of financial support to third parties, there will be no recovery if the participant has done everything possible to retrieve the undue amounts from the third party receiving the support (including legal proceedings) and non-recovery is not due to an error or negligence on its part

- checks, reviews, audits and investigations by the EU (Article 25): will be conducted taking into account the rules and procedures specifically agreed between them and the framework agreement (if any)

- impact evaluation (Article 26): will be conducted in accordance with the participant's internal rules and procedures and the framework agreement (if any)

- grant agreement suspension (Article 31): certain costs incurred during grant suspension are eligible (notably, minimum costs necessary for a possible resumption of the action and costs relating to contracts which were entered into before the pre-information letter was received and which could not reasonably be suspended, reallocated or terminated on legal grounds)

- grant agreement termination (Article 32): the final grant amount and final payment will be calculated taking into account also costs relating to contracts due for execution only after termination takes effect, if the contract was entered into before the pre-information letter was received and could not reasonably be terminated on legal grounds

- liability for damages (Article 33.2): the granting authority must be compensated for damage it sustains as a result of the implementation of the action or because the action was not implemented in full compliance with the Agreement only if the damage is due to an infringement of the participant's internal rules and procedures or due to a violation of third parties' rights by the participant or one of its employees or individual for whom the employees are responsible.

Participants whose pillar assessment covers procurement and granting procedures may also do purchases, subcontracting and financial support to third parties (Article 6.2) in accordance with their internal rules and procedures for purchases, subcontracting and financial support.

Participants whose pillar assessment covers data protection rules may rely on their internal standards, rules and procedures for data protection (Article 15).

The participants may however not rely on provisions which would breach the principle of equal treatment of applicants or beneficiaries or call into question the decision awarding the grant, such as in particular:

- eligibility (Article 6)

- consortium roles and set-up (Articles 7-9)

- security and ethics (Articles 13, 14)

- IPR (including background and results, access rights and rights of use), communication, dissemination and visibility (Articles 16 and 17)
- information obligation (Article 19)
- payment, reporting and amendments (Articles 21, 22 and 39)
- rejections, reductions, suspensions and terminations (Articles 27, 28, 29-32)

If the pillar assessment was subject to remedial measures, reliance on the internal systems, rules and procedures is subject to compliance with those remedial measures.

Participants whose assessment has not yet been updated to cover (the new rules on) data protection may rely on their internal systems, rules and procedures, provided that they ensure that personal data is:

- processed lawfully, fairly and in a transparent manner in relation to the data subject
- collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes
- adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed
- accurate and, where necessary, kept up to date
- kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the data is processed and
- processed in a manner that ensures appropriate security of the personal data.

Participants must inform the coordinator without delay of any changes to the systems, rules and procedures that were part of the pillar assessment. The coordinator must immediately inform the granting authority.

Pillar-assessed participants that have also concluded a framework agreement with the EU, may moreover — under the same conditions as those above (i.e. not call into question the decision awarding the grant or breach the principle of equal treatment of applicants or beneficiaries) — rely on provisions set out in that framework agreement.

SECTION 2 RULES FOR CARRYING OUT THE ACTION

ARTICLE 11 — PROPER IMPLEMENTATION OF THE ACTION

11.1 Obligation to properly implement the action

The beneficiaries must implement the action as described in Annex 1 and in compliance with the provisions of the Agreement, the call conditions and all legal obligations under applicable EU, international and national law.

11.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 12 — CONFLICT OF INTERESTS

12.1 Conflict of interests

The beneficiaries must take all measures to prevent any situation where the impartial and objective implementation of the Agreement could be compromised for reasons involving family, emotional life, political or national affinity, economic interest or any other direct or indirect interest (‘conflict of interests’).

They must formally notify the granting authority without delay of any situation constituting or likely to lead to a conflict of interests and immediately take all the necessary steps to rectify this situation.

The granting authority may verify that the measures taken are appropriate and may require additional measures to be taken by a specified deadline.

12.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28) and the grant or the beneficiary may be terminated (see Article 32).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 13 — CONFIDENTIALITY AND SECURITY

13.1 Sensitive information

The parties must keep confidential any data, documents or other material (in any form) that is identified as sensitive in writing (‘sensitive information’) — during the implementation of the action and for at least until the time-limit set out in the Data Sheet (see Point 6).

If a beneficiary requests, the granting authority may agree to keep such information confidential for a longer period.

Unless otherwise agreed between the parties, they may use sensitive information only to implement the Agreement.

The beneficiaries may disclose sensitive information to their personnel or other participants involved in the action only if they:

(a) need to know it in order to implement the Agreement and

(b) are bound by an obligation of confidentiality.

The granting authority may disclose sensitive information to its staff and to other EU institutions and bodies.

It may moreover disclose sensitive information to third parties, if:

(a) this is necessary to implement the Agreement or safeguard the EU financial interests and

(b) the recipients of the information are bound by an obligation of confidentiality.

The confidentiality obligations no longer apply if:

(a) the disclosing party agrees to release the other party

(b) the information becomes publicly available, without breaching any confidentiality obligation

(c) the disclosure of the sensitive information is required by EU, international or national law.

Specific confidentiality rules (if any) are set out in Annex 5.

13.2 Classified information

The parties must handle classified information in accordance with the applicable EU, international or national law on classified information (in particular, Decision 2015/444[12] and its implementing rules).

Deliverables which contain classified information must be submitted according to special procedures agreed with the granting authority.

Action tasks involving classified information may be subcontracted only after explicit approval (in writing) from the granting authority.

Classified information may not be disclosed to any third party (including participants involved in the action implementation) without prior explicit written approval from the granting authority.

Specific security rules (if any) are set out in Annex 5.

13.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 14 — ETHICS AND VALUES

14.1 Ethics

The action must be carried out in line with the highest ethical standards and the applicable EU, international and national law on ethical principles.

Specific ethics rules (if any) are set out in Annex 5.

14.2 Values

The beneficiaries must commit to and ensure the respect of basic EU values (such as respect for

[12] Commission Decision 2015/444/EC, Euratom of 13 March 2015 on the security rules for protecting EU classified information (OJ L 72, 17.3.2015, p. 53).

human dignity, freedom, democracy, equality, the rule of law and human rights, including the rights of minorities).

Specific rules on values (if any) are set out in Annex 5.

14.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 15 — DATA PROTECTION

15.1 Data processing by the granting authority

Any personal data under the Agreement will be processed under the responsibility of the data controller of the granting authority in accordance with and for the purposes set out in the Portal Privacy Statement.

For grants where the granting authority is the European Commission, an EU regulatory or executive agency, joint undertaking or other EU body, the processing will be subject to Regulation 2018/1725[13].

15.2 Data processing by the beneficiaries

The beneficiaries must process personal data under the Agreement in compliance with the applicable EU, international and national law on data protection (in particular, Regulation 2016/679[14]).

They must ensure that personal data is:

- processed lawfully, fairly and in a transparent manner in relation to the data subjects
- collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes
- adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed
- accurate and, where necessary, kept up to date
- kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the data is processed and
- processed in a manner that ensures appropriate security of the data.

[13] Regulation (EU) 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions, bodies, offices and agencies and on the free movement of such data, and repealing Regulation (EC) No 45/2001 and Decision No 1247/2002/EC (OJ L 295, 21.11.2018, p. 39).

[14] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (‘GDPR’) (OJ L 119, 4.5.2016, p. 1).

The beneficiaries may grant their personnel access to personal data only if it is strictly necessary for implementing, managing and monitoring the Agreement. The beneficiaries must ensure that the personnel is under a confidentiality obligation.

The beneficiaries must inform the persons whose data are transferred to the granting authority and provide them with the Portal Privacy Statement.

15.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 16 — INTELLECTUAL PROPERTY RIGHTS (IPR) — BACKGROUND AND RESULTS —ACCESS RIGHTS AND RIGHTS OF USE

16.1 Background and access rights to background

The beneficiaries must give each other and the other participants access to the background identified as needed for implementing the action, subject to any specific rules in Annex 5.

'Background' means any data, know-how or information — whatever its form or nature (tangible or intangible), including any rights such as intellectual property rights — that is:

(a) held by the beneficiaries before they acceded to the Agreement and

(b) needed to implement the action or exploit the results.

If background is subject to rights of a third party, the beneficiary concerned must ensure that it is able to comply with its obligations under the Agreement.

16.2 Ownership of results

The granting authority does not obtain ownership of the results produced under the action.

'Results' means any tangible or intangible effect of the action, such as data, know-how or information, whatever its form or nature, whether or not it can be protected, as well as any rights attached to it, including intellectual property rights.

16.3 Rights of use of the granting authority on materials, documents and information received for policy, information, communication, dissemination and publicity purposes

The granting authority has the right to use non-sensitive information relating to the action and materials and documents received from the beneficiaries (notably summaries for publication, deliverables, as well as any other material, such as pictures or audio-visual material, in paper or electronic form) for policy information, communication, dissemination and publicity purposes — during the action or afterwards.

The right to use the beneficiaries' materials, documents and information is granted in the form of a royalty-free, non-exclusive and irrevocable licence, which includes the following rights:

(a) **use for its own purposes** (in particular, making them available to persons working for the granting authority or any other EU service (including institutions, bodies, offices, agencies, etc.) or EU Member State institution or body; copying or reproducing them in whole or in part, in unlimited numbers; and communication through press information services)

(b) **distribution to the public** (in particular, publication as hard copies and in electronic or digital format, publication on the internet, as a downloadable or non-downloadable file, broadcasting by any channel, public display or presentation, communicating through press information services, or inclusion in widely accessible databases or indexes)

(c) **editing or redrafting** (including shortening, summarising, inserting other elements (e.g. meta-data, legends, other graphic, visual, audio or text elements), extracting parts (e.g. audio or video files), dividing into parts, use in a compilation)

(d) **translation**

(e) **storage** in paper, electronic or other form

(f) **archiving**, in line with applicable document-management rules

(g) the right to authorise **third parties** to act on its behalf or sub-license to third parties the modes of use set out in Points (b), (c), (d) and (f), if needed for the information, communication and publicity activity of the granting authority and

(h) **processing**, analysing, aggregating the materials, documents and information received and **producing derivative works**.

The rights of use are granted for the whole duration of the industrial or intellectual property rights concerned.

If materials or documents are subject to moral rights or third party rights (including intellectual property rights or rights of natural persons on their image and voice), the beneficiaries must ensure that they comply with their obligations under this Agreement (in particular, by obtaining the necessary licences and authorisations from the rights holders concerned).

Where applicable, the granting authority will insert the following information:

> "© – [year] – [name of the copyright owner]. All rights reserved. Licensed to the [name of granting authority] under conditions."

16.4 Specific rules on IPR, results and background

Specific rules regarding intellectual property rights, results and background (if any) are set out in Annex 5.

16.5 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such a breach may also lead to other measures described in Chapter 5.

ARTICLE 17 — COMMUNICATION, DISSEMINATION AND VISIBILITY

17.1 Communication — Dissemination — Promoting the action

Unless otherwise agreed with the granting authority, the beneficiaries must promote the action and its results by providing targeted information to multiple audiences (including the media and the public), in accordance with Annex 1 and in a strategic, coherent and effective manner.

Before engaging in a communication or dissemination activity expected to have a major media impact, the beneficiaries must inform the granting authority.

17.2 Visibility — European flag and funding statement

Unless otherwise agreed with the granting authority, communication activities of the beneficiaries related to the action (including media relations, conferences, seminars, information material, such as brochures, leaflets, posters, presentations, etc., in electronic form, via traditional or social media, etc.), dissemination activities and any infrastructure, equipment, vehicles, supplies or major result funded by the grant must acknowledge the EU support and display the European flag (emblem) and funding statement (translated into local languages, where appropriate):

The emblem must remain distinct and separate and cannot be modified by adding other visual marks, brands or text.

Apart from the emblem, no other visual identity or logo may be used to highlight the EU support.

When displayed in association with other logos (e.g. of beneficiaries or sponsors), the emblem must be displayed at least as prominently and visibly as the other logos.

For the purposes of their obligations under this Article, the beneficiaries may use the emblem without first obtaining approval from the granting authority. This does not, however, give them the right to

exclusive use. Moreover, they may not appropriate the emblem or any similar trademark or logo, either by registration or by any other means.

17.3 Quality of information — Disclaimer

Any communication or dissemination activity related to the action must use factually accurate information.

Moreover, it must indicate the following disclaimer (translated into local languages where appropriate):

> "Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or [name of the granting authority]. Neither the European Union nor the granting authority can be held responsible for them."

17.4 Specific communication, dissemination and visibility rules

Specific communication, dissemination and visibility rules (if any) are set out in Annex 5.

17.5 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 18 — SPECIFIC RULES FOR CARRYING OUT THE ACTION

18.1 Specific rules for carrying out the action

Specific rules for implementing the action (if any) are set out in Annex 5.

18.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such a breach may also lead to other measures described in Chapter 5.

SECTION 3 GRANT ADMINISTRATION

ARTICLE 19 — GENERAL INFORMATION OBLIGATIONS

19.1 Information requests

The beneficiaries must provide — during the action or afterwards and in accordance with Article 7 — any information requested in order to verify eligibility of the lump sum contributions declared, proper implementation of the action and compliance with the other obligations under the Agreement.

The information provided must be accurate, precise and complete and in the format requested, including electronic format.

19.2 Participant Register data updates

The beneficiaries must keep — at all times, during the action or afterwards — their information stored in the Portal Participant Register up to date, in particular, their name, address, legal representatives, legal form and organisation type.

19.3 Information about events and circumstances which impact the action

The beneficiaries must immediately inform the granting authority (and the other beneficiaries) of any of the following:

(a) **events** which are likely to affect or delay the implementation of the action or affect the EU's financial interests, in particular:

(i) changes in their legal, financial, technical, organisational or ownership situation (including changes linked to one of the exclusion grounds listed in the declaration of honour signed before grant signature)

(ii) linked action information: not applicable

(b) **circumstances** affecting:

(i) the decision to award the grant or

(ii) compliance with requirements under the Agreement.

19.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 20 — RECORD-KEEPING

20.1 Keeping records and supporting documents

The beneficiaries must — at least until the time-limit set out in the Data Sheet (see Point 6) — keep records and other supporting documents to prove the proper implementation of the action (proper implementation of the work and/or achievement of the results as described in Annex 1) in line with the accepted standards in the respective field (if any); beneficiaries do not need to keep specific records on the actual costs incurred.

The records and supporting documents must be made available upon request (see Article 19) or in the context of checks, reviews, audits or investigations (see Article 25).

If there are on-going checks, reviews, audits, investigations, litigation or other pursuits of claims under the Agreement (including the extension of findings; see Article 25), the beneficiaries must keep these records and other supporting documentation until the end of these procedures.

The beneficiaries must keep the original documents. Digital and digitalised documents are considered

originals if they are authorised by the applicable national law. The granting authority may accept non-original documents if they offer a comparable level of assurance.

20.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, lump sum contributions insufficiently substantiated will be ineligible (see Article 6) and will be rejected (see Article 27), and the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 21 — REPORTING

21.1 Continuous reporting

The beneficiaries must continuously report on the progress of the action (e.g. **deliverables, milestones, outputs/outcomes, critical risks, indicators,** etc; if any), in the Portal Continuous Reporting tool and in accordance with the timing and conditions it sets out (as agreed with the granting authority).

Standardised deliverables (e.g. progress reports not linked to payments, reports on cumulative expenditure, special reports, etc; if any) must be submitted using the templates published on the Portal.

21.2 Periodic reporting: Technical reports and financial statements

In addition, the beneficiaries must provide reports to request payments, in accordance with the schedule and modalities set out in the Data Sheet (see Point 4.2):

- for additional prefinancings (if any): **an additional prefinancing report**
- for interim payments (if any) and the final payment: a **periodic report**

The prefinancing and periodic reports include a technical and financial part.

The technical part includes an overview of the action implementation. It must be prepared using the template available in the Portal Periodic Reporting tool.

The financial part of the additional prefinancing report includes a statement on the use of the previous prefinancing payment.

The financial part of the periodic report includes:

- the financial statement (consolidated statement for the consortium)
- the explanation on the use of resources (or detailed cost reporting table): not applicable
- the certificates on the financial statements (CFS): not applicable.

The **financial statement** must contain the lump sum contributions indicated in Annex 2, for the work packages that were completed during the reporting period.

For the last reporting period, the beneficiaries may exceptionally also declare partial lump sum

contributions for work packages that were not completed (e.g. due to force majeure or technical impossibility).

Lump sum contributions which are not declared in a financial statement will not be taken into account by the granting authority.

By signing the financial statement (directly in the Portal Periodic Reporting tool), the coordinator confirms (on behalf of the consortium) that:

- the information provided is complete, reliable and true
- the lump sum contributions declared are eligible (in particular, the work packages have been completed, that the work has been properly implemented and/or the results were achieved in accordance with Annex 1; see Article 6)
- the proper implementation and/or achievement can be substantiated by adequate records and supporting documents (see Article 20) that will be produced upon request (see Article 19) or in the context of checks, reviews, audits and investigations (see Article 25).

In case of recoveries (see Article 22), beneficiaries will be held responsible also for the lump sum contributions declared for their affiliated entities (if any).

21.3 Currency for financial statements and conversion into euros

The financial statements must be drafted in euro.

21.4 Reporting language

The reporting must be in the language of the Agreement, unless otherwise agreed with the granting authority (see Data Sheet, Point 4.2).

21.5 Consequences of non-compliance

If a report submitted does not comply with this Article, the granting authority may suspend the payment deadline (see Article 29) and apply other measures described in Chapter 5.

If the coordinator breaches its reporting obligations, the granting authority may terminate the grant or the coordinator's participation (see Article 32) or apply other measures described in Chapter 5.

ARTICLE 22 — PAYMENTS AND RECOVERIES — CALCULATION OF AMOUNTS DUE

22.1 Payments and payment arrangements

Payments will be made in accordance with the schedule and modalities set out in the Data Sheet (see Point 4.2).

They will be made in euro to the bank account indicated by the coordinator (see Data Sheet, Point 4.2) and must be distributed without unjustified delay (restrictions may apply to distribution of the initial prefinancing payment; see Data Sheet, Point 4.2).

Payments to this bank account will discharge the granting authority from its payment obligation.

The cost of payment transfers will be borne as follows:

- the granting authority bears the cost of transfers charged by its bank
- the beneficiary bears the cost of transfers charged by its bank
- the party causing a repetition of a transfer bears all costs of the repeated transfer.

Payments by the granting authority will be considered to have been carried out on the date when they are debited to its account.

22.2 Recoveries

Recoveries will be made, if — at beneficiary termination, final payment or afterwards — it turns out that the granting authority has paid too much and needs to recover the amounts undue.

Each beneficiary's financial responsibility in case of recovery is in principle limited to their own debt and undue amounts of their affiliated entities.

In case of enforced recoveries (see Article 22.4), affiliated entities will be held liable for repaying debts of their beneficiaries, if required by the granting authority (see Data Sheet, Point 4.4).

22.3 Amounts due

22.3.1 Prefinancing payments

The aim of the prefinancing is to provide the beneficiaries with a float.

It remains the property of the EU until the final payment.

For **initial prefinancings** (if any), the amount due, schedule and modalities are set out in the Data Sheet (see Point 4.2).

For **additional prefinancings** (if any), the amount due, schedule and modalities are also set out in the Data Sheet (see Point 4.2). However, if the statement on the use of the previous prefinancing payment shows that less than 70% was used, the amount set out in the Data Sheet will be reduced by the difference between the 70% threshold and the amount used.

The contribution to the Mutual Insurance Mechanism will be retained from the prefinancing payments (at the rate and in accordance with the modalities set out in the Data Sheet, see Point 4.2) and transferred to the Mechanism.

Prefinancing payments (or parts of them) may be offset (without the beneficiaries' consent) against amounts owed by a beneficiary to the granting authority — up to the amount due to that beneficiary.

For grants where the granting authority is the European Commission or an EU executive agency, offsetting may also be done against amounts owed to other Commission services or executive agencies.

Payments will not be made if the payment deadline or payments are suspended (see Articles 29 and 30).

22.3.2 Amount due at beneficiary termination — Recovery

In case of beneficiary termination, the granting authority will determine the provisional amount due for the beneficiary concerned.

This will be done on the basis of work packages already completed in previous interim payments. Payments for ongoing/not yet completed work packages which the beneficiary was working on before termination (if any) will therefore be made only later on, with the next interim or final payments when those work packages have been completed.

The **amount due** will be calculated in the following step:

Step 1 — Calculation of the total accepted EU contribution

Step 1 — Calculation of the total accepted EU contribution

The granting authority will first calculate the 'accepted EU contribution' for the beneficiary, on the basis of the beneficiary's lump sum contributions for the work packages which were approved in previous interim payments.

After that, the granting authority will take into account grant reductions (if any). The resulting amount is the 'total accepted EU contribution' for the beneficiary.

The **balance** is then calculated by deducting the payments received (if any; see report on the distribution of payments in Article 32), from the total accepted EU contribution:

{total accepted EU contribution for the beneficiary

minus

{prefinancing and interim payments received (if any)}}.

If the balance is **negative**, it will be **recovered** in accordance with the following procedure:

The granting authority will send a **pre-information letter** to the beneficiary concerned:

- formally notifying the intention to recover, the amount due, the amount to be recovered and the reasons why and
- requesting observations within 30 days of receiving notification.

If no observations are submitted (or the granting authority decides to pursue recovery despite the observations it has received), it will confirm the amount to be recovered and ask this amount to be paid to the coordinator (**confirmation letter**).

If payment is not made to the coordinator by the date specified in the confirmation letter, the granting authority may call on the Mutual Insurance Mechanism to intervene, if continuation of the action is guaranteed and the conditions set out in the rules governing the Mechanism are met.

In this case, it will send a **beneficiary recovery letter**, together with a **debit note** with the terms and date for payment.

The debit note for the beneficiary will include the amount calculated for the affiliated entities which also had to end their participation (if any).

If payment is not made by the date specified in the debit note, the granting authority will **enforce recovery** in accordance with Article 22.4.

22.3.3 Interim payments

Interim payments reimburse the eligible lump sum contributions claimed for work packages implemented during the reporting periods (if any).

Interim payments (if any) will be made in accordance with the schedule and modalities set out the Data Sheet (see Point 4.2).

Payment is subject to the approval of the periodic report and the work packages declared. Their approval does not imply recognition of compliance, authenticity, completeness or correctness of their content.

Incomplete work packages and work packages that have not been delivered or cannot be approved will be rejected (see Article 27).

The **interim payment** will be calculated by the granting authority in the following steps:

Step 1 — Calculation of the total accepted EU contribution

Step 2 — Limit to the interim payment ceiling

Step 1 — Calculation of the total accepted EU contribution

The granting authority will first calculate the 'accepted EU contribution' for the action for the reporting period, by calculating the lump sum contributions for the approved work packages.

After that, the granting authority will take into account grant reductions from beneficiary termination (if any). The resulting amount is the 'total accepted EU contribution'.

Step 2 — Limit to the interim payment ceiling

The resulting amount is then capped to ensure that the total amount of prefinancing and interim payments (if any) does not exceed the interim payment ceiling set out in the Data Sheet (see Point 4.2).

Interim payments (or parts of them) may be offset (without the beneficiaries' consent) against amounts owed by a beneficiary to the granting authority — up to the amount due to that beneficiary.

For grants where the granting authority is the European Commission or an EU executive agency, offsetting may also be done against amounts owed to other Commission services or executive agencies.

Payments will not be made if the payment deadline or payments are suspended (see Articles 29 and 30).

22.3.4 Final payment — Final grant amount — Revenues and Profit — Recovery

The final payment (payment of the balance) reimburses the remaining eligible lump sum contributions claimed for the implemented work packages (if any).

The final payment will be made in accordance with the schedule and modalities set out in the Data Sheet (see Point 4.2).

Payment is subject to the approval of the final periodic report and the work packages declared. Their approval does not imply recognition of compliance, authenticity, completeness or correctness of their content.

Work packages (or parts of them) that have not been delivered or cannot be approved will be rejected (see Article 27).

The **final grant amount for the action** will be calculated in the following steps:

Step 1 — Calculation of the total accepted EU contribution

Step 2 — Limit to the maximum grant amount

Step 3 — Reduction due to the no-profit rule

Step 1 — Calculation of the total accepted EU contribution

The granting authority will first calculate the 'accepted EU contribution' for the action for all reporting periods, by calculating the lump sum contributions for the approved work packages.

After that, the granting authority will take into account grant reductions (if any). The resulting amount is the 'total accepted EU contribution'.

Step 2 — Limit to the maximum grant amount

Not applicable

Step 3 — Reduction due to the no-profit rule

Not applicable

The **balance** (final payment) is then calculated by deducting the total amount of prefinancing and interim payments already made (if any), from the final grant amount:

{final grant amount

minus

{prefinancing and interim payments made (if any)}}.

If the balance is **positive**, it will be **paid** to the coordinator.

The amount retained for the Mutual Insurance Mechanism (see above) will be released and **paid** to the coordinator (in accordance with the rules governing the Mechanism).

The final payment (or part of it) may be offset (without the beneficiaries' consent) against amounts owed by a beneficiary to the granting authority — up to the amount due to that beneficiary.

For grants where the granting authority is the European Commission or an EU executive agency, offsetting may also be done against amounts owed to other Commission services or executive agencies.

Payments will not be made if the payment deadline or payments are suspended (see Articles 29 and 30).

If — despite the release of the Mutual Insurance Mechanism contribution — the balance is **negative**, it will be **recovered** in accordance with the following procedure:

The granting authority will send a **pre-information letter** to the coordinator:

- formally notifying the intention to recover, the final grant amount, the amount to be recovered and the reasons why
- requesting a report on the distribution of payments to the beneficiaries within 30 days of receiving notification and
- requesting observations within 30 days of receiving notification.

If no observations are submitted (or the granting authority decides to pursue recovery despite the observations it has received) and the coordinator has submitted the report on the distribution of payments, it will calculate the **share of the debt per beneficiary**, by:

(a) identifying the beneficiaries for which the amount calculated as follows is negative:

{{{total accepted EU contribution for the beneficiary

divided by

total accepted EU contribution for the action}

multiplied by

final grant amount for the action},

minus

{prefinancing and interim payments received by the beneficiary (if any)}}

and

(b) dividing the debt:

{{amount calculated according to point (a) for the beneficiary concerned

divided by

the sum of the amounts calculated according to point (a) for all the beneficiaries identified according to point (a)}

multiplied by

the amount to be recovered}.

and confirm the amount to be recovered from each beneficiary concerned (**confirmation letter**), together with **debit notes** with the terms and date for payment.

The debit notes for beneficiaries will include the amounts calculated for their affiliated entities (if any).

If the coordinator has not submitted the report on the distribution of payments, the granting authority

will **recover** the full amount from the coordinator (**confirmation letter** and **debit note** with the terms and date for payment).

If payment is not made by the date specified in the debit note, the granting authority will **enforce recovery** in accordance with Article 22.4.

22.3.5 Audit implementation after final payment — Revised final grant amount — Recovery

If — after the final payment (in particular, after checks, reviews, audits or investigations; see Article 25) — the granting authority rejects lump sum contributions (see Article 27) or reduces the grant (see Article 28), it will calculate the **revised final grant amount** for the beneficiary concerned.

The **beneficiary revised final grant amount** will be calculated in the following step:

Step 1 — Calculation of the revised total accepted EU contribution

Step 1 — Calculation of the revised total accepted EU contribution

The granting authority will first calculate the 'revised accepted EU contribution' for the beneficiary, by calculating the 'revised accepted contributions'.

After that, it will take into account grant reductions (if any). The resulting 'revised total accepted EU contribution' is the beneficiary revised final grant amount.

If the revised final grant amount is lower than the beneficiary's final grant amount (i.e. its share in the final grant amount for the action), it will be **recovered** in accordance with the following procedure:

The **beneficiary final grant amount** (i.e. share in the final grant amount for the action) is calculated as follows:

{{total accepted EU contribution for the beneficiary

divided by

total accepted EU contribution for the action}

multiplied by

final grant amount for the action}.

The granting authority will send a **pre-information letter** to the beneficiary concerned:

- formally notifying the intention to recover, the amount to be recovered and the reasons why and
- requesting observations within 30 days of receiving notification.

If no observations are submitted (or the granting authority decides to pursue recovery despite the observations it has received), it will confirm the amount to be recovered (**confirmation letter**), together with a **debit note** with the terms and the date for payment.

Recoveries against affiliated entities (if any) will be handled through their beneficiaries.

If payment is not made by the date specified in the debit note, the granting authority will **enforce recovery** in accordance with Article 22.4.

22.4 Enforced recovery

If payment is not made by the date specified in the debit note, the amount due will be recovered:

(a) by offsetting the amount — without the coordinator or beneficiary's consent — against any amounts owed to the coordinator or beneficiary by the granting authority.

In exceptional circumstances, to safeguard the EU financial interests, the amount may be offset before the payment date specified in the debit note.

For grants where the granting authority is the European Commission or an EU executive agency, debts may also be offset against amounts owed by other Commission services or executive agencies.

(b) financial guarantee(s): not applicable

(c) joint and several liability of beneficiaries: not applicable

(d) by holding affiliated entities jointly and severally liable (if any, see Data Sheet, Point 4.4)

(e) by taking legal action (see Article 43) or, provided that the granting authority is the European Commission or an EU executive agency, by adopting an enforceable decision under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 100(2) of EU Financial Regulation 2018/1046.

If the Mutual Insurance Mechanism was called on by the granting authority to intervene, recovery will be continued in the name of the Mutual Insurance Mechanism. If two debit notes were sent, the second one (in the name of the Mutual Insurance Mechanism) will be considered to replace the first one (in the name of the granting authority). Where the MIM intervened, offsetting, enforceable decisions or any other of the above-mentioned forms of enforced recovery may be used mutatis mutandis.

The amount to be recovered will be increased by **late-payment interest** at the rate set out in Article 23.5, from the day following the payment date in the debit note, up to and including the date the full payment is received.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2015/2366[15] applies.

For grants where the granting authority is an EU executive agency, enforced recovery by offsetting or enforceable decision will be done by the services of the European Commission (see also Article 43).

22.5 Consequences of non-compliance

22.5.1 If the granting authority does not pay within the payment deadlines (see above), the beneficiaries are entitled to **late-payment interest** at the reference rate applied by the European

[15] Directive (EU) 2015/2366 of the European Parliament and of the Council of 25 November 2015 on payment services in the internal market, amending Directives 2002/65/EC, 2009/110/EC and 2013/36/EU and Regulation (EU) No 1093/2010, and repealing Directive 2007/64/EC (OJ L 337, 23.12.2015, p. 35).

Central Bank (ECB) for its main refinancing operations in euros, plus the percentage specified in the Data Sheet (Point 4.2). The ECB reference rate to be used is the rate in force on the first day of the month in which the payment deadline expires, as published in the C series of the *Official Journal of the European Union*.

If the late-payment interest is lower than or equal to EUR 200, it will be paid to the coordinator only on request submitted within two months of receiving the late payment.

Late-payment interest is not due if all beneficiaries are EU Member States (including regional and local government authorities or other public bodies acting on behalf of a Member State for the purpose of this Agreement).

If payments or the payment deadline are suspended (see Articles 29 and 30), payment will not be considered as late.

Late-payment interest covers the period running from the day following the due date for payment (see above), up to and including the date of payment.

Late-payment interest is not considered for the purposes of calculating the final grant amount.

22.5.2 If the coordinator breaches any of its obligations under this Article, the grant may be reduced (see Article 28) and the grant or the coordinator may be terminated (see Article 32).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 23 — GUARANTEES

Not applicable

ARTICLE 24 — CERTIFICATES

Not applicable

ARTICLE 25 — CHECKS, REVIEWS, AUDITS AND INVESTIGATIONS — EXTENSION OF FINDINGS

25.1 Granting authority checks, reviews and audits

25.1.1 Internal checks

The granting authority may — during the action or afterwards — check the proper implementation of the action and compliance with the obligations under the Agreement, including assessing lump sum contributions, deliverables and reports.

25.1.2 Project reviews

The granting authority may carry out reviews on the proper implementation of the action and compliance with the obligations under the Agreement (general project reviews or specific issues reviews).

Such project reviews may be started during the implementation of the action and until the time-limit

set out in the Data Sheet (see Point 6). They will be formally notified to the coordinator or beneficiary concerned and will be considered to start on the date of the notification.

If needed, the granting authority may be assisted by independent, outside experts. If it uses outside experts, the coordinator or beneficiary concerned will be informed and have the right to object on grounds of commercial confidentiality or conflict of interest.

The coordinator or beneficiary concerned must cooperate diligently and provide — within the deadline requested — any information and data in addition to deliverables and reports already submitted. The granting authority may request beneficiaries to provide such information to it directly. Sensitive information and documents will be treated in accordance with Article 13.

The coordinator or beneficiary concerned may be requested to participate in meetings, including with the outside experts.

For **on-the-spot visits**, the beneficiary concerned must allow access to sites and premises (including to the outside experts) and must ensure that information requested is readily available.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

On the basis of the review findings, a **project review report** will be drawn up.

The granting authority will formally notify the project review report to the coordinator or beneficiary concerned, which has 30 days from receiving notification to make observations.

Project reviews (including project review reports) will be in the language of the Agreement, unless otherwise agreed with the granting authority (see Data Sheet, Point 4.2).

25.1.3 Audits

The granting authority may carry out audits on the proper implementation of the action and compliance with the obligations under the Agreement.

Such audits may be started during the implementation of the action and until the time-limit set out in the Data Sheet (see Point 6). They will be formally notified to the beneficiary concerned and will be considered to start on the date of the notification.

The granting authority may use its own audit service, delegate audits to a centralised service or use external audit firms. If it uses an external firm, the beneficiary concerned will be informed and have the right to object on grounds of commercial confidentiality or conflict of interest.

The beneficiary concerned must cooperate diligently and provide — within the deadline requested — any information (including complete accounts, individual salary statements or other personal data) to verify compliance with the Agreement. Sensitive information and documents will be treated in accordance with Article 13.

For **on-the-spot** visits, the beneficiary concerned must allow access to sites and premises (including for the external audit firm) and must ensure that information requested is readily available.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

On the basis of the audit findings, a **draft audit report** will be drawn up.

The auditors will formally notify the draft audit report to the beneficiary concerned, which has 30 days from receiving notification to make observations (contradictory audit procedure).

The **final audit report** will take into account observations by the beneficiary concerned and will be formally notified to them.

Audits (including audit reports) will be in the language of the Agreement, unless otherwise agreed with the granting authority (see Data Sheet, Point 4.2).

25.2 European Commission checks, reviews and audits in grants of other granting authorities

Where the granting authority is not the European Commission, the latter has the same rights of checks, reviews and audits as the granting authority.

25.3 Access to records for assessing simplified forms of funding

The beneficiaries must give the European Commission access to their statutory records for the periodic assessment of simplified forms of funding which are used in EU programmes.

25.4 OLAF, EPPO and ECA audits and investigations

The following bodies may also carry out checks, reviews, audits and investigations — during the action or afterwards:

- the European Anti-Fraud Office (OLAF) under Regulations No 883/2013[16] and No 2185/96[17]
- the European Public Prosecutor's Office (EPPO) under Regulation 2017/1939
- the European Court of Auditors (ECA) under Article 287 of the Treaty on the Functioning of the EU (TFEU) and Article 257 of EU Financial Regulation 2018/1046.

If requested by these bodies, the beneficiary concerned must provide full, accurate and complete information in the format requested (including complete accounts, individual salary statements or other personal data, including in electronic format) and allow access to sites and premises for on-the-spot visits or inspections — as provided for under these Regulations.

To this end, the beneficiary concerned must keep all relevant information relating to the action, at least until the time-limit set out in the Data Sheet (Point 6) and, in any case, until any ongoing checks, reviews, audits, investigations, litigation or other pursuits of claims have been concluded.

25.5 Consequences of checks, reviews, audits and investigations — Extension of findings

[16] Regulation (EU, Euratom) No 883/2013 of the European Parliament and of the Council of 11 September 2013 concerning investigations conducted by the European Anti-Fraud Office (OLAF) and repealing Regulation (EC) No 1073/1999 of the European Parliament and of the Council and Council Regulation (Euratom) No 1074/1999 (OJ L 248, 18/09/2013, p. 1).

[17] Council Regulation (Euratom, EC) No 2185/96 of 11 November 1996 concerning on-the-spot checks and inspections carried out by the Commission in order to protect the European Communities' financial interests against fraud and other irregularities (OJ L 292, 15/11/1996, p. 2).

25.5.1 Consequences of checks, reviews, audits and investigations in this grant

Findings in checks, reviews, audits or investigations carried out in the context of this grant may lead to rejections (see Article 27), grant reduction (see Article 28) or other measures described in Chapter 5.

Rejections or grant reductions after the final payment will lead to a revised final grant amount (see Article 22).

Findings in checks, reviews, audits or investigations during the action implementation may lead to a request for amendment (see Article 39), to change the description of the action set out in Annex 1.

Checks, reviews, audits or investigations that find systemic or recurrent errors, irregularities, fraud or breach of obligations in any EU grant may also lead to consequences in other EU grants awarded under similar conditions (‘extension to other grants’).

Moreover, findings arising from an OLAF or EPPO investigation may lead to criminal prosecution under national law.

25.5.2 Extension from other grants

Findings of checks, reviews, audits or investigations in other grants may be extended to this grant, if:

(a) the beneficiary concerned is found, in other EU grants awarded under similar conditions, to have committed systemic or recurrent errors, irregularities, fraud or breach of obligations that have a material impact on this grant and

(b) those findings are formally notified to the beneficiary concerned — together with the list of grants affected by the findings — within the time-limit for audits set out in the Data Sheet (see Point 6).

The granting authority will formally notify the beneficiary concerned of the intention to extend the findings and the list of grants affected.

If the extension concerns **rejections of lump sum contributions**: the notification will include:

(a) an invitation to submit observations on the list of grants affected by the findings

(b) the request to submit revised financial statements for all grants affected

(c) the correction rate for extrapolation, established on the basis of the systemic or recurrent errors, to calculate the amounts to be rejected, if the beneficiary concerned:

(i) considers that the submission of revised financial statements is not possible or practicable or

(ii) does not submit revised financial statements.

If the extension concerns **grant reductions**: the notification will include:

(a) an invitation to submit observations on the list of grants affected by the findings and

(b) the **correction rate for extrapolation**, established on the basis of the systemic or recurrent errors and the principle of proportionality.

The beneficiary concerned has **60 days** from receiving notification to submit observations, revised financial statements or to propose a duly substantiated **alternative correction method/rate**.

On the basis of this, the granting authority will analyse the impact and decide on the implementation (i.e. start rejection or grant reduction procedures, either on the basis of the revised financial statements or the announced/alternative method/rate or a mix of those; see Articles 27 and 28).

25.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, lump sum contributions insufficiently substantiated will be ineligible (see Article 6) and will be rejected (see Article 27), and the grant may be reduced (see Article 28).

Such breaches may also lead to other measures described in Chapter 5.

ARTICLE 26 — IMPACT EVALUATIONS

26.1 Impact evaluation

The granting authority may carry out impact evaluations of the action, measured against the objectives and indicators of the EU programme funding the grant.

Such evaluations may be started during implementation of the action and until the time-limit set out in the Data Sheet (see Point 6). They will be formally notified to the coordinator or beneficiaries and will be considered to start on the date of the notification.

If needed, the granting authority may be assisted by independent outside experts.

The coordinator or beneficiaries must provide any information relevant to evaluate the impact of the action, including information in electronic format.

26.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the granting authority may apply the measures described in Chapter 5.

CHAPTER 5 CONSEQUENCES OF NON-COMPLIANCE

SECTION 1 REJECTIONS AND GRANT REDUCTION

ARTICLE 27 — REJECTION OF CONTRIBUTIONS

27.1 Conditions

The granting authority will — at interim payment, final payment or afterwards — reject any lump sum contributions which are ineligible (see Article 6), in particular following checks, reviews, audits or investigations (see Article 25).

The rejection may also be based on the extension of findings from other grants to this grant (see Article 25).

Ineligible lump sum contributions will be rejected.

27.2 Procedure

If the rejection does not lead to a recovery, the granting authority will formally notify the coordinator or beneficiary concerned of the rejection, the amounts and the reasons why. The coordinator or beneficiary concerned may — within 30 days of receiving notification — submit observations if it disagrees with the rejection (payment review procedure).

If the rejection leads to a recovery, the granting authority will follow the contradictory procedure with pre-information letter set out in Article 22.

27.3 Effects

If the granting authority rejects lump sum contributions, it will deduct them from the lump sum contributions declared and then calculate the amount due (and, if needed, make a recovery; see Article 22).

ARTICLE 28 — GRANT REDUCTION

28.1 Conditions

The granting authority may — at beneficiary termination, final payment or afterwards — reduce the grant for a beneficiary, if:

(a) the beneficiary (or a person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed:

  (i) substantial errors, irregularities or fraud or

  (ii) serious breach of obligations under this Agreement or during its award (including improper implementation of the action, non-compliance with the call conditions, submission of false information, failure to provide required information, breach of ethics or security rules (if applicable), etc.), or

(b) the beneficiary (or a person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed — in other EU grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (extension of findings; see Article 25.5).

The amount of the reduction will be calculated for each beneficiary concerned and proportionate to the seriousness and the duration of the errors, irregularities or fraud or breach of obligations, by applying an individual reduction rate to their accepted EU contribution.

28.2 Procedure

If the grant reduction does not lead to a recovery, the granting authority will formally notify the

coordinator or beneficiary concerned of the reduction, the amount to be reduced and the reasons why. The coordinator or beneficiary concerned may — within 30 days of receiving notification — submit observations if it disagrees with the reduction (payment review procedure).

If the grant reduction leads to a recovery, the granting authority will follow the contradictory procedure with pre-information letter set out in Article 22.

28.3 Effects

If the granting authority reduces the grant, it will deduct the reduction and then calculate the amount due (and, if needed, make a recovery; see Article 22).

SECTION 2 SUSPENSION AND TERMINATION

ARTICLE 29 — PAYMENT DEADLINE SUSPENSION

29.1 Conditions

The granting authority may — at any moment — suspend the payment deadline if a payment cannot be processed because:

(a) the required report (see Article 21) has not been submitted or is not complete or additional information is needed

(b) there are doubts about the amount to be paid (e.g. ongoing extension procedure, queries about eligibility, need for a grant reduction, etc.) and additional checks, reviews, audits or investigations are necessary, or

(c) there are other issues affecting the EU financial interests.

29.2 Procedure

The granting authority will formally notify the coordinator of the suspension and the reasons why.

The suspension will **take effect** the day the notification is sent.

If the conditions for suspending the payment deadline are no longer met, the suspension will be **lifted** — and the remaining time to pay (see Data Sheet, Point 4.2) will resume.

If the suspension exceeds two months, the coordinator may request the granting authority to confirm if the suspension will continue.

If the payment deadline has been suspended due to the non-compliance of the report and the revised report is not submitted (or was submitted but is also rejected), the granting authority may also terminate the grant or the participation of the coordinator (see Article 32).

ARTICLE 30 — PAYMENT SUSPENSION

30.1 Conditions

The granting authority may — at any moment — suspend payments, in whole or in part for one or more beneficiaries, if:

(a) a beneficiary (or a person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed or is suspected of having committed:

(i) substantial errors, irregularities or fraud or

(ii) serious breach of obligations under this Agreement or during its award (including improper implementation of the action, non-compliance with the call conditions, submission of false information, failure to provide required information, breach of ethics or security rules (if applicable), etc.), or

(b) a beneficiary (or a person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed — in other EU grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (extension of findings; see Article 25.5).

If payments are suspended for one or more beneficiaries, the granting authority will make partial payment(s) for the part(s) not suspended. If suspension concerns the final payment, the payment (or recovery) of the remaining amount after suspension is lifted will be considered to be the payment that closes the action.

30.2 Procedure

Before suspending payments, the granting authority will send a **pre-information letter** to the beneficiary concerned:

- formally notifying the intention to suspend payments and the reasons why and
- requesting observations within 30 days of receiving notification.

If the granting authority does not receive observations or decides to pursue the procedure despite the observations it has received, it will confirm the suspension (**confirmation letter**). Otherwise, it will formally notify that the procedure is discontinued.

At the end of the suspension procedure, the granting authority will also inform the coordinator.

The suspension will **take effect** the day after the confirmation notification is sent.

If the conditions for resuming payments are met, the suspension will be **lifted**. The granting authority will formally notify the beneficiary concerned (and the coordinator) and set the suspension end date.

During the suspension, no prefinancing will be paid to the beneficiaries concerned. For interim payments, the periodic reports for all reporting periods except the last one (see Article 21) must not contain any financial statements from the beneficiary concerned (or its affiliated entities). The coordinator must include them in the next periodic report after the suspension is lifted or — if suspension is not lifted before the end of the action — in the last periodic report.

ARTICLE 31 — GRANT AGREEMENT SUSPENSION

31.1 Consortium-requested GA suspension

31.1.1 Conditions and procedure

The beneficiaries may request the suspension of the grant or any part of it, if exceptional circumstances — in particular *force majeure* (see Article 35) — make implementation impossible or excessively difficult.

The coordinator must submit a request for **amendment** (see Article 39), with:

- the reasons why
- the date the suspension takes effect; this date may be before the date of the submission of the amendment request and
- the expected date of resumption.

The suspension will **take effect** on the day specified in the amendment.

Once circumstances allow for implementation to resume, the coordinator must immediately request another **amendment** of the Agreement to set the suspension end date, the resumption date (one day after suspension end date), extend the duration and make other changes necessary to adapt the action to the new situation (see Article 39) — unless the grant has been terminated (see Article 32). The suspension will be **lifted** with effect from the suspension end date set out in the amendment. This date may be before the date of the submission of the amendment request.

During the suspension, no prefinancing will be paid. Moreover, no work may be done. Ongoing work packages must be interrupted and no new work packages may be started.

31.2 EU-initiated GA suspension

31.2.1 Conditions

The granting authority may suspend the grant or any part of it, if:

(a) a beneficiary (or a person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed or is suspected of having committed:

  (i) substantial errors, irregularities or fraud or

  (ii) serious breach of obligations under this Agreement or during its award (including improper implementation of the action, non-compliance with the call conditions, submission of false information, failure to provide required information, breach of ethics or security rules (if applicable), etc.), or

(b) a beneficiary (or a person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed — in other EU grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (extension of findings; see Article 25.5)

(c) other:

(i) linked action issues: not applicable

(ii) the action has lost its scientific or technological relevance, for EIC Accelerator actions: the action has lost its economic relevance, for challenge-based EIC Pathfinder actions and Horizon Europe Missions: the action has lost its relevance as part of the Portfolio for which it has been initially selected

31.2.2 Procedure

Before suspending the grant, the granting authority will send a **pre-information letter** to the coordinator:

- formally notifying the intention to suspend the grant and the reasons why and
- requesting observations within 30 days of receiving notification.

If the granting authority does not receive observations or decides to pursue the procedure despite the observations it has received, it will confirm the suspension (**confirmation letter**). Otherwise, it will formally notify that the procedure is discontinued.

The suspension will **take effect** the day after the confirmation notification is sent (or on a later date specified in the notification).

Once the conditions for resuming implementation of the action are met, the granting authority will formally notify the coordinator a **lifting of suspension letter**, in which it will set the suspension end date and invite the coordinator to request an amendment of the Agreement to set the resumption date (one day after suspension end date), extend the duration and make other changes necessary to adapt the action to the new situation (see Article 39) — unless the grant has been terminated (see Article 32). The suspension will be **lifted** with effect from the suspension end date set out in the lifting of suspension letter. This date may be before the date on which the letter is sent.

During the suspension, no prefinancing will be paid. Moreover, no work may be done. Ongoing work packages must be interrupted and no new work packages may be started.

The beneficiaries may not claim damages due to suspension by the granting authority (see Article 33).

Grant suspension does not affect the granting authority's right to terminate the grant or a beneficiary (see Article 32) or reduce the grant (see Article 28).

ARTICLE 32 — GRANT AGREEMENT OR BENEFICIARY TERMINATION

32.1 Consortium-requested GA termination

32.1.1 Conditions and procedure

The beneficiaries may request the termination of the grant.

The coordinator must submit a request for **amendment** (see Article 39), with:

- the reasons why
- the date the consortium ends work on the action ('end of work date') and

- the date the termination takes effect (‘termination date’); this date must be after the date of the submission of the amendment request.

The termination will **take effect** on the termination date specified in the amendment.

If no reasons are given or if the granting authority considers the reasons do not justify termination, it may consider the grant terminated improperly.

32.1.2 Effects

The coordinator must — within 60 days from when termination takes effect — submit a **periodic report** (for the open reporting period until termination).

The granting authority will calculate the final grant amount and final payment on the basis of the report submitted and taking into account the lump sum contributions for activities implemented before the end of work date (see Article 22). Partial lump sum contributions for work packages that were not completed (e.g. due to technical reasons) may exceptionally be taken into account.

If the granting authority does not receive the report within the deadline, only lump sum contributions which are included in an approved periodic report will be taken into account (no contributions if no periodic report was ever approved).

Improper termination may lead to a grant reduction (see Article 28).

After termination, the beneficiaries’ obligations (in particular Articles 13 (confidentiality and security), 16 (IPR), 17 (communication, dissemination and visibility), 21 (reporting), 25 (checks, reviews, audits and investigations), 26 (impact evaluation), 27 (rejections), 28 (grant reduction) and 42 (assignment of claims)) continue to apply.

32.2 Consortium-requested beneficiary termination

32.2.1 Conditions and procedure

The coordinator may request the termination of the participation of one or more beneficiaries, on request of the beneficiary concerned or on behalf of the other beneficiaries.

The coordinator must submit a request for **amendment** (see Article 39), with:

- the reasons why
- the opinion of the beneficiary concerned (or proof that this opinion has been requested in writing)
- the date the beneficiary ends work on the action (‘end of work date’)
- the date the termination takes effect (‘termination date’); this date must be after the date of the submission of the amendment request.

If the termination concerns the coordinator and is done without its agreement, the amendment request must be submitted by another beneficiary (acting on behalf of the consortium).

The termination will **take effect** on the termination date specified in the amendment.

If no information is given or if the granting authority considers that the reasons do not justify termination, it may consider the beneficiary to have been terminated improperly.

32.2.2 Effects

The coordinator must — within 60 days from when termination takes effect — submit:

(i) a **report on the distribution of payments** to the beneficiary concerned

(ii) a **termination report** from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work

(iii) a second **request for amendment** (see Article 39) with other amendments needed (e.g. reallocation of the tasks and the estimated budget of the terminated beneficiary; addition of a new beneficiary to replace the terminated beneficiary; change of coordinator, etc.).

The granting authority will calculate the amount due to the beneficiary on the basis of the reports submitted in previous interim payments (i.e. beneficiary's lump sum contributions for completed and approved work packages).

Lump sum contributions for ongoing/not yet completed work packages will have to be included in the periodic report for the next reporting periods when those work packages have been completed.

If the granting authority does not receive the report on the distribution of payments within the deadline, it will consider that:

- the coordinator did not distribute any payment to the beneficiary concerned and that
- the beneficiary concerned must not repay any amount to the coordinator.

If the second request for amendment is accepted by the granting authority, the Agreement is **amended** to introduce the necessary changes (see Article 39).

If the second request for amendment is rejected by the granting authority (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the grant may be terminated (see Article 32).

Improper termination may lead to a reduction of the grant (see Article 31) or grant termination (see Article 32).

After termination, the concerned beneficiary's obligations (in particular Articles 13 (confidentiality and security), 16 (IPR), 17 (communication, dissemination and visibility), 21 (reporting), 25 (checks, reviews, audits and investigations), 26 (impact evaluation), 27 (rejections), 28 (grant reduction) and 42 (assignment of claims)) continue to apply.

32.3 EU-initiated GA or beneficiary termination

32.3.1 Conditions

The granting authority may terminate the grant or the participation of one or more beneficiaries, if:

(a) one or more beneficiaries do not accede to the Agreement (see Article 40)

(b) a change to the action or the legal, financial, technical, organisational or ownership situation of a beneficiary is likely to substantially affect the implementation of the action or calls into question the decision to award the grant (including changes linked to one of the exclusion grounds listed in the declaration of honour)

(c) following termination of one or more beneficiaries, the necessary changes to the Agreement (and their impact on the action) would call into question the decision awarding the grant or breach the principle of equal treatment of applicants

(d) implementation of the action has become impossible or the changes necessary for its continuation would call into question the decision awarding the grant or breach the principle of equal treatment of applicants

(e) a beneficiary (or person with unlimited liability for its debts) is subject to bankruptcy proceedings or similar (including insolvency, winding-up, administration by a liquidator or court, arrangement with creditors, suspension of business activities, etc.)

(f) a beneficiary (or person with unlimited liability for its debts) is in breach of social security or tax obligations

(g) a beneficiary (or person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has been found guilty of grave professional misconduct

(h) a beneficiary (or person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed fraud, corruption, or is involved in a criminal organisation, money laundering, terrorism-related crimes (including terrorism financing), child labour or human trafficking

(i) a beneficiary (or person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) was created under a different jurisdiction with the intent to circumvent fiscal, social or other legal obligations in the country of origin (or created another entity with this purpose)

(j) a beneficiary (or person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed:

  (i) substantial errors, irregularities or fraud or

  (ii) serious breach of obligations under this Agreement or during its award (including improper implementation of the action, non-compliance with the call conditions, submission of false information, failure to provide required information, breach of ethics or security rules (if applicable), etc.)

(k) a beneficiary (or person having powers of representation, decision-making or control, or person essential for the award/implementation of the grant) has committed — in other EU grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (extension of findings; see Article 25.5)

(l) despite a specific request by the granting authority, a beneficiary does not request — through the coordinator — an amendment to the Agreement to end the participation of one of its

affiliated entities or associated partners that is in one of the situations under points (d), (f), (e), (g), (h), (i) or (j) and to reallocate its tasks, or

(m) other:

(i) linked action issues: not applicable

(ii) the action has lost its scientific or technological relevance, for EIC Accelerator actions: the action has lost its economic relevance, for challenge-based EIC Pathfinder actions and Horizon Europe Missions: the action has lost its relevance as part of the Portfolio for which it has been initially selected

32.3.2 Procedure

Before terminating the grant or participation of one or more beneficiaries, the granting authority will send **a pre-information letter** to the coordinator or beneficiary concerned:

- formally notifying the intention to terminate and the reasons why and
- requesting observations within 30 days of receiving notification.

If the granting authority does not receive observations or decides to pursue the procedure despite the observations it has received, it will confirm the termination and the date it will take effect (**confirmation letter**). Otherwise, it will formally notify that the procedure is discontinued.

For beneficiary terminations, the granting authority will — at the end of the procedure — also inform the coordinator.

The termination will **take effect** the day after the confirmation notification is sent (or on a later date specified in the notification; 'termination date').

32.3.3 Effects

(a) for **GA termination**:

The coordinator must — within 60 days from when termination takes effect — submit a **periodic report** (for the last open reporting period until termination).

The granting authority will calculate the final grant amount and final payment on the basis of the report submitted and taking into account the lump sum contributions for activities implemented before termination takes effect (see Article 22). Partial lump sum contributions for work packages that were not completed (e.g. due to technical reasons) may exceptionally be taken into account.

If the grant is terminated for breach of the obligation to submit reports, the coordinator may not submit any report after termination.

If the granting authority does not receive the report within the deadline, only lump sum contributions which are included in an approved periodic report will be taken into account (no contributions if no periodic report was ever approved).

Termination does not affect the granting authority's right to reduce the grant (see Article 28) or to impose administrative sanctions (see Article 34).

The beneficiaries may not claim damages due to termination by the granting authority (see Article 33).

After termination, the beneficiaries' obligations (in particular Articles 13 (confidentiality and security), 16 (IPR), 17 (communication, dissemination and visibility), 21 (reporting), 25 (checks, reviews, audits and investigations), 26 (impact evaluation), 27 (rejections), 28 (grant reduction) and 42 (assignment of claims)) continue to apply.

(b) for **beneficiary termination**:

The coordinator must — within 60 days from when termination takes effect — submit:

(i) a **report on the distribution of payments** to the beneficiary concerned

(ii) a **termination report** from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work

(iii) a **request for amendment** (see Article 39) with any amendments needed (e.g. reallocation of the tasks and the estimated budget of the terminated beneficiary; addition of a new beneficiary to replace the terminated beneficiary; change of coordinator, etc.).

The granting authority will calculate the amount due to the beneficiary on the basis of the reports submitted in previous interim payments (i.e. beneficiary's lump sum contributions for completed and approved work packages).

Lump sum contributions for ongoing/not yet completed work packages will have to be included in the periodic report for the next reporting periods when those work packages have been completed.

If the granting authority does not receive the report on the distribution of payments within the deadline, it will consider that:

- the coordinator did not distribute any payment to the beneficiary concerned and that
- the beneficiary concerned must not repay any amount to the coordinator.

If the request for amendment is accepted by the granting authority, the Agreement is **amended** to introduce the necessary changes (see Article 39).

If the request for amendment is rejected by the granting authority (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the grant may be terminated (see Article 32).

After termination, the concerned beneficiary's obligations (in particular Articles 13 (confidentiality and security), 16 (IPR), 17 (communication, dissemination and visibility), 21 (reporting), 25 (checks, reviews, audits and investigations), 26 (impact evaluation), 27 (rejections), 28 (grant reduction) and 42 (assignment of claims)) continue to apply.

SECTION 3 OTHER CONSEQUENCES: DAMAGES AND ADMINISTRATIVE SANCTIONS

ARTICLE 33 — DAMAGES

33.1 Liability of the granting authority

The granting authority cannot be held liable for any damage caused to the beneficiaries or to third parties as a consequence of the implementation of the Agreement, including for gross negligence.

The granting authority cannot be held liable for any damage caused by any of the beneficiaries or other participants involved in the action, as a consequence of the implementation of the Agreement.

33.2 Liability of the beneficiaries

The beneficiaries must compensate the granting authority for any damage it sustains as a result of the implementation of the action or because the action was not implemented in full compliance with the Agreement, provided that it was caused by gross negligence or wilful act.

The liability does not extend to indirect or consequential losses or similar damage (such as loss of profit, loss of revenue or loss of contracts), provided such damage was not caused by wilful act or by a breach of confidentiality.

ARTICLE 34 — ADMINISTRATIVE SANCTIONS AND OTHER MEASURES

Nothing in this Agreement may be construed as preventing the adoption of administrative sanctions (i.e. exclusion from EU award procedures and/or financial penalties) or other public law measures, in addition or as an alternative to the contractual measures provided under this Agreement (see, for instance, Articles 135 to 145 EU Financial Regulation 2018/1046 and Articles 4 and 7 of Regulation 2988/95[18]).

SECTION 4 FORCE MAJEURE

ARTICLE 35 — FORCE MAJEURE

A party prevented by force majeure from fulfilling its obligations under the Agreement cannot be considered in breach of them.

‘Force majeure’ means any situation or event that:

- prevents either party from fulfilling their obligations under the Agreement,
- was unforeseeable, exceptional situation and beyond the parties’ control,
- was not due to error or negligence on their part (or on the part of other participants involved in the action), and
- proves to be inevitable in spite of exercising all due diligence.

Any situation constituting force majeure must be formally notified to the other party without delay, stating the nature, likely duration and foreseeable effects.

[18] Council Regulation (EC, Euratom) No 2988/95 of 18 December 1995 on the protection of the European Communities financial interests (OJ L 312, 23.12.1995, p. 1).

The parties must immediately take all the necessary steps to limit any damage due to force majeure and do their best to resume implementation of the action as soon as possible.

CHAPTER 6 FINAL PROVISIONS

ARTICLE 36 — COMMUNICATION BETWEEN THE PARTIES

36.1 Forms and means of communication — Electronic management

EU grants are managed fully electronically through the EU Funding & Tenders Portal ('Portal').

All communications must be made electronically through the Portal in accordance with the Portal Terms and Conditions and using the forms and templates provided there (except if explicitly instructed otherwise by the granting authority).

Communications must be made in writing and clearly identify the grant agreement (project number and acronym).

Communications must be made by persons authorised according to the Portal Terms and Conditions. For naming the authorised persons, each beneficiary must have designated — before the signature of this Agreement — a 'legal entity appointed representative (LEAR)'. The role and tasks of the LEAR are stipulated in their appointment letter (see Portal Terms and Conditions).

If the electronic exchange system is temporarily unavailable, instructions will be given on the Portal.

36.2 Date of communication

The sending date for communications made through the Portal will be the date and time of sending, as indicated by the time logs.

The receiving date for communications made through the Portal will be the date and time the communication is accessed, as indicated by the time logs. Formal notifications that have not been accessed within 10 days after sending, will be considered to have been accessed (see Portal Terms and Conditions).

If a communication is exceptionally made on paper (by e-mail or postal service), general principles apply (i.e. date of sending/receipt). Formal notifications by registered post with proof of delivery will be considered to have been received either on the delivery date registered by the postal service or the deadline for collection at the post office.

If the electronic exchange system is temporarily unavailable, the sending party cannot be considered in breach of its obligation to send a communication within a specified deadline.

36.3 Addresses for communication

The Portal can be accessed via the Europa website.

The address for paper communications to the granting authority (if exceptionally allowed) is the official mailing address indicated on its website.

For beneficiaries, it is the legal address specified in the Portal Participant Register.

ARTICLE 37 — INTERPRETATION OF THE AGREEMENT

The provisions in the Data Sheet take precedence over the rest of the Terms and Conditions of the Agreement.

Annex 5 takes precedence over the Terms and Conditions.

The Terms and Conditions take precedence over the Annexes other than Annex 5.

Annex 2 takes precedence over Annex 1.

ARTICLE 38 — CALCULATION OF PERIODS AND DEADLINES

In accordance with Regulation No 1182/71[19], periods expressed in days, months or years are calculated from the moment the triggering event occurs.

The day during which that event occurs is not considered as falling within the period.

'Days' means calendar days, not working days.

ARTICLE 39 — AMENDMENTS

39.1 Conditions

The Agreement may be amended, unless the amendment entails changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

Amendments may be requested by any of the parties.

39.2 Procedure

The party requesting an amendment must submit a request for amendment signed directly in the Portal Amendment tool.

The coordinator submits and receives requests for amendment on behalf of the beneficiaries (see Annex 3). If a change of coordinator is requested without its agreement, the submission must be done by another beneficiary (acting on behalf of the other beneficiaries).

The request for amendment must include:

- the reasons why
- the appropriate supporting documents and
- for a change of coordinator without its agreement: the opinion of the coordinator (or proof that this opinion has been requested in writing).

The granting authority may request additional information.

[19] Regulation (EEC, Euratom) No 1182/71 of the Council of 3 June 1971 determining the rules applicable to periods, dates and time-limits (OJ L 124, 8/6/1971, p. 1).

If the party receiving the request agrees, it must sign the amendment in the tool within 45 days of receiving notification (or any additional information the granting authority has requested). If it does not agree, it must formally notify its disagreement within the same deadline. The deadline may be extended, if necessary for the assessment of the request. If no notification is received within the deadline, the request is considered to have been rejected.

An amendment **enters into force** on the day of the signature of the receiving party.

An amendment **takes effect** on the date of entry into force or other date specified in the amendment.

ARTICLE 40 — ACCESSION AND ADDITION OF NEW BENEFICIARIES

40.1 Accession of the beneficiaries mentioned in the Preamble

The beneficiaries which are not coordinator must accede to the grant by signing the accession form (see Annex 3) directly in the Portal Grant Preparation tool, within 30 days after the entry into force of the Agreement (see Article 44).

They will assume the rights and obligations under the Agreement with effect from the date of its entry into force (see Article 44).

If a beneficiary does not accede to the grant within the above deadline, the coordinator must — within 30 days — request an amendment (see Article 39) to terminate the beneficiary and make any changes necessary to ensure proper implementation of the action. This does not affect the granting authority's right to terminate the grant (see Article 32).

40.2 Addition of new beneficiaries

In justified cases, the beneficiaries may request the addition of a new beneficiary.

For this purpose, the coordinator must submit a request for amendment in accordance with Article 39. It must include an accession form (see Annex 3) signed by the new beneficiary directly in the Portal Amendment tool.

New beneficiaries will assume the rights and obligations under the Agreement with effect from the date of their accession specified in the accession form (see Annex 3).

Additions are also possible in mono-beneficiary grants.

ARTICLE 41 — TRANSFER OF THE AGREEMENT

In justified cases, the beneficiary of a mono-beneficiary grant may request the transfer of the grant to a new beneficiary, provided that this would not call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiary must submit a request for **amendment** (see Article 39), with

- the reasons why
- the accession form (see Annex 3) signed by the new beneficiary directly in the Portal Amendment tool and

- additional supporting documents (if required by the granting authority).

The new beneficiary will assume the rights and obligations under the Agreement with effect from the date of accession specified in the accession form (see Annex 3).

ARTICLE 42 — ASSIGNMENTS OF CLAIMS FOR PAYMENT AGAINST THE GRANTING AUTHORITY

The beneficiaries may not assign any of their claims for payment against the granting authority to any third party, except if expressly approved in writing by the granting authority on the basis of a reasoned, written request by the coordinator (on behalf of the beneficiary concerned).

If the granting authority has not accepted the assignment or if the terms of it are not observed, the assignment will have no effect on it.

In no circumstances will an assignment release the beneficiaries from their obligations towards the granting authority.

ARTICLE 43 — APPLICABLE LAW AND SETTLEMENT OF DISPUTES

43.1 Applicable law

The Agreement is governed by the applicable EU law, supplemented if necessary by the law of Belgium.

Special rules may apply for beneficiaries which are international organisations (if any; see Data Sheet, Point 5).

43.2 Dispute settlement

If a dispute concerns the interpretation, application or validity of the Agreement, the parties must bring action before the EU General Court — or, on appeal, the EU Court of Justice — under Article 272 of the Treaty on the Functioning of the EU (TFEU).

For non-EU beneficiaries (if any), such disputes must be brought before the courts of Brussels, Belgium — unless an international agreement provides for the enforceability of EU court judgements.

For beneficiaries with arbitration as special dispute settlement forum (if any; see Data Sheet, Point 5), the dispute will — in the absence of an amicable settlement — be settled in accordance with the Rules for Arbitration published on the Portal.

If a dispute concerns administrative sanctions, offsetting or an enforceable decision under Article 299 TFEU (see Articles 22 and 34), the beneficiaries must bring action before the General Court — or, on appeal, the Court of Justice — under Article 263 TFEU.

For grants where the granting authority is an EU executive agency (see Preamble), actions against offsetting and enforceable decisions must be brought against the European Commission (not against the granting authority; see also Article 22).

ARTICLE 44 — ENTRY INTO FORCE

The Agreement will enter into force on the day of signature by the granting authority or the coordinator, depending on which is later.

SIGNATURES

For the coordinator

Mateo VALERO with ECAS id nvalerme signed in the Participant Portal on 15/04/2024 at 16:38:08 (transaction id SigId-23602-eQdWdnYazffsLQytg0nUkZR8zMWq2sM9qNJqzVrOwTr5gWcWdqmtP75gf5XG44mveg5zkn1oUxxT8f6b3ogYR8e-yntOf97TTHq5xTIBX3dHX0-uFP24XUWzlcVzlWUnn0Gc4VzImqJaf5rjmwEWzx7nvAiwxgJzG9h82SkQ6dGcaEFpa6guSpFguvgqBzT7BYzJUZW). Timestamp by third party at 2024.04.15 16:38:12 CEST

For the granting authority

Signed by Peter PETROV with ECAS id petropt as an authorised representative on 02-05-2024 10:46:53 (transaction id SigId-32596-I3xhP2dNfCAiWopjIh5goF3zarTk7mdzm0HOKw78solSPY5qZoBEYnbcSSl3uLqBYjT75ga6Cr6agIocd5QmI5-yntOf97TTHq8GZt5aBGF4O-jc5k5jwpEWyjKvwd3sVF5ZXoMK4KntRLmxs0e7SsaJ2i76t4mxOoNEj8zzuUUCNeZKtuES6Um5YcrH8UO2K2P4)
2024.05.02 10:46:56 CEST

ANNEX 1

Horizon Europe (HORIZON)

Description of the action (DoA)

Part A

Part B

DESCRIPTION OF THE ACTION (PART A)

COVER PAGE

Part A of the Description of the Action (DoA) must be completed directly on the Portal Grant Preparation screens.

PROJECT *Grant Preparation (General Information screen) — Enter the info.*	
Project number:	101147377
Project name:	Towards a digital twin for forecasting of power production to wind energy demand
Project acronym:	WindTwin
Call:	HORIZON-CL5-2023-D3-02
Topic:	HORIZON-CL5-2023-D3-02-14
Type of action:	HORIZON-RIA
Service:	CINEA/C/02
Project starting date:	first day of the month following the entry into force date
Project duration:	36 months

TABLE OF CONTENTS

PROJECT SUMMARY

Project summary

Grant Preparation (General Information screen) — Provide an overall description of your project (including context and overall objectives, planned activities and main achievements, and expected results and impacts (on target groups, change procedures, capacities, innovation etc)). This summary should give readers a clear idea of what your project is about.

Use the project summary from your proposal.

The expected growth of both on- and offshore wind energy is enormous and many new wind parks are planned for the coming years. Experience from the existing wind farms shows the importance of a proper micrositing of the wind turbines as well their efficient interconnection within the farm. In addition, bringing wind farms together into clusters toward a wind power plant concept might induce long distance negative interaction between the farms, reducing their expected efficiency. This might happen both on- and offshore. The high amount of connected wind power and the expected increase during the coming years, requires that this technology has to be prepared to take a more important role as of its contribution to the reliability and security of the electricity system. The present proposal, WinDTwin, targets to develop and validate an offshore wind farm digital twin (DT) for highly accurate prediction of power production and energy demand of the end user. The DT will give users tailored access to high-quality information, services, models, scenarios, forecasts, and visualisations, as a central hub for offshore wind decision-makers. And will also serve as platform, offering users access to a comprehensive array of high-quality resources, services, models, scenarios, forecasts, and visualisations. WinDTwin seeks to revolutionise the way industry professionals make informed choices. To reach WinDTwin expected impact, the ambitious innovation-led research proposed necessitates bringing together a range of skills and expertise which cannot be found within a single member country or institution. We have put together a unique team that has a broad range of expertise through the whole wind energy development process; ranging from the management of wind energy production and development of industrial codes, numerical methods, algorithms, ensuring the uptake of improved methodologies.. The WinDTwin consortium consists of 13 organizations from 7 different Member States.

LIST OF PARTICIPANTS

PARTICIPANTS

Grant Preparation (Beneficiaries screen) — Enter the info.

Number	Role	Short name	Legal name	Country	PIC
1	COO	BSC	BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION	ES	999655520
2	BEN	FHG-IEE	FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV	DE	999984059
3	BEN	WAVEC	WAVEC/OFFSHORE RENEWABLES - CENTRO DE ENERGIA OFFSHORE ASSOCIACAO	PT	999543485
4	BEN	EPRI	EPRI EUROPE DAC	IE	913811393
5	BEN	SOLUTE	ETULOS SOLUTE SL	ES	952762325
6	BEN	UKS	UNIVERSITAET KASSEL	DE	999852624
7	BEN	IBERDROLA	IBERDROLA RENOVABLES ENERGIA SA	ES	953093774
8	BEN	SINTEF	SINTEF OCEAN AS	NO	997806603
9	BEN	+ATLANTIC	+ATLANTIC ASSOCIACAO PARA UM LABORATORIO COLABORATIVO DO ATLANTICO	PT	898055586

PARTICIPANTS

Grant Preparation (Beneficiaries screen) — Enter the info.

Number	Role	Short name	Legal name	Country	PIC
10	BEN	OPEN CASCADE	OPEN CASCADE	FR	942422416
11	BEN	EDP NEW	CNET CENTRE FOR NEW ENERGY TECHNOLOGIES SA	PT	933299857
12	BEN	MET Centre	MARIN ENERGI TESTSENTER AS	NO	928496902
13	BEN	ENGIE Laborelec	BELGISCH LABORATORIUM VAN ELEKTRICITEITSINDUSTRIE	BE	998728200

LIST OF WORK PACKAGES

Work packages

Grant Preparation (Work Packages screen) — Enter the info.

Work Package No	Work Package name	Lead Beneficiary	Effort (Person-Months)	Start Month	End Month	Deliverables
WP1	Project coordination and management	1 - BSC	47.00	1	36	D1.1 – Project Management and Quality Guidelines D1.2 – Equality, Ethics and Inclusiveness management D1.3 – Project Management and Quality Guidelines mid-project update
WP2	Data Management (acquisition/collection & storage/preparation)	10 - OPEN CASCADE	27.50	3	36	D2.1 – Data model specification D2.2 – Common data storage implementation D2.3 – Data Management Plan
WP3	Modelling of wake effects and wind turbines	1 - BSC	108.50	1	36	D3.1 – Validation report on high-resolution and machine learning based models D3.2 – Detailed numerical models for benchmark studies D3.3 – Results of numerical benchmark studies
WP4	Resource assessment and forecasting of power production	8 - SINTEF	181.00	1	36	D4.1 – Report on the description metocean climate (wind, wave, current) D4.2 – Optimization tool for offshore power plants D4.3 – Guidelines for developing data-driven methodologies for short-term wind power forecasting D4.4 – Guideline for optimizing O&M long-term planning and short-term

Work packages

Grant Preparation (Work Packages screen) — Enter the info.

Work Package No	Work Package name	Lead Beneficiary	Effort (Person-Months)	Start Month	End Month	Deliverables
						scheduling for bottom fixed and floating wind farms
WP5	Energy distribution and demand of the end user	3 - WAVEC	101.00	1	36	D5.1 – Interactive map for end-user location and needs for the Portuguese, UK and German coasts D5.2 – Assessment report on the modelling of short-term demand and electricity price forecasting models D5.3 – Power system modelling D5.4 – Power system operation evaluation D5.5 – Quantification of the needs and economic impacts of different energy storage solutions in offshore wind projects D5.6 – Short-term energy storage control strategies for integration in offshore wind projects D5.7 – Short-term energy storage control model
WP6	Digital Twin Development	10 - OPEN CASCADE	99.50	1	30	D6.1 – Specification of Digital Twin Core Components D6.2 – Guidelines for component development for the Digital Twin platform D6.3 – Definition of components API D6.4 – First version of Digital Twin Back End core components D6.5 – First version of Digital Twin Front End core components D6.6 – First version of integration of business components in the Digital Twin

Work packages

Grant Preparation (Work Packages screen) — Enter the info.

Work Package No	Work Package name	Lead Beneficiary	Effort (Person-Months)	Start Month	End Month	Deliverables
						D6.7 – Compilation of Digital Twin open source component repositories
WP7	Technology Verification, Validation, and Industrial Assessment	11 - EDP NEW	73.00	1	36	D7.1 – Case Studies Specification D7.2 – Report on the validation tasks D7.3 – Techno-economic analysis of the Digital Twin performance and measurement of the potential financial benefits from the different modules
WP8	Stakeholder engagement, Communication, Dissemination and Exploitation	3 - WAVEC	57.50	1	36	D8.1 – Communication Plan D8.2 – Website D8.3 – WinDTwin brand identity D8.4 – Project tools repository D8.5 – 1st Annual communication and dissemination report D8.6 – 2nd Annual communication and dissemination report D8.7 – Final communication and dissemination report D8.8 – WinDTwin exploitation and business plan D8.9 – Final project tools repository D8.10 – Final event of the project with stakeholders D8.11 – Stakeholder engagement report D8.12 – Report on training activities and workshops D8.13 – Roadmap for achieving TRL9

Work package WP1 – Project coordination and management

Work Package Number	WP1	Lead Beneficiary	1 - BSC
Work Package Name	Project coordination and management		
Start Month	1	End Month	36

Objectives

This work package deals with the overall project management; more specifically, it has the following objectives:
- To deliver on the scientific and technical objectives of the project within the time and budget constraints
- To ensure that there is clear and effective communication between partners; to detect management and technical issues as early as possible and bring them to resolution
- To establish and enforce effective management and quality procedures that will result in high quality project deliverables
- To provide efficient operational management support including: administrative and financial planning, reporting to the EC, management of project legal aspects including project-related contracts and IPR, and management of day-to-day operational and technical progress

Description

The following is a list of the tasks required to achieve the objectives of this work package. It also includes an overview of the most important procedures which will be further defined in the early months.

Task 1.1: Administrative and financial management [M01-M36]

Leader: BSC - Contributing partners: All

Led by BSC, this task will establish the corresponding procedures, tools and methodologies to enable correct project management, including administrative and financial management. It will also involve the monitoring of the technical progress and coordinating input/output flows between the various work packages, as well as the coordination of the timely production of deliverables, and the organization of meetings and reviews.

On a 6-month basis, the project coordinator will monitor resources usage, producing internal reports to ensure the project resources expenditure is on track with the work progress.

At the beginning of the project, the organizational structure will be established, appointing its key components (e.g., General Assembly [GA], or the Project Executive Committee [PEC], as the body responsible for the overall management and the day-to-day execution of the project), and defining their roles. This structure will enable a clear decision-making process and ensure the involvement of all partners.

Task 1.2: Internal communication, quality and risk management [M01-M36]

Leader: BSC - Contributing partners: All

In this task, we will determine the appropriate strategy to ensure clear communication channels between all partners in order to facilitate the exchange of critical project documentation and news and to encourage participation in the decision-making process. The task will require defining and maintaining internal collaborative tools for sharing documentation and communicating work status.

In this task, we will also define and implement the appropriate quality assurance processes that ensure accurate documentation, reporting and justification of the work being carried out. A process will be developed (and tools if applicable) to ensure that the deliverables have been reviewed by a broad spectrum of individuals against a well-defined set of criteria. The minimum level of quality required for the presentation of the official outcomes of the project to the EC will be determined. The principles guiding these procedures will be agreed at the KoM.

Moreover, this task will deal with any potential risks and perform risk management. It is highly important to specify risk identification, evaluation, monitoring, and treatment strategies to avoid unwanted known or unknown incidents, in particular those related to security issues (see Task 1.3).

Risks will be constantly assessed and evaluated in four steps: a) risk identification and classification, b) risk quantification, c) proposed mitigation measures, and d) risk control and report. The administrative project management procedures defined in Task 1.1, quality assurance and risk management processes will be documented in D1.1. For every income and outcome of the DT, an evaluation of each intellectual property (IP) will be made, ensuring that appropriate safeguarding measures are taken. The Task Leader will provide regular updates to all partners regarding the activities, outcomes, and decisions arising from this task

Task 1.3: Equality, Ethics and Inclusiveness management [M01-M36]

Leader: BSC - Contributing partners: All

This task involves:

● Policy and Procedure Audit: Conduct a comprehensive review of our organization's existing equality, ethics, and inclusiveness policies and procedures. ● Gap Analysis: Identify gaps, inconsistencies, or areas in need of enhancement within the current policies and procedures. ● Regulatory Compliance: Ensure that our organization's policies and practices align with all relevant laws and regulations concerning equality, ethics, and inclusiveness. ● Ethical Behavior Promotion: Develop strategies to promote ethical behavior throughout the organization, emphasizing transparency, honesty, and integrity. ● Diversity and Inclusion Assessment: Assess the organization's efforts in fostering diversity and inclusion in its workforce, ensuring that it reflects a broad spectrum of backgrounds, experiences, and perspectives. ● Awareness and Training: Design and implement training programs to educate employees about equality, ethics, and inclusiveness principles, emphasizing their significance in day-to-day operations. ● Monitoring and Reporting: Establish mechanisms for monitoring compliance with the revised policies and procedures, along with a reporting system for addressing concerns. ● Communication Plan: Develop a communication strategy to inform employees about the changes, emphasizing the organization's commitment to equality, ethics, and inclusiveness.

Work package WP2 – Data Management (acquisition/collection & storage/preparation)

Work Package Number	WP2	**Lead Beneficiary**	10 - OPEN CASCADE
Work Package Name	Data Management (acquisition/collection & storage/preparation)		
Start Month	3	**End Month**	36

Objectives
The main objective of this work package is to define the data needed to build the digital twin and use the features developed in the frame of the different work packages. Data can be available from various sources and in various forms.

Description
Task 2.1 - Data schema definition [M03-M36] Leader: BSC - Contributing partners: BSC, Open Cascade, WavEC The goal of this task is to identify the kind of data needed to build the digital twin. This analysis will list input needed by the different components of the Digital Twin, and the results they will produce, but also all the possible intermediate data that may be needed. Then, for each type of data identified, a process to collect it will be specified: ● From which source: public databases, results files, sensor data… ● Using which interface: direct connection to an external database, using existing APIs… ● If necessary, how the data need to be formatted, transformed or adapted… The result of this task will be a specification that will describe all the necessary data workflow needed by the following work packages. Under this task the project's Data Management Plan (DMP) will be developed, outlining: (i) how research data will be collected, processed or generated within the project; (ii) what methodology and standards will be adopted; (iii) whether and how this data will be shared and/or made open. Task 2.2 - Common data storage design [M06-M18] Leader: Open Cascade - Contributing partners: Open Cascade, BSC, IBERDROLA This task will use the specifications created in the frame of the previous task to implement the needed common data storage for all the types of data identified. Depending on the type of data, the data storage may be implemented as databases, files with specific format (csv, XML, JSon) or definition of interfaces.

Work package WP3 – Modelling of wake effects and wind turbines

Work Package Number	WP3	**Lead Beneficiary**	1 - BSC
Work Package Name	Modelling of wake effects and wind turbines		

Start Month	1	End Month	36

Objectives

This WP focuses on implementing models and tools for wake effects and wind turbine physics. The models are used in WP4 for resource assessment and for short, medium and long term forecasting of power production. Main objectives include:

- To develop high resolution LES models together with the dynamical downscaling methodology to couple with mesoscale flows, to account for realistic atmospheric conditions.
- To improve wake models with the modeling of floating wind turbine platforms taking advantage of novel ML algorithms.
- To improve and develop detailed physical modelling of wind turbines.

Description

Task 3.1 – High-resolution spatial weather and wake modelling [M1-M24]
Leader: BSC - Contributing partners: BSC, SOLUTE
This task will develop numerical models to accurately forecast wind flow for offshore scenarios. These models will address how weather conditions affect power production. The main objective is the development of high resolution Large Eddy Simulations (LES) models together with dynamical downscaling to couple with mesoscale flows.
Microscale modelling will be achieved using the actuator disk (AD) model. On the one hand, this approach will be used for generating high-fidelity weather forecasts using meso-microscale coupling to consequently feed data-driven machine learning models to improve their accuracy, particularly in scenarios with a lack of measured data. On the other hand, it will be applied for wind resource assessment using RANS (or averaged LES) for different wind directions. This methodology will allow us to have a better understanding of the wind flow within the wind farm and its surroundings. Furthermore, it will contribute to gaining physical insights into the turbulence coherent behavior and the impact on wind power production, as this approach will predict the wakes of each turbine and the interaction among them.
The modelling methodology will consider the effects and climatology of the marine atmospheric boundary layer (MABL) to relate the MABL stability and height with power production losses due to blockage effects using thermally coupled simulations. Further parameters and their influence will be analyzed such as low-level jets, as well as waves using either wave-phase-resolved models, sea surface-roughness models or wave-phase-resolved models.
For the downscaling approach, a strategy based on MS (Matrix Simulation) will be followed and will be part of sensitivity studies. Numerical simulations will be performed to distinguish the cases for atmospheric stability with Monin-Obukhov length ranges, geostrophic wind regime and terrain complexity. In order to include a good representation of wind farms and their interactions (e.g., wakes and blockage effects), and starting from a mesoscale point of view, we will validate the Fitch parametrization for the cases registered in the modelling matrix.
Task 3.2 – AI and empirical models for farm and cluster wake effects [M1-M36]
Leader: UKS - Contributing partners: UKS, FHG-IEE, SINTEF, BSC
This task addresses spatial interactions of wind turbines and wind farms using AI end empirical models. Its objective is to provide a suite of modelling approaches to the digital twin which:

- accurately model the wake effects of wind turbines in a wind farm
- accurately represent the interactions between wind farms and wind farm clusters including cluster wakes and blockage effects
- are computationally efficient, so that they can readily be used in forecasting scenario modelling and wind farm layout and operation strategy optimisation
- are able to continuously learn from operational data of the wind farm and continuously improve their accuracy

UKS will focus on the development in integration of the machine learning based approaches. This includes the use of high-fidelity models, SCADA-Data and wind measurement data. Moreover, the UKS will work to develop a method to facilitate robust and accurate continuous learning from the operational data of the wind farm. This includes developing the APIs to integrate these data sources into the models and contributing to development of the APIs to integrate the data into the digital twin. UKS will contribute to the integration of PyWake into the digital twin and implement a method to fit a simple engineering model to operational data. Together with the UKS FHG-IEE develop the continuous learning approach to refit the model to data that becomes available during operation. SINTEF will contribute to generate time varying wind input at wake affected turbines, based on PyWake results, the DWM method, and data driven approaches. BSC will combine modal decompositions and neural networks to reduce data dimensionality. To do so, singular value decomposition or autoencoder techniques will be used to reduce the problem dimension to some variation modes (spatial problem). And, a ML algorithm will be developed to evaluate the mode's evolution in time.
Task 3.3 – Detailed physical modelling of the wind turbines [M1-M36]
Leader: SINTEF - Contributing partners: WavEC

The aim of this task is to implement physical models of the dynamic responses of floating wind turbines to wind, waves and current. The responses include motions, accelerations, structural loads of different components of the system and, most importantly, the power production. The environmental loads on the umbilical cables for different metocean conditions and operating regimes of the floating wind turbine will also be studied.
Detailed modelling will enable including the effects of the platform motions on the power production forecasting, in case of the floating WTs. More generally, detailed modelling of the WTs will provide complementary information on the responses to wind and waves, compared to LES + actuator disk, namely in terms of loads on different components of the system. Such information is useful for assessment of fatigue damage. The floating wind turbine, including moorings and umbilical cables will be modelled with two different software tools namely SIMA and Orcaflex. The aim is to demonstrate the ability of the Digital Twin to integrate different tools. For a given platform and umbilical cable design (length, material, and number of buoyancy elements), different wind, wave, current conditions, and turbine operating regimes, the environmental loads on the umbilical cables will be calculated. The impact of different loads on the umbilical cables in terms of stress and fatigue will be studied using finite element models (ANSYS). These results will feed into the maintenance task in “T4.5: Strategic maintenance planning and operational optimization”, to provide valuable insights on the remaining useful life of the umbilical cables throughout the project lifetime. Secondly, fully coupled RANS-CFD studies to a single floating wind turbine in a farm array when exposed to combined wave and wind conditions will be carried out. The high-fidelity CFD-RANS simulations will focus on studying the hydrodynamic response of the floater, thrust and torque of the turbine, blade loads, but most importantly, the impacts of the floating wind turbine motions and displacement (e.g. static pitch of the tower), on the wake field mixing, evaluate whether additional mixing occurs, and whether any measurable impacts on farm AEP can be expected (compared to bottom-fixed wind). These high-fidelity CFD-RANS results will be compared to coupled dynamic responses obtained from the multi-physics tool in order to quantify the corrective factor to be applied to turbine yield, wake evolution and loads on the turbine predicted by simplified models that do not account for the floating wind motions and displacement (e.g. static pitch of the tower). This comparison will provide insight on the accuracy of the different numerical tools.

Work package WP4 – Resource assessment and forecasting of power production

Work Package Number	WP4	**Lead Beneficiary**	8 - SINTEF
Work Package Name	Resource assessment and forecasting of power production		
Start Month	1	**End Month**	36

Objectives

The main objective of this WP is the integration into the DT of methodologies developed for the wind resource assessment tools optimized considering characteristic weather conditions and orography of potential sites, state-of-the-art wind power and weather forecasting models at different prediction horizons and optimization tools for the strategic maintenance planning and operation of offshore wind farms.

Description

Task 4.1 – Historical climate baseline for the case studies [M01-M12]
Leader: SINTEF - Contributing partners: +ATLANTIC, UKS, IBERDROLA
The general steps to achieve this objective are the following:
• Given a specific area for the wind farm, detailed geographical information (e.g., bathymetry/orography/coastline) will be acquired either from EMODNET database or any other available source of information.
• Metocean (wind, wave, current) data from global databases (Copernicus, ECMWF, NOAA etc) are statistically analysed and used as boundary conditions.
• Regional (finer-scale) models (wind: WRF, wave: SWAN, current: SINMOD) are run using input from Steps 1 and 2 for the specific area.
• Detailed statistical analysis of the derived data (i) wind, (ii) wave, (iii) wind power resource, (iv) wave power resource.
Historical climate baselines are based on weather statistical data. Such data is site specific and it needs to be produced for each location based on the historical global data from meteorological offices. Local models (WRF and SWAN) will be run offline using processed (homogenized, corrected) global input from now to the past to produce hindcasts. On a second step, the hindcast data will be post-processed to generate the relevant statistics related to wind, waves and current, together with the related energy spectra.

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The analysis will have the possibility to assimilate new data acquired during the operation of the wind farm, both from sensors and from simulations.
A non-exhaustive list of aspects of the statistical analysis of raw metocean data includes:
o Probabilistic analysis: the study of the probability structure of one parameter at one location, the joint probability structure of two related parameters at one location, the geographic distribution of probability quantiles (50%, 90%, 95% etc), the geographic distribution of probabilities of an event (e.g., P[wave height > 5m])
o Seasonal analysis: the study of the mean daily/monthly/annual variability at one location, the geographical distribution of mean quantities in a cascade of mean daily/monthly/annual fields.
o Directional analysis: the study of the directional distribution of a parameter at one location (rose), the circular probability analysis of the direction at one location, the geographic distribution of mean direction, the geographic distribution of roses.
o Extreme-value analysis: the study of extreme-value estimation for return periods (e.g., 50, 100 years) based on several methods (e.g., Annual Maxima, POT etc) at one location, the geographic distribution of extreme values, the geographic distribution of probabilities of an extreme events (e.g., P[wave height > 15m]), the directional distribution of extreme values.
o Correlation analysis: the study of the auto-/cross-correlation of one/two parameters at one location, the geographical distribution of (Pearson) correlation coefficient.
o Duration analysis: to study the probability of the duration of an event (e.g., the time that wave height value lies between 3m and 4m) at one location, the joint probability of duration and mean events at one location, the geographic distribution of probabilities of the duration of an event.
Task 4.2 – Wind resource assessment for offshore power plants [M12-M30]
Leader: SOLUTE - Contributing partners: BSC
This task assesses the development and feasibility phase of an offshore wind farm using wind resource assessment (WRA) tools. Led by SOLUTE and their expertise on WRA using their industry-standardized software Furow, a calculation engine and an optimization tool will be developed for WRA of offshore power plants.
Firstly, a calculation engine will be developed and tested using two alternative approaches: one that leverages public WRA datasets and one that uses the custom offshore-climate baselines generated in Task 4.1. For the first approach, the input information will consist of publicly available wind resource maps such as the Global Wind Atlas and the New European Wind Atlas. Whenever available, tariffs, land availability restrictions (due to policies, impact on tourism and fishing, environmental impact, and impact on maritime traffic and aviation), logistics, transmission and other aspects will be considered. On the other hand, custom offshore-climate baselines, as well as other data generated for the specific case studies such as losses due to wake and blockage effects, will allow us to calibrate the ability of the calculation engine, as public wind resource datasets are not specifically tailored for offshore power plant conditions nor they might not cover an area of interest as offshore power plants are moving further away from the coast. Nevertheless, the use of public datasets is still worthwhile as potential digital twin users might not have the computational nor technical resources to create their own custom climate baselines. In both cases, the calculation engine will be validated and further calibrated using the actual data collected from the case studies contemplated in this project.
Secondly, an optimization tool will be developed and calibrated taking into consideration the particular features of offshore power plants in terms of orography and weather conditions. This optimization tool will allow us to quantify wind resource parameters such as average annual energy production (AEP). This estimation will be based on both wind flow modelling and on-site wind measurements of the area of interest. Industry-standardized linear wind flow models will be used for the core spatial extrapolation and AEP computation, where losses from wake and blockage effects will be derived from WP4. Further parameters will be considered to optimize the offshore power plant such as the position of the first turbine, direction of the wind and the shape of the layout (both regular and irregular designs). The optimization of the array cable design (that is, the cables connecting the offshore power plant to either the shore or an offshore substation) will be defined as well. In addition, not only losses, but uncertainty will be estimated. There is inherent uncertainty in forecasting the long-term wind resource and the AEP over the lifetime of the power plant due to year-to-year variations in wind stemming from long-term cyclical phenomena such as El Niño and La Niña, Statistical modelling will be applied to extrapolate information from the measurement wind data to the lifetime of an offshore power plant.
Task 4.3 – Data-driven methodologies for short-term wind power forecasts [M06-M36]
Leader: FHG-IEE - Contributing partners: SOLUTE, UKS
This task will develop the forecasting modules for the DT to accurately simulate and predict the operation of offshore wind farms and their turbines in real time, providing the ability to interactively adjust operating conditions. Data-driven machine learning models will be used to build a highly accurate DT of wind farm assets, ensuring high performance and interactive operation of the digital representation.
The accuracy and depth of the models will be enhanced by pre-train them with data derived from detailed physical models (WP3). This approach will allow us to reproduce intricate effects that would normally require very complex simulations. Once in operation, these models exhibit rapid adaptation to the pretrained parameters, a feat achieved through the integration of transfer learning, online learning, and incremental learning techniques.

Another important aspect of this approach is the representation of the interaction of wind turbines due to wake effects. This is achieved by using graph neural networks to effectively couple the different prediction models of each turbine. Furthermore, wind turbine control will be modelled by incorporating additional features to ensure a realistic representation of their operation.

Models are trained and calibrated using the detailed, high-resolution models derived from WP3. It successfully emulates the characteristics of these high-resolution models while ensuring high performance and efficiency under operational conditions. The models will quickly adapt to the actual data and operating conditions of the physical counterpart.

To address the prediction uncertainties inherent in the models, we will use an ensemble prediction approach. This method provides a comprehensive and reliable forecast able to account for potential variability and ensures that the DT is a true-to-life representation of the wind farms.

Task 4.4 – Medium and long term weather and power production forecasting [M01-M36]

Leader: FHG-IEE - Contributing partners: +ATLANTIC, UKS

Historical data recorded within a wind farm can be used to derive monthly or seasonal statistics, from which weather and power production for the coming months and years can be predicted. In contrast to this, medium and long term weather forecasts are based on forecasts from few global producing centres that comply with WMO standards to that effect. These long-range predictions differ from short-term because they entail ensemble simulations of possible weather scenarios, i.e. they offer a probabilistic overview of long term conditions, from weeks to months in advance, by introducing small disturbances in the initial conditions of each ensemble model. In this DT, we will retrieve such hindcast time series of seasonal predictions, which are generated on a global scale and available from the Copernicus Climate Change Service, and match them with the output of the historical climate baselines to develop a data-driven approach for bias correction and downscaling. The aim is to train machine learning models that use the historical climate baselines as the response variable to adjust the extended range/seasonal forecast to the local-specific conditions. After validation, and provided that a good accuracy is achieved, the model may become operational providing monthly updates of local-specific parameters, from weeks to months in advance. As with the historical climate baselines, the wave, wind and current statistics are established for the specific case study sites. Combined with the AI-based wake model developed in task 3.2, the historical baseline as well as the medium- and long-term weather forecasts will then be used for power production forecasting for single wind turbines and the whole wind farm, and both approaches will be compared, focussing on aspects such as the dependance of the timing and the period of the forecasting. A blended model, combining and weighting the results of short-, medium- and long-term forecasting and including an uncertainty estimation will then be developed to achieve a gapless prediction of power production from hours to years.

The +ATLANTIC CoLAB will retrieve and collocate the available metocean data for a case study area, develop the exploratory data analysis on the existing extended range forecast errors and biases, and develop preliminary machine learning models for seasonal forecast accuracy improvement. FHG-IEE will conduct the power production prediction, analyze and compare the results and develop the blended model. UKS will contribute with uncertainty estimations.

Task 4.5 – Strategic maintenance planning and operational optimization [M12-M32]

Leader: WavEC - Contributing partners: EPRI

Task 4.5 will develop an advanced strategic maintenance planning model to be integrated in the offshore wind farm digital twin to provide an integrated and holistic view of the offshore wind farm’s maintenance in the long-term. This long-term model will be complemented with tools to optimize operation and maintenance actions during the wind farm operation. The approach involves the integration of reliability insights and resource availability trends, forecast potential failures and optimize maintenance schedules that minimize downtime and costs.

A sophisticated reliability model will be created, using industry-validated data to simulate the long-term performance of offshore wind farm components (turbines, moorings, cables, etc.). This modeling will provide insights into degradation rates, remaining useful life of components, and future failures, while accounting for operational and environmental factors. Utilizing the reliability model's outcomes alongside on-site weather observations and market conditions, strategic maintenance plans will be formulated. These plans will minimize overall operational costs, covering direct (e.g., vessel and fuel expenses) and indirect costs (stemming from production losses). These strategies will encompass optimized logistical solutions (vessels, ports, technicians, equipment) and efficient spare-part approaches to reduce procurement delays.

The model will support scenario planning by simulating various environmental (e.g., changing climate-induced wind and wave patterns), technical, and market scenarios (e.g., curtailment, price trends, procurement delays). Reliability insights on the umbilical cables derived from Task 3.3 will be integrated in the model. This will lead to the development of resilient maintenance strategies that ensure the wind farm's robustness and profitability across different possible futures. Additionally, operational data from existing wind farms can be incorporated into the model to update maintenance plans and compare performance against industry standards.

Regarding the model's structure, Task 4.5 will also design methodologies and models for optimizing short-term Operations and Maintenance (O&M) activities. This involves deploying forecasting tools that consider historical and, when available, real-time data from wind turbines, as well as utilizing high-resolution models for wind, wave, and

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weather forecasts. The primary aim is to enhance decision-making in O&M actions based on the actual behavior of the wind farm.
The task will draw on data from WP2 - Data Management, WP4 -Modelling of wake effects and wind turbines, WP5 - Energy Distribution and Demand of the End User, and WP7 - Technology Verification, Validation, and Industrial Assessment.

Work package WP5 – Energy distribution and demand of the end user

Work Package Number	WP5	Lead Beneficiary	3 - WAVEC
Work Package Name	Energy distribution and demand of the end user		
Start Month	1	End Month	36

Objectives
The objective of this WP5 is to integrate into the DT analyses on energy demand and price predictions of electricity for long-term and short-term horizons, energy distribution, and the role offshore wind storage solutions play in mitigating curtailment, for the chosen study cases (GE and PT).

Description
Task 5.1 - End user main requirements and overall prediction for long-term electricity prices and demand [M01-M16] Leader: EDP NEW - Contributing partners: WavEC This task will have a two-fold goal: from one hand it will screen the end user location needs (Portuguese, UK and German coasts) and, then, it will complement this analysis with a prediction of user demand and electricity price on long-term scenarios to steer development plans, considering, namely the type of demand, curtailment scenarios and hybridization possibilities. The end-user location needs will be screened for the Portuguese, UK and German coasts. The goal is to build a comprehensive and high-level map that lists the main location needs in terms of grid, supply chain, environmental and societal requirements. This map should create a high-level understanding for operators, promoters and EPC companies in these markets. The task and maps will be complemented with comprehensive long-term forecastings of energy demand in the above-mentioned countries, while also considering the type of demand (constant load, cyclic, Industrial/residential, etc). The main inputs of this task are: long series of past consumption data (monthly average); predictors for electricity price forecasting; predictors for user demand forecasting; EU, UK, PT and German energy roadmaps and offshore wind strategies; and the main output will be a list of end user location needs filtered complemented with long-term energy prices and demand forecasting. Task 5.2 - Prediction of short-term electricity prices and demand [M01-M18] Leader: SOLUTE - Contributing partners: FHG-IEE, WavEC, +ATLANTIC This task will leverage statistical modelling and machine learning based prediction algorithms to develop day-ahead user demand and electricity price forecasts. As a starting point, open-source tools (such as the epftoolbox , which includes electricity price forecasting baseline models) and open-source data from European markets and European TSOs will be used to develop tailored state-of-the-art prediction models. A benchmark using well-established best practices to evaluate models will be performed to establish strong conclusions on the ability of the developed models. The specific objectives of this task is the development and implementation of state-of-the-art algorithms for the prediction of day-ahead electricity prices and user demand, since the day-ahead electricity market is the main source of trading in Europe. Best practices will be applied to establish what methodologies work better, such as using at least one year of data to evaluate electricity price forecasting models to take into consideration all possible effects that occur over a year, as well as metrics with adequate statistical properties such as rMAE for electricity price forecasting. Task 5.3 - Modelling of interconnection to satisfy grid requirements and ancillary services [M01-M36] Leader: UKS - Contributing partners: FHG-IEE, WavEC, EDP NEW The main objective of task 5.3 is to prove the technical feasibility based on the general system setup on the respective forecasts in conjunction with end user/regional power demands. Therefore sub-goals are the modelling of the power system infrastructure in the different investigated regions , the development of respective time series for demand and provision and the derivation of system operation and ancillary service needs and realisations in order to be able to ensure a secure and efficient operation of the overall power system .

In this task, the electrical grid infrastructures and topologies will be modelled in order to serve as a realistic test and validation environment for analysis of ancillary service generated by DER with focus on offshore wind farms (or respective connection assets such as HVDC-systems) . Main aspects are grid modelling, optimization of system operation and coordination of ancillary services at interconnection points (ICP) with respect to requirements which must be fulfilled by DER or respective connection systems .
The developed grid modelling should be realised in an environment that allows simple replacements of model aspects (grid components, topology and/or connected consumers and generation units) by realistic grid data for later and further applications and purposes. Realistic simulation regime, generic/public/system operator provided grid data, time series data for generation and end users/regions will be the inputs to generate pandapower-based grid models for the study cases regions, time series of flexibilities and power flows, power system operation schemes , and report on requirements for the used and realised time series simulation.
Task 5.4 - Economic potential of storage solutions to meet demand fluctuations [M12-M30]
Leader: WavEC - Contributing partners: EDP NEW
In this task, the main objectives are twofold: i) long-term: evaluate the optimal installed capacity of different energy storage technologies (hydrogen, lithium-ion) for the entire lifetime of the offshore wind project, to minimize fluctuations on the electricity generation, harmonize yield with load demand, and maximize economic return of the project, ii) short-term: develop a short-term storage control model that aims to minimize future power fluctuations and curtailment based on forecast of energy yield, electricity price and demand.
By integrating energy storage systems, excess energy can be captured during periods of low demand and later released to meet electricity demand during peak hours, enhancing grid stability, reducing curtailment rates, and maximizing the economic potential of offshore wind energy, ensuring a more reliable and efficient renewable energy supply.
Task 5.4. focuses on conducting a comprehensive assessment of the economic potential of energy management strategies involving sustainable energy storage solutions such as green hydrogen and lithium-ion in combination with offshore wind energy taking into consideration future electricity demand, market price, mitigating potential curtailment scenarios. Relevant economic and financial metrics such as levelized cost of energy (LCOE), net present value (NPV) and internal rate of return (IRR) will be generated to evaluate different energy storage solutions. Moreover, for different offshore wind revenue schemes (e.g. CfD vs market-based), a given storage technology and capacity, a short-term energy storage control model will be developed to maximize the economic return of the offshore wind + storage project. The model will generate the optimal near-future charge/discharge cycles, considering the technical limitations of different storage technologies (e.g., ramp up curves of the electrolyzer, degradation of lithium-ion), forecasts of offshore wind yield, electricity market price and demand.
For the long-term assessment and short-term energy storage model, this task will leverage on the outputs from Task 5.1 and Task 5.2, respectively.

Work package WP6 – Digital Twin Development

Work Package Number	WP6	**Lead Beneficiary**	10 - OPEN CASCADE
Work Package Name	Digital Twin Development		
Start Month	1	**End Month**	30

Objectives

The goal of this WP is to implement the Digital Twin platform. The platform will be implemented as a classic web-based client-server application with client part running in a browser and backend part hosted in a cluster of containers. The business code hosted in the backend will be split into several modules, each dedicated to a specific business case. Each module will be developed separately in the frame of other WPs, and delivered as a container that will provide an API to communicate with the other modules.
First, the core component needed to build the backend will be developed, and component interactions will be defined. Then the backend will be implemented with the integration of the different modules. Finally, the frontend will be created by defining UIs for each module.

Description

Task 6.1 - Design of the Digital Twin core component [M01-M06]
Leader: Open Cascade - Contributing partners: Open Cascade,FHG-IEE, BSC, SOLUTE
The objective of this task is to design the core component of the Digital Twin platform. The core component’s purpose is

to act as a common information storage to facilitate communications between other system components and to provide a set of controllers for the generic user interfaces.
The general approach to information storage and inter component communications in the project is to make them decentralised. This means that each component is responsible for storing and providing an access to the set of data that lies within its boundaries of responsibility. Similarly, direct interactions between components are encouraged with the help of service mesh approach. At the same time, it is understood that certain information needs to be stored in the central location which is the digital twin core component, and certain information exchanges between system components also will be performed through the core of the system.
The digital twin core component will also be responsible for the management of the project entities. It will not be responsible for the user management because it will be performed externally by the application gateway and user identity management services.
The digital twin core component will store its data in the postgres database which will be colocated in its K8s pod.
Task 6.2 - Standardisation of component interaction [M06-M12]
Leader: Open Cascade - Contributing partners: Open Cascade, all partners developing a components
This task defines the way components communicate together. A peer-to-peer approach will be implemented so that each pair of services will be performed through direct REST requests. Each service will provide its API documentation ahead of time in the OpenAPI format standard. Any changes made later to this API documentation will be propagated to all other components.
Service mesh approach will be used to help resolve component naming and addressing issues inside the cluster and will allow every component to address any other component by its name which will be known beforehand.
It is understood that certain inter component communication will require long running operations. REST protocol may not be the best solution for such interactions and therefore a messaging system based on Apache Kafka will also be available inside the cluster. Each component that would want to provide services accessible through the message queue will be required to publish its MQ API and data types beforehand.
It is also understood that play loads of some requests will be too large to be efficiently exchanged over the REST protocol. Data exchange for such requests will be performed through the shared file system which every component will have access to.
For this task, Open Cascade will provide requirements and documentation on how to implement a component and communicate with other components. Then partners developing components will follow the requirements for the implementation of their components. Open Cascade will organize and lead a developers' club for partners to discuss together about their developments, share results and issues and find solutions in a collaborative manner.
Task 6.3 - Implementation of back end code of the Digital Twin core component [M07-M18]
Leader: Open Cascade - Contributing partners: Open Cascade
The core component of the Digital Twin will be implemented in the frame of this task, based on the specifications produced in the frame of task 6.1.
Back end of the digital twin core component will be written in Java programming language. Working prototype of the digital twin core component backend to be delivered as a result of this task.
Task 6.4 - Implementation of the Digital Twin core component front end [M13-M24]
Leader: Open Cascade - Contributing partners: Open Cascade
The objective of this task is to implement the Front End of the digital twin core component. It will provide the user interface for the generic features of the Digital Twin such as users management and project management.
The Front End will be written in Angular programming language.
The specifications of the front end core components will be written in a collaborative way with all partners to benefit from the different perspectives of final user profiles and provide the best possible user experience.
The result of this task will be the working prototype of the digital twin core component backend and frontend.
Task 6.5 - Implementation of Components front end [M19-M30]
Leader: Open Cascade - Contributing partners: Open Cascade, all partners developing a components
The user interfaces needed for the components developed in the frame of other work packages will be developed in the frame of this task. The goal of the implementation is to provide good visualisation of the data produced by each component and also provide a seamless user interface for all component's data and user inputs.
User interface for system components will be browser based and written in TypeScript programming language using Angular library.

Work package WP7 – Technology Verification, Validation, and Industrial Assessment

Work Package Number	WP7	**Lead Beneficiary**	11 - EDP NEW
Work Package Name	Technology Verification, Validation, and Industrial Assessment		

Start Month	1	End Month	36

Objectives

The objective of this WP is to validate the Digital Twin (DT) with real data from operating offshore wind farms (at least 1 bottom-fixed and 1 floating). The WP will start with a thorough specification of the use cases to steer both the developments and the later validation tasks, and provide clear metrics and guidelines for the evaluation of the Digital Twin results. The final task of the WP aims to provide a techno-economic analysis on the impact of the project's solutions from an end-user point of view.

Description

Task 7.1 - Case Studies Specification [M1-M6]
Leader: ENGIE Laborelec - Contributing partners: EDP NEW, BSC, IBERDROLA, Open Cascade, MET Centre
This task will specify the case studies to be used for the DT validation with end-users' real data.
EDP NEW, ENGIE Laborelec and IBERDROLA will assist the WP 3 to 6 in providing a utility perspective when describing the data needs for the different models, as well as in evaluating the possible impact of the fidelity of models and detail of the input data on the representativeness, robustness and scalability of the DT. This will result in a realistic overview of available data inputs and expected quality of the predicted power production.
The sites for which the DT will be validated will be specified and a comprehensive analysis of the site characteristics and available data will be done alongside the DT requirements. Where necessary, missing data will be gathered from open data sources that are representative for the selected sites and use cases (e.g. starting from an IEA wind turbine model). A set of KPIs will be associated with each use case study, to provide clear guidelines and metrics to evaluate the performance and robustness of the models and the overall DT.
Task 7.2 - Validation of forecasting of power production [M18-M36]
Leader: ENGIE Laborelec - Contributing partners: IBERDROLA, EDP NEW, SOLUTE, SINTEF, WavEC, EPRI, +ATLANTIC, Open Cascade, BSC, MET Centre
Task 7.2 will have two validation periods: the first one starting in M18 will focus on an intermediate validation of the DT. The outcomes of the validation will be provided to the technology developers and on M30-M36 a final validation will be undertaken with the final DT structure and developments.
• Subtask 7.2.1: Validation of the forecasted power production for a floating wind farm in offline mode. [M18-M36]; Subtask Leader: ENGIE Laborelec; Participants: EDP NEW, BSC, SINTEF, Open Cascade
The forecasting results of the DT are validated for a floating wind farm, employing historical data. An evaluation in realtime mode is difficult because the floater movement brings in an additional unknown that affects the power production. ENGIE Laborelec will evaluate the predicted power production with actual data, for selected wave and wind conditions. The effect of floater movement on structural health will not be evaluated into detail within the WinDTwin project, since this requires more detailed data inputs (e.g. SHM data) and modelling tools as the ones that are expected to be used for the DT.
• Subtask 7.2.2: Validation of the short-term power prediction in realtime mode. [M18-M36]; Subtask Leader: IBERDROLA; Participants: EDP NEW, BSC, SINTEF, Open Cascade
A validation in realtime mode is important to evaluate the DT on its applicability for an end user in a fleet monitoring perspective. The validation will be done on an IBERDROLA's fixed offshore wind farm use case.
This assessment will be made by validating different power forecasts approaches of the corresponding partners against measurements and compared against IBERDROLA industry state of the art prediction system for the wind farm:
○ Validation of the operational experiment for six months in real time configuration. An hourly update of the forecast is expected, whose horizon will be of three days with hourly steps.
○ Analysis of results from each individual wind farm and aggregated results considering different forecast horizons grouped by typical market considerations (short time, day ahead, etc).
ENGIE Laborelec and IBERDROLA will perform the analysis of produced power using the data made available for the wind farms of Ocean Winds and IBERDROLA, respectively, using state-of-the-art and proven power production assessment and/or forecast methods. This is proposed to avoid possible concerns on data confidentiality. The results of the validation of the forecasts made with the developed DT against existing methods will be shared with the project partners, not the data themselves.
Task 7.3 - Validation of energy distribution and demand [M18-M36]
Leader: EDP NEW - Contributing partners: SOLUTE, SINTEF, WavEC, EPRI, +ATLANTIC, Open Cascade
Task 7.3 will follow the same approach of T7.2, having two validation stages. An intermediate on starting in M18 and the final one starting on M30. The task itself will focus on the validation of the DT's short-term electricity prices and demand for the specific case of Portugal. Moreover, day-ahead electricity market prices forecasting will be validated for some Portuguese case studies (to be specified in T7.1) as well as the short-term energy storage control model to

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maximize the economic return of projects coupling offshore wind farms with large scale storage units. The validation of the latter will be done looking at a specific floating wind farm in Portugal, to better assess the techno-economic benefits of hybrid parks.
Task 7.4 - Techno-Economic impact analysis [M28-M36]
Leader: EDP NEW - Contributing partners: WavEC, MET Centre
A financial assessment using EDP NEW's proprietary TEM (techno economic model) tool for the calculation of the LCOE and other financial indicators such as NPV, IRR, ROI, payback time, etc. will be done to evaluate the Digital Twin performance and measure the potential financial benefits from the different modules (e.g. OPEX reduction estimation). The task will also leverage on the outcomes of tasks T.7.2 and T7.3 (where different modules of the digital twin will be tested), to introduce factors such as improved forecast accuracy (short-mid term), downtime reduction estimation, and others to compute the economic value of the Digital Twin, namely in terms of financial impact of wind power productions and reduced maintenance costs.

Work package WP8 – Stakeholder engagement, Communication, Dissemination and Exploitation

Work Package Number	WP8	**Lead Beneficiary**	3 - WAVEC
Work Package Name	Stakeholder engagement, Communication, Dissemination and Exploitation		
Start Month	1	**End Month**	36

Objectives

The objectives of this WP are grouped in three sections:
For stakeholder engagement, the specific objectives are: 1) promote collaboration across different sectors by coordinating various engagement activities; 2) improve the utilization of the developed Digital Twin by enabling and supporting the involvement, knowledge exchange, and skills development of all involved players (including stakeholders, scientists, policymakers, and citizens).
The objective of this WP regarding Communication and Dissemination is to optimize the influence of the project's outcomes by effectively sharing and communicating them with pertinent audiences. An effort will be made to obtain fast feed-back on intermediate results by the community and substantial emphasis will be placed on training activities toward the project's conclusion to ensure the effective utilization of the developed Digital Twin and related tools. The specific goals for Communication and Dissemination are: 1) set up and maintain the project website as a transparent source of information and dynamic publicity; 2) create an open-source dissemination framework for the developed tools, and develop and maintain a repository for the tools created during the project, to guarantee their widespread utilization within the community; 3) coordinate press releases, participation in selected conferences, and involvement in professional exhibitions; 4) generate effective synergies with the BRIDGE Initiative
Finally, the main objective for Exploitation is to create a comprehensive exploitation plan that incorporates efficient business strategies, ensuring the continued viability of the Digital Twin and associated tools after the end of the project and, additionally in coordination with WP1, guarantee the protection of intellectual property rights (IPR) related to both the project's incomes and outcomes.
WinDTwin project will contribute, upon invitation by the CINEA, to common information and dissemination activities to increase the visibility and synergies between Horizon Europe supported actions.

Description

Task 8.1 - Stakeholder engagement [M8-M36]
Leader: WavEC - Contributing partners: All
• Subtask 8.1.1: Stakeholder local workshops [M12-M36]; Subtask Leader: WavEC; Participants: All
This subtask consists in the implementation of two (M12 and M34) stakeholder local workshops held in the pilot countries (Portugal and Germany). These workshops will encourage interactions among scientists while fostering enduring collaborations with educational institutions such as universities, and partnerships among local stakeholders. Furthermore, these workshops will serve as a catalyst for local capacity advancement, encompassing various training initiatives aimed at diverse end-users. A final event presenting the main outputs of the project will be organized with most relevant stakeholders.
• Subtask 8.1.2: Regular training and workshops [M18-M36]; Subtask Leader: WavEC; Participants: All
Regular training (1 per year) and workshops will be organized to develop the necessary capabilities to use the developed

Digital Twin to future end-users after the duration of the project. The workshops will target technical, managerial, and business skills.

Task 8.2 - Implementation of dissemination and communication strategies [M1-M36]

Leader: WavEC - Contributing partners: All

• Subtask 8.2.1: Strategic Communication and Dissemination plan [M1-M2]; Subtask Leader: WavEC; Participants: All

A comprehensive Strategic Communication and Dissemination Communication Plan will be developed at the beginning of the project, incorporating a thorough assessment of key actors constituting the target audience. The plan will remain dynamic and undergo updates throughout the project to improve its effectiveness. Partners will use this plan as a roadmap for information dissemination and result exploitation. This document will identify appropriate scientific conferences, symposia, and committee meetings to enhance the Digital Twin visibility in the offshore wind community such as the European Turbulence Conference; Torque; Wind Energy Science Conference; Wake Conference; DLES; ETMM, ECCOMAS; EERA Deepwind Conference and many other. The most relevant outcomes and presence at pertinent events will be supported by press releases.

• Subtask 8.2.2: Design and development of project identity and website [M1-M36]; Subtask Leader: WavEC; Participants: All

This subtask will design a strong project identity and the project website. The project's visual elements, such as the logo, colour schemes, fonts, and promotional material will be designed collaboratively within the consortium and subsequently made accessible to all partners (M4). This subtask entails the complete process of designing, developing, launching with initial project content (M6), and maintaining and updating the WinDTwin project website (M3). Throughout the project's duration, the website will be regularly maintained and updated to reflect the evolving progress of the project. Public deliverables and transparent access to the tools and manuals developed for the DT will be made available through the website. Other offline and online marketing tools will be used to disseminate the project’s developments and outcomes. In order to maximize the dissemination activities of the project, project partners will enrol in specific Working Groups from the BRIDGE initiative, according to the needs and scope of WinDTwin. WinDTwin partners are also expected to participate (around 1-3 person-months per partner) in BRIDGE activities and events, which are regularly scheduled to promote cooperation between different European-funded projects.

• Subtask 8.2.3: WinDTwin tools access and manuals repository [M1-M36]; Subtask Leader: WavEC; Participants: BSC, Open Cascade

An open-source dissemination framework for the developed tools and a repository for the manual and related documents will be hosted or linked on the project’s website. Interactive self-tutorial manuals will be created to provide self-training on the developed tools.

Task 8.3 - DT Exploitation (technology transfer & business development) [M12-M36]

Leader: WavEC - Contributing partners: All

This task will develop strategies for the exploitation of the DT and its appeal to the end-users, market assessment and definition of the business models, with focus on using the latest EU guidance on maximising the impact of the research and development to ensure that the results are effectively used. A thorough strategy and business planning will be developed. It will involve all partners, aiming for sustainable global success in offshore wind. The exploitation and business plans will include business case strategies, market analysis, IP assessment, and framework agreements. The strategy will integrate project outcomes, identify markets, model business, and create coherent plans, considering value propositions, segmentation, pricing, and more. A roadmap to level up the Digital Twin to TRL9 and exploitation options will be created.

STAFF EFFORT

Staff effort per participant

Grant Preparation (Work packages - Effort screen) — Enter the info.

Participant	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	Total Person-Months
1 - BSC	30.00	4.00	30.00	2.00		12.00	12.00	6.00	96.00
2 - FHG-IEE			4.00	24.00	10.00	9.00		2.00	49.00
3 - WAVEC	3.00	2.00	16.00	14.00	22.00	3.00	3.00	23.00	86.00
4 - EPRI	2.00			12.00	8.00	1.00		2.00	25.00
5 - SOLUTE	3.00	3.00	6.00	54.00	18.00	12.00	4.00	5.00	105.00
6 - UKS			32.00	20.00	16.00			2.00	70.00
7 - IBERDROLA	2.00	2.00		1.00			8.00	2.00	15.00
8 - SINTEF	1.00		15.50	19.00			3.00	2.00	40.50
9 - +ATLANTIC	1.00			28.00	10.00			2.00	41.00
10 - OPEN CASCADE	1.00	10.50				56.50	2.00	2.00	72.00
11 - EDP NEW	2.00	6.00	3.00	5.00	17.00	6.00	22.00	4.00	65.00
12 - MET Centre	1.00						10.00	4.50	15.50
13 - ENGIE Laborelec	1.00		2.00	2.00			9.00	1.00	15.00
Total Person-Months	47.00	27.50	108.50	181.00	101.00	99.50	73.00	57.50	695.00

LIST OF DELIVERABLES

Deliverables

Grant Preparation (Deliverables screen) — Enter the info.

The labels used mean:

Public — fully open (⚠ automatically posted online)
Sensitive — limited under the conditions of the Grant Agreement
EU classified —RESTREINT-UE/EU-RESTRICTED, CONFIDENTIEL-UE/EU-CONFIDENTIAL, SECRET-UE/EU-SECRET under Decision 2015/444

Deliverable No	Deliverable Name	Work Package No	Lead Beneficiary	Type	Dissemination Level	Due Date (month)
D1.1	Project Management and Quality Guidelines	WP1	1 - BSC	R — Document, report	SEN - Sensitive	2
D1.2	Equality, Ethics and Inclusiveness management	WP1	1 - BSC	R — Document, report	PU - Public	36
D1.3	Project Management and Quality Guidelines mid-project update	WP1	1 - BSC	R — Document, report	SEN - Sensitive	20
D2.1	Data model specification	WP2	1 - BSC	R — Document, report	PU - Public	8
D2.2	Common data storage implementation	WP2	10 - OPEN CASCADE	OTHER	PU - Public	18
D2.3	Data Management Plan	WP2	1 - BSC	DMP — Data Management Plan	PU - Public	6
D3.1	Validation report on high-resolution and machine learning based models	WP3	1 - BSC	R — Document, report	PU - Public	24
D3.2	Detailed numerical models for benchmark studies	WP3	8 - SINTEF	R — Document, report	PU - Public	24
D3.3	Results of numerical benchmark studies	WP3	8 - SINTEF	R — Document, report	PU - Public	36
D4.1	Report on the description metocean climate (wind, wave, current)	WP4	8 - SINTEF	R — Document, report	PU - Public	16
D4.2	Optimization tool for offshore power plants	WP4	5 - SOLUTE	OTHER	SEN - Sensitive	30

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Deliverable No	Deliverable Name	Work Package No	Lead Beneficiary	Type	Dissemination Level	Due Date (month)
D4.3	Guidelines for developing data-driven methodologies for short-term wind power forecasting	WP4	2 - FHG-IEE	R — Document, report	PU - Public	36
D4.4	Guideline for optimizing O&M long-term planning and short-term scheduling for bottom fixed and floating wind farms	WP4	3 - WAVEC	R — Document, report	PU - Public	32
D5.1	Interactive map for end-user location and needs for the Portuguese, UK and German coasts	WP5	11 - EDP NEW	R — Document, report	SEN - Sensitive	16
D5.2	Assessment report on the modelling of short-term demand and electricity price forecasting models	WP5	5 - SOLUTE	R — Document, report	PU - Public	18
D5.3	Power system modelling	WP5	6 - UKS	R — Document, report	SEN - Sensitive	24
D5.4	Power system operation evaluation	WP5	6 - UKS	R — Document, report	PU - Public	34
D5.5	Quantification of the needs and economic impacts of different energy storage solutions in offshore wind projects	WP5	3 - WAVEC	R — Document, report	PU - Public	22
D5.6	Short-term energy storage control strategies for integration in offshore wind projects	WP5	3 - WAVEC	OTHER	PU - Public	28
D5.7	Short-term energy storage control model	WP5	3 - WAVEC	OTHER	SEN - Sensitive	32

Deliverables

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Deliverable No	Deliverable Name	Work Package No	Lead Beneficiary	Type	Dissemination Level	Due Date (month)
D6.1	Specification of Digital Twin Core Components	WP6	10 - OPEN CASCADE	R — Document, report	PU - Public	6
D6.2	Guidelines for component development for the Digital Twin platform	WP6	10 - OPEN CASCADE	R — Document, report	PU - Public	7
D6.3	Definition of components API	WP6	10 - OPEN CASCADE	OTHER	SEN - Sensitive	12
D6.4	First version of Digital Twin Back End core components	WP6	10 - OPEN CASCADE	OTHER	SEN - Sensitive	18
D6.5	First version of Digital Twin Front End core components	WP6	10 - OPEN CASCADE	OTHER	SEN - Sensitive	24
D6.6	First version of integration of business components in the Digital Twin	WP6	10 - OPEN CASCADE	OTHER	SEN - Sensitive	30
D6.7	Compilation of Digital Twin open source component repositories	WP6	10 - OPEN CASCADE	OTHER	PU - Public	30
D7.1	Case Studies Specification	WP7	13 - ENGIE Laborelec	R — Document, report	SEN - Sensitive	9
D7.2	Report on the validation tasks	WP7	11 - EDP NEW	R — Document, report	SEN - Sensitive	36
D7.3	Techno-economic analysis of the Digital Twin performance and measurement of the potential financial benefits from the different modules	WP7	11 - EDP NEW	R — Document, report	SEN - Sensitive	36
D8.1	Communication Plan	WP8	3 - WAVEC	R — Document, report	PU - Public	2

Deliverables

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Deliverable No	Deliverable Name	Work Package No	Lead Beneficiary	Type	Dissemination Level	Due Date (month)
D8.2	Website	WP8	3 - WAVEC	OTHER	PU - Public	3
D8.3	WinDTwin brand identity	WP8	3 - WAVEC	OTHER	SEN - Sensitive	3
D8.4	Project tools repository	WP8	3 - WAVEC	OTHER	SEN - Sensitive	12
D8.5	1st Annual communication and dissemination report	WP8	3 - WAVEC	R — Document, report	PU - Public	12
D8.6	2nd Annual communication and dissemination report	WP8	3 - WAVEC	R — Document, report	PU - Public	24
D8.7	Final communication and dissemination report	WP8	3 - WAVEC	R — Document, report	PU - Public	36
D8.8	WinDTwin exploitation and business plan	WP8	3 - WAVEC	R — Document, report	PU - Public	34
D8.9	Final project tools repository	WP8	3 - WAVEC	R — Document, report	SEN - Sensitive	36
D8.10	Final event of the project with stakeholders	WP8	3 - WAVEC	R — Document, report	PU - Public	36
D8.11	Stakeholder engagement report	WP8	3 - WAVEC	R — Document, report	PU - Public	36
D8.12	Report on training activities and workshops	WP8	3 - WAVEC	R — Document, report	PU - Public	36
D8.13	Roadmap for achieving TRL9	WP8	3 - WAVEC	R — Document, report	PU - Public	36

Deliverable D1.1 – Project Management and Quality Guidelines

Deliverable Number	D1.1	**Lead Beneficiary**	1 - BSC
Deliverable Name	Project Management and Quality Guidelines		
Type	R — Document, report	**Dissemination Level**	SEN - Sensitive
Due Date (month)	2	**Work Package No**	WP1

Description
Linked to T1.1 and T1.2. Handbook describing the project's internal management procedures, detailing the project's Quality assurance process as well as a detailed Risk evaluation and internal communication tools and mechanisms

Deliverable D1.2 – Equality, Ethics and Inclusiveness management

Deliverable Number	D1.2	**Lead Beneficiary**	1 - BSC
Deliverable Name	Equality, Ethics and Inclusiveness management		
Type	R — Document, report	**Dissemination Level**	PU - Public
Due Date (month)	36	**Work Package No**	WP1

Description
Linked to T1.3. A comprehensive report detailing the policy and procedure audit findings. Ethical behaviour promotion strategies. Diversity and inclusion improvement recommendations.Monitoring and reporting mechanisms.

Deliverable D1.3 – Project Management and Quality Guidelines mid-project update

Deliverable Number	D1.3	**Lead Beneficiary**	1 - BSC
Deliverable Name	Project Management and Quality Guidelines mid-project update		
Type	R — Document, report	**Dissemination Level**	SEN - Sensitive
Due Date (month)	20	**Work Package No**	WP1

Description
Linked to T1.1 and T1.2. Updated version of D1.1 in sight of the foreseen monitoring at WinDTwin's midpoint.

Deliverable D2.1 – Data model specification

Deliverable Number	D2.1	**Lead Beneficiary**	1 - BSC
Deliverable Name	Data model specification		
Type	R — Document, report	**Dissemination Level**	PU - Public
Due Date (month)	8	**Work Package No**	WP2

Description
Linked to T2.1. Report that will describe all the necessary data workflow needed by the project.

Associated with document Ref. Ares(2024)2593643 - 09/04/2024

Deliverable D2.2 – Common data storage implementation

Deliverable Number	D2.2	**Lead Beneficiary**	10 - OPEN CASCADE
Deliverable Name	Common data storage implementation		
Type	OTHER	**Dissemination Level**	PU - Public
Due Date (month)	18	**Work Package No**	WP2

Description
Linked to T2.2. Implementation the needed common data storage for all the types of data identified.

Deliverable D2.3 – Data Management Plan

Deliverable Number	D2.3	**Lead Beneficiary**	1 - BSC
Deliverable Name	Data Management Plan		
Type	DMP — Data Management Plan	**Dissemination Level**	PU - Public
Due Date (month)	6	**Work Package No**	WP2

Description
Linked to T2.1. This is a document outlining how the research data collected or generated will be handled

Deliverable D3.1 – Validation report on high-resolution and machine learning based models

Deliverable Number	D3.1	**Lead Beneficiary**	1 - BSC
Deliverable Name	Validation report on high-resolution and machine learning based models		
Type	R — Document, report	**Dissemination Level**	PU - Public
Due Date (month)	24	**Work Package No**	WP3

Description
Linked to T3.1 and T3.2. A comprehensive validation report to provide a description of the modelling methodologies applied and showcase the validation of the high-resolution and machine learning models developed in tasks 3.1 and 3.2.

Deliverable D3.2 – Detailed numerical models for benchmark studies

Deliverable Number	D3.2	**Lead Beneficiary**	8 - SINTEF
Deliverable Name	Detailed numerical models for benchmark studies		
Type	R — Document, report	**Dissemination Level**	PU - Public
Due Date (month)	24	**Work Package No**	WP3

Description
Linked to T3.3. Detailed numerical models of (floating) wind turbines, and a report documenting the development of these models, for use in benchmark studies.

Deliverable D3.3 – Results of numerical benchmark studies

Deliverable Number	D3.3	Lead Beneficiary	8 - SINTEF
Deliverable Name	Results of numerical benchmark studies		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	36	Work Package No	WP3

Description
Linked to T3.1, T3.2 and T3.3. Report on the performance of the detailed numerical models when applied to benchmark study cases.

Deliverable D4.1 – Report on the description metocean climate (wind, wave, current)

Deliverable Number	D4.1	Lead Beneficiary	8 - SINTEF
Deliverable Name	Report on the description metocean climate (wind, wave, current)		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	16	Work Package No	WP4

Description
Linked to T4.1. A comprehensive report containing results of statistical analysis of historical data. The data will be derived by regional models with boundary conditions from global models. Statistical analysis techniques include both classical and enhanced methods for the analysis of Big type Data.

Deliverable D4.2 – Optimization tool for offshore power plants

Deliverable Number	D4.2	Lead Beneficiary	5 - SOLUTE
Deliverable Name	Optimization tool for offshore power plants		
Type	OTHER	Dissemination Level	SEN - Sensitive
Due Date (month)	30	Work Package No	WP4

Description
Linked to T4.2. This deliverable provides an alpha version of the optimization tool for offshore power plants into the code repository

Deliverable D4.3 – Guidelines for developing data-driven methodologies for short-term wind power forecasting

Deliverable Number	D4.3	Lead Beneficiary	2 - FHG-IEE
Deliverable Name	Guidelines for developing data-driven methodologies for short-term wind power forecasting		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	36	Work Package No	WP4

Description
Linked to T4.3. This report aims to describe the data-driven methodologies developed in task 4.3. The report will identify the strengths of such methodologies and their impact on the operation of offshore power plants.

Deliverable D4.4 – Guideline for optimizing O&M long-term planning and short-term scheduling for bottom fixed and floating wind farms

Deliverable Number	D4.4	**Lead Beneficiary**	3 - WAVEC
Deliverable Name	Guideline for optimizing O&M long-term planning and short-term scheduling for bottom fixed and floating wind farms		
Type	R — Document, report	**Dissemination Level**	PU - Public
Due Date (month)	32	**Work Package No**	WP4

Description
Linked to T4.2, T4.3, T4.4 and T4.5. The guideline aims to incorporate the impact of ambient conditions (i.e. wind, weather, waves), logistics costs and time for vessel operation, market conditions, and wind turbine information both long term and real time.

Deliverable D5.1 – Interactive map for end-user location and needs for the Portuguese, UK and German coasts

Deliverable Number	D5.1	**Lead Beneficiary**	11 - EDP NEW
Deliverable Name	Interactive map for end-user location and needs for the Portuguese, UK and German coasts		
Type	R — Document, report	**Dissemination Level**	SEN - Sensitive
Due Date (month)	16	**Work Package No**	WP5

Description
Linked to T5.1. A comprehensive and high-level map that lists the main location needs in terms of grid, supply chain, environmental and societal requirements.

Deliverable D5.2 – Assessment report on the modelling of short-term demand and electricity price forecasting models

Deliverable Number	D5.2	**Lead Beneficiary**	5 - SOLUTE
Deliverable Name	Assessment report on the modelling of short-term demand and electricity price forecasting models		
Type	R — Document, report	**Dissemination Level**	PU - Public
Due Date (month)	18	**Work Package No**	WP5

Description
Linked to T5.2. The characteristics of the modelling methodologies developed in this task will vary depending on factors such as the electricity market. This report will identify these factors and provide guidelines to adapt the methodologies to any other area of interest.

Deliverable D5.3 – Power system modelling

Deliverable Number	D5.3	Lead Beneficiary	6 - UKS
Deliverable Name	Power system modelling		
Type	R — Document, report	Dissemination Level	SEN - Sensitive
Due Date (month)	24	Work Package No	WP5

Description
Linked to T5.3. Grid models for the investigated regions in the pandapower-format as well as respective documentation can be provided

Deliverable D5.4 – Power system operation evaluation

Deliverable Number	D5.4	Lead Beneficiary	6 - UKS
Deliverable Name	Power system operation evaluation		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	34	Work Package No	WP5

Description
Linked to T5.3. Report and scientific publication on the realised power system operation and it's evaluation based on the generation and demand patterns. Description of ancillary services provided by DER or their connections systems as well as the overall system operational approaches in terms of congestion management and system services.

Deliverable D5.5 – Quantification of the needs and economic impacts of different energy storage solutions in offshore wind projects

Deliverable Number	D5.5	Lead Beneficiary	3 - WAVEC
Deliverable Name	Quantification of the needs and economic impacts of different energy storage solutions in offshore wind projects		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	22	Work Package No	WP5

Description
Linked to T5.4. This deliverable will report the economic assessment of different energy storage solutions (in respect to technologies and sizings) for a given offshore wind project, considering different long-term market price and demand forecasts

Deliverable D5.6 – Short-term energy storage control strategies for integration in offshore wind projects

Deliverable Number	D5.6	Lead Beneficiary	3 - WAVEC
Deliverable Name	Short-term energy storage control strategies for integration in offshore wind projects		
Type	OTHER	Dissemination Level	PU - Public

Due Date (month)	28	Work Package No	WP5

Description
Linked to T5.4. This deliverable provides a comprehensive description of the short-term energy storage control model, detailing the results for different case studies.

Deliverable D5.7 – Short-term energy storage control model

Deliverable Number	D5.7	Lead Beneficiary	3 - WAVEC
Deliverable Name	Short-term energy storage control model		
Type	OTHER	Dissemination Level	SEN - Sensitive
Due Date (month)	32	Work Package No	WP5

Description
Linked to T5.4. Release of alpha version of the short-term energy storage control algorithms into code repository

Deliverable D6.1 – Specification of Digital Twin Core Components

Deliverable Number	D6.1	Lead Beneficiary	10 - OPEN CASCADE
Deliverable Name	Specification of Digital Twin Core Components		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	6	Work Package No	WP6

Description
Linked to T6.1. The deliverable will consist of comprehensive documentation describing the specifications of the Digital Twin platform and the main components. It will detail the main use cases when using the platform: connection, creation of a study, preparation, execution, visualization of results. This concerns the platform itself and the main components. This document will also describe the technical requirements for the deployment of the platform and the components.

Deliverable D6.2 – Guidelines for component development for the Digital Twin platform

Deliverable Number	D6.2	Lead Beneficiary	10 - OPEN CASCADE
Deliverable Name	Guidelines for component development for the Digital Twin platform		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	7	Work Package No	WP6

Description
Linked to T6.1. The deliverable will consist of comprehensive documentation describing the requirements for the development of components that make the system (its structure, interfaces to be implemented, accessing the general data storage, etc.) and the approach to communicating with other components (send and fetch the data, setup the parameters, trigger algorithm execution, etc.)

Deliverable D6.3 – Definition of components API

Deliverable Number	D6.3	Lead Beneficiary	10 - OPEN CASCADE
Deliverable Name	Definition of components API		
Type	OTHER	Dissemination Level	SEN - Sensitive
Due Date (month)	12	Work Package No	WP6

Description
Linked to T6.2. Working prototype of a Kubernetes cluster with service mesh, message queue and a shared file system.

Deliverable D6.4 – First version of Digital Twin Back End core components

Deliverable Number	D6.4	Lead Beneficiary	10 - OPEN CASCADE
Deliverable Name	First version of Digital Twin Back End core components		
Type	OTHER	Dissemination Level	SEN - Sensitive
Due Date (month)	18	Work Package No	WP6

Description
Linked to T6.3. Working prototype of the digital twin core component backend into code repository

Deliverable D6.5 – First version of Digital Twin Front End core components

Deliverable Number	D6.5	Lead Beneficiary	10 - OPEN CASCADE
Deliverable Name	First version of Digital Twin Front End core components		
Type	OTHER	Dissemination Level	SEN - Sensitive
Due Date (month)	24	Work Package No	WP6

Description
Linked to T6.4. Working prototype of the digital twin core component front end into code repository

Deliverable D6.6 – First version of integration of business components in the Digital Twin

Deliverable Number	D6.6	Lead Beneficiary	10 - OPEN CASCADE
Deliverable Name	First version of integration of business components in the Digital Twin		
Type	OTHER	Dissemination Level	SEN - Sensitive
Due Date (month)	30	Work Package No	WP6

Description
Linked to T6.5. Working prototype of the front end of the system components into code repository

Associated with document Ref. Ares(2024)2593643 - 09/04/2024

Deliverable D6.7 – Compilation of Digital Twin open source component repositories

Deliverable Number	D6.7	**Lead Beneficiary**	10 - OPEN CASCADE
Deliverable Name	Compilation of Digital Twin open source component repositories		
Type	OTHER	**Dissemination Level**	PU - Public
Due Date (month)	30	**Work Package No**	WP6

Description
Linked to T6.2, T6.3, T6.4 and T6.5. Aggregated open source components of the Digital Twin, including non-sensitive code from the Kubernetes cluster, core back end, core front end and front end of the system (i.e., non-sensitive components included in D6.3, D6.4, D6.5 and D6.6)

Deliverable D7.1 – Case Studies Specification

Deliverable Number	D7.1	**Lead Beneficiary**	13 - ENGIE Laborelec
Deliverable Name	Case Studies Specification		
Type	R — Document, report	**Dissemination Level**	SEN - Sensitive
Due Date (month)	9	**Work Package No**	WP7

Description
Linked to T7.1. Report describing the case studies that will be used for the validation of the DT

Deliverable D7.2 – Report on the validation tasks

Deliverable Number	D7.2	**Lead Beneficiary**	11 - EDP NEW
Deliverable Name	Report on the validation tasks		
Type	R — Document, report	**Dissemination Level**	SEN - Sensitive
Due Date (month)	36	**Work Package No**	WP7

Description
Linked to T7.2 and T7.3. The report will present the main outcomes of the validation tasks, reflecting the performance of the DT

Deliverable D7.3 – Techno-economic analysis of the Digital Twin performance and measurement of the potential financial benefits from the different modules

Deliverable Number	D7.3	**Lead Beneficiary**	11 - EDP NEW
Deliverable Name	Techno-economic analysis of the Digital Twin performance and measurement of the potential financial benefits from the different modules		
Type	R — Document, report	**Dissemination Level**	SEN - Sensitive
Due Date (month)	36	**Work Package No**	WP7

Description

Linked to T7.1. The deliverable will report the results of the techno-economic assessment of the Digital Twin's performance for the difference case studies specified in T7.1. The goal is to measure the potential technical and financial benefits from the different modules.

Deliverable D8.1 – Communication Plan

Deliverable Number	D8.1	**Lead Beneficiary**	3 - WAVEC
Deliverable Name	Communication Plan		
Type	R — Document, report	**Dissemination Level**	PU - Public
Due Date (month)	2	**Work Package No**	WP8

Description
Linked to T8.2. A comprehensive Strategic Communication Plan will be created at the beginning of the project, with a detailed analysis of the target audience. It will be regularly updated for enhanced effectiveness and serve as a guide for partners in disseminating information and leveraging results.

Deliverable D8.2 – Website

Deliverable Number	D8.2	**Lead Beneficiary**	3 - WAVEC
Deliverable Name	Website		
Type	OTHER	**Dissemination Level**	PU - Public
Due Date (month)	3	**Work Package No**	WP8

Description
Linked to T8.2. A dedicated project website will be created and regularly maintained to reflect the evolving progress of the project.

Deliverable D8.3 – WinDTwin brand identity

Deliverable Number	D8.3	**Lead Beneficiary**	3 - WAVEC
Deliverable Name	WinDTwin brand identity		
Type	OTHER	**Dissemination Level**	SEN - Sensitive
Due Date (month)	3	**Work Package No**	WP8

Description
Linked to T8.2. The project's visual elements, such as the logo, colour schemes, fonts, and promotional material will be designed collaboratively within the consortium and subsequently made accessible to all partners

Deliverable D8.4 – Project tools repository

Deliverable Number	D8.4	**Lead Beneficiary**	3 - WAVEC
Deliverable Name	Project tools repository		
Type	OTHER	**Dissemination Level**	SEN - Sensitive

Due Date (month)	12	Work Package No	WP8

Description
Linked to T8.2. An open-source dissemination framework for the developed tools and a repository for the manual and related documents will be hosted or linked on the project's website.

Deliverable D8.5 – 1st Annual communication and dissemination report

Deliverable Number	D8.5	Lead Beneficiary	3 - WAVEC
Deliverable Name	1st Annual communication and dissemination report		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	12	Work Package No	WP8

Description
Linked to T8.2. A report with updates of the communication and dissemination activities during the first year of the project.

Deliverable D8.6 – 2nd Annual communication and dissemination report

Deliverable Number	D8.6	Lead Beneficiary	3 - WAVEC
Deliverable Name	2nd Annual communication and dissemination report		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	24	Work Package No	WP8

Description
Linked to T8.2. A report with updates of the communication and dissemination activities during the second year of the project.

Deliverable D8.7 – Final communication and dissemination report

Deliverable Number	D8.7	Lead Beneficiary	3 - WAVEC
Deliverable Name	Final communication and dissemination report		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	36	Work Package No	WP8

Description
Linked to T8.2. The final communication and dissemination report will contain updates on the communication and dissemination activities conducted throughout the project's duration

Deliverable D8.8 – WinDTwin exploitation and business plan

Deliverable Number	D8.8	Lead Beneficiary	3 - WAVEC

Deliverable Name	WinDTwin exploitation and business plan		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	34	Work Package No	WP8

Description
Linked to T8.3. The Consortium will develop strategies for the exploitation of the Digital Twin and its appeal to the end-users, market assessment and definition of the business models, with focus on using the latest EU guidance on maximising the impact of the research and development to ensure that the results are effectively used.

Deliverable D8.9 – Final project tools repository

Deliverable Number	D8.9	Lead Beneficiary	3 - WAVEC
Deliverable Name	Final project tools repository		
Type	R — Document, report	Dissemination Level	SEN - Sensitive
Due Date (month)	36	Work Package No	WP8

Description
Linked to T8.2. The final open-source dissemination framework for the developed tools and a repository for the manual and related documents will be hosted or linked on the project's website.

Deliverable D8.10 – Final event of the project with stakeholders

Deliverable Number	D8.10	Lead Beneficiary	3 - WAVEC
Deliverable Name	Final event of the project with stakeholders		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	36	Work Package No	WP8

Description
Linked to T8.1. A final event presenting the main outputs of the project will be organized with most relevant stakeholders.

Deliverable D8.11 – Stakeholder engagement report

Deliverable Number	D8.11	Lead Beneficiary	3 - WAVEC
Deliverable Name	Stakeholder engagement report		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	36	Work Package No	WP8

Description
Linked to T8.1. Two stakeholder local workshops will be implemented in the pilot countries (Portugal and Germany). These workshops will encourage interactions among scientists while fostering enduring collaborations with educational institutions such as universities, and partnerships among local stakeholders.

Deliverable D8.12 – Report on training activities and workshops

Deliverable Number	D8.12	Lead Beneficiary	3 - WAVEC
Deliverable Name	Report on training activities and workshops		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	36	Work Package No	WP8

Description
Linked to T8.1. A report with the regular trainings and workshops that will be organized to develop the necessary capabilities to use the developed Digital Twin to future end-users after the duration of the project.

Deliverable D8.13 – Roadmap for achieving TRL9

Deliverable Number	D8.13	Lead Beneficiary	3 - WAVEC
Deliverable Name	Roadmap for achieving TRL9		
Type	R — Document, report	Dissemination Level	PU - Public
Due Date (month)	36	Work Package No	WP8

Description
Linked to T8.3. A roadmap to level up the Digital Twin to TRL9 and exploitation options will be created.

Associated with document Ref. Ares(2024)2593643 - 09/04/2024

LIST OF MILESTONES

Milestones

Grant Preparation (Milestones screen) — Enter the info.

Milestone No	Milestone Name	Work Package No	Lead Beneficiary	Means of Verification	Due Date (month)
1	Kick-off meeting	WP1	1 - BSC	Web news	1
2	Progress and Final Meetings	WP1	1 - BSC	Web news	36
3	Data workflow specification completed	WP2	1 - BSC	Submission of Deliverable 2.1	8
4	High-fidelity and machine-learning based spatial weather and wake modelling developed and data sets finished	WP3	1 - BSC	Submission of Deliverable 3.1	24
5	Detailed wind turbine physical models available	WP3	8 - SINTEF	Submission of Deliverable 3.2	24
6	Statistical analysis of climate historical data finished.	WP4	8 - SINTEF	Submission of Deliverable 4.1	16
7	Optimization tool for offshore power plants completed	WP4	5 - SOLUTE	Submission of Deliverable 4.2	30
8	Interactive map for end-user location and needs for the Portuguese, UK and German coasts defined.	WP5	11 - EDP NEW	Submission of Deliverable 5.1	16
9	Power system models developed	WP5	6 - UKS	Submission of Deliverable 5.3	24
10	Short term energy storage model completed	WP5	3 - WAVEC	Submission of Deliverable 5.7	32
11	Specifications of the Digital Twin main components	WP6	10 - OPEN CASCADE	Submission of Deliverable 6.1	6
12	First version of the Digital Twin available	WP6	10 - OPEN CASCADE	Submission of Deliverable 6.4	18
13	Validation studies defined	WP7	13 - ENGIE Laborelec	Submission of Deliverable 7.1	9
14	Setting up the website	WP8	3 - WAVEC	Deliverable 8.2	3

Milestones

Grant Preparation (Milestones screen) — Enter the info.

Milestone No	Milestone Name	Work Package No	Lead Beneficiary	Means of Verification	Due Date (month)
15	International Stakeholder form	WP8	3 - WAVEC	Events taking place. Deliverable 8.6	12

LIST OF CRITICAL RISKS

Critical risks & risk management strategy

Grant Preparation (Critical Risks screen) — Enter the info.

Risk number	Description	Work Package No(s)	Proposed Mitigation Measures
1	High interdependence between tasks, this can lead to delays in the completion of WPs. (Medium/low)	WP2, WP1, WP5, WP8	Working groups among related tasks will be created to establish synergies. Clear communication will be established by Open Cascade to ensure the integration of all tools into the DT.
2	Low commitment of partners to the project plan and completion of deadlines (Low/low)	WP1	All partners are experienced in European-funded R&D projects. WP leaders will directly assess partners' lack of commitment. If unsuccessful, the PM will reallocate tasks and resources.
3	Lack of computational resources (Low/medium)	WP3, WP4	Additional computational resources will be obtained in calls of HPC centers (i.e., PRACE, RES, EuroHPC).
4	Part of the validation data is confidential (Low/low)	WP3, WP4, WP5, WP7	A non-disclosure agreement and Consortium Agreement dealing with management of IPR will be signed.
5	Disputes over the ownership of IPR among partners (Medium/medium)	WP1, WP7, WP8	IPR and access right clauses will be integrated in the consortium agreement. The documents will be signed before the start of the project.
6	Administrative risks: WP delay > 3 months, variations in budget of > 20%, delay outcome > 3 months, etc.	WP1	Specific measures will be defined by the GA under the supervision of the Commission: redistribution of budget, incorporation of new partners, etc.

PROJECT REVIEWS

Project Reviews

Grant Preparation (Reviews screen) — Enter the info.

Review No	**Timing** (month)	**Location**	**Comments**
RV1	21	TBC	
RV2	36	TBC	

WinDTwin

WindDTwin: Towards a digital twin for forecasting of power production to wind energy demand

History of changes

Version	Author	Page	Changes
1.0	David Montaña		Description and lists of work packages, deliverables, efforts, milestones and risks have been removed of Part B: tables 3.1a, 3.1b, 3.1c, 3.1e from section 3.1. The section 4 'ethics self-assessment' has been included.
1.1	Oriol Lehmkuhl	p. 9	Explanation of the role of EPRI in leveraging the inputs from WinNER.
		p. 11	Re-writing of the part of the methodology relative to Technology Verification, Validation, and Industrial Assessment (WP7) for the sake of clarity.
		p. 13	Addition of digital twins in Destination Earth, as target for potential synergic action.
		p. 22	Addition of EPRI's part on the exploitation strategy.
		p. 29	Inclusion of WinDTwin's gantt.
1.2	Albert Guerero	N/A	Standardised naming of partners.
1.3	Albert Guerrero	N/A	Acronyms modifications: • EEU to EPRI • IRE to IBERDROLA • SO / SO OCEAN to SINTEF • +ATL to +ATLANTIC
		p. 25	Corrected text referring to WP tables, effort tables, and deliverables and milestones.
		p. 25 and p. 29	Gantt chart moved from section 3.2 (p. 29) to section 3.1 (p. 25)
		p. 29	Description of MET Centre in section 3.2
1.4	Albert Guerrero	p. 20	MET Centre's contribution to the dissemination strategy of WinDTwin has been added.
		p. 22	MET Centre's contribution to the exploitation strategy of WinDTwin has been added.

Table of contents

1. Excellence

1.1 Objectives and ambition

1.1.1 Objectives

Context:
According to the Paris Agreement adopted in December 2015 (UNFCC, 2015), the global energy demand is expected to experience a large growth over the 28 years from 2012 to 2040. However, energy scarcity or inefficient usage can lead to higher prices, which will have a critical impact on the economy, as emphasized by the Energy Challenge in the Horizon Europe work program. In particular, during the COVID-19 pandemic, many industry sectors were negatively affected. Overall, the global energy demand fell by 5% in 2020. This was also the case of fossil fuels, which were less used and whose financing fell 9% the same year. However, at the same time, the pandemic accelerated renewable energy usage. For instance, in the US the consumption of this energy increased by 40% in the first ten weeks of lockdown. Therefore, even though it is clear that the production of renewable energy requires a large infrastructure investment and it is difficult to have it in times of crisis, COVID-19 can probably reinforce the integration of renewable energy sources. This situation strengthens the need to have stable sources and increase efficiency to face negative pandemic effects.
On one hand, the **commercial development of wind energy** in the last decades has been driven by continuous incremental improvements in all aspects of design, production, installation, and exploitation of wind turbines, leading to current-day turbines of up to **8 MW** and **220 m height**. The **industry expects** turbines of **20 MW** and **365 m height by 2030.** The increase in size and height of modern wind turbines has challenged our current design and operational tools because the **wind conditions change dramatically from 50-100 to 100-400 meters above the ground.** The multiscale nature of wind variations, and their interaction with the environment, are a challenge for current state of art design and operational tools. This **challenge has significant implications for the design and construction of wind turbines** as well as the operation, maintenance, and power production during the lifetime of these machines. Addressing this critical knowledge gap is consequently a vital contribution to continue the reduction

of wind energy costs that we have seen over the last decades. Hence, it could **enable** the EU to deliver on its **renewable energy target of at least 27% of energy consumption** and a commitment to continue reducing greenhouse gas emissions, setting a reduction target of **40% by 2030 relative to 1990 levels**.

On the other hand, **digital twins for wind farm design** are an emerging and evolving field in the renewable energy industry. Digital twins are **virtual representations of physical assets, processes, or systems that enable real-time monitoring, analysis, and simulation**. In the context of wind farm optimization, digital twins can play a **crucial role** in **optimizing performance, reducing downtime, and enhancing overall operational efficiency**. The use of digital twins for wind farms (specially in an open-source framework), can help to improve some of the gaps previously mentioned. In particular, the following aspects could be improved thanks to introducing digital twins into the wind farm design and operation community:

- **Integrated Design and Simulation:** Digital twins allow for the integration of various aspects of wind farm design, such as turbine layout, terrain analysis, wind resource assessment, and turbine performance simulation. This integration can lead to better-informed decisions during the design phase.
- **Real-Time Monitoring and Control:** Digital twins enable continuous real-time monitoring of wind farm components, including individual turbines and overall farm performance. This monitoring facilitates the early detection of anomalies or potential issues, leading to improved maintenance planning and reduced downtime.
- **Data-Driven Insights:** By combining sensor data, historical information, and advanced analytics, digital twins can provide valuable insights into wind farm behavior. These insights can aid in predicting maintenance needs, optimizing energy output, and enhancing overall system reliability.
- **Advanced Analytics and AI:** Artificial intelligence (AI) and machine learning (ML) techniques can be applied to digital twin data to develop predictive maintenance models, optimize turbine performance, and enhance energy production efficiency.
- **Collaborative Design and Decision-Making:** Digital twins facilitate collaboration among various stakeholders, such as engineers, designers, operators, and investors. This collaborative environment can lead to more informed and holistic decision-making throughout the wind farm's lifecycle.
- **Lifecycle Management:** Digital twins are not limited to the design phase; they extend throughout the entire lifecycle of the wind farm, from construction and operation to decommissioning. This ensures that the digital twin remains a valuable tool for decision-making at every stage.
- **Remote Operation and Control:** Digital twins can enable remote monitoring and control of wind farms, reducing the need for on-site visits and enhancing operational efficiency, especially in offshore wind farms.
- **Risk Assessment and Scenario Analysis**: Through simulations and modeling, digital twins can help assess the potential risks associated with different design choices or operational strategies. This aids in making informed decisions to minimize risks and optimize overall wind farm performance.

Objectives:

The present proposal, **WinDTwin**, targets to develop and validate an offshore wind farm digital twin (DT) for highly accurate prediction of power production and energy demand of the end user. The DT will give users tailored access to high-quality information, services, models, scenarios, forecasts, and visualizations, as a central hub for offshore wind decision-makers.

The proposed initiative, **WinDTwin**, aims to develop and validate an advanced offshore wind farm digital twin (DT) that significantly enhances the precision of power production forecasts and end-user energy demand projections. This digital twin will serve as a tailored platform, offering users access to a comprehensive array of high-quality resources, services, models, scenarios, forecasts, and visualizations. As a central hub for offshore wind decision-makers, WinDTwin seeks to revolutionize the way industry professionals make informed choices.

The achievement of this ambitious goal involves a series of strategic objectives that the WinDTwin consortium will diligently pursue:

1. ***Enhanced Wind and Weather Forecasting***: Incorporating the influence of external physical factors like temperature, precipitation, turbulence, waves, and currents into wind and weather predictions.
2. ***Advanced Spatial and Wake Modeling:*** Developing precise models for wind farm clusters and within-individual wind farms to better understand wake effects and optimize spatial layout.
3. ***Farm-Level Turbine Control:*** Implementing control strategies at the wind farm level to optimize turbine performance and energy production.
4. ***Energy Hybridization and Sustainability:*** Exploring hybrid energy solutions and sustainable practices, including hydrogen integration, to promote eco-friendly energy generation.
5. ***Accurate Energy Yield Prediction***: Enhancing energy yield predictions through sophisticated simulation techniques for more precise estimations.

6. ***Grid Integration Modeling:*** Creating models that simulate grid interconnections, ensuring compliance with grid requirements and enhancing overall system stability.
7. ***User Demand and Price Projection:*** Developing predictive models for both user electricity demand and electricity price fluctuations.
8. ***Predictive Maintenance and Structural Health:*** Implementing advanced analytics for predictive maintenance and real-time structural health monitoring of wind turbines.
9. ***Personalized User Experience:*** Tailoring the digital twin to individual end user locations and specific needs, enhancing user engagement and satisfaction.
10. ***Robust Data Management:*** Establishing efficient systems for data acquisition, generation, and storage throughout the operational phase.
11. ***Open-Source Digital Twin Architecture:*** Creating an open-source framework for the digital twin architecture, fostering collaboration and innovation into the European wind energy community.
12. ***Digital Twin Exploitation:*** Designing a comprehensive plan for the exploitation of the digital twin, including a detailed business strategy and a roadmap for future developments.

Through the collaborative efforts of the **WinDTwin** partnership, this initiative aims to drive forward the capabilities of offshore wind farm management and decision-making, ushering in a new era of precision, sustainability, and innovation.

1.1.2 Ambition

The effectiveness of the Digital Twin and its related innovations within **WinDTwin** relies on the quality of research carried out within the project and its capability to yield valuable results. The following sections offer a comprehensive overview of WinDTwin's contributions, pushing beyond the limits of present advancements and delving into the realm of cutting-edge progress across the technical domains relevant to the project:

Modelling of wake effects and wind turbines

High resolution modeling and High Performance Computing:

WinDTwin will further **develop the mesoscale-to-microscale coupling** approach that uses mesoscale tendencies, proposed by Sanz Rodrigo et al. 2017, and tested in complex terrain by BSC and CENER in ALEX17 experiment during the NEWA project (https://www.neweuropeanwindatlas.eu). In the proposed strategy the mesoscale output data from ERA5 or WRF model code is obtained by extracting some budget terms of the horizontal momentum and thermodynamic equations, following the methodology described in Lehner (2012). Before reading this data by the microscale model code an intermediate step is performed, horizontally space-averaging the outputs from WRF using a Python script implemented by Sanz Rodrigo et al. (2017). This coupling strategy will be applied for **LES wind farm modeling and extended to near coastal offshore wind farms and high altitude winds.** The proposed strategy is quite **expensive from the computational point of view**, and will be feasible thanks to two important factors. First, BSC is hosting one of the biggest supercomputers of Europe and is part of the EuroHPC Joint Undertaking (EuroHPC JU). Recently, EuroHPC JU have agreed to acquire and deploy three integrated world-class high-performance pre-Exascale systems by 2020, and two Exascale systems by 2022-2023, of which at least one will be based on European technology. **One of the pre-Exascale systems will be hosted by BSC**, and is expected to be the main platform for the present project calculations. Secondly, the BSC team is developing the High-Performance Computing code Alya within the EoCoE-II project focusing on wind energy applications. Alya scales well in the biggest European supercomputers. While the CPU implementation is currently our default approach, we are working strongly on a GPU version within the EoCoE-II project. We expect to use the **GPU implementation** during this project to take advantage of the newest EuroHPC JU architectures available during the project implementation.

Data-driven modeling:

During the last years, reduced order models (**ROMs**) have been introduced as an **efficient alternative to modeling the flow with high accuracy** but with **reduced computational cost** of traditional **CFD** solvers. However, to obtain reliable **Artificial Intelligence**-generated predictions using **ROMs**, it is essential to have an extensive and **physically accurate training** and validation dataset containing a representative set of physical events to set up the ROM adequately. In this regard, **WinDTwin** proposes developing novel tools and methods (i) to generate high-fidelity datasets containing information on microscale and the mesoscale interactions (including both numerical and experimental data); (ii) to gain further insight into wake modelling and wind farm interactions (iii) develop a **prototype tool** integrating the developed **ROMs** capable of **accurately forecasting wind flow** and **power production**, and **improving wake modeling** and the **integration of models** with **real condition wind farm** data. The present proposal proposes a combination of theoretical, experimental, numerical, and data-driven science that will simulate and help to design new disruptive technologies for better wind power production forecasting and the design of wind energy technology components.

Resource assessment and forecasting of power production

WinDTwin will initially employ local weather characterization by utilizing historical data to establish a "historical climate baseline." This baseline will serve as the foundation for resource assessment and subsequent resource evaluation. Following this, a distinction will be drawn between short-term forecasting, which spans a few days, and medium- to long-term forecasting, which extends up to a year. This categorization aligns with the standard lead times of weather forecasting systems. In numerical weather prediction (NWP), short-range forecasts encompass lead times from near-real time to a few days ahead. In contrast, long-term or extended-range forecasts offer predictions ranging from two weeks to a year. These extended forecasts, often referred to as climate outlooks, provide probabilistic overviews.

For short-term weather and power production forecasting at specific sites, reliance will be placed on meteorological service's short-term weather forecasts. Conversely, medium, and long-term weather forecasts will be integrated into the historical baseline to yield probabilistic insights into weather conditions and power production over those timeframes.

The projection of power production for the typical local climate, as well as medium and long-term power production forecasting, hinges on the probabilities of wind turbine malfunctions leading to non-production, alongside the maintenance schedule. Consequently, an activity focusing on maintenance strategies will be undertaken to address the impact of maintenance decisions on power production.

A comprehensive approach aimed at optimizing long-term operation and maintenance (O&M) strategies, along with operational decisions, will be meticulously developed. This guiding framework will encompass a diverse array of variables influencing wind farm operation, spanning weather, waves, wind, market conditions, as well as the reliability of wind turbine and foundation components, among others. The overarching goal of this guideline is to provide project developers and operators with the tools to optimize their O&M strategies for both bottom-fixed and floating wind farms.

Energy distribution and demand of the end user

The primary end-user requirements and long-term electricity price and demand predictions will be initiated through an analysis of historical consumption data (monthly averages), utilizing predictors for electricity price and user demand forecasting. This process will also involve considering energy roadmaps and offshore wind strategies for the selected study cases (EU, GE, UK, PT). The outcome of this analysis will be an interactive map that integrates end-user locations and needs into the Digital Twin (DT). Subsequently, statistical modeling and machine learning-based prediction algorithms will be employed to formulate day-ahead forecasts for user demand and electricity prices. These advanced algorithms will supply day-ahead price forecasts and day-ahead grid load forecasts for integration into the DT.

The modeling of electrical grid infrastructures and topologies will be executed using a realistic simulation regime and generic grid electricity data. This model will serve as an authentic testing and validation environment for analyzing the ancillary services generated by Distributed Energy Resources (DER), with a specific focus on offshore wind farms. Consequently, the DT will incorporate a grid model providing a time series depicting flexibility and the requirements of each simulation time step.

Lastly, the potential of energy storage systems in enhancing the reliability and efficiency of renewable energy supply will be explored. This involves capturing energy surpluses during periods of low demand and subsequently releasing them to meet electricity demands during peak hours. This strategy improves grid stability, reduces curtailment rates, and maximizes the economic viability of offshore wind energy. The comprehensive approach will explore various storage technology solutions to assess the economic potential of energy management strategies that involve sustainable storage solutions like green hydrogen, combined with offshore wind energy, to effectively tackle fluctuations in the electricity market. The outcome will be the integration of a techno-economic model into the DT, enabling the production of Levelized Cost of Electricity (LCOE), Levelized Cost of Hydrogen (LCOH) estimations, Net Present Value (NPV) and Internal Rate of Return (IRR). These estimations will facilitate investment decisions concerning sustainable storage solutions (such as green hydrogen) combined with offshore wind energy, aimed at effectively addressing fluctuations in the electricity market. Additionally, a short-term energy storage control model will be created to maximize the charge/discharge cycles for the near future.

Digital Twin Development

Our primary aim within this **WinDTwin** is to construct a robust Digital Twin platform. This platform will take the form of a classic web-based client-server application, wherein the client component operates directly within a web browser, and the backend component is hosted within a cluster of containers. The essential business logic hosted in this backend will be divided into discrete modules, each tailored to a specific business use case. These modules will undergo separate development processes as part of other work packages (WPs) and will be delivered as containers,

each equipped with an API for seamless communication with other modules. The following steps will be carried out: i)Core Component Development: In the initial phase, we will focus on developing the core component necessary for constructing the backend. This will entail defining the interactions between components to establish a strong foundation; ii)Backend Implementation: Following the core component's development, we will proceed to implement the backend. This stage involves integrating various modules into the backend, effectively creating a cohesive system. iii)Frontend Creation: In the final phase, we will design and implement the frontend. This will involve crafting user interfaces (UIs) tailored to the unique requirements of each module, ensuring a seamless and intuitive user experience. By following this structured approach, we aim to create a powerful Digital Twin platform that seamlessly integrates various modules, providing a robust, user-friendly solution for our project.

Technology Verification, Validation, and Industrial Assessment

The **design of numeric models requires a systematic approach to verify and validate them**, in order to demonstrate consistency of the computational code with the physical model and understand deviations with respect to the real world (Sanz Rodrigo et al., 2017). In **WinDTwin**, **the verification process will be carried out using idealized test cases w**here the solution is known from theory or from a higher-fidelity model (code-to-code comparison). **Sensitivity analysis in idealized conditions** helps **to determine the main drivers of the model**, which directly affect the quantities of interest, while anticipating their **main sources of uncertainty**. **Validation**, however, deals with **code-to-observation comparison to quantify the accuracy** of the model representing the physics in terms of the application of interest. From the wind energy forecast, the quantities of interest are the wind conditions that are directly related to the production of energy and the design characteristics of wind turbines. These are (1) wind speed, (2) turbulence intensity, as well as its dynamics for wake effects, and how all of these affect wind turbine performance, energy production and mechanical fatigue loads. During this **exhaustive assessment for industrial requirements**, **WinDTwin** partners will compile all data used in the project. This data will be filtered and processed in order to generate the validation datasets. Then, **the data will be standardized based on extended good practices** and guidelines from the IEA Wind Task 43, warranting the quality and goodness for the purposes of the project and future use when possible. Additionally, the sites where the DT modules will be tested should be specified and a comprehensive analysis of the site characteristics and available data should be done alongside the DT requirements. A set of KPIs will be associated with each case study, to provide clear guidelines and metrics to evaluate the performance and robustness of the models. Potential user training needs will be taken into consideration throughout the development of the project.

#§PRJ-OBJ-PO§#

1.2 Methodology

The proposed methodology follows a top-down approach to allow industry to fully exploit the last generation of high-performance computing, modelling and data-driven science innovations. To demonstrate the market impact of this project, IBERDROLA and EDP NEW have defined for **WinDTwin** a series of market relevant problems (see WP7).

Modelling of wake effects and wind turbines (WP3)

WP3 will focus on the improvement of the modelling of wake effects and wind turbines exploiting three different levels: i) Generating high fidelity simulations of wind farms, ii) Developing ROM accelerated by different dada driven technologies, and, iii) Developing novel detailed wind turbine models.
In WP3, BSC will generate **high resolution microscale data** by means of a **meso-to-microscale downscaling strategy, using URANS and LES turbulence models in the microscale model**[1]. The LES and URANS models will be compared in accuracy and time to solution. BSC's microscale code (Alya) will read the space-averaged data coming from WRF, which will be interpolated and added as source terms to the momentum and energy equations. This coupling strategy will be applied for LES/URANS wind farm modeling and extended to near coastal offshore wind farms and high altitude winds. At the microscale level, LES equations will be discretized using a finite-element non-stabilized formulation, with a non-incremental fractional step method to stabilize pressure, allowing equal order interpolation for pressure and velocity. This non-dissipative formulation, using an energy-conserving discretization, highly enhances the accuracy of the LES, and is a key element for the generation of high fidelity data sets[2]. These **highly resolved data sets** will help to **gain physical insight into the turbulence coherence** behavior and its **impact on wind power production and component design** under different stability conditions. SOLUTE will also participate in the high-resolution modeling, which poses different challenges to generate more reliable approaches related to wind and wave conditions in wind farms, wake interactions, blockage effects, and understanding of the

[1] http://dx.doi.org/10.1088/1742-6596/1934/1/012002

[2] Lehmkuhl O, et al. A low-dissipation finite element scheme for scale resolving simulations of turbulent flows. JCP. 390:51–65, 2019. ISSN 0021-9991.

role of the PBL cycle during simulations. The RANS, LES and URANS models have different performance, and making the validations in a great number of atmospheric situations is a need. SOLUTE will produce a strategy based on MS (Matrix Simulation)[3] that must be part of the sensitivity studies for every technology. SOLUTE will segregate the cases for atmospheric stability with Monin–Obukhov length ranges, geostrophic wind regime and terrain complexity. Another main issue is to include in the models a good representation of wind farms and their interactions (wakes, blockage effect and others) to improve forecasted energy and load calculations. For the calculation of wake farms, SOLUTE proposes to start from a mesoscale conception of this calculation, validating the Fitch parametrization[4] for the cases registered in the modeling matrix.

Additionally in **WinDTwin** we will develop and integrate data-driven methods for wake modelling and wind farm interactions into the digital twin. These are computationally significantly cheaper than the high-fidelity simulations previously mentioned and provide an important basis for wake modelling in applications like forecasting, scenario modelling and optimisation of operational strategies. The models will draw on the output of high-fidelity, high-resolution models, SCADA data from operational wind farms as well as wind measurements to derive data-driven models suitable for a wide range of applications at different phases of the planning phase and lifetime of a wind park. This will be done using two methods:

1. A data-driven version of engineering models commonly used in wind energy applications for wake-modelling.
2. Machine-Learning based models based on high fidelity models and operational data.

The first approach uses well established engineering models like the Gaussian[5] or Jensen[6] models to provide a baseline wake modelling to the digital twin. Within the digital twin the implementation of the models will be based on the open source software packages Floris [7]and PyWake[8]. These packages are tailored towards applying these models to different wind farm configurations. The project aims at developing methods to adapt these models by fitting their empirical parameters to high fidelity simulations and data from operational wind farms, which are provided to the digital twin. To enable simulation of wake affected turbines' dynamic response in WP3, dynamic wake meandering (DWM) based extensions of the steady wake modelling will be pursued. The DWM implementation in SINTEF's DIWA tool may be used as baseline, with further development to be done using the high fidelity simulations produced in **WinDTwin** as reference. While (simplified) engineering type models are constrained in their ability to capture the entire complexity of wake interactions in large wind farms or to properly represent all atmospheric influences on wake characteristics, they have a long tradition in the wind industry and are widely used in many applications. This makes them especially suitable for extrapolations to situations, which are not sufficiently represented in the empirical data.

The second approach uses machine-learning models to better represent the complexity of the wind turbine and park wakes. The complex architecture of these models is able better capture and represent complex environmental/atmospheric influences on wake characteristics. Also, the ML-models are better suited to exploit the complex characteristics of wakes modelled in the high fidelity simulations and represent the details of the wind turbine wakes[9]. The machine-learning based approach will be designed in a way that it is able to ingest operational turbine data that is generated during the operation of the wind farm in a continuous process. This continuous learning approach has been demonstrated to improve model performance in other energy related ML-models significantly[10]. This allows a quasi-online improvement of the accuracy of wake modelling during the operational phase of the wind park. One of the key focuses of this work will be to ensure the robustness of the models for a range of applications and conditions. For development and training the data-driven models the project will draw on several different data sources:

- *High fidelity simulations:*

  High fidelity simulations will be used to train the data driven models in the absence of operational turbine data. The output from the high fidelity simulations thereby serves several different purposes:

[3] IEC 61400-1 (2019), “Wind energy generation systems, Part 1: Design requirements”, Edition 4.0

[4] Notes on using the mesoscale wind farm parametrization of Firch et al. (2012) in WRF

[5] Bastankhah M and Porté-Agel F (2014). A new analytical model for wind-turbine wakes. Renewable Energy. 70: 116-123, 2014. ISSN 0960-1481

[6] Jensen NO (1983). A note on wind generator interaction. Risø National Laboratory, 1983.

[7] https://github.com/nrel/floris

[8] Pedersen M. M., et al. (2023). PyWake 2.5.0: An open-source wind farm simulation tool. URL: https://gitlab.windenergy.dtu.dk/TOPFARM/PyWake

[9] Ti Z et al. (2020) Wake modeling of wind turbines using machine learning. Applied Energy. 257: 114025, 2020. ISSN 0306-2619

[10] Brauns et al. (2022) Vertical power flow forecast with LSTMs using regular training update strategies. Energy and AI. 8: 100143, 2022. ISSN 2666-5468

I. It corresponds to the planning phase of the wind farm. It allows an adjustment to the park and site specific conditions, even if there is no operational data available, yet.
II. High fidelity simulations will provide input to the data driven models for operational conditions, which have not been encountered (yet) during the operation of the wind park. Such as new control strategies.
III. The output of high fidelity simulations fills gaps in operational data, where little data is available - such as park or even cluster wake effects.

In **WinDTwin** specific simulations will be carried out to cater the above mentioned points and their benefit to the data-driven models will be demonstrated. The project also develops an API to easily ingest new high fidelity simulations into the training and fitting process.

- *Operational data from wind farms:*

Here the project plans to operational data, which is publically available such as the Alpha Ventus wind farm, but also data from wind farm operators such as the Ørsted data packages[11] of the wind farms Anholt and Westermost Rough. The historical operational data will be used to develop, train and test the data-driven models. Also, a simple API for data continuous ingestion during the operation of the wind farm will be developed.

- *Wind measurements:*

The second category of empirical data for the development of wake models are offshore wind measurements. Here the focus is put on remote sensing data using long range scanning from past campaigns. In particular, the project will build on scanning lidar/multi-lidar[12] data obtained during the Window project by Fraunhofer (FHG-IEE) and the University of Kassel (UKS), but also on scanning lidar data that is freely available from measurements aimed at characterising the wind conditions for the German wind energy areas[13]. These data sets mainly provide valuable inputs for wakes from whole wind farms or wind farm clusters.
Finally, in WP3 physical models of the wind turbines' dynamic responses of floating wind turbines and umbilical power cables to wind, waves and current will be developed. These models will provide information in terms of effects of platform motions on the power production for floating wind turbines and on wake modelling, to correct the predictions within WP4 based on CFD simulations for bottom fixed wind turbines. They will also provide loads on the umbilical cables which will feed into the Digital Twin maintenance strategies.
SINTEF's commercial software will be used for demonstration purposes, namely SIMO, and RIFLEX and DIWA for the calculations and SIMA for the modelling and simulation management. The final model will include and couple: sub-structure hydrodynamics, elastic tower and blades, power generator with control, control of blades pitch and mooring system (in case of floating WTs). The substructure hydrodynamics will be modelled by radiation-diffraction potential flow methods, with corrections for viscous effects. The tower and blades will be represented by a finite element model (FEM), while the wind loads on the rotor are calculated by the blade element momentum approach. The mooring system will be also represented by a FEM with hydrodynamic loading given by Morison formulation.
The digital twin will be able to connect to alternative simulation software provided the input/output is prepared according to the digital twin protocols. To demonstrate this feature, the wind turbines will also be modelled with ORCAFLEX.
High-fidelity CFD-RANS simulations for one wind turbine will be run to assess the effects of floating platform motions on the wake flow field. Furthermore, the responses of the wind turbine will be compared to coupled dynamic responses obtained from the multi-physics tools to provide insight on the accuracy of the different numerical tools.

Resource assessment and forecasting of power production (WP4)

This WP entails the implementation of cutting-edge data-driven methodologies for the optimization of two critical stages in the life cycle of a wind energy project: the wind resource assessment stage to determine quantitatively the wind resources of a wind farm using well-known parameters such as the average annual energy production (AEP), and the O&M of a wind farm which has been commissioned, so O&M activities are performed and scheduled in a short- and long-term basis. High-fidelity weather forecast and operational data play a key role to develop these modules for the DT.

[11] https://orsted.com/en/what-we-do/renewable-energy-solutions/offshore-wind/offshore-wind-data#offshore-operational-data

[12] Pauscher L et al. (2016) An Inter-Comparison Study of Multi- and DBS Lidar Measurements in Complex Terrain Remote Sensing 8(9):782. https://doi.org/10.3390/rs8090782

[13] https://pinta.bsh.de/?lang=en

Characterizing the historical climate baseline is the first stage to evaluate the suitability of a potential region of interest to build an offshore wind farm (Task 4.1). Detailed geographical information (e.g., bathymetry, orography, coastline) together with wind and wave historical global databases such as Copernicus or ERA5 (ECMWF)14 will be used as inputs to run local models (WRF, SWAN) offline to generate hindcasts, which will be later post-processed to generate a relevant description of the metocean (wind, waves, current etc) climate of the area, together with wind resource assessment[15,16]. The analysis performed to characterize the historical climate baselines of the several case studies will include the possibility of assimilating new data collected during the operation of the wind farm, both from sensors and simulations. Longer-term weather forecasts will be estimated in Task 4.4 and will be integrated into the historical climate baseline, creating a set of bias-adjusted and accuracy-improved seasonal forecasts for the case studies. Available metocean data from in-situ sensors (e.g, lidar buoys, depending on availability) will be retrieved for the case study areas and be analyzed together with hindcast model runs (e.g., ERA5 reanalysis data), extended range forecasts (monthly, seasonal outlooks from Copernicus Climate Change Service), local-specific geographic parameters (e.g., orography, bathymetry), and climate mode classifications for teleconnection estimates (NOAA) to perform the required exploratory data analysis on the existing range forecast errors and biases to later develop machine learning models to improve seasonal forecast accuracy.

The custom offshore-climate baselines developed in Task 4.1. will be one of the main inputs for the wind resource assessment of offshore power plants (Task 4.2). Using industry-standardized software for WRA activities, this task will consist in the development of a calculation engine and an optimization tool tailored for offshore wind farms. For the first subtask, both the data from Task 4.1 and open-source wind resource data will be considered for the configuration and validation of the calculation engine. Based on this, the second subtask will be focused on the development of an optimization tool configured for offshore power plants, taking into consideration aspects such as the orography and the climate to provide accurate values of parameters such as the annual energy production (AEP), average annual wind speed at hub height, shear, Weibull parameters, uncertainty analysis, and air and turbulence density. Apart from the historical climate baselines to be obtained in Task 4.1, other inputs required for this task are wakes, wake losses and blockage effects, which will be retrieved from WP3, power and thrust curve of the wind turbines, and wind and ocean measurements combined with sensor technical data.

A data-driven machine learning approach is proposed for the development and implementation of short-term wind power forecasting models (Task 4.3). Data obtained from WP3 will play a key role in successfully completing this task. Model pretraining and calibration will be achieved using data from high-fidelity weather forecasts, as well as data from detailed physical models. Wake and blockage effects are also taken into consideration to model the interaction between wind turbines using graph neural networks. This approach is also characterized by its adaptability to data and operation conditions of the physical representation of the wind farm. Forecast uncertainty will be addressed by building ensemble predictions.[17,18] To ensure the actual ability of the forecasting models, the recommended practices for the implementation of renewable energy forecasting solutions proposed by the IEA Wind Task 36[19] will be followed at length.

The short-term wind power forecasting models will not only be implemented in terms of accuracy, but software engineering best practices applied to the life cycle of ML models - known as MLOps[20] - will be adopted to facilitate their integration into the DT, using tools such as Kubernetes to ensure the scalability and robustness of the models deployed in operation. In addition, continuous integration/continuous deployment (CI/CD) pipelines will be established for the predictive models, and model training and deployment will be automated. The output of the short-term forecasting module includes power forecasts per time step (both at wind farm and wind turbine level), disturbed wind speed for each location and wake losses per timestep.

Task 4.4 deals with medium and long term weather forecasts, which are based on forecasts from few global producing centres that comply with WMO standards to that effect. These long-range predictions differ from short-term because they entail ensemble simulations of possible weather scenarios, i.e., they offer a probabilistic overview of long term conditions, from weeks to months in advance, by introducing small disturbances in the initial conditions of each ensemble model. The resulting predictions can then be framed as a probabilistic distribution of main weather

[14] Stefanakos, Ch. Global Wind and Wave Climate Based on Two Reanalysis Databases: ECMWF ERA5 and NCEP CFSR. *J. Mar. Sci. Eng.* **2021**, *9*, 990. https://doi.org/10.3390/jmse9090990

[15] Stefanakos Ch, Tedeschi E, and Broenner U (2021). "Offshore wind and wave energy resource assessment in the Norwegian waters based on ERA5 reanalysis," in 31th International Offshore and Polar Engineering Conference, ISOPE'2021, Rhodes, Greece, pp. 651–658.

[16] Stefanakos Ch, de Vaal J, and Rodrigues JM (2023). "Investigation of the feasibility for a combined offshore wind and wave energy plant in the Norwegian waters," in 33rd International Offshore and Polar Engineering Conference, ISOPE'2023, Ottawa, Canada, pp. 741–748.

[17] Bessa, R. J., Möhrlen, C., Fundel, V., Siefert, M., Browell, J., Haglund El Gaidi, S., ... & Kariniotakis, G. (2017). Towards improved understanding of the applicability of uncertainty forecasts in the electric power industry. *Energies*, *10*(9), 1402.

[18] Yan, J., Möhrlen, C., Göçmen, T., Kelly, M., Wessel, A., & Giebel, G. (2022). Uncovering wind power forecasting uncertainty sources and their propagation through the whole modelling chain. *Renewable and Sustainable Energy Reviews*, *165*, 112519.

[19] Möhrlen, C., Zack, J. W., & Giebel, G. (2022). *IEA Wind Recommended Practice for the Implementation of Renewable Energy Forecasting Solutions*. Elsevier Science & Technology.

[20] Kreuzberger, D., Kühl, N., & Hirschl, S. (2023). Machine learning operations (MLOps): Overview, definition, and architecture. *IEEE Access*.

conditions. The DT will retrieve the hindcast time series of seasonal predictions which are generated on a global scale and available from the Copernicus Climate Change Service, and match them with the output of the historical climate baselines to develop a data-driven approach for bias correction and downscaling. The aim is to train machine learning models that use the historical climate baselines as the response variable to adjust the extended range/seasonal forecast to the local-specific conditions. After validation the model becomes operational providing monthly updates of local-specific parameters, from weeks to months in advance. As with the historical climate baselines, the wave, wind and current statistics are established for the specific case study sites.

Further data-driven insights will be obtained in Task 4.5 for the strategic maintenance planning and optimization of offshore power plants. Two lines of work arise from this task: a long-term one with a strong focus on advanced reliability data-driven models able to simulate the main components of offshore wind farms (e.g., turbine, moorings, cables) and an operational one where the main goal is the development of decision-support tools to optimize short-term O&M scheduling activities based on real data. The main inputs required for this task are wind turbine performance and reliability data (WP2), high-resolution weather forecasts (Task 4.4), energy distribution and demand projections (WP5), real-time data from the wind turbine (WP6), technology verification and validation data (WP7), and available industry-wide reliability data. The end users will benefit from the tools developed in this task with the following outputs: 1) strategic long-term maintenance plans and infrastructure recommendations for optimizing farm availability and minimizing life-cycle costs, 2) insights into future energy demand and supply for advanced maintenance and operational decisions, 3) cost-benefit analysis for various long-term maintenance strategies to support decision-making and resource allocation, 4) short-term maintenance schedules and operation plans based on real-time intelligence and predictive models, 5) enhanced turbine performance and reduced downtime through optimized O&M planning, and 6) data-driven insights for improved short-term decision-making in O&M operations. In addition, EPRI Europe DAC (EPRI) will leverage a collaborative reliability model on wind turbine components created by EPRI in a collaborative effort with the global industry (WinNER). At this moment, WinNER encompasses 40+ GW of installed wind power capacity from 30+ industry members. Task 4.5 will leverage WinNER inputs and look for correlations with operational strategies and environmental conditions, to identify main drivers for relative differences on reliability among similar turbines.

Energy distribution and demand of the end user (WP5)

WP5 - Energy distribution and demand of the end user focuses on energy demand and price predictions of electricity for long-term and short-term horizons, energy distribution, and the role that energy storage technologies (e.g. hydrogen, lithium-ion) play in mitigating curtailment for the entire lifetime of the offshore wind project. The end user main requirements and overall prediction for long-term electricity prices and demand is first performed based on a series of past consumption data (monthly average), predictors for electricity price and user demand forecasting, and energy roadmaps and offshore wind strategies for the chosen study cases (EU, GE, UK, PT) (Task 5.1). This analysis will result in an interactive map for end-user location and needs integrated into the DT. Secondly, statistical modelling and machine learning based prediction algorithms will be applied to develop day-ahead user demand and electricity price forecasts (Task 5.2). The developed algorithms will provide not only day-ahead price forecasts but also day-ahead grid load forecasts for the DT. Electrical grid infrastructures and topologies will be modelled based on realistic simulation regimes and generic grid electricity data, to serve as a reliable test and validation environment for analysis of ancillary service generated by DER with focus on offshore wind farms (Task 5.3). As a result, a grid model providing a time series of flexibility and requirements of each time step's simulation will be incorporated into the DT.

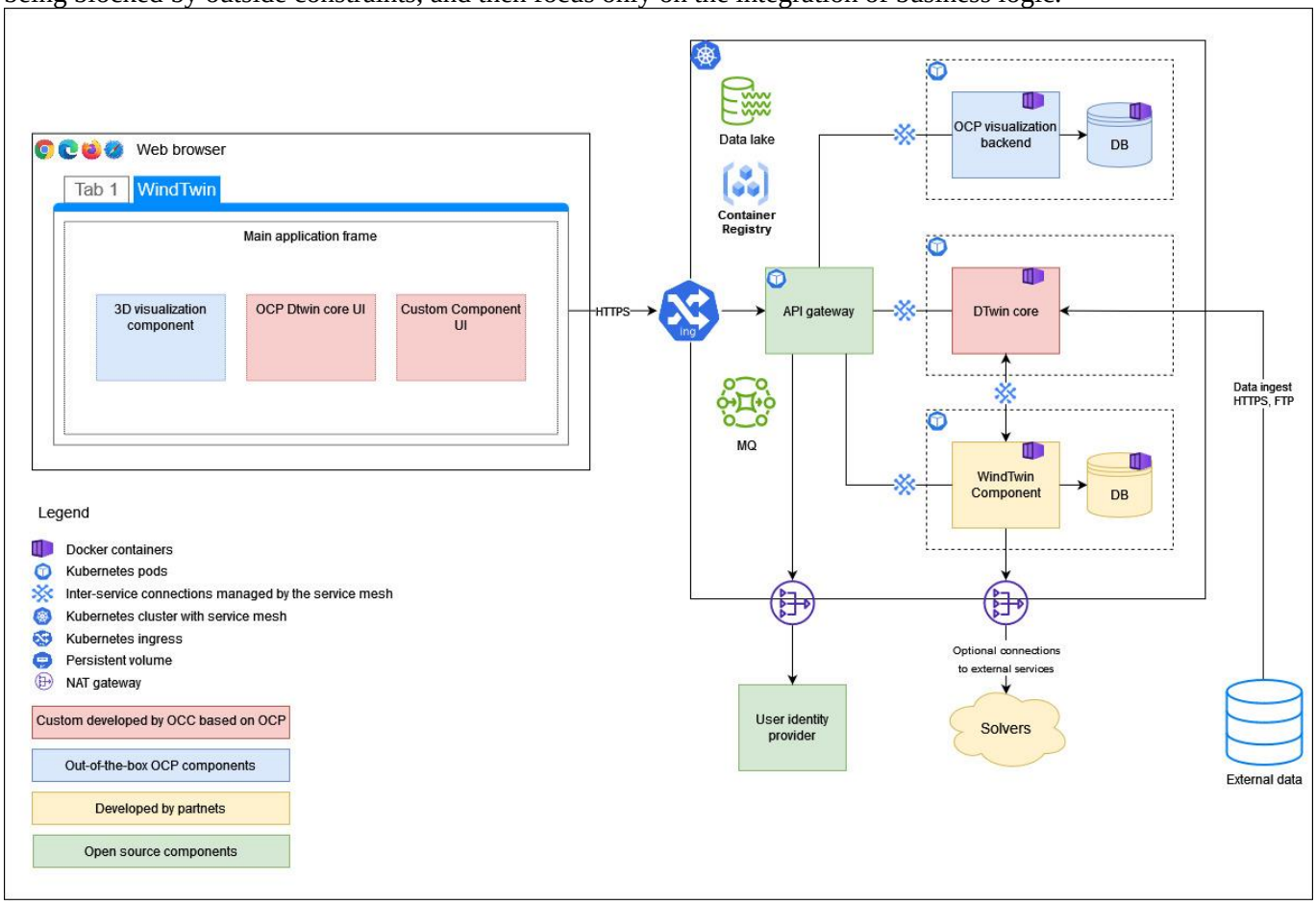
Finally, using outputs from the previous tasks (Task 5.1 and Task 5.2), WP5 will focus on the crucial role of different energy storage solutions in mitigating curtailment (Task 5.4). The work will address the capability of energy storage systems to ensure a more reliable and efficient renewable energy supply by capturing energy excesses during periods of low demand and later releasing it to meet electricity demand during peak hours, enhancing grid stability, reducing curtailment rates, and maximizing the economic potential of offshore wind energy. The holistic approach will study different storage technology solutions to perform assessment of the economic potential of energy management strategies involving such options as green hydrogen or lithium-ion, in combination with offshore wind energy, to effectively address electricity market fluctuations. As a result, a comprehensive assessment model of the economic potential of energy management strategies involving sustainable energy storage solutions will be integrated into the DT to produce relevant economic and financial metrics (LCOE, NPV, IRR). Additionally, a short-term energy storage control model will be created to optimize the financial gains of the offshore wind project in combination with the possible storage solutions. This model will formulate the optimal charge/discharge cycles for the near future, taking into consideration forecasts of offshore wind yield, electricity market prices, and energy requirements.

Digital Twin Development (WP6)

The Development of the Digital Twin for the WinDTwin project will be done by following good practices for the development of such a platform. The goal is not to develop a new platform from scratch, but to use existing components (mostly open-source) to build the platform. Only specific components, including business logic needed for the WinDTwin project, will be developed specifically.
The specific components to be developed will concern the global management of the platform like:

- user management: creation of users, management of roles, …
- project management: creation of projects, assignment of projects to users, sharing of projects between users, …

The architecture of the platform will be modular, and decentralised. Different components, each answering a specific problem, will be implemented as independent modules. Each component is responsible for storing and providing access to the set of data that lies within its boundaries of responsibility. The components will be developed in the frame of work packages 3, 4 and 5 by different partners. Communication between the different components will be specified using the OpenAPI standard. This language allows the consumer of the API to discover and interact easily with the remote service.
This modular and decentralised approach will allow each partner to develop its component independently, without being blocked by outside constraints, and then focus only on the integration of business logic.



After implementing the back end part of the digital twin application, the front end will be developed as a browser based application. The Front End of the core component and the business components will be implemented using Angular programming language, and will communicate with the back end components using the REST API specified in the OpenAPI format.
Development of the front end will include visualisation components to exploit results computed by the business components. These visualisation components will include components used in “classic” dashboard, but also specific components specific to the wind energy sector.

Technology Verification, Validation, and Industrial Assessment (WP7)

The primary aim of this WP is to conduct a rigorous validation of the **WinDTwin** DT using real data obtained from operational offshore wind farms- from at least one bottom fixed and one floating wind farm to enhance the representativeness of the validation.

To achieve this, the WP7 will start by specifying the real use cases to further validate the methodologies developed in the previous WPs. Power production forecasts will be validated following a two-stage process. Firstly, the models will be evaluated offline using historical data for a floating wind farm. At a second stage, models will be evaluated in real time to verify several factors of relevance such as the accuracy of the models (using relevant KPIs such as NMAE to compare the predictions with the real measurements) and the availability of the model in a real-case scenario. The forecasts will be benchmarked with the industry state-of-the-art prediction system currently used by IBERDROLA. The same approach will be followed for electricity price and demand forecasts.

In the final phase of WP7, our objective is to perform a techno-economic analysis. This analysis will offer insights into the impact of the project's solutions, particularly from the perspective of end-users. Through these systematic steps, we intend to ensure that the **WinDTwin** DT is not only rigorously validated but also provides valuable insights that are economically viable and beneficial to end-users.

1.2.1 Synergies with other activities or national/international projects

BSC is developing the High-Performance Computing code Alya within the EoCoE-II project focusing on wind energy applications. Additionally, BSC has a long-term agreement (from 2013 to present) with IRE to develop wind energy resource software to design wind farms. Finally, BSC was coordinator of the recently finished H2020 project ENERXICO , where the BSC team did develop disruptive coupling methodologies between meso-scale and micro-scale models, this is expected to be the starting point for BSC **WinDTwin** activities.
FHG-IEE has more than 20 years of experience in research and development projects of wind energy and energy consumption forecasts which is one of the core activities of **WinDTwin**. FH-IEE led the **EWeLiNE** project (cooperation with all German transmission system operators), which focused on the development of innovative weather and energy forecasting models to improve the grid integration of weather-dependent energy sources. Similarly, the **Gridcast** (cooperation with all German TSOs) project aims to increase grid security through flexible weather and power forecasting models. Both projects were funded by the German Ministry for Economic Affairs and Climate Action (BMWK).
The UKS and FH-IEE performed several joint projects aimed at grid integration of renewable energies and specifically offshore wind energy, which will help to integrate this aspect into **WinDTwin**. The H2020 **EU-SysFlex** project with the participation of FH-IEE and UKS addresses the challenges of the European power grid with a high penetration of renewable energy systems, in particular regarding the provision of ancillary services and the coordinated use of flexibility. Moreover, the Projects **NSON** and **NSON II** projects **(**BMWK funded), with the participation of FH-IEE and UKS investigated and developed new technically and economically efficient possibilities for short and medium-term connection of offshore systems and addressing scientific issues relating to the regulation, operational management, and planning of such systems. In the joint project **WINDOW (**BMWK funded**),** led by UKS and with participation of FH-IEE, a machine-learning and measurement-based wind field in and around offshore wind farms is developed. This provides an ideal starting point for the data driven and machine learning wake models developed and implemented in **WinDTwin**. Moreover, measurement data generated in the **WINDOW** project will be used in **WinDTwin**. The **MEDAILLON** project **(**BMWK funded) of the FH-IEE and UKS aims to create a new, user-friendly, open, optimized and high-resolution meteorological data set for Germany and Eruope and its establishment as a meteorological standard data set within system analysis and energy economy.
IBERDROLA is leading ROMEO, a project which aims to reduce the O&M cost of offshore wind power facilities with the development of new technical solutions. The **WinDTwin** project will allow an optimization of the best weather forecast techniques, improving the ROMEO approach for this purpose and consequently, allowing when necessary, a more accurate estimation of the cost of those O&M activities in offshore wind farms where forecast is relevant. Additionally, IBERDROLA is leading the H2020 FLAGSHIP project. It is an initiative that aims to demonstrate the viability and profitability of installing 10 MW wind turbines on offshore platforms. This new technology will be part of IBERDROLA assets in the near future and the **WinDTwin** project, providing test platforms with data to check the skills of current methodologies and identify possible improvements.
SOLUTE has been leading R&D projects aligned to the goals of WinDTwin. **SOLUMET** is a R&D project co-financed by CDTI (public organization for technology development based in Spain) to develop a weather forecasting app enhanced with high-resolution regional meteorological models developed in this project. This is a contribution expected in WinDTwin, as high-resolution weather forecasting models are required for meso-to-microscale coupling to enhance weather and energy predictions. **APHELION** has been another CDTI-funded project to develop Aphelion Wind, an energy and weather forecasting decision-support tool tailored for operators of wind farm assets. Short-term wind power forecasting using data-driven machine learning techniques were developed in this project, and SOLUTE aims to keep enhancing them contributing to the short-term wind power forecasting module to be integrated into the DT. **EOLIAN** has been funded by the Spanish Ministry of Science with the aim of designing and implementing new techniques based on edge computing and deep learning for predictive maintenance of wind turbines. In the same line,

the **AQUILON** project is funded by the Spanish Ministry of Science to develop weather forecasting models for the renewable energy sector, including the detection and prediction of adverse weather conditions for offshore wind farms.
WavEC is currently involved in a number of ongoing R&D projects that are closely aligned and synergistic with the WinDTwin project. WavEC is involved in the ILIAD H2020 project (Grant Agreement no. 101037643) which has the objective of developing a digital twin of the oceans. As part of the project, WavEC is currently developing its Short-Term Operation Maintenance Planning tool, which provides recommendations on short-term O&M scheduling decisions based on weather forecasts and a given list of offshore work activities. It is envisaged that in WinDTwin, this operational digital win will be further enhanced in respect to functionalities (e.g. integrating reliability assessments into the decision-making process) and computational-time and validated against real operational data. As part of the EU-SCORES EU project (Grant Agreement no. 101036457), WavEC is leading the long-term, strategic O&M modelling for multi-source offshore renewable energy farms (combining wave, wind, and offshore solar). In WinDTwin, WavEC will significantly expand the functionalities of the strategic O&M modelling tool first developed in DTOceanPlus (Grant agreement no. 785921) and subsequently improved in EU-SCORES so that it is integrated in the digital twin and interfaces with the wind turbine reliability modelling done by EPRI.
CoLAB +ATLANTIC (+ATLANTIC) is involved in the Horizon Europe EDITO-Model Lab project, working to develop the next generation of ocean numerical models to be integrated into the EU public infrastructure of the European Digital Twin of the Ocean and providing access to focus applications and simulations of what-if scenarios for the sustainable management of marine environments.
ENGIE Laborelec has delivered technical expertise to its parent company ENGIE in different stages of the development and construction of Windfloat Atlantic(https://www.windfloat-atlantic.com/), a 25 MW floating wind farm that has been commissioned in 2020. Today we collaborate with Ocean Winds and EDP NEW in a review of operational data. This involves SCADA data as well as data from a nacelle-based LiDAR. These data will be used in the validation of the models and tools developed in WinDTwin.
Furthermore, the WinDTwin consortium aims to establish a robust interaction with Destination Earth's available Digital Twins (DTs), with the BSC being a highly engaged partner. This collaboration ensures the comprehensive utilization of all accessible data, and it guarantees compatibility between WinDTwin developments and the ongoing initiatives within the Destination Earth framework.

1.2.2 Interdisciplinary approach

WinDTwin is based on the combination of theoretical modelling, experimental techniques, high performance computing, and data-driven science innovations. Therefore, there is a clear interdisciplinary approach combining HPC, data analysis, with measurements and traditional numerical methodologies for wind energy forecast and wind farm design. Is expected that this interdisciplinary approach will bring new opportunities to achieve the main objectives of the **HORIZON-CL5-2023-D3-02-14** call.

1.2.3 Gender dimension

The research activities of **WinDTwin** targets to develop and validate an offshore wind farm digital twin (DT) for highly accurate prediction of power production and energy demand of the end. We are fully aware of the existence of gender bias in research, especially due to unconscious perceptions about gender. Nonetheless, after carefully considering and analyzing the possible implications of the gender dimension in this particular study, we concluded that the core research activities do not have gender dimension impact. In fact, gender differences could not affect the design of our research. Gender would not be a variable in the analysis of the data, and the data interpretation cannot be influenced by stereotypical assumptions about gender. Therefore, we do not consider the gender dimension to be relevant in this specific project.
Anyhow, gender dimension will be systematically controlled throughout the research process. For example, in WP6 DT will be developed. In particular, the design of the user interface (UI) will be carried out taking into account the user experience (UX). In this development, the team will survey potential users in order to design the UI according to the best UX possible. These tasks will integrate inputs from both women and male potential users equally in order to accommodate all the possible sensibilities into the final design.

1.2.4 Open practices

The Open Science Practices (OSPs) are entangled in the **WinDTwin** methodology. Communication with other projects of the call and other EU projects will continuously be performed. The information between partners will be shared following security measures, according to the levels of confidentiality agreed in the consortium and the applicable legislation. Data Management activities will take care of applying best practices and FAIR principles

throughout the whole data lifecycle and will be detailed and continuously updated in the Data Management Plan of the project.
For FAIR purposes, the input and validation output data used and generated by partners teams will be made available through the DT, together with documentation, metadata, descriptions, and the datasets persistent identifiers. Whenever applicable, simulation and experimental results will also be published on a publicly accessible discipline-specific platform dedicated to wind energy. To provide the relevant and non-reproducible data beyond the project horizon, general community data repositories will be selected during the project. All code developments with respect to the simulation codes will be versioned, to allow traceability. Regarding commercial codes, best practice and methodology guidelines will be provided for future use in wind energy forecasting. The consortium will ensure OA to peer-reviewed scientific publications and seek opportunities to provide open access to other scientific publications (monographs, journal papers, conference proceedings, etc.). Publication in Open Research Europe (ORE, https://open-research-europe.ec.europa.eu/) platform will be prioritized and published in institutional and disciplinary repositories allowing licenses and PIDs assignment (according to FAIR principles). The consortium will ensure OA through the journal or by depositing the post-print, data and code, when relevant, in a trusted open repository for hybrid publication. Presentations, white papers and posters will be uploaded to SlideShare, while videos of workshops or training courses will be uploaded to YouTube.

1.2.5 Research data management and management of other research outputs

The project will deliver a first detailed data management plan by month 6 of its implementation. It will be kept up to date during the project, reporting the project data management choices, and revised at M36, when the final version of the project DMP will be delivered. The Data Management Plan (DMP) of the **WinDTwin** will gather information about:

- Datasets, standards, metadata collected and generated during the project.
- Methodologies and tools for data management during the project.
- Strategy for data preservation and curation after the project ends.
- Findability, Accessibility, Interoperability and Reusability of data and codes.

Some of the datasets generated in the project are expected to be confidential and, in consequence, not distributable. The selection of the licensing criteria will be discussed in the project implementation phase, following the principle "as open as possible, as close as necessary". Each of the project databases will be created according to the following general structure (some of the following databases may be omitted depending on the configuration case): i) Boundary conditions; ii) Experimental set-up; iii) Available experimental data; iv) Numerical set-up; v) Parallel set-up and CPU cost; and vi) Simulation results.
Based on the FAIR metrics, for each configuration a summary table with the main information of the configuration and a second table detailing information about the repositories will be provided. Besides, a descriptive table of each of the codes and experimental setup used within the project which covers their main characteristics. The FAIR Guiding Principles[21] describe distinct considerations for contemporary data publishing environments with respect to supporting both manual and automated deposition, exploration, sharing and reuse. A metric to quantify the degree of "FAIRness" of each dataset and of code in **WinDTwin** will be defined. In order to improve the "FAIRness" of each dataset in **WinDTwin** several actions will be taken into account:

- **Making WinDTwin data findable**: **WinDTwin** datasets suited for publication will be easily citable and easily findable with the assignment of Persistent Identifiers: 1)The codes (both for numerical simulations but also experimental data processing) will be stored in repositories which permit versioning and tags for the identification of official releases and the connection with their outputs; 2)Whenever possible, a rich metadata model and the register in disciplinary and generic repositories will be used to allow other scientists to find the datasets produced by the project; 3)Given the variety of the data of the project, the specific solutions and data models adopted for each dataset and software defined during the project will be published in the final DMP.
- **Making WinDTwin data openly accessible**: Dataset access will depend on the different cases and will be described in the corresponding dataset table. Restriction of access will be guaranteed in cases where confidential data is used or generated. Metadata will be made available on the web, independently on the accessibility of data.
- **Making WinDTwin data interoperable:** The choice of metadata standards and the way to access the data is still under discussion between the consortium members and is part of the planned activities in WP4 and WP5. Metadata standards will be chosen to guarantee maximum interoperability.

[21] https://www.eoscsecretariat.eu/working-groups/fair-working-group

- **Making WinDTwin data reusable:** All the **WinDTwin** datasets will be licensed under some Creative Commons data licensing[22](CC-BY will be preferred).

#§CON-MET-CM§# #§COM-PLE-CP§# #§REL-EVA-RE§#

2. Impact

2.1 Project's pathways towards impact

2.1.1 Unique contributions towards outcomes of this topic, and wider impacts of the work programme

WinDTwin will impact several objectives of the call HORIZON-CL5-2021-D3-03-04 from different points of view (i.e, scientific, economical, and social), hereafter the most relevant are discussed.

Scientific Impact:

Modelling of wake effects and wind turbines (WP3)

To meet our renewable energy targets, offshore wind energy gained importance over the last years. On the other hand, onshore wind farms are being installed over increasingly complex terrain. It is necessary to reduce wind model uncertainties to enhance wind farm design and improve wind resource assessment and forecasting. Onshore local processes in the ABL are affected by mesoscale circulations, which need to be modeled using numerical weather prediction (NWP) models. The use of a consistent meso-micro dynamical downscaling strategy couples a high-resolution large eddy simulation (LES) microscale model with NWP models. This coupling enables high fidelity simulation of local-flow structures while incorporating large-scale variability, accounting for the interaction of a vast range of spatial and temporal scales. The dynamic coupling is a helpful tool for wind farm optimization and short-term forecasting. Improvement in wind energy forecasting models has a substantial economic impact. **WinDTwin** will use machine learning (ML) techniques, fed with simulation results and data measurements to improve wind energy forecasting. Data fusion techniques will be used to improve the wake effects modeling and its understanding. Offshore wind farm energy production is affected by the wake produced by neighboring wind farms; the strength of this wake and energy losses are being modeled nowadays with high uncertainty. Wind farm wakes will be considered in wind energy forecasting models in **WinDTwin**. Different wind farm parametrizations in WRF will be compared against data measurements and LES model results to propose improvements. With the help of ML and reduced-order models (ROM), much faster high-resolution results for a particular wind farm will be obtained under different ABL conditions. The impact is the use of ML to extrapolate previous results to obtain the wind field under new wind conditions. We will reduce the solution and consider modes containing all the important physics, such as wakes, coherent structures, etc…
Finally, up to now, wind turbines and floaters have been designed independently, without accounting for their interaction. **WinDTwin** will develop a design tool for an optimum design of floating wind turbines, integrating wind turbine and floater interaction in terms of meteoceanic conditions for the first time.

Resource assessment and forecasting of power production (WP4)

The wind resource assessment phase is critical to determine the financial viability of any wind project. For instance, an approximately 10% inaccuracy in annual energy production can lead to 10% inaccuracy in revenue. This will be covered in **WinDTwin** with the development of an optimization tool tailored for offshore wind farms, taking into account such uncertainties to be later used in the financial assessment of the asset. The quality of the data is critical for this stage as well, as wind power plants projects are likely to be either delayed or rejected if the wind measurement campaign has not been conducted rigorously in terms of the calibration of measurement devices, data management, or wind flow modelling. This is addressed with the creation of historical climate baselines for the case studies combined with improved seasonal forecasts corrected with machine learning based models to have high quality data for WRA.
Decision-support tools based on short-term and longer-term wind power and weather forecasting are required for increasing the share of wind energy in the electricity mix across the world, as the electricity generated by wind energy systems is not easily dispatchable due the volatile nature of wind speeds. Such forecasts contribute to the management of the grid and balancing electricity consumption and generation, keeping the grid free from supply shortages or any other type of disruption. The importance of weather and wind power forecasts will only rise in the near future, as the

[22] https://creativecommons.org/about/cclicenses/

electricity system flexibility must increase by at least two-thirds even for the most modest energy transition scenarios projected by the International Energy Agency. On another note, accurate wind power forecasts can be leveraged for the decision-making process of participants in electricity markets, whereas high-resolution weather forecasts are essential to deploy data-driven O&M strategies.
O&M expenditures account for about 30% of the lifetime costs of an offshore wind project. As importantly, farm reliability and maintainability have a significant impact on the total energy yield of offshore wind farms, thus affecting the cost of energy per MWh. Both long-term and short-term O&M decision support models will be integrated into the offshore wind digital twin. The long-term strategic O&M model will provide the means to evaluate different O&M strategies (e.g. in respect to vessel chartering, port logistics and spare component strategies) for a given offshore wind farm, in different future long-term scenarios (e.g. varying farm clustering conditions that may arise due to the ongoing expansion and deployment of offshore wind farms). For farm developers and operators, the advanced reliability modelling of the offshore wind farm components will provide the means to perform data-driven decisions that optimize the operation and maintenance of an offshore wind farm, but also benchmark the reliability and maintainability of a given farm against industry averages. For policy-makers, the bird's eye view over the reliability and maintainability of different farms will improve transparency and support the development of informed policies.In respect to the short-term O&M model, when integrated into the offshore wind digital twin, will provide the means to improve short-term operational decisions based on weather forecasts, minimizing operation costs, energy losses and mitigating health and safety risks caused by weather uncertainty.

Energy distribution and demand of the end user (WP5)

WP5 will potentially help bridging a relevant gap between industry and the academia/research community, by generating sets of relevant data on offshore wind power generation, electricity price and user demand trends through the prism of a digital twin's (DT) philosophy. This will provide the building blocks of a novel and interdisciplinary approach to tackle, from the R&D&I standpoint, the multifaceted dynamics of VRE generation and user energy consumption, providing a fertile ground for innovative scientific breakthroughs. The approach merges the realms of energy engineering, data science, and predictive modelling.
The scientific impact of the WP reverberates across several key dimensions. At its core, the work addresses a critical challenge in the renewable energy sector - the intermittent and variable nature of wind power generation, and its alignment with the dynamic energy requirements of end users. By coupling wind power generation with real-time data on energy consumption patterns, research avenues eventually delve into uncharted territory. Additionally, WP5 potentially contributes to the advancement of predictive algorithms by underpinning on historical energy usage patterns, combined with other data required for the operationalization of the DT. Such data articulation pushes the boundaries of machine learning, statistical modelling, and optimization, providing a stage for the development of improved accuracy forecasting methods applicable not only to wind energy but also to broader energy distribution systems.
The WP's scientific implications further extend to the domain of sustainable energy integration. As renewable sources such as wind power become more prevalent, their harmonization with traditional energy grids becomes paramount. The WP's focus on end-user energy demand takes into account the intricate relationship between supply and consumption, facilitating research on the development of models that enable seamless integration of VRE sources into the larger energy ecosystem. This scientific aspect addresses a pressing need in the transition towards more sustainable energy landscapes.
The WPs focus on the assessment of energy management strategies involving sustainable storage solutions in combination with offshore wind energy effectively impacts a research topic of the utmost interest in recent years. Energy prices tend to fluctuate more than the prices of other commodities due to changes in supply and demand. The research of measures to mitigate the impact of such fluctuations and provide flexibility to offshore wind promoters is essential. Efficient, cost-effective, and environmentally friendly storage technologies can offer enhanced overall system performance, grid stability, and widespread renewable energy utilization.

Economic Impact:

In recent years, the increase of size in turbines is becoming an important driver in the cost reduction of wind energy, which is a key point to meet the carbon neutrality of the European Union by 2050. **Higher tower height and turbine rotors allow to increase the wind resource** and its corresponding wind power generation, **improving also the performance of the design and construction of wind turbines**, as well as their **operation and maintenance processes**. Thus, the atmospheric layer relevant in the wind energy production has growth to the first 400m of the atmosphere. This fact requires developing a better knowledge of the wind processes at higher altitudes and scales, considering its importance for both, the design of the different elements involved in wind generation and the forecast of wind power. It is expected that the **increase of wind resources due to a higher altitude** will allow a **higher**

Annual Energy Production (AEP) of any wind energy project and also an extension of the locations where a wind project can be profitable. However, the physical processes involved in wind energy generation at higher altitudes must be well understood in order to quantify and reduce the current uncertainty of the wind resource at higher above ground levels[23]. **The WinDTwin project** will contribute in this sense, **providing open access to an important amount of numerical data and tools capable of characterizing the behavior of wind processes at high altitude for representative conditions**.

Aspects related to the design of wind farm components for high altitude configurations must be also analyzed in this new context. For example, the frequency constraint lower bound must consider the high altitude or the loads could be highly increased, as well as a higher fatigue damage[24]. Additionally, **optimal design** could decrease the losses (e.g. wake effects), **increasing the AEP of the wind farm**. The optimization of all these design aspects for the new conditions is also crucial if it is considered its impact in the cost of production, the preventive maintenance or even the construction logistics. **The public availability of high resolution simulations of 3D wind fields and measurements under typical scenarios generated during the WinDTwin project, will provide an excellent opportunity for the industry to improve and optimize the design of the relevant components of wind turbines as well as their foundations**. This will impact the future costs of wind energy projects: operational expenditures (**OPEX**) will be **lower due to the decrease of the maintenance needs of the components** and consequently a **minor unavailability of the turbine will increase the AEP**. It is expected that the **gained knowledge** regarding high altitude conditions and the optimization of components allowed **will decrease uncertainty** for new projects, enlarging the market of components for high wind turbines, which will **decrease** the total capital expenditures (**CAPEX**) due to **scale economy**. One of the drivers of the optimization of the layout of a wind farm is the minimization of the losses due to wake effects. Bathelmie[25] estimated losses of 8% in onshore and 12% in offshore wind farms due to this effect. High resolution numerical simulations has been proven useful simulating the wakes effects[26] and are a proper tool for optimizing the wind farms layout[27]. Therefore, the **experimental and high resolution modeling data** for high altitude provided by the WinDTwin project **will contribute to the optimization of the layout for big turbine wind farms**, decreasing their losses, which will have a **positive effect** on their corresponding **AEP**. **Wind energy forecast is key for balancing the power system**, which is crucial for a proper integration of renewable energy into the electricity market. The quality of the forecast determines the amount of reserves to be procured, whose decrease save significant cost of operating the system[28]. The electricity markets respond to this need by means of regulation. Thus, the EU electricity markets follow a harmonization process for imbalance settlement[29] and although each country develops its own regulations, it is considered that the imbalances to the system due to forecast errors must be paid by the responsible parties. Therefore, **the improvements in wind energy forecast has a positive impact in the return of the wind energy projects investments**. Additionally, **speed and wind energy forecast become essential for a proper control of wind turbines, reducing uncertainty** and avoiding overflows[30], **adding grid stability to the electric system**. Besides, recent reports published by ECMWF and NOAA remarks the need to **improve** not only models and methodologies applied to meteorological forecasts, but also **the delivery of public information** to any public or private entity interested in meteorological data. At this regard, ECMWF established in their strategy for 2021 -2030[31] three main pillars:

- Science and technology, improving and maximizing observations through accurate modeling and high-performance computing big data and AI methodologies.
- Impact, looking to improve simulations of past, present, and future predictions and giving easy access to use the data to a wide user base
- Organization and People, building up a collaborative environment of people, companies, and associations in meteorological activities

[23] Lantz, Eric, Owen Roberts, Jake Nunemaker, Edgar DeMeo, Katherine Dykes, and George Scott. 2019. Increasing Wind Turbine Tower Heights: Opportunities and Challenges. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-73629.https://www.nrel.gov/docs/fy19osti/73629.pdf.

[24] Damiani, R. 2016. "Design of Offshore Wind Turbine Towers." Offshore Wind Farms Technologies, Design and Operation. ISBN: 978-0-08-100779-2. O'Reilly.

[25] Barthelmie RJ et al. Flow and wake in large wind farms in complex terrain and offshore. InEuropean Wind Energy Conference and Exhibition, Brussels, 2008

[26] Sanderse B. Review of computational fluid dynamics for wind turbine wake aerodynamics. Wind Energy. 2011 Feb; p. 799–819.

[27] Antonini, E. G. A., CFD-based Methodology for Wind Farm Layout Optimization, University of Toronto, 2018

[28] Value of Forecast for a wind power plant Owner, IEA Wind Task 36- Forecasting for Wind Power, Ea Energy Analyses , 2021

[29] COMMISSION REGULATION (EU) 2017/2195 of 23 November 2017 Article 52(2) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R2195&from=EN

[30] Wang Y. et al. "Optimal Wind Power Uncertainty Intervals for Electricity Market Operation," IEEE Transactions on Sustainable Energy, Vol. 9, No. 1, pp. 199-210, 2018.

[31] ECMWF STRATEGY 2021 - 2030. https://www.ecmwf.int/sites/default/files/elibrary/2021/ecmwf-strategy-2021-2030-en.pdf

Also, NOAA science advisory board[32], remarks three main pillars to build the report: Observations and data assimilation, Forecasting and Information delivery. Therefore, all efforts for the next years in main meteorological associations and public entities in Europe and USA moves around three key ideas:

- Improving observations and data assimilations through new technologies, which will help to improve meteorological forecasts.
- Use the data and high-performance computing to improve forecast with the focus in extreme events which are damaging economies and societies
- Information delivery in an integrated framework that can be accessed easily, helping to take fast decisions towards future extreme meteorological events to reduce socio-economic losses.

WinDTwin comes to research and develop these ideas oriented to the future of the wind industry that for the next decades is expected to have a steady growth in offshore projects up to 35GW[33] of capacity installed for 2030 and 2.000 GW for 2050 worldwide. **WinDTwin will increase data assimilation for offshore sites and meteorological modeling improvements for medium and high layers**. It will develop specific wind energy forecast approaches to improve the skills of current forecast methodologies. Data-driven machine learning methodologies using the experimental and numerical data will be applied to help design new disruptive technologies for improving wind energy forecasts. Additionally, t**he database of the experimental and high-resolution modeling of the flow could be employed for improving parameterizations or assumptions of models that are usable in operational forecasts**. Also, it will give **public and easy access through the digital twin produced within the project**, tailored for the wind energy industry. This platform is able to show forecasts of several meteorological models at the same time for different variables as well as show the machine learning forecasts results for energy or any meteorological variable.

An additional contribution of WinDTwin is in the field of operation and maintenance planning. The global wind industry installed capacity, in particular in Europe, is set to grow at a pace which highly challenges its supply chain capabilities. There is a big constraint in resource availability (i.e. major components and spare parts showing excessive lead times and high manufacturing costs), , as well as in crucial services (i.e. vessels, specialized technicians) needed to install and operate offshore wind farms. This context puts operators under a big pressure which ultimately has its impact on projects' availability and LCoE. WinDTwin will exploit available models within the consortium to develop optimization strategies for components sourcing, maintenance strategies and operations planning.

In conclusion, it is expected that **the WinDTwin project will contribute to decrease the cost of energy production (CAPEX and OPEX) and increase the production (AEP), allowing a decrease of the levelized cost of energy (LCOE)**. This is perfectly aligned with the framework established in the Horizon Europe program. In fact, Key Strategic Orientations (KSO) of Horizon Europe program claims for the *promoting an open strategic autonomy by leading the development of key digital, enabling and emerging technologies, sectors and value chains* to accelerate the green transitions (KSO-A) and as KSO-C for *Making Europe the first digitally enabled circular, climate-neutral and sustainable economy through the transformation of its mobility, energy, construction and production systems*.

Social Impact:

WinDTwin aims to help to increase the TRL of modern wind farms by the combination of theoretical, experimental, high-performance computing, and data-driven science innovations. The resulting developments will be integrated into a tool ready to be used as a knowledge hub, but also as a forecasting and design platform of disruptive wind turbine concepts (with increasing size and height). Therefore, the **WinDTwin** project may help in the achievement of the European Green Deal by the European Commission whereby Member States first milestone is to reduce their greenhouse gas (GHG) emissions by 55% by 2030[34]. Additionally, **WinDTwin** will also help link the energy sector (wind energy in particular) with the European Digitalisation strategy[35]. Recently, the European Union expressed the political commitment to participate and win in the race for the development of the most performant Computing and Artificial Intelligence technology (as compared to other world regions) has justified supporting the development of research infrastructure in high-performance computing. Scientific communities can now have access to the most powerful computing resources and use these to run simulations focused on energy challenges. Simulation enables us to plan for and work towards the clean energy sources of tomorrow in a digital framework, reducing considerably prototyping waste and costs. **WinDTwin** will make steps in this direction linking strong players in the EuroHPC system with key players (both in industry and research) of the wind energy sector. In this sense **WinDTwin** will help

[32] NOAA Cooperative Science Center in Atmospheric Science and Meteorology : "Priorities for Weather Research" December 2021. http://ncas-m.org/news/dec21-report-priorities-for-weather-research/

[33] GWEC. Global Offshore Wind Report. 9 September 2021. https://gwec.net/global-offshore-wind-report-2021/

[34] See Clean Energy fact sheet published by the European Commission on December 11, 2019.

[35] See "2030 Digital Compass: the European way for the Digital Decade", COM(2021)118 of March 9, 2021.

to develop the appropriate methodology and data analysis framework to plan investment and impact in energy efficiency. This is one of the key research lines recently proposed by EERA (European Energy Research Alliance) for the energy sector, where the need to support the development of tuned data models and simulation codes for energy thematic areas is pointed out as one of the key factors to achieve EU policy agenda to accelerate decarbonisation.

2.1.2 Describe any requirements and potential barriers

Below, barriers and framework conditions that need to be assessed in order to maximize the impact of **WinDTwin** are presented. The table focuses on the barriers that relate specifically to the spreading of knowledge and scientific research results, the concept and its implementation in the market.

N	Barrier	Approach
1	Restricted willingness to adopt new, numerical based, operative support tools in the market	The integration tools will be demonstrated on historical data throughout the Project to build confidence among end users of their validity. The front-end developed in WP6 will have a user-friendly setup and use.
2	Market governance and data restrictions from turbine manufacturer and wind farm operators	For operational decisions and control mode optimization, a relative estimation of fatigue loading between different possible modes of operation is adequate, that can be determined with sufficient accuracy from turbine data typically available to the operator. The control system behavior, especially in case of extreme events, should be included in technical documentation or can be deduced from SCADA data or operator owned measurements
3	Liability issues linked to decision support	Extensive testing with historic off-line data in order to build up confidence. Certification by a third party or certifying body.
4	Limitations in the quantification of modeling improvements forecasting wind power tested offline when became operational	WP7 will perform a real time validation of those modeling approaches forecasting wind power during a test period. Deliverable D7.2 will compare the results of both, the offline and the real time validation, in order to have an estimation of the future application of the improvements under real operational forecasting conditions. Project partners with easier access to operational data (IBERDROLA, ENGIE Laborelec, EDP NEW) can actively support the WinDTwin partners in challenging model outputs within well defined boundaries of data confidentiality.
5	A new forecast tool could derive into a complex interface. Learning curve for the user could be high	A user manual will be uploaded in the forecast tool so the user has enough help to reduce the learning curve as much as possible.
6	Limited access to real grid and grid connection system data or limited willingness to share this data and provide open access (esp. WP5)	Use generic grid data and information based on experience in national projects and international research. Restrictions in publication of provided grid and grid connection system data might be overcome by anonymisation of respective data.

2.2 Measures to maximise impact - Dissemination, exploitation and communication

Dissemination and Exploitation activities will be the cornerstone for generating a deep impact of the results reached in **WinDTwin**. To maximize the impact beyond the lifetime of the project, the backbone of the Plan for the Exploitation and Dissemination of Results (PED) has two main objectives (1) Dissemination: Telling the right stakeholders of the project results; (2) Exploitation: Getting the project results used to create innovation with impact. The starting point is the draft of PED. Later, this plan will be updated. The Dissemination and Communication Plan (D8.1) and the Exploitation and Business Plan (D8.8) will represent the two master plans of the **WinDTwin** PED strategy. The former will provide a framework and schedule for the different Communication, Engagement and Dissemination (CED) activities. Impact indicators are created with all the dissemination players, to monitor the impacts of the dissemination activities. Moreover, the CED plan includes a detailed methodology to package the knowledge produced according to the targeted audiences´ needs and serves as an internal communication tool within the consortium. In this sense, the project will:

- Identify the target audiences and stakeholders. Define concrete/measurable objectives for each group;

- Implement an innovative and multiplier-effect communication strategy, accompanied by a realistic plan to reach the above mentioned objectives;
- Set up the different CED channels and tools that will be used to implement the PEDR plan and reach the involvement of targeted audiences and
- Monitor the impact of the communication strategy in order to apply corrective actions whenever necessary and identify opportunities that can maximize the impact and visibility of project results.

WavEC will be responsible for the CED strategy and will coordinate its actions with the Communication team of the EC to disseminate actions and results through the available Horizon Europe channels.

Dissemination strategy:

Our overreaching approach for the dissemination strategy and its subsequent activities is to use the results generated during the project to create value within the target communities/initiatives within the EU. This approach ensures that public funding will lead the progress and positioning of European Industries as benchmark players within the global market. To conclude, dissemination concerns the communication of the project ("raising awareness") and its results ("achievements") targeted to target stakeholders, clusters, business communities and other potential users of the results. The project will promote the results and benefits for the external awareness creation and knowledge building with relevant stakeholders in an European Innovation Ecosystem, that is the offshore wind industry, other relevant industries, investors, governments and research and academia across Europe.

Partners	
IBERDROLA SOLUTE WAVEC ENGIE Laborelec EDP NEW OPEN CASCADE SINTEF MET Centre	Great capacities to impact in the Offshore Wind Energy Sector and complementary industry sectors including their client networks and commercialization channels. A special emphasis will be put on engaging investors associations and by demonstrating the added business value of the tools and competences developed in WinDTwin in the dissemination. Dissemination efforts will be focused on identifying and engaging potential clusters, businesses and investors interested in exploiting the results generated.
IBERDROLA SOLUTE	Great capacities to impact in the relevant sectors such advanced manufacturing, new materials and ICT and complementary industry sectors including their client networks and communication channels. Dissemination efforts will be focused on identifying and engaging potential clusters, businesses and investors interested in exploiting the results.
BSC FHG-IEE WAVEC SOLUTE ENGIE Laborelec EDP NEW SINTEF MET Centre	Engage the scientific, development agencies and business communities across Europe to raise awareness about the project and contribute to knowledge generation. Introduce new research lines and training programs aligned with the key pillars of the excellence in science established in HEU
+ATLANTIC UKS BSC SINTEF	The scientific community will be a focal point, with research papers and presentations at international conferences showcasing the technological breakthroughs and methodologies employed in the project.

As mentioned, to create an innovation ecosystem consist of several stakeholder types, such as clusters, industry, government, investors and research and academia. In the dissemination strategy, we will take an innovation ecosystem approach and the project will promote the results and benefits within the targeted user identified in the table below:

Target groups	Communication channels
Clusters (offshore wind clusters, etc.)	Conferences, industry workshop, European Cluster platform and European Smart Specialization Platform
Industry (industry associations, relevant businesses)	Web & social media; Press releases, conferences, industry events, dedicated workshops
Governments and decision makers (EC, National and Regional governments)	Web & social media; Policy workshops, Press releases, conferences, scientific journals.
Investors (investor associations, industrial investors, seed, venture and private capital)	Web & social media; Investors workshops, Press releases, conferences.
Research and academia	Web & social media; Press releases, journals and conferences
General Public and media	Web & social media; Press Releases

During the project, a common framework will be established for the exploitation and dissemination of project results covering all communities involved such as clusters, industry, governments, investors and research & academia) based on their presence and positioning in "multiplier networks'". Both dissemination and exploitation activities will be completely aligned with the needs of each member of the consortium. **WinDTwin** Partners will disseminate the results through a set of dissemination channels. The dissemination activities planned are:

- **Conferences and workshops:** EGU meeting; AGU meeting; AMS symposium on Boundary Layers and Turbulence; APS-DFD meeting; European Turbulence Conference; Torque; Wind Energy Science Conference; Wake Conference; DLES; ETMM, ECCOMAS; EERA Deepwind Conference; Science Meets Industry conference (Norway); European Union Sustainable Energy Week; IEEE PowerTech
- **Publication of results in high-impact journals:** Q. J. Roy. Meteorol. Soc., J. of Atmospheric Sciences, J. of Fluid Mechanics, J. of Geophysical Research- Atmospheres, Wind Energy, and J. Computational Physics, IEEE. Open-access options will be used whenever possible.

Exploitation plan:
The objective of the exploitation plan is to stimulate the project results to be used to create innovation with impact. Our plan has two dimensions (1) The Innovation Ecosystem dimension and (2) partner dimensions. These dimensions are fully integrated and will reinforce each other:

WinDTwin's strategy:
The core result of the **WinDTwin** project is to create a European Innovation Ecosystem in offshore wind. An innovation ecosystem has features such as (1) Diverse funding landscape (2) experienced serial entrepreneurs, (3) Public programs initiated in niche sectors (4) Highly transparent knowledge flow and specialized communities.

Partner's strategy:

- **IBERDROLA:** In **WinDTwin** the IBERDROLA forecasting methodology for 372 wind farms (20 GW in 15 countries) will be validated in an offshore wind farm and compared with the methodologies developed during **WinDTwin**. All the possible benefits of the new methodologies will be considered as future possible improvements to be applied to the rest of the assets. Additionally, all the gained knowledge regarding floating offshore wind farms will be employed to define a proper forecast methodology, ready for being used when the first IBERDROLA floating wind farm will be operational. Improvements of the methodology will be disseminated, following IBERDROLA's Innovation Policy.
- **BSC:** BSC will use the results of this project to improve its internal research lines in the fields of high-performance computing, machine learning and wind energy. The main benefits will be the development of new algorithms and methods, and the collaboration with key partners from the European wind energy ecosystem. Some of the BSC developments in this project will be used inside the final DT, thus enhancing BSC's technology transfer.

- **SOLUTE:** SOLUTE aims to improve their weather forecasting and wind resource assessment services. On the one hand, WRF modelling will contribute to improving the quality of the forecasts shown through Aphelion Weather, a web-based forecasting platform for all types of public. Improved wind power forecasting and resource assessment tools will be useful for further development of the in-house products developed by SOLUTE.
- **FHG-IEE:** The FHG-IEESociety is the largest organization for applied research in Europe. Through numerous industry contacts, the developed forecasts and power system studies can be transferred into broad (industry) application.
- **CoLAB +ATLANTIC:** Besides aiming to improve its knowledge of the wind energy sector, +ATLANTIC aims to leverage digital platforms to disseminate project updates, resources, and findings to a wider audience, fostering broader awareness and understanding of the project's outcomes.
- **OPEN CASCADE:** OPEN CASCADE will use the results of this project to improve its own commercial platform, especially visualisation components to be used to display results or dashboard. OPEN CASCADE is also looking to develop its knowledge of the wind energy sector to adapt its products to the specific needs related to this domain.
- **UNIVERSITAET KASSEL:** The e2n department at the UKS primarily pursues the acquisition of new knowledge, which is used directly for the education of students and PhD students. Dissemination activities are implemented in a targeted manner through the publication of scientific results in master's and doctoral theses as well as in specialist journals and at conferences in the form of posters and lectures.
- **WAVEC:** WavEC aims to leverage this project to improve and validate its own numerical tools related to O&M planning, reliability assessment and umbilical cable fatigue damage modelling in floating offshore wind systems. Building on the developed tools and acquired knowledge, WavEC will continue to develop consultancy services to offshore wind project and technology developers, during and post project.
- **SINTEF**: SINTEF is the largest research organization in Scandinavia with strong collaboration with the offshore wind energy sector. Several of the winDTwin project results will be exploited through contracted research services provided to the industry, namely: energy resource assessment studies, optimization of farm layouts and modelling of wake field flows within the wind farm.
- **ENGIE Laborelec** and **EDP NEW** will support Ocean Winds through internal innovation projects driven by their respective parent companies ENGIE and EDP. An enhanced forecasting of power production and more reliable operation of the offshore wind assets will result in optimized O&M and profitability of existing assets. For new projects, a better insight in uncertainties will result in a higher bankability and lower investment risks for new projects. ENGIE Laborelec will also benefit from the knowledge acquired in the project to improve its service activities for power performance measurements and wind measurements through enhanced analysis of LiDAR data.
- **EPRI** will incorporate the results of WinDTwin project within EPRI Wind and Offshore Wind programs and support its adoption by technology transfer to members from the industry.
- **MET Centre**, being the administrative body of the Norwegian Offshore Wind Cluster, will leverage its position to facilitate the exploitation of the results from WinDTwin. More concretely, there are several working groups under the umbrella of the cluster that may serve exploitation purposes.

Strategy for knowledge management and protection:
Our assessment is that on project level there will not be produced knowledge that is relevant for IP. The entire point of an innovation ecosystem is to share knowledge and build transparency in the networks. However, we will develop a strategy for the knowledge management and protection for the SMEs applying for the support schemes.

Communication Strategies:
Communication covers all actions that will help to disseminate the results achieved beyond the project consortium and the stakeholders involved. This maximizes the contribution of the project allowing to attract a wide number of stakeholders to embrace and benefit from the **WinDTwin** exploitable results. In this sense, the project will: i) Identify the target audiences and stakeholders. Define concrete and measurable objectives for each group; ii) Implement an innovative and multiplier-effect communication strategy, accompanied by a realistic plan to reach the above mentioned objectives. iii) Set up the different communication channels and tools that will be used to implement the PEDR plan and reach the involvement of targeted audiences and iv) Monitor the impact of the communication strategy to apply corrective actions whenever necessary and identify opportunities that can maximize the impact and visibility of the project. The consortium will try to reach the audience target groups below:

A. **Clusters and industry:** European and national cluster organization, relevant regional clusters in Europe, industry organization at EU, national and regional level.
B. **WinDTwin stakeholders:** Partners and relevant stakeholders in **WinDTwin** and other relevant EU projects.

C. **Research & Academia:** Researchers and academics from universities, research org. and R&D industry departments.
D. **Policy Makers:** at European, National and Regional level (Governments, Ministries, Agencies, etc.)
E. **Investor communities:** Investor association/organization at regional, national and European level.
F. **General audience:** Civil Society interested in the project.
G. **Media:** Generalist, specialized magazines, free-lance journalist focused on Energy and Environment

The communication measures within **WinDTwin** are tightly coupled with the different dissemination activities:

Mean	Description	KPI	Target
Logo & Presentations	Logo and Presentation Template for all Partners	1	B
Project Website & Positioning	Website: providing information about the project, demos and results, showcasing project's news	4000 visits	All
Videos & Multimedia	One promotional video and information pills presenting the overall progress during the project	500 views of Youtube	All
Social Media Channels	Twitter account (information, general domain news and communicating with parties); LinkedIn page to gather interested stakeholders	200 followers 100 members	All
Communication Material	Posters/Rollups presenting the project; Flyers/Leaflets that will contain general project information, best practices for events	1	All
Advanced Business/Success story Brochure	Development of a brochure gathering key information of the success stories, results and template developed (Factsheets, Specifications)	1	A, B, C, D, E and G
Joint events, workshops, round tables & networking	Events organized/co-organized by project inviting experts, researchers, clients and industry audience and events where the project will be invited to present its work and vision. All events will have presence on the website and Twitter	50 participant on the event/25 participant on the workshops	A, B C, D, E and G
Public Relations with Media	Press releases coinciding with the milestones of the project. Promotion of interviews and articles in specialized magazines and press conferences	6	A, B, C, D, E and G

#§COM-DIS-VIS-CDV§#

2.3 Summary

SPECIFIC NEEDS
The expected growth of both on- and offshore wind energy is enormous and many new wind parks are planned for the coming years. Experience from the existing wind farms shows the importance of a proper micrositing of the wind turbines as well their efficient interconnection within the farm. In addition, bringing wind farms together into clusters toward a wind power plant concept might induce long distance negative interaction between the farms, reducing their expected efficiency. This might happen both on- and offshore. The high amount of connected wind power and the expected increase during the coming years, requires that this technology has to be prepared to take a more important role as of its contribution to the reliability and security of the electricity system. The needs of this project is to develop a new digital twin to optimize the exploitation of individual wind farms as well as wind farm clusters, in view of transforming them into virtual power plants delivering a more reliable and secure electricity system.

EXPECTED RESULTS

- A Digital Twin platform to optimize the exploitation of wind farms. The platform will be implemented as a classic web-based client-server application with client part running in a browser and backend part hosted in a cluster of containers.
- High resolution LES models together with the dynamical downscaling methodology to couple with mesoscalar flows, to account for realistic atmospheric conditions.
- Improved wake models with the modeling of floating wind turbine platforms taking advantage of novel ML algorithms.
- Improved detailed physical modelling of wind turbines.
- Integration into the DT of methodologies developed for the wind resource assessment tools optimized considering characteristic weather conditions and orography of potential sites, state-of-the-art wind power and weather forecasting models at different prediction horizons and optimization tools for the strategic maintenance planning and operation of offshore wind farms.
- Integration into the DT analyses on energy demand and price predictions of electricity for long-term and short-term horizons, energy distribution, and the role offshore wind storage solutions play in mitigating curtailment
- Validation of the DT with real data from operating offshore wind farms.

D & E & C MEASURES

Dissemination and Communication

- Logo & Presentations: Visual identity to identify the project.
- Project Website & Positioning: Regularly updated platform displaying project progress and outcomes.
- Videos & Multimedia: Development of visual communication for the project website, social media channels and events.
- Social Media Channels: Set-up and maintenance of two channels: LinkedIn and Twitter.
- Communication Material: Preparation of a roll-up and a leaflet explaining the purpose of the project.
- Advanced Business/Success story Brochure: Preparation of a brochure to be presented at relevant events and distributed to stakeholders and the public.
- Joint events, workshops, round tables & networking: Engaging industry experts and stakeholders through presentations.
- Public Relations with Media: Issuing press releases and contact with media to generate news about the project.

Exploitation

- **WinDTwin** will develop a business plan aiming to define the most appropriate exploitation routes

TARGET GROUPS

- Clusters (offshore wind clusters, etc.)
- Industry (industry associations , relevant businesses)
- Governments and decision makers (EC, National and Regional governments)
- Investors (investor associations, industrial investors, seed, venture and private capital)
- Research and academia

OUTCOMES

- Increase the TRL of modern wind farms and wind turbines by the combination of theoretical, HPC, and data-driven science innovations.
- New methodologies and data analysis frameworks to plan investment and impact in wind energy applications.
- Public and easy access through the project DT which will be fully operative, and its development will be optimized from the scratch for the wind energy industry.

IMPACTS

Economic Impacts:

- Decrease the cost of energy production (CAPEX and OPEX).
- Increase the production (AEP).
- Decrease of the levelized cost of energy (LCOE).

Scientific impacts:

- Accurate modelling linked with high-performance computing big data and AI methodologies.
- Easy access to use the data and the DT to a wide user base.

#§IMP-ACT-IA§#

3. Quality and efficiency of the implementation

3.1 Work plan and resources

WinDTwin is structured in eight Work Packages (WPs). WP2 to WP7 include the technical aspects to ensure the innovation of the proposed research by technology evaluation, error quantification and assessment of the results. WP1 deals with the coordination and management of the entire project, WP8 addresses dissemination and exploitation strategies.
The relations and timing of the WPs and tasks within them are reflected, respectively, in Figure 1 and Figure 2 below. The tables containing the WP list, description, resources dedicated, and associated deliverables and milestones can be found in Annex 1 Part A.

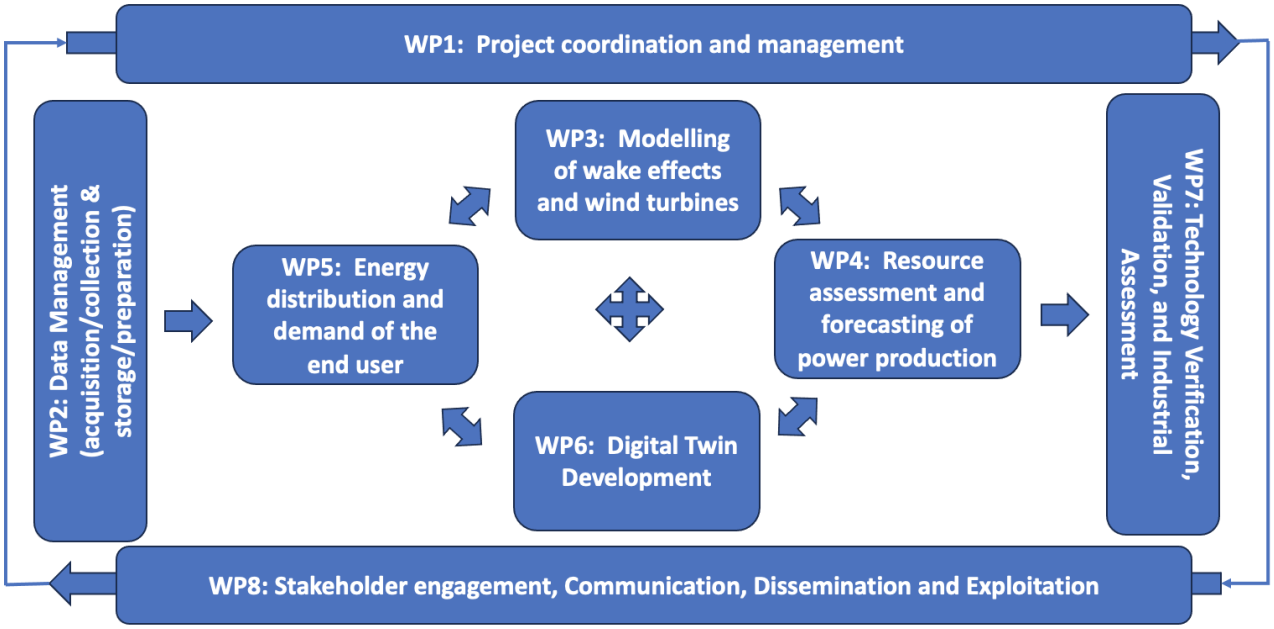


*Figure 1: Work Packages of **WinDTwin** and main relationships*

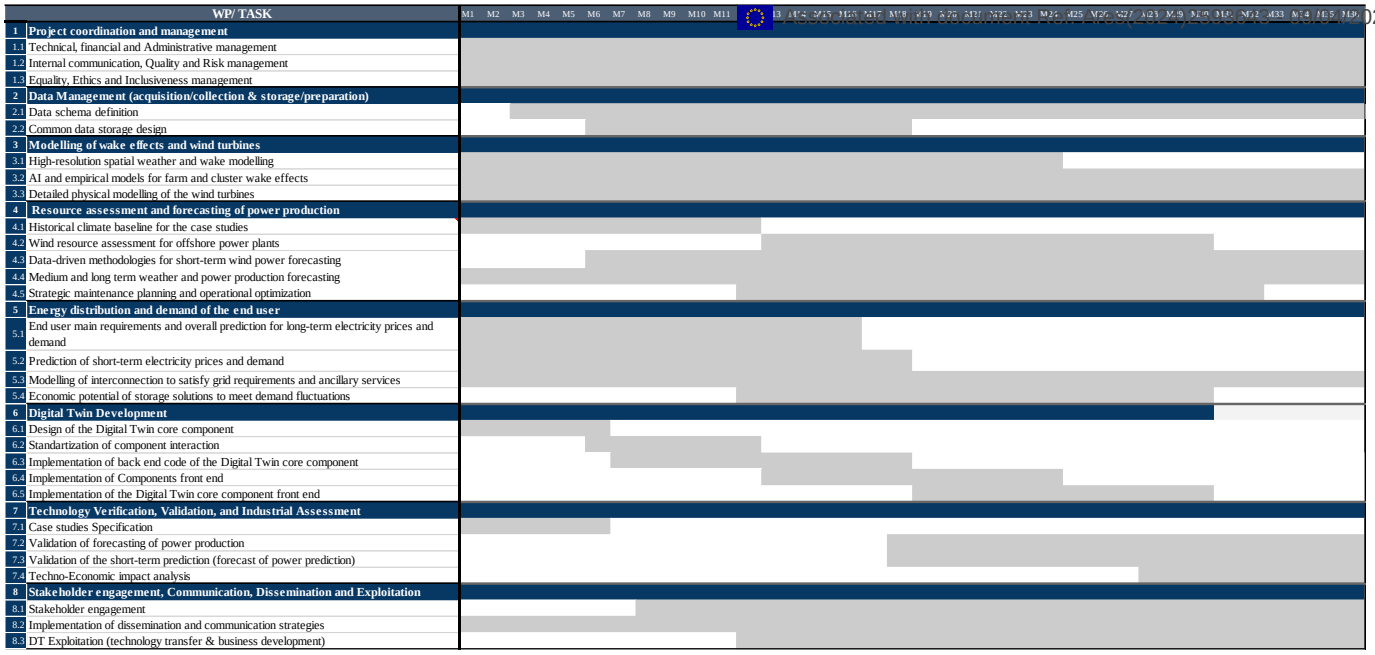


Figure 2: Gantt chart of WinDTwin containing all Work Packages split in tasks

3.2 Capacity of participants and consortium as a whole

To reach **WinDTwin** expected impact, the ambitious innovation-led research proposed necessitates bringing together a range of skills and expertise which cannot be found within a single member country or institution. This is why the **WinDTwin** consortium has carefully brought together leading groups working in the atmospheric, experimental, mathematical and computational sciences fields from 7 different European countries. We have put together a unique team that has a broad range of expertise through the whole wind energy development process; ranging from the management of wind energy production and development of industrial codes through to experts in measurement methods, numerical methods, algorithms and sensors, ensuring the uptake of improved methodologies. The **WinDTwin** consortium consists of 13 organizations from 7 different Member States:

Barcelona Supercomputing Center Description: The Barcelona Supercomputing Center – Centro Nacional de Supercomputación (BSC) was established in 2005 and serves as the Spanish national supercomputing facility. BSC hosts the MN 4 cluster with a peak performance capacity of 13,7 Petaflop/s. The Large-Scale Computational Fluid Dynamics (LS/CFD) team is focused on the development of numerical tools, turbulence models and data driven methodologies. The LS/CFD team currently is participating in 5 European projects (one coordinated) and 2 National projects (one coordinated). Additionally, the LS/CFD team is collaborating with ITPAero, IBERDROLA, OceanWinds and Airbus, besides academic collaborations with KTH, NASA, CTR Stanford, MIT, Queen's University, UPM or UPC. *Role in the project:* Scientific, Technical and Administrative Project Coordinator, WP1 and WP3 Leader.

FRAUNHOFER-IEEINSTITUTE FOR ENERGY ECONOMICS AND ENERGY SYSTEM TECHNOLOGY Description: FHG-IEE in Kassel, Germany, conducts research for the transformation of energy systems. It develops solutions for technical and economic challenges in order to further reduce the costs of using renewable energies, to secure supply despite volatile generation, to ensure grid stability at a high level and to lead the energy transition to economic success. IEE offers a rich portfolio of services, know-how and products that can be adapted to the needs of the customers from the energy supply, grid operation, energy electronics, energy informatics, wind energy, photovoltaics, bioenergy and investment sectors. The research field »Energy Meteorology and Geo Information Systems« is dealing with basic and applied research with focus on weather effects on energy systems. Research activities are performed to determine the characteristics of the renewable energy sources in high spatial and temporal resolution. Regional potentials are quantified on a long-term scale and assessed on their dynamic behaviour. The development and operation of RES forecast systems is one of the largest business areas at FHG-IEE. The focus of the grid planning and operation division's considerations is on the transformation process of energy grid infrastructures (electricity, gas and heat) in the context of decarbonisation (energy transition through renewable energies, heat pumps and electric vehicles), decentralisation (many small plants in the distribution grid instead of large power plants in the transmission grid) and digitalisation. To support this transformation, we are developing new methodologies and software solutions for grid analysis, planning and operations management. In the grid operation

department, innovative operation management concepts are (further) developed and introduced to real grid operation via IT system and control room solutions. The FHG-IEE in Kassel researches for the national and international transformation of energy systems. It develops technical and economic solutions in order to further reduce the costs of using renewable energies, to secure the supply despite volatile generation, to ensure grid stability at the high level and to promote the success of the energy transition business model. IEE offers a rich portfolio of services, know-how and products that can be adapted to the needs of the customers from the energy supply, grid operation, energy electronics, energy informatics, wind energy, photovoltaics, bioenergy and investment sectors.

WavEC Description: WavEC Offshore Renewables is a non-profit R&D-based organization dedicated to the development and promotion of marine renewable energies and other ocean engineering projects, having more than 20 years' experience in this field. WavEC encompasses all marine renewable technologies, as well as developments linked with other maritime sectors, exploiting positive synergies in technology developments, infrastructure, supply chain and policies. WavEC mission is to develop sustainable solutions for the blue economy through innovation, knowledge transfer and dissemination. WavEC's team is composed of specialists with a broad range of experience on ocean renewable energy, including both the technical (numerical modelling, wave resource, site selection, to monitoring, technology) and non-technical (economic models, environmental impacts and legislation and licensing, public policies, dissemination, public outreach) subjects. WavEC's track-record includes the involvement in major offshore renewable projects, developed in Portugal, such as: the Windfloat Atlantic (Windplus), Waveroller (AW Energy) and WaveBoost (CorPower).

CoLAB +ATLANTIC (+ATLANTIC) Description: +ATLANTIC range of operations spans from robotics (submarine and aerial), climate modelling and renewable energies to satellites and remote sensing services. With a multidisciplinary staff in remote sensing, data science and numerical modelling, +ATLANTIC aims at advancing knowledge on the interactions between the Ocean, Atmosphere, Climate and Energy in the Atlantic, with an integrated approach from deep sea to space, while building and leveraging on the expertise of its founding member. +ATLANTIC has a record of accomplishment on international projects, ranging from ESA and ECMWF/C3S Invitations to Tender to Horizon Europe (A-AAGORA, EDITO). Furthermore, given its mission in bridging the gap between the business fabric, public administration, and the scientific community, +ATLANTIC is also well positioned in facilitating the communication of the scientific outcomes to relevant stakeholders/final users, namely through easily understandable spatiotemporal data visualisation outputs. As a collaborative laboratory, +ATLANTIC brings together scientific, academic, and industrial communities by promoting and exploiting synergies between companies, universities, associations and research institutes. An example of an associate is WavEC, member of this consortium, dedicated to the development of marine renewable energy projects.

SOLUTE Description: SOLUTE is a multidisciplinary technical engineering consultancy with more than 15 years of experience headquartered in Madrid and with regional branches located in Spain. SOLUTE has specialized in the renewable energy sector, particularly with a strong focus on the wind energy industry, where our capabilities cover all phases of a wind farm development project, including but not limited to design, optimisation and certification of turbine components, life extension evaluation of towers and foundations, hybrid plants development, wind resource assessment, weather and energy forecasting, and design and certification of wind turbines foundations. SOLUTE's mission is to provide multidisciplinary solutions through technical rigor and knowledge of our engineers to guarantee the quality and excellence of our work in each project. SOLUTE has successfully been awarded several grants for the R&D sector which have been leveraged to develop and enhance in-house specialized software for wind resource assessment, energy forecasting and digitisation and virtualisation of wind energy services.

EPRI EUROPE DAC Description: EPRI Europe DAC (EPRI) was founded in 2019 to promote science and research as a non-profit organisation to conduct objective and independent energy and environmental research, development and demonstration projects, for the benefit of the public, with the ultimate goal of enhancing the quality of life by making electric power safe, reliable, affordable and environmentally responsible. EPRI participates in HORIZON Europe collaborative programmes as well as other research projects with European governments, bodies and stakeholders. EPRI focuses on electricity generation, delivery, and use, provides technology, policy and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI was established by the Electric Power Research Institute (EPRI) as its European research arm, and benefits from the wealth of experience, project knowledge and international network of EPRI. While most EPRI members are electric utilities, others are businesses; government agencies; regulators; and public or private entities engaged in some aspect of the generation, delivery, or use of electricity. Through advisory roles in EPRI research programs, EPRI members help identify critical and emerging electricity industry issues and support the application and technology transfer of EPRI's research and development. Within the power generation sector, EPRI has a specific program and dedicated team to Wind Power Generation. The Wind Power Generation program tracks global trends

and R&D and strengthens EPRI's global collaboration and engagement in research and development. Additionally, it is a primary technology transfer platform between R&D programs and utilities. The experience and know how developed in the Wind Power generation program will be used, within **WinDTwin**, for developing approaches for assessing and improving wind farm performance, reduce O&M costs of wind turbines, wind farm, and wind fleets, improve wind farm energy production and performance efficiency and extend life of wind power assets through monitoring and predictive maintenance.

UNIVERSITAET KASSEL Description:
The department of "Energy Management and Operation of Electrical Networks" (e^2n) represents in research and teaching the technically and economically optimised design, control and operation of the future decentralised energy supply system (smart grid) with a high proportion of renewable energies as an important challenge of the energy transition to ensure a secure, cost-efficient and sustainable energy supply. The department is part of the Competence Centre for Decentralised Electrical Energy Supply Technology (KDEE) and closely linked to the FHG-IEEInstitute for Energy Economics and Energy System Technology (IEE) at the Kassel site. The main focus is on technically and economically optimised concepts and procedures for the analysis, design, control and operational management of electrical grids. The main methodological focus is on the development of methods for modelling and simulation for the analysis and description of the system on all time scales and system levels as well as the multi-criteria optimisation of the design, control and operation management (incl. methods of complexity reduction). Moreover, one research group is dealing with energy meteorology. The group works on different aspects of weather influences on the planning and operation of energy systems like remote sensing methods, forecasts for energy systems, space-time dependencies and location-specific mapping of generation and consumption.

IBERDROLA RENOVABLES ENERGIA SA Description: IBERDROLA is the largest wind energy company worldwide, operating in more than 20 countries including the world markets with the greatest growth and development potential in this sector, and has made the environment and sustainable development the key pillars of its future business strategy to meet the global undertaking to reduce emissions. Boasting a base of operational renewable assets, mainly wind. At the middle of the year 2023, IBERDROLA's total installed capacity came to 62.045 MW, of which 66.5% (specifically 41.250 MW) were accounted for owned renewable sources, being the offshore wind installed capacity 1.370 MW in 2023, which has allowed consolidating its leadership position. IBERDROLA is also a world leader in the development of offshore wind energy, with operational capacity pipeline and early-stage developments of more than 38,000 MW. Focused on countries with ambitious targets, the company expects to have 18,000 MW of offshore wind energy in operation by 2030. In Europe, IBERDROLA is at the forefront of the offshore wind market with 1,300 MW of operational capacity in Germany and the UK (East Anglia ONE and West of Duddon Sands) and almost 1,000 MW coming soon in Germany (Baltic Eagle) and France (St. Brieuc). It manages a large portfolio of projects in the UK, France and Germany, as well as in new growth platforms such as Ireland, Sweden and Poland. In the US, where the construction of Vineyard Wind with 800 MW is being finished, IBERDROLA is participating in the development of Park City Wind (804 MW) and Kitty Hawk (1,300 MW). In the rest of the World, the company is consolidating new growth platforms in various regions, with a significant project pipeline in Asia (Japan and Taiwan), as well as in other emerging markets, such as Brazil. Additionally, IBERDROLA is taking a leading position in the field of floating offshore wind power by spearheading the European FLAGSHIP project. The initiative aims to demonstrate the viability and profitability of installing 10 MW+ wind turbines on floating platforms in Norway. Because it is involved in other similar projects, the company is able to gain an understanding of every stage in the development of this technology, which will prove crucial in achieving the global goals set for the energy sector.

SINTEF OCEAN AS Description: SINTEF is the largest independent research organization in Scandinavia, it is a non-profit research institute that applies research to produce new knowledge and innovative solutions in technology, medicine, natural and social sciences. The SINTEF Group performs contract R&D for industry and the public sector, aiming to fulfill the vision of "technology for a better society". SINTEF OCEAN AS is a separate company within the SINTEF Group, and has about 350 employees. SINTEF operates some of the worlds' most advanced marine technology laboratories, develops professional engineering software and performs research and innovation within the marine technology sector, with particular focus on: Ocean renewable energy, Oil and gas, Maritime, Aquaculture, Environmental technology, Fisheries, Fish processing and Biomarine resources. Mainly two departments will be involved in the WindTwin project: the Department of Ships and Ocean Structures and the Energy and Transport Department. SINTEF will have responsibility for WP4, which focuses on methods for resource assessment (wind and power production) for offshore wind farms and on short, medium and long term forecasting of power production and demonstration of their application within the project Digital Twin. Within the same WP4, SITEF Ocean will generate site specific historical climate baselines for the case studies, meaning the wind, waves and current statistics

representing a site's "normal" climate. Within WP3, SINTEF Ocean will use and expand its own software for wake modelling in wind farms (DIWA) and use and integrate methods for detailed modelling of fixed and floating wind turbines. The latter is aimed at predictions of the system responses with wind and waves e.g. motions, accelerations, structural loads and power production. SINTEF will also collaborate in the validation activities within WP7 and the communication, and dissemination activities in WP8.

BELGISCH LABORATORIUM VAN ELEKTRICITEITSINDUSTRIE Description: ENGIE Laborelec is a leading research and competence centre in electrical power technology. It was established in 1962 in order to support Belgian electricity companies with research, development, and specialized services. Today it is an active partner of ENGIE's Research & Innovation organisation. ENGIE Laborelec is an international consultant and service provider in electrical power technology inside and outside the ENGIE Group. The company executes worldwide project and service activities related to the entire value chain of electrical power technology: generation, transmission and distribution, storage and end-use. Our headquarters are located near Brussels, and we are part of a network of other ENGIE Labs in the ENGIE R&I community (Paris, the Netherlands, Germany, Middle-East, Chile, Brazil and Singapore). The ENGIE Group, the mother company of ENGIE Laborelec, is a global reference in low-carbon energy and services. In response to the urgency of climate change, ENGIE's ambition is to become the world leader in accelerating the zero carbon transition, together with its customers, in particular global companies and local authorities. ENGIE is active in 31 countries, employs 100,000 people worldwide and operates about 102.7 GW of electricity production capacity, including 38 GW of renewable energy (incl. 14.4 GW of wind energy). In 2019, ENGIE and EDPR decided to join their activities in offshore wind in the company OCEAN WINDS. Today, OCEAN WINDS has a gross capacity portfolio of 16.6 GW, involving 1.5 GW in operation, 1.9 GW in construction and 13.2 GW in development. This includes both bottom-fixed and floating wind projects. Role in the project: ENGIE Laborelec will collaborate intensively with EDP NEW R&D for the techno-economical validation in WP7. We will mainly focus on the technical evaluation of the elements of the Digital Twin developed in WindTwin, through a detailed benchmarking with operational data of floating and bottom-fixed assets of OCEAN WINDS. This evaluation will rely on our deep knowledge in wind resource evaluation and wind measurements, power performance measurements and structural health monitoring (SHM). This includes an experience with the execution and analysis of LiDAR measurements, SHM and SCADA data of more than 3 years of operation of the Windfloat Atlantic project, a pioneer project in the industrialization of floating wind.

OPEN CASCADE, a company from the Capgemini group, is a software company which is focused on the digital transformation of industries through the use of the latest technologies and services. Open Cascade is a highly experienced and constantly growing team at the service of industry. The company now offers end-user industrial software products and delivers software customization and integration services worldwide. Based on a wide range of high-performance proprietary software tools and services, Open Cascade develops the latest solutions in end-user industrial software products and delivers software customization and integration services worldwide. Besides mastering the various technologies that are relevant in the WinDTwin project, OPEN CASCADE Company has more than twenty years of experience in understanding customers' real needs and integrating various software components in order to build industrial software applications and open and flexible software platforms that fit to users' expectations respecting deadlines and budget constraints. OPEN CASCADE will act as the main integrator of the project and will define the architecture of the digital twin platform, develop the core component and guide other partners to develop their business components, and lead the development of user interfaces.

EDP NEW is EDP's Research and Development Center. EDP – Energias de Portugal is an integrated energy utility, with a global presence that includes operations in Europe (especially focused in Portugal and Spain but with relevant positions in France, Belgium, Italy, Romania, Poland and UK), in the United States and in Brazil. Throughout its 40-year-history, EDP has transformed from Portugal's incumbent electricity company to a major multinational energy company, producing, distributing and marketing energy (electricity and gas) worldwide. EDP NEW, founded in 2014, is a subsidiary of EDP Group and has the mission of creating value through collaborative R&D in the energy sector. It is fully committed to research and development with a strong focus in technology demonstration projects. As a result of an internal reorganization process in 2014, EDP NEW – also known as EDP NEW (Center for New Energy Technologies) – centralizes the Group's R&D activities and is established inside EDP Labelec – EDP's laboratorial facilities and technical excellence center. EDP NEW will collaborate intensively with ENGIE Laborelec for the techno-economical validation in WP7, focusing on the technical evaluation of the elements of the Digital Twin developed in WindTwin, through a detailed benchmarking with operational data of floating and bottom-fixed assets of OCEAN WINDS and using its proprietary Techno Economic Tool to assess the Digital Twin impact.

Marine Energy Test Centre Description: Founded in 2009, MET Centre is recognized as a world leading North Sea test centre for testing new marine renewable energy technologies such as floating wind power, solar energy and wave energy under various conditions. The test centre provides concessions, infrastructure and services required for testing in deep waters (200+ metres). Although floating offshore wind is a relatively new field, MET Centre already has a proud history. Equinor installed the world's very first floating wind turbine in MET Centre in 2009. METCentre's test area for floating offshore wind is located 10 km offshore close to yards, port, and several deep water quays. METCentre is also the administrative body of Norwegian Offshore Wind Cluster which is the largest offshore wind cluster in Norway with more than 370 member companies.

4. Ethics self-assessment

No ethics issues are identified within the project

ANNEX 2

ESTIMATED BUDGET (LUMP SUM BREAKDOWN) FOR THE ACTION

	Estimated EU contribution								
	Estimated eligible lump sum contributions (per work package)								Maximum grant amount[1]
	WP1 Project coordination and management	WP2 Data Management (acquisition/collection & storage/preparation)	WP3 Modelling of wake effects and wind turbines	WP4 Resource assessment and forecasting of power production	WP5 Energy distribution and demand of the end user	WP6 Digital Twin Development	WP7 Technology Verification, Validation, and Industrial Assessment	WP8 Stakeholder engagement, Communication, Dissemination and Exploitation	
Forms of funding	Lump sum contribution	Lump sum contribution	Lump sum contribution	Lump sum contribution	Lump sum contribution	Lump sum contribution	Lump sum contribution	Lump sum contribution	
	a	b	c	d	e	f	g	h	i = a + b + c + d + e + f + g + h
1 - BSC	179 750.00	27 500.00	179 750.00	13 750.00	0.00	77 750.00	85 250.00	43 750.00	607 500.00
2 - FHG-IEE	0.00	0.00	41 393.05	267 694.05	115 654.13	97 302.24	0.00	26 032.27	548 075.74
3 - WAVEC	57 850.00	14 500.00	139 250.00	99 100.00	178 600.00	21 750.00	21 750.00	201 606.25	734 406.25
4 - EPRI	26 250.00	0.00	0.00	170 625.00	108 750.00	13 125.00	0.00	28 125.00	346 875.00
5 - SOLUTE	20 250.00	15 000.00	42 750.00	312 656.25	106 953.13	65 000.00	20 000.00	26 250.00	608 859.38
6 - UKS	0.00	0.00	275 835.00	172 725.00	148 385.00	0.00	0.00	16 670.00	613 615.00
7 - IBERDROLA	38 750.00	17 500.00	0.00	8 750.00	0.00	0.00	70 000.00	17 500.00	152 500.00
8 - SINTEF	14 125.00	0.00	222 625.00	300 125.00	0.00	0.00	42 375.00	28 250.00	607 500.00
9 - +ATLANTIC	17 125.00	0.00	0.00	210 000.00	66 250.00	0.00	0.00	13 750.00	307 125.00
10 - OPEN CASCADE	10 375.00	73 312.50	0.00	0.00	0.00	449 687.50	14 875.00	18 250.00	566 500.00
11 - EDP NEW	30 500.00	38 750.00	18 750.00	31 875.00	104 375.00	37 500.00	154 250.00	31 000.00	447 000.00
12 - MET Centre	15 000.00	0.00	0.00	0.00	0.00	0.00	125 000.00	60 000.00	200 000.00
13 - ENGIE Laborelec	21 000.00	0.00	32 000.00	32 000.00	0.00	0.00	157 750.00	16 000.00	258 750.00
Σ consortium	430 975.00	186 562.50	952 353.05	1 619 300.30	828 967.26	762 114.74	691 250.00	527 183.52	5 998 706.37

[1] The 'maximum grant amount' is the maximum grant amount fixed in the grant agreement (on the basis of the sum of the beneficiaries' lump sum shares for the work packages).

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV (FHG-IEE), PIC 999984059, established in HANSASTRASSE 27C, MUNCHEN 80686, Germany,

hereby agrees

to become beneficiary

in Agreement No 101147377 — WindTwin ('the Agreement')

between BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC) **and** the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Christoph SCHULTE with ECAS id nschulch signed in the Participant Portal on 27/05/2024 at 11:26:40 (transaction id SigId-46940-q07Y59KbYGTk1lCYQfzQ781fdE6IJoB881d3SCNiMVGSS9qPsXOMxZSNk5hW3dfIBLjt9lRi78DapiyL3bmIzN-yntOf97TTHqoPPtGMdHyoy-TyjZvm8UFj5zZIqTogVK6QztJlT2cztYVBkmsvzxSeKpzH92DvvIl2LmEMLkDHeVYxnTrEH31482Uj68QQaiKK1). Timestamp by third party at 2024.05.27 11:26:47 CEST

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

WAVEC/OFFSHORE RENEWABLES - CENTRO DE ENERGIA OFFSHORE ASSOCIACAO (WAVEC), PIC 999543485, established in EDIFICIO DIOGO CAO, DOCA DE ALCANTA NORTE, LISBOA 1350-352, Portugal,

hereby agrees

to become beneficiary

in Agreement No 101147377 — WindTwin ('the Agreement')

between BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC) **and** the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Marco ALVES with ECAS id nalvesmc signed in the Participant Portal on 02/05/2024 at 13:35:44 (transaction id SigId-36039-m6ONPSAmyC47qFJtG4GHxxozsAjWRuuHy4FfdW11hUXGFiR2wo82vWDRp14qHALmYhph0Zzv7HhYqJhcOzUoFSG-yntOf97TTHq8GZt5aBGF4O-Gst1x0n1NP4Y8vxEzjgS6rgdjB6VOMk1ZMmxvna0qlURLuYxx9IzXk9D5DltEEjjfSrgdMSVMv4UPLiEEnB6HQ). Timestamp by third party at 2024.05.02 13:35:49 CEST

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

EPRI EUROPE DAC (EPRI), PIC 913811393, established in 3 DUBLIN LANDINGS NORTH WALL QUAY, DUBLIN D01 C4E0, Ireland,

hereby agrees

to become beneficiary

in Agreement No 101147377 — WindTwin ('the Agreement')

between BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC) **and** the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Eamonn LANNOYE with ECAS id nlanneam signed in the Participant Portal on 03/05/2024 at 12:44:39 (transaction id SigId-49535-4t6OrUQ7mySECmDNR52O0zvvqzyzryAEzJ6ngZpQ8xDWr6eWQYOwoDel2vCIipjkqgzpDeTeSXUPwekDC6V0N23-yntOf97TTHq8GZt5aBGF4O-34AzTXTG1QVHFzii8QO3FE1dcRL3FFCPymDwW67RrzX0MDwWAHaAYtmlzc33ft3RzmiGBRdiCiLIWkjtlzeC6Gq0). Timestamp by third party at 2024.05.03 12:44:45 CEST

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

ETULOS SOLUTE SL (SOLUTE), PIC 952762325, established in Av. Cerro del Aguila 3, SAN SEBASTIAN DE LOS REYES 28703, Spain,

hereby agrees

to become beneficiary

in Agreement No 101147377 — WindTwin ('the Agreement')

between BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC) **and** the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Ignacio RODRÍGUEZ with ECAS id nroiacio signed in the Participant Portal on 03/05/2024 at 10:29:22 (transaction id SigId-46477-RUEwf19sKV9zxckF7sPnr8V2hlJopUwUTYWafTsmYqtTABfGPnZdayO02FOLFeDzKE4gsebbAgmUUbc6rMUrqH-yntOf97TTHq8GZt5aBGF4O-215sCMjxeJ7zbrcXn2s35O6ct6XbhxesMsicl1lzTc00rjiTGzRgjBpsVHsPhzdzsjs61fbAr68cXzH3PR6n7glW). Timestamp by third party at 2024.05.03 10:29:28 CEST

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITAET KASSEL (UKS), PIC 999852624, established in MONCHEBERGSTRASSE 19, KASSEL 34125, Germany,

hereby agrees

to become beneficiary

in Agreement No 101147377 — WindTwin ('the Agreement')

between BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC) **and** the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Oliver FROMM with ECAS id nfrommol signed in the Participant Portal on 13/05/2024 at 09:01:37 (transaction id SigId-24758-GcpJnkkZEC40W8zdUNsztzZ2FzYAzNQCjenyWSm1Bs0KIUS6zSzoQFWt9v0oXGo2wsvgpqv0loycQgfIyRQ1euCO-yntOf97TTHqGzTPAPycp26-0j4zZzLP8SN9FWx9iBBhRcTbciw7y2lBdv8nSK1gCotyuVcgzdy3TpYVKuCClVMRb2alunljWqvIrQlqAP7XmzO). Timestamp by third party at 2024.05.13 09:01:46 CEST

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

IBERDROLA RENOVABLES ENERGIA SA (IBERDROLA), PIC 953093774, established in PLAZA EUSKADI 5, BILBAO 48009, Spain,

hereby agrees

to become beneficiary

in Agreement No 101147377 — WindTwin ('the Agreement')

between BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC) **and** the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Roberto MARISCAL with ECAS id nmarisro signed in the Participant Portal on 21/05/2024 at 10:33:57 (transaction id SigId-8294-MmhFN7Uzrj7OGrjteFo0V9RYP2NC6XanTZ8hBgYUiRAWOzVcSFmTvzemlAgc2fWXUN3q9O6VSMwFybHShbAuB5W-jpJZscgsw0KDbQkMPDydyW-sd7QIpFKpMzPUTF1cCLbUYHwDfvaGutLyXziYuzfFlUPTKAl8hPrzSmtzmsRPnvBsJ8Mg4Hq9Cd1zxAQbwQsiXze). Timestamp by third party at 2024.05.21 10:34:02 CEST

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

SINTEF OCEAN AS (SINTEF), PIC 997806603, established in PAUL FJERMSTADS VEG 59, TRONDHEIM 7052, Norway,

hereby agrees

to become beneficiary

in Agreement No 101147377 — WindTwin ('the Agreement')

between BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC) **and** the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Julie Brandhaug with ECAS id n002ct6q signed in the Participant Portal on 02/05/2024 at 12:40:02 (transaction id SigId-35209-oAYXCD RcHe259AcA7Ren7TQSEtBFRVJdyhQ6kIHznmxbcm5iauzsmaggyiafEz syx1ongPzbjOA23QMnDMlBJFS-yntOf97TTHq8GZt5aBGF4O-04UQ4X Yut6rbLUsW6GvdlnEQxD1R6TmQEzXw4HMMgQ7ieEmyKHb3KTzQT HgRD3d6choMvPwGVF22B0U2D3SOe8). Timestamp by third party at 2024.05.02 12:40:12 CEST

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

+ATLANTIC ASSOCIACAO PARA UM LABORATORIO COLABORATIVO DO ATLANTICO (+ATLANTIC), PIC 898055586, established in INSTITUTO POLITECNICO DE LEIRIA ESCOLA TECNOLOGIA DO MAR RUA DO CONHECIMENT 4, PENICHE 2520-614, Portugal,

hereby agrees

to become beneficiary

in Agreement No 101147377 — WindTwin ('the Agreement')

between BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC) **and** the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Nuno Lourenço with ECAS id n0030x6g signed in the Participant Portal on 29/05/2024 at 16:32:22 (transaction id SigId-30522-6IuDan6QLoNzX6PJijKZQ008hbdAqbkCtYdHWPGQ02q9YFBOvrt1YdNtxqfcGcQMN9hzZv9pLupYKnzyaJV1q30-jpJZscgsw0KDbQkMPDydyW-OG3LbrmztjOQyinleHuzWkmGuwpRcoy1Tt5eP3JbwS9ZwwP98FAY8Q35dMpQIDchr9x8kRjdykLyCmi9o5nKyj). Timestamp by third party at 2024.05.29 16:32:32 CEST

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

OPEN CASCADE (OPEN CASCADE), PIC 942422416, established in 1 PLACE DES FRERES MONTGOLFIER, GUYANCOURT 78280, France,

hereby agrees

to become beneficiary

in Agreement No 101147377 — WindTwin ('the Agreement')

between BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC) **and** the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

KAZAKOV MIKHAÏL with ECAS id nmikhaka signed in the Participant Portal on 02/05/2024 at 11:04:24 (transaction id SigId-32956-JGLXP7zumnIIEuzsVUIldrSgraWqbrlfsagRQDzyRKNosqzWjOvOWtRLLFzSNZNWDzmOu4DnBznangJzNOtP2Ak3-yntOf97TTHq8GZt5aBGF4O-kQs1SRCU0RCAM1bPiCZtVxudrgBsfdXkqPh3POEGbIRYX57Z0TUiLx9AyEP2MyptzklNRwBAg2JswS94vM74HS). Timestamp by third party at 2024.05.02 11:04:30 CEST

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

CNET CENTRE FOR NEW ENERGY TECHNOLOGIES SA (EDP NEW), PIC 933299857, established in RUA CIDADE DE GOA 4, SACAVEM E PRIOR VELHO LISBOA 2685 039, Portugal,

hereby agrees

to become beneficiary

in Agreement No 101147377 — WindTwin ('the Agreement')

between BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC) **and** the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

João Gonçalo MACIEL with ECAS id nmaciejo signed in the Participant Portal on 09/05/2024 at 11:56:21 (transaction id SigId-17351-LzqOy8F ztWqsiiGB8zIMl7tazW4pnhznqzkzsSkC3Irmzt6kO5Z33YOMn6CIydCn2 IiXsNE9RKtpkl3b6UzjE5PA0-yntOf97TTHqGzTPAPycp26-nHojyze8WmI XIZpIrj2u54KsJzmafFkN7UQKoBLcWaUhjSzvasA9pFeCiznwYBgzoTFsn bBzXC4LsOTTqeWTuDeG). Timestamp by third party at 2024.05.09 11:56:25 CEST

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

MARIN ENERGI TESTSENTER AS (MET Centre), PIC 928496902, established in HELGANESVEGEN 41, AVALDSNES 4299, Norway,

hereby agrees

to become beneficiary

in Agreement No 101147377 — WindTwin ('the Agreement')

between BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC) **and** the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Arvid NESSE with ECAS id nnessarv signed in the Participant Portal on 03/05/2024 at 11:21:59 (transaction id SigId-47692-BLAQG5y1yp TpsAHaIPyzsDcdd3Tm4NbXM3zWZNvKOpv6XmRGERW3O1UZO0Vp wjxwmbWXCXl3RulAcouAEbMzLA0-yntOf97TTHq8GZt5aBGF4O-6t9c XoxhzaO1JbaRRhGIzk7D0anbEcqPA9PVrLd9yFuyjFRd6rXXYqCRTv1I bcK68KHRjEzpi1638VwlwnATWHG). Timestamp by third party at 2024.05.03 11:22:06 CEST

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

BELGISCH LABORATORIUM VAN ELEKTRICITEITSINDUSTRIE (ENGIE Laborelec), PIC 998728200, established in RODESTRAAT 125, LINKEBEEK 1630, Belgium,

hereby agrees

to become beneficiary

in Agreement No 101147377 — WindTwin ('the Agreement')

between BARCELONA SUPERCOMPUTING CENTER CENTRO NACIONAL DE SUPERCOMPUTACION (BSC) **and** the **European Climate, Infrastructure and Environment Executive Agency (CINEA)** ('EU executive agency' or 'granting authority'), under the powers delegated by the European Commission ('European Commission'),

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 39.

By signing this accession form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and terms and conditions it sets out.

SIGNATURE

For the beneficiary

Philippe DE RAEDEMAEKER with ECAS id nraedeph signed in the Participant Portal on 24/05/2024 at 08:50:55 (transaction id SigId-29937-o407YNYiUzXUMUPPiHD6IqqxM967n1tQ6O5iqRpZ22Mhxj6sQhhA1lfXXA36QgesWEzY2IyEzbXpG919THQUOC0-yntOf97TTHqoPPtGMdHyoy-xzRB5ShI7gghRaSSTbw35dJMZVwuTi6GT4rUCjdrgaYY3ZIziGIE1uoPAf9VA6WUhWP5IIZ1YmnPurdxzcsuzJ8). Timestamp by third party at 2024.05.24 08:51:02 CEST

FINANCIAL STATEMENT FOR THE ACTION FOR REPORTING PERIOD [NUMBER]

	EU contribution											
	Eligible lump sum contributions (per work package)											Requested EU contribution
	WP1 [name]	WP2 [name]	WP3 [name]	WP4 [name]	WP5 [name]	WP6 [name]	WP7 [name]	WP8 [name]	WP9 [name]	WP10 [name]	WP [XX]	
Forms of funding	[Lump sum contribution]/[Financing not linked to costs]	[Lump sum contribution]/[Financing not linked to costs]	[Lump sum contribution]/[Financing not linked to costs]	[Lump sum contribution]/[Financing not linked to costs]	[Lump sum contribution]/[Financing not linked to costs]	[Lump sum contribution]/[Financing not linked to costs]	[Lump sum contribution]/[Financing not linked to costs]	[Lump sum contribution]/[Financing not linked to costs]	[Lump sum contribution]/[Financing not linked to costs]	[Lump sum contribution]/[Financing not linked to costs]	[Lump sum contribution]/[Financing not linked to costs]	
Status of completion	**COMPLETED**	**COMPLETED**	**COMPLETED**	**COMPLETED**	**COMPLETED**	**COMPLETED**	**COMPLETED**	**PARTIALLY COMPLETED**	**PARTIALLY COMPLETED**	**COMPLETED**	**NOT COMPLETED**	
	a	b	c	d	e	f	g	h	i	j	k	l = a + b+ c + d+ e+ f+ g+ h+ i+ j+ k
1 – [short name beneficiary]												
1.1 – [short name affiliated entity]												
2 – [short name beneficiary]												
2.1 – [short name affiliated entity]												
X – [short name associated partner]												
Total consortium												

The consortium hereby confirms that:

The information provided is complete, reliable and true.

The lump sum contributions declared are eligible (in particular, the work packages have been completed and the work has been properly implemented and/or the results were achieved; see Article 6).

The proper implementation of the action/achievement of the results can be substantiated by adequate records and supporting documentation that will be produced upon request or in the context of checks, reviews, audits and investigations (see Articles 19, 21 and 25).

ANNEX 5

SPECIFIC RULES

CONFIDENTIALITY AND SECURITY (— ARTICLE 13)

Sensitive information with security recommendation

Sensitive information with a security recommendation must comply with the additional requirements imposed by the granting authority.

Before starting the action tasks concerned, the beneficiaries must have obtained all approvals or other mandatory documents needed for implementing the task. The documents must be kept on file and be submitted upon request by the coordinator to the granting authority. If they are not in English, they must be submitted together with an English summary.

For requirements restricting disclosure or dissemination, the information must be handled in accordance with the recommendation and may be disclosed or disseminated only after written approval from the granting authority.

EU classified information

If EU classified information is used or generated by the action, it must be treated in accordance with the security classification guide (SCG) and security aspect letter (SAL) set out in Annex 1 and Decision 2015/444[1] and its implementing rules — until it is declassified.

Deliverables which contain EU classified information must be submitted according to special procedures agreed with the granting authority.

Action tasks involving EU classified information may be subcontracted only with prior explicit written approval from the granting authority and only to entities established in an EU Member State or in a non-EU country with a security of information agreement with the EU (or an administrative arrangement with the Commission).

EU classified information may not be disclosed to any third party (including participants involved in the action implementation) without prior explicit written approval from the granting authority.

ETHICS (— ARTICLE 14)

Ethics and research integrity

The beneficiaries must carry out the action in compliance with:

- ethical principles (including the highest standards of research integrity)

[1] Commission Decision 2015/444/EC, Euratom of 13 March 2015 on the security rules for protecting EU classified information (OJ L 72, 17.3.2015, p. 53).

and

- applicable EU, international and national law, including the EU Charter of Fundamental Rights and the European Convention for the Protection of Human Rights and Fundamental Freedoms and its Supplementary Protocols.

No funding can be granted, within or outside the EU, for activities that are prohibited in all Member States. No funding can be granted in a Member State for an activity which is forbidden in that Member State.

The beneficiaries must pay particular attention to the principle of proportionality, the right to privacy, the right to the protection of personal data, the right to the physical and mental integrity of persons, the right to non-discrimination, the need to ensure protection of the environment and high levels of human health protection.

The beneficiaries must ensure that the activities under the action have an exclusive focus on civil applications.

The beneficiaries must ensure that the activities under the action do not:

- aim at human cloning for reproductive purposes
- intend to modify the genetic heritage of human beings which could make such modifications heritable (with the exception of research relating to cancer treatment of the gonads, which may be financed)
- intend to create human embryos solely for the purpose of research or for the purpose of stem cell procurement, including by means of somatic cell nuclear transfer, or
- lead to the destruction of human embryos (for example, for obtaining stem cells).

Activities involving research on human embryos or human embryonic stem cells may be carried out only if:

- they are set out in Annex 1 or
- the coordinator has obtained explicit approval (in writing) from the granting authority.

In addition, the beneficiaries must respect the fundamental principle of research integrity — as set out in the European Code of Conduct for Research Integrity[2].

This implies compliance with the following principles:

- reliability in ensuring the quality of research reflected in the design, the methodology, the analysis and the use of resources
- honesty in developing, undertaking, reviewing, reporting and communicating research in a transparent, fair and unbiased way

[2] European Code of Conduct for Research Integrity of ALLEA (All European Academies).

- respect for colleagues, research participants, society, ecosystems, cultural heritage and the environment

- accountability for the research from idea to publication, for its management and organisation, for training, supervision and mentoring, and for its wider impacts

and means that beneficiaries must ensure that persons carrying out research tasks follow the good research practices including ensuring, where possible, openness, reproducibility and traceability and refrain from the research integrity violations described in the Code.

Activities raising ethical issues must comply with the additional requirements formulated by the ethics panels (including after checks, reviews or audits; see Article 25).

Before starting an action task raising ethical issues, the beneficiaries must have obtained all approvals or other mandatory documents needed for implementing the task, notably from any (national or local) ethics committee or other bodies such as data protection authorities.

The documents must be kept on file and be submitted upon request by the coordinator to the granting authority. If they are not in English, they must be submitted together with an English summary, which shows that the documents cover the action tasks in question and includes the conclusions of the committee or authority concerned (if any).

VALUES (— ARTICLE 14)

Gender mainstreaming

The beneficiaries must take all measures to promote equal opportunities between men and women in the implementation of the action and, where applicable, in line with the gender equality plan. They must aim, to the extent possible, for a gender balance at all levels of personnel assigned to the action, including at supervisory and managerial level.

INTELLECTUAL PROPERTY RIGHTS (IPR) — BACKGROUND AND RESULTS — ACCESS RIGHTS AND RIGHTS OF USE (— ARTICLE 16)

Definitions

Access rights — Rights to use results or background.

Dissemination — The public disclosure of the results by appropriate means, other than resulting from protecting or exploiting the results, including by scientific publications in any medium.

Exploit(ation) — The use of results in further research and innovation activities other than those covered by the action concerned, including among other things, commercial exploitation such as developing, creating, manufacturing and marketing a product or process, creating and providing a service, or in standardisation activities.

Fair and reasonable conditions — Appropriate conditions, including possible financial terms or royalty-free conditions, taking into account the specific circumstances of the request for access, for example the actual or potential value of the results or background to which access is requested and/or the scope, duration or other characteristics of the exploitation envisaged.

FAIR principles — ‘findability’, ‘accessibility’, ‘interoperability’ and ‘reusability’.

Open access — Online access to research outputs provided free of charge to the end-user.

Open science — An approach to the scientific process based on open cooperative work, tools and diffusing knowledge.

Research data management — The process within the research lifecycle that includes the organisation, storage, preservation, security, quality assurance, allocation of persistent identifiers (PIDs) and rules and procedures for sharing of data including licensing.

Research outputs — Results to which access can be given in the form of scientific publications, data or other engineered results and processes such as software, algorithms, protocols, models, workflows and electronic notebooks.

Scope of the obligations

For this section, references to ‘beneficiary’ or ‘beneficiaries’ do not include affiliated entities (if any).

Agreement on background

The beneficiaries must identify in a written agreement the background as needed for implementing the action or for exploiting its results.

Where the call conditions restrict control due to strategic interests reasons, background that is subject to control or other restrictions by a country (or entity from a country) which is not one of the eligible countries or target countries set out in the call conditions and that impact the exploitation of the results (i.e. would make the exploitation of the results subject to control or restrictions) must not be used and must be explicitly excluded from it in the agreement on background — unless otherwise agreed with the granting authority.

Ownership of results

Results are owned by the beneficiaries that generate them.

However, two or more beneficiaries own results jointly if:

- they have jointly generated them and
- it is not possible to:
  - establish the respective contribution of each beneficiary, or
  - separate them for the purpose of applying for, obtaining or maintaining their protection.

The joint owners must agree — in writing — on the allocation and terms of exercise of their joint ownership (‘**joint ownership agreement**’), to ensure compliance with their obligations under this Agreement.

Unless otherwise agreed in the joint ownership agreement or consortium agreement, each joint owner may grant non-exclusive licences to third parties to exploit the jointly-owned results (without any right to sub-license), if the other joint owners are given:

- at least 45 days advance notice and
- fair and reasonable compensation.

The joint owners may agree — in writing — to apply another regime than joint ownership.

If third parties (including employees and other personnel) may claim rights to the results, the beneficiary concerned must ensure that those rights can be exercised in a manner compatible with its obligations under the Agreement.

The beneficiaries must indicate the owner(s) of the results (results ownership list) in the final periodic report.

Protection of results

Beneficiaries which have received funding under the grant must adequately protect their results — for an appropriate period and with appropriate territorial coverage — if protection is possible and justified, taking into account all relevant considerations, including the prospects for commercial exploitation, the legitimate interests of the other beneficiaries and any other legitimate interests.

Exploitation of results

Beneficiaries which have received funding under the grant must — up to four years after the end of the action (see Data Sheet, Point 1) — use their best efforts to exploit their results directly or to have them exploited indirectly by another entity, in particular through transfer or licensing.

If, despite a beneficiary's best efforts, the results are not exploited within one year after the end of the action, the beneficiaries must (unless otherwise agreed in writing with the granting authority) use the Horizon Results Platform to find interested parties to exploit the results.

If results are incorporated in a standard, the beneficiaries must (unless otherwise agreed with the granting authority or unless it is impossible) ask the standardisation body to include the funding statement (see Article 17) in (information related to) the standard.

Additional exploitation obligations

Where the call conditions impose additional exploitation obligations (including obligations linked to the restriction of participation or control due to strategic assets, interests, autonomy or security reasons), the beneficiaries must comply with them — up to four years after the end of the action (see Data Sheet, Point 1).

Where the call conditions impose additional exploitation obligations in case of a public emergency, the beneficiaries must (if requested by the granting authority) grant for a limited period of time specified in the request, non-exclusive licences — under fair and reasonable conditions — to their results to legal entities that need the results to address the public emergency and commit to rapidly and broadly exploit the resulting products and services at fair and reasonable conditions. This provision applies up to four years after the end of the action (see Data Sheet, Point 1).

Additional information obligation relating to standards

Where the call conditions impose additional information obligations relating to possible standardisation, the beneficiaries must — up to four years after the end of the action (see Data Sheet, Point 1) — inform the granting authority, if the results could reasonably be expected to contribute to European or international standards.

Transfer and licensing of results

Transfer of ownership

The beneficiaries may transfer ownership of their results, provided this does not affect compliance with their obligations under the Agreement.

The beneficiaries must ensure that their obligations under the Agreement regarding their results are passed on to the new owner and that this new owner has the obligation to pass them on in any subsequent transfer.

Moreover, they must inform the other beneficiaries with access rights of the transfer at least 45 days in advance (or less if agreed in writing), unless agreed otherwise in writing for specifically identified third parties including affiliated entities or unless impossible under the applicable law. This notification must include sufficient information on the new owner to enable the beneficiaries concerned to assess the effects on their access rights. The beneficiaries may object within 30 days of receiving notification (or less if agreed in writing), if they can show that the transfer would adversely affect their access rights. In this case, the transfer may not take place until agreement has been reached between the beneficiaries concerned.

Granting licences

The beneficiaries may grant licences to their results (or otherwise give the right to exploit them), including on an exclusive basis, provided this does not affect compliance with their obligations.

Exclusive licences for results may be granted only if all the other beneficiaries concerned have waived their access rights.

Granting authority right to object to transfers or licensing — Horizon Europe actions

Where the call conditions in Horizon Europe actions provide for the right to object to transfers or licensing, the granting authority may — up to four years after the end of the action (see Data Sheet, Point 1) — object to a transfer of ownership or the exclusive licensing of results, if:

- the beneficiaries which generated the results have received funding under the grant
- it is to a legal entity established in a non-EU country not associated with Horizon Europe, and
- the granting authority considers that the transfer or licence is not in line with EU interests.

Beneficiaries that intend to transfer ownership or grant an exclusive licence must formally notify the granting authority before the intended transfer or licensing takes place and:

- identify the specific results concerned
- describe in detail the new owner or licensee and the planned or potential exploitation of the results, and
- include a reasoned assessment of the likely impact of the transfer or licence on EU interests, in particular regarding competitiveness as well as consistency with ethical principles and security considerations.

The granting authority may request additional information.

If the granting authority decides to object to a transfer or exclusive licence, it must formally notify the beneficiary concerned within 60 days of receiving notification (or any additional information it has requested).

No transfer or licensing may take place in the following cases:

- pending the granting authority decision, within the period set out above
- if the granting authority objects
- until the conditions are complied with, if the granting authority objection comes with conditions.

A beneficiary may formally notify a request to waive the right to object regarding intended transfers or grants to a specifically identified third party, if measures safeguarding EU interests are in place. If the granting authority agrees, it will formally notify the beneficiary concerned within 60 days of receiving notification (or any additional information requested).

Granting authority right to object to transfers or licensing — Euratom actions

Where the call conditions in Euratom actions provide for the right to object to transfers or licensing, the granting authority may — up to four years after the end of the action (see Data Sheet, Point 1) — object to a transfer of ownership or the exclusive or non-exclusive licensing of results, if:

- the beneficiaries which generated the results have received funding under the grant
- it is to a legal entity established in a non-EU country not associated to the Euratom Research and Training Programme 2021-2025 and
- the granting authority considers that the transfer or licence is not in line with the EU interests.

Beneficiaries that intend to transfer ownership or grant a licence must formally notify the granting authority before the intended transfer or licensing takes place and:

- identify the specific results concerned
- describe in detail the results, the new owner or licensee and the planned or potential exploitation of the results, and
- include a reasoned assessment of the likely impact of the transfer or licence on EU interests, in particular regarding competitiveness as well as consistency with

ethical principles and security considerations (including the defence interests of the EU Member States under Article 24 of the Euratom Treaty).

The granting authority may request additional information.

If the granting authority decides to object to a transfer or licence, it will formally notify the beneficiary concerned within 60 days of receiving notification (or any additional information requested).

No transfer or licensing may take place in the following cases:

- pending the granting authority decision, within the period set out above
- if the granting authority objects
- until the conditions are complied with, if the granting authority objection comes with conditions.

A beneficiary may formally notify a request to waive the right to object regarding intended transfers or grants to a specifically identified third party, if measures safeguarding EU interests are in place. If the granting authority agrees, it will formally notify the beneficiary concerned within 60 days of receiving notification (or any additional information requested).

Limitations to transfers and licensing due to strategic assets, interests, autonomy or security reasons of the EU and its Member States

Where the call conditions restrict participation or control due to strategic assets, interests, autonomy or security reasons, the beneficiaries may not transfer ownership of their results or grant licences to third parties which are established in countries which are not eligible countries or target countries set out in the call conditions (or, if applicable, are controlled by such countries or entities from such countries) — unless they have requested and received prior approval by the granting authority.

The request must:

- identify the specific results concerned
- describe in detail the new owner and the planned or potential exploitation of the results, and
- include a reasoned assessment of the likely impact of the transfer or license on the strategic assets, interests, autonomy or security of the EU and its Member States.

The granting authority may request additional information.

Access rights to results and background

Exercise of access rights — Waiving of access rights — No sub-licensing

Requests to exercise access rights and the waiver of access rights must be in writing.

Unless agreed otherwise in writing with the beneficiary granting access, access rights do not include the right to sub-license.

If a beneficiary is no longer involved in the action, this does not affect its obligations to grant access.

If a beneficiary defaults on its obligations, the beneficiaries may agree that that beneficiary no longer has access rights.

Access rights for implementing the action

The beneficiaries must grant each other access — on a royalty-free basis — to background needed to implement their own tasks under the action, unless the beneficiary that holds the background has — before acceding to the Agreement —:

- informed the other beneficiaries that access to its background is subject to restrictions, or

- agreed with the other beneficiaries that access would not be on a royalty-free basis.

The beneficiaries must grant each other access — on a royalty-free basis — to results needed for implementing their own tasks under the action.

Access rights for exploiting the results

The beneficiaries must grant each other access — under fair and reasonable conditions — to results needed for exploiting their results.

The beneficiaries must grant each other access — under fair and reasonable conditions — to background needed for exploiting their results, unless the beneficiary that holds the background has — before acceding to the Agreement — informed the other beneficiaries that access to its background is subject to restrictions.

Requests for access must be made — unless agreed otherwise in writing — up to one year after the end of the action (see Data Sheet, Point 1).

Access rights for entities under the same control

Unless agreed otherwise in writing by the beneficiaries, access to results and, subject to the restrictions referred to above (if any), background must also be granted — under fair and reasonable conditions — to entities that:

- are established in an EU Member State or Horizon Europe associated country

- are under the direct or indirect control of another beneficiary, or under the same direct or indirect control as that beneficiary, or directly or indirectly controlling that beneficiary and

- need the access to exploit the results of that beneficiary.

Unless agreed otherwise in writing, such requests for access must be made by the entity directly to the beneficiary concerned.

Requests for access must be made — unless agreed otherwise in writing — up to one year after the end of the action (see Data Sheet, Point 1).

Access rights for the granting authority, EU institutions, bodies, offices or agencies and national authorities to results for policy purposes — Horizon Europe actions

In Horizon Europe actions, the beneficiaries which have received funding under the grant must grant access to their results — on a royalty-free basis — to the granting authority, EU institutions, bodies, offices or agencies for developing, implementing and monitoring EU policies or programmes. Such access rights do not extend to beneficiaries' background.

Such access rights are limited to non-commercial and non-competitive use.

For actions under the cluster 'Civil Security for Society', such access rights also extend to national authorities of EU Member States for developing, implementing and monitoring their policies or programmes in this area. In this case, access is subject to a bilateral agreement to define specific conditions ensuring that:

- the access rights will be used only for the intended purpose and
- appropriate confidentiality obligations are in place.

Moreover, the requesting national authority or EU institution, body, office or agency (including the granting authority) must inform all other national authorities of such a request.

Access rights for the granting authority, Euratom institutions, funding bodies or the Joint Undertaking Fusion for Energy — Euratom actions

In Euratom actions, the beneficiaries which have received funding under the grant must grant access to their results — on a royalty-free basis — to the granting authority, Euratom institutions, funding bodies or the Joint Undertaking Fusion for Energy for developing, implementing and monitoring Euratom policies and programmes or for compliance with obligations assumed through international cooperation with non-EU countries and international organisations.

Such access rights include the right to authorise third parties to use the results in public procurement and the right to sub-license and are limited to non-commercial and non-competitive use.

Additional access rights

Where the call conditions impose additional access rights, the beneficiaries must comply with them.

COMMUNICATION, DISSEMINATION, OPEN SCIENCE AND VISIBILITY (— ARTICLE 17)

Dissemination

Dissemination of results

The beneficiaries must disseminate their results as soon as feasible, in a publicly available format, subject to any restrictions due to the protection of intellectual property, security rules or legitimate interests.

A beneficiary that intends to disseminate its results must give at least 15 days advance notice to the other beneficiaries (unless agreed otherwise), together with sufficient information on the results it will disseminate.

Any other beneficiary may object within (unless agreed otherwise) 15 days of receiving notification, if it can show that its legitimate interests in relation to the results or background would be significantly harmed. In such cases, the results may not be disseminated unless appropriate steps are taken to safeguard those interests.

Additional dissemination obligations

Where the call conditions impose additional dissemination obligations, the beneficiaries must also comply with those.

Open Science

Open science: open access to scientific publications

The beneficiaries must ensure open access to peer-reviewed scientific publications relating to their results. In particular, they must ensure that:

- at the latest at the time of publication, a machine-readable electronic copy of the published version or the final peer-reviewed manuscript accepted for publication, is deposited in a trusted repository for scientific publications

- immediate open access is provided to the deposited publication via the repository, under the latest available version of the Creative Commons Attribution International Public Licence (CC BY) or a licence with equivalent rights; for monographs and other long-text formats, the licence may exclude commercial uses and derivative works (e.g. CC BY-NC, CC BY-ND) and

- information is given via the repository about any research output or any other tools and instruments needed to validate the conclusions of the scientific publication.

Beneficiaries (or authors) must retain sufficient intellectual property rights to comply with the open access requirements.

Metadata of deposited publications must be open under a Creative Common Public Domain Dedication (CC 0) or equivalent, in line with the FAIR principles (in particular machine-actionable) and provide information at least about the following: publication (author(s), title, date of publication, publication venue); Horizon Europe or Euratom funding; grant project name, acronym and number; licensing terms; persistent identifiers for the publication, the authors involved in the action and, if possible, for their organisations and the grant. Where applicable, the metadata must include persistent identifiers for any research output or any other tools and instruments needed to validate the conclusions of the publication.

Only publication fees in full open access venues for peer-reviewed scientific publications are eligible for reimbursement.

Open science: research data management

The beneficiaries must manage the digital research data generated in the action (‘data’) responsibly, in line with the FAIR principles and by taking all of the following actions:

- establish a data management plan (‘DMP’) (and regularly update it)

- as soon as possible and within the deadlines set out in the DMP, deposit the data in a trusted repository; if required in the call conditions, this repository must be federated in the EOSC in compliance with EOSC requirements

- as soon as possible and within the deadlines set out in the DMP, ensure open access — via the repository — to the deposited data, under the latest available version of the Creative Commons Attribution International Public License (CC BY) or Creative Commons Public Domain Dedication (CC 0) or a licence with equivalent rights, following the principle 'as open as possible as closed as necessary', unless providing open access would in particular:

    - be against the beneficiary's legitimate interests, including regarding commercial exploitation, or

    - be contrary to any other constraints, in particular the EU competitive interests or the beneficiary's obligations under this Agreement; if open access is not provided (to some or all data), this must be justified in the DMP

- provide information via the repository about any research output or any other tools and instruments needed to re-use or validate the data.

Metadata of deposited data must be open under a Creative Common Public Domain Dedication (CC 0) or equivalent (to the extent legitimate interests or constraints are safeguarded), in line with the FAIR principles (in particular machine-actionable) and provide information at least about the following: datasets (description, date of deposit, author(s), venue and embargo); Horizon Europe or Euratom funding; grant project name, acronym and number; licensing terms; persistent identifiers for the dataset, the authors involved in the action, and, if possible, for their organisations and the grant. Where applicable, the metadata must include persistent identifiers for related publications and other research outputs.

Open science: additional practices

Where the call conditions impose additional obligations regarding open science practices, the beneficiaries must also comply with those.

Where the call conditions impose additional obligations regarding the validation of scientific publications, the beneficiaries must provide (digital or physical) access to data or other results needed for validation of the conclusions of scientific publications, to the extent that their legitimate interests or constraints are safeguarded (and unless they already provided the (open) access at publication).

Where the call conditions impose additional open science obligations in case of a public emergency, the beneficiaries must (if requested by the granting authority) immediately deposit any research output in a repository and provide open access to it under a CC BY licence, a Public Domain Dedication (CC 0) or equivalent. As an exception, if the access would be against the beneficiaries' legitimate interests, the beneficiaries must grant non-exclusive licenses — under fair and reasonable conditions — to legal entities that need the research output to address the public emergency and commit to rapidly and broadly exploit the resulting products and services at fair and reasonable conditions. This provision applies up to four years after the end of the action (see Data Sheet, Point 1).

Plan for the exploitation and dissemination of results including communication activities

Unless excluded by the call conditions, the beneficiaries must provide and regularly update a plan for the exploitation and dissemination of results including communication activities.

SPECIFIC RULES FOR CARRYING OUT THE ACTION (— ARTICLE 18)

Implementation in case of restrictions due to strategic assets, interests, autonomy or security of the EU and its Member States

Where the call conditions restrict participation or control due to strategic assets, interests, autonomy or security, the beneficiaries must ensure that none of the entities that participate as affiliated entities, associated partners, subcontractors or recipients of financial support to third parties are established in countries which are not eligible countries or target countries set out in the call conditions (or, if applicable, are controlled by such countries or entities from such countries) — unless otherwise agreed with the granting authority.

The beneficiaries must moreover ensure that any cooperation with entities established in countries which are not eligible countries or target countries set out in the call conditions (or, if applicable, are controlled by such countries or entities from such countries) does not affect the strategic assets, interests, autonomy or security of the EU and its Member States.

Recruitment and working conditions for researchers

The beneficiaries must take all measures to implement the principles set out in the Commission Recommendation on the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers[3], in particular regarding:

- working conditions
- transparent recruitment processes based on merit, and
- career development.

The beneficiaries must ensure that researchers and all participants involved in the action are aware of them.

Specific rules for access to research infrastructure activities

Definitions

Research Infrastructures — Facilities that provide resources and services for the research communities to conduct research and foster innovation in their fields. This definition includes the associated human resources, and it covers major equipment or sets of instruments; knowledge-related facilities such as collections, archives or scientific data infrastructures; computing systems, communication networks, and any other infrastructure, of a unique nature and open to external users, essential to achieve excellence in research and innovation. Where relevant, they may be used beyond research, for example

[3] Commission Recommendation 2005/251/EC of 11 March 2005 on the European Charter for Researchers and on a Code of Conduct for the Recruitment of Researchers (OJ L 75, 22.3.2005, p. 67).

for education or public services, and they may be 'single-sited', 'virtual' or 'distributed'[4]:

When implementing access to research infrastructure activities, the beneficiaries must respect the following conditions:

- for transnational access:
  - access which must be provided:

    The access must be free of charge, transnational access to research infrastructure or installations for selected user-groups.

    The access must include the logistical, technological and scientific support and the specific training that is usually provided to external researchers using the infrastructure. Transnational access can be either in person (hands-on), provided to selected users that visit the installation to make use of it, or remote, through the provision to selected user-groups of remote scientific services (e.g. provision of reference materials or samples, remote access to a high-performance computing facility).

  - categories of users that may have access:

    Transnational access must be provided to selected user-groups, i.e. teams of one or more researchers (users).

    The majority of the users must work in a country other than the country(ies) where the installation is located (unless access is provided by an international organisation, the Joint Research Centre (JRC), an ERIC or similar legal entity).

    Only user groups that are allowed to disseminate the results they have generated under the action may benefit from the access (unless the users are working for SMEs).

    Access for user groups with a majority of users not working in a EU Member State or Horizon Europe associated country is limited to 20% of the total amount of units of access provided under the grant (unless a higher percentage is foreseen in Annex 1).

  - procedure and criteria for selecting user groups:

    The user groups must request access by submitting (in writing) a description of the work that they wish to carry out and the names, nationalities and home institutions of the users.

    The user groups must be selected by (one or more) selection panels set up by the consortium.

[4] See Article 2(1) of the Horizon Europe Framework Programme Regulation 2021/695.

The selection panels must be composed of international experts in the field, at least half of them independent from the consortium (unless otherwise specified in Annex 1).

The selection panels must assess all proposals received and recommend a short-list of the user groups that should benefit from access.

The selection panels must base their selection on scientific merit, taking into account that priority should be given to user groups composed of users who:

- have not previously used the installation and
- are working in countries where no equivalent research infrastructure exist.

It will apply the principles of transparency, fairness and impartiality.

Where the call conditions impose additional rules for the selection of user groups, the beneficiaries must also comply with those.

- other conditions:

The beneficiaries must request written approval from the granting authority for the selection of user groups requiring visits to the installations exceeding 3 months (unless such visits are foreseen in Annex 1).

In addition, the beneficiaries must:

- advertise widely, including on a their websites, the access offered under the Agreement
- promote equal opportunities in advertising the access and take into account the gender dimension when defining the support provided to users
- ensure that users comply with the terms and conditions of the Agreement
- ensure that its obligations under Articles 12, 13, 17 and 33 also apply to the users
- keep records of the names, nationalities, and home institutions of users, as well as the nature and quantity of access provided to them

- for virtual access:
  - access which must be provided:

The access must be free of charge, virtual access to research infrastructure or installations.

'Virtual access' means open and free access through communication networks to digital resources and services needed for research, without selecting the users to whom access is provided.

The access must include the support that is usually provided to external users.

Where allowed by the call conditions, beneficiaries may in justified cases define objective eligibility criteria (e.g. affiliation to a research or academic institution) for specific users.

- other conditions:

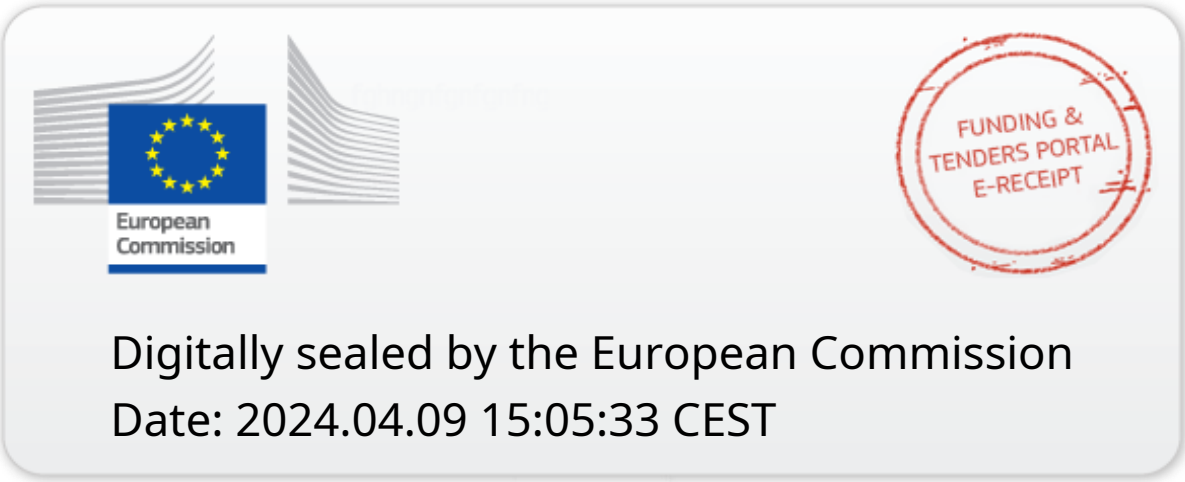
  The beneficiaries must have the virtual access services assessed periodically by a board composed of international experts in the field, at least half of whom must be independent from the consortium (unless otherwise specified in Annex 1). For this purpose, information and statistics on the users and the nature and quantity of the access provided, must be made available to the board.

  The beneficiaries must advertise widely, including on a dedicated website, the access offered under the grant and the eligibility criteria, if any.

  Where the call conditions impose additional traceability[5] obligations, information on the traceability of the users and the nature and quantity of access must be provided by the beneficiaries.

These obligations apply regardless of the form of funding or budget categories used to declare the costs (unit costs or actual costs or a combination of the two).

[5] According to the definition given in ISO 9000, i.e.: "Traceability is the ability to trace the history, application, use and location of an item or its characteristics through recorded identification data." The users can be traced, for example, by authentication and/or by authorization or by other means that allows for analysis of the type of users and the nature and quantity of access provided.



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