



EUROPEAN COMMISSION
Research Executive Agency

Director



GRANT AGREEMENT

NUMBER 955650 — CATCHY

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

on the one part,

the **Research Executive Agency (REA)** ('the Agency'), under the powers delegated by the European Commission ('the Commission'), represented for the purposes of signature of this Agreement by Head of Unit, Research Executive Agency, Excellent Science, Marie Skłodowska-Curie Innovative Training Networks, Klaus HAUPT,

and

on the other part,

1. 'the coordinator':

KATHOLIEKE UNIVERSITEIT LEUVEN (KUL), established in OUDE MARKT 13, LEUVEN 3000, Belgium, VAT number: BE0419052173, represented for the purposes of signing the Agreement by Head of European and International Projects, Elke LAMMERTYN

and the following other beneficiaries, if they sign their 'Accession Form' (see Annex 3 and Article 56):

2. **BUDAPESTI MUSZAKI ES GAZDASAGTUDOMANYI EGYETEM (BME)**, established in MUEGYETEM RAKPART 3, BUDAPEST 1111, Hungary, VAT number: HU15308799,

3. **DANMARKS TEKNISKE UNIVERSITET (DTU)**, established in ANKER ENGELUNDSVEJ 1 BYGNING 101 A, KGS LYNGBY 2800, Denmark, VAT number: DK30060946,

4. **FURUKAWA ELECTRIC TECHNOLOGIAI INTEZET KORLATOLT FELELOSSEGU TARSASAG (FETI)**, established in KESMARK UTCA 28/A, BUDAPEST 1158, Hungary, VAT number: HU10489536,

5. **PAUL SCHERRER INSTITUT (PSI)**, established in FORSCHUNGSTRASSE 111, VILLIGEN PSI 5232, Switzerland, VAT number: CHE116133392MWST,

6. **STICHTING KATHOLIEKE UNIVERSITEIT (RU)**, established in GEERT GROOTEPLEIN NOORD 9, NIJMEGEN 6525 EZ, Netherlands, VAT number: NL002968721B01,

7. **TEER COATINGS LIMITED (TCL)**, established in WEST STONE HOUSE WEST STONE BERRY HILL INDUSTRIAL ESTATE, DROITWICH WR9 9AS, United Kingdom, VAT number: GB376145539,

8. **UNIVERSITEIT ANTWERPEN (UA)**, established in PRINSSTRAAT 13, ANTWERPEN 2000, Belgium, VAT number: BE0257216482,

9. **UNIVERSITAET ULM (UU)**, established in HELMHOLTZSTRASSE 16, ULM 89081, Germany, VAT number: DE173703203,

10. **VLAAMSE INSTELLING VOOR TECHNOLOGISCH ONDERZOEK N.V. (VITO)**, established in BOERETANG 200, MOL 2400, Belgium, VAT number: BE0244195916,

Unless otherwise specified, references to ‘beneficiary’ or ‘beneficiaries’ include the coordinator.

The parties referred to above have agreed to enter into the Agreement under the terms and conditions below.

By signing the Agreement or the Accession Form, the beneficiaries accept the grant and agree to implement it under their own responsibility and in accordance with the Agreement, with all the obligations and conditions it sets out.

The Agreement is composed of:

Terms and Conditions

- | | |
|---------|---|
| Annex 1 | Description of the action |
| Annex 2 | Estimated budget for the action |
| | 2a Additional information on the estimated budget |
| Annex 3 | Accession Forms |
| Annex 4 | Model for the financial statements |
| Annex 5 | Not applicable |
| Annex 6 | Not applicable |

TERMS AND CONDITIONS

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CHAPTER 1 GENERAL

ARTICLE 1 — SUBJECT OF THE AGREEMENT

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

CHAPTER 2 ACTION

ARTICLE 2 — ACTION TO BE IMPLEMENTED

The grant is awarded for the action entitled ‘**Design, implementation and production upscaling of novel, high-performance, cluster-based catalysts for CO₂ hydrogenation**’ — ‘**CATCHY**’ (‘**action**’), as described in Annex 1.

ARTICLE 3 — DURATION AND STARTING DATE OF THE ACTION

The duration of the action will be **48 months** as of 1 November 2020 (‘**starting date of the action**’).

ARTICLE 4 — ESTIMATED BUDGET AND BUDGET TRANSFERS

4.1 Estimated budget

The ‘**estimated budget**’ for the action is set out in Annex 2.

It contains the estimated eligible costs and the forms of costs, broken down by beneficiary and budget category (see Articles 5, 6).

4.2 Budget transfers

The estimated budget breakdown indicated in Annex 2 may be adjusted by transfers of amounts between beneficiaries.

This does not require an amendment according to Article 55, if the action is implemented as described in Annex 1.

However, no more than 40% of the maximum grant amount (see Article 5.1) may be allocated to beneficiaries located in the same country or to any one international European interest organisation or international organisation.

CHAPTER 3 GRANT

ARTICLE 5 — GRANT AMOUNT, FORM OF GRANT, REIMBURSEMENT RATES AND FORMS OF COSTS

5.1 Maximum grant amount

The '**maximum grant amount**' is **EUR 3 729 508.56** (three million seven hundred and twenty nine thousand five hundred and eight EURO and fifty six eurocents).

5.2 Form of grant, reimbursement rate and form of costs

The grant reimburses **100 %** of the action's eligible costs (see Article 6) ('**reimbursement of eligible costs grant**') (see Annex 2).

The estimated eligible costs of the action are **EUR 3 729 508.56** (three million seven hundred and twenty nine thousand five hundred and eight EURO and fifty six eurocents).

Eligible costs (see Article 6) must be declared under the following form ('**form of costs**')

- (a) for **costs for recruited researchers** (living, mobility and family allowances): on the basis of the amount(s) per unit set out in Annex 2 ('**unit costs**') and
- (b) for **institutional costs** (research, training and networking costs and management and indirect costs): on the basis of the amount per unit set out in Annex 2 (**unit costs**).

5.3 Final grant amount — Calculation

The '**final grant amount**' depends on the actual extent to which the action is implemented in accordance with the Agreement's terms and conditions.

This amount is calculated by the Agency — when the payment of the balance is made (see Article 21.4) — in the following steps:

- Step 1 – Application of the reimbursement rate to the eligible costs
- Step 2 – Limit to the maximum grant amount
- Step 3 – Reduction due to substantial errors, irregularities or fraud or serious breach of obligations

5.3.1 Step 1 — Application of the reimbursement rates to the eligible costs

The reimbursement rate (see Article 5.2) is applied to eligible costs (unit costs; see Article 6) declared by the beneficiaries and approved by the Agency (see Article 21).

5.3.2 Step 2 — Limit to the maximum grant amount

If the amount obtained following Step 1 is higher than the maximum grant amount set out in Article 5.1, it will be limited to the latter.

5.3.3 Step 3 — Reduction due to substantial errors, irregularities or fraud or serious breach of obligations — Reduced grant amount — Calculation

If the grant is reduced (see Article 43), the Agency will calculate the reduced grant amount by deducting the amount of the reduction (calculated in proportion to the seriousness of the errors, irregularities or fraud or breach of obligations, in accordance with Article 43.2) from the maximum grant amount set out in Article 5.1.

The final grant amount will be the lower of the following two:

- the amount obtained following Steps 1 and 2 or
- the reduced grant amount following Step 3.

5.4 Revised final grant amount — Calculation

If — after the payment of the balance (in particular, after checks, reviews, audits or investigations; see Article 22) — the Agency rejects costs (see Article 42) or reduces the grant (see Article 43), it will calculate the ‘**revised final grant amount**’ for the beneficiary concerned by the findings.

This amount is calculated by the Agency on the basis of the findings, as follows:

- in case of **rejection of costs**: by applying the reimbursement rate to the revised eligible costs approved by the Agency for the beneficiary concerned;
- in case of **reduction of the grant**: by calculating the concerned beneficiary’s share in the grant amount reduced in proportion to the seriousness of the errors, irregularities or fraud or breach of obligations (see Article 43.2).

In case of **rejection of costs and reduction of the grant**, the revised final grant amount for the beneficiary concerned will be the lower of the two amounts above.

ARTICLE 6 — ELIGIBLE AND INELIGIBLE COSTS

6.1 General conditions for costs to be eligible

Unit costs are eligible (‘eligible costs’) if:

(a) they are calculated as follows:

{amounts per unit set out in Annex 2
multiplied by
the number of actual units}.

(b) the number of actual units complies with the following:

- the units must be actually used or produced in the period set out in Article 3;
- the units must be necessary for implementing the action or produced by it, and
- the number of units must be identifiable and verifiable, in particular supported by records and documentation (see Article 18).

6.2 Specific conditions for costs to be eligible

Costs are eligible, if they comply with the general conditions (see above) and the specific conditions set out below for each of the following two budget categories:

A. Costs for recruited researchers (A.1 Living allowance, A.2 Mobility allowance and A.3 Family allowance) are eligible, if:

(a) the number of units declared:

- (i) corresponds to the actual number of months spent by the recruited researchers on the research training activities and
 - (ii) does not exceed 36 months (per researcher);
- (b) the recruited researchers comply with the following conditions:
- (i) be recruited by the beneficiary under an **employment contract** (or other direct contract with equivalent benefits, including social security coverage) or — if not otherwise possible under national law — under a fixed amount fellowship agreement with minimum social security coverage;
 - (ii) be employed for at least 3 months;
 - (iii) be employed full-time, unless the Agency has approved a part-time employment for personal or family reasons;
 - (iv) be working exclusively for the action;
 - (v) not have resided in the country of the recruiting beneficiary for more than 12 months in the 3 years immediately before the recruitment date (and not have carried out their main activity (work, studies, etc.) in that country) — unless as part of a procedure for obtaining refugee status under the Geneva Convention¹.
- For beneficiaries that are international European interest organisations or international organisations: not have spent with the beneficiary more than 12 months in the 3 years immediately before the recruitment date.
- (vi) be — at the date of recruitment — an ‘**early stage researcher**’ (i.e. in the first four years of his/her research career and not have a doctoral degree).
- (c) the costs have been fully incurred for the benefit of the recruited researchers.

This latter condition is met if:

{{total remuneration costs (salaries, social security contributions, taxes and other costs included in the remuneration under the employment contract or other direct contract) or **total fixed-amount fellowship costs** for the researcher during the action

plus

total mobility costs (household, relocation and travel expenses and, if they must be paid under national law, taxes, duties and social security contributions) for the researcher during the action}

plus

total family costs for the researcher during the action}

divided by

the number of actual units}.

¹ 1951 Refugee Convention and the 1967 Protocol.

is equal to or higher than the following amount:

{amount per unit cost set out in Annex 2 as living allowance
 plus
 amount per unit cost set out in Annex 2 as mobility allowance}
 plus
 if it is due, amount per unit cost set out in Annex 2 as family allowance}.

The family allowance is due if the researcher has a family at the time of recruitment.

‘Family’ means persons linked to the researcher by marriage (or a relationship with equivalent status to a marriage recognised by the legislation of the country where this relationship was formalised) or dependent children who are actually being maintained by the researcher.

B. Institutional costs (B.1 Research, training and networking costs and B.2 Management and indirect costs) are eligible if the costs for the recruited researchers (living allowance, mobility allowance, family allowance; see above) are eligible.

6.3 Ineligible costs

‘Ineligible costs’ are:

- (a) costs that do not comply with the conditions set out above (in Article 6.1), and in particular costs incurred during suspension of the action implementation (see Article 49);
- (b) costs declared under another EU or Euratom grant (including grants awarded by a Member State and financed by the EU or Euratom budget and grants awarded by bodies other than the Agency for the purpose of implementing the EU or Euratom budget), in particular, indirect costs if the beneficiary is already receiving an operating grant financed by the EU or Euratom budget in the same period, unless it can demonstrate that the operating grant does not cover any costs of the action.

6.4 Consequences of declaration of ineligible costs

Declared costs that are ineligible will be rejected (see Article 42).

This may also lead to any of the other measures described in Chapter 6.

CHAPTER 4 RIGHTS AND OBLIGATIONS OF THE PARTIES

SECTION 1 RIGHTS AND OBLIGATIONS RELATED TO IMPLEMENTING THE ACTION

ARTICLE 7 — GENERAL OBLIGATION TO PROPERLY IMPLEMENT THE ACTION

7.1 General 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 and all legal obligations under applicable EU, international and national law.

7.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 8 — RESOURCES TO IMPLEMENT THE ACTION — THIRD PARTIES INVOLVED IN THE ACTION

The beneficiaries must have the appropriate resources to implement the action.

If it is necessary to implement the action, the beneficiaries may:

- call upon entities with a capital or legal link to the beneficiaries², to implement certain action tasks described in Annex 1 (i.e. hosting and training of researchers);
- call upon partner organisations to implement certain action tasks described in Annex 1 (i.e. hosting and training researchers during secondments).

In this case, the beneficiaries retain sole responsibility towards the Agency for implementing the action.

ARTICLE 9 — IMPLEMENTATION OF ACTION TASKS BY BENEFICIARIES NOT RECEIVING EU FUNDING

Not applicable

ARTICLE 10 — PURCHASE OF GOODS, WORKS OR SERVICES

Not applicable

ARTICLE 11 — USE OF IN-KIND CONTRIBUTIONS PROVIDED BY THIRD PARTIES AGAINST PAYMENT

Not applicable

ARTICLE 12 — USE OF IN-KIND CONTRIBUTIONS PROVIDED BY THIRD PARTIES FREE OF CHARGE

Not applicable

² ‘Entities with a capital or legal link’ are entities 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.

ARTICLE 13 — IMPLEMENTATION OF ACTION TASKS BY SUBCONTRACTORS

Not applicable

ARTICLE 14 — IMPLEMENTATION OF ACTION TASKS BY LINKED THIRD PARTIES

Not applicable

ARTICLE 15 — FINANCIAL SUPPORT TO THIRD PARTIES

Not applicable

ARTICLE 16 — PROVISION OF TRANS-NATIONAL OR VIRTUAL ACCESS TO RESEARCH INFRASTRUCTURE

Not applicable

SECTION 2 RIGHTS AND OBLIGATIONS RELATED TO THE GRANT ADMINISTRATION

ARTICLE 17 — GENERAL OBLIGATION TO INFORM

17.1 General obligation to provide information upon request

The beneficiaries must provide — during implementation of the action or afterwards and in accordance with Article 41.2 — any information requested in order to verify eligibility of the costs, proper implementation of the action and compliance with any other obligation under the Agreement.

17.2 Obligation to keep information up to date and to inform about events and circumstances likely to affect the Agreement

Each beneficiary must keep information stored in the Participant Portal Beneficiary Register (via the electronic exchange system; see Article 52) up to date, in particular, its name, address, legal representatives, legal form and organisation type.

Each beneficiary must immediately inform the coordinator — which must immediately inform the Agency and the other beneficiaries — of any of the following:

- (a) **events** which are likely to affect significantly or delay the implementation of the action or the EU's financial interests, in particular:
 - (i) changes in its legal, financial, technical, organisational or ownership situation (or those of an entity with a capital or legal link);
 - (ii) changes in the name, address, legal form or organisation type of an entity with a capital or legal link;
- (b) **circumstances** affecting:
 - (i) the decision to award the grant or

- (ii) compliance with requirements under the Agreement.

17.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 18 — KEEPING RECORDS — SUPPORTING DOCUMENTATION

18.1 Obligation to keep records and other supporting documentation

The beneficiaries must — for a period of five years after the payment of the balance — keep records and other supporting documentation in order to prove the proper implementation of the action and the costs they declare as eligible.

They must make them available upon request (see Article 17) or in the context of checks, reviews, audits or investigations (see Article 22).

If there are on-going checks, reviews, audits, investigations, litigation or other pursuits of claims under the Agreement (including the extension of findings; see Articles 22), the beneficiaries must keep the 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 Agency may accept non-original documents if it considers that they offer a comparable level of assurance.

18.1.1 Records and other supporting documentation on the scientific and technical implementation

The beneficiaries must keep records and other supporting documentation on scientific and technical implementation of the action in line with the accepted standards in the respective field.

18.1.2 Records and other documentation to support the costs declared

The beneficiaries must keep adequate records and other supporting documentation to prove the number of units declared and that the costs for recruited researchers (living allowance, mobility allowance, family allowance) have been fully incurred for the benefit of the researchers.

18.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, costs insufficiently substantiated will be ineligible (see Article 6) and will be rejected (see Article 42), and the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 19 — SUBMISSION OF DELIVERABLES

19.1 Obligation to submit deliverables

The coordinator must:

- submit a ‘**progress report**’ within 30 days after one year from the starting date of the action;
- organise a ‘**mid-term meeting**’ between the beneficiaries, entities with a capital or legal link, partner organisations and the Agency before the deadline for the submission of the report for RP 1 (reporting period 1);
- establish a **supervisory board** of the network;
- submit any **other deliverables** identified in Annex 1, in accordance with the timing and conditions set out in it.

The beneficiaries must:

- submit a ‘**researcher declaration**’ within 20 days after the recruitment of each researcher.

19.2 Consequences of non-compliance

If a beneficiary or the coordinator breaches any of its obligations under this Article, the Agency may apply any of the measures provided for in Chapter 6.

ARTICLE 20 — REPORTING — PAYMENT REQUESTS

20.1 Obligation to submit reports

The coordinator must submit to the Agency (see Article 52) the technical and financial reports set out in this Article. These reports include the requests for payments and must be drawn up using the forms and templates provided in the electronic exchange system (see Article 52).

20.2 Reporting periods

The action is divided into the following ‘**reporting periods**’:

- RP1: from month 1 to month 24
- RP2: from month 25 to month 48

20.3 Periodic reports — Requests for interim payments

The coordinator must submit a periodic report within 60 days following the end of each reporting period.

The **periodic report** must include the following:

- (a) a ‘**periodic technical report**’ containing:
 - (i) an **explanation of the work carried out** by the beneficiaries;
 - (ii) an **overview of the progress** towards the objectives of the action, including milestones and deliverables identified in Annex 1.

This report must include explanations justifying the differences between work expected to be carried out in accordance with Annex 1 and that actually carried out.

The report must detail the exploitation and dissemination of the results and — if required in Annex 1 — an updated '**plan for the exploitation and dissemination of the results**'.

The report must indicate the communication activities;

- (iii) a **summary** for publication by the Agency;
- (iv) the answers to the '**questionnaire**', covering issues related to the action implementation and the economic and societal impact, notably in the context of the Horizon 2020 key performance indicators and the Horizon 2020 monitoring requirements;

(b) a '**periodic financial report**' containing:

- (i) an '**individual financial statement**' (see Annex 4) from each beneficiary, for the reporting period concerned.

The individual financial statement must detail the eligible costs (see Article 6) for each budget category (see Annex 2).

The beneficiaries must declare all eligible costs even if they exceed the amounts indicated in the estimated budget (see Annex 2). Amounts which are not declared in the individual financial statement will not be taken into account by the Agency.

If an individual financial statement is not submitted for a reporting period, it may be included in the periodic financial report for the next reporting period.

Each beneficiary must **certify** that:

- the information provided is full, reliable and true;
 - the costs declared are eligible (see Article 6);
 - the costs can be substantiated by adequate records and supporting documentation (see Article 18) that will be produced upon request (see Article 17) or in the context of checks, reviews, audits and investigations (see Article 22)
- (ii) not applicable;
 - (iii) not applicable;
 - (iv) a '**periodic summary financial statement**', created automatically by the electronic exchange system, consolidating the individual financial statements for the reporting period concerned and including — except for the last reporting period — the **request for interim payment**.

20.4 Final report — Request for payment of the balance

In addition to the periodic report for the last reporting period, the coordinator must submit the final report within 60 days following the end of the last reporting period.

The final report must include the following:

- (a) a **‘final technical report’** with a summary for publication containing:
 - (i) an overview of the results and their exploitation and dissemination;
 - (ii) the conclusions on the action, and
 - (iii) the socio-economic impact of the action;
- (b) a **‘final financial report’** containing a **‘final summary financial statement’**, created automatically by the electronic exchange system, consolidating the individual financial statements for all reporting periods and including the **request for payment of the balance**

20.5 Information on cumulative expenditure incurred

Not applicable

20.6 Currency for financial statements

Financial statements must be drafted in euro.

20.7 Language of reports

All reports (technical and financial reports, including financial statements) must be submitted in the language of the Agreement.

20.8 Consequences of non-compliance

If the reports submitted do not comply with this Article, the Agency may suspend the payment deadline (see Article 47) and apply any of the other measures described in Chapter 6.

If the coordinator breaches its obligation to submit the reports and if it fails to comply with this obligation within 30 days following a written reminder, the Agency may terminate the Agreement or apply any of the other measures described in Chapter 6.

ARTICLE 21 — PAYMENTS AND PAYMENT ARRANGEMENTS

21.1 Payments to be made

The following payments will be made to the coordinator:

- one **pre-financing payment**;
- one or more **interim payments**, on the basis of the request(s) for interim payment (see Article 20), and
- one **payment of the balance**, on the basis of the request for payment of the balance (see Article 20).

21.2 Pre-financing payment — Amount — Amount retained for the Guarantee Fund

The aim of the pre-financing is to provide the beneficiaries with a float.

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

The amount of the pre-financing payment will be EUR **2 983 606.85** (two million nine hundred and eighty three thousand six hundred and six EURO and eighty five eurocents).

The Agency will — except if Article 48 applies — make the pre-financing payment to the coordinator within 30 days from the entry into force of the Agreement (see Article 58) or from 10 days before the starting date of the action (see Article 3).

An amount of EUR **186 475.43** (one hundred and eighty six thousand four hundred and seventy five EURO and forty three eurocents), corresponding to 5% of the maximum grant amount (see Article 5.1), is retained by the Agency from the pre-financing payment and transferred into the ‘**Guarantee Fund**’.

21.3 Interim payments — Amount — Calculation

Interim payments reimburse the eligible costs incurred for the implementation of the action during the corresponding reporting periods.

The Agency will pay to the coordinator the amount due as interim payment within 90 days from receiving the periodic report (see Article 20.3), except if Articles 47 or 48 apply.

Payment is subject to the approval of the periodic report. Its approval does not imply recognition of the compliance, authenticity, completeness or correctness of its content.

The **amount due as interim payment** is calculated by the Agency in the following steps:

Step 1 – Application of the reimbursement rates

Step 2 – Limit to 90% of the maximum grant amount

21.3.1 Step 1 — Application of the reimbursement rates

The reimbursement rate(s) (see Article 5.2) are applied to the eligible costs (actual costs, unit costs and flat-rate costs; see Article 6) declared by the beneficiaries (see Article 20) and approved by the Agency (see above) for the concerned reporting period.

21.3.2 Step 2 — Limit to 90% of the maximum grant amount

The total amount of pre-financing and interim payments must not exceed 90% of the maximum grant amount set out in Article 5.1. The maximum amount for the interim payment will be calculated as follows:

{90% of the maximum grant amount (see Article 5.1)

minus

{pre-financing and previous interim payments} }.

21.4 Payment of the balance — Amount — Calculation — Release of the amount retained for the Guarantee Fund

The payment of the balance reimburses the remaining part of the eligible costs incurred by the beneficiaries for the implementation of the action.

If the total amount of earlier payments is greater than the final grant amount (see Article 5.3), the payment of the balance takes the form of a recovery (see Article 44).

If the total amount of earlier payments is lower than the final grant amount, the Agency will pay the balance within 90 days from receiving the final report (see Article 20.4), except if Articles 47 or 48 apply.

Payment is subject to the approval of the final report. Its approval does not imply recognition of the compliance, authenticity, completeness or correctness of its content.

The amount due as the balance is calculated by the Agency by deducting the total amount of pre-financing and interim payments (if any) already made, from the final grant amount determined in accordance with Article 5.3:

$$\begin{aligned} & \{ \text{final grant amount (see Article 5.3)} \\ & \text{minus} \\ & \{ \text{pre-financing and interim payments (if any) made} \} \}. \end{aligned}$$

At the payment of the balance, the amount retained for the Guarantee Fund (see above) will be released and:

- if the balance is positive: the amount released will be paid in full to the coordinator together with the amount due as the balance;
- if the balance is negative (payment of the balance taking the form of recovery): it will be deducted from the amount released (see Article 44.1.2). If the resulting amount:
 - is positive, it will be paid to the coordinator
 - is negative, it will be recovered.

The amount to be paid may however be offset — without the beneficiaries' consent — against any other amount owed by a beneficiary to the Agency, the Commission or another executive agency (under the EU or Euratom budget), up to the maximum EU contribution indicated, for that beneficiary, in the estimated budget (see Annex 2).

21.5 Notification of amounts due

When making payments, the Agency will formally notify to the coordinator the amount due, specifying whether it concerns an interim payment or the payment of the balance.

For the payment of the balance, the notification will also specify the final grant amount.

In the case of reduction of the grant or recovery of undue amounts, the notification will be preceded by the contradictory procedure set out in Articles 43 and 44.

21.6 Currency for payments

The Agency will make all payments in euro.

21.7 Payments to the coordinator — Distribution to the beneficiaries

Payments will be made to the coordinator.

Payments to the coordinator will discharge the Agency from its payment obligation.

The coordinator must distribute the payments between the beneficiaries without unjustified delay.

Pre-financing may however be distributed only:

- (a) if the minimum number of beneficiaries set out in the call for proposals has acceded to the Agreement (see Article 56) and
- (b) to beneficiaries that have acceded to the Agreement (see Article 56).

21.8 Bank account for payments

All payments will be made to the following bank account:

Name of bank: KBC BANK NV

Full name of the account holder: KU LEUVEN RESEARCH & DEVELOPMENT

IBAN code: BE86432001659150

21.9 Costs of payment transfers

The cost of the payment transfers is borne as follows:

- the Agency 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.

21.10 Date of payment

Payments by the Agency are considered to have been carried out on the date when they are debited to its account.

21.11 Consequences of non-compliance

21.11.1 If the Agency does not pay within the payment deadlines (see above), the beneficiaries are entitled to **late-payment interest** at the rate applied by the European Central Bank (ECB) for its main refinancing operations in euros ('reference rate'), plus three and a half points. The reference rate 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 upon 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).

Suspension of the payment deadline or payments (see Articles 47 and 48) will not be considered as late payment.

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.

21.11.2 If the coordinator breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or the participation of the coordinator may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 22 — CHECKS, REVIEWS, AUDITS AND INVESTIGATIONS — EXTENSION OF FINDINGS

22.1 Checks, reviews and audits by the Agency and the Commission

22.1.1 Right to carry out checks

The Agency or the Commission will — during the implementation of the action or afterwards — check the proper implementation of the action and compliance with the obligations under the Agreement, including assessing deliverables and reports.

For this purpose the Agency or the Commission may be assisted by external persons or bodies.

The Agency or the Commission may also request additional information in accordance with Article 17. The Agency or the Commission may request beneficiaries to provide such information to it directly.

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

22.1.2 Right to carry out reviews

The Agency or the Commission may — during the implementation of the action or afterwards — carry out reviews on the proper implementation of the action (including assessment of deliverables and reports), compliance with the obligations under the Agreement and continued scientific or technological relevance of the action.

Reviews may be started up to two years after the payment of the balance. They will be formally notified to the coordinator or beneficiary concerned and will be considered to have started on the date of the formal notification.

The Agency or the Commission may carry out reviews directly (using its own staff) or indirectly (using external persons or bodies appointed to do so). It will inform the coordinator or beneficiary concerned of the identity of the external persons or bodies. They have the right to object to the appointment on grounds of commercial confidentiality.

The coordinator or beneficiary concerned must provide — within the deadline requested — any information and data in addition to deliverables and reports already submitted (including information on the use of resources). The Agency or the Commission may request beneficiaries to provide such information to it directly.

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

For **on-the-spot** reviews, the beneficiaries must allow access to their sites and premises, including to external persons or bodies, 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 ‘**review report**’ will be drawn up.

The Agency or the Commission will formally notify the review report to the coordinator or beneficiary concerned, which has 30 days to formally notify observations (‘**contradictory review procedure**’).

Reviews (including review reports) are in the language of the Agreement.

22.1.3 Right to carry out audits

The Agency or the Commission may — during the implementation of the action or afterwards — carry out audits on the proper implementation of the action and compliance with the obligations under the Agreement.

Audits may be started up to two years after the payment of the balance. They will be formally notified to the coordinator or beneficiary concerned and will be considered to have started on the date of the formal notification.

The Agency or the Commission may carry out audits directly (using its own staff) or indirectly (using external persons or bodies appointed to do so). It will inform the coordinator or beneficiary concerned of the identity of the external persons or bodies. They have the right to object to the appointment on grounds of commercial confidentiality.

The coordinator or beneficiary concerned must provide — within the deadline requested — any information (including complete accounts, individual salary statements or other personal data) to verify compliance with the Agreement. The Agency or the Commission may request beneficiaries to provide such information to it directly.

For **on-the-spot** audits, the beneficiaries must allow access to their sites and premises, including to external persons or bodies, 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 Agency or the Commission will formally notify the draft audit report to the coordinator or beneficiary concerned, which has 30 days to formally notify observations (‘**contradictory audit procedure**’). This period may be extended by the Agency or the Commission in justified cases.

The ‘**final audit report**’ will take into account observations by the coordinator or beneficiary concerned. The report will be formally notified to it.

Audits (including audit reports) are in the language of the Agreement.

The Agency or the Commission may also access the beneficiaries’ statutory records for the periodical assessment of unit costs or flat-rate amounts.

22.2 Investigations by the European Anti-Fraud Office (OLAF)

Under Regulations No 883/2013³ and No 2185/96⁴ (and in accordance with their provisions and procedures), the European Anti-Fraud Office (OLAF) may — at any moment during implementation of the action or afterwards — carry out investigations, including on-the-spot checks and inspections, to establish whether there has been fraud, corruption or any other illegal activity affecting the financial interests of the EU.

22.3 Checks and audits by the European Court of Auditors (ECA)

Under Article 287 of the Treaty on the Functioning of the European Union (TFEU) and Article 161 of the Financial Regulation No 966/2012⁵, the European Court of Auditors (ECA) may — at any moment during implementation of the action or afterwards — carry out audits.

The ECA has the right of access for the purpose of checks and audits.

22.4 Checks, reviews, audits and investigations for international organisations

Not applicable

22.5 Consequences of findings in checks, reviews, audits and investigations — Extension of findings

22.5.1 Findings in this grant

Findings in checks, reviews, audits or investigations carried out in the context of this grant may lead to the rejection of ineligible costs (see Article 42), reduction of the grant (see Article 43), recovery of undue amounts (see Article 44) or to any of the other measures described in Chapter 6.

Rejection of costs or reduction of the grant after the payment of the balance will lead to a revised final grant amount (see Article 5.4).

Findings in checks, reviews, audits or investigations may lead to a request for amendment for the modification of Annex 1 (see Article 55).

³ 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).

⁴ Council Regulation (Euratom, EC) No 2185/1996 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).

⁵ Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation (EC, Euratom) No 1605/2002 (OJ L 298, 26.10.2012, p. 1).

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

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

22.5.2 Findings in other grants

The Agency or the Commission may extend findings from other grants to this grant (**‘extension of findings from other grants to this grant’**), if:

- (a) the beneficiary concerned is found, in other EU or Euratom 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 — no later than two years after the payment of the balance of this grant.

The extension of findings may lead to the rejection of costs (see Article 42), reduction of the grant (see Article 43), recovery of undue amounts (see Article 44), suspension of payments (see Article 48), suspension of the action implementation (see Article 49) or termination (see Article 50).

22.5.3 Procedure

The Agency or the Commission will formally notify the beneficiary concerned the systemic or recurrent errors and its intention to extend these audit findings, together with the list of grants affected.

22.5.3.1 If the findings concern **eligibility of costs**: the formal 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 by the Agency or the Commission 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.

The beneficiary concerned has 90 days from receiving notification to submit observations, revised financial statements or to propose a duly substantiated **alternative correction method**. This period may be extended by the Agency or the Commission in justified cases.

The Agency or the Commission may then start a rejection procedure in accordance with Article 42, on the basis of:

- the revised financial statements, if approved;

- the proposed alternative correction method, if accepted

or

- the initially notified correction rate for extrapolation, if it does not receive any observations or revised financial statements, does not accept the observations or the proposed alternative correction method or does not approve the revised financial statements.

22.5.3.2 If the findings concern **substantial errors, irregularities or fraud or serious breach of obligations**: the formal notification will include:

- (a) an invitation to submit observations on the list of grants affected by the findings and
- (b) the flat-rate the Agency or the Commission intends to apply according to the principle of proportionality.

The beneficiary concerned has 90 days from receiving notification to submit observations or to propose a duly substantiated alternative flat-rate.

The Agency or the Commission may then start a reduction procedure in accordance with Article 43, on the basis of:

- the proposed alternative flat-rate, if accepted

or

- the initially notified flat-rate, if it does not receive any observations or does not accept the observations or the proposed alternative flat-rate.

If the Agency or the Commission accepts the alternative flat-rate proposed by the beneficiary concerned, it will formally notify the application of the accepted alternative flat-rate.

22.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, any insufficiently substantiated costs will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 23 — EVALUATION OF THE IMPACT OF THE ACTION

23.1 Right to evaluate the impact of the action

The Agency or the Commission may carry out interim and final evaluations of the impact of the action measured against the objective of the EU programme.

Evaluations may be started during implementation of the action and up to five years after the payment of the balance. The evaluation is considered to start on the date of the formal notification to the coordinator or beneficiaries.

The Agency or the Commission may make these evaluations directly (using its own staff) or indirectly (using external bodies or persons it has authorised to do so).

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

23.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the Agency may apply the measures described in Chapter 6.

SECTION 3 RIGHTS AND OBLIGATIONS RELATED TO BACKGROUND AND RESULTS

SUBSECTION 1 GENERAL

ARTICLE 23a — MANAGEMENT OF INTELLECTUAL PROPERTY

23a.1 Obligation to take measures to implement the Commission Recommendation on the management of intellectual property in knowledge transfer activities

Beneficiaries that are universities or other public research organisations must take measures to implement the principles set out in Points 1 and 2 of the Code of Practice annexed to the Commission Recommendation on the management of intellectual property in knowledge transfer activities⁶.

This does not change the obligations set out in Subsections 2 and 3 of this Section.

The beneficiaries must ensure that the researchers, entities with a capital or legal link and partner organisations are aware of them.

23a.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the Agency may apply any of the measures described in Chapter 6.

SUBSECTION 2 RIGHTS AND OBLIGATIONS RELATED TO BACKGROUND

ARTICLE 24 — AGREEMENT ON BACKGROUND

24.1 Agreement on background

The beneficiaries must identify and agree (in writing) on the background for the action (**‘agreement on background’**).

‘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:

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

⁶ Commission Recommendation C (2008) 1329 of 10.4.2008 on the management of intellectual property in knowledge transfer activities and the Code of Practice for universities and other public research institutions attached to this recommendation.

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

24.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 25 — ACCESS RIGHTS TO BACKGROUND

25.1 Exercise of access rights, — Waiving of access rights — No sub-licensing

To exercise access rights, this must first be requested in writing (**‘request for access’**).

‘Access rights’ means rights to use results or background under the terms and conditions laid down in this Agreement.

Waivers of access rights are not valid unless in writing.

Unless agreed otherwise, access rights do not include the right to sub-license.

25.2 Access rights for other beneficiaries, for implementing their own tasks under the action

The beneficiaries must give 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 —:

- (a) informed the other beneficiaries that access to its background is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel), or
- (b) agreed with the other beneficiaries that access would not be on a royalty-free basis.

25.3 Access rights for other beneficiaries, for exploiting their own results

The beneficiaries must give each other access — under fair and reasonable conditions — to background needed for exploiting their own 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 legal restrictions or limits, including those imposed by the rights of third parties (including personnel).

‘Fair and reasonable conditions’ means 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.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

25.4 Access rights for affiliated entities

Unless otherwise agreed in the consortium agreement, access to background must also be given

— under fair and reasonable conditions (see above; Article 25.3) and unless it is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel) — to affiliated entities⁷ established in an EU Member State or ‘**associated country**’⁸, if this is needed to exploit the results generated by the beneficiaries to which they are affiliated.

Unless agreed otherwise (see above; Article 25.1), the affiliated entity concerned must make the request directly to the beneficiary that holds the background.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

25.5 Access rights for researchers

The beneficiaries must — on a royalty-free basis — give access to the recruited researchers to background necessary for their research training activities under the action.

25.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

SUBSECTION 3 RIGHTS AND OBLIGATIONS RELATED TO RESULTS

ARTICLE 26 — OWNERSHIP OF RESULTS

26.1 Ownership by the beneficiary that generates the results

Results are owned by the beneficiary that generates them.

‘**Results**’ means any (tangible or intangible) output of the action such as data, knowledge or

⁷ For the definition, see Article 2.1(2) of Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for participation and dissemination in “Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)” (‘**Rules for Participation Regulation No 1290/2013**’) (OJ L 347, 20.12.2013 p.81): ‘**affiliated entity**’ means any legal entity that is:

- under the direct or indirect control of a participant, or
- under the same direct or indirect control as the participant, or
- directly or indirectly controlling a participant.

‘Control’ may take any of the following forms:

- (a) the direct or indirect holding of more than 50% of the nominal value of the issued share capital in the legal entity concerned, or of a majority of the voting rights of the shareholders or associates of that entity;
- (b) the direct or indirect holding, in fact or in law, of decision-making powers in the legal entity concerned.

However the following relationships between legal entities shall not in themselves be deemed to constitute controlling relationships:

- (a) the same public investment corporation, institutional investor or venture-capital company has a direct or indirect holding of more than 50% of the nominal value of the issued share capital or a majority of voting rights of the shareholders or associates;
- (b) the legal entities concerned are owned or supervised by the same public body.

⁸ For the definition, see Article 2.1(3) Rules for Participation Regulation No 1290/2013: ‘**associated country**’ means a non EU-country (third country) which is party to an international agreement with the Union, as identified in Article 7 of the H2020 Framework Programme Regulation No 1291/2013. Article 7 sets out the conditions for association of non-EU countries to Horizon 2020.

information — whatever its form or nature, whether it can be protected or not — that is generated in the action, as well as any rights attached to it, including intellectual property rights.

26.2 Joint ownership by several beneficiaries

Two or more beneficiaries own results jointly if:

- (a) they have jointly generated them and
- (b) it is not possible to:
 - (i) establish the respective contribution of each beneficiary, or
 - (ii) separate them for the purpose of applying for, obtaining or maintaining their protection (see Article 27).

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, each joint owner may grant non-exclusive licences to third parties to exploit jointly-owned results (without any right to sub-license), if the other joint owners are given:

- (a) at least 45 days advance notice and
- (b) fair and reasonable compensation.

Once the results have been generated, joint owners may agree (in writing) to apply another regime than joint ownership (such as, for instance, transfer to a single owner (see Article 30) with access rights for the others).

26.3 Rights of third parties (including personnel)

If third parties (including personnel) may claim rights to the results, the beneficiary concerned must ensure that it complies with its obligations under the Agreement.

If a third party generates results, the beneficiary concerned must obtain all necessary rights (transfer, licences or other) from the third party, in order to be able to respect its obligations as if those results were generated by the beneficiary itself.

If obtaining the rights is impossible, the beneficiary must refrain from using the third party to generate the results.

26.4 Agency ownership, to protect results

26.4.1 The Agency may — with the consent of the beneficiary concerned — assume ownership of results to protect them, if a beneficiary intends — up to four years after the period set out in Article 3 — to disseminate its results without protecting them, except in any of the following cases:

- (a) the lack of protection is because protecting the results is not possible, reasonable or justified (given the circumstances);

- (b) the lack of protection is because there is a lack of potential for commercial or industrial exploitation, or
- (c) the beneficiary intends to transfer the results to another beneficiary or third party established in an EU Member State or associated country, which will protect them.

Before the results are disseminated and unless any of the cases above under Points (a), (b) or (c) applies, the beneficiary must formally notify the Agency and at the same time inform it of any reasons for refusing consent. The beneficiary may refuse consent only if it can show that its legitimate interests would suffer significant harm.

If the Agency decides to assume ownership, it will formally notify the beneficiary concerned within 45 days of receiving notification.

No dissemination relating to these results may take place before the end of this period or, if the Agency takes a positive decision, until it has taken the necessary steps to protect the results.

26.4.2 The Agency may — with the consent of the beneficiary concerned — assume ownership of results to protect them, if a beneficiary intends — up to four years after the period set out in Article 3 — to stop protecting them or not to seek an extension of protection, except in any of the following cases:

- (a) the protection is stopped because of a lack of potential for commercial or industrial exploitation;
- (b) an extension would not be justified given the circumstances.

A beneficiary that intends to stop protecting results or not seek an extension must — unless any of the cases above under Points (a) or (b) applies — formally notify the Agency at least 60 days before the protection lapses or its extension is no longer possible and at the same time inform it of any reasons for refusing consent. The beneficiary may refuse consent only if it can show that its legitimate interests would suffer significant harm.

If the Agency decides to assume ownership, it will formally notify the beneficiary concerned within 45 days of receiving notification.

26.5 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to the any of the other measures described in Chapter 6.

ARTICLE 27 — PROTECTION OF RESULTS — VISIBILITY OF EU FUNDING

27.1 Obligation to protect the results

Each beneficiary must examine the possibility of protecting its results and must adequately protect them — for an appropriate period and with appropriate territorial coverage — if:

- (a) the results can reasonably be expected to be commercially or industrially exploited and
- (b) protecting them is possible, reasonable and justified (given the circumstances).

When deciding on protection, the beneficiary must consider its own legitimate interests and the legitimate interests (especially commercial) of the other beneficiaries.

27.2 Agency ownership, to protect the results

If a beneficiary intends not to protect its results, to stop protecting them or not seek an extension of protection, the Agency may — under certain conditions (see Article 26.4) — assume ownership to ensure their (continued) protection.

27.3 Information on EU funding

Applications for protection of results (including patent applications) filed by or on behalf of a beneficiary must — unless the Agency requests or agrees otherwise or unless it is impossible — include the following:

“The project leading to this application has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 955650”.

27.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 28 — EXPLOITATION OF RESULTS

28.1 Obligation to exploit the results

Each beneficiary must — up to four years after the period set out in Article 3 — take measures aiming to ensure ‘**exploitation**’ of its results (either directly or indirectly, in particular through transfer or licensing; see Article 30) by:

- (a) using them in further research activities (outside the action);
- (b) developing, creating or marketing a product or process;
- (c) creating and providing a service, or
- (d) using them in standardisation activities.

This does not change the security obligations in Article 37, which still apply.

28.2 Results that could contribute to European or international standards — Information on EU funding

If results are incorporated in a standard, the beneficiary concerned must — unless the Agency requests or agrees otherwise or unless it is impossible — ask the standardisation body to include the following statement in (information related to) the standard:

“Results incorporated in this standard received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 955650”.

28.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced in accordance with Article 43.

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 29 — DISSEMINATION OF RESULTS — OPEN ACCESS — VISIBILITY OF EU FUNDING

29.1 Obligation to disseminate results

Unless it goes against their legitimate interests, each beneficiary must — as soon as possible — ‘**disseminate**’ its results by disclosing them to the public by appropriate means (other than those resulting from protecting or exploiting the results), including in scientific publications (in any medium).

This does not change the obligation to protect results in Article 27, the confidentiality obligations in Article 36, the security obligations in Article 37 or the obligations to protect personal data in Article 39, all of which still apply.

A beneficiary that intends to disseminate its results must give advance notice to the other beneficiaries of — unless agreed otherwise — at least 45 days, together with sufficient information on the results it will disseminate.

Any other beneficiary may object within — unless agreed otherwise — 30 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 dissemination may not take place unless appropriate steps are taken to safeguard these legitimate interests.

If a beneficiary intends not to protect its results, it may — under certain conditions (see Article 26.4.1) — need to formally notify the Agency before dissemination takes place.

29.2 Open access to scientific publications

Each beneficiary must ensure open access (free of charge online access for any user) to all peer-reviewed scientific publications relating to its results.

In particular, it must:

- (a) as soon as possible and at the latest on publication, deposit a machine-readable electronic copy of the published version or final peer-reviewed manuscript accepted for publication in a repository for scientific publications;

Moreover, the beneficiary must aim to deposit at the same time the research data needed to validate the results presented in the deposited scientific publications.

- (b) ensure open access to the deposited publication — via the repository — at the latest:
 - (i) on publication, if an electronic version is available for free via the publisher, or

- (ii) within six months of publication (twelve months for publications in the social sciences and humanities) in any other case.
- (c) ensure open access — via the repository — to the bibliographic metadata that identify the deposited publication.

The bibliographic metadata must be in a standard format and must include all of the following:

- the terms “Marie Skłodowska-Curie Actions”;
- the name of the action, acronym and grant number;
- the publication date, and length of embargo period if applicable, and
- a persistent identifier.

29.3 Open access to research data

Regarding the digital research data generated in the action (‘**data**’), the beneficiaries must:

- (a) deposit in a research data repository and take measures to make it possible for third parties to access, mine, exploit, reproduce and disseminate — free of charge for any user — the following:
 - (i) the data, including associated metadata, needed to validate the results presented in scientific publications, as soon as possible;
 - (ii) other data, including associated metadata, as specified and within the deadlines laid down in the ‘data management plan’ (see Annex 1);
- (b) provide information — via the repository — about tools and instruments at the disposal of the beneficiaries and necessary for validating the results (and — where possible — provide the tools and instruments themselves).

This does not change the obligation to protect results in Article 27, the confidentiality obligations in Article 36, the security obligations in Article 37 or the obligations to protect personal data in Article 39, all of which still apply.

As an exception, the beneficiaries do not have to ensure open access to specific parts of their research data if the achievement of the action's main objective (as described in Annex 1) would be jeopardised by making those specific parts of the research data openly accessible. In this case, the data management plan must contain the reasons for not giving access.

29.4 Information on EU funding — Obligation and right to use the EU emblem

Unless the Agency requests or agrees otherwise or unless it is impossible, any dissemination of results (in any form, including electronic) must:

- (a) display the EU emblem and
- (b) include the following text:

“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 955650”.

When displayed together with another logo, the EU emblem must have appropriate prominence.

For the purposes of their obligations under this Article, the beneficiaries may use the EU emblem without first obtaining approval from the Agency.

This does not however give them the right to exclusive use.

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

29.5 Disclaimer excluding Agency responsibility

Any dissemination of results must indicate that it reflects only the author's view and that the Agency is not responsible for any use that may be made of the information it contains.

29.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 30 — TRANSFER AND LICENSING OF RESULTS

30.1 Transfer of ownership

Each beneficiary may transfer ownership of its results.

It must however ensure that its obligations under Articles 26.2, 26.4, 27, 28, 29, 30 and 31 also apply to the new owner and that this owner has the obligation to pass them on in any subsequent transfer.

This does not change the security obligations in Article 37, which still apply.

Unless agreed otherwise (in writing) for specifically-identified third parties or unless impossible under applicable EU and national laws on mergers and acquisitions, a beneficiary that intends to transfer ownership of results must give at least 45 days advance notice (or less if agreed in writing) to the other beneficiaries that still have (or still may request) access rights to the results. This notification must include sufficient information on the new owner to enable any beneficiary concerned to assess the effects on its access rights.

Unless agreed otherwise (in writing) for specifically-identified third parties, any other beneficiary may object within 30 days of receiving notification (or less if agreed in writing), if it can show that the transfer would adversely affect its access rights. In this case, the transfer may not take place until agreement has been reached between the beneficiaries concerned.

30.2 Granting licenses

Each beneficiary may grant licences to its results (or otherwise give the right to exploit them), if:

(a) this does not impede the access rights under Article 31

(b) not applicable.

In addition to Points (a) and (b), exclusive licences for results may be granted only if all the other beneficiaries concerned have waived their access rights (see Article 31.1).

This does not change the dissemination obligations in Article 29 or security obligations in Article 37, which still apply.

30.3 Agency right to object to transfers or licensing

Not applicable

30.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 31 — ACCESS RIGHTS TO RESULTS

31.1 Exercise of access rights — Waiving of access rights — No sub-licensing

The conditions set out in Article 25.1 apply.

The obligations set out in this Article do not change the security obligations in Article 37, which still apply.

31.2 Access rights for other beneficiaries, for implementing their own tasks under the action

The beneficiaries must give each other access — on a royalty-free basis — to results needed for implementing their own tasks under the action.

31.3 Access rights for other beneficiaries, for exploiting their own results

The beneficiaries must give each other — under fair and reasonable conditions (see Article 25.3) — access to results needed for exploiting their own results.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

31.4 Access rights of affiliated entities

Unless agreed otherwise in the consortium agreement, access to results must also be given — under fair and reasonable conditions (Article 25.3) — to affiliated entities established in an EU Member State or associated country, if this is needed for those entities to exploit the results generated by the beneficiaries to which they are affiliated.

Unless agreed otherwise (see above; Article 31.1), the affiliated entity concerned must make any such request directly to the beneficiary that owns the results.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

31.5 Access rights for the EU institutions, bodies, offices or agencies and EU Member States

The beneficiaries must give access to their results — on a royalty-free basis — to EU institutions, bodies, offices or agencies, for developing, implementing or monitoring EU policies or programmes.

Such access rights are limited to non-commercial and non-competitive use.

This does not change the right to use any material, document or information received from the beneficiaries for communication and publicising activities (see Article 38.2).

31.6 Access rights for researchers

The beneficiaries must — on a royalty-free basis — give access to the recruited researchers to results necessary for their research training activities under the action.

31.7 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

SECTION 4 OTHER RIGHTS AND OBLIGATIONS

ARTICLE 32 — RECRUITMENT AND WORKING CONDITIONS FOR RECRUITED RESEARCHERS

32.1 Obligations towards recruited researchers

The beneficiaries must respect the following recruitment and working conditions for the researchers recruited under the action:

- (a) 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 Researchers⁹ and ensure that the researchers are aware of them;
- (b) advertise and publish vacancies internationally, including on the web-sites requested by the Agency;
- (c) recruit the researchers, following an open, transparent, impartial and equitable recruitment procedure, on the basis of:
 - (i) their scientific skills and the relevance of their research experience;
 - (ii) the impact of the proposed training on the researcher's career;

⁹ 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).

- (iii) a fair gender representation (by promoting genuine equal access opportunities between men and women throughout the recruitment process);
- (d) ensure that no conflict of interest exists in or arises from the recruitment;
- (e) ensure that the researchers enjoy at the place of the implementation at least the same standards and working conditions as those applicable to local researchers holding a similar position;
- (f) ensure that the employment contract, other direct contract or fixed amount-fellowship agreement (see Article 6) specifies :
 - (i) the starting date and duration of the research training activities under the action;
 - (ii) the monthly support for the researcher under this Agreement (in euro and, if relevant, in the currency in which the remuneration is paid);
 - (iii) the obligation of the researcher to work exclusively for the action;
 - (iv) the obligation of the researcher not to receive for activities carried out in the frame of the action, other incomes than those received from the beneficiary (or other entity mentioned in Annex 1);
 - (v) the obligation of the researcher to inform the beneficiary as soon as possible of any events or circumstances likely to affect the Agreement (see Article 17);
 - (vi) the arrangements related to the intellectual property rights between the beneficiary and the researcher — during implementation of the action and afterwards;
 - (vii) the obligation of the researcher to maintain confidentiality (see Article 36);
 - (viii) the obligation of the researcher to ensure the visibility of EU funding in communications or publications and in applications for the protection of results (see Articles 27, 28, 29 and 38);
- (g) assist the researchers in the administrative procedures related to their recruitment;
- (h) inform the researchers about:
 - the description, conditions, location and the timetable for the implementation of the research training activities under the action and the name of the supervisor;
 - the rights and obligations of the beneficiary toward the researcher under this Agreement;
 - the obligation of the researcher to complete and submit — at the end of the training — the evaluation questionnaire and — two years later — follow-up questionnaire provided by the Agency;
- (i) ensure that the researchers do not receive, for activities carried out in the frame of the action, other incomes than those received from the beneficiaries (or other entity mentioned in Annex 1);

- (j) ensure that the researchers do not have to bear any costs for the implementation of the action as described in Annex 1;
- (k) host the researchers at their premises (or at the premises of an entity with a capital or legal link);
- (l) provide training and the necessary means for implementing the action (or ensure that such training and means are provided by entities with a capital or legal link);
- (m) ensure that the researchers are adequately supervised;
- (n) ensure that a career development plan is established and support its implementation;
- (o) ensure an appropriate exposure to the non-academic sector;
- (p) limit secondments to a maximum of 30% of the actual months spent implementing the research training activities under the action.

32.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 33 — GENDER EQUALITY

33.1 Obligation to aim for gender equality

The beneficiaries must take all measures to promote equal opportunities between men and women in the implementation of the action. 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.

33.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the Agency may apply any of the measures described in Chapter 6.

ARTICLE 34 — ETHICS AND RESEARCH INTEGRITY

34.1 Obligation to comply with ethical and research integrity principles

The beneficiaries must carry out the action in compliance with:

- (a) ethical principles (including the highest standards of research integrity)
- and
- (b) applicable international, EU and national law.

Funding will not be granted for activities carried out outside the EU if they are prohibited in all Member States or for activities which destroy human embryos (for example, for obtaining stem cells).

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:

- (a) aim at human cloning for reproductive purposes;
- (b) intend to modify the genetic heritage of human beings which could make such changes heritable (with the exception of research relating to cancer treatment of the gonads, which may be financed), or
- (c) 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.

In addition, the beneficiaries must respect the fundamental principle of research integrity — as set out, for instance, in the European Code of Conduct for Research Integrity¹⁰.

This implies compliance with the following fundamental 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;
- **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 and refrain from the research integrity violations described in this Code.

This does not change the other obligations under this Agreement or obligations under applicable international, EU or national law, all of which still apply.

34.2 Activities raising ethical issues

Activities raising ethical issues must comply with the ‘**ethics requirements**’ set out as deliverables in Annex 1.

Before the beginning of an activity raising an ethical issue, each beneficiary must have obtained:

- (a) any ethics committee opinion required under national law and
- (b) any notification or authorisation for activities raising ethical issues required under national and/or European law

needed for implementing the action tasks in question.

¹⁰ European Code of Conduct for Research Integrity of ALLEA (All European Academies)
http://ec.europa.eu/research/participants/data/ref/h2020/other/hi/h2020-ethics_code-of-conduct_en.pdf

The documents must be kept on file and be submitted upon request by the coordinator to the Agency (see Article 52). If they are not in English, they must be submitted together with an English summary, which shows that the action tasks in question are covered and includes the conclusions of the committee or authority concerned (if available).

34.3 Activities involving human embryos or human embryonic stem cells

Activities involving research on human embryos or human embryonic stem cells may be carried out, in addition to Article 34.1, only if:

- they are set out in Annex 1 or
- the coordinator has obtained explicit approval (in writing) from the Agency (see Article 52).

34.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or participation of the beneficiary may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 35 — CONFLICT OF INTERESTS

35.1 Obligation to avoid a conflict of interests

The beneficiaries must take all measures to prevent any situation where the impartial and objective implementation of the action is compromised for reasons involving economic interest, political or national affinity, family or emotional ties or any other shared interest (**'conflict of interests'**).

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

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

35.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or participation of the beneficiary may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 36 — CONFIDENTIALITY

36.1 General obligation to maintain confidentiality

During implementation of the action and for four years after the period set out in Article 3, the parties must keep confidential any data, documents or other material (in any form) that is identified as confidential at the time it is disclosed (**'confidential information'**).

If a beneficiary requests, the Agency may agree to keep such information confidential for an additional period beyond the initial four years.

If information has been identified as confidential only orally, it will be considered to be confidential only if this is confirmed in writing within 15 days of the oral disclosure.

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

The beneficiaries may disclose confidential information to their personnel, entities with a capital or legal link or partner organisations only if they:

- (a) need to know to implement the Agreement and
- (b) are bound by an obligation of confidentiality.

This does not change the security obligations in Article 37, which still apply.

The Agency may disclose confidential information to its staff, other EU institutions and bodies. It may disclose confidential information to third parties, if:

- (a) this is necessary to implement the Agreement or safeguard the EU's financial interests
and
- (b) the recipients of the information are bound by an obligation of confidentiality.

Under the conditions set out in Article 4 of the Rules for Participation Regulation No 1290/2013¹¹, the Commission must moreover make available information on the results to other EU institutions, bodies, offices or agencies as well as Member States or associated countries.

The confidentiality obligations no longer apply if:

- (a) the disclosing party agrees to release the other party;
- (b) the information was already known by the recipient or is given to him without obligation of confidentiality by a third party that was not bound by any obligation of confidentiality;
- (c) the recipient proves that the information was developed without the use of confidential information;
- (d) the information becomes generally and publicly available, without breaching any confidentiality obligation, or
- (e) the disclosure of the information is required by EU or national law.

36.2 Consequences of non-compliance

¹¹ Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for the participation and dissemination in “Horizon 2020 – the Framework Programme for Research and Innovation (2014-2020)” (OJ L 347, 20.12.2013 p.81).

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 37 — SECURITY-RELATED OBLIGATIONS

37.1 Results with a security recommendation

Not applicable

37.2 Classified information

Not applicable

37.3 Activities involving dual-use goods or dangerous materials and substances

Not applicable

37.4 Consequences of non-compliance

Not applicable

ARTICLE 38 — PROMOTING THE ACTION — VISIBILITY OF EU FUNDING

38.1 Communication activities by beneficiaries

38.1.1 Obligation to promote the action and its results

The beneficiaries must promote the action and its results, by providing targeted information to multiple audiences (including the media and the public) in a strategic and effective manner.

This does not change the dissemination obligations in Article 29, the confidentiality obligations in Article 36 or the security obligations in Article 37, all of which still apply.

Before engaging in a communication activity expected to have a mainstream media coverage the beneficiaries must inform the Agency (see Article 52).

38.1.2 Information on EU funding — Obligation and right to use the EU emblem

Unless the Agency requests or agrees otherwise or unless it is impossible, any communication activity related to the action (including in electronic form, via social media, etc.) and any infrastructure, equipment and major results funded by the grant must:

- (a) display the EU emblem and
- (b) include the following text:

For communication activities:

“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 955650”.

For infrastructure, equipment and major results:

“This [*infrastructure*][*equipment*][*insert type of result*] is part of a project that has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 955650”.

When displayed together with another logo, the EU emblem must have appropriate prominence.

For the purposes of their obligations under this Article, the beneficiaries may use the EU emblem without first obtaining approval from the Agency.

This does not, however, give them the right to exclusive use.

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

38.1.3 Disclaimer excluding Agency and Commission responsibility

Any communication activity related to the action must indicate that it reflects only the author's view and that the Agency and the Commission are not responsible for any use that may be made of the information it contains.

38.2 Communication activities by the Agency and the Commission

38.2.1 Right to use beneficiaries’ materials, documents or information

The Agency and the Commission may use, for its communication and publicising activities, information relating to the action, documents notably summaries for publication and public deliverables as well as any other material, such as pictures or audio-visual material received from any beneficiary (including in electronic form).

This does not change the confidentiality obligations in Article 36 and the security obligations in Article 37, all of which still apply.

If the Agency’s or the Commission’s use of these materials, documents or information would risk compromising legitimate interests, the beneficiary concerned may request the Agency or the Commission not to use it (see Article 52).

The right to use a beneficiary’s materials, documents and information includes:

- (a) **use for its own purposes** (in particular, making them available to persons working for the Agency, the Commission or any other EU institution, body, office or agency or body or institutions in EU Member States; and copying or reproducing them in whole or in part, in unlimited numbers);
- (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** for communication and publicising activities (including shortening, summarising, inserting other elements (such as 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) giving **access in response to individual requests** under Regulation No 1049/2001¹³, without the right to reproduce or exploit;
- (f) **storage** in paper, electronic or other form;
- (g) **archiving**, in line with applicable document-management rules, and
- (h) the right to authorise **third parties** to act on its behalf or sub-license the modes of use set out in Points (b), (c), (d) and (f) to third parties if needed for the communication and publicising activities of the Agency or the Commission.

If the right of use is subject to rights of a third party (including personnel of the beneficiary), the beneficiary must ensure that it complies with its obligations under this Agreement (in particular, by obtaining the necessary approval from the third parties concerned).

Where applicable (and if provided by the beneficiaries), the Agency or the Commission will insert the following information:

“© – [year] – [name of the copyright owner]. All rights reserved. Licensed to the Research Executive Agency (REA) and the European Union (EU) under conditions.”

38.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 39 — PROCESSING OF PERSONAL DATA

39.1 Processing of personal data by the Agency and the Commission

Any personal data under the Agreement will be processed by the Agency or the Commission under Regulation No 45/2001¹⁴ and according to the ‘notifications of the processing operations’ to the Data Protection Officer (DPO) of the Agency or the Commission (publicly accessible in the DPO register).

Such data will be processed by the ‘**data controller**’ of the Agency or the Commission for the purposes of implementing, managing and monitoring the Agreement or protecting the financial interests of the EU or Euratom (including checks, reviews, audits and investigations; see Article 22).

The persons whose personal data are processed have the right to access and correct their own personal data. For this purpose, they must send any queries about the processing of their personal data to the

¹³ Regulation (EC) No 1049/2001 of the European Parliament and of the Council of 30 May 2001 regarding public access to European Parliament, Council and Commission documents, OJ L 145, 31.5.2001, p. 43.

¹⁴ Regulation (EC) No 45/2001 of the European Parliament and of the Council of 18 December 2000 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data (OJ L 8, 12.01.2001, p. 1).

data controller, via the contact point indicated in the privacy statement(s) that are published on the Agency and the Commission websites.

They also have the right to have recourse at any time to the European Data Protection Supervisor (EDPS).

39.2 Processing of personal data by the beneficiaries

The beneficiaries must process personal data under the Agreement in compliance with applicable EU and national law on data protection (including authorisations or notification requirements).

The beneficiaries may grant their personnel access only to data that is strictly necessary for implementing, managing and monitoring the Agreement.

The beneficiaries must inform the personnel whose personal data are collected and processed by the Agency or the Commission. For this purpose, they must provide them with the privacy statement(s) (see above), before transmitting their data to the Agency or the Commission.

39.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 39.2, the Agency may apply any of the measures described in Chapter 6.

ARTICLE 40 — ASSIGNMENTS OF CLAIMS FOR PAYMENT AGAINST THE AGENCY

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

If the Agency has not accepted the assignment or 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 Agency.

CHAPTER 5 DIVISION OF BENEFICIARIES' ROLES AND RESPONSIBILITIES **— RELATIONSHIP WITH COMPLEMENTARY BENEFICIARIES —** **RELATIONSHIP WITH PARTNERS OF A JOINT ACTION**

ARTICLE 41 — DIVISION OF BENEFICIARIES' ROLES AND RESPONSIBILITIES **— RELATIONSHIP WITH COMPLEMENTARY BENEFICIARIES —** **RELATIONSHIP WITH PARTNERS OF A JOINT ACTION**

41.1 Roles and responsibility towards the Agency

The beneficiaries have full responsibility for implementing the action and complying with the Agreement.

The beneficiaries are jointly and severally liable for the **technical implementation** of the action as described in Annex 1. If a beneficiary fails to implement its part of the action, the other beneficiaries

become responsible for implementing this part (without being entitled to any additional EU funding for doing so), unless the Agency expressly relieves them of this obligation.

The **financial responsibility** of each beneficiary is governed by Article 44.

41.2 Internal division of roles and responsibilities

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

(a) Each **beneficiary** must:

- (i) keep information stored in the Participant Portal Beneficiary Register (via the electronic exchange system) up to date (see Article 17);
- (ii) inform the coordinator immediately of any events or circumstances likely to affect significantly or delay the implementation of the action (see Article 17);
- (iii) submit to the coordinator in good time:
 - individual financial statements for itself and, if required, certificates on the financial statements (see Article 20);
 - the data needed to draw up the technical reports (see Article 20);
 - ethics committee opinions and notifications or authorisations for activities raising ethical issues (see Article 34);
 - any other documents or information required by the Agency or the Commission under the Agreement, unless the Agreement requires the beneficiary to submit this information directly to the Agency or the Commission.

(b) The **coordinator** must:

- (i) monitor that the action is implemented properly (see Article 7);
- (ii) act as the intermediary for all communications between the beneficiaries and the Agency (in particular, providing the Agency with the information described in Article 17), unless the Agreement specifies otherwise;
- (iii) request and review any documents or information required by the Agency and verify their completeness and correctness before passing them on to the Agency;
- (iv) submit the deliverables and reports to the Agency (see Articles 19 and 20);
- (v) ensure that all payments are made to the other beneficiaries without unjustified delay (see Article 21);
- (vi) inform the Agency of the amounts paid to each beneficiary, when required under the Agreement (see Articles 44 and 50) or requested by the Agency.

The coordinator may not delegate or subcontract the above-mentioned tasks to any other beneficiary or third party (including entities with a capital or legal link and partner organisations).

41.3 Internal arrangements between beneficiaries — Consortium agreement

The beneficiaries must have internal arrangements regarding their operation and co-ordination to ensure that the action is implemented properly. These internal arrangements must be set out in a written ‘**consortium agreement**’ between the beneficiaries, which may cover:

- internal organisation of the consortium;
- management of access to the electronic exchange system;
- distribution of EU funding;
- additional rules on rights and obligations related to background and results (including whether access rights remain or not, if a beneficiary is in breach of its obligations) (see Section 3 of Chapter 4);
- settlement of internal disputes;
- liability, indemnification and confidentiality arrangements between the beneficiaries.

The consortium agreement must not contain any provision contrary to the Agreement.

41.4 Relationship with complementary beneficiaries — Collaboration agreement

Not applicable

41.5 Relationship with partners of a joint action — Coordination agreement

Not applicable

CHAPTER 6 REJECTION OF COSTS — REDUCTION OF THE GRANT — RECOVERY — SANCTIONS — DAMAGES — SUSPENSION — TERMINATION — FORCE MAJEURE

SECTION 1 REJECTION OF COSTS — REDUCTION OF THE GRANT — RECOVERY — SANCTIONS

ARTICLE 42 — REJECTION OF INELIGIBLE COSTS

42.1 Conditions

The Agency will — after **termination of the participation of a beneficiary**, at the time of an **interim payment, at the payment of the balance or afterwards** — reject any costs which are ineligible (see Article 6), in particular following checks, reviews, audits or investigations (see Article 22).

The rejection may also be based on the **extension of findings from other grants to this grant** (see Article 22.5.2).

42.2 Ineligible costs to be rejected — Calculation — Procedure

Ineligible costs will be rejected in full.

If the rejection of costs does not lead to a recovery (see Article 44), the Agency will formally notify the coordinator or beneficiary concerned of the rejection of costs, the amounts and the reasons why (if applicable, together with the notification of amounts due; see Article 21.5). The coordinator or beneficiary concerned may — within 30 days of receiving notification — formally notify the Agency of its disagreement and the reasons why.

If the rejection of costs leads to a recovery, the Agency will follow the contradictory procedure with pre-information letter set out in Article 44.

42.3 Effects

If the Agency rejects costs **after termination of the participation of a beneficiary**, it will deduct them from the costs declared by the beneficiary in the termination report and include the rejection in the calculation after termination (see Article 50.2 and 50.3).

If the Agency rejects costs at the time of an **interim payment** or **the payment of the balance**, it will deduct them from the total eligible costs declared, for the action, in the periodic or final summary financial statement (see Articles 20.3 and 20.4). It will then calculate the interim payment or payment of the balance as set out in Articles 21.3 or 21.4.

If the Agency — **after an interim payment but before the payment of the balance** — rejects costs declared in a periodic summary financial statement, it will deduct them from the total eligible costs declared, for the action, in the next periodic summary financial statement or in the final summary financial statement. It will then calculate the interim payment or payment of the balance as set out in Articles 21.3 or 21.4.

If the Agency rejects costs **after the payment of the balance**, it will deduct the amount rejected from the total eligible costs declared, by the beneficiary, in the final summary financial statement. It will then calculate the revised final grant amount as set out in Article 5.4.

ARTICLE 43 — REDUCTION OF THE GRANT

43.1 Conditions

The Agency may — **after termination of the participation of a beneficiary, at the payment of the balance or afterwards** — reduce the grant, if :

- (a) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed:
 - (i) substantial errors, irregularities or fraud or
 - (ii) serious breach of obligations under the Agreement or during the award procedure (including improper implementation of the action, submission of false information, failure to provide required information, breach of ethical principles) or
- (b) a beneficiary (or a natural person who has the power to represent or take decision on its behalf) has committed — in other EU or Euratom 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 from other grants to this grant**; see Article 22.5.2).

43.2 Amount to be reduced — Calculation — Procedure

The amount of the reduction will be proportionate to the seriousness of the errors, irregularities or fraud or breach of obligations.

Before reduction of the grant, the Agency will formally notify a ‘**pre-information letter**’ to the coordinator or beneficiary concerned:

- informing it of its intention to reduce the grant, the amount it intends to reduce and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If the Agency does not receive any observations or decides to pursue reduction despite the observations it has received, it will formally notify **confirmation** of the reduction (if applicable, together with the notification of amounts due; see Article 21).

43.3 Effects

If the Agency reduces the grant **after termination of the participation of a beneficiary**, it will calculate the reduced grant amount for that beneficiary and then determine the amount due to that beneficiary (see Article 50.2 and 50.3).

If the Agency reduces the grant **at the payment of the balance**, it will calculate the reduced grant amount for the action and then determine the amount due as payment of the balance (see Articles 5.3.4 and 21.4).

If the Agency reduces the grant **after the payment of the balance**, it will calculate the revised final grant amount for the beneficiary concerned (see Article 5.4). If the revised final grant amount for the beneficiary concerned is lower than its share of the final grant amount, the Agency will recover the difference (see Article 44).

ARTICLE 44 — RECOVERY OF UNDUE AMOUNTS

44.1 Amount to be recovered — Calculation — Procedure

The Agency will — after **termination of the participation of a beneficiary, at the payment of the balance or afterwards** — claim back any amount that was paid, but is not due under the Agreement.

Each beneficiary’s financial responsibility in case of recovery is limited to its own debt, except for the amount retained for the Guarantee Fund (see Article 21.4).

44.1.1 Recovery after termination of a beneficiary’s participation

If recovery takes place after termination of a beneficiary’s participation (including the coordinator), the Agency will claim back the undue amount from the beneficiary concerned, by formally notifying it a debit note (see Article 50.2 and 50.3). This note will specify the amount to be recovered, the terms and the date for payment.

If payment is not made by the date specified in the debit note, the Agency or the Commission will **recover** the amount:

- (a) by ‘**offsetting**’ it — without the beneficiary’s consent — against any amounts owed to the beneficiary concerned by the Agency, the Commission or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU’s financial interests, the Agency or the Commission may offset before the payment date specified in the debit note;

- (b) not applicable;

- (c) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date specified in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the Agency or the Commission receives full payment of the amount.

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 2007/64/EC¹⁵ applies.

44.1.2 Recovery at payment of the balance

If the payment of the balance takes the form of a recovery (see Article 21.4), the Agency will formally notify a ‘**pre-information letter**’ to the coordinator:

- informing it of its intention to recover, the amount due as the balance and the reasons why;
- specifying that it intends to deduct the amount to be recovered from the amount retained for the Guarantee Fund;
- requesting the coordinator to submit a report on the distribution of payments to the beneficiaries within 30 days of receiving notification, and
- inviting the coordinator to submit observations within 30 days of receiving notification.

If no observations are submitted or the Agency decides to pursue recovery despite the observations it has received, it will **confirm recovery** (together with the notification of amounts due; see Article 21.5) and:

- pay the difference between the amount to be recovered and the amount retained for the Guarantee Fund, **if the difference is positive** or

¹⁵ Directive 2007/64/EC of the European Parliament and of the Council of 13 November 2007 on payment services in the internal market amending Directives 97/7/EC, 2002/65/EC, 2005/60/EC and 2006/48/EC and repealing Directive 97/5/EC (OJ L 319, 05.12.2007, p. 1).

- formally notify to the coordinator a **debit note** for the difference between the amount to be recovered and the amount retained for the Guarantee Fund, **if the difference is negative**. This note will also specify the terms and the date for payment.

If the coordinator does not repay the Agency by the date in the debit note and has not submitted the report on the distribution of payments: the Agency or the Commission will **recover** the amount set out in the debit note from the coordinator (see below).

If the coordinator does not repay the Agency by the date in the debit note, but has submitted the report on the distribution of payments: the Agency will:

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

$\left\{ \left\{ \left\{ \text{beneficiary's costs declared in the final summary financial statement and approved by the Agency multiplied by the reimbursement rate set out in Article 5.2 for the beneficiary concerned} \right\} \right\}$

divided by

$\left\{ \text{the EU contribution for the action calculated according to Article 5.3.1} \right\}$

multiplied by

$\left\{ \text{the final grant amount (see Article 5.3)} \right\}$,

minus

$\left\{ \text{pre-financing and interim payments received by the beneficiary} \right\}$.

- (b) formally notify to each beneficiary identified according to point (a) a **debit note** specifying the terms and date for payment. The amount of the debit note is calculated as follows:

$\left\{ \left\{ \text{amount calculated according to point (a) for the beneficiary concerned} \right\} \right\}$

divided by

$\left\{ \left\{ \text{the sum of the amounts calculated according to point (a) for all the beneficiaries identified according to point (a)} \right\} \right\}$

multiplied by

$\left\{ \left\{ \text{the amount set out in the debit note formally notified to the coordinator} \right\} \right\}$.

If payment is not made by the date specified in the debit note, the Agency or the Commission will **recover** the amount:

- (a) by **offsetting** it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the Agency, the Commission or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the Agency or the Commission may offset before the payment date specified in the debit note;

- (b) by **drawing on the Guarantee Fund**. The Agency or the Commission will formally notify the beneficiary concerned the debit note on behalf of the Guarantee Fund and recover the amount:

- (i) not applicable;

- (ii) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the Agency or the Commission receives full payment of the amount.

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 2007/64/EC applies.

44.1.3 Recovery of amounts after payment of the balance

If, for a beneficiary, the revised final grant amount (see Article 5.4) is lower than its share of the final grant amount, it must repay the difference to the Agency.

The beneficiary's share of the final grant amount is calculated as follows:

$\left\{ \left\{ \text{beneficiary's costs declared in the final summary financial statement and approved by the Agency multiplied by the reimbursement rate set out in Article 5.2 for the beneficiary concerned} \right\} \right\}$

divided by

$\left\{ \text{the EU contribution for the action calculated according to Article 5.3.1} \right\}$

multiplied by

$\left\{ \text{the final grant amount (see Article 5.3)} \right\}$.

If the coordinator has not distributed amounts received (see Article 21.7), the Agency will also recover these amounts.

The Agency will formally notify a **pre-information letter** to the beneficiary concerned:

- informing it of its intention to recover, the due amount and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If no observations are submitted or the Agency decides to pursue recovery despite the observations it has received, it will **confirm** the amount to be recovered and formally notify to the beneficiary concerned a **debit note**. This note will also specify the terms and the date for payment.

If payment is not made by the date specified in the debit note, the Agency or the Commission will **recover** the amount:

- (a) by **offsetting** it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the Agency, the Commission or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the Agency or the Commission may offset before the payment date specified in the debit note;

(b) by **drawing on the Guarantee Fund**. The Agency or the Commission will formally notify the beneficiary concerned the debit note on behalf of the Guarantee Fund and recover the amount:

(i) not applicable;

(ii) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the date for payment in the debit note, up to and including the date the Agency or the Commission receives full payment of the amount.

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 2007/64/EC applies.

ARTICLE 45 — ADMINISTRATIVE SANCTIONS

In addition to contractual measures, the Agency or the Commission may also adopt administrative sanctions under Articles 106 and 131(4) of the Financial Regulation No 966/2012 (i.e. exclusion from future procurement contracts, grants, prizes and expert contracts and/or financial penalties).

SECTION 2 LIABILITY FOR DAMAGES

ARTICLE 46 — LIABILITY FOR DAMAGES

46.1 Liability of the Agency

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

The Agency cannot be held liable for any damage caused by any of the beneficiaries or third parties involved in the action, as a consequence of implementing the Agreement.

46.2 Liability of the beneficiaries

Except in case of force majeure (see Article 51), the beneficiaries must compensate the Agency 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.

SECTION 3 SUSPENSION AND TERMINATION

ARTICLE 47 — SUSPENSION OF PAYMENT DEADLINE

47.1 Conditions

The Agency may — at any moment — suspend the payment deadline (see Article 21.2 to 21.4) if a request for payment (see Article 20) cannot be approved because:

- (a) it does not comply with the provisions of the Agreement (see Article 20);
- (b) the technical or financial reports have not been submitted or are not complete or additional information is needed, or
- (c) there is doubt about the eligibility of the costs declared in the financial statements and additional checks, reviews, audits or investigations are necessary.

47.2 Procedure

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

The suspension will **take effect** the day notification is sent by the Agency (see Article 52).

If the conditions for suspending the payment deadline are no longer met, the suspension will be **lifted** — and the remaining period will resume.

If the suspension exceeds two months, the coordinator may request the Agency if the suspension will continue.

If the payment deadline has been suspended due to the non-compliance of the technical or financial reports (see Article 20) and the revised report or statement is not submitted or was submitted but is also rejected, the Agency may also terminate the Agreement or the participation of the beneficiary (see Article 50.3.1(l)).

ARTICLE 48 — SUSPENSION OF PAYMENTS

48.1 Conditions

The Agency may — at any moment — suspend payments, in whole or in part and interim payments or the payment of the balance for one or more beneficiaries, if:

- (a) a beneficiary (or a natural person who has the power to represent or take decision on its behalf) has committed or is suspected of having committed:
 - (i) substantial errors, irregularities or fraud or
 - (ii) serious breach of obligations under the Agreement or during the award procedure (including improper implementation of the action, submission of false information, failure to provide required information, breach of ethical principles) or
- (b) a beneficiary (or a natural person who has the power to represent or take decision on its behalf) has committed — in other EU or Euratom 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 from other grants to this grant**; see Article 22.5.2).

If payments are suspended for one or more beneficiaries, the Agency will make partial payment(s) for the part(s) not suspended. If suspension concerns the payment of the balance, — once suspension is lifted — the payment or the recovery of the amount(s) concerned will be considered the payment of the balance that closes the action.

48.2 Procedure

Before suspending payments, the Agency will formally notify the coordinator or beneficiary concerned:

- informing it of its intention to suspend payments and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If the Agency does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify **confirmation** of the suspension. Otherwise, it will formally notify that the suspension procedure is not continued.

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

If the conditions for resuming payments are met, the suspension will be **lifted**. The Agency will formally notify the coordinator or beneficiary concerned.

During the suspension, the periodic report(s) for all reporting periods except the last one (see Article 20.3), must not contain any individual financial statements from the beneficiary concerned. 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.

The beneficiaries may suspend implementation of the action (see Article 49.1) or terminate the Agreement or the participation of the beneficiary concerned (see Article 50.1 and 50.2).

ARTICLE 49 — SUSPENSION OF THE ACTION IMPLEMENTATION

49.1 Suspension of the action implementation, by the beneficiaries

49.1.1 Conditions

The beneficiaries may suspend implementation of the action or any part of it, if exceptional circumstances — in particular *force majeure* (see Article 51) — make implementation impossible or excessively difficult.

49.1.2 Procedure

The coordinator must immediately formally notify to the Agency the suspension (see Article 52), stating:

- the reasons why and
- the expected date of resumption.

The suspension will **take effect** the day this notification is received by the Agency.

Once circumstances allow for implementation to resume, the coordinator must immediately formally notify the Agency and request an **amendment** of the Agreement to set the date on which the action will be resumed, extend the duration of the action and make other changes necessary to adapt the action to the new situation (see Article 55) — unless the Agreement or the participation of a beneficiary has been terminated (see Article 50).

The suspension will be **lifted** with effect from the resumption date set out in the amendment. This date may be before the date on which the amendment enters into force.

Costs incurred during suspension of the action implementation are not eligible (see Article 6).

49.2 Suspension of the action implementation, by the Agency

49.2.1 Conditions

The Agency may suspend implementation of the action or any part of it, if:

- (a) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed or is suspected of having committed:
 - (i) substantial errors, irregularities or fraud or
 - (ii) serious breach of obligations under the Agreement or during the award procedure (including improper implementation of the action, submission of false information, failure to provide required information, breach of ethical principles);
- (b) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed — in other EU or Euratom 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 from other grants to this grant**; see Article 22.5.2), or
- (c) the action is suspected of having lost its scientific or technological relevance.

49.2.2 Procedure

Before suspending implementation of the action, the Agency will formally notify the coordinator or beneficiary concerned:

- informing it of its intention to suspend the implementation and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If the Agency does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify **confirmation** of the suspension. Otherwise, it will formally notify that the procedure is not continued.

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

It will be **lifted** if the conditions for resuming implementation of the action are met.

The coordinator or beneficiary concerned will be formally notified of the lifting and the Agreement will be **amended** to set the date on which the action will be resumed, extend the duration of the action and make other changes necessary to adapt the action to the new situation (see Article 55) — unless the Agreement has already been terminated (see Article 50).

The suspension will be lifted with effect from the resumption date set out in the amendment. This date may be before the date on which the amendment enters into force.

Costs incurred during suspension are not eligible (see Article 6).

The beneficiaries may not claim damages due to suspension by the Agency (see Article 46).

Suspension of the action implementation does not affect the Agency's right to terminate the Agreement or participation of a beneficiary (see Article 50), reduce the grant or recover amounts unduly paid (see Articles 43 and 44).

ARTICLE 50 — TERMINATION OF THE AGREEMENT OR OF THE PARTICIPATION OF ONE OR MORE BENEFICIARIES

50.1 Termination of the Agreement, by the beneficiaries

50.1.1 Conditions and procedure

The beneficiaries may terminate the Agreement.

The coordinator must formally notify termination to the Agency (see Article 52), stating:

- the reasons why and
- the date the termination will take effect. This date must be after the notification.

If no reasons are given or if the Agency considers the reasons do not justify termination, the Agreement will be considered to have been '**terminated improperly**'.

The termination will **take effect** on the day specified in the notification.

50.1.2 Effects

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

- (i) a periodic report (for the open reporting period until termination; see Article 20.3) and
- (ii) the final report (see Article 20.4).

If the Agency does not receive the reports within the deadline (see above), only costs which are included in an approved periodic report will be taken into account.

The Agency will **calculate** the final grant amount (see Article 5.3) and the balance (see Article 21.4) on the basis of the reports submitted. Only costs incurred until termination are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

Improper termination may lead to a reduction of the grant (see Article 43).

After termination, the beneficiaries' obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38, 40, 42, 43 and 44) continue to apply.

50.2 Termination of the participation of one or more beneficiaries, by the beneficiaries

50.2.1 Conditions and procedure

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

The coordinator must formally notify termination to the Agency (see Article 52) and inform the beneficiary concerned.

If the coordinator's participation is terminated without its agreement, the formal notification must be done by another beneficiary (acting on behalf of the other beneficiaries).

The notification must include:

- the reasons why;
- the opinion of the beneficiary concerned (or proof that this opinion has been requested in writing);
- the date the termination takes effect. This date must be after the notification, and
- a request for amendment (see Article 55), with a proposal for reallocation of the tasks and the estimated budget of the beneficiary concerned (see Annexes 1 and 2) and, if necessary, the addition of one or more new beneficiaries (see Article 56). If termination takes effect after the period set out in Article 3, no request for amendment must be included unless the beneficiary concerned is the coordinator. In this case, the request for amendment must propose a new coordinator.

If this information is not given or if the Agency considers that the reasons do not justify termination, the participation will be considered to have been **terminated improperly**.

The termination will **take effect** on the day specified in the notification.

50.2.2 Effects

The coordinator must — within 30 days from when termination takes effect — submit:

- (i) a report on the distribution of payments to the beneficiary concerned and
- (ii) if termination takes effect during the period set out in Article 3, a '**termination report**' from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work, an overview of the use of resources, the individual financial statement and, if applicable, the certificate on the financial statement (see Articles 20.3 and 20.4).

The information in the termination report must also be included in the periodic report for the next reporting period (see Article 20.3).

If the request for amendment is rejected by the Agency, (because it calls into question the decision

awarding the grant or breaches the principle of equal treatment of applicants), the Agreement may be terminated according to Article 50.3.1(c).

If the request for amendment is accepted by the Agency, the Agreement is **amended** to introduce the necessary changes (see Article 55).

The Agency will — on the basis of the periodic reports, the termination report and the report on the distribution of payments — **calculate** the amount which is due to the beneficiary and if the (pre-financing and interim) payments received by the beneficiary exceed this amount.

The **amount which is due** is calculated in the following steps:

Step 1 — Application of the reimbursement rate to the eligible costs

The grant amount for the beneficiary is calculated by applying the reimbursement rate(s) to the total eligible costs declared by the beneficiary in the termination report and approved by the Agency.

Only costs incurred by the beneficiary concerned until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

Step 2 — Reduction due to substantial errors, irregularities or fraud or serious breach of obligations

In case of a reduction (see Article 43), the Agency will calculate the reduced grant amount for the beneficiary by deducting the amount of the reduction (calculated in proportion to the seriousness of the errors, irregularities or fraud or breach of obligations, in accordance with Article 43.2) from the grant amount for the beneficiary.

If the payments received **exceed the amounts due**:

- if termination takes effect during the period set out in Article 3 and the request for amendment is accepted, the beneficiary concerned must repay to the coordinator the amount unduly received. The Agency will formally notify the amount unduly received and request the beneficiary concerned to repay it to the coordinator within 30 days of receiving notification. If it does not repay the coordinator, the Agency will draw upon the Guarantee Fund to pay the coordinator and then notify a **debit note** on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);
- in all other cases, in particular if termination takes effect after the period set out in Article 3, the Agency will formally notify a **debit note** to the beneficiary concerned. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the Agency the amount due and the Agency will notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);
- if the beneficiary concerned is the former coordinator, it must repay the new coordinator according to the procedure above, unless:
 - termination takes effect after an interim payment and

- the former coordinator has not distributed amounts received as pre-financing or interim payments (see Article 21.7).

In this case, the Agency will formally notify a **debit note** to the former coordinator. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the Agency the amount due. The Agency will then pay the new coordinator and notify a debit note on behalf of the Guarantee Fund to the former coordinator (see Article 44).

If the payments received **do not exceed the amounts due**: amounts owed to the beneficiary concerned will be included in the next interim or final payment.

If the Agency does not receive the termination report within the deadline (see above), only costs included in an approved periodic report will be taken into account.

If the Agency does not receive the report on the distribution of payments within the deadline (see above), 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.

Improper termination may lead to a reduction of the grant (see Article 43) or termination of the Agreement (see Article 50).

After termination, the concerned beneficiary's obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38, 40, 42, 43 and 44) continue to apply.

50.3 Termination of the Agreement or the participation of one or more beneficiaries, by the Agency

50.3.1 Conditions

The Agency may terminate the Agreement or the participation of one or more beneficiaries, if:

- (a) one or more beneficiaries do not accede to the Agreement (see Article 56);
- (b) a change to their legal, financial, technical, organisational or ownership situation (or those of an entity with a capital or legal link) is likely to substantially affect or delay the implementation of the action or calls into question the decision to award the grant;
- (c) following termination of participation for one or more beneficiaries (see above), the necessary changes to the Agreement would call into question the decision awarding the grant or breach the principle of equal treatment of applicants (see Article 55);
- (d) implementation of the action is prevented by force majeure (see Article 51) or suspended by the coordinator (see Article 49.1) and either:
 - (i) resumption is impossible, or
 - (ii) the necessary changes to the Agreement would call into question the decision awarding the grant or breach the principle of equal treatment of applicants;

- (e) a beneficiary is declared bankrupt, being wound up, having its affairs administered by the courts, has entered into an arrangement with creditors, has suspended business activities, or is subject to any other similar proceedings or procedures under national law;
- (f) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has been found guilty of professional misconduct, proven by any means;
- (g) a beneficiary does not comply with the applicable national law on taxes and social security;
- (h) the action has lost scientific or technological relevance;
- (i) not applicable;
- (j) not applicable;
- (k) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed fraud, corruption, or is involved in a criminal organisation, money laundering or any other illegal activity;
- (l) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed:
 - (i) substantial errors, irregularities or fraud or
 - (ii) serious breach of obligations under the Agreement or during the award procedure (including improper implementation of the action, submission of false information, failure to provide required information, breach of ethical principles);
- (m) a beneficiary (or the natural person who has the power to represent or take decisions on its behalf) has committed — in other EU or Euratom 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 from other grants to this grant**; see Article 22.5.2);
- (n) despite a specific request by the Agency, a beneficiary does not request — through the coordinator — an amendment to the Agreement to end the participation of a partner organisation or an entity with a capital or legal link that is in one of the situations under points (e), (f), (g), (k), (l) or (m) and to reallocate its tasks.

50.3.2 Procedure

Before terminating the Agreement or participation of one or more beneficiaries, the Agency will formally notify the coordinator or beneficiary concerned:

- informing it of its intention to terminate and the reasons why and
- inviting it, within 30 days of receiving notification, to submit observations and — in case of Point (l.ii) above — to inform the Agency of the measures to ensure compliance with the obligations under the Agreement.

If the Agency does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify to the coordinator or beneficiary concerned **confirmation** of

the termination and the date it will take effect. Otherwise, it will formally notify that the procedure is not continued.

The termination will **take effect**:

- for terminations under Points (b), (c), (e), (g), (h), and (l.ii) above: on the day specified in the notification of the confirmation (see above);
- for terminations under Points (a), (d), (f), (k), (l.i) and (m) above: on the day after the notification of the confirmation is received.

50.3.3 Effects

(a) for **termination of the Agreement**:

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

- (i) a periodic report (for the last open reporting period until termination; see Article 20.3) and
- (ii) a final report (see Article 20.4).

If the Agreement is terminated for breach of the obligation to submit reports (see Articles 20.8 and 50.3.1(l)), the coordinator may not submit any reports after termination.

If the Agency does not receive the reports within the deadline (see above), only costs which are included in an approved periodic report will be taken into account.

The Agency will **calculate** the final grant amount (see Article 5.3) and the balance (see Article 21.4) on the basis of the reports submitted. Only costs incurred until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

This does not affect the Agency's right to reduce the grant (see Article 43) or to impose administrative sanctions (Article 45).

The beneficiaries may not claim damages due to termination by the Agency (see Article 46).

After termination, the beneficiaries' obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38, 40, 42, 43 and 44) continue to apply.

(b) for **termination of the participation of one or more beneficiaries**:

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 request for amendment (see Article 55), with a proposal for reallocation of the tasks and estimated budget of the beneficiary concerned (see Annexes 1 and 2) and, if necessary, the addition of one or more new beneficiaries (see Article 56). If termination is notified after the period set out in Article 3, no request for amendment must be submitted unless the beneficiary concerned is the coordinator. In this case the request for amendment must propose a new coordinator, and

- (iii) if termination takes effect during the period set out in Article 3, a **termination report** from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work, an overview of the use of resources, the individual financial statement and, if applicable, the certificate on the financial statement (see Article 20).

The information in the termination report must also be included in the periodic report for the next reporting period (see Article 20.3).

If the request for amendment is rejected by the Agency, (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the Agreement may be terminated according to Article 50.3.1(c).

If the request for amendment is accepted by the Agency, the Agreement is **amended** to introduce the necessary changes (see Article 55).

The Agency will — on the basis of the periodic reports, the termination report and the report on the distribution of payments — **calculate** the amount which is due to the beneficiary and if the (pre-financing and interim) payments received by the beneficiary exceed this amount.

The **amount which is due** is calculated in the following steps:

Step 1 — Application of the reimbursement rate to the eligible costs

The grant amount for the beneficiary is calculated by applying the reimbursement rate(s) to the total eligible costs declared by the beneficiary in the termination report and approved by the Agency.

Only costs incurred by the beneficiary concerned until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

Step 2 — Reduction due to substantial errors, irregularities or fraud or serious breach of obligations

In case of a reduction (see Article 43), the Agency will calculate the reduced grant amount for the beneficiary by deducting the amount of the reduction (calculated in proportion to the seriousness of the errors, irregularities or fraud or breach of obligations, in accordance with Article 43.2) from the grant amount for the beneficiary.

If the payments received **exceed the amounts due**:

- if termination takes effect during the period set out in Article 3 and the request for amendment is accepted, the beneficiary concerned must repay to the coordinator the amount unduly received. The Agency will formally notify the amount unduly received and request the beneficiary concerned to repay it to the coordinator within 30 days of receiving notification. If it does not repay the coordinator, the Agency will draw upon the Guarantee Fund to pay the coordinator and then notify a **debit note** on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);

- in all other cases, in particular if termination takes effect after the period set out in Article 3, the Agency will formally notify a **debit note** to the beneficiary concerned. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the Agency the amount due and the Agency will notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);
- if the beneficiary concerned is the former coordinator, it must repay the new coordinator according to the procedure above, unless:
 - termination takes effect after an interim payment and
 - the former coordinator has not distributed amounts received as pre-financing or interim payments (see Article 21.7).

In this case, the Agency will formally notify a **debit note** to the former coordinator. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the Agency the amount due. The Agency will then pay the new coordinator and notify a debit note on behalf of the Guarantee Fund to the former coordinator (see Article 44).

If the payments received **do not exceed the amounts due**: amounts owed to the beneficiary concerned will be included in the next interim or final payment.

If the Agency does not receive the termination report within the deadline (see above), only costs included in an approved periodic report will be taken into account.

If the Agency does not receive the report on the distribution of payments within the deadline (see above), 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.

After termination, the concerned beneficiary's obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38, 40, 42, 43 and 44) continue to apply.

SECTION 4 FORCE MAJEURE

ARTICLE 51 — FORCE MAJEURE

'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 third parties involved in the action), and
- proves to be inevitable in spite of exercising all due diligence.

The following cannot be invoked as force majeure:

- any default of a service, defect in equipment or material or delays in making them available, unless they stem directly from a relevant case of force majeure,
- labour disputes or strikes, or
- financial difficulties.

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

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.

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

CHAPTER 7 FINAL PROVISIONS

ARTICLE 52 — COMMUNICATION BETWEEN THE PARTIES

52.1 Form and means of communication

Communication under the Agreement (information, requests, submissions, ‘formal notifications’, etc.) must:

- be made in writing and
- bear the number of the Agreement.

All communication must be made through the Participant Portal **electronic** exchange system and using the forms and templates provided there.

If— after the payment of the balance — the Agency finds that a formal notification was not accessed, a second formal notification will be made by registered post with proof of delivery (‘formal notification on **paper**’). Deadlines will be calculated from the moment of the second notification.

Communications in the electronic exchange system must be made by persons authorised according to the Participant Portal Terms & 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 his/her appointment letter (see Participant Portal Terms & Conditions).

If the electronic exchange system is temporarily unavailable, instructions will be given on the Agency and Commission websites.

52.2 Date of communication

Communications are considered to have been made when they are sent by the sending party (i.e. on the date and time they are sent through the electronic exchange system).

Formal notifications through the **electronic** exchange system are considered to have been made when

they are received by the receiving party (i.e. on the date and time of acceptance by the receiving party, as indicated by the time stamp). A formal notification that has not been accepted within 10 days after sending is considered to have been accepted.

Formal notifications **on paper** sent by **registered post** with proof of delivery (only after the payment of the balance) are considered to have been made on either:

- 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.

52.3 Addresses for communication

The **electronic** exchange system must be accessed via the following URL:

<https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/myarea/projects>

The Agency will formally notify the coordinator and beneficiaries in advance any changes to this URL.

Formal notifications on paper (only after the payment of the balance) addressed **to the Agency** must be sent to the official mailing address indicated on the Agency's website.

Formal notifications on paper (only after the payment of the balance) addressed **to the beneficiaries** must be sent to their legal address as specified in the Participant Portal Beneficiary Register.

ARTICLE 53 — INTERPRETATION OF THE AGREEMENT

53.1 Precedence of the Terms and Conditions over the Annexes

The provisions in the Terms and Conditions of the Agreement take precedence over its Annexes.

Annex 2 takes precedence over Annex 1.

53.2 Privileges and immunities

Not applicable

ARTICLE 54 — CALCULATION OF PERIODS, DATES AND DEADLINES

In accordance with Regulation No 1182/71¹⁶, 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.

ARTICLE 55 — AMENDMENTS TO THE AGREEMENT

¹⁶ 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).

55.1 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.

55.2 Procedure

The party requesting an amendment must submit a request for amendment signed in the electronic exchange system (see Article 52).

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 Agency may request additional information.

If the party receiving the request agrees, it must sign the amendment in the electronic exchange system within 45 days of receiving notification (or any additional information the Agency 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 agreed by the parties or, in the absence of such an agreement, on the date on which the amendment enters into force.

ARTICLE 56 — ACCESSION TO THE AGREEMENT

56.1 Accession of the beneficiaries mentioned in the Preamble

The other beneficiaries must accede to the Agreement by signing the Accession Form (see Annex 3) in the electronic exchange system (see Article 52) within 30 days after its entry into force (see Article 58).

They will assume the rights and obligations under the Agreement with effect from the date of its entry into force (see Article 58).

If a beneficiary does not accede to the Agreement within the above deadline, the coordinator must

— within 30 days — request an amendment to make any changes necessary to ensure proper implementation of the action. This does not affect the Agency's right to terminate the Agreement (see Article 50).

56.2 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 55. It must include an Accession Form (see Annex 3) signed by the new beneficiary in the electronic exchange system (see Article 52).

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

ARTICLE 57 — APPLICABLE LAW AND SETTLEMENT OF DISPUTES

57.1 Applicable law

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

57.2 Dispute settlement

If a dispute concerning the interpretation, application or validity of the Agreement cannot be settled amicably, the General Court — or, on appeal, the Court of Justice of the European Union — has sole jurisdiction. Such actions must be brought under Article 272 of the Treaty on the Functioning of the EU (TFEU).

As an exception, if such a dispute is between the Agency and PAUL SCHERRER INSTITUT, the competent Belgian courts have sole jurisdiction.

If a dispute concerns administrative sanctions, offsetting or an enforceable decision under Article 299 TFEU (see Articles 44, 45 and 46), the beneficiaries must bring action before the General Court — or, on appeal, the Court of Justice of the European Union — under Article 263 TFEU. Actions against offsetting and enforceable decisions must be brought against the Commission (not against the Agency).

ARTICLE 58 — ENTRY INTO FORCE OF THE AGREEMENT

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

SIGNATURES

For the coordinator

For the Agency



EUROPEAN COMMISSION
Research Executive Agency

The Director



ANNEX 1 (part A)

European Training Networks

NUMBER — 955650 — CATCHY

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1.1. The project summary

Project Number ¹	955650	Project Acronym ²	CATCHY
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One form per project

General information

Project title ³	Design, implementation and production upscaling of novel, high-performance, cluster-based catalysts for CO ₂ hydrogenation
Starting date ⁴	01/11/2020
Duration in months ⁵	48
Call (part) identifier ⁶	H2020-MSCA-ITN-2020
Topic	MSCA-ITN-2020 Innovative Training Networks
Fixed EC Keywords	Chemical reactions: mechanisms, dynamics, kinetics and catalytic reactions, Spectroscopic and spectrometric techniques, Heterogeneous catalysis, Nano-materials: oxides, alloys, composite, organic-inorganic hybrid, nanoparticles, Electrochemistry, electro dialysis, microfluidics, sensors
Free keywords	metal clusters, methanol, density functional theory, reaction kinetics

Abstract ⁷

The European Training Network CATCHY provides a concerted effort to design novel high-performance thermo- and electrocatalysts for the conversion of CO₂ into added-value synthetic fuels, while delivering a unique range of training opportunities providing young researchers with the expertise and skills required by employers in nanotechnology. Catalysis research is dedicated to the understanding and optimization of existing catalysts and the tailor-made design of new materials with a focus on high-activity, high-selectivity, and economic feasibility. CATCHY will tailor new high performance CO₂ conversion catalysts by a new multidisciplinary catalysis-by-design approach combining: i. production of bimetallic gas phase clusters of controlled homogeneity mixing transition, noble, and post-transition metals and deposition on various supports; ii. extensive characterization of their morphology (ex situ and in situ); iii. fundamental experimental and theoretical reactivity studies; and iv. (electro)catalytic laboratory tests. A prototype of the most promising electrocatalyst will be tested under realistic operative conditions.

CATCHY offers an interactive training approach combining new capabilities for the fabrication and characterization of cluster-based nanostructured surfaces to produce innovative applications. A complementary academic and industrial environment ensures an intersectorial training programme. Industry oriented training will be provided by focusing on selected catalysis applications directly related to energy and climate change issues of paramount importance to the EU and the world. The balanced program combines local expert training by academia and industrial partners, a network-wide secondment scheme, and network-wide training. The societal and environmental urgency to mitigate adverse climate change effects in the coming decades, and the particular advanced catalyst design approach, will guarantee the employability of CATCHY's young researchers.

1.2. List of Beneficiaries

Project Number ¹	955650	Project Acronym ²	CATCHY
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List of Beneficiaries

No	Name	Short name	Country	Project entry month ⁸	Project exit month
1	KATHOLIEKE UNIVERSITEIT LEUVEN	KUL	Belgium	1	48
2	BUDAPESTI MUSZAKI ES GAZDASAGTUDOMANYI EGYETEM	BME	Hungary	1	48
3	DANMARKS TEKNISKE UNIVERSITET	DTU	Denmark	1	48
4	FURUKAWA ELECTRIC TECHNOLOGIAI INTEZET KORLATOLT FELELOSSEGU TARSASAG	FETI	Hungary	1	48
5	PAUL SCHERRER INSTITUT	PSI	Switzerland	1	48
6	STICHTING KATHOLIEKE UNIVERSITEIT	RU	Netherlands	1	48
7	TEER COATINGS LIMITED	TCL	United Kingdom	1	48
8	UNIVERSITEIT ANTWERPEN	UA	Belgium	1	48
9	UNIVERSITAET ULM	UU	Germany	1	48
10	VLAAMSE INSTELLING VOOR TECHNOLOGISCH ONDERZOEK N.V.	VITO	Belgium	1	48

1.3. Workplan Tables - Detailed implementation

1.3.1. WT1 List of work packages

WP Number ⁹	WP Title	Lead beneficiary ¹⁰	Start month ¹²	End month ¹³
WP1	Cluster Deposition	1 - KUL	6	48
WP2	Characterization of Deposited Clusters	5 - PSI	6	48
WP3	Theoretical Modelling	4 - FETI	6	48
WP4	Free Cluster Reactivity	9 - UU	6	48
WP5	Catalysts Testing and Prototyping of a Model Gas Diffusion Electrode	3 - DTU	6	48
WP6	Training	6 - RU	6	48
WP7	Dissemination, Exploitation, Communication, and Outreach	1 - KUL	1	48
WP8	Project Management	1 - KUL	1	48
WP9	Ethics requirements	1 - KUL	1	48

1.3.2. WT2 list of deliverables

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D1.1	cluster deposition EC	WP1	3 - DTU	Report	Confidential, only for members of the consortium (including the Commission Services)	12
D1.2	cluster deposition TC	WP1	1 - KUL	Report	Confidential, only for members of the consortium (including the Commission Services)	16
D1.3	cluster production upscaling	WP1	7 - TCL	Report	Confidential, only for members of the consortium (including the Commission Services)	18
D2.1	in situ characterization TC	WP2	5 - PSI	Report	Confidential, only for members of the consortium (including the Commission Services)	24
D2.2	in situ characterization EC	WP2	5 - PSI	Report	Confidential, only for members of the consortium (including the Commission Services)	24
D2.3	in situ TEM characterization	WP2	8 - UA	Report	Confidential, only for members of the consortium (including the Commission Services)	24
D3.1	theoretical characterization noble metal cluster EC	WP3	4 - FETI	Report	Confidential, only for members of the consortium (including the Commission Services)	18
D3.2	theoretical characterization post-transition metal cluster TC	WP3	2 - BME	Report	Confidential, only for members of the consortium (including the Commission Services)	18

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D3.3	modelling reaction path free cluster	WP3	4 - FETI	Report	Confidential, only for members of the consortium (including the Commission Services)	22
D3.4	modelling TC reaction path	WP3	2 - BME	Report	Confidential, only for members of the consortium (including the Commission Services)	22
D4.1	mass spectra metal-oxide clusters	WP4	9 - UU	Report	Confidential, only for members of the consortium (including the Commission Services)	12
D4.2	reactivity free metal-oxide clusters	WP4	9 - UU	Report	Confidential, only for members of the consortium (including the Commission Services)	24
D4.3	mass spectra bi-metal-oxide clusters	WP4	9 - UU	Report	Confidential, only for members of the consortium (including the Commission Services)	30
D4.4	IR spectroscopy cluster-CO ₂	WP4	6 - RU	Report	Confidential, only for members of the consortium (including the Commission Services)	36
D5.1	cluster-based TCs in gas flow reactors	WP5	3 - DTU	Report	Confidential, only for members of the consortium (including the Commission Services)	23
D5.2	cluster-based EC in electrochemical cell	WP5	3 - DTU	Report	Confidential, only for members of the consortium (including the Commission Services)	24
D5.3	optimisation cluster modified electrode	WP5	10 - VITO	Report	Confidential, only for members	24

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
					of the consortium (including the Commission Services)	
D6.1	NWT1	WP6	1 - KUL	Report	Public	10
D6.2	NWT2	WP6	3 - DTU	Report	Public	25
D6.3	NWT3	WP6	4 - FETI	Report	Public	17
D6.4	NWT4	WP6	5 - PSI	Report	Public	35
D6.5	NWT5	WP6	9 - UU	Report	Public	25
D6.6	NWT6	WP6	6 - RU	Report	Public	40
D6.7	secondment summary report	WP6	6 - RU	Report	Confidential, only for members of the consortium (including the Commission Services)	42
D6.8	NWT7	WP6	1 - KUL	Report	Public	45
D6.9	PhD theses	WP6	6 - RU	Report	Confidential, only for members of the consortium (including the Commission Services)	48
D7.1	website online	WP7	1 - KUL	Websites, patents filling, etc.	Public	1
D7.2	Communication and Dissemination Plan	WP7	1 - KUL	Other	Confidential, only for members of the consortium (including the Commission Services)	3
D7.3	website intranet and ESR specific info	WP7	1 - KUL	Websites, patents filling, etc.	Public	7
D7.4	IPR policy	WP7	1 - KUL	Other	Confidential, only for members of the consortium (including the Commission Services)	7
D7.5	microdocs	WP7	1 - KUL	Websites, patents filling, etc.	Public	21

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D7.6	first papers	WP7	1 - KUL	Websites, patents filling, etc.	Public	25
D7.7	presentations at conferences	WP7	1 - KUL	Websites, patents filling, etc.	Public	40
D7.8	confidential summary report	WP7	1 - KUL	Report	Confidential, only for members of the consortium (including the Commission Services)	41
D7.9	second papers	WP7	1 - KUL	Websites, patents filling, etc.	Public	42
D7.10	exploitation plan	WP7	1 - KUL	Other	Confidential, only for members of the consortium (including the Commission Services)	48
D8.1	Supervisory Board	WP8	1 - KUL	Other	Confidential, only for members of the consortium (including the Commission Services)	2
D8.2	Consortium Agreement	WP8	1 - KUL	Other	Confidential, only for members of the consortium (including the Commission Services)	2
D8.3	positions advertised	WP8	1 - KUL	Other	Public	2
D8.4	Data Management Plan	WP8	1 - KUL	ORDP: Open Research Data Pilot	Confidential, only for members of the consortium (including the Commission Services)	6
D8.5	personal career development plans	WP8	1 - KUL	Report	Confidential, only for members of the consortium (including the Commission Services)	7
D8.6	progress report	WP8	1 - KUL	Report	Confidential, only for members	13

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
					of the consortium (including the Commission Services)	
D8.7	Project check - reports	WP8	1 - KUL	Report	Confidential, only for members of the consortium (including the Commission Services)	15
D9.1	EPQ - Requirement No. 1	WP9	1 - KUL	Ethics	Confidential, only for members of the consortium (including the Commission Services)	12

1.3.3. WT3 Work package descriptions

Work package number ⁹	WP1	Lead beneficiary ¹⁰	1 - KUL
Work package title	Cluster Deposition		
Start month	6	End month	48

Objectives

STO1 - To synthesize gas-phase nanoclusters deposited on surfaces. Easy to stabilize mass-selected mono- and bimetallic clusters mixing 3d transition Cu, Ni, Co, noble Au, Ag, Pd, and Pt and post-transition Zn, Ga, In, Sn, Bi metals (few atoms to 5.0 nm) will be deposited onto suitable substrates for the production of novel TCs and ECs.

Description of work and role of partners

WP1 - Cluster Deposition [Months: 6-48]

KUL

Task 1.1 TC production. KUL (ESR1) will deposit series of mass-selected bimetallic clusters, mixing 3d-metal (Cu, Ni, Co), noble (Au, Ag, Pd, Pt) and post-transition metal (Zn, Ga, In, Sn, Bi) onto various supports with a high and controllable homogeneity. In a first stage, the focus will be on CuZn, PdPt and PdBi systems. Cluster composition will be precisely controlled either by using alloyed targets of the desired composition or by a dual-target dual-laser approach by tuning the power of the two ablating lasers. These clusters will be deposited onto Si wafers, graphite, alumina, TiO₂, MgO, and CeO (ESR1). DTU (ESR11) will produce series of Ni_xGa_{1-x} and Co_xCu_{1-x} clusters over a large composition range (x = 0 to 1) using alloyed targets deposited in micro reactors. In parallel, TCL (ESR2) will gradually scale-up the production of clusters corresponding to the most promising size and bimetallic compositions with their innovative multiple magnetron source based on hollow cathode sputtering and direct depositing onto oxide powders (TiO₂, MgO, CeO_x, AlO_x etc) for prototyping.

Task 1.2 EC production. KUL (ESR8) will deposit series of mass-selected bimetallic clusters of Task 1.1 onto conducting glassy carbon and FTO electrodes. DTU (ESR12) will produce series of clusters of Task 1.1 on electrodes in electrochemical cells (ECs) (connection with WP5). TCL (ESR2) will deposit clusters of Task 1.1 on larger surface area electrodes for the prototyping stage. Selected EC and TC clusters will be directly deposited on electron microscope grids/reactors for in situ TEM investigations (connection with WP4 and ESR10). EC and TC clusters will be tested for their catalytic CO₂ conversion properties (connection with WP2) and most performant systems will be investigated by advanced in situ characterisation techniques (connection with WP2 and ESR 9 & 14). Understanding of the most promising TC and EC systems will be assisted by theoretical modelling, suggesting interesting composition, size, morphology, etc. (connection with WP3 and ESR 5 & 6).

In terms of upscaling, the target is to demonstrate a capacity of producing 10 grams of catalyst in powder form per day, assuming the loading of metal nanocluster on the powder is 1% in weight. This paves a way for further development to reach a commercially viable product rate at a level of 1 kg catalyst per day.

Participation per Partner

Partner number and short name ¹⁰
1 - KUL
3 - DTU
7 - TCL

List of deliverables

Deliverable Number¹⁴	Deliverable Title	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D1.1	cluster deposition EC	3 - DTU	Report	Confidential, only for members of the consortium (including the Commission Services)	12
D1.2	cluster deposition TC	1 - KUL	Report	Confidential, only for members of the consortium (including the Commission Services)	16
D1.3	cluster production upscaling	7 - TCL	Report	Confidential, only for members of the consortium (including the Commission Services)	18

Description of deliverables

D1.1 : cluster deposition EC [12]
 1st report on successful deposition of bimetallic clusters on electrodes (CMEs) for electrocatalysts

D1.2 : cluster deposition TC [16]
 1st report on successful deposition of bimetallic clusters on SiO₂ and micro reactors for thermocatalysts

D1.3 : cluster production upscaling [18]
 1st report on upscaling the production of clusters

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS6	upscaled cluster production	7 - TCL	18	Upscaled cluster deposition on powders and electrodes for thermo catalysts and electrocatalysts.

Work package number ⁹	WP2	Lead beneficiary ¹⁰	5 - PSI
Work package title	Characterization of Deposited Clusters		
Start month	6	End month	48

Objectives

STO2 - To physically characterize the clusters arrays as prepared and under realistic thermo- and electro-catalytic reaction conditions.

Cluster morphology and electronic properties will be characterized ex situ with AFM, STM, and ((S)TEM) and reaction conditions reaction conditions with in situ TEM, PM-IRRAS, DRIFTS, FEL-IR and XAFS

Description of work and role of partners

WP2 - Characterization of Deposited Clusters [Months: 6-48]

PSI

Task 2.1 Ex situ characterization. The structure and morphology of the deposited clusters will be studied routinely by AFM, STM, AES, and RBS at KUL and TCL (ESR1,2,8), while the electronic properties of selected cluster systems will be investigated by XPS at KUL (ESR1,8). A more detailed study of the atomic structure and morphology of the clusters and the influence of the substrate will be carried out on different types of grids compatible with aberration-corrected scanning transmission electron microscopy (TEM) and/or STM (KUL, DTU, UA) (ESR1,8,10,11,12). The nature of CO₂ and H₂ adsorption (activation, dissociative adsorption) onto deposited clusters will be investigated at RU by FEL based IR-visible sum-frequency generation (ESR7), allowing for a detailed structural probe, with potential for real-time dynamic information.

Task 2.2 In situ characterization. Sub-task 2.2.1 TCs investigation. Advanced in situ characterization using micro reactors based on MEMS technology will be performed at DTU (ESR11). Following catalysis testing (WP5), the most promising systems will be measured with operando IR-VIS SFG spectroscopy at the FEL facility at RU and PM-IRRAS and DRIFTS at PSI, KUL (ESR1,7,8,9,14) to provide information on the active site through the vibrational characteristics of the chemisorbed reagents. In situ XAFS (PSI, KUL; ESR1,9) under high pressure gas flow (TCs) using in-house cells will be carried out at SuperXAS beamline of Swiss Light Source (SLS) at PSI and ESRF and other synchrotron facilities. High-pressure cell combined with mass spectrometry and gas chromatography for analysis of products will provide new insight on the changes of structure and electronic properties of the cluster-based catalysts under working conditions. The electronic properties (d-band structure) as well as the dynamic structure (segregation/alloying) of bimetallic clusters as a function of size, composition, support, and gas atmosphere will be probed by varieties of XAFS methods including extended X-ray absorption fine structure (EXAFS), X-ray absorption near edge structure (XANES), high-energy-resolution fluorescence detection (HERFD)-XANES and valence band Resonant Inelastic X-ray Scattering (RIXS). Time-resolved and high-energy-resolution measurements requiring high flux will be carried out at an undulator beamline (ID26) at ESRF. The understanding gained of the electronic properties of the synthesized clusters will feed into theoretical modelling (WP3). In situ transmission electron microscopy (in situ TEM) investigations of clusters under reactive environments will be carried out by combining state-of-the-art ThermoFisher Titan transmission electron microscopes with in situ TEM holders, including a gas/heating system (DensSolutions Climate holder) and a dedicated heating system (DensSolutions Wildfire holder) available at UA (ESR10). This will allow uncovering the structure and dynamics of catalyst surfaces, correlate composition/activity and elucidate the role of the active sites under reaction conditions. Sub-task 2.2.2 ECs investigation. Following electrocatalysis testing (WP5), the most performant ECs will be investigated in situ by XAFS spectroscopy under electrochemical conditions using existing and newly developed in-house cells at SuperXAS beamline at PSI (ESR14) and at ESRF by KUL (ESR8) and by in situ TEM using a liquid-biasing system (DensSolutions Stream holder) at UA (ESR10). Specifically, a novel hanging-meniscus electrochemical cell allowing in situ XAFS measurements on these geometrically-challenging samples will be developed (ESR14), as to perform XANES, EXAFS and HERFD-XANES measurements that will lead to unprecedented insight on the d-band structure of electro-catalysts under working conditions.

Participation per Partner

Partner number and short name ¹⁰
1 - KUL
3 - DTU
5 - PSI
6 - RU
7 - TCL
8 - UA

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D2.1	in situ characterization TC	5 - PSI	Report	Confidential, only for members of the consortium (including the Commission Services)	24
D2.2	in situ characterization EC	5 - PSI	Report	Confidential, only for members of the consortium (including the Commission Services)	24
D2.3	in situ TEM characterization	8 - UA	Report	Confidential, only for members of the consortium (including the Commission Services)	24

Description of deliverables

D2.1 : in situ characterization TC [24]
 1st report on in situ characterization of a clusters-based TC in cell and microreactors

D2.2 : in situ characterization EC [24]
 1st report on in situ characterization of a clusters-based EC in electrochemical cell

D2.3 : in situ TEM characterization [24]
 1st report on in situ TEM characterization of a clusters-based catalyst

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS7	in situ characterization	5 - PSI	25	1st peer-reviewed publications on in situ characterization of bimetallic clusters under

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
				CO2 hydrogenation (thermocatalysts) and CO2 electro-reduction (electrocatalysts)

Work package number ⁹	WP3	Lead beneficiary ¹⁰	4 - FETI
Work package title	Theoretical Modelling		
Start month	6	End month	48

Objectives

STO3 - To use advanced theoretical modelling/computational simulations to identify active materials. Cluster deposition will be assisted by ab initio theoretical modelling that will aim at directing the synthesis towards the most promising materials in terms of sensitivity and/or reactivity.

Description of work and role of partners

WP3 - Theoretical Modelling [Months: 6-48]

FETI

Description of Work and Role of Specific Beneficiary:

First-principles simulations will be performed, in a fully interactive mode with the experimental partners, to describe the interaction between both free and deposited clusters and the CO₂ and H₂ molecules. Geometrical structures of gas phase clusters will be investigated using stochastic global minimization as well as using systematic models. Deposited particles will be studied using periodic as well as finite cluster models. Depending on the acquired structural and energetic data, conventional statistical methods or machine learning will be used to help the design of active cluster TC and EC catalysts by a selection process, predicting combinations of the key parameters that generate high performances (connection to WP5). An important part of the work will be to interpret the simulation results as well as the experimental findings by the analysis of the chemical bonding, non-covalent interactions and the electronic structure. The ultimate goal is to understand the site preference of the catalytic reactivity and propose more active catalysts.

Task 3.1 EC reaction modelling. FETI (ESR5), in close collaboration with UU (ESR3) and BME (ESR6), will investigate the geometry and the electronic structure of gas phase noble metal clusters and use the outcome of the characterization and reactivity measurements (link with WP2 and WP5) as input for calculations and in return will provide concepts for the preparation of new materials. Although DFT will be mainly used, high level ab-initio computations will also be carried out (using CCSD(T) or LNO-CCSD(T)) to validate the method for selected systems. The results will be interpreted using Energy Decomposition Analysis. Subsequently the geometric and the electronic structure of deposited noble metal clusters prepared by KUL (ESR8) will be investigated. The structural and reactivity investigations of WP2 and WP5 by DTU (ESR12) and PSI (ESR14) will be used as inputs for the computations, and the reaction mechanisms will be returned. The ultimate goal is to uncover the electronic and structural effects responsible for the good catalytic activity, set up scaling relations and suggest better catalysts. EC reaction mechanisms will be investigated using computational hydrogen electrode model as well as using grand canonical DFT.

Task 3.2 TC reaction modelling. BME (ESR6) in collaboration with RU (ESR4) and FETI (ESR5) will investigate the geometric, electronic and geometric structures of gas phase post-transition metal clusters and will explore the reaction paths using quantum chemical methods. The results will be interpreted using chemical bonding and charge analysis with an ultimate goal to understand the preferred reaction sites and the cluster size and composition effect on the reactivity. Subsequently, post-transition metal clusters, supported on various oxides (e.g. Al₂O₃, TiO₂ etc.) prepared by KUL (ESR1) will be investigated together with PSI (ESR9), UA (ESR10) and DTU (ESR11) to predict the geometric and electronic structure of clusters and obtain thermodynamic, kinetic, and spectroscopic information to assist interpretation of the experimental results. Finite temperature effects will be investigated using molecular dynamics simulations as well as thermodynamic modelling. UU (ESR3) will model the reactive and catalytic properties of metal oxide clusters as a function of cluster size and metal to oxygen ratio.

Participation per Partner

Partner number and short name ¹⁰
1 - KUL
2 - BME
4 - FETI

Partner number and short name ¹⁰
9 - UU

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D3.1	theoretical characterization noble metal cluster EC	4 - FETI	Report	Confidential, only for members of the consortium (including the Commission Services)	18
D3.2	theoretical characterization post-transition metal cluster TC	2 - BME	Report	Confidential, only for members of the consortium (including the Commission Services)	18
D3.3	modelling reaction path free cluster	4 - FETI	Report	Confidential, only for members of the consortium (including the Commission Services)	22
D3.4	modelling TC reaction path	2 - BME	Report	Confidential, only for members of the consortium (including the Commission Services)	22

Description of deliverables

<p>D3.1 : theoretical characterization noble metal cluster EC [18] 1st report on theoretical characterization of noble metal and noble metal oxide clusters for EC</p> <p>D3.2 : theoretical characterization post-transition metal cluster TC [18] 1st report on theoretical characterization of post-transition metal clusters for TC</p> <p>D3.3 : modelling reaction path free cluster [22] 1st report on theoretical characterization of a catalytic reaction path for a free cluster</p> <p>D3.4 : modelling TC reaction path [22] 1st report on theoretical characterization of a cluster based thermocatalytic reaction path</p>
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Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS8	theoretical characterization	4 - FETI	25	1st peer-reviewed papers on theoretical characterization

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
				of free and supported cluster reactivity

Work package number ⁹	WP4	Lead beneficiary ¹⁰	9 - UU
Work package title	Free Cluster Reactivity		
Start month	6	End month	48

Objectives

STO4 - To use free-cluster approaches to study elementary reaction processes on model systems. Free 3d metal and metal-oxide cluster active sites for CO₂ hydrogenation will be studied with ion-trap mass spectrometry and IR spectroscopy, to achieve a fundamental understanding of molecule-catalyst interaction and to aid design of deposited clusters-based catalysts.

Description of work and role of partners

WP4 - Free Cluster Reactivity [Months: 6-48]

UU

Task 4.1 Free cluster catalysis tests. UU (ESR3) will produce metal-oxide free clusters such as Cu_xO_y⁺, Zn_xO_y⁺ XCu_xO_y⁺ and XZn_xO_y⁺ (X=Au,Pd), with exactly controlled elementary composition and charge state, and investigate their reactive properties as a function of metal to oxygen ratio in ion trap pre-filled with the reactant molecules (CO₂, CO and H₂). After reaction all ions, products, and intermediates, are extracted and mass analysed by a quadrupole mass filter.

Task 4.2 Free clusters and reaction intermediates structural characterisation. RU (ESRs 4 and 7) will produce CuZn and NiGa bimetallic few-atom free clusters in a large composition range and investigate their adsorption properties towards CO₂, CO and H₂ molecules using an IR-FEL laser at RU. In addition, the systems investigated by ESR3 will be structurally studied using IR spectroscopy at RU and the catalytic activity of systems studied by ESR4 will be investigated in an ion trap at UU.

Task 4.3 Free clusters active sites. Ion-trap mass spectrometry in conjunction with DFT calculations (connection to WP3) will allow identifying important reaction intermediates and the active centers of a selection of Cu- and Ni-based free clusters at the origin of their selectivity and catalytic activity with very detailed intrinsic cluster-molecule interaction and independently of the support role at FETI (ESR5). This will be used as a guide to design Cu- and Ni-based deposited clusters TCs and ECs (connection to WP1, WP4, and WP5).

Participation per Partner

Partner number and short name	¹⁰
2 - BME	
6 - RU	
9 - UU	

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D4.1	mass spectra metal-oxide clusters	9 - UU	Report	Confidential, only for members of the consortium (including the Commission Services)	12
D4.2	reactivity free metal-oxide clusters	9 - UU	Report	Confidential, only for members of the	24

List of deliverables

Deliverable Number¹⁴	Deliverable Title	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
				consortium (including the Commission Services)	
D4.3	mass spectra bi-metal-oxide clusters	9 - UU	Report	Confidential, only for members of the consortium (including the Commission Services)	30
D4.4	IR spectroscopy cluster-CO2	6 - RU	Report	Confidential, only for members of the consortium (including the Commission Services)	36

Description of deliverables

D4.1 : mass spectra metal-oxide clusters [12]
 1st report on mass spectra of metal-oxide clusters with different metal/ oxygen ratios

D4.2 : reactivity free metal-oxide clusters [24]
 1st report on reactivity of metal-oxide clusters as function of O content

D4.3 : mass spectra bi-metal-oxide clusters [30]
 1st report on the successful preparation bi-metal-oxide clusters with different M/O ratio

D4.4 : IR spectroscopy cluster-CO2 [36]
 1st report on IR spectra of CO2 adsorption structure on free clusters

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS9	free cluster reactivity	9 - UU	25	1st peer-reviewed paper on the reactivity of free clusters

Work package number ⁹	WP5	Lead beneficiary ¹⁰	3 - DTU
Work package title	Catalysts Testing and Prototyping of a Model Gas Diffusion Electrode		
Start month	6	End month	48

Objectives

STO5 - To test TCs based on the most promising systems. Activity and selectivity of selected supported clusters catalysts will be tested in high pressure gas flow reactors and micro reactors.

STO6 - To test ECs based on the most promising systems. Selected cluster-modified electrodes (CMEs) will be tested by voltammetry and impedance spectroscopy in cells.

STO7 - To test first prototype of a gas diffusion CME-EC in realistic operative conditions. Criteria and critical aspects in view of an industrial up-scaling & standardization will be identified.

Description of work and role of partners

WP5 - Catalysts Testing and Prototyping of a Model Gas Diffusion Electrode [Months: 6-48]

DTU

Task 5.1 TCs testing. Bimetallic clusters deposited on (semi)conducting flat oxides (SiO₂, TiO₂, CeO₂) at KUL (ESR1) will be tested for CO₂ hydrogenation with methanol and CO probe molecules using a Temperature Programmed Desorption (TPD) setup at KUL conducted in an UHV environment to increase the sensitivity of molecule detection, equipped with a mass spectrometer, gas doser and temperature controller. In parallel KUL (ESR1) will measure the CO₂ hydrogenation catalytic activity via test oxidations & reductions of the most promising clusters-based catalysts deposited on (oxide) powders at TCL (ESR2). The specially designed gas flow reactors will be fitted with an ultra-sensitive detection technique using ppb-level mass spectrometers. This will allow monitoring the chemical conversion over the limited number of clusters present in a typical supported-catalyst assembly. Reactivity testing of miniscule amounts of NiGa and CoCu-based clusters will be carried out at DTU (ESR11) using micro reactors coupled with CBD. They have a volume of only 235nL and are directly connected to a mass spectrometer providing unique capabilities of measuring minimal amounts of NPs under relevant conditions. Selected TCs will also be tested under CO₂ hydrogenation in gas flow reactors at PSI (ESR9).

For the hydrogenation of CO₂ to methanol via thermal catalysis, the project targets a selectivity of the best performing nanocluster catalyst above 80%.

Task 5.2 ECs testing. KUL (ESR8) will investigate the CO₂ electro-reduction properties of bimetallic clusters (3d-noble metal) on carbon glassy electrodes and FTO deposited at KUL and TCL in ex situ laboratory testing via voltammetry and impedance spectroscopy. In parallel DTU (ESR12) will test CO₂ electro-reduction using NiGa and CoCu-based ECs with voltammetry and impedance spectroscopy. In addition to the catalytic work, dynamic structure of selected highly performant TCs and ECs will be investigated in operando mode with in situ TEM at UA (ESR10) and XAFS at PSI (ESR14).

Task 5.3 Prototyping of a Model Gas Diffusion Electrode. A model gas diffusion electrode based on the highest performance CME-EC system will be taken forward into prototyping. Prototyping will be guided by VITO (ESR13) and TCL (ESR2), with contributions of KUL (ESR8), by identifying criteria and critical aspects in view of an industrial up-scaling & standardization. TCL (ESR2) will investigate production up-scaling for deposition of the optimized clusters (in terms of size and composition) on electrodes using multiple magnetron source cluster deposition technology. VITO (ESR13) will develop and upscale gas diffusion electrodes (GDEs) for electrochemical CO₂ reduction based on proprietary VITO technologies VITO CORE® and VITO CASE®, overcoming CO₂ mass transport limitations by implementing newly developed cluster-based ECs for CO₂ electroreduction. This will be done by integrating the (metallic / ceramic) cluster-based ECs using carbon based support layers, in order to assess their electrocatalytic efficiency and scalability towards higher TRL (performance, process window, stability under longer operation). VITO will investigate their capabilities for CO₂ electroreduction in realistic operative conditions in lab-scale microflow cells up to electrode sizes of 10 cm². A prototype electrode for CO₂ electrochemical conversion towards methanol and/or ethylene will be produced.

Participation per Partner

Partner number and short name ¹⁰
1 - KUL
3 - DTU
5 - PSI
7 - TCL
8 - UA
10 - VITO

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D5.1	cluster-based TCs in gas flow reactors	3 - DTU	Report	Confidential, only for members of the consortium (including the Commission Services)	23
D5.2	cluster-based EC in electrochemical cell	3 - DTU	Report	Confidential, only for members of the consortium (including the Commission Services)	24
D5.3	optimisation cluster modified electrode	10 - VITO	Report	Confidential, only for members of the consortium (including the Commission Services)	24

Description of deliverables

D5.1 : cluster-based TCs in gas flow reactors [23]
 1st report on successful test of a bimetallic cluster-based TCs in gas flow reactors

D5.2 : cluster-based EC in electrochemical cell [24]
 1st report on successful test of a bimetallic cluster-based EC in electrochemical cell

D5.3 : optimisation cluster modified electrode [24]
 1st report on the optimisation to targeted standards, operative conditions testing of a tailored cluster modified gas diffusion electrode

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS10	CO2 conversion	3 - DTU	25	1st peer reviewed publications on CO2 conversion on cluster-based thermocatalysts

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
				(microreactors) and electrocatalysts (electrochemical cells)
MS11	prototype	10 - VITO	40	Prototype of a bimetallic cluster-based electrocatalysts tailored gas diffusion electrode

Work package number ⁹	WP6	Lead beneficiary ¹⁰	6 - RU
Work package title	Training		
Start month	6	End month	48

Objectives

Coordinate training activities; to closely follow-up and support training programmes of 14 ESRs

Description of work and role of partners

WP6 - Training [Months: 6-48]

RU

The role of this work package is the full implementation of and responsibility for the training programme. This includes managing PCDPs, helping in the organization of secondments, supporting the organization of the schools, conferences and workshops. RU coordinates the WP. All beneficiaries contribute to the training as detailed in Tables 1.2a & 1.2b.

Participation per Partner

Partner number and short name ¹⁰
1 - KUL
2 - BME
3 - DTU
4 - FETI
5 - PSI
6 - RU
7 - TCL
8 - UA
9 - UU
10 - VITO

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D6.1	NWT1	1 - KUL	Report	Public	10
D6.2	NWT2	3 - DTU	Report	Public	25
D6.3	NWT3	4 - FETI	Report	Public	17
D6.4	NWT4	5 - PSI	Report	Public	35
D6.5	NWT5	9 - UU	Report	Public	25
D6.6	NWT6	6 - RU	Report	Public	40
D6.7	secondment summary report	6 - RU	Report	Confidential, only for members of the	42

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
				consortium (including the Commission Services)	
D6.8	NWT7	1 - KUL	Report	Public	45
D6.9	PhD theses	6 - RU	Report	Confidential, only for members of the consortium (including the Commission Services)	48

Description of deliverables

<p>D6.1 : NWT1 [10] Kick-off training events (NWT1) completed</p> <p>D6.2 : NWT2 [25] School on surface catalysis completed (NWT2)</p> <p>D6.3 : NWT3 [17] School on electronic structure theory completed (NWT3)</p> <p>D6.4 : NWT4 [35] School on characterization of catalysts by x-rays (NWT4) completed</p> <p>D6.5 : NWT5 [25] CATCHY@ISSPIC 21 meeting (NWT5) completed</p> <p>D6.6 : NWT6 [40] Young researcher's conference completed (NWT6)</p> <p>D6.7 : secondment summary report [42] Final summary report on secondments for 14 ESRs</p> <p>D6.8 : NWT7 [45] Career Launch final training event (NWT7) completed</p> <p>D6.9 : PhD theses [48] 14 PhDs theses submitted (first ones by month 42, all by month 54)</p>

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS3	personal career development plans	6 - RU	9	Personal career development plan of each ESR approved by the supervisory board
MS4	Doctoral Guidance Committees	6 - RU	9	Doctoral guidance committee of each ESR established and approved by the supervisory board

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS12	training completed	6 - RU	42	all network wide training events completed (NWT 1 to 7)

Work package number ⁹	WP7	Lead beneficiary ¹⁰	1 - KUL
Work package title	Dissemination, Exploitation, Communication, and Outreach		
Start month	1	End month	48

Objectives

i) to enhance visibility and understanding of the opportunities related to cluster-based catalysts, ii) to coordinate dissemination of project results to several target audiences, and iii) to protect and exploit project results.

Description of work and role of partners

WP7 - Dissemination, Exploitation, Communication, and Outreach [Months: 1-48]

KUL

A dissemination and communication plan is drafted, executed and monitored by the SB.

Task 7.1a Communication. CATCHY communicates to a variety of audiences as described in Table 2.1 The outreach incorporates a dynamic project website and other outreach activities (e.g. Microdocs, Newsletter, LinkedIn Company page) with the active support of the ESRs.

Task 7.1b Dissemination of research results. CATCHY disseminates to the scientific, industrial community through peer-reviewed papers, posters, conferences, seminars. The SB stimulates an open access publishing strategy of non-confidential results.

Task. 7.2. Exploitation Strategy is outlined in section 2.3.2. The exploitation plan and IPR policy (developed by M7 and coordinated by the IPM), covers follow-up projects targeting higher TRLs, industrial implementation, patenting of breakthrough results, and spin off creation.

Participation per Partner

Partner number and short name ¹⁰
1 - KUL
2 - BME
3 - DTU
4 - FETI
5 - PSI
6 - RU
7 - TCL
8 - UA
9 - UU
10 - VITO

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D7.1	website online	1 - KUL	Websites, patents filling, etc.	Public	1

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D7.2	Communication and Dissemination Plan	1 - KUL	Other	Confidential, only for members of the consortium (including the Commission Services)	3
D7.3	website intranet and ESR specific info	1 - KUL	Websites, patents filling, etc.	Public	7
D7.4	IPR policy	1 - KUL	Other	Confidential, only for members of the consortium (including the Commission Services)	7
D7.5	microdocs	1 - KUL	Websites, patents filling, etc.	Public	21
D7.6	first papers	1 - KUL	Websites, patents filling, etc.	Public	25
D7.7	presentations at conferences	1 - KUL	Websites, patents filling, etc.	Public	40
D7.8	confidential summary report	1 - KUL	Report	Confidential, only for members of the consortium (including the Commission Services)	41
D7.9	second papers	1 - KUL	Websites, patents filling, etc.	Public	42
D7.10	exploitation plan	1 - KUL	Other	Confidential, only for members of the consortium (including the Commission Services)	48

Description of deliverables

D7.1 : website online [1]
 CATCHY website publicly available

D7.2 : Communication and Dissemination Plan [3]
 Communication and Dissemination Plan approved

D7.3 : website intranet and ESR specific info [7]
 ESR specific information on the CATCHY website and CATCHY intranet (or area with restricted access) ready

D7.4 : IPR policy [7]

intellectual property rights policy finalized

D7.5 : microdocs [21]

Every ESR has made a microdoc /project video (outreach activity - OA2)

D7.6 : first papers [25]

Every ESR has a first peer-reviewed paper accepted

D7.7 : presentations at conferences [40]

Every ESR has presented results at an international conference

D7.8 : confidential summary report [41]

Confidential reports for each ESR summarising all results (delivering on milestones, status PhDs, exploitation routes)

D7.9 : second papers [42]

Second peer-reviewed paper obtained (accepted) by all ESRs

D7.10 : exploitation plan [48]

Final exploitation plan

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
--------------------------------------	------------------------	-------------------------	-----------------------------	------------------------------

Work package number ⁹	WP8	Lead beneficiary ¹⁰	1 - KUL
Work package title	Project Management		
Start month	1	End month	48

Objectives

To organise the timely recruitment of the 14 ESRs; to monitor and support the implementation, progress and achievements of project; to collect and review reports and other deliverables and submit to EU; to organise meetings of the SB; to ensure effective, transparent, and lasting data management.

Description of work and role of partners

WP8 - Project Management [Months: 1-48]

KUL

Coordinating the recruitment of the ESRs. The management bodies and functions supervise progress made by each ESR within his/her doctoral programme, and monitor the evolution of individual profiles toward the development of interdisciplinarity and intersectorial professionalism. The management structure and methodology is described in detail in section 3.2.1.

Participation per Partner

Partner number and short name ¹⁰
1 - KUL
2 - BME
3 - DTU
4 - FETI
5 - PSI
6 - RU
7 - TCL
8 - UA
9 - UU
10 - VITO

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D8.1	Supervisory Board	1 - KUL	Other	Confidential, only for members of the consortium (including the Commission Services)	2
D8.2	Consortium Agreement	1 - KUL	Other	Confidential, only for members of the consortium (including	2

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
				the Commission Services)	
D8.3	positions advertised	1 - KUL	Other	Public	2
D8.4	Data Management Plan	1 - KUL	ORDP: Open Research Data Pilot	Confidential, only for members of the consortium (including the Commission Services)	6
D8.5	personal career development plans	1 - KUL	Report	Confidential, only for members of the consortium (including the Commission Services)	7
D8.6	progress report	1 - KUL	Report	Confidential, only for members of the consortium (including the Commission Services)	13
D8.7	Project check - reports	1 - KUL	Report	Confidential, only for members of the consortium (including the Commission Services)	15

Description of deliverables

D8.1 : Supervisory Board [2]
supervisory board established

D8.2 : Consortium Agreement [2]
Consortium Agreement provided to REA

D8.3 : positions advertised [2]
14 ESR positions advertised (EURAXESS and other websites)

D8.4 : Data Management Plan [6]
Data management plan, in line with open research data management, validated

D8.5 : personal career development plans [7]
14 Personal Career Development Plans prepared

D8.6 : progress report [13]
Progress Report submitted

D8.7 : Project check - reports [15]
Following the project check meeting with REA PO the following documents must be submitted: agenda, list of participants, presentations, minutes, etc.

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	Pre-recruitment	1 - KUL	3	Pre-Recruitment: 14 ESR positions advertised, 42 ESR candidates preselected for Skype interviews
MS2	Recruitment Completed	1 - KUL	12	Recruitment of 14 ESRs
MS5	Midterm meeting	1 - KUL	13	Mid-term meeting between REA and all Beneficiaries (Scientists-in-charge and ESRs) and Partner Organisations

Work package number ⁹	WP9	Lead beneficiary ¹⁰	1 - KUL
Work package title	Ethics requirements		
Start month	1	End month	48

Objectives

The objective is to ensure compliance with the 'ethics requirements' set out in this work package.

Description of work and role of partners

WP9 - Ethics requirements [Months: 1-48]

KUL

This work package sets out the 'ethics requirements' that the project must comply with.

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D9.1	EPQ - Requirement No. 1	1 - KUL	Ethics	Confidential, only for members of the consortium (including the Commission Services)	12

Description of deliverables

The 'ethics requirements' that the project must comply with are included as deliverables in this work package.

D9.1 : EPQ - Requirement No. 1 [12]

Further information about the possible harm to the environment caused by the research and the measures that will be taken to mitigate the risks must be kept on file (to be specified in the grant agreement). Copies of authorisations for relevant facilities (e.g., security classification of laboratories) must be kept on file (to be specified in the grant agreement). The applicants must demonstrate that appropriate health and safety procedures conforming to relevant local/national guidelines/legislation, including the Code conduct for responsible nanosciences and nanotechnologies research, are followed for staff involved in this project, including the ESRs. This must be confirmed in the grant agreement before signature. Copies of relevant authorizations and individual safety training documents must be kept on file (to be specified in the grant agreement).

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
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1.3.4. WT4 List of milestones

Milestone number ¹⁸	Milestone title	WP number ⁹	Lead beneficiary	Due Date (in months) ¹⁷	Means of verification
MS1	Pre-recruitment	WP8	1 - KUL	3	Pre-Recruitment: 14 ESR positions advertised, 42 ESR candidates preselected for Skype interviews
MS2	Recruitment Completed	WP8	1 - KUL	12	Recruitment of 14 ESRs
MS3	personal career development plans	WP6	6 - RU	9	Personal career development plan of each ESR approved by the supervisory board
MS4	Doctoral Guidance Committees	WP6	6 - RU	9	Doctoral guidance committee of each ESR established and approved by the supervisory board
MS5	Midterm meeting	WP8	1 - KUL	13	Mid-term meeting between REA and all Beneficiaries (Scientists-in-charge and ESRs) and Partner Organisations
MS6	upscaled cluster production	WP1	7 - TCL	18	Upscaled cluster deposition on powders and electrodes for thermo catalysts and electrocatalysts.
MS7	in situ characterization	WP2	5 - PSI	25	1st peer-reviewed publications on in situ characterization of bimetallic clusters under CO ₂ hydrogenation (thermocatalysts) and CO ₂ electro-reduction (electrocatalysts)
MS8	theoretical characterization	WP3	4 - FETI	25	1st peer-reviewed papers on theoretical characterization of free and supported cluster reactivity
MS9	free cluster reactivity	WP4	9 - UU	25	1st peer-reviewed paper on the reactivity of free clusters
MS10	CO ₂ conversion	WP5	3 - DTU	25	1st peer reviewed publications on CO ₂ conversion on cluster-based thermocatalysts (microreactors) and electrocatalysts (electrochemical cells)
MS11	prototype	WP5	10 - VITO	40	Prototype of a bimetallic cluster-based electrocatalysts tailored gas diffusion electrode

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS12	training completed	WP6	6 - RU	42	all network wide training events completed (NWT 1 to 7)

1.3.5. WT5 Critical Implementation risks and mitigation actions

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
1	Delay in recruitment	WP8	Strict timing will be followed to recruit all the ESRs at M6. In case of a delay of max a few months, the CATCHY timetable will be readjusted in agreement with all the Participants.
2	Loss of expertise: key staff leaving the project	WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	All the Beneficiaries have multiple scientists that can be supervisors or cosupervisors. The work and training plan have sufficient overlap, allowing a change of responsibilities if needed. The SB will assign an appropriate replacement.
3	Lack of cooperation from a participant	WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	The CATCHY network builds on established relations between the Participants, who are familiar with each other's working practises and have already formed strong working relationships. The implementation plan defines clear tasks and roles and there will be regular contacts among the participants at the various events.
4	Conflict about intellectual property	WP7	Guidelines for IPR and technology transfer are clearly described in the consortium agreement. There will be a NDA between the involved Participants. Possible IP conflicts are a recurrent item on supervisory board meetings after which the IPM follows up with the involved parties.
5	PhD aborted if project funding stops after 36 months	WP6	Beneficiaries commit to foresee complementary funding to finish the PhD in line with the regular time for a PhD in each country (in several countries this is 48 months)
6	Insufficient training progress of an ESR	WP6	Regular progress monitoring by local supervisor and the doctoral guidance committee (DGC), based on the personalized career development plan (PCDP). This allows short-term intervention. Remediation discussed after elevation to the training lead.
7	Low reproducibility in cluster production at one partner	WP1, WP2, WP5	Production will be transferred to another partner equipped with a compatible cluster source (available at KUL, DTU & TCL). Advice and help sought through extensive network expertise on cluster production.
8	Delays due to interdependencies between WPs	WP1, WP2, WP3, WP4, WP5	Experience of academic partners in integrating experimental work with theoretical modelling will be exploited. WP leaders will work in close collaboration and the strong secondment program ensures an efficient communication between interdependent work packages.
9	Competence of recruited ESRs is insufficient	WP1, WP2, WP3, WP4, WP5	Recruitment will be conducted with care to attract the best students and to select the most suitable candidates. Continuous progress monitoring (PCDP) will make it possible to take remediation actions, in the event that deficiencies are detected.

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
10	Failure of instruments at beneficiaries	WP1, WP2, WP4, WP5	None of the ESRs uniquely relies on a single instrument. Repair of most custom-made instruments is affordable for all the beneficiaries. Instrument complementarity/redundancy in CATCHY will be utilized and expertise in instrumentation within the network will be exploited.
11	Failure in modelling catalytic reaction paths	WP3	Modelling parameters will be fine-tuned in order to achieve the desired convergence threshold. Alternative models will be considered.
12	Simulation results do not correspond to experiments	WP1, WP2, WP3, WP4, WP5	Early communications with experimentalists; extensive discussions and consideration of the experimental conditions. Evaluate and reduce experimental and computational uncertainties. Compare model systems and real catalysts geometry and make better models.
13	Risk of scientific misconduct by a project member (data falsification, fabrication, plagiarism)	WP1, WP2, WP3, WP4, WP5	It is the tasks of every individual in CATCHY to act in line with the European Code of Conduct for Research Integrity. All participants have to report any breaches with respect to this code to the local supervisors, who elevate to the supervisory board. ESRs follow a mandatory course on science integrity (NWT1). In the unlikely case of scientific misconduct, the institutional procedures for handling misconduct will be followed.

1.3.6. WT6 Summary of project effort contribution

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9
1 - KUL	✓	✓	✓		✓	✓	✓	✓	✓
2 - BME			✓	✓		✓	✓	✓	
3 - DTU	✓	✓			✓	✓	✓	✓	
4 - FETI			✓			✓	✓	✓	
5 - PSI		✓			✓	✓	✓	✓	
6 - RU		✓		✓		✓	✓	✓	
7 - TCL	✓	✓			✓	✓	✓	✓	
8 - UA		✓			✓	✓	✓	✓	
9 - UU			✓	✓		✓	✓	✓	
10 - VITO					✓	✓	✓	✓	

1.3.7. WT7 Tentative schedule of project reviews

No project reviews indicated

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

2. Project acronym

Use the project acronym as given in the submitted proposal. It can generally not be changed. The same acronym **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

3. Project title

Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date

Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry into force of the Grant Agreement (NB : entry into force = signature by the Agency). Please note that if a fixed starting date is used, you will be required to provide a written justification.

5. Duration

Insert the duration of the project in full months.

6. Call (part) identifier

The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Abstract

8. Project Entry Month

The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

9. Work Package number

Work package number: WP1, WP2, WP3, ..., WPn

10. Lead beneficiary

This must be one of the beneficiaries in the grant (not a third party) - Number of the beneficiary leading the work in this work package

11. Person-months per work package

The total number of person-months allocated to each work package.

12. Start month

Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

13. End month

Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

14. Deliverable number

Deliverable numbers: D1 - Dn

15. Type

Please indicate the type of the deliverable using one of the following codes:

R	Document, report
DEM	Demonstrator, pilot, prototype
DEC	Websites, patent filings, videos, etc.
OTHER	
ETHICS	Ethics requirement
ORDP	Open Research Data Pilot
DATA	data sets, microdata, etc.

16. Dissemination level

Please indicate the dissemination level using one of the following codes:

- PU Public
- CO Confidential, only for members of the consortium (including the Commission Services)
- EU-RES Classified Information: RESTREINT UE (Commission Decision 2005/444/EC)
- EU-CON Classified Information: CONFIDENTIEL UE (Commission Decision 2005/444/EC)
- EU-SEC Classified Information: SECRET UE (Commission Decision 2005/444/EC)

17. Delivery date for Deliverable

Month in which the deliverables will be available, month 1 marking the start date of the project, and all delivery dates being relative to this start date.

18. Milestone number

Milestone number: MS1, MS2, ..., MSn

19. Review number

Review number: RV1, RV2, ..., RVn

20. Installation Number

Number progressively the installations of a same infrastructure. An installation is a part of an infrastructure that could be used independently from the rest.

21. Installation country

Code of the country where the installation is located or IO if the access provider (the beneficiary or linked third party) is an international organization, an ERIC or a similar legal entity.

22. Type of access

- VA if virtual access,
- TA-uc if trans-national access with access costs declared on the basis of unit cost,
- TA-ac if trans-national access with access costs declared as actual costs, and
- TA-cb if trans-national access with access costs declared as a combination of actual costs and costs on the basis of unit cost.

23. Access costs

Cost of the access provided under the project. For virtual access fill only the second column. For trans-national access fill one of the two columns or both according to the way access costs are declared. Trans-national access costs on the basis of unit cost will result from the unit cost by the quantity of access to be provided.



**Marie Skłodowska-Curie Actions (MSCA)
Innovative Training Networks (ITN)
H2020-MSCA-ITN-2020**

955650 - CATCHY
**Annex 1 to the Grant Agreement
(Description of the Action)
Part B**

European training network on the design, implementation and production upscaling of novel, high-performance, cluster-based catalysts for CO₂ hydrogenation

History of Changes

June 9, 2020:

- Part A, description of WP1 and WP5 updated with targets for catalytic performance and quantities for up-scaling
- Part B, section 2.4.1 Added a paragraph about Communication of the project results to industry.
- Part B, section 4. Ethics Aspects added
- Part B, section 3.1d secondment plan of ESR 11 adapted

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List of participating organisations

Consortium member	Legal entity short name	Academic	Non-academic	Awards doctoral degrees	Country	Dept./ Division / Laboratory	Scientist -in- Charge	Role of Partner Organization
Beneficiaries								
KU Leuven	KUL	✓		✓	Belgium	Department of Physics and Astronomy	Ewald Janssens	
Budapest University of Technology and Economics	BME	✓		✓	Hungary	Department of Inorganic and Analytical Chemistry	László Nyulászi	
Technical University of Denmark	DTU	✓		✓	Denmark	Department of Physics	Christian Danvad Damsgaard	
Furukawa Electric Institute of Technology	FETI		✓		Hungary	Nanomaterials Science Group	Tibor Höltzl	
Paul Scherrer Institute	PSI	✓			Switzerland	Energy and Environment & Photon Science Divisions	Olga V. Safonova	
Stichting Katholieke Universiteit	RU	✓		✓	Netherlands	FELIX Laboratory	Joost M. Bakker	
Teer Coatings Ltd.	TCL		✓		United Kingdom	Department of R&D	Jinlong Yin	
University of Antwerp	UA	✓		✓	Belgium	Electron Microscopy for Materials Research	Sara Bals	
Ulm University	UU	✓		✓	Germany	Institut für Oberflächen-chemie und Katalyse	Sandra M. Lang	
VITO NV	VITO	✓			Belgium		Deepak Pant	
Partner Organisations								
ETH Zürich	ETH	✓		✓	Switzerland	Department of Chemistry and Applied Biosciences	Christophe Copéret	Doctoral school and academic supervision of the ESRs hired by PSI
Heraeus Deutschland GmbH & Co. KG	HDE		✓		Germany	Heraeus Precious Metals	Christian Gebauer	Host secondments and contribute to network wide training

Data for non-academic Beneficiaries

Name	Location of research premises: city, country	Type of R&D activities	No. of full-time employees	No. of employees in R&D	Website	Annual turnover (in euro)	Enterprise status (Yes/No)	SME status (Yes/No)
TCL	United Kingdom	PVD coating development, high-flux gas phase cluster source development	50	8	www.teercoatings.co.uk	€6.2 m	Yes	Yes
FETI	Budapest, Hungary	simulations, material development, automotive development	45	17	furukawa.co.hu	€3.5 m	Yes	No

Declarations

Name (institution/individual)	Nature of inter-relationship
Tibor Höltzl (FETI)	Position as honorary associate professor at BME. BME is the PhD awarding institute for the ESR recruited by FETI.
Thomas J. Schmidt (PSI)	Position as professor at ETH. ETH is the PhD awarding institute for the ESRs recruited by PSI.
VITO/KUL	VITO and KU Leuven are part of the joint research centre Energyville in Genk (Belgium), which works on sustainable energy and intelligent energy systems.

1. Excellence

1.1 Quality, innovative aspects and credibility of the research programme

1.1.1 Introduction, objectives and overview of the research programme

Renewable energy is arriving too slowly. Current estimates suggest that the world will fail to meet the International Energy Agency's (IEA) 2040 target for renewable energy of 28%. This is the figure the IEA believes we must achieve to mitigate the impacts of climate change. In all likelihood renewables will account for just 18% by this date, putting our social and environmental sustainability in a perilous position.¹ Despite European^{2,3} and global⁴ actions, and efforts to develop renewable energy sources, the majority of the energy used today and for the foreseeable future, derives from non-renewable fossil fuels. The ever-increasing amounts of CO₂ these fuels release into the atmosphere (a staggering 37 gigatonnes in 2018⁵) is destabilising the climate and maintaining global warming on an alarming trajectory.

Converting the CO₂ into valuable products. Capturing CO₂ directly from the atmosphere, or more practically as it is produced from coal- or gas-burning power plants, and then converting it into useful fuels and chemicals is the most credible route to securing our future until we stop releasing so much CO₂ into the atmosphere. The conversion of CO₂ into methanol and C2 products (ethanol, ethylene, etc.), convenient chemical intermediates for a host of products,⁶ offers us a tremendous opportunity to limit the problems we face. Two routes, thermo- and electro-chemical reactions, are being explored, but both are hindered by the high stability of the CO₂ molecule (it has a dissociation energy of 1072 kJ mol⁻¹). This means that breakthroughs in the performance of thermo- and electro-catalysts for CO₂ conversion are our best hope of controlling CO₂ levels in the atmosphere.

Tackling the talent shortage in Europe's catalysis value chain. Despite the tremendous progress made in catalysis, Europe faces an acute talent shortage in this sector. With catalysis becoming increasingly central to combatting global climate change, the need for Europe to be training talented people in this area is increasingly necessary. Catalysis represents one of the most extended value chains, stretching from sub-nanometre scale materials at one end to large-scale industrial devices at the other. The CATCHY project trains a group of highly motivated young researchers, who want to take their scientific careers to the PhD level and beyond, with a much broader skills set, gives them the ability to see the big picture and tasks them with taking Europe into the 2020s and beyond.

Overall aim of the CATCHY ETN project. CATCHY will create new, high-performance cluster-based catalysts for the conversion of atmospheric CO₂ into added-value synthetic materials with a catalysis-by-design approach based on advances in our atomic-scale understanding, analytical and *in situ/in operando* tools, and computational methods (**Figure 1.1**), while delivering a training programme that will give 14 early-stage researchers the expertise and skills required by employers in the European nanotechnology sector.⁷ The training programme is industry oriented, covering catalysis applications that relate directly to energy and climate-change problems. It is innovative, interdisciplinary and intersectorial, involving 10 Beneficiaries and 2 Partner Organisations. CATCHY will offer an interactive training approach that will cover the whole value chain, from the fabrication and characterization of cluster-based nanostructured surfaces, including non-deposited or free-cluster and theoretical modelling developments, to the realisation of innovative applications. CATCHY will contribute to Europe holding a competitive advantage for catalysis research in industry and academia.

¹ M. Younas et al., *Fundamental challenges, and opportunities in catalytic methanation of CO₂*. *Energy Fuels* **2016**, *30*, 8815

² A. Álvarez, A et al., *Challenges in the greener production of formates/formic acid, methanol, and DME by heterogeneously catalyzed CO₂ hydrogenation processes*. *Chem. Rev.* **2017**, *117*, 9804.

³ The European Strategic Energy Technology Plan, and the European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP), <https://zeroemissionsplatform.eu/>

⁴ Intergovernmental Panel on Climate Change (IPCC), UN Framework Commission on Climate Change, *the Global climate change initiative*.

⁵ R.B. Jackson et al., *Global energy growth is outpacing decarbonization*. *Environ. Res. Lett.* **2018**, *13*, 120401.

⁶ G.A. Olah, A. Goepfert, G.K. Surya Prakash, *Beyond oil and gas: The methanol economy* (2nd edition, Wiley-VCH), **2011**.

⁷ I. Malsch, *Nano-education from a European perspective: Nano-training for non-Research jobs*, *Nanotech. Rev.* **2013**, *3*, 211.

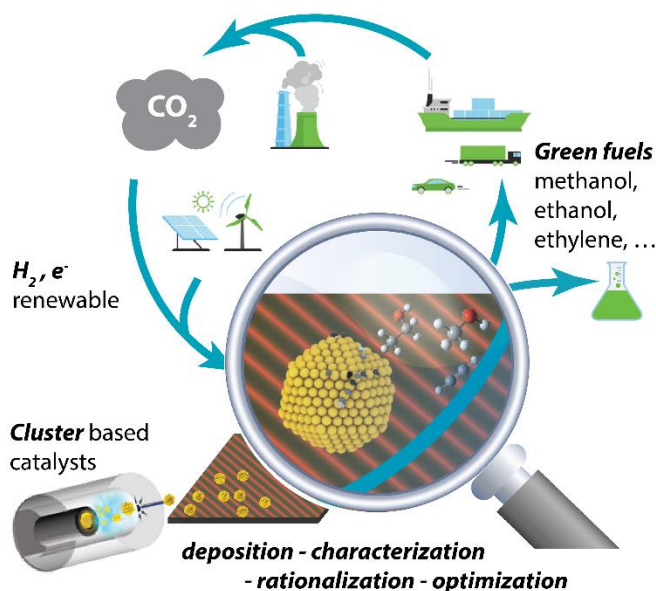


Figure 1.1: Schematic idea of the scientific aim of CATCHY: to understand and optimize the catalytic activity of tailor-made bimetallic clusters with full control over size, composition, and cluster-support interaction for a fully integrated catalysis-by-design approach to efficient and selective hydrogenation CO₂ catalyst development.

CO₂ hydrogenation involves two primary routes: thermochemical, i.e. by thermal bond breakage, or electrochemical, where an electric potential drives the reaction. While both routes have their own specificities, they have several bottlenecks in common so addressing them jointly in a single project is expected to create important synergies. The main scientific and technologic objectives (STOs) of CATCHY are aligned with the research work packages (WPs) of the project:

STO1: To synthesize gas-phase nanoclusters and deposit them on surfaces (WP1, ESRs 1, 2, 8, 11 & 12) – We will use a novel method to synthesize a series of supported cluster arrays that are reproducible and homogeneous. Next, easy-to-stabilize, mass-selected, gas-phase-produced, mono- and bi-metallic clusters that mix 3d transition metals (Cu, Ni, Co), noble metals (Au, Ag, Pd and Pt), and post-transition metals (Zn, Ga, In, Sn, Bi) with sizes from a few atoms to 5.0 nm, will be deposited onto suitable substrates for the production of novel thermo-catalysts (TCs) and electro-catalysts (ECs).

STO2: To physically characterize the synthesized cluster arrays, as prepared and under thermo- and electro-catalytic reaction conditions (WP2, ESRs 1, 2, 7, 8, 9, 10, 11, 12, 14) – The morphological, structural and electronic properties of the clusters will be characterized *ex situ* with Atomic Force Microscopy (AFM), Scanning Tunnelling Microscopy (STM), (Scanning) Transmission Electron Microscopy ((S)TEM), Infrared-Visible Sum Frequency Generation (IR-VIS SFG), and X-ray Photoelectron Spectroscopy (XPS), and under realistic thermo- and electro-catalytic reaction conditions with *in situ* Transmission Electron Microscopy (*in situ* TEM), Polarization Modulation Infrared Reflexion Absorption Spectroscopy (PM-IRRAS), Diffuse Reflectance Infrared Fourier-Transform Spectroscopy (DRIFTS), and X-ray Absorption Fine-Structure (XAFS) Spectroscopy.

STO3: To use theoretical modelling/computational simulations to identify active materials (WP3, ESRs 3, 5, 6 & 8) – Using *ab initio* theoretical modelling and screening, we will direct the synthesis towards materials that possess the best activity and selectivity.

STO4: To use free-cluster approaches to study elementary reaction processes on model systems (WP4, ESRs 3, 4, 5 & 7) – The gas-phase approach allows for very controlled changes to the reactive and catalytic properties via atom-by-atom manipulation of the cluster size (< 50 atoms), the metal-to-oxygen ratio, and the ratio of the different metals. Based on step-by-step changes to the model systems (metallic Cu–Zn and Ni–Ga alloys and metal-oxides Cu_xO_y⁺, Zn_xO_y⁺, XCu_xO_y⁺, XZn_xO_y⁺ with X=Au,Pd), we will be able to establish the fundamental driving forces that determine the catalytic activity of a particle.

STO5: To test the thermo-catalysts (TCs) from the most prospective systems (WP5, ESRs 1, 9, 10 & 11) –

The activities and selectivities of the supported cluster catalysts will be tested in high-pressure, temperature-controlled, gas-flow reactors, microreactors, and *operando* reactors.

STO6: To test the electro-catalysts (ECs) from the most prospective systems (WP5, ESRs 8, 12, 13 & 14) –

Selected cluster-modified electrodes (CMEs) will be tested with respect to CO₂ electrochemical reduction using voltammetry and impedance spectroscopy in cells. Selected CMEs will be integrated into a simple fuel-cell, gas-diffusion electrode and tested for stability and performance.

STO7: To test the first prototype of a model gas diffusion electrode based on the highest performance CME-EC system in realistic operating conditions (WP5, ESRs 2, 8 & 13) – We will define the critical fuel-cell parameters for industrial up-scaling and standardization.

Achieving these objectives will involve a multi-level interdisciplinary collaboration between laboratories specialized in different basic-science disciplines (physics, chemistry, and engineering) and between different research fields (TC & EC). CATCHY will also initiate an intersectorial collaboration that will reduce the on-going fragmentation of the nanotechnology sector in the EU. The strong inter-technology synergies between the CATCHY participants will build bridges between thermo-catalysis and electro-catalysis applications and accelerate the development of better catalysts for CO₂ conversion.

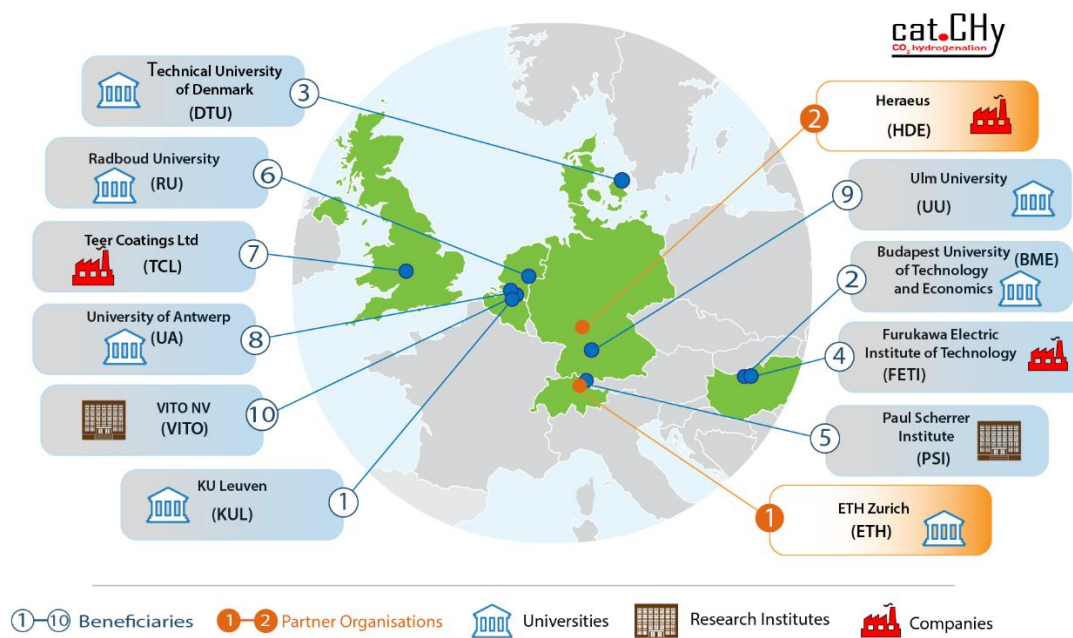


Figure 1.2: Schematic overview of the CATCHY Participants

The specific objectives of the 14 PhD projects for the ESRs. In the build up to this proposal, during meetings in August and September 2019, every ESR project was assessed in terms of quality, innovation and scientific and industrial relevance. This is reflected in the beyond-the-state-of-the-art objectives and the high-level description of the work packages in Section 1.1.2, and the content of the individual projects, which are described in **Table 3.1d**.

Research & Innovation excellence based on a top-flight consortium. CATCHY is a training network, but this does not mean that any sacrifices had to be made in recruiting the very best of Europe's research teams focused on catalysis. The partners include ERC Advanced and Consolidator Grant holders, Profs. Ib Chorkendorff and Sara Bals; one of the largest precious metal material providers with its main research centre being one of Europe's largest catalysis R&D centres (HDE); top-ranked innovative universities like KU Leuven, DTU and ETH; key companies in computational modelling (FETI) and nanoparticle and thin layer coatings (TCL); two of Europe's major non-profit research organisations (VITO and PSI); and unique X-ray and infrared light sources (PSI and RU) as well as electron microscopy facilities (UA) for materials characterization. All the Beneficiaries and Partner Organisations (see the map in **Figure 1.2**) offer their own brand of expertise and play a vital role in the project: hosting ESRs, providing secondments and contributing to the training at network level.

1.1.2 Research methodology and approach

State-of-the-art (SOTA): thermochemical CO₂ conversion. The hydrogenation of CO₂ into useful chemicals is a thermodynamically favoured process: the direct hydrogenation of CO₂ into methanol (CO₂ + 3H₂ → CH₃OH + H₂O) is exothermic. However, it is kinetically hindered by energy barriers, which means high temperatures are needed. Unfortunately, under such conditions this reaction competes with the endothermic reverse water gas shift reaction (rWGS, CO₂ + H₂ → CO + H₂O). As a result, there is a higher selectivity to CO and H₂O, and a reduction in the CO₂ equilibrium conversion rate. In industry, the synthesis of methanol and ethanol by direct CO₂ hydrogenation is thermo-catalysed by Cu/ZnO nanoparticles on an alumina substrate, with conversions of 35–45% per pass and a high selectivity at 260 °C and 60 bar.⁸ The nature of the active sites and the role of the promoter oxide is still the subject of considerable debate,^{9,10} as the reaction can occur entirely on the surface of nanometre-sized Cu particles. However, it is accepted that the active site for methanol synthesis is a metallic Zn atom on the Cu surface.¹¹ Similarly, the reactions proceed via several mechanisms, which are also still being debated. The high pressures and temperatures required for methanol hydrogenation using a Cu/ZnO/Al₂O₃ catalyst make this technology expensive. Moreover, stability problems have been reported due to the presence of water, since the rWGS accelerates the sintering of active sites in the catalysts, leading to their deactivation. What prevents us from having an efficient and stable catalytic system, which can promote CO₂ activation, without by-product formation, and operating below 180°C, is a lack of knowledge about the nature of the active sites and the reaction mechanism.

SOTA: electrochemical CO₂ conversion. Electrochemical reduction is another way to convert CO₂ into fuels and chemicals with a high energy density, such as C1 carbon monoxide (CO) or methanol. Multi-carbon (C2+) alcohol and hydrocarbons such as ethylene¹² and ethanol are also produced. They have a higher value, a higher energy density and a broader applicability than C1 products.¹³ This route can also be considered sustainable, as it simultaneously reduces the emission of CO₂ and can store intermittent renewable electricity. However, due to the stability of the linear CO₂ molecule, the electrochemical process requires a high overpotential as the electron and proton transfer are kinetically unfavourable.¹⁴ Additionally, the competing hydrogen-evolution reaction (HER, 2H⁺ + 2e⁻ → H₂) further decreases the Faradaic efficiency of the CO₂ reduction due to their similar reduction potentials. Cu is currently the only metal capable of efficiently reducing CO₂ to hydrocarbons and alcohols, mainly because of its moderate CO binding and the stabilization of certain intermediates, but it exhibits poor stability. Although there are some recent promising results,¹² the electrochemical route has only had limited success, highlighting the need for novel efficient catalysts with high activity and selectivity to achieve high-energy efficiency at reasonable current densities. There is increasing evidence that nanostructuring with single-atoms, few-atom clusters, and nanoparticles (NPs) provides the bulk electrode surface with more efficient active sites,¹⁴ so significantly improving the performance of CO₂-reduction ECs.

Beyond SOTA of CO₂-conversion: catalysts based on bimetallic clusters. With the thermochemical and electrochemical routes, nanometre or even sub-nanometre particles are the key. At the same time, single-metal catalysts clearly cannot fulfil both the stability and activity criteria. Thus, in order to design new TCs and ECs that could offer CO₂ sequestration, a new range of parameters that influence performance must be considered:

- **Size and Shape.** The size of the metallic particles is important for CO₂ reduction because of the high surface-to-volume-ratio and high density of low-coordinated surface sites.¹⁵ In **TCs**, the catalytic activity for methanol synthesis is a function of the Cu_n (n = 3, 4, 20) cluster size, with a Cu₄/Al₂O₃ catalyst showing the highest turnover rate.¹⁶ In **ECs**, small Cu nanoparticle (NP) clusters have an increased activity,¹³ but have poor selectivity towards

⁸ J. Artz *et al.*, *Sustainable conversion of carbon dioxide: An integrated review of catalysis and life cycle assessment*. Chem Rev **2018**, *118*, 434.

⁹ M. Behrens *et al.*, *The active site of methanol synthesis over Cu/ZnO/Al₂O₃ industrial catalysts*. Science **2012**, *336*, 893.

¹⁰ S. Kuld *et al.*, *Quantifying the promotion of Cu catalysts by ZnO for methanol synthesis*. Science **2016**, *352*, 969.

¹¹ J. Nakamura *et al.*, Comment on “Active sites for CO₂ hydrogenation to methanol on Cu/ZnO catalysts”. Science **2017**, *357*, 6354.

¹² C. Dinh *et al.*, *CO₂ electroreduction to ethylene via hydroxide-mediated copper catalysis at an abrupt interface*. Science **2018**, *360*, 783.

¹³ M. Arán-Ais *et al.*, *Structure- and electrolyte-sensitivity in CO₂ electroreduction*. Acc. Chem. Res. **2018**, *51*, 2906.

¹⁴ D. Gao *et al.*, *Nanostructured heterogeneous catalysts for electrochemical reduction of CO₂*. Curr. Opin. Green Sustain. Chem. **2017**, *3*, 39.

¹⁵ L. Molina *et al.*, *Size-dependent selectivity and activity of silver nanoclusters in the partial oxidation ...* Catal. Today **2011**, *160*, 116.

¹⁶ B. Yang *et al.*, *Copper cluster size effect in methanol synthesis from CO₂*. J. Phys. Chem. C **2017**, *121*, 10406.

hydrocarbon production. A similar effect was reported for Au₂₅ clusters.¹⁷ Cu NPs of cubic shape were recently shown to selectively catalyse the electrochemical formation of ethylene.¹⁸

- **Composition.** The elemental composition and structure of bimetallic particles that can change during operation,¹⁹ strongly influence catalytic performance. In **TCs**, pure Ag and Au, and noble-metal-alloyed Cu catalysts have better reactivity for CO₂ hydrogenation.¹⁰ Pd-Zn-based catalysts are also active and selective for the hydrogenation of CO₂ to methanol, while suppressing the rWGS reaction.²⁰ Pd-In, GaPd₂/SiO₂ as well as Pt-based alloy catalysts such Pt₃Co octapods also show good performance.²¹ In **ECs**, the relatively low selectivity towards hydrocarbons and oxygenates of Cu NPs could be improved by designing bimetallic CuPd, AuCu, or Cu-free bimetallic AgSn or AuPt NPs.²²
- **Support.** The nature of the support that determines the metal-support interaction from moderate (SiO₂) to strong (TiO₂) is also significant. In **TCs**, the importance of the synergy between Pt and SiO₂ and TiO₂ oxide supports has been highlighted and the incorporation of different additives, such as Al₂O₃, SiO₂, Ga₂O₃ and ZrO₂,²³ improves the activity, stability and thermal resistance compared with unmodified Cu/ZnO catalysts.²⁴ In **ECs**, strong interactions at the metal/metal-oxide interfaces were found to be responsible for a higher reactivity and stability.

Challenges with going beyond SOTA. New TCs and ECs require the design, synthesis, and immobilization of novel, multi-metallic NPs with close control over the three key parameters above. The NPs should not be coagulated, and the surface coverage must be quantified. This prospect is hindered by the conventional ‘wet-chemistry’ NP synthesis that often does not allow the synthesis of bimetallic NPs, nor offer accurate control over their size, composition, and support interaction.

The CATCHY route. CATCHY proposes a paradigm shift of using physical synthesis methods that are capable of producing catalysts based on metallic clusters of virtually any elemental combination with the tightest control over size, composition and support. Once designed, synthesized and characterized, the production of these new materials can be scaled-up with industrial Cluster Beam Deposition (CBD) equipment or using chemical methods.

How CATCHY goes beyond the SOTA: cluster-deposition sources with mass selection to produce new catalysts. CBD techniques allow the production of ligand-free bimetallic arrays of clusters, mixing virtually any metal elements, immobilized on surfaces with control over: (i) cluster mass (size) from 5 nm down to the sub-nanometer range through sophisticated mass-selection techniques; (ii) cluster composition through alloyed precursor material of defined stoichiometry or alloying dual-target sources; (iii) nature of the substrate, as CBD allows deposition onto virtually any type of substrate; (iv) cluster attachment to the surface through the choice of an optimal individual cluster landing energy to ‘pin’ the particles to the surface; (v) cluster coverage through deposition time.²⁵

CBD technology is ideal for the bottom-up synthesis of nanostructured materials and for the development of industrial processes based on nanotechnology. Unlike chemical methods, this unique physical approach allows the direct modification of supports with tailored, pre-formed, metal nanoparticles, avoiding further catalyst activation/processing steps. In CATCHY we will produce a series of bimetallic arrays of 3d transition metals (Cu, Ni, Co), alloyed with noble metals (Au, Ag, Pt, Pd) or post-transition metals (Zn, Ga, In, Sn, Bi) with a very high and controllable homogeneity (**WP1**) and extensive *ex-* and *in situ* structural characterization using state-of-the-art advanced *in situ* TEM, and IR-VIS SFG and XAFS techniques (**WP2**). CATCHY goes beyond merely a new synthesis route, because it is seeking a fundamental understanding of the cluster/NP properties and the catalytic activity, with and without support effects, by including *ab-initio* computational modelling (**WP3**) and gas-phase free-cluster reaction studies (**WP4**) to obtain a detailed, atomic-level understanding of the electronic and geometric structure-function

¹⁷ D.R. Kauffman *et al.*, *Experimental and Computational Investigation of Au₂₅ clusters and CO₂*: ...J. Am. Chem. Soc. **2012**, *134*, 10237.

¹⁸ F.S. Roberts *et al.* *High selectivity for ethylene from carbon dioxide reduction over copper nanocube electrocatalysts*. Angew. Chem. Int. Ed. **2015**, *54*, 5179.

¹⁹ D. Liu *et al.*, *Identifying dynamic structural changes of active sites in Pt–Ni bimetallic catalysts using multimodal approaches*. ACS Catal. **2018**, *8*, 4120.

²⁰ H. Bahruji *et al.*, *Pd/ZnO catalysts for direct CO₂ hydrogenation to methanol*. J Catal. **2016**, *343*, 133.

²¹ S. Kattel *et al.*, *CO₂ hydrogenation over oxide-supported PtCo catalysts: Role of the oxide support...* Angew. Chem. Int. Ed. **2016**, *55*, 7968.

²² M. Ma *et al.*, *Electrochemical reduction of CO₂ on compositionally variant Au-Pt bimetallic thin films*. Nano Energy **2017**, *42*, 51.

²³ E. Lam *et al.*, *Isolated Zr surface sites on silica promote hydrogenation of CO₂ to CH₃OH in supported Cu catalysts*. J. Am. Chem. Soc. **2018**, *140*, 10530.

²⁴ M.M.J. Li *et al.*, *Enhanced CO₂ hydrogenation to methanol over CuZn nanalloy in Ga modified Cu/ZnO catalysts*. J Catal. **2016**, *343*, 157.

²⁵ Y. Huttel, ed. – *Gas-phase Synthesis of Nanoparticles*, **2017** (Wiley)

relationships of the clusters/NPs. The most promising thermo- and electro-catalysts will be tested (**WP5**) in gas-flow reactors/microreactors and on CMEs, respectively, and then taken to the next stage of prototyping (**WP5**).

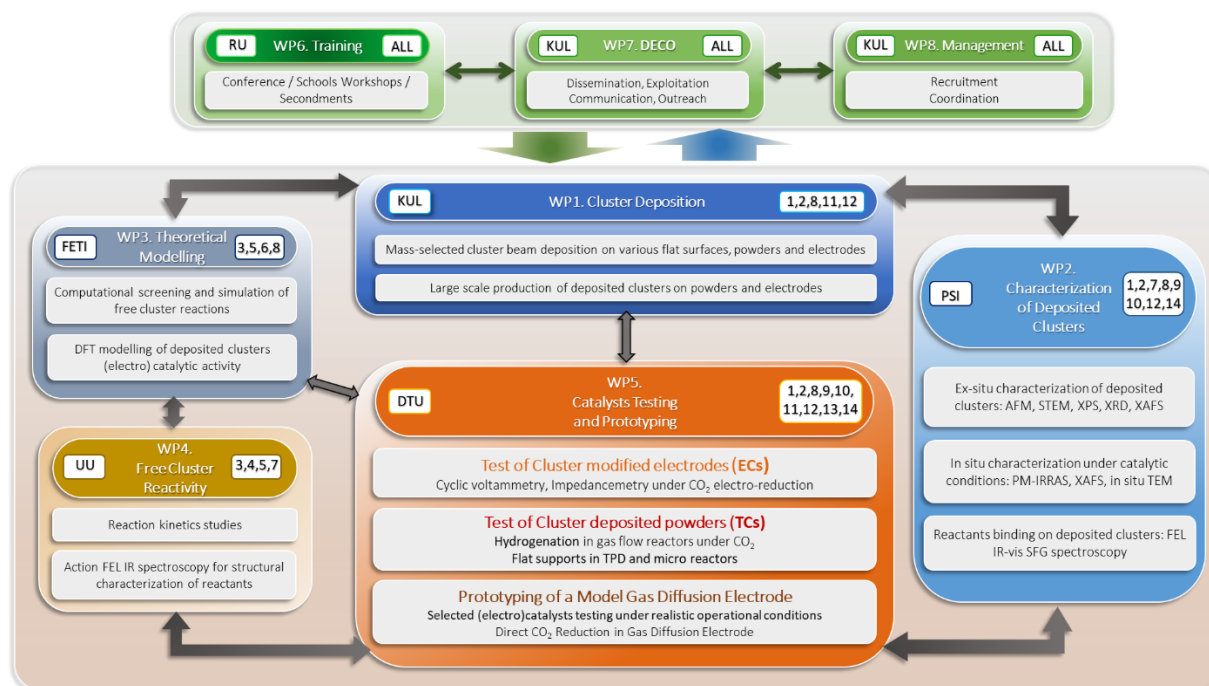


Figure 1.3: Content summary and interconnection of the work packages in CATCHY, including the lead Beneficiary, and the involved ESRs.

To achieve its main objective, CATCHY is divided in 8 WPs (**Table 1.1**), including 5 science and technology (S&T) WPs, with clear objectives, milestones, deliverables and due dates (see implementation **Tables 3.1a-c**). A general overview of the S&T WPs and their objectives, is given below. As illustrated in **Figure 1.3**, the S&T **WPs 1 to 5** are interconnected and carried out in close collaboration with academic and industrial Participants. In the other three work packages, training (**WP6**), dissemination, exploitation, communication, and outreach (DECO, **WP7**), and project management (**WP8**) are addressed. A description of the different WPs with the addressed S&T objectives, involved partners (leading partner), and ESRs, is given below.

Table 1.1: Work Package (WP) List

WP	WP Title	Lead Benef.	Start month	End month	Activity Type	ESR involvement
WP1	Cluster Deposition	KUL	M6	M48	Research- exploration	ESR 1,2,8,11,12
WP2	Charact. of Deposited Clusters	PSI	M6	M48	Research- exploration	ESR 1,2,7,8,9,10,11,12,14
WP3	Theoretical Modelling	FETI	M6	M48	Research- exploration	ESR 3,5,6,8
WP4	Free Cluster Reactivity	UU	M6	M48	Research- exploration	ESR 3,4,5,7
WP5	Catalysts Testing and Prototyping	DTU	M6	M48	Research- testing- prototyping	ESR 1,2,8,9,10,11,12,13,14
WP6	Training	RU	M6	M48	Training	All ESRs
WP7	Dissemination, Exploitation, Communication, and Outreach	KUL	M1	M48	Dissemination	All ESRs
WP8	Project management	KUL	M1	M48	Management	All ESRs
WP9	Ethics Requirements	KUL	M1	M48	Ethics	All ESRs

WP1: Clusters Deposition (addressing **STO1**, involving **KUL**, DTU & TCL and mainly involving **ESRs 1,2,8,11,12**) **ESRs 1** and **8** will produce a series of mass-selected (a few atoms to 5 nm), bimetallic clusters, mixing 3d (Ni, Co, Cu), noble (Au, Ag, Pd, Pt) and post-transition (Zn, Ga, In, Sn, Bi) metals, focusing in the first stage on CuZn, PdPt, PdBi systems. These clusters will be deposited onto oxide supports for TCs (**ESR1**), and onto conducting glassy carbon and FTO electrodes for ECs (**ESR8**). **ESRs 11** and **12** will produce a series of (1 to 5 nm) $\text{Ni}_x\text{Ga}_{1-x}$ and $\text{Co}_x\text{Cu}_{1-x}$ clusters, using alloyed targets for the catalytic activity measurements in micro-reactors (TCs) and electrochemical cells (ECs) (in connection with **WP5**). In parallel, **ESR2** will investigate the production scale-up of clusters with the best activity characteristics and deposit them onto oxide powders for TCs and large-surface-area electrodes for ECs and to prepare the prototyping of a CME-EC gas diffusion electrode (in connection with **WP5**). The best-performing clusters, identified by **ESRs 1, 2, 8, 11, and 12**, will be investigated *in situ* with *in situ* TEM, PM-IRRAS DRIFTS, IR-VIS SFG and XAFS techniques in collaboration with **ESRs 7, 9, 10 and 14** (in connection with **WP2**).

WP2: Characterization of Deposited Clusters (addressing **STO2**, involving KUL, DTU, RU, **PSI**, UA, HDE and mainly involving **ESRS 1, 2, 7, 8, 9, 10, 11, 12, & 14**) **ESRs 1, 2, 8, 11** and **12** will study the structure and morphology of the bimetallic clusters deposited in **WP1** using AFM, STM, Atomic Emission Spectroscopy (AES), Rutherford BackScattering (RBS), and aberration-corrected (S)TEM. Extended *in situ/in operando* characterization of their structures, morphologies and electronic properties will be carried out under CO_2 -hydrogenation and electro-reduction conditions by **ESRs 1, 2, 7, 9-12** and **14**. The characterization of the clusters using XPS will be carried out by **ESR1** and using micro-reactors by **ESR11**. **ESRs 9** and **14** will develop a new *in situ/in operando* grazing incidence X-ray spectroscopy setup to investigate clusters on surfaces, coupled with PM-IRRAS. The *in operando* conditions exploited by **ESR9** and **14** will provide information on the active site based on the vibrational characteristics of the chemisorbed reagents. **ESRs 1, 8, 9, and 14** will carry out *in situ* XAFS under high-pressure gas flow (TCs) or electrochemical (ECs) conditions using in-house cells at the Swiss Light Source (SLS) at PSI and at the European Synchrotron (ESRF). **ESR10** will perform *in situ* TEM investigations on the deposited clusters under reactive environments. **ESR7** will develop the use of IR-VIS SFG spectroscopy for reactive adsorption on the deposited clusters under CO_2 -hydrogenation conditions. This innovative technique, inherently surface- and vibrational state-specific, will exploit the exceptional spectral brightness of an IR-FEL and the inherent time-resolution of SFG to uncover the structure and potentially also the dynamics of the catalyst surfaces.²⁶ Combined with the PM-IRRAS and XAFS results, IR-VIS SFG spectroscopy will help to reveal the role of the active sites under reaction conditions. These combined experimental results will be used by **ESR6** as the input to the theoretical modelling of catalysts (**WP3**).

WP3: Theoretical Modeling (addressing **STO3** involving **FETI**, BME, UU and mainly involving **ESRS 3, 5, 6, 8**) First-principles simulations will be performed to describe the interaction between both the free and the deposited clusters with CO_2 and H_2 molecules, and to explore the mechanisms of the hydrogenation reaction using quantum chemical methods, molecular dynamics, and statistical thermodynamics. Depending on the acquired structural and energetic data, conventional statistical methods or machine learning will be used to design the active cluster-based TCs and ECs by a selection process that predicts combinations of the key parameters that generate high performance TCs and ECs. This, together with the reaction paths, will assist in the rational design of novel catalyst materials. The aim of the theoretical computations is to determine the effect of the cluster composition and size on the reaction mechanisms and on the catalytic activity.

ESR3 will investigate EC reaction mechanisms, in collaboration with **ESR5**. As a first step the effect of the oxygen content on the electronic structure and reactivity of noble metal and noble metal oxide clusters prepared in **WP4** will be investigated using quantum chemical computations. The structural information obtained will be used subsequently, together with **ESRS 8, 12, and 14**, to build a geometric model and study the electronic structure of deposited bimetallic clusters prepared in **WP1**, mixing 3d (Cu, Ni, Co), noble (Au, Ag, Pd, Pt) and post-transition (Zn, Ga, In, Sn, Bi) metals, supported on various oxides (e.g. Al_2O_3 , TiO_2 , FTO etc.). The ultimate goal is to understand the EC reactivity using computational hydrogen electrode model and grand canonical Density Functional Theory (DFT) computations, and based on scaling relations suggest improved catalytic clusters.

²⁶ S.J. Kweskin *et al.*, *High-pressure adsorption of ethylene on cubic Pt nanoparticles and Pt(1000) single crystals probed by in situ sum frequency generation vibrational spectroscopy*. *ACS Catal.* **2012**, *2*, 2377.

ESR6 will investigate the TC reaction mechanisms. In close collaboration with **ESR4** the geometric and the electronic structures as well as the gas phase thermal reactivity of gas phase post-transition metal clusters (Zn, Ga, In, Sn) will be studied. Subsequently, the geometric and electronic structure as well as the TC reactivity, of post-transition metal clusters deposited on oxide or graphite surface, prepared by **ESR1**, will be investigated together with **ESRs 9-11** to obtain thermodynamic, kinetic, and spectroscopic information to support the experimental results. While the oxide supports bind the clusters with ionic bonds (thus the clusters' geometries and properties change considerably compared to the free clusters), for graphene weaker interactions are responsible for the binding. The findings will be interpreted on the basis of electronic structure analyses, with the ultimate goal to identify the active sites responsible for their CO₂ hydrogenation activity.

WP4: Free Cluster Reactivity (addressing **STO4** involving **UU** & RU and mainly involving **ESRs 3, 4, 5, 7**) will study the influence of oxidation and alloying effects on cluster reactivity/catalytic activity. **ESR3** will produce mono-metal-oxide clusters such as Cu_xO_y⁺, Zn_xO_y⁺ and the bimetallic clusters XCu_xO_y⁺ and XZn_xO_y⁺ (X=Au,Pd) and investigate their reactive/catalytic properties for CO₂ hydrogenation as a function of cluster size and metal-to-oxygen ratio using ion-trap mass-spectrometry reaction kinetics. In parallel, **ESR4**, aided by **ESR7**, will produce CuZn and NiGa bimetallic free clusters over a wide compositional range and characterize the structure of the adsorption (entrance) and intermediate products in the CO₂ hydrogenation using an IR-FEL. The reaction kinetics and IR spectroscopy in conjunction with DFT calculations by **ESR5** (in connection with **WP3**) will make it possible to identify the active centres of a selection of clusters independently of the role of the support. These findings will feed into the supported-cluster WPs (in connection with **WPs 1, 2 and 5**), where the promising structural motifs can be tested. The support-charging effects can be effectively switched on by selecting the different charge states of the free clusters.

Such fundamental studies, especially when feedback from the deposited-cluster WPs is taken into account, will help us to understand the reaction mechanisms. This was, for instance, demonstrated in gold-cluster catalysis, where cluster-charging effects by the surface were paralleled compellingly by selecting different charge states of the free clusters.²⁷ The conceptual approach of gas-phase reactivity will not only provide an in-depth understanding, but also quantitative benchmarks that validate the theoretical treatment at a level unattained on surfaces.²⁸

WP5: Catalysts Testing and Prototyping of a Model Gas Diffusion Electrode (addressing **STO5, STO6** and **STO7**, involving **DTU, KUL, TCL, PSI, UA, VITO, HDE** and involving mainly **ESR1, 2, 8, 9, 10, 11, 12, 13, 14**) Bimetallic clusters of different compositions based on 3d-transition, noble and post-transition metals deposited on flat oxides (SiO₂, TiO₂, CeO₂) at KUL will be tested for CO₂ hydrogenation (TCs) with Temperature Programmed Desorption (TPD) in an ultra-high-vacuum (UHV) environment by **ESR1**. In parallel **ESR1** will measure the CO₂-hydrogenation catalytic activity via test oxidations and reductions of the best clusters-based catalysts deposited on oxide powders by **ESR2**. **ESR11** will test the CO₂ hydrogenation reactivity of NiGa and CoCu cluster-based TCs that are not exposed to ambient conditions using micro-reactors. Following the catalysis testing, high-performance TCs will be characterized *in operando* conditions using *in situ* TEM and IR & XAFS spectroscopies by **ESR 7, 9** and **10** (in connection with **WP2**).

ESR8 will investigate the CO₂ electro-reduction properties of bimetallic clusters on carbon glassy electrodes and FTO deposited at KUL and TCL in *ex situ* laboratory testing using voltammetry and impedance spectroscopy. In parallel, **ESR12** will test CO₂ electro-reduction using NiGa- and CoCu-based ECs with voltammetry and impedance spectroscopy. Again, the best ECs will be characterized *in operando* by **ESR14** using XAFS spectroscopy (in connection with **WP2**).

A model gas-diffusion electrode based on the best CME-EC systems developed in CATCHY will be taken forward into prototyping by **ESR 13** in collaboration with **ESRs 2, 8, 12, 14**. **ESRs 13** and **2** will develop and upscale the gas-diffusion electrodes (GDEs) for electrochemical CO₂ reduction based on proprietary VITO technologies, overcoming the CO₂ mass transport limitations by implementing newly developed cluster-based ECs for CO₂ electroreduction. This will be done by integrating the metallic/ceramic cluster-based ECs (produced and deposited by **ESRS 2** and **8**) using carbon-based support layers, in order to assess their electrocatalytic efficiency and scalability towards higher

²⁷ B. Yoon, *et al.*, *Charging effects on bonding and catalyzed oxidation of CO on Au₈ clusters on MgO*. Science **2005**, 307, 403.

²⁸ J. Roithová, and D. Schröder, *Selective activation of alkanes by gas-phase metal ions*. Chem. Rev. **2010**, 110, 1170.

TRLs (performance, process window, stability under longer operation). **ESR 13** will investigate their capabilities for CO₂ electro-reduction in realistic operating conditions. A prototype electrode for CO₂ electrochemical conversion to methanol and/or ethylene will be produced.

1.1.3 Originality and innovative aspects of the research programme

- Fully Integrated catalysis by design approach.** The CATCHY network consists of specialist researchers from the academic and industrial sectors that will bring together a spectrum of advanced and innovative CBD-based nanofabrication and *operando* characterization techniques including free-cluster reactivity in ion traps, *in situ* electron microscopy, free-electron laser infrared and synchrotron-based X-ray absorption spectroscopies. This allows for original approaches to catalytic CO₂ capture and conversion into valuable fuels and chemicals. On the one hand, catalysts that are difficult to prepare by conventional chemical methods will be designed with atomic precision, and a full mechanistic understanding of the chemical processes that play a role in CO₂ activation and hydrogenation will be obtained by combining experimental results with theoretical modelling. On the other hand, deposited cluster-based catalysts will be tested under realistic operating conditions. The CATCHY network will cover cluster-based catalyst production, *ex situ* and *in situ* characterization, testing, modelling, and production up-scaling. This integrated coverage of catalysis research will benefit from internode feedback: novel catalyst materials discovered in *in situ/in operando* studies can be rapidly tested under realistic operation conditions, while free cluster studies bring insight in support-free size and composition dependencies, and provide valuable information for chemical engineers that upscale catalyst production.
- Synergistic approach.** By combining highly diverse experimental characterization techniques on a limited set of EC and TC catalyst systems, the approach of CATCHY will accelerate technological progress, both in catalyst development and in characterization methodologies. An experimental infrastructure that includes synchrotrons, free electron lasers, *in situ* TEM characterization tools, and microreactors, and their expert operators, will take the characterization well beyond the state of the art.
- Economic viability complemented by fundamental insights.** The strong participation of the private sector will strongly enhance the potential for valorisation of the CATCHY findings, including a continuous assessment of market feasibility, while the strong academic participation, guarantees atomic-level insight into the catalytic processes.
- Existing projects and networks.** Among the 40 existing H2020 and ERC European projects (Cordis website) related to the catalytic conversion of CO₂ with TCs or ECs, only OPERANDOCAT-ERC creates synergy from the simultaneous investigation of TCs and ECs. None of these projects realizes a catalysis-by-design approach using bimetallic clusters deposited by CBD technology.

ESR No.	Recruit. Partic.	PhD awarding entities	Start Month (Duration)	S&T WP*					Secondments		
									Academic	Industry**	Duration
ESR1	KUL	KUL	M6 (36)	1	2		5	DTU, PSI	TCL	6M	
ESR2	TCL	KUL	M6 (36)	1	2		5	KUL, UA	VITO	5M	
ESR3	UU	UU	M6 (36)			3	4	RU	FETI	6M	
ESR4	RU	RU	M6 (36)				4	UU, DTU	FETI	6M	
ESR5	FETI	BME	M6 (36)			3	4	PSI, UU		5M	
ESR6	BME	BME	M6 (36)			3		KUL, RU	VITO	6M	
ESR7	RU	RU	M6 (36)		2		4	KUL, UA	TCL	6M	
ESR8	KUL	KUL	M6 (36)	1	2	3	5	PSI, BME	VITO	6M	
ESR9	PSI	ETH	M6 (36)		2		5	DTU, UA	HDE	6M	
ESR10	UA	UA	M6 (36)		2		5	DTU, PSI	FETI	5M	
ESR11	DTU	DTU	M6 (36)	1	2		5	BME	HDE	4M	
ESR12	DTU	DTU	M6 (36)	1	2		5	KUL, PSI	TCL	5M	
ESR13	VITO	KUL	M6 (36)				5	DTU, KUL		6M	
ESR14	PSI	ETH	M6 (36)	2			5	KUL, DTU	VITO	4M	

The DGC of each ESR is defined in Table 3.1d.

* The involvement an ESR in the different WPs is indicated by the shading; the darker the shading, the stronger the involvement

** In categorizing the CATCHY beneficiaries, the research institute VITO was considered non-academic in view of its work environment and business culture (<https://vito.be/en/about-vito/vito-values>), while the research institute PSI was considered academic (<https://www.psi.ch/about/psi-in-brief>).

1.2 Quality and innovative aspects of the training programme

CATCHY will offer its 14 ESRs (Table 1.2a) a fully integrated research & innovation training programme that is international, intersectoral and interdisciplinary. The program, tailored to the ESRs needs, integrates “hard-skill” research-track training with soft-skill innovation-track training. This new form of training programme was developed on the basis of the skills that will be in demand in the 2020s, as outlined in the World Economic Forum’s *The Future of Jobs Report 2018*.²⁹ These new skills include Emotional intelligence, Critical thinking & analysis, and Active learning & learning strategies, all of which will be elements of the CATCHY training programme.

Each ESR will be hired for 36 months.³⁰ The 14 ESR positions (Table 1.2a), which are all to result in a PhD degree, are distributed among 10 Beneficiaries in 7 countries (Belgium: KUL, UA and VITO; Denmark: DTU; Germany: UU; Hungary: FETI and BME; Switzerland: PSI/ETH; The Netherlands: RU; United Kingdom: TCL) (Figure 1.2).

Table 1.2a Recruitment Deliverables per Beneficiary

ESR No.	Recruit. Partic.	PhD awarding entities	Start Month (Duration)	S&T WP*			Secondments			
							Academic	Industry**	Duration	
ESR1	KUL	KUL	M6 (36)	1	2		5	DTU, PSI	TCL	6M
ESR2	TCL	KUL	M6 (36)	1	2		5	KUL, UA	VITO	5M
ESR3	UU	UU	M6 (36)			3	4	RU	FETI	6M
ESR4	RU	RU	M6 (36)				4	UU, DTU	FETI	6M
ESR5	FETI	BME	M6 (36)			3	4	PSI, UU		5M
ESR6	BME	BME	M6 (36)			3		KUL, RU	VITO	6M
ESR7	RU	RU	M6 (36)		2		4	KUL, UA	TCL	6M
ESR8	KUL	KUL	M6 (36)	1	2	3	5	PSI, BME	VITO	6M
ESR9	PSI	ETH	M6 (36)		2		5	DTU, UA	HDE	6M
ESR10	UA	UA	M6 (36)		2		5	DTU, PSI	FETI	5M
ESR11	DTU	DTU	M6 (36)	1	2		5	BME	HDE	4M
ESR12	DTU	DTU	M6 (36)	1	2		5	KUL, PSI	TCL	5M
ESR13	VITO	KUL	M6 (36)				5	DTU, KUL		6M
ESR14	PSI	ETH	M6 (36)		2		5	KUL, DTU	VITO	4M

The DGC of each ESR is defined in Table 3.1d.

* The involvement an ESR in the different WPs is indicated by the shading; the darker the shading, the stronger the involvement

** In categorizing the CATCHY beneficiaries, the research institute VITO was considered non-academic in view of its work environment and business culture (<https://vito.be/en/about-vito/vito-values>), while the research institute PSI was considered academic (<https://www.psi.ch/about/psi-in-brief>).

1.2.1 Overview and content structure of the training

Personalised guidance. Each recruited ESR will formally be supervised by a Doctoral Guidance Committee (DGC) consisting of (i) an appointed principal supervisor from the recruiting Beneficiary, and (ii) co-supervisors from each Participant where (s)he will be seconded. If the Beneficiary is not a university (and cannot award a PhD), then (iii) the academic supervisor (responsible for the PhD track) will be part of the DGC. The ESR will also be assigned a mentor, an employee of his/her degree-granting institution, whose role is to provide pastoral support, and who will not be a member of the project team or close colleague (to be selected by the supervisor and the ESR).

Personalised training. After recruitment, ESRs will prepare a Personal Career Development Plan (PCDP), that will define, based on an individual skills analysis, the level and type of complementary knowledge, skills, and expertise that the (s)he is expected to gain during her/his time in the CATCHY project. It will clearly define the research work that will be performed in the network, the secondment periods that will be envisaged, and the seminars, workshops, conferences, and schools that will be attended. The PCDP will be updated annually following formal meetings with the DGC (in line with the regulations of the doctoral schools) and will be subject to approval and progress checks by the training lead (TL, the leader of WP6). The PCDP will also encompass career planning and the ESRs will be encouraged to take action to achieve current and future career goals by making use of local and network-wide career-

²⁹ http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf

³⁰ 36 months is a period in which scientific work leading to a PhD can be performed. Should additional time be needed for the completion of doctoral studies (4th year), additional funding will be provided by each of the Beneficiaries from other financial sources..

planning resources. The non-university beneficiaries FETI, VITO, TCL, and partner organisation HDE will actively integrate and improve the research and educational efforts of the project by delivering specialized services or training in career planning, interview and negotiation skills and entrepreneurship. The intersectorial collaboration in the CATCHY network will give the ESRs more options to orient their career towards industry and/or spin-offs.

Structure of the training programme (summarised in **Table 1.3**). Each ESR will get a tailored, cross-disciplinary and cross-sectorial training program that involves local expert training through research (**IT-1**), an interdisciplinary secondment and sector-exposure programme (**IT-2**), and local complementary skills training provided by the local doctoral school (**IT-3**). Network-wide training, involves both network-wide science and technology (S&T) training, including schools with recognized credits, and training in transferrable skills (training events **NWT1-7**). The hard-skills research-track training is geared to allow the ESR to develop into a specialist, with experience in state-of-the-art research methodology; while the broader soft-skills training is aimed at developing ESRs with the skills that will be in demand in the 2020s.²⁹

Hard skills. The research-track training will take place in a truly interdisciplinary environment, where not only a fundamental, atomistic understanding of chemical reactions, but also awareness of chemical engineering constraints and economic aspects will be taught. CATCHY aims to provide a platform on which fundamental chemical studies are linked to real chemical-engineering situations, and where academic research overlaps with industrial R&D. High-tech industry will play a key role in advancing technological innovation as part of the training programme. The involvement of high-tech companies and institutes like FETI, HDE, TCL, and VITO will mean that CATCHY can offer the highest-quality leading-edge training to its ESRs. This training will involve the training through research (see individual training **IT-1**), the secondments (**IT-2**) and elements of the Network-Wide Training events (**Table 1.2b**).

Soft skills. This part of the training will give the ESRs the skills they need to deal with an ever-changing work environment, whether it be in industry, academia or in their own start up. The innovation-oriented soft-skills training will be based around the local soft-skills training (**IT-3**) and elements of the Network-Wide Training events. One of the key elements is learning to learn. It is no longer conceivable that the skills that the ESRs acquire during their PhD studies will get them through 40 years of employment. During this time they will need to be learning new skills and new ways of working as technologies and needs will change over the coming decades.

Individual training (IT)

- **(IT-1) Local expert training through research.** Each ESR will receive personalized, locally delivered, expert training through research. Each partner participating in CATCHY offers state-of-the-art production, characterization or measurement expertise that it will transfer to the ESR it employs. Important components include one-to-one interactions with the supervisor, group meetings, interactions and training from technical staff and other ESRs in the training environment. Hands-on experience will develop project-specific technical competences and nurture the development of scientific methods and research management skills. **IT-1** also includes local seminars given by the ESRs in the framework of their Beneficiary discussion groups, to monitor the progress of the research work and receive local group feedback.
- **(IT-2) Interdisciplinary secondment programme and sector exposure.** All the ESRs will spend 4-6 months of their time within the network with at least two different secondment hosts. Each secondment is carefully selected to provide all ESRs complementary expertise that can help them to address their primary research task. Moreover, the intersectorial and interdisciplinary nature of the secondments will provide the ESRs with invaluable knowledge, competence, and skills preparing them for their future career. At the same time, secondees will also transfer knowledge to both secondment and Beneficiary organisations, thereby maximising the potential to exploit complementary techniques within the network. Knowledge transfer will take the form of seminars by the ESRs on arrival, and after secondment completion, summarising their activity and the key new knowledge they have gained. Finally, they will provide an evaluation report to their supervisor(s) as well as to the TL. For full dissemination to all participants of the network, these presentations will be made available on the Participant-only access part of the CATCHY website.
- **(IT-3) Local complementary skills training.** The university partners build their research training on locally organized multidisciplinary doctoral schools. The Arenberg Doctoral School at KUL, the George Olah doctoral school at BME, and the PhD programmes at DTU, RU, UU, UA and ETH. To obtain the targeted soft skills training, ESRs will, in addition to the NWTs (see below), also make use of training organised by the doctoral school. Local training courses covering most aspects of technical and research management skills related to the

specific project are organised by each beneficiary. In addition, we recognize that CATCHY ESRs may desire to improve their English language skills. An initial evaluation of the language skills of the ESRs will be undertaken and where necessary external courses or additional one-on-one tuition will be arranged.

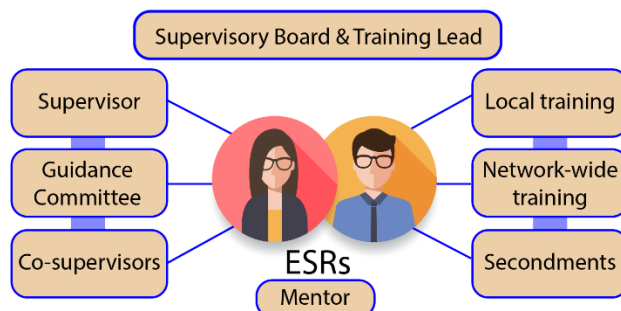


Figure 1.4: Schematic overview of the personalized training scheme, including supervision and coaching

Network-wide training

CATCHY will organise seven NWT events that include schools, conferences, workshops, and innovation skills training, with industry participation. Most of these events will be open to external participants. They will be advertised through the CATCHY website and mailing lists. This approach will serve to push the training and knowledge transfer goals beyond the boundaries of the network by forging links with other researchers in closely aligned fields. The ESRs will be actively involved in the practical organisation of these events, and will have the full responsibility to organise **NWT6** (CATCHY's Young Researchers conference). Each school will be centred on a series of hands-on exercises and lectures. Lectures and exercises will be given by leading academics from the field, from within and external to the CATCHY network. The schools will form an essential part of the training programme and every ESR will attend these events, where they will also present their own work to the whole network.

Table 1.2b: Main Network-Wide Training Events

NWT Main Training Events & Conferences [responsible for programme part]		ECTS	Lead	Month
1	Kick-off training event (organized when all ESRs are recruited)		KUL	M7
	<ul style="list-style-type: none"> • CATCHY project (1 day) [all beneficiaries] Presentation of CATCHY's objectives and proposed methodology followed by presentations of the activities/expertise of all beneficiaries and associate partners. • S&T training (2 days) [KUL,VITO] Truncus communis with state-of-the-art on thermo- and electro-catalysts for capturing and conversion of atmospheric CO₂ into added-value fuels (experts from in- and outside CATCHY). • Skills training (2 days) [KUL,VITO] Courses aimed to obtain skills needed to successfully complete a PhD project: <ul style="list-style-type: none"> • project and time management, open science (incl. data management and open-access policies) DP (VITO) and Bas Jansen (ElroyCOM), see https://elroycom.nl/en/training/phd-students/management-leadership/taking-charge-of-your-phd-project/ • scientific integrity & research ethics, gender balance awareness [Margriet van Bael (KUL) and Luca Consoli (RU), see https://www.ru.nl/imm/graduate-school/training-program-courses-phd-candidates/courses-phd-candidates-0/scientific-integrity/ 			
2	School on surface catalysis	4	DTU	M13
	<ul style="list-style-type: none"> • S&T training (4 days) [DTU] School on catalysis, featuring internationally known invited speakers with complementary backgrounds in the theoretical [Jens Nørskov (DTU)] and experimental [IC (DTU)] aspects of photocatalysis, electrocatalysis, and heterogeneous catalysis. Experts will present a span of lectures from basic concepts in catalysis and characterization techniques to cutting edge research with special focus on sustainable pathways to fuels and chemicals. <ul style="list-style-type: none"> • ESRs will give short talks or present posters of their own research plans and first results. • Lecture about precious metal catalysis research in an industrial environment [CG (HDE)]. • Site visit (1 day) [DTU] Visit of Haldor Topsoe leading methanol catalyst company, R&D centre in Lyngby, Denmark. 			
3	School on electronic structure theory and material design & Innovation training Event	3	FETI	M17
	<ul style="list-style-type: none"> • S&T training (2.5 days) [BME] School on basic and more advanced concepts in modern electronic structure theory, including DFT for computational design of new functional materials [Tamás Veszprémi (BME)], models in inorganic chemistry [LN (BME)], molecular dynamics simulations and surfaces [DSz (BME)], and advanced chemical simulations [TH (FETI)]. • Skills training (2.5 days) [FETI] Providing ESRs with a skill set for innovation and entrepreneurship and protecting strategies for intellectual property; training in approaches to search for innovative solutions to problems faced within the network, as well within scientific research as in product development and outreach; training in Prototyping including Life cycle analysis (LCA) and techno-economic analysis (TEA) [MT, Business Development (VITO)]. Local companies will contribute with presentations and demonstration projects. 			

4	School on in situ / operando characterization of catalysts by X-rays and electron beams	3	PSI	M21
<ul style="list-style-type: none"> • S&T training (3 days) [PSI] School with lectures by leading scientists (in- and outside network) developing X-ray spectroscopy [OVS, MN, Adam Clark (PSI)], <i>in situ/operando</i> IR spectroscopy [DF (PSI)], and electron microscopy-based methods [SB, TA (UA)] for characterization of (electro-)catalysts under working conditions. • Skills training [VITO] Dissemination and outreach skills (presentation techniques, scientific writing and science communication in the age of social media) providing tools to efficiently engage with the general public. [DP (VITO) as an Elsevier Editor in collaboration with IHE Delft (NL) and the Brussels based SME 'Sustainability Consult']. An important output of this training are personal project pitches for each CATCHY ESR, describing her/his thesis project for a general public (OA2). • Site visit (0.5 days) [PSI] Visit of the Swiss Light Source synchrotron, Villigen • Workshop (1 day) [TCL] Techniques for cluster generation and cluster deposition, including scale-up possibilities and use of cluster deposition in applications [speakers include Richard Palmer (Swansea University) and JY (TCL)]. 				
5	CATCHY@ISSPIC21: International meeting on the use of clusters in catalysis.		UU	M25
<ul style="list-style-type: none"> • S&T training (5 days) [UU] Biannual International Symposium on Small Particles and Inorganic Clusters (ISSPIC21),³² the leading conference in the field of atomic or molecular clusters, will be organized in Berlin, with SML (UU) as co-organizer. CATCHY ESRs contribute via oral and poster presentations at this meeting. • S&T training (1 days) [UU] CATCHY's ISSPIC satellite meeting with all ESRs presenting their project progress in oral contributions; reflection session on ISSPIC contributions. 				
6	CATCHY young researcher's conference		RU	M37
<p>3 day student-centred meeting modelled on the highly successful GRC Research Seminars, organized by all ESRs.</p> <ul style="list-style-type: none"> • S&T training [all ESRs] Scientific presentations related to the different CATCHY WPs; by the ESRs and colleagues working on related topics. On invitation of the ESRs, high-profile experienced researchers will provide tutorial lectures. • Skills training [all ESRs] This meeting will be organized by the ESRs themselves, providing a unique opportunity to lead the decision-making processes involved in hosting a scientific conference, as well as the day-to-day operational aspects. • Site visit (0.5 days) [RU] Visit of the FELIX Laboratory and the High Field Magnet Laboratory, Nijmegen. • Workshop (1 day) [RU] Workshop on free-electron laser science and structural characterization via infrared spectroscopy, including time-resolved IR spectroscopy given by Jos Oomens (RU), Mischa Bonn (MPG Mainz, Germany), and other leading scientists. 				
7	Career launch training event		KUL	M42
<ul style="list-style-type: none"> • Skills training (2 days) [KUL] Training focussed on giving the ESRs the skills they need to successfully progress their careers, including CV preparation [Viki Vandermeeren, HR (KUL)], masterclass on scientific writing [Eldon Rene (IHE Delft)], writing winning research proposals [An Jansen, research coordination office (KUL)], and workshop on job interviews for academia/industry [DP (VITO)]. • Site visit (1 day) [VITO] Visit of the VITO research centre, Mol, Belgium. 				

Complementary to the schools, two workshops are dedicated to teach state-of-the-art experimental techniques that are used in CATCHY. Additionally, selected lectures offered at one Participant will be made available via live-streaming webinars.

The multi-day network-wide training events are summarized in **Table 1.2b**. While organised by one host, different Beneficiaries can be responsible for different parts within a single physical meeting. The NWT schools will award ECTS credits for active participation, which can be recognized as part of the ESRs' PhD training programmes.

1.2.2 Role of non-academic sector in the training programme

The companies FETI, HDE, TCL, and industry-oriented research institute VITO³¹ are heavily involved in the CATCHY training programme through organisation and participation in the NWT events, secondments and interactions with the doctoral schools. Each ESR will be exposed to the non-academic sector through the extensive secondment programme (**Tables 1.2a** and **3.1d**). Through organizing specific parts of the NWT events, the non-university partners will transfer their industrial and commercial expertise to all CATCHY ESRs and provide them with the valuable skills and knowledge that are required on the job market, ensuring them excellent career prospects. Progress in acquiring industry-required skills, made by each ESR, will be carefully monitored by representatives of industry-related partners systematically composing each ESR's DGC. Their specific involvement includes:

- **ESRs 2, 5, 13** hired at companies FETI, TCL and the industry-oriented research institute VITO.
- All ESRs hired at academic Beneficiaries will be seconded to industrial Participants (FETI, HDE, TCL, VITO) to acquire industrial expertise and skills (see **Table 1.2a**). They will be exposed to industrial R&D cultures of team-working and will interact with staff in operational divisions to improve their communication networks.

³¹ In categorizing the CATCHY beneficiaries, the research institute VITO was considered non-academic in view of its work environment and business culture (<https://vito.be/en/about-vito/vito-values>), while the research institute PSI was considered academic (<https://www.psi.ch/about/psi-in-brief>).

- All ESRs will be stimulated to participate in the valorisation of research results and products. This will be greatly facilitated through the transfer of commercial and industrial knowledge from the industrial Participants to the ESRs (see in particular **NWT3**).
- Organization of specific training in NWTs (FETI-**NWT3**, HDE-**NWT2**, TCL-**NWT4**, VITO-**NWTs 1, 3, 4, 7**);
- Site visits at Haldor Topsoe and VITO (**NWTs 2, 7**).

Table 1.3 Summary of Skills and Expertise taught in CATCHY training

Research-track hard skills and expertise	
Empirical techniques (defining a scientific question, formulating hypotheses, designing efficient experiments to test hypotheses, quantitative data analysis)	IT
Research expertise (cluster beam deposition, catalysis fundamentals, catalyst structural characterization, catalyst testing, computational modelling)	NWT
Managing scientific research (project planning, deliverables/milestones, information retrieval)	NWT
Open science (green and gold open access policies, open data and data management)	NWT
Science communication (oral/written presentation skills, peer review)	IT – NWT
Scientific integrity & research ethics	NWT
Health & safety in the workplace	IT
Soft skills and expertise	
Public engagement and dissemination (communicating science to the wider public)	IT – NWT
Communicating ideas and insights (structuring knowledge for written/oral communication, teaching, ability to summarise, document and reflect on progress)	IT – NWT
Personal effectiveness, work-life balance, career development (pitching yourself, interviewing skills, preparing CV)	NWT
Learning to learn	IT
Team working and leadership (appreciating learning/working styles, mentoring, cooperation with supervisors, colleagues, peers)	IT – NWT
Research valorisation (IPR, patenting, industrial collaboration, start-ups), innovation in science and technology	NWT
Gender equality (implicit and explicit gender bias)	NWT

1.3 Quality of the supervision

1.3.1 Qualifications and supervision experience of supervisors

In line with the European Charter for Researchers, all the academic supervisors in CATCHY have extensive experience in the supervision of PhD students and in the management of research projects. The main supervisors (including those from industry) of CATCHY have on average a publication record of 130 papers in peer-reviewed journals, an average h-index of 32, and have trained on average 14 PhD students, who are now fully integrated into a wide range of knowledge-based enterprises in Europe and beyond, both in academia and in industry. Some examples of this include Catsense ESRs Bela Sebok (Spectroinlets, Copenhagen, Denmark), Salvatore Cosentino (Atlas Copco, Antwerp, Belgium), Philomena Schlexer-Lamoureux (Bloom, San Diego, USA) and ESRs Jeroen Jalink (NXP, Nijmegen, The Netherlands) and Albert Diaz-Bachs (ASML, Eindhoven, The Netherlands). The academic Participants in network have an extensive track record of collaboration (DTU with Haldor Topsoe, KUL with Teer Coatings Ltd, UA with Nanomegas and DENSSolutions) and spin-off companies RenCat, Spectroinlets (DTU). The industrial supervisors are all experts within their fields and have a track record of successful collaborations with university researchers **JY** (TCL) with KUL, University Warwick, Brunel University (UK), **TH** (FETI) with BME, KUL, University of Manchester, and StreamNovation Ltd. They have experience with the training and supervision of ESRs in European networks, as for instance **SB** (UA) in MUMMERING, **DP** (VITO) in ENMIX, **AK** (RU) in FANTOMAS and **PL**, **DG** (KUL), **IC** (DTU) and **JY** (TCL) in CATSENSE coordinated by **PL**. See Section 5 for detailed information about individual supervisors.

1.3.2 Quality of the joint supervision arrangements

In order to provide a balanced university/non-university and inter-disciplinary ESR supervision, a DGC is assembled for each ESR, which ensures that the ESR is exposed to different environments and that the broad range of expertise within the network is efficiently applied in collaborative research activities. ESRs recruited by the universities will be enrolled into the Beneficiary's PhD program with a local main supervisor and have at least one industry-related secondment for at least 2 months where a co-supervisor is appointed as part of the DGC. The ESRs recruited by non-

degree-awarding Beneficiaries will enrol in the PhD programmes of BME (**ESR5 – FETI**), ETH (**ESR9** and **ESR14 – PSI**), and KUL (**ESR2 – TCL** and **ESR13 – VITO**). Those ESRs have an academic supervisor at the PhD doctoral school and a research and development supervisor at the non-university Beneficiary.

The academic PhD supervisor will be responsible for (i) ensuring that the quality of the overall research and training programme of the ESR fulfils all the requirements for successful completion of their research project in order to attain the PhD degree, (ii) monitoring the progress and the quality of the ESRs research project and PhD program, and (iii) giving detailed feedback on progress to the ESR. Experts at the non-academic Beneficiaries will (i) supervise the ESRs either as main host or during secondments, (ii) be responsible for training the ESR in a complementary skill-set relevant to a career in industry identified in the ESRs PCDP. They will work with academic supervisors to formulate PhD programs that have both a high scientific research content and a strong focus on industrial innovation. Progress of each ESR is monitored annually by meetings of the DGC, who will update the PCDP, and report to the TL.

1.4 Quality of the proposed interaction between the participating organisations

1.4.1 Contribution of all participating organisations to the research and training programme

Table 1.2b demonstrates that all CATCHY Participants have important roles in the Network-Wide Training events, where they are involved in the hard-skills research track training, the soft-skills innovation training, site visits, lectures or organisation. As all the Beneficiaries hire ESRs, host a number of secondments and participate in the 14 DGCs (**Tables 1.2a** and **3.1d**), there will be a lot of high-quality interactions between all the Participants.

1.4.2 Synergies between participating organisations

The CATCHY consortium is based on the complementary expertise of 3 companies, 2 research institutes and 7 universities. The ESRs will benefit from five levels of synergy between the participating organisations:

- **Inter-disciplinary synergy:** The large inter-discipline expertise between physics (KUL, DTU, HDE, RU, PSI, UA, TCL), chemistry (KUL, DTU, PSI, RU, UU, ETH, HDE), quantum chemistry (FETI, BME), and engineering (FETI, HDE, TCL, VITO) creates excellent training opportunities for the ESRs in very complementary scientific fields.
- **Inter-technique synergy in state-of-the-art techniques:** Gas-phase cluster production and deposition techniques are gaining more interest from the nanotechnology sector and are starting to be applied in industrial production; the innovative inter-technique expertise between five partners (KUL, DTU, RU, UU, TCL) operating complementary cluster sources and characterization techniques.
- **Inter-technology synergy** between the partners working on thermal catalysis (KUL, DTU, ETH, HDE, PSI) and electrocatalysis technology (KUL, DTU, ETH, PSI, HDE, VITO) will allow the ESRs to share knowledge and technological skills between these two sectors of CO₂ conversion catalysis to stimulate creativity and product innovation. The ESRs will directly benefit from this new approach by learning a unique combination of expertise and skills, such as creativity, new-product innovation, technology strategy, and technology innovation that will be required in their future careers.
- **Inter-sectoral synergy:** The industry or industry-oriented partners (FETI, HDE, TCL, VITO), have expertise in industrial and commercial practices, provide extensive transfer of expertise to universities or more academic-oriented research institutes (BME, DTU, ETH, KUL, RU, UA, UU, PSI) concerning industry-related issues such as research management, new-product innovation, technology strategy and innovation, as well as an IP risk-assessment methodology and environmental sustainability.
- **Inter-education synergy:** The local and NWT courses are important instruments to stimulate interdisciplinary communication, initiatives and awareness, which will contribute to the training of the ESRs. Local doctoral schools at each partner will also be improved through adoption of other partners' best practices.

1.4.3 Exposure of recruited researchers to different (research) environments, and the complementarity thereof

Each recruited ESR will be seconded at least twice for a period of at least four months. Care is taken to make sure that all the secondments are relevant, feasible, and beneficial to the ESRs. Every ESR recruited by a university is seconded to at least one non-university participant where (s)he will have a co-supervisor and vice versa (76 secondment

months have been planned, of which 40 are intersectorial). This will also allow them to complete their local hands-on research training and research work and gain complementary skills and expertise in another discipline and/or sector such as industrial catalyst development. Exposure to the study of fundamental chemical interactions on one hand of the spectrum, and to the applicability and monetizability of commercial catalyst solutions on the other hand will broaden the ESR's horizon. The ESRs will gain entrepreneurship, confidence, flexibility, personal resilience and lasting professional relationships that will help them to develop a wider and more stimulating career.

At the same time, the secondees will have a dual role since they will also take back the knowledge they acquire, bringing benefits to the Beneficiaries. To ensure its success, the secondment programme will be carefully planned and supported with clear and effective standardised secondment guidelines (**IT-2** in section 1.2.1).

2. Impact

2.1 Enhancing the career perspectives and employability of researchers and contribution to their skills development

2.1.1 Needs of Europe and transferability

Catalysis represents a key technology for the European economy and its sustainable future. Europe is a leading player in both academic research on catalysis and the industrial production of catalysts. This has a huge economic impact, worth €3-4 billion (about a quarter of the global catalyst market), with the consequent social ramifications.³² However, its leadership is under threat from competing economies such as China, India, US and Japan, but also by the lack of fundamental research and the shortage of key researchers/professionals with the kinds of skills that will be developed in CATCHY.

CO₂ conversion, the core of the CATCHY project, is expected to radically change the demand for catalysts with respect to storing electric energy and replacing the feedstocks for fuels and chemical products. This could suppress the catalyst market by as much as 70%, with the loss of more than 200,000 jobs across Europe if no efficient new catalysts are introduced (see www.catalysiscluster.eu).

Identifying the best catalysts and process-related opportunities, accelerating the R&D that improves energy efficiency, and facilitating R&D on *game changers* to lower the barriers and the operating costs, are important steps that must be taken at the European level in the next 10 years. In particular, the emerging opportunity for 'catalysis by design', as proposed in CATCHY, is tremendously exciting and represents a potential source of future competitive advantage. The ESRs trained by CATCHY will become a new generation of scientists, able to work in a highly interdisciplinary, pervasive and trans-sectoral field. They will transfer new knowledge and skills to academia and industry, contributing to the identification of the catalysts of the future that will allow the energy transition. The societal and environmental urgency to alleviate climate change in future decades, and the particular advanced catalyst design approach, will guarantee the employability of CATCHY young researchers.

2.1.2 Skills and expertise needed in catalysis and in the nanotechnology sector

In a study of the EU funded NanoEIS project (Nanotechnology education for industry and society), nanotechnology employers reported problems with scarcity of skilled staff, lack of experience in technology transfer and of nanospecific knowledge.³³ In another study, employers in nanotechnology said that they prefer new hires to have doctoral degrees, and 57% of them value highly specialized researchers with a broader background.³⁴ All the employers recognized that researchers with a multidisciplinary background, who have been exposed to a broader range of people and disciplines, are more able to think outside the single-discipline box. Employers ranked the *desired expertise* in the following priority order: (1) knowledge of R&D management and project management; (2) product innovation and technology strategy; (3) knowledge of intellectual property, risk-assessment methodology, and environmental sustainability. The *desired skills* were ranked in the following priority order: (1) creativity and flexibility, (2) good communication skills and (3) adept at solving problems. Business is about problem solving, so young scientists should demonstrate flexibility in the kinds of projects they work on and have the ability to communicate well so as to ensure that the work gets done. CATCHY's ESRs will experience the full Technology Readiness Level (TRL) scale, from lab

³² Catalysis, ECo., *Science and Technology Roadmap on Catalysis for Europe* (www.catalysiscluster.eu). 2016.

³³ NanoEIS, GA NMP4-SA-2012-319054, Deliverable D2.1, P. Queipo et al., *Report on European industry needs*, June 2013

³⁴ Report: Institute of Nanotechnology, University of Stirling, UK "Survey of industry skills and training needs", 2007

to market, and understand how a holistic integrated approach is necessary to promote a new sustainable and low-carbon vision, with training to identify techno-economic, sustainable or policy windows of opportunities and risks early on. This experience will improve EU-wide cooperation in research, and accelerate the implementation of research, innovation and business opportunities (so as to bridge the gap and promote business and entrepreneurial capabilities).

2.1.3 Strong interdisciplinary training program

Nanotechnology is now common in almost all branches of industry and is intrinsically a strongly interdisciplinary area. This is particularly true in catalysis, as a successful catalytic process requires control over multiple scales, from the molecular aspects of the reaction at the active site (nm scale) to the multi-metre scale of an industrial catalytic reactor. CATCHY provides in-depth scientific training by experts with expertise in diverse research and training domains such as cluster production, reaction kinetics, structural characterization, thermo- and electrocatalysis, electrode design, molecular modelling, and chemical simulations. This guarantees exposure of the ESRs to contemporary scientific knowledge. The ESRs have to handle their own scientific research project while being embedded in an interdisciplinary field and having access to state-of-the-art equipment and facilities. The individual programme involves at least two secondments, including at least one in a sector different to that of the primary host (40 of the 76 secondment months in CATCHY are intersectorial). Within the NWT (in particular **NWT3**), additional S&T training and complementary soft-skills trainings are given, with the emphasis on entrepreneurship and innovation. The complementary-skills trainings are carefully integrated into the PCDP of each ESR, which makes it possible to plan, promote, and support the ESR's personal professional and career development to maximise future employability. Mutual recognition of the training by the different Participants, allows the ESRs to collect credits for their own doctoral programmes by performing secondments and attending NWTs.

2.1.4 Career paths in different sectors

Since most PhD students are not trained with a real multi-disciplinary approach, there are very good career opportunities for ESRs entering the fields of nanotechnology and catalysis with the kind of training offered by CATCHY. These multi-disciplinary skills are also relevant to materials science, chemistry, biotechnology, and microelectronics. Moreover, giving the possibility to ESRs to perform research in an interdisciplinary and intersectorial training network, will help them to build a dynamic career within the EU, potentially at CATCHY partners. Throughout the entire training programme, they will become acquainted with crucial concepts such as circular economy, environmental impact assessment, and resource-scarcity. CATCHY will allow the ESRs to develop the expertise and skills that are today required to work in the field of nanotechnology applied to catalysis, stimulate their creativity and entrepreneurial mind-set, and significantly increase their career prospects. It is our vision to train nanocatalysis experts and provide them with excellent career prospects, tailored to the needs of the market, whether it is for industry, teaching, or public bodies. The kind of background that CATCHY will provide will mean that the 14 ESRs will also be excellent candidates for postdoctoral positions at universities and research institutes.

2.2 Contribution to structuring doctoral/early-stage research training at the European level and to strengthening European innovation capacity

Contribution of the non-academic sector to the doctoral/research training. CATCHY has four non-university Beneficiaries (companies TCL and FETI; research institutes VITO and PSI) and one company as Partner Organisation (HDE) who are all also heavily involved in the CATCHY training programme, which means that the non-academic sector is making a very large contribution to the training in the network. Through the recruitment of 5 of the 14 ESRs and participation in the NWT events (in particular **NWTs 1, 3, 4, and 7**) we have the opportunity to provide the ESRs with tremendous opportunities to see how European industry is working in the area of catalysis. The ESRs will be meaningfully exposed to industry through an extensive secondment programme (**Tables 1.2a and 3.1d**). The specific involvement of the industry sector in the training programme is detailed in Section 1.2.2.

Structuring of the doctoral training. The structuring of the doctoral research training at the EU level is fully enshrined in CATCHY. Apart from fully respecting the 'Salzburg Principles II' for EU doctoral training, the ESRs are supervised by a predefined DGC with supervisors from various institutes, including non-academic ones. CATCHY also offers NWT with mutually recognised ECTS credits and will structure training by considering the best practices of the participating doctoral schools.

CATCHY targets a durable frame for cooperation that extends beyond the EU-project phase, converting the ETN into a long lasting, structured training programme that is to involve all the Participants and their future PhD students and postdocs. This will be achieved by the following, as described in the paragraphs below.

Setting up long-lasting training platforms. The seminars, workshops, and schools organized by CATCHY on the innovative scientific and technological supra-disciplinary field of clusters applied to catalysis will establish innovative and long-lasting platforms in nanotechnology training at the various Participants. The first platform will be based on the science of designing cluster-based materials, a full collaboration between all the academia Participants. The second will be based on the application of cluster-based materials to catalysts technologies with full complementary expertise between the universities, research institutes, and companies. Based on these two platforms, secondments can be continued after the 4-year project in their current forms and/or integrated into the doctoral schools to train future ESRs.

Strengthening European innovation capacity. CATCHY is not only aimed at research/training in novel CO₂ conversion catalysts, but also at strengthening the cluster-based catalysts network at the EU level. Our goal is to establish a new, long-lasting network for European research institutions with renowned expertise in cluster deposition, *in situ* characterization, and the theoretical modelling of the electronic and catalytic properties of clusters. It will also create a strong interconnection between the academic and the industry partners, stimulating joint dissemination, innovation, exploitation activities, and entrepreneurship in the field of cluster-based TCs and ECs.

CATCHY's capacity to strengthen European innovation will be based on:

Development of true multidisciplinary training. Despite a universal recognition that researchers in nanoscience and nanotechnology require a portfolio of interdisciplinary skills & techniques, today's training is often fragmented and based around single disciplines. CATCHY brings together diverse, cutting-edge, but complementary techniques and approaches, to provide training standards that cross the traditional boundaries of physical and chemical sciences to deliver realistic, individualized training that will enable the ESRs to become experts in their chosen area, but at the same time are aware of critical issues in other areas.

Enhancing network capacities for research. CATCHY will strengthen future research and training excellence at the EU level by: (i) increasing the research group sizes of consortium partners; (ii) increasing interactions with colleagues and improved working relationships between participants; (iii) providing a competitive research platform to compete effectively with competitors in Asia and the US; (iv) spreading best practice from different disciplines, sectors, and countries; (v) building improved training programs, seminars, and conferences, further promoting the excellence of the individual teams; (vi) providing strong support for new funding for applied and fundamental research training; (vii) profiling these institutions as attractive working places for other researchers and particularly young scientists.

Inter-technique competence centre. The unique complementary expertise in gas-phase cluster deposition science, state-of-the art *in situ* characterization techniques, and cluster-based materials with tailored properties designed on the basis of a deep chemical understanding, put together in CATCHY, will be the starting point for the organisation of a new Inter-technique Competence Centre at the EU level. This centre will significantly enhance the partners' research excellence by facilitating the cross-application of novel and appropriate techniques and the integration of approaches (e.g., by sharing equipment and facilities), and widening the context for future research collaborations.

Intersectorial professional network. A novel, supra-disciplinary collaboration between industrial partners and academic institutions on cluster science applied to catalysis will be the basis for establishing a professional network with shared expertise on research, industrial, and commercial practices in this field. This will be a very strong support to academia for future exploitation of their research findings into industrial applications, such as spin-off development. This will also allow academic partners to significantly increase their research potential and give their laboratory a strong asset for pursuing long-term research, training and commercial collaboration with the industrial partners (FETI, HDE, TCL), as well as for developing joint projects with catalysis industries for different applications, but also with industries from other activity sectors (photovoltaic, memory storage, etc.). This new professional network will be supported after the end of CATCHY by (i) the network of former ESRs and (ii) the continuation of our extensive secondment scheme between academia and industry for the new ESRs recruited at the Participants.

Network of CATCHY alumni. ESRs will be motivated to join the Marie Curie Alumni Association from the start of their employment.³⁵ We will keep close contact with the CATCHY alumni via an e-mail list and the distribution of an e-newsletter. This will make it possible to continue working with them via joint publications, following their career development and receiving valuable feedback on how to make the research training even more relevant in the future. They will provide a valuable network of contacts to bring in additional organizations to our consortium/training platform, hence enhancing further our long-term capacity to structure the training in Europe.

2.3 Quality of the proposed measures to exploit and disseminate the results

2.3.1 Dissemination of the research results

To researchers working in the same and similar fields. The dissemination of non-confidential CATCHY results will target academic and industrial stakeholders through a variety of channels. Scientific discoveries will be disseminated through scientific journals (such as *Angew. Chem. Int. Ed.*, *J. Am. Chem. Soc.*, *ACS Catal.*, *Nat. Catal.*, and *J. Phys. Chem. Lett.*), participation at international conferences, popular press, and through the internet. As planned in each ESR's PCDP, they will attend one international conference per year. A mix of multidisciplinary conferences such as the EuropaCat conference and the E-MRS Spring Meeting, multidisciplinary cross-sectorial conferences dealing with the broad problem of CO₂ utilisation, such as the International Conference on Carbon Dioxide Utilization (ICCDU), as well as more specialised conferences in relevant fields (ISSPIC, electrochemistry and thermal chemistry conferences) will be targeted. CATCHY results will also be presented by each ESR at the network events, including workshops and schools.

Papers will be co-authored by all the researchers who contributed to the results. After writing a concept manuscript related to their work and results, the ESRs will be guided by iterative feedback towards a publication by their local supervisor and co-supervisors. Following H2020's open-access policy, the consortium aims to make scientific publications generated from the project available through open-access journals. All peer-reviewed scientific publications will be deposited in open-access repositories, e.g., the OpenAIRE-compliant Lirias repository of KU Leuven.³⁶ For the partners without access to an OpenAIRE-compliant system, the KU Leuven Open Access desk will provide help in depositing outputs in Zenodo and linking these to the project in OpenAIRE.

To interested members of the public. The CATCHY website will be established (and regularly updated). This is of key importance when it comes to informing the public about the collaborative nature of the network, its goals, vision and results. It will provide as much public information as possible about the CATCHY achievements, not only scientific ones (in a format understandable to a general audience), but also about the people behind them. A part of the website will be accessible to the network only and will be used to disseminate the results between the network Participants, enhancing communication and helping to drive the research. The exchange of ideas and results within the network and the dissemination of the developed knowledge to the community and industry will be strengthened by opening NWT events to PhD students working in related scientific areas in the EU and associated countries. Those training events are important instruments for the transfer of the concepts developed in CATCHY to other fields. Highlights will also be communicated via social media, e.g. LinkedIn and Twitter, which efficiently disseminates the results of the network to a broad international audience.

2.3.2 Exploitation of results and intellectual property

The IP of results obtained within the network will be with the Beneficiary that employs the ESR who has generated the results (see also Section 3.2.6). Following the 'Communicating EU research and innovation guidance for project participants'³⁷ all ESRs (*cf* specific training in **NWT3**) will in compliance with their contractual arrangements and together with their supervisors, ensure that the results of their research are disseminated and exploited or, if appropriate, commercialised.

Exploitation of results. An active promoting policy will be pursued in CATCHY, attempting to influence policy-making and ensure follow-up by industry and the scientific community. FETI & TCL will, in collaboration with VITO, carry out market-based assessments of the relevant cost and quality metrics. The freedom to operate has already been assessed for all of the ESR projects prior to the decision to include them in the network. Following a successful outcome in terms of performance and cost/quality of any new prototypes, a product-launch cycle will be initiated.

³⁵ <https://www.mariecuriealumni.eu/>

³⁶ <https://lirias.kuleuven.be/>

³⁷ http://ec.europa.eu/research/participants/data/ref/h2020/other/gm/h2020-guide-comm_en.pdf, 2014.

For example, knowledge transfer of ECs will constitute a major benefit for HDE and VITO. Enhanced awareness of the state-of-the-art requirements for gas-phase cluster-deposition equipment, for both academic & industrial research, and, potentially, for industrial production, will allow TCL to further refine its commercial equipment catalogue, ultimately benefiting research at the EU level and European industry from future availability of relevant equipment, and to promote future exports on a worldwide basis. This, together with an increased pool of talented ESRs familiar with this technology, will increase future high-technology employment and provide a sustainable basis for medium- and long-term exploitation of the technology. In the interim, TCL will be able to offer a bespoke nanocluster production service, to a range of academic and industrial end users, based on the nanocluster structures, compositions and deposition methodologies developed and verified within the project. The ESRs will be involved in the exploration of a possible start-up based on the CATCHY IP results.

Intellectual property rights (IPR). An IPR policy will be adopted that facilitates the transfer of materials, people and project related know-how between the Participants. This will include IPR regulations based on models that have been successfully used in other European projects in which the partners have participated. IPR will be managed with the professional help of the IPR offices at the institutions of the network beneficiaries, who have expert knowledge of the subject. In particular, it is worth mentioning that the KU Leuven, thanks to its well-organized technology transfer office (KU Leuven Research & Development – KUL-LRD), is four years in a row (2016-2019) ranked by Reuters as the most innovative university in Europe.³⁸ The IP Manager (IPM, see Section 3.2.1) will have the pivotal role in the discussions between the network scientists and the IPR offices. Research results will only be published after an initial review of their potential for patenting and intellectual property rights. The potential transfer of technology will be a fixed point on the agenda at the meetings of the SB.

The private partners TCL, HDE & FETI presently own extensive IPR in the fields of catalysis cluster technology and quantum chemical computations, and will file both new and divisional patents as appropriate to continue to broaden this protection, and cover any new areas of novelty that emerge from this work. Where appropriate, licenses will be agreed upon between partners to ensure appropriate recognition of inventive inputs, as well as to promote smooth exploitation. More information about IPR can be found in Section 3.2.6.

2.4 Quality of the proposed measures to communicate the activities to different target audiences

2.4.1 Communication and public-engagement strategy

Internal Communication. Conventional communication methods, principally electronic mail (all subject headings to start with [CATCHY]), videoconference (Webex, Skype), the distribution of an internal e-newsletter, experimental protocols and literature references, and the CATCHY website (including a discussion forum for ESRs) will allow efficient network communications. Direct contacts between the researchers in different teams will be strongly encouraged. Teams that are involved with the same scientific objectives will be expected to interact frequently. Visits by researchers in the framework of the extensive secondment program to the collaborating teams will take place regularly.

CATCHY website. A website of the ETN will be created with the management funds and updated weekly. This website will have two types of access: *Internet public access* will contain non-confidential project information, such as summary, aims, public announcement of schools, workshops, etc., copies of work presented at symposia and an e-newsletter. CATCHY will reach out externally via a LinkedIn and Twitter. Links will also be made with other LinkedIn groups, in particular MCAA. *Participant-only access* will contain a full and detailed presentation of each Participant group, including a list of staff involved in the project with their photos and contact addresses, a list of techniques and training available, practical information on secondment organisation, and links to other relevant websites to help the newly recruited ESRs in organising their research and training projects. It will feature a monthly newsletter and an online agenda of network events. It will contain the presentations of the ESRs and lectures in the schools, which will be downloadable. Ongoing results of the WPs will also be available, as well as preprints (and versions in progress) of papers. It will also include a secondment section that will track secondments and present all the relevant reports. Each ESR will participate in CATCHY's outreach programme (see **Table 2.1**) and disseminate results.





Communication of project results to industry. In order to communicate the research results to the industry, the industrial stakeholders (from both within and outside the project consortium) will be involved in most training

³⁸ <https://www.reuters.com/article/rpbt01002019/reuters-top-100-europes-most-innovative-universities-2019-announced-idUSKCN1S60PA>

(NWT1,2,3,4,7) and dissemination actions. As such, the CATCHY consortium is a balanced mix of academia, applied research institutes and companies. They have the capacities, through local/network-wide training and dedicated activities (schools, meetings, workshops) and by fostering teamwork among the ESRs, to stimulate the transfer of ideas to innovation. In most of these activities, the representatives of the relevant industries (catalysis, materials) will be invited and learn about the project results from the ESRs first hand. The consortium partners are also involved in Industrial stakeholder groups such as SUSHCHEM, SPIRE, Catalisti, VOLTA, CO2ValueEurope, European Catalysis society etc. and representatives will be invited to project dissemination events. The publications, news and other updates arising out of CATCHY will from time to time be sent to industrial contacts.

CATCHY Public Engagement and Outreach Activities (OAs). To reach a broad audience, we will be active at different levels through OAs that are adapted to the target audience. The near-term impact of each activity and that of the whole project will be assessed with questionnaires or the number of hits of internet pages and detailed in the annual report. The target audiences and planned outreach activities are summarised in **Table 2.1**.

Table 2.1: CATCHY Public Engagement and Outreach Activities

Target audience	Activity	Description
<i>General Audience:</i> helping to develop the public understanding of science, nano-technology, CATCHY research field and its social and economic benefits.	OA1: Marie Skłodowska-Curie Ambassador	 Each ESR will participate (at least once a year) in an open door event to promote her/his research field and raise awareness of the Marie Curie Actions. To obtain visibility with the general public in line with the Horizon 2020 Open Science policy, ESRs will participate in i) European Researchers' Night; ii) EU events, conferences and Open Days; iii) Marie Curie Alumni Association; iv) EU campaigns; v) Regular School visits to motivate school-age people to pursue a research career including practical demonstration of how science works will be organised each year (EU Study Report "Research Careers in Europe", prepared to improve H2020 MSCA).
	OA2: Microdocs / project video	 Video-clips of 1-2 minutes micro-documentaries: each ESR will prepare a microdoc for a broad audience about her/his research topic, to be released on CATCHY website and YouTube Channel. (see https://youtu.be/vGO2aUfTC-U for an example from RU)
	OA3: e-newsletters:	 Recruited ESRs will develop a publicly accessible internet version of the CATCHY intranet e-Newsletter
	OA4: LinkedIn and Twitter posts	 Will allow people to get information and be able to comment on CATCHY results
	OA5: Public talk / article in local newspapers	Each recruited fellow will give a public talk or write an article about the results of the project and how these results could be relevant to the general public.
	OA6: Open day	Visit of the CATCHY research institutes /labs will be organized jointly with local outreach events.
	OA7: Kekulé lecture	UA and VITO will jointly host a Kekulé lecture evening with invited talks for a broad audience by pioneers from industry and academia in the field of CATCHY (https://www.uantwerpen.be/en/research/science-for-everyone/kekule/). This event provides good networking opportunities for the ESRs.
	OA8: Session at G-STIC conference	CATCHY ESRs will organise a session for young innovators to showcase their ideas and stimulate debate at the Global Sustainable Technology & Innovation Community (G-STIC) conference that is organized yearly by VITO in Brussels.
<i>Scientific/Industrial Audience:</i> helping to identify Europe as a home for nanoscience & nanotechnology.	OA1-SI: Marie-Skłodowska-Curie Ambassador	ESRs will visit universities and R&D labs to provide professionals with training and materials to conduct education, including the European Researcher's night and the Pint of science festival. https://www.pintofscience.be/brussels
	OA9: Network Schools	About 10-20 PhD students external to the CATCHY network are expected to attend the schools of NWTs 2, 3, and 4 as well as NWT5.
	OA10: International conferences	ESRs will attend one international conference a year.

3. Implementation

3.1 Coherence and effectiveness of the work plan

3.1.1 Work Package description – included in part A

3.1.2 List of major deliverables – included in part A

3.1.3 List of major milestones – included in part A

3.1.4 ESRs' individual projects

Table 3.1d: Individual Research Projects

ESR1	Host: KUL	PhD: Y	M6 (36M)	supervisor: EJ (KUL), co-supervisors: CDD (DTU), OVS (PSI), HS (TCL)
Project Title and WP(s): Production and characterization of novel CO₂ hydrogenation thermo-catalysts based on bimetallic deposited clusters – WP1,2,5				
Objectives: To deposit mass-selected bimetallic clusters, based on 3d-metals mixed with noble or post-transition metal, onto oxides supports (STO1); (ii) to investigate catalytic activity in microreactors, (iii) to characterize the mixed cluster structural and electronic properties by XAFS <i>ex situ</i> and <i>in situ</i> under CO ₂ hydrogenation (STO2); (iv) to measure the catalytic activity of clusters on flat supports with TPD and on powders (delivered by TCL) with gas-flow reactors (STO5).				
Expected Results: Identification of high-performance CO ₂ hydrogenation catalysts; detailed dynamic structural changes under reaction condition; understanding of the reaction mechanism in collaboration with theoretical modelling.				
Doctoral School Enrolment: Arenberg Doctoral School (ADS) – KUL				
Planned secondment(s): DTU (M15-16) for activity characterization in microreactors; PSI (M23-24) for <i>in situ</i> XAFS structural characterization under reaction conditions; TCL (M30-31) training in magnetron technology and to acquire industrial skills.				
ESR2	Host: TCL	PhD: Y	M6 (36M)	supervisor: JY (TCL), PhD promotor: EJ (KUL), co-supervisors: DP (VITO), SB (UA)
Project Title and WP(s): Large scale production of deposited clusters on powders and electrodes – WP1,2,5				
Objectives: (i) to implement new concepts/approaches (e.g. hollow cathode sputtering) to scale up the cluster production (STO7); (ii) to prepare and characterize the structure of the alloy clusters prepared on the up-scaled system (STO1); (iii) to investigate the influencing factors on the growth of clusters under extreme conditions, and propose the most likely physical mechanism (STO1).				
Expected Results: Identification of the most critical factor for the large-scale production of clusters; better understanding of the physical process happened in the aggregation zone; knowledge on the size and composition control of alloy clusters; large scale production of cluster-based TCs and ECs.				
Doctoral School Enrolment: Arenberg Doctoral School (ADS) – KUL				
Planned secondment(s): Training in characterization of size-controlled alloy clusters by TPD at KUL (M17-19) and by TEM at UA (M26-27) and investigate ECs properties of a cluster decorated CME-EC system at VITO (M30).				
ESR3	Host: UU	PhD: Y	M6 (36M)	supervisor: SML (UU), co-supervisors: OA (FETI), JB (RU)
Project Title and WP(s): Influence of oxygen content on the catalytic activity of gas phase mono-and bi-metallic clusters for green CO₂ hydrogenation – WP4,3				
Objectives: (i) to produce mono-metal-oxide free clusters such as Cu _x O _y ⁺ , Zn _x O _y ⁺ XCu _x O _y ⁺ and XZn _x O _y ⁺ (X=Au,Pd); (ii) to investigate their reactive and catalytic properties as a function of cluster size and metal to oxygen ratio (STO4); (iii) to identify important reaction intermediates and characterize their structure using infrared vibrational spectroscopy and computational modelling (STO3, STO4).				
Expected Results: Information on the change of the reactive and catalytic properties for H ₂ , CO ₂ activation and conversion as a function of the metal to oxygen ratio; tuning the reactive and catalytic properties of metal-oxides by introducing a heterometal atom. Providing atomistic level insight in the reaction mechanisms, which may assist the formulation of design guidelines for deposited clusters TCs and ECs.				

Doctoral School Enrolment: PhD programme at UU				
Planned secondment(s): FETI (<i>M15-17</i>) training in computational studies of reaction pathways and modelling of spectroscopic data; RU (<i>M26-28</i>) training on infrared vibrational spectroscopy of reaction intermediates.				
ESR4	Host: RU	PhD: Y	M6 (36M)	supervisor: JB (RU), PhD promotor: AK (RU) co-supervisors: SML (UU), TH (FETI), CDD (DTU)
Title and WP(s): Understanding bifunctional reaction mechanisms in CO ₂ hydrogenation on free clusters – WP4				
Objectives: i) to investigate target materials to create alloyed clusters (e.g. Cu/Zn, Ni/Ga) of exact elemental composition and size in a laser vaporization source; ii) to investigate their reactive and catalytic properties under CO ₂ hydrogenation as a function of cluster charge, structural motif and alloying composition (STO4); iii) characterize the structure of the clusters, cluster-molecule complexes, and intermediate products using IR photofragmentation spectroscopy (STO2).				
Expected Results: Fundamental insight in the variation of reactive and catalytic properties of these clusters in CO ₂ hydrogenation, relating to e.g. local charge, structural motif and alloying composition; identification of alloy bifunctional reaction mechanisms.				
Doctoral School Enrolment: Doctoral programme at RU				
Planned secondment(s): UU (<i>M19-20</i>) ion trap experiments to study cluster reactivity; FETI (<i>M28-29</i>) DFT calculations describing observed IR spectra and kinetics; DTU (<i>M35-36</i>) training in chemical process considerations for catalyst design.				
ESR5	Host: FETI	PhD: Y	M6 (36M)	supervisor: TH (FETI/BME), co-supervisors: DF (PSI), SML (UU)
Title and WP(s): Theoretical modelling and computational screening of cluster reactions for CO ₂ EC – WP3,4				
Objectives: (i) to find the lowest energy structure of different clusters and different sizes in the gas phase (bimetallic transition metal clusters and free Cu and Zn-based oxide clusters) and on oxide and graphite support and explore the electrocatalytic reaction mechanisms (STO3 , STO6) (ii) investigate the finite potential effects using computational hydrogen electrode model and grand canonical Density Functional Theory computations (STO3); (iii) interpret the results using Energy Decomposition Analysis and set up scaling relations (iv) suggest more active ECs based on the scaling relations (STO6).				
Expected Results: Cluster structure in the gas phase and on the support; electrocatalytic reaction mechanism and general understanding of chemical bonding and its effect on the reaction feasibility; effects of finite potential; defining guidelines for effective cluster catalyst design.				
Doctoral School Enrolment: BME George Olah PhD programme				
Planned secondment(s): PSI (<i>M15-17</i>) for modelling work of electrocatalysts under realistic conditions; UU (<i>M29-30</i>) experimental training on reactivity measurements in an ion trap.				
ESR6	Host: BME	PhD: Y	M6 (36M)	supervisor: LN (BME), co-supervisors: PL (KUL), DP (VITO), JB (RU)
Project Title and WP(s): DFT-based theoretical modelling of the catalytic activity of deposited clusters – WP3				
Objectives: (i) determine the lowest energy post-transition metal cluster structure and its thermal CO ₂ hydrogenation reactivity in the gas phase; (ii) investigate the finite temperature effects using statistical thermodynamics and molecular dynamics simulations; (iii) interpret the results using chemical bonding and charge analysis (STO3) (iv) defining guidelines for effective deposited cluster catalyst selection (STO5).				
Expected Results: Geometrical and electronic structure of different deposited clusters. Effect of surface on the cluster reactivity and participation of surface atoms in the reaction path. Thermal catalytic reaction mechanism by nudged elastic band computations and finite temperature effects using statistical thermodynamics and molecular dynamics.				
Doctoral School Enrolment: BME George Olah PhD programme				
Planned secondment(s): KUL (<i>M10-11</i>) TPD measurements to study deposited cluster reactivity; VITO (<i>M19-20</i>) modeling of catalysts under realistic reaction conditions; RU (<i>M31-32</i>) training on IR vibrational spectroscopy of cluster-molecule complexes.				
ESR7	Host: RU	PhD: Y	M6 (36M)	supervisor: JB (RU), PhD promotor: AK (RU) co-supervisors: EJ (KUL), TA (UA), PN (TCL)
Project Title and WP(s): IR-FEL based sum-frequency generation (SFG) as diagnostic for reactive adsorption – WP2,4				

Objectives: (i) to develop an experimental IR-FEL based SFG spectroscopy diagnostic platform for molecular adsorption on deposited nanoparticles (**STO2**); (ii) to characterize the adsorption of CO₂ and H₂ on samples produced in WP1 (**STO2**).

Expected Results: Sensitive detection scheme for molecular adsorption on clusters and extended surfaces with possible application in different pressure regimes; nature of CO₂ adsorption onto various samples of deposited clusters.

Doctoral School Enrolment: Doctoral programme at RU

Planned secondment(s): KUL (**M13-14**) training in cluster deposition techniques; UA (**M24-25**) training on *in situ* TEM characterization tools; TCL (**M35-36**) training about scalability of deposition techniques and industrial exposure.

ESR8	Host: KUL	PhD: Y	M6 (36M)	supervisor: DG (KUL), PhD promotor: PL (KUL) co-supervisors: MN (PSI), JV (VITO), LN (BME)
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Project Title and WP(s): Production and characterization of novel CO₂ reduction electrocatalysts based on bimetallic deposited clusters – **WP1,2,3,5**

Objectives: (i) To deposit mass-selected bimetallic clusters, based on 3d-metals mixed with noble or post-transition metal, onto oxides supports (**STO1**); (ii) to characterize the mixed cluster structural and electronic properties *ex situ* by XPS /XAFS and *in situ* under CO₂ electro-reduction with XAFS (**STO2**); (iii) to measure the catalytic activity of cluster-modified electrodes by voltammetry and impedance spectroscopy in cells (**STO6**).

Expected Results: Identification of high-performance CO₂ electro-reduction catalysts; detailed dynamic structural changes under reaction condition; understanding of the reaction mechanism in collaboration with theoretical modelling.

Doctoral School Enrolment: Arenberg Doctoral School (ADS) – KUL

Planned secondment(s): PSI (**M12-13**) training on *in situ* XAFS; VITO (**M23-24**) fabrication of cluster decorated industrial electrodes; BME (**M36-37**) computational modelling of the electrocatalytic reactions of deposited clusters.

ESR9	Host: PSI	PhD: Y	M6 (36M)	supervisor: OVS (PSI), PhD promotor: CC (ETH) co-supervisors: IC (DTU), TA(UA), CG (HDE)
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Project Title and WP(s): Structure-activity relationships in supported size-selected clusters under CO₂ hydrogenation conditions – **WP2,5**

Objectives: (i) to develop *in situ/in operando* setups for XAFS and IR characterization of supported clusters under controlled temperature, pressure, gas compositions allowing simultaneous activity testing (**STO2, STO5**); (ii) to uncover the structure of clusters during CO₂ hydrogenation (**STO2**); (iii) to rationalize how the activity, selectivity and stability of CO₂ hydrogenation catalysts can be improved by tuning the cluster composition, size and the nature of the support (**STO5**).

Expected Results: Development of *in situ/in operando* setups; information on the reactivity of each metal in the clusters under CO₂ to methanol hydrogenation; correlations between structure, activity, selectivity and stability of clusters; identification of the role of the support.

Doctoral School Enrolment: ETH Zurich PhD programme

Planned secondment(s): DTU (**M11-12**) training in cluster deposition and activity characterization in microreactors; UA (**M19-20**) training on *in situ* TEM; HDE (**M25-26**) training in electrolytic conversion of small organic molecules and industrial activity measurements.

ESR10	Host: UA	PhD: Y	M6 (36M)	supervisor: SB (UA), co-supervisors: IC (DTU), TH (FETI), DF (PSI)
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Project Title and WP(s): Structure, dynamics and function of nanoparticles for methanol synthesis studied by electron microscopy – **WP2,5**

Objectives: (i) to investigate dynamic response to changes of particle size, structure and composition in gas atmosphere and liquid environment, using *in situ* TEM (**STO2**); (ii) to correlate composition, chemisorption measurements and activity data for cluster-based catalysts prepared by network partners (**STO2, STO5**).

Expected Results: Detailed structural and morphological change of clusters such as CuZn and NiGa under reaction conditions. Identification of new methanol catalysts that are more efficient at a lower temperature and pressure.

Doctoral School Enrolment: UA PhD programme

Planned secondment(s): DTU (**M12-13**) training in production of clusters and characterization with complementary techniques. PSI (**M29**) training in XAFS measurements to identify *in operando* oxidation states of clusters. FETI (**M32-33**) training in computational modelling of the structures and activity of supported nanoparticles.

ESR11	Host: DTU	PhD: Y	M6 (36M)	supervisor: CDD (DTU), co-supervisors: OVS (PSI), DSz (BME)
Title and WP(s): Testing activity of small clusters to nanometer sized catalysts for methanol synthesis – WP1,2,5				
Objectives: i) to produce and test small clusters and nanoparticles for methanol activity (STO1, STO5); ii) to investigate response to changes of size and composition in DTU's microreactor platform (STO2); iii) to correlate activity with composition in reduced and oxidized state using XPS (STO2, STO5).				
Expected Results: Identification of new more efficient methanol catalysts. Separate the methanol synthesis and the reverse water gas-shift reaction to improve selectivity. We expect to find entirely new prescription of the conventional CuZn catalysts, or new catalysts of the type NiGa (intermetallic alloy) which has been proven active by standard synthesis methods.				
Doctoral School Enrolment: DTU PhD programme				
Planned secondment(s): PSI (M17-18) training in XAFS measurements to identify oxidations states of clusters under reaction conditions mimicking the microreactor; BME (M23-24) computational modelling of clusters under reactions mimicking the microreactor.				
ESR12	Host: DTU	PhD: Y	M6 (36M)	supervisor: JK (DTU), co-supervisors.: JY (TCL), DG (KUL), MN (PSI)
Project Title and WP(s): Testing activity of small cluster to nanometre-sized catalyst for electrochemical CO₂ hydrogenation – WP1, 2, 5				
Objectives: i) to test small clusters and nanoparticles for CO ₂ activity (STO1, STO6); ii) to investigate response to changes of size and composition in our electrochemical cell and characterize its Faradaic efficiency towards useful compounds like ethylene and ethanol (STO6); iii) correlate activity with composition in reduced and oxidized state using XPS and <i>in situ</i> XAFS methods (STO2).				
Expected Results: To identify new efficient catalysts with high selectivity towards products like ethylene or ethanol. Understand how we can tune the selectivity and even get high value products like aldehydes. Understand the correlation between size, composition and activity. Understand how these methods could be scaled up.				
Doctoral School Enrolment: DTU PhD programme				
Planned secondment(s): TCL (M14-15) training in magnetron technology and upscaling of cluster production; KUL (M24) training in producing complementary clusters; PSI (M32-33) training in XAFS measurements to identify oxidations states of clusters under working conditions.				
ESR13	Host: VITO	PhD: Y	M6 (36M)	supervisor: DP (VITO); PhD promotor: EJ (KUL) co-supervisor: JK (DTU)
Title and WP(s): Development of gas diffusion electrodes (GDEs) for electrochemical CO₂ reduction – WP5				
Objectives: i) to develop GDEs for selected cluster-based catalysts for electrochemical CO ₂ reduction towards methanol (STO6, STO7); (ii) to develop a model/prototype electrode for CO ₂ reduction to methanol (STO7); (iii) to validate the model electrode with other cluster-based catalysts for other products, e.g. oxalate (STO7).				
Expected Results: Fabrication of gas diffusion model/prototype electrodes based on different cluster-based catalyst types supported on carbon developed for electrochemical cells (small size 10 cm ² to medium size 400 cm ²). Testing the electrodes in electrochemical environment. Validating the model electrode with other catalysts toward selective production of other products.				
Doctoral School Enrolment: Arenberg Doctoral School (ADS) – KUL				
Planned secondment(s): KUL (M16-19) cluster deposition and structural characterisation & educational aspects of the doctoral training at KUL. DTU (M27-28) training in evaluating new model GDEs for dynamic operation and electrolyte selection.				
ESR14	Host: PSI	PhD: Y	M6 (36M)	supervisor: JHS (PSI); PhD promotor: TJS (PSI/ETH) co-supervisors: MB (VITO), DG (KUL), CDD (DTU)
Project Title and WP(s): Structure-activity relationships in supported size-selected clusters under CO₂ electro-reduction conditions – WP2,5				
Objectives: i) To electrochemically test Pt-Pd and Pd-Bi bimetallic cluster systems with different nanoparticle structures, compositions and sizes (STO6); (ii) to develop a novel electrochemical cell for <i>in situ</i> XAFS measurements of these and other materials in CATCHY (STO2); (iii) to determine the structural and electronic properties of the deposited clusters				

of interest using *in situ* XAFS under CO₂ electro-reduction conditions (STO2); (iv) to correlate these results with those derived from the modelling of equivalent catalytic systems (STO3).

Expected Results: Design principles (i.e., structure, composition, particle size) for the preparation of bimetallic Pt-Pd and Pd-Bi catalysts for CO₂-to-C1 electro-reduction, accompanied by greatly-needed spectroscopic/modelling insight regarding the effect of the *d*-band structure on the activity and selectivity of such catalysts. Improved understanding of the reaction mechanisms and reactivity descriptors leading to each product. Potential implementation of the most interesting catalytic system(s) in device-relevant GDEs (STO7, WP5).

Doctoral School Enrolment: ETH Zurich PhD programme

Planned secondment(s): VITO (M16-17) for training in industrial electrode design; KUL (M26) to fabricate cluster-decorated electrodes, and DTU (M34) to exchange know-how on electrocatalyst characterization.

3.2 Appropriateness of the management structures and procedures

3.2.1 Network organisation and management structure

The CATCHY network is organized around 8 WPs: 5 S&T WPs, a training WP, a DECO WP, and a management WP. The management WP (WP8) ensures effective internal communications, interactions between Beneficiaries, good data management, and progress reporting. The management structure of the network is depicted in **Figure 3**.

The Supervisory Board (SB), which is described in Section 3.2.2, is the ultimate decision-making body of the network and is responsible for the overall performance of the programme and compliance with the obligations of the Grant Agreement and the Consortium Agreement (CA). Members of the Management Team and/or of the Research Lead Team will attend the SB meetings to provide information about the status with regard to the objectives and targets. The ESR representatives will safeguard the needs, working conditions, and interests of the ESRs. The external advisor will consider the interests of the different stakeholders, oversee communications within the network, and encourage best-practice collaboration within the network.

Decision-making procedure. At the WP and SB levels, decisions will be taken by negotiation until a consensus is reached. If members of the WPs are still not happy, the conflict will be elevated to the SB and the SB has the final decision-making power. If consensus in the SB fails, the conflict will be resolved by a vote (2/3 majority needed). Voting is carried out by the senior representatives of the Beneficiaries (one vote per Beneficiary). The external advisor, members of the management team, and ad hoc members have no voting rights. A similar procedure will be followed in the event of conflicts between WPs or Participants. In these cases, it will be up to the PC to attempt to mediate a resolution. In the case of failure, the SB will take responsibility.

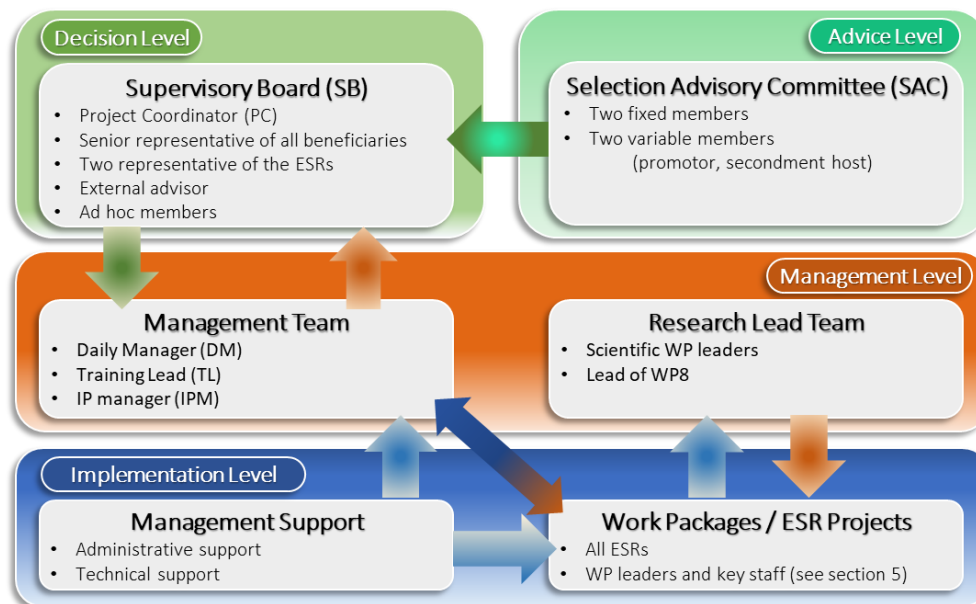


Figure 3: Scheme of the organisational and management structure of CATCHY

The **Project Coordinator (PC)** is Prof. Ewald Janssens (KUL), who has experience of managing international research collaborations and project management experience as a promoter of national projects. His staff members and the Management Team will assist him. The PC will perform all the tasks as described in the related agreements and will act as intermediary between the European Commission and the members of the network. He is actively involved in the risk-management process (See section 3.2.4).

The **Management Team** is the executive body of the network and is responsible for the ‘day-to-day’ management, training management, and resource management, including coordination of the research exchange and scientific dissemination and exploitation, financial, planning and control matters. It will consist of the Daily Manager, the Training Lead, and the IP Manager. The management team will meet every three months (face-to-face at training events or via conference calls) or more frequently if special issues need to be discussed.

- Dr Didier Grandjean (KUL) will be the **Daily Manager (DM)** of CATCHY. He has experience of managing the FP7-PEOPLE-2013-ITN Catsense. The DM prepares the meetings, follows up on progress and deliverables, and reports to the PC. The DM will also manage the financial reporting, conduct budget monitoring, and take care of the day-to-day coordination of the project.
- Dr Joost Bakker (RU) will be the **Training Lead (TL)**, who guarantees that the content of NWT and of the ESRs’ PCDPs correspond with CATCHY’s overall training programme. Dr Bakker has experience of training PhD students and doctoral schools and will initially be advised in this task by his colleague Prof. Andrei Kirilyuk (RU), who has been training coordinator of RTN DYNAMICS (2002–2006) and ITN FANTOMAS (2008–2012).
- Dr Debasish Chakraborty (DTU) will be the **IP Manager (IPM)**, who is responsible for IPR management as described in Sections 2.3.2 and 3.2.6. Dr Chakraborty is a business developer at DTU, co-inventor of four patents and co-founder of two spin-out companies.

The management team can rely on additional administrative and technical management support from the KU Leuven Research & Development (LRD), a separate entity within KUL with the mission to promote and support the transfer of knowledge and technology between the university and industry. LRD offers professional advice with regard to legal, technical, and business-related issues and will support the PC and DM regarding: i) overall financial and administrative control, ii) drafting and maintenance of the CA, iii) advice on legal and ethical issues, iv) follow-up of the Grant Agreement, and v) knowledge management activities (IP protection, technology, transfer, dissemination).

The **Research Lead Team** consists of the leaders of the scientific work packages: **WP1** – Prof. Dr. Peter Lievens (KUL), **WP2** – Dr. Olga V. Safonova (PSI), **WP3** – Dr. Tibor Höltzl (FETI), **WP4** – PD Dr. Sandra M. Lang (UU), **WP5** – Prof. Dr. Christian D. Damsgaard (DTU) and the leader of project management **WP8** – Prof. Dr. Ewald Janssens (KUL). The Research Lead Team is responsible for the overall research progress of the network and the reporting thereof within the network, as well as for the detailed coordination, planning, monitoring and reporting of the research within each WP and with the other WPs in the project.

One SB member will be appointed as the **Equal Opportunities Officer** (EOO, PD Dr. Sandra Lang (UU), guiding and monitoring gender and minority issues. One of the SB members (Dr. Jinlong Yin (TCL)) will be appointed as **Ombudsperson** (OP) to provide feedback from the ESRs and to function as a mediator in case of conflicts between an ESR and his/her supervisor(s).

The participants of the work packages will report to their responsible work package leader every 3 months via short progress reports. Participants of a work package will meet according to the specific needs of its tasks, under the chairmanship of the work package leaders, at least every six months.

3.2.2 Supervisory Board

The Supervisory Board (SB) is the final responsible for the coordination and supervision of the recruitment, training, and secondment activities of the young researchers. In the unlikely case that decisions need to be taken about misconduct, large budget shifts, or controversial matters, the SB is the responsible body. The SB is chaired by the Project Coordinator (PC) and consists of one senior representative of all the Beneficiaries and Partner Organisations, two representatives of the ESRs (to be elected by the ESRs), and an external adviser. The external adviser will be selected by consensus at the beginning of the project by the senior representatives of the Beneficiaries. The external adviser will be independent (e.g., no co-supervisor of ESRs) and paid for his/her participation in the SB meetings. The SB meets at least every 6 months, (if possible aligned with the timing of NWTs). The SB reviews and assesses the recruitment and progress of the ESRs with respect to the PCDPs. The SB also monitors the progress and

implementation of the NWT activities. At the SB meetings, decisions are taken regarding high-level management issues, e.g., formal approval of changes, resolution of project conflicts, and acceptance of deliverables. If important decisions need to be taken urgently, conference calls will be organised to draw up action plans.

3.2.3 Recruitment strategy

The Supervisory Board (SB) is responsible for the joint recruitment strategy, while the responsibility to hire the ESRs and the final recruitment decisions lie with the respective Beneficiaries (**Table 1.2a**). The SB assists the Beneficiaries in their recruitment activities, by appointing a **Selection Advisory Committee (SAC)** for each ESR, with a mixture of expertise and involvement of different sectors. The SAC is led by the future principal supervisor from the Beneficiary, and includes the hosts for the secondments (i.e., the future co-supervisors), two other senior members of the Beneficiary, and two independent members (including the Equal Opportunities Officer), who will be in each SAC. These two independent members will monitor transparency, possible discrimination aspects and fairness in the selection process. The SB will ensure a balanced SAC (gender, country of origin, academic and non-academic sectors), who will act in line with the principles and requirements of the European Code of Conduct for the Recruitment of Researchers.³⁹ The SAC further ascertains that the vacancy description is not only transparent concerning subject and objectives of the ESRs research project, but also concerning the working conditions, entitlements and career-development aspects. Prior to the recruitment procedure, the members of the SAC will follow a recruitment course, as for example provided by “Recruitment Matters International”, to optimize their recruitment skills in order to attract and select the most suitable candidates.

ESRs will be recruited from the European Union and beyond, by internationally publicizing the vacancies in press, on websites, on social media, and at conferences. Each vacancy will be advertised on the CATCHY website, on the EURAXESS platform, and on at least three further international high-visibility vacancy platforms (e.g., NatureJobs, ResearchGate, Academics.eu). In the advertisements a EUROPASS CV⁴⁰ format will be required for uniformity. These advertisements will give a description of the required knowledge and competencies; they will also be checked by the EOO for gender neutrality and an absence of any bias. Enough time (3 months) will be given between the vacancy’s advertisement and the application deadline. Candidates should present evidence of past performance at their educational institutes, provide motivation for why they are applying for a specific project, and make available at least two reference contacts. To ensure transparency, candidates will, prior to selection, be informed about the recruitment process and selection criteria. The CATCHY network actively encourages equal opportunities (gender, ethnic origin...) through the appointments program, while maintaining excellence in science as the primary consideration (see also Section 3.2.7). The assistance for applicants with a refugee background to relocate their families, and language and culture courses will be included and mentioned clearly in the advertisement.

3.2.4 Progress monitoring and evaluation of individual projects

At the project level, the progress will be monitored (at the SB) against the identified deliverables (**Table 3.1b**), milestones (**Table 3.1c**). Each Beneficiary will report on progress, problems and achievements at the meetings of the SB. WP leaders are expected to submit a written summary two weeks before each meeting. These will be distributed along with details and agenda for the meetings electronically by the PC a week before the meeting. Actions and notes will be circulated after each meeting. At the management level, the DM will inform the participants about the expected deliverables by periodically updating the project agendas. Consolidated reports, actions and notes will be posted on the intranet page of CATCHY. The intranet will serve as record of the work done and will provide a route for rapid, pre-publication communication. Interactive management meetings and scientific meetings will have an important role in this strategy. All information (minutes of meetings, visit reports, WP reports, relevant publications, etc.) will be communicated to the DM, who will be responsible for channelling this information to the other members of the network.

For each ESR project the objectives, milestones, and deliverables will be detailed in the PCDPs. The progress of the ESR projects is monitored and evaluated during monthly (face-to-face) meetings with the supervisor and 4 times (**M7**, **M16**, **M28**, and **M40**) at more formal progress meetings with the ESR’s DGC (aligned with the regulations stipulated by the involved doctoral schools).

3.2.5 Risk management at the consortium level – included in part A

³⁹ <https://euraxess.ec.europa.eu/jobs/charter/code>

⁴⁰ <https://europass.cedefop.europa.eu/>

3.2.6 Intellectual property rights (IPR)

The Beneficiaries will provide 3 monthly reports to the IPM, who will evaluate, communicate (to SB) and guide the IP process. Whenever foreground IP with a potential for commercial exploitation is identified, the owners of this IP will take appropriate measures to ensure the protection of this IP, e.g., via submission of a patent application. Exploitation of the generated IP will give preference to the transfer of IP to the industrial partners of CATCHY. The second priority is the creation of a spin off with the appropriate IP transfer from the beneficiaries. In all other cases rapid dissemination of the concerned knowledge will be ensured via publications in peer-reviewed open-access journals. In order to prevent any unwanted disclosures, a publication-release procedure, including approval by all CATCHY Beneficiaries (who have two weeks to respond) will be implemented. The Participants have the right to block the disclosure of certain material, if this material is based on data they provided. The emphasis thus lies on data and not on ideas: work done by one of the Participants that is based only on a suggestion or an idea of one of the other partners is in principle publishable, provided the intellectual source of the idea is attributed appropriately, e.g., by co-authorship. Further, the participants agree to preserve the confidentiality of results identified as such during the execution of the project and an agreed period after the end of the project.

The handling of IPR issues will be detailed in the CA, which will be based on the latest DESCA Horizon 2020 Model Consortium Agreement, and will deal with the policy, rights and obligations on this matter. This agreement will also contain a plan for the use and dissemination of the obtained results after the official end date of the project. This agreement may include a non-disclosure agreement (NDA) to be signed by researchers of one Beneficiary that enter the premises of another Beneficiary.

3.2.7 Gender aspects

The CATCHY consortium is aware of issues related to gender equality and equal career opportunities in natural sciences and technology. The network is committed to gender equality and equal treatment irrespective of ethnic origin through the recruitment programme and will seek to sustain this equality, while maintaining the excellence of the science through training and professional development. As discussed in Section 3.2.3, the Selection Advisory Committee (SAC) will check for any possible discrimination in the recruitment process. The SB will ensure that the SAC is informed about implicit gender bias in the recruitment procedures. The advertisements will be formulated in a general way to avoid the under-application of female candidates. Indeed, research has indicated that female scientists tend not to apply for positions if too many criteria are listed, qualifying themselves lower than male candidates do. A quorum will be placed on the shortlisted candidates for all the ESR vacancies, with a minimum of 30% of either gender.

The EOO will ensure the interests of female ESRs at the decision-making level. In addition, the OP will have a relation of trust with the ESRs and will represent the ESRs in the SB to notify of problems or dissatisfaction. The OP will pay close attention to the feedback from female and minority ESRs in order to secure equal opportunities and prevent any discrimination. At **NWT1** the ESRs will receive training in equal opportunity awareness.

3.2.8 Data management plan

Good data management is imperative and should be underpinned by information-management practices. This ensures visibility and data sharing where appropriate, as well as clear procedures for the storage, organization, and preservation of data, and the reporting thereof. The management of the generated research data, including where relevant Open Research Data, will be stipulated in the research Data Management Plan (DMP). The SB is responsible for the implementation of the DMP for data generated within the network. The DMP will prescribe procedures for the collection and storage of all the relevant research data, its use, reuse and preservation pertaining to the lifetime of a research project as well as to its aftermath, including transfer procedures when members of a research group leave the consortium. For research results that are fully open (status public), the data needed to validate the results presented in scientific publications will be made available.

The DMP will comply with the recommendations stipulated in the LERU Roadmap for research data⁴¹ and with the KU Leuven guidelines for a data management policy.⁴² The SB is responsible for the formulation and implementation

⁴¹ https://www.kuleuven.be/english/research/integrity/practices/LERU_roadmap_research_data.pdf

⁴² <https://www.kuleuven.be/english/research/integrity/practices/datamanagement>

of the DMP. All the Participants of CATCHY should be aware of the DMP and comply with its regulations regarding ownership, research ethics, and secure data-storage procedures.

3.2.9 Financial Management

The work plan of CATCHY has been organized such that Beneficiaries contribute to hosting the secondments and the organisation of trainings, meetings and workshop, in proportion to the unit-based funds it will receive. Hence, no redistribution of funds is required for secondments, training events, and supervision in general. Each Beneficiary will reserve about 10% of its budget for “Research, training and networking” for the organization of the NWT events. Each Beneficiary is also responsible for the funding of the 4th year of the PhD, should PhD programs last longer than the maximum of 36 months that can be funded by CATCHY. In order to financially and organizationally manage CATCHY, the Beneficiaries have agreed to contribute €500 per ESR research month for “Management and Overheads” to the coordinator for assignment of the Daily Manager and for organising the Management Support. The financial management strategy is described in detail in the CA.

3.3 Appropriateness of the infrastructure of the participating organisations

As outlined in Section 5 (Participating Organisations), all the Beneficiaries and Partner Organisations are well equipped with the state-of-the-art laboratories necessary to complete the trainings and the research projects planned in CATCHY. Furthermore, all the Beneficiaries and Partner Organisations clearly show (in Sections 1.3.1. and 5) experience and high quality with respect to the training and hosting of ESRs and the achievement of high-quality research, which is further substantiated by proven track records in valorising research through patents, products and/or processes and industrial collaborations. The Beneficiaries and Partner Organisations have experience in EU projects and have well-established doctoral schools, IPR, tech-transfer and research managers to support the project coordinator, the DM, the SB, and the ESRs in the successful completion of CATCHY. The project unites some of the finest facilities available in Europe for the production of model and scaled-up catalysts based on CBD technology (KUL, DTU, TCL) for their advanced *operando* characterization (PSI, RU, UA) and their computation theoretical modelling (FETI, BME) as well as non-university/industrial facilities (FETI, VITO, TCL, HDE) that will implement their exploitation. These settings, which cover all TRL levels, will not only develop flexible, multidisciplinary ESRs with excellent technical skills, but also allow the maximum training in transferrable skills, including dissemination and public engagement and training beyond generations and the CATCHY training network.

3.4 Competences, experience and complementarity of the participating organisations and their commitment to the programme

3.4.1 Consortium composition and exploitation of the organisation’s complementarities

The CATCHY proposal responds to Europe’s need for novel catalysts that will assist the energy and environmental transition by transforming the CO₂ greenhouse gas into a resource opportunity and tackle the talent shortage in the EU nanotechnology and catalysis sector. CATCHY has pooled the expertise from a total of 10 Beneficiaries and 2 Partner Organisations, distributed over distinct but complementary disciplines and technological fields. The CATCHY Beneficiaries cover the whole value chain, from fundamental and strategic basic research to applied research, pilot-scale operations and industrial production.

Beneficiaries KUL, DTU, and TCL were members of the very successful Catsense ITN and have since developed strong research collaborations. Five of the Participants in CATCHY are internationally recognized groups working on gas-phase clusters and are equipped with fully complementary state-of-the-art CBD sources. Each source possesses a unique design with distinct assets: bimetallic clusters (KUL), *in situ* microreactors (DTU), and large quantity cluster production (TCL), and free clusters in the gas-phase (UU and RU). DTU is a major player in the field of methanol synthesis catalysts. HDE is a world-leading catalysis company with interest in precious metal based methanol synthesis catalysts. UA is equipped with state-of-the-art electron microscopes equipped with advanced *in situ* gas-flow cells in an *in situ* TEM. PSI hosts the Swiss Light Source synchrotron facility, which is a state-of-the-art institute for the *operando* characterisation of TC and ECs and has expertise in the field of bimetallic NP-based catalysts in a tight collaboration with the associated partner ETH. RU hosts the FELIX Free Electron Laser facility, whose unique brilliance properties are bound to enhance our understanding of catalytic processes at the molecular level, an important asset for CATCHY. FETI, a research subsidiary of the global Furukawa Electric Company, and BME have expertise in the computational modelling of free and deposited clusters and are equipped with high-performance computing facilities. They will use the network’s experimental results as their input for their calculations to unravel the active sites and mechanisms involved at the atomic level. TCL is one of the few companies in Europe equipped with industrial

CBD and will scale-up the cluster production for VITO, who will focus on the exploitation of CATCHY's results by developing a model/prototype of a CO₂ fuel cell using the network's best catalysts. The distinct technical expertise and science domains of the Participants are described in more details in Section 5 and summarised in **Table 3.3**. The CATCHY Participants provide the interdisciplinarity expertise that is required for S&T breakthroughs in the design of novel high-performance catalysts for CO₂ conversion into valuable fuels and chemicals. The CATCHY network, which is distributed over seven countries in Europe, is coordinated by KUL, a university with a great deal of experience in ITNs.

3.4.2 Commitment of the Beneficiaries and Partner Organisations to the programme

The close interaction of the 10 Beneficiaries and the Partner Organisations is fundamental to the intersectorial and interdisciplinary training of the ESRs. All the Beneficiaries accept their role and duties assigned by this proposal: 1) to allocate appropriate time for their participating staff members; 2) make available all the required equipment and infrastructure to the ESRs for their own projects and for collaborations within the network; 3) follow procedures with respect to commercialisation, dissemination, presentation; 4) follow-up all training moments of the ESRs; 5) guard the equal opportunity policy of this network; 6) organize all designated schools, workshops, and skills training; 7) provide all the planned reports and information to the PC and SB; 8) accommodate all the incoming and outgoing secondments, with KUL coordinating the network. Through CATCHY's extended secondment programme, the ESRs will benefit from the integrating activities between academia and industry by obtaining a full range of trainings, ranging from advanced education to practical application (industrial scale-up and prototyping). The non-university Beneficiaries will gain an insight into recent problems that could create novel initiatives for academic research. They will be able to use the unique facilities provided by the network and be exposed to bright researchers that will become potential candidates for recruitment. The Partner Organisations have signed the formal Letter of Commitment in which their roles are explained. Finally, all the Participants have the ambition and the track record to transform CATCHY into a larger long-term structural training network for the benefit of society.

Table 3.3: Complementarities, synergies between hosts and breakdown of training capacity by host

Partner	KUL	BME	DTU	FETI	UA	PSI	RU	UU	TCL	VITO	
Disciplines	Physics	X	X	X	X	X	X		X		
	Chemistry	X	X	X	X	X	X	X			
	Engineering				X				X	X	
	Quant. Chem.		X		X			X			
Technique	Cluster source	X		X			X	X	X		
Technology	Thermo-catalysis	X	X	X	X	X					
	Electro-catalysis	X		X	X	X	X			X	
Sector	Aca-demic	Aca-demic	Aca-demic	Private	Aca-demic	No-profit	Aca-demic	Aca-demic	Private	No-profit	
Personnel	Investigators	8	5	7	17	9	11	10	2	10	6
	Post-docs	7	2	12	-	22	4	6	-	-	4
	Current ESRs	24	5	23	15	32	18	14	2	-	8
	Tech/Support	6	1	6	28	9	3	10	2	7	4
	Total	43	13	48	60	72	36	50	6	17	22
(% female)	(22%)	(46%)	(20%)	(27%)	(60%)	(30%)	(28%)	(50%)	(53%)	(5%)	

4. Ethics Aspects

The following item was identified in the Ethics Screening:

- The research involves the use of nanoparticles/nanoclusters and highly toxic substances (methanol, CO) that may cause harm to the environment and to humans (including research staff).

However only minor toxic effects are foreseen in CATCHY as nanoparticles/nanoclusters deposited on substrates are fixed with no dispersion risk, whereas methanol and CO will generally be used at very high dilution levels (1 to 5% CO in He).

The research activities in CATCHY will respect fundamental ethics principles. In particular, the researchers will follow the "European Commission Recommendation of 07/02/2008 on a Code of Conduct for Responsible Nanosciences and Nanotechnologies Research". Every partner in CATCHY will comply with all relevant National and EU legislations relating to the use of toxic substances.

Compliance Environmental protection and safety regulation will be secured by:

- Information about the possible harm to the environment caused by the research and the measures that will be taken to mitigate the risks will be kept on file.
- Copies of authorization for relevant facilities (e.g., security classification of laboratories) will be kept on file.
- Each partner has appropriate health and safety procedures conforming to relevant local/national guidelines/legislation, including the Code Conduct for Responsible Nanosciences and Nanotechnologies Research, are will ensure they are followed by all staff involved in this project.
- Copies of health and safety procedures, and individual safety training documents will be kept on file.

ESTIMATED BUDGET FOR THE ACTION

		Estimated eligible ¹ costs (per budget category)										EU contribution			
		A. Costs for recruited researchers					B. Institutional costs					Total costs	Reimbursement rate %	Maximum EU contribution ²	Maximum grant amount ³
		A.1 Living allowance		A.2 Mobility allowance		A.3 Family allowance		B.1 Research, training and networking costs		B.2 Management and indirect ⁴ costs					
		Unit		Unit		Unit		Unit		Unit					
		Costs per unit ⁶	Total a ⁷	Costs per unit ⁶	Total b ⁷	Costs per unit ^{6,8}	Total c ⁷	Costs per unit ⁶	Total d ⁷	Costs per unit ⁶	Total e ⁷	f = a+b+c+d+e	g	h	i
1. KUL	72.00	3 270.00	235 440.00	600.00	43 200.00	250.00	18 000.00	1 800.00	129 600.00	1 200.00	86 400.00	512 640.00	100.00	512 640.00	n/a
2. BME	36.00	2 530.98	91 115.28	600.00	21 600.00	250.00	9 000.00	1 800.00	64 800.00	1 200.00	43 200.00	229 715.28	100.00	229 715.28	n/a
3. DTU	72.00	4 414.50	317 844.00	600.00	43 200.00	250.00	18 000.00	1 800.00	129 600.00	1 200.00	86 400.00	595 044.00	100.00	595 044.00	n/a
4. FETI	36.00	2 530.98	91 115.28	600.00	21 600.00	250.00	9 000.00	1 800.00	64 800.00	1 200.00	43 200.00	229 715.28	100.00	229 715.28	n/a
5. PSI	72.00	3 963.24	285 353.28	600.00	43 200.00	250.00	18 000.00	1 800.00	129 600.00	1 200.00	86 400.00	562 553.28	100.00	562 553.28	n/a
6. RU	72.00	3 528.33	254 039.76	600.00	43 200.00	250.00	18 000.00	1 800.00	129 600.00	1 200.00	86 400.00	531 239.76	100.00	531 239.76	n/a
7. TCL	36.00	4 571.46	164 572.56	600.00	21 600.00	250.00	9 000.00	1 800.00	64 800.00	1 200.00	43 200.00	303 172.56	100.00	303 172.56	n/a
8. UA	36.00	3 270.00	117 720.00	600.00	21 600.00	250.00	9 000.00	1 800.00	64 800.00	1 200.00	43 200.00	256 320.00	100.00	256 320.00	n/a
9. UU	36.00	3 171.90	114 188.40	600.00	21 600.00	250.00	9 000.00	1 800.00	64 800.00	1 200.00	43 200.00	252 788.40	100.00	252 788.40	n/a
10. VITO	36.00	3 270.00	117 720.00	600.00	21 600.00	250.00	9 000.00	1 800.00	64 800.00	1 200.00	43 200.00	256 320.00	100.00	256 320.00	n/a
Total consortium	504.00	n/a	1 789 108.56	n/a	302 400.00	n/a	126 000.00	n/a	907 200.00	n/a	604 800.00	3 729 508.56	100.00	3 729 508.56	3 729 508.56

¹ See Article 6 for the eligibility conditions.

² This is the theoretical amount of EU contribution that the system calculates automatically (by multiplying all the budgeted costs by the reimbursement rate). This theoretical amount is capped by the 'maximum grant amount' (that the Commission/Agency decided to grant for the action) (see Article 5.1).

³ The 'maximum grant amount' is the maximum grant amount decided by the Commission/Agency. It normally corresponds to the requested grant, but may be lower.

⁴ The indirect costs covered by the operating grant (received under any EU or Euratom funding programme; see Article 6.3(b)) are ineligible under the GA. Therefore, a beneficiary that receives an operating grant during the action's duration cannot declare indirect costs for the year(s)/reporting period(s) covered by the operating grant (i.e. the unit cost for management and indirect costs will be halved for person-months that are incurred during the period covered by the operating grant), unless it can demonstrate that the operating grant does not cover any costs of the action.

⁵ See Article 5 for the forms of costs.

⁶ See Annex 2a 'Additional information on the estimated budget' for the details on the costs per unit.

⁷ Total = costs per unit x number of units (person-months).

ESTIMATED BUDGET FOR THE ACTION

⁸ The amount for the family allowance inserted by the system represents an average (with/without family). For the financial statements (Annex 4), this amount will be adjusted according to the actual family status of the recruited researchers (as specified in the 'researcher declaration').

ANNEX 2a

ADDITIONAL INFORMATION ON THE ESTIMATED BUDGET

- Instructions and footnotes in blue will not appear in the text generated by the IT system (since they are internal instructions only).
- For options [in square brackets]: the applicable option will be chosen by the IT system. Options not chosen will automatically not appear.
- For fields in [grey in square brackets] (even if they are part of an option as specified in the previous item): IT system will enter the appropriate data.

Marie Skłodowska-Curie unit costs

MSCA-ITN unit costs

Costs for the recruited researcher(s) — Living allowance

Units: months spent by the researcher(s) on the research training activities ('person-months')

Amount per unit *: see Annex 2

- * Amount calculated as follows:
 - { the monthly living allowance for researchers in MSCA-ITN actions
 - multiplied by
 - country-specific correction coefficient of the country in which the researcher is recruited }

The monthly living allowance and the country-specific correction coefficients are set out in the Work Programme (section 3 MSCA) in force at the time of the call:

- for calls *before* Work Programme 2018-2020:
 - for the monthly living allowance:
 - ITN: **EUR 3 110**
 - for the country-specific correction coefficients: see Work Programme 2014-2015 and Work Programme 2016-2017 (available on the [Participant Portal Reference Documents](#) page)
- for calls *under* Work Programme 2018-2020:
 - for the monthly living allowance:
 - ITN: **EUR 3 270**
 - for the country-specific correction coefficients: see Work Programme 2018-2020 (available on the [Participant Portal Reference Documents](#) page).

Estimated number of units: see Annex 2

Costs for the recruited researcher(s) — Mobility allowance

Units: months spent by the researcher(s) on the research training activities ('person-months')

Amount per unit¹: see Annex 2

Estimated number of units: see Annex 2

¹ Same amount for all beneficiaries.
Amount for the mobility allowance set out in the [Main Work Programme — MSCA](#) in force at the time of the call.

Costs for the recruited researcher(s) — Family allowance

Units: months spent by the researcher(s) on the research training activities ('person-months')

Amount per unit²: see Annex 2

Estimated number of units: see Annex 2

Institutional costs — Research, training and networking costs

Units: months spent by the researcher(s) on the research training activities ('person-months')

Amount per unit³: see Annex 2

Estimated number of units: see Annex 2

Institutional costs — Management and indirect costs

Units: months spent by the researcher(s) on the research training activities ('person-months')

Amount per unit⁴: see Annex 2

Estimated number of units: see Annex 2

² Same amount for all beneficiaries.
Average based on the amount for the family allowance set out in the [Main Work Programme — MSCA](#) in force at the time of the call (half of the number of units with family, half without).

³ Same amount for all beneficiaries.
Amount for research, training and networking costs set out in the [Main Work Programme — MSCA](#) in force at the time of the call.

⁴ Same amount for all beneficiaries.
Amount for management and indirect costs set out in the [Main Work Programme — MSCA](#) in force at the time of the call.

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

BUDAPESTI MUSZAKI ES GAZDASAGTUDOMANYI EGYETEM (BME), established in MUEGYETEM RAKPART 3, BUDAPEST 1111, Hungary, VAT number: HU15308799, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('2')

in Grant Agreement No 955650 ('the Agreement')

between KATHOLIEKE UNIVERSITEIT LEUVEN **and** the Research Executive Agency (REA) ('the Agency'), under the powers delegated by the European Commission ('the Commission'),

for the action entitled 'Design, implementation and production upscaling of novel, high-performance, cluster-based catalysts for CO₂ hydrogenation (CATCHY)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

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 conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

DANMARKS TEKNISKE UNIVERSITET (DTU), established in ANKER ENGELUNDSVEJ 1 BYGNING 101 A, KGS LYNGBY 2800, Denmark, VAT number: DK30060946, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('3')

in Grant Agreement No 955650 ('the Agreement')

between KATHOLIEKE UNIVERSITEIT LEUVEN **and** the Research Executive Agency (REA) ('the Agency'), under the powers delegated by the European Commission ('the Commission'),

for the action entitled 'Design, implementation and production upscaling of novel, high-performance, cluster-based catalysts for CO₂ hydrogenation (CATCHY)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

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 conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

FURUKAWA ELECTRIC TECHNOLOGIAI INTEZET KORLATOLT FELELOSSEGU TARSASAG (FETI), established in KESMARK UTCA 28/A, BUDAPEST 1158, Hungary, VAT number: HU10489536, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('4')

in Grant Agreement No 955650 ('the Agreement')

between KATHOLIEKE UNIVERSITEIT LEUVEN **and** the Research Executive Agency (REA) ('the Agency'), under the powers delegated by the European Commission ('the Commission'),

for the action entitled 'Design, implementation and production upscaling of novel, high-performance, cluster-based catalysts for CO₂ hydrogenation (CATCHY)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

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 conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

PAUL SCHERRER INSTITUT (PSI), established in FORSCHUNGSTRASSE 111, VILLIGEN PSI 5232, Switzerland, VAT number: CHE116133392MWST, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('5')

in Grant Agreement No 955650 ('the Agreement')

between KATHOLIEKE UNIVERSITEIT LEUVEN **and** the Research Executive Agency (REA) ('the Agency'), under the powers delegated by the European Commission ('the Commission'),

for the action entitled 'Design, implementation and production upscaling of novel, high-performance, cluster-based catalysts for CO₂ hydrogenation (CATCHY)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

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 conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

STICHTING KATHOLIEKE UNIVERSITEIT (RU), established in GEERT GROOTEPLEIN NOORD 9, NIJMEGEN 6525 EZ, Netherlands, VAT number: NL002968721B01, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('6')

in Grant Agreement No 955650 ('the Agreement')

between KATHOLIEKE UNIVERSITEIT LEUVEN **and** the Research Executive Agency (REA) ('the Agency'), under the powers delegated by the European Commission ('the Commission'),

for the action entitled 'Design, implementation and production upscaling of novel, high-performance, cluster-based catalysts for CO₂ hydrogenation (CATCHY)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

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 conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

TEER COATINGS LIMITED (TCL), established in WEST STONE HOUSE WEST STONE BERRY HILL INDUSTRIAL ESTATE, DROITWICH WR9 9AS, United Kingdom, VAT number: GB376145539, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('7')

in Grant Agreement No 955650 ('the Agreement')

between KATHOLIEKE UNIVERSITEIT LEUVEN **and** the Research Executive Agency (REA) ('the Agency'), under the powers delegated by the European Commission ('the Commission'),

for the action entitled 'Design, implementation and production upscaling of novel, high-performance, cluster-based catalysts for CO₂ hydrogenation (CATCHY)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

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 conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITEIT ANTWERPEN (UA), established in PRINSSTRAAT 13, ANTWERPEN 2000, Belgium, VAT number: BE0257216482, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('8')

in Grant Agreement No 955650 ('the Agreement')

between KATHOLIEKE UNIVERSITEIT LEUVEN **and** the Research Executive Agency (REA) ('the Agency'), under the powers delegated by the European Commission ('the Commission'),

for the action entitled 'Design, implementation and production upscaling of novel, high-performance, cluster-based catalysts for CO₂ hydrogenation (CATCHY)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

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 conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITAET ULM (UU), established in HELMHOLTZSTRASSE 16, ULM 89081, Germany, VAT number: DE173703203, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('9')

in Grant Agreement No 955650 ('the Agreement')

between KATHOLIEKE UNIVERSITEIT LEUVEN **and** the Research Executive Agency (REA) ('the Agency'), under the powers delegated by the European Commission ('the Commission'),

for the action entitled 'Design, implementation and production upscaling of novel, high-performance, cluster-based catalysts for CO₂ hydrogenation (CATCHY)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

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 conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

VLAAMSE INSTELLING VOOR TECHNOLOGISCH ONDERZOEK N.V. (VITO), established in BOERETANG 200, MOL 2400, Belgium, VAT number: BE0244195916, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('10')

in Grant Agreement No 955650 ('the Agreement')

between KATHOLIEKE UNIVERSITEIT LEUVEN **and** the Research Executive Agency (REA) ('the Agency'), under the powers delegated by the European Commission ('the Commission'),

for the action entitled 'Design, implementation and production upscaling of novel, high-performance, cluster-based catalysts for CO₂ hydrogenation (CATCHY)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

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 conditions it sets out.

SIGNATURE

For the beneficiary

MODEL ANNEX 4 FOR H2020 MGA MSCA-ITN — MULTI

FINANCIAL STATEMENT FOR BENEFICIARY [name] FOR REPORTING PERIOD [reporting period]

		Eligible ¹ costs (per budget category)										EU contribution					
		A. Costs for recruited researchers					B. Institutional costs					Total costs	Reimbursement rate %	Maximum EU contribution	Requested EU contribution		
		A.1 Living allowance		A.2 Mobility allowance		A.3 Family allowance	B.1. Research, training and networking costs		B2. Management and indirect ² costs								
Form of costs ³		Unit		Unit		Unit		Unit		Unit							
Name of the fellows ⁶		Number of units (person-months)		Costs per unit ⁴	Total ⁵	Costs per unit ⁴	Total ⁵	Costs per unit ⁴	Total ⁵	Costs per unit ⁴	Total ⁵	Costs per unit ⁴	Total ⁵	f = a+b+c+d+e	g	h	i
Total beneficiary																	

Checkbox 1: I confirm that the total amount of the allowances used (including compulsory deductions) for the researcher is equal to or higher than the living allowance, the mobility allowance and the family allowance as set out in Annex 2 of the Agreement or that any underpayments in reporting period 1 will be corrected by the end of the action.

Checkbox 2:	Did you receive any EU/Euratom operating grant during this reporting period?	<input type="radio"/> YES <input type="radio"/> NO	
	If yes, pls indicate how many of the total person-months (see 'total beneficiary' above) were incurred DURING the period covered by the operating grant?		Number of person-months
	If yes, can you confirm all of the following: - the operating grant is a partial operating grant (i.e. does not cover your entire annual budget) - you have used analytical accounting which allows for a cost accounting management with cost allocation keys and cost accounting codes - you have recorded: - all costs incurred for the operating grant (i.e. personnel, general running costs and other operating costs linked to the work programme) and - all costs incurred for the action grants (including the indirect costs linked to the action) ion - you have used allocation keys and cost accounting codes to identify and separate the recorded costs (i.e. to allocate them to either the action grant or the operating grant) - you have done the allocation in a way that leads to a fair, objective, realistic result.	<input type="radio"/> YES <input type="radio"/> NO	

The beneficiary hereby confirms that:
 The information provided is complete, reliable and true.
 The costs declared are eligible (see Article 6).
 The costs 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 17, 18 and 22).

¹ Please declare all person-months, even if you exceed the estimated budget (see Annex 2). Only person-months that were declared in your individual financial statements can be taken into account lateron, in order to replace other costs that are found to be ineligible.

² See Article 6 for the eligibility conditions

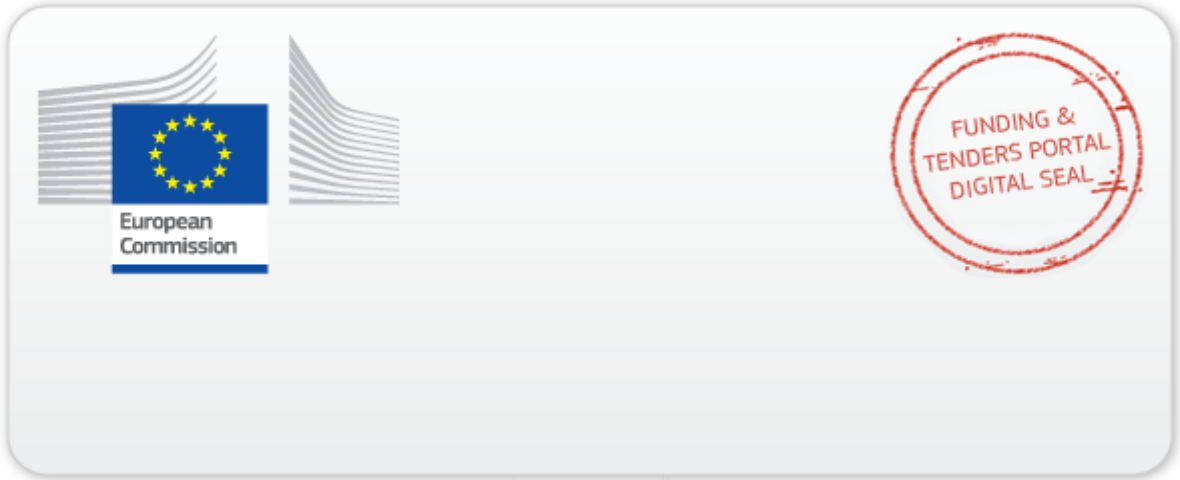
³ The indirect costs claimed must be free of any amounts covered by an operating grant (received under any EU or Euratom funding programme; see Article 6.3(b)). If you have received an operating grant during this reporting period, indirect costs will not be reimbursed for the person-months incurred during the period covered by the operating grant, unless you can demonstrate that the operating grant does not cover any costs of the action.

⁴ See Article 5 for the forms of costs

⁵ See Annex 2a 'Additional information on the estimated budget' for the details on the costs per unit.

⁶ Total = costs per unit x number of units (person-months)

⁷ Name of the researcher and related units for living (A.1) and family (A.3) allowances will be prefilled on the basis of the information provided by the beneficiary in the 'researcher declaration'



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