Plug-N-Harvest

WP5 – CIRCULAR ECONOMY BUSINESS MODEL AND EXPLOITATION PLAN

ORGANIZATION: AIGUASOL
PRESENTER(S): ARNAU GONZALEZ, DIANA VAZ (AIGUASOL), NIKOS MARGARITIS (CERTH), ROGER SEGARRA (EIG)

Plug-N-Harvest: Presentation Outline

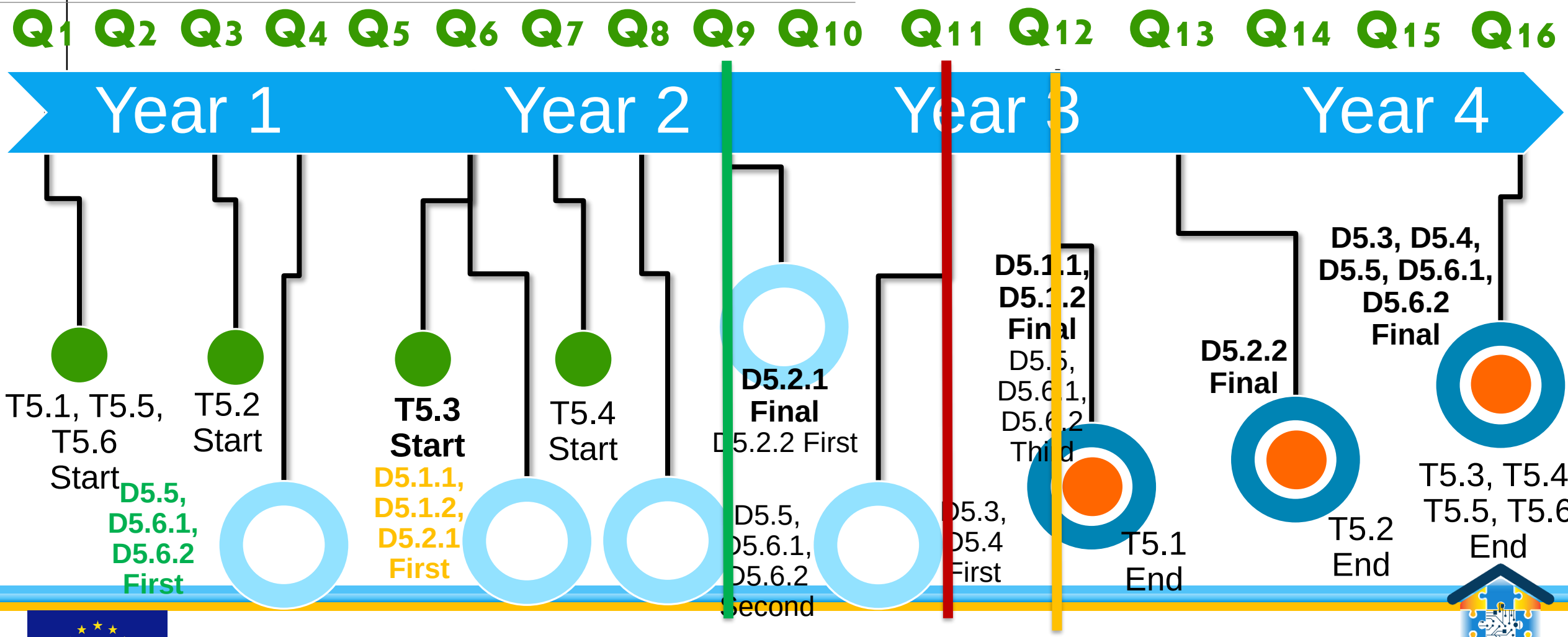
1. WP5 schedule and progress
2. Overview of WP5 Tasks progress
    1. Task 5.1 – Circular Economy design requirements, conditioners & Material DataBase
    2. Task 5.2 – Evaluation methodologies and Impact Assessment of CE solutions
    3. Task 5.3 – Life Cycle Costing analysis
    4. Task 5.4 – Development of financial Business Models and implementation for demo cases
    5. Task 5.5 – Standardization Models and Analysis
    6. Task 5.6 – Exploitation Strategy and Business Plans

WP5 Schedule and Progress

WP5 progress

- Task 5.1: delivered first versions of D5.1.1 and D5.1.2 on February 28th
  - **T5.1.1 – Five Circular Economy design requirements – Task in Progress, due M36 (August 2020)**
  - **T5.1.2 – Development of a materials database based on circular materials and products – Task in Progress, due M36 (August 2020)**
- Task 5.2: T5.2.1 delivered first version of D5.2.1 on February 28th, T5.2.2 in progress (March 2019)
  - **T5.2.1 – Design of a methodology to assess the degree of compliance of CE principles for the construction and building renovation sector – completed (November 2019)**
  - **T5.2.2 – Life Cycle Assessment – completed (January 2020)**
- Task 5.3: in progress (October 2018)
  - **Life Cycle Costing Analysis – Task in Progress, due M33 (May 2020)**
- Task 5.4: in progress (March 2019)
  - **Development of Financial Business Models – Task in Progress, due M33 (May 2020)**
- Task 5.5: delivered second version of D5.5 on August 31st that will be annually updated
  - **Standardization Models and Analysis – Task in Progress, update of D5.5 due M36 (August 2020)**
- Task 5.6: delivered second versions of D5.6.1 and D5.6.2 on August 31st that will be annually updated
  - **T5.6.1 – Market analysis and Business Plans – Task in progress, update of D5.6.1 due M36 (August 2020)**
  - **T5.6.2 – Exploitation Plans– Task in progress, update of D5.6.1 due M36 (August 2020)**

WP5 Timeline



Overview of WP5 Tasks progress

WP5 – Circular Economy Business Model & Exploitation Plan

T5.1 CIRCULAR ECONOMY DESIGN DELIMITANTS, CONDITIONERS & MATERIALS DATABASE

TASK RESPONSIBLE: EIG
PRESENTER(S): ROGER SEGARRA

MEETING: 7TH PLENARY MEETING, BRUSSELS, 26 FEBRUARY 2020

Task 5.1 Circular Economy design requirements, conditioners & Material Database

- Task Leader: EIG
- Task activities:
  - Determination of Circular Economy Design Requirements and internal and external dissemination of them
  - Development of a Materials Database Web Tool, including materials and solutions of façades and for different latitudes and technical requirements
- Deliverables:
  - D5.1.1a Guidelines On Circular Economy Design Requirements And Conditioners (submitted)
  - D5.1.2a Materials Database Web Tool (submitted)
  - D5.1.1b Guidelines On Circular Economy Design Delimitants And Conditioners (due August 2020)
  - D5.1.2b Materials Database Web Tool (due August 2020)
- Status of task: 1st stage completed, 2nd stage ongoing

WP5 – Circular Economy Business Model & Exploitation Plan

T5.2 EVALUATION METHODOLOGIES AND IMPACT ASSESSMENT OF CIRCULAR ECONOMY SOLUTIONS

TASK RESPONSIBLE: AIGUASOL
PRESENTER(S): ARNAU GONZALEZ, TONI HERENA

MEETING: 7TH PLENARY MEETING, BRUSSELS, 26 FEBRUARY 2020

Task 5.2 Evaluation methodologies and Impact Assessment of CE solutions

- Task Leader: AIGUASOL
- Task activities:
  - Development of a methodology to assess the degree of compliance of CE principles in the field of construction sector
  - Performance of a Life Cycle Assessment (LCA) of the designed solutions
- Deliverables:
  - D5.2.1a Methodology To Check The Degree Of Compliance Of CE Principles On The Initial Stages Of Design (submitted)
  - D5.2.2a Report On Environmental Impact Assessment (submitted)
  - D5.2.1b Methodology To Check The Degree Of Compliance Of CE Principles On The Initial Stages Of Design (submitted)
  - D5.2.2b Report On Environmental Impact Assessment (due November 2020)
- Status of task: T5.2.1 completed; T5.2.2 1st stage completed

Plug-N-Harvest: WPX - Title

Task: 5.2.1 - Evaluation methodology for circular economy solutions implementation degree

Task 5.2.1: goal and framework of analysis

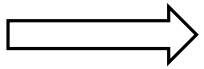
Creation of a Circular Economy degree of compliance assessment methodology within a lifecycle framework (EN15978)

Evaluation of circularity with a twofold approach:

- Impact assessment and circular flow perspective
- Business perspective

Calculation of “Circularity Indicators” associated to four vectors:

- Energy
- Materials
- Social Added Value
- Economic Value



Energy Circularity Indicator (ECI)
Materials Circularity Indicator (MCI)
Social Added Value Circularity Indicator (SCI)
Life Cycle Costing (LCC)

Task 5.2.1: Circularity Indicators

$$ECI[\%] = \frac{RE_{A1-3} + RE_{A4-5} + RE_B + RE_C\ [kWh_{PE}]}{E_{th} + E_e\ [kWh_{PE}]}$$

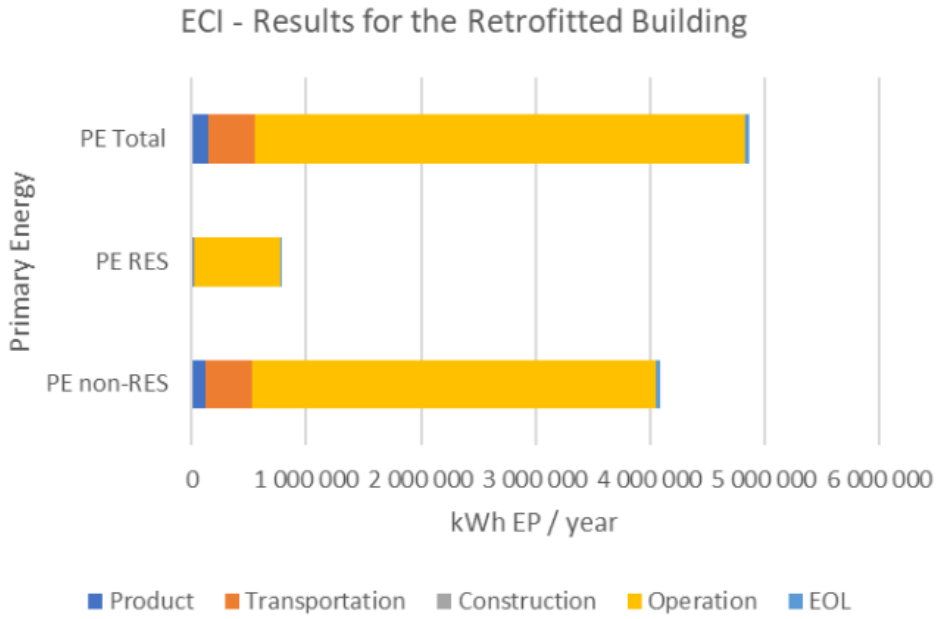
$$MCI[\%] = \frac{\sum TMI\ from\ Cycled\ Sources + \sum MO\ to\ Cycled\ Paths\ \ Sources\ [kg]}{\sum TMI + \sum TMO\ [kg]}$$

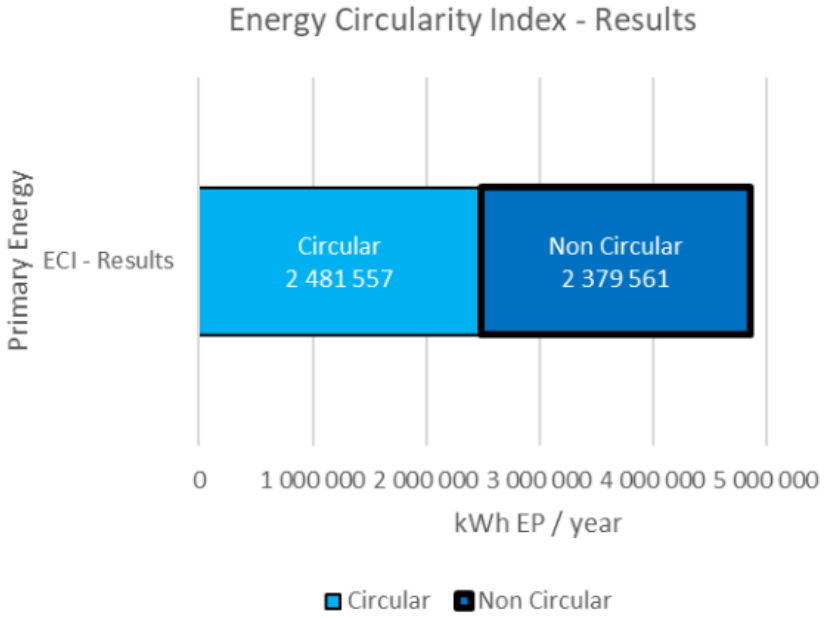
$$SCI[\%] = \frac{SI_{A1-3} + SI_{A4-5} + SI_{B1} + SI_{B2-B5} + SI_C}{N_{A1-3} + N_{A4-5} + N_{B1} + N_{B2-B5} + N_C}\ [\%]$$

Task 5.2.1: Building Circularity Assessment example

AHC Catalonia's pilot – Sant Quirze del Vallès

Energy Circularity Indicator





ECI %	51.05%

Operation stage is the most relevant

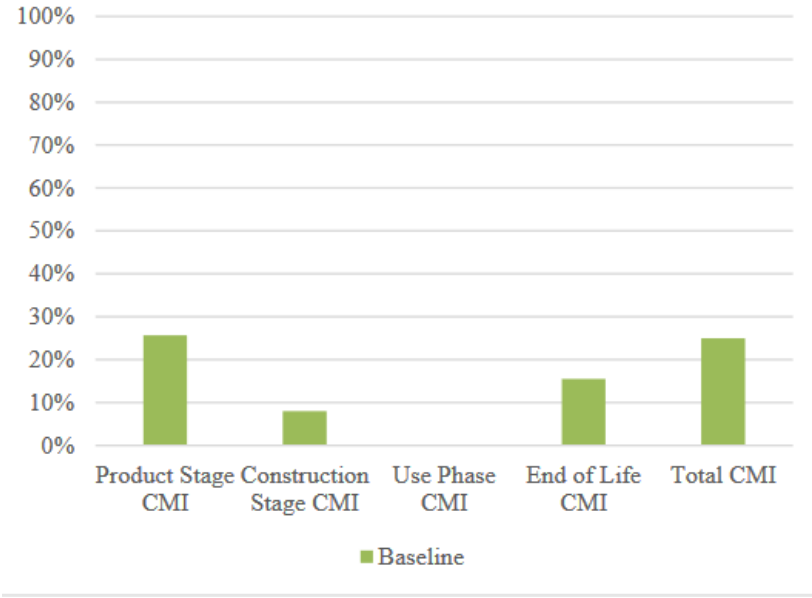
Task 5.2.1: Building Circularity Assessment example

AHC Catalonia's pilot – Sant Quirze del Vallès

Materials Circularity Indicator

System	∑TMI from cycled sources (kg)	∑TMO to cycled paths (kg)	∑TMI (kg)	∑TMO (kg)	MCI [%]
ETICS	211,67	6,05	827,89	43,23	25%

Overall MCI result is closely linked to the result of the MCI at the **production stage**



Task 5.2.1: Building Circularity Assessment example

AHC Catalonia's pilot – Sant Quirze del Vallès

Social Circularity Indicator

Not based on flow analysis

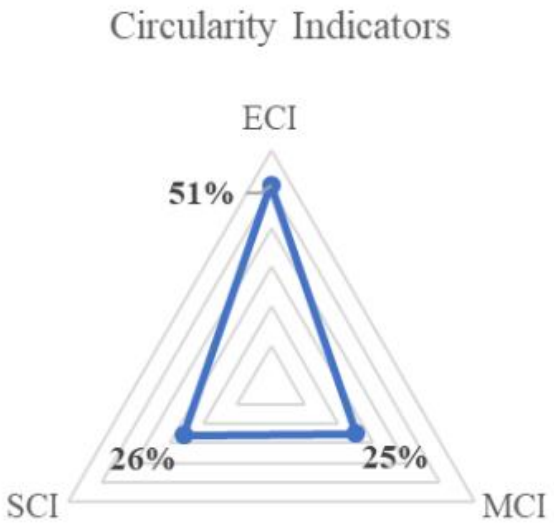
$$SCI[\%] = 26\%$$

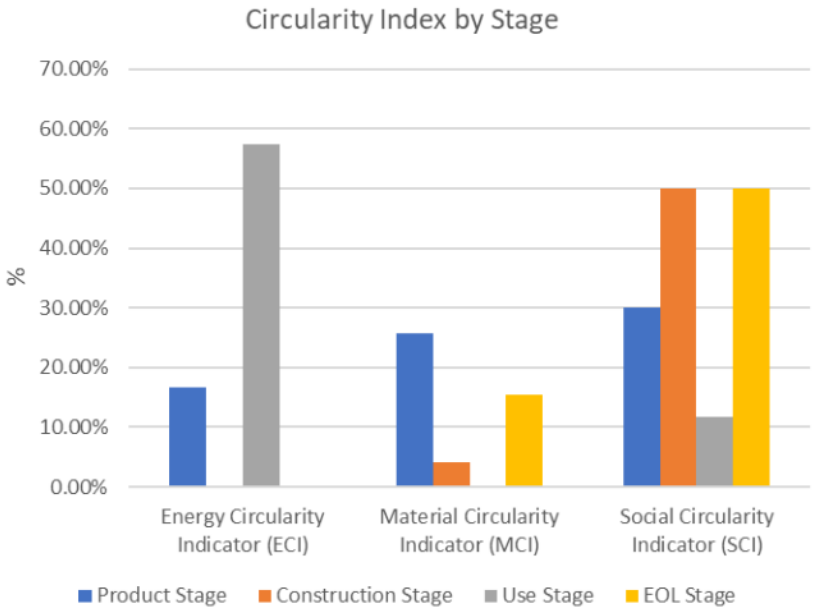
Product stage: C2C certification
All the other stages: evaluation matrix

Assumption: compliance with the Spanish normative

Task 5.2.1: Building Circularity Assessment example

AHC Catalonia's pilot – Sant Quirze del Vallès

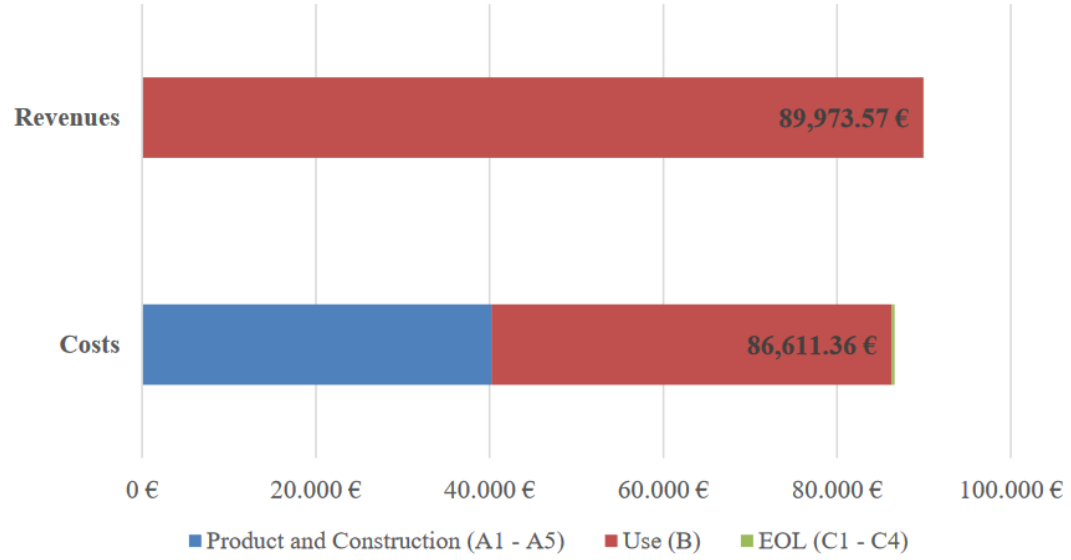


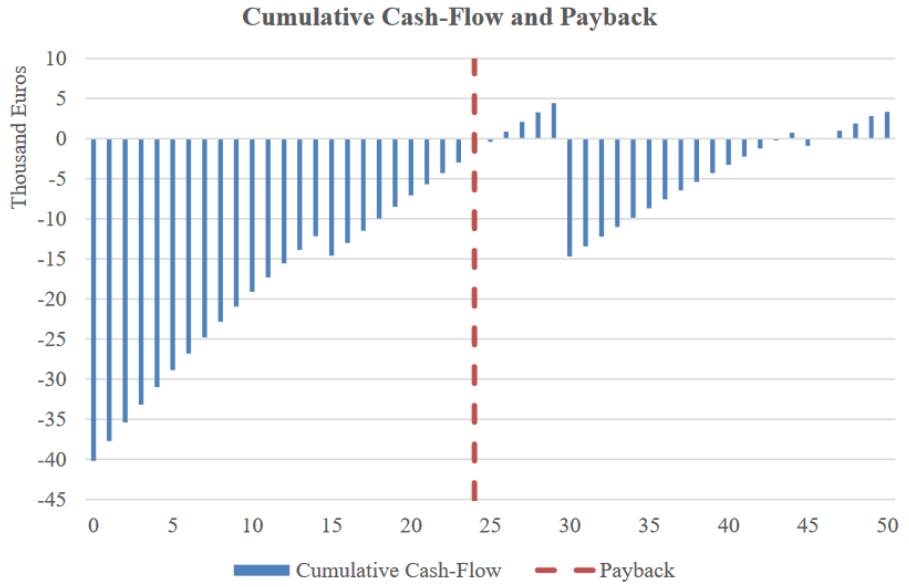


Task 5.2.1: Building Circularity Assessment example

AHC Catalonia's pilot – Sant Quirze del Vallès

Life Cycle Cost Analysis





Plug-N-Harvest: WPX - Title

Task: 5.2.2 - Circular economy-based environmental impact assessment and LCA metrics

Task 5.2.2: goal and scope

Environmental assessment of the PLUG-N-HARVEST project in **life cycle** terms:

- pre-defined widely acceptable protocols (ISO 14040)
- boundaries include the manufacturing stage, the operation stage (considering as well as the avoided emissions by the operation of the PLUG-N-HARVEST) and the EOL stage
- investigation of the disassembly of the composite materials (in line with the materials selected in Task 5.1.2)
- examination of further utilization of the produced materials, in the framework of the circular economy

LIFE CYCLE ASSESSMENT

Task 5.2.2 – LCA tools and sources

LCA calculation tool
version 1.7

LCI and LCIA database
version 3.5

Task 5.2.2 – LCA: work structure (ISO 14040:2006)

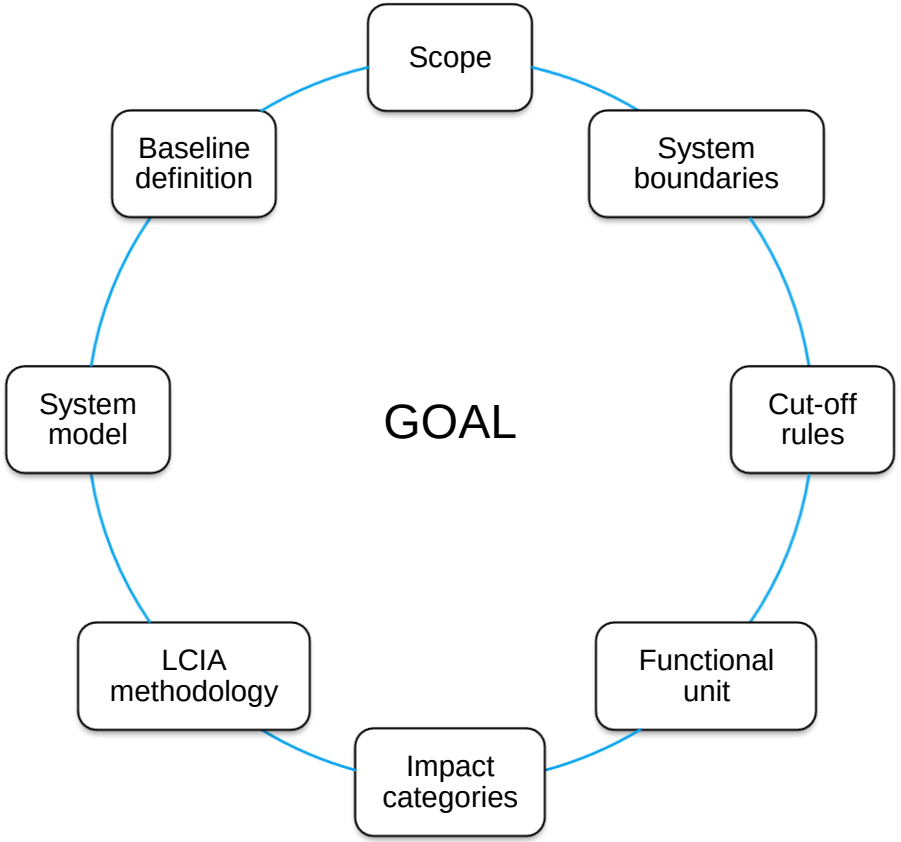
Goal and scope definition

Development of the Life Cycle Inventory (LCI)

Life Cycle Impact Assessment (LCIA)

Interpretation of results and conclusions

Task 5.2.2 – LCA: goal and scope



Task 5.2.2 – LCA: work structure (ISO 14040:2006)

Goal and scope definition

Development of the Life Cycle Inventory (LCI)

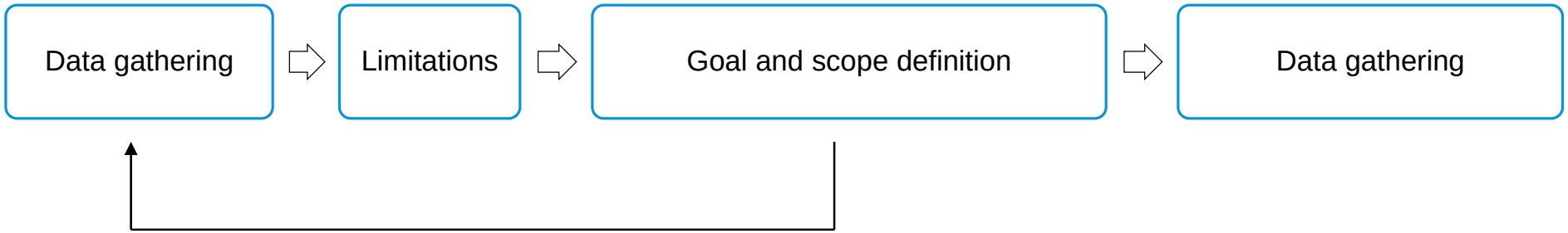
Life Cycle Impact Assessment (LCIA)

Interpretation of results and conclusions

Task 5.2.2 – LCI

Development of the Life Cycle Inventory (LCI)

Inventory of input and output flows that concern to each process of the lifetime of the object of study



Task 5.2.2 – LCA: work structure (ISO 14040:2006)

Goal and scope definition

Development of the Life Cycle Inventory (LCI)

Life Cycle Impact Assessment (LCIA)

Conversion of flows into **impact category indicators**

Interpretation of results and conclusions

Task 5.2.2 – LCA: work structure (ISO 14040:2006)

Goal and scope definition

Development of the Life Cycle Inventory (LCI)

Development of the Life Cycle Impact Assessment (LCIA)

Interpretation of results and conclusions

Task 5.2.2 – PLUG-N-HARVEST LCA: goal

PLUG-N-HARVEST retrofitting product

Conventional retrofitting

Most critical stages of life

Most critical products

Task 5.2.2 – PLUG-N-HARVEST LCA: goal

PLUG-N-HARVEST retrofitting product

Conventional retrofitting

Task 5.2.2 – LCA: scope

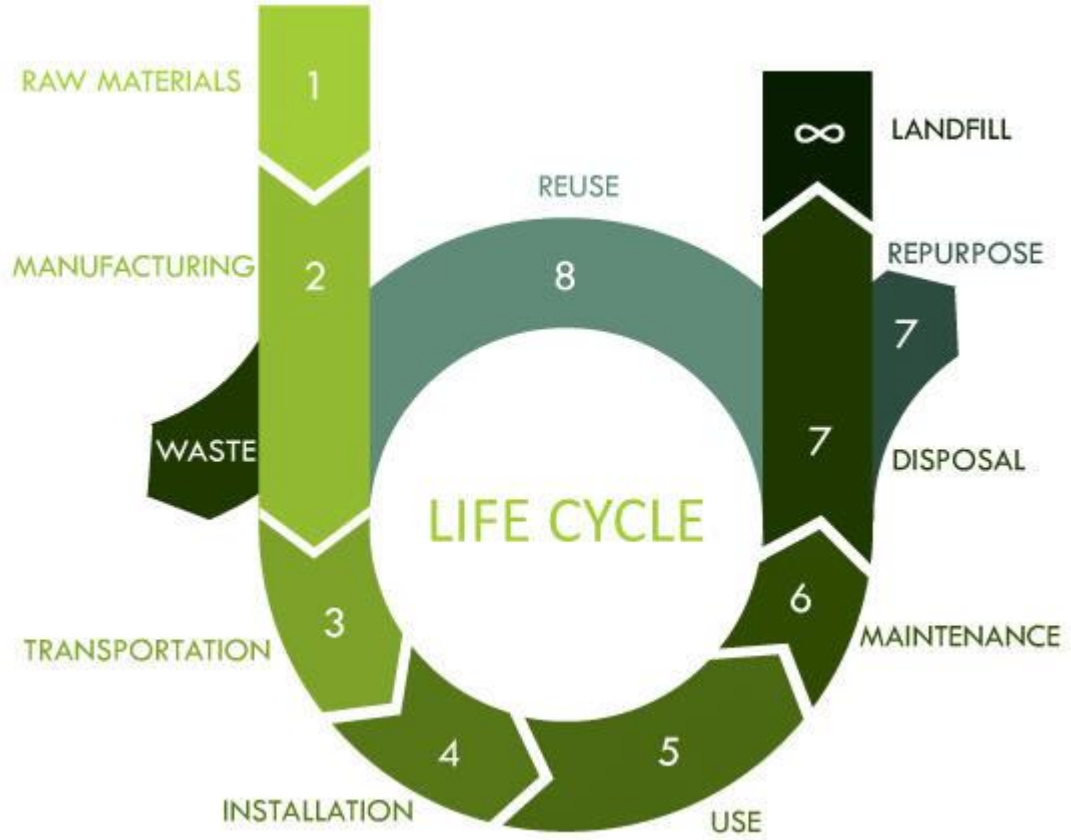
A. Product Stage (A1 – A3):
- A1. Raw material supply.
- A2. Transport.
- A3. Manufacturing.

A. Construction process stage (A4 – A5):
- A4. Transport.
- A5. Construction installation process.

B. Use Stage (B1 – B7):
- B2. Replacement
- B5. Refurbishment.
- ~~B6. Operational energy use.~~

C. End of Life (C1 – C4):
- C1. De-construction demolition.
- C2. Transport.
- C3. Waste processing.
- C4. Disposal.

D. Benefits and loads beyond system boundaries.



Source: Southwest Environmental Limited

Task 5.2.2 – LCA: system boundaries

From extraction of raw materials until waste treatment at the EOL of final products.

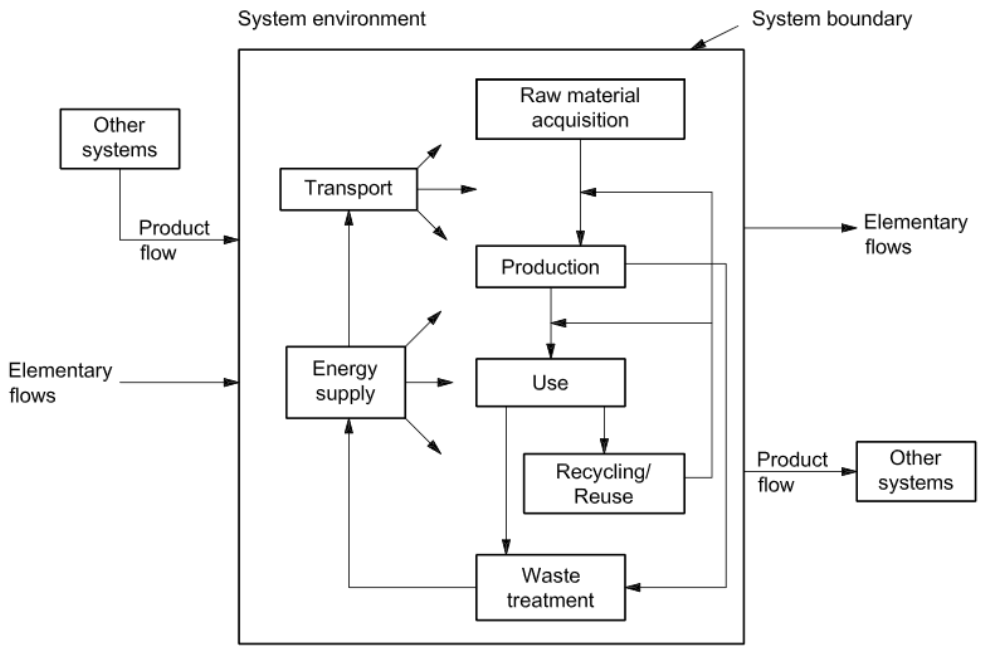
Out of the scope:

- All subsidiary tasks (i.e. administrative tasks of the involved companies)
- All products not directly related with the renovation (i.e. the gas used by a construction worker to drive to the construction site)
- Infrastructure and machinery construction necessary for manufacturing processes, unless it is already comprised in the processes' datasets.

Task 5.2.2 – LCA: system model

Allocation at the point of substitution (APOS)

- Expansion of product systems



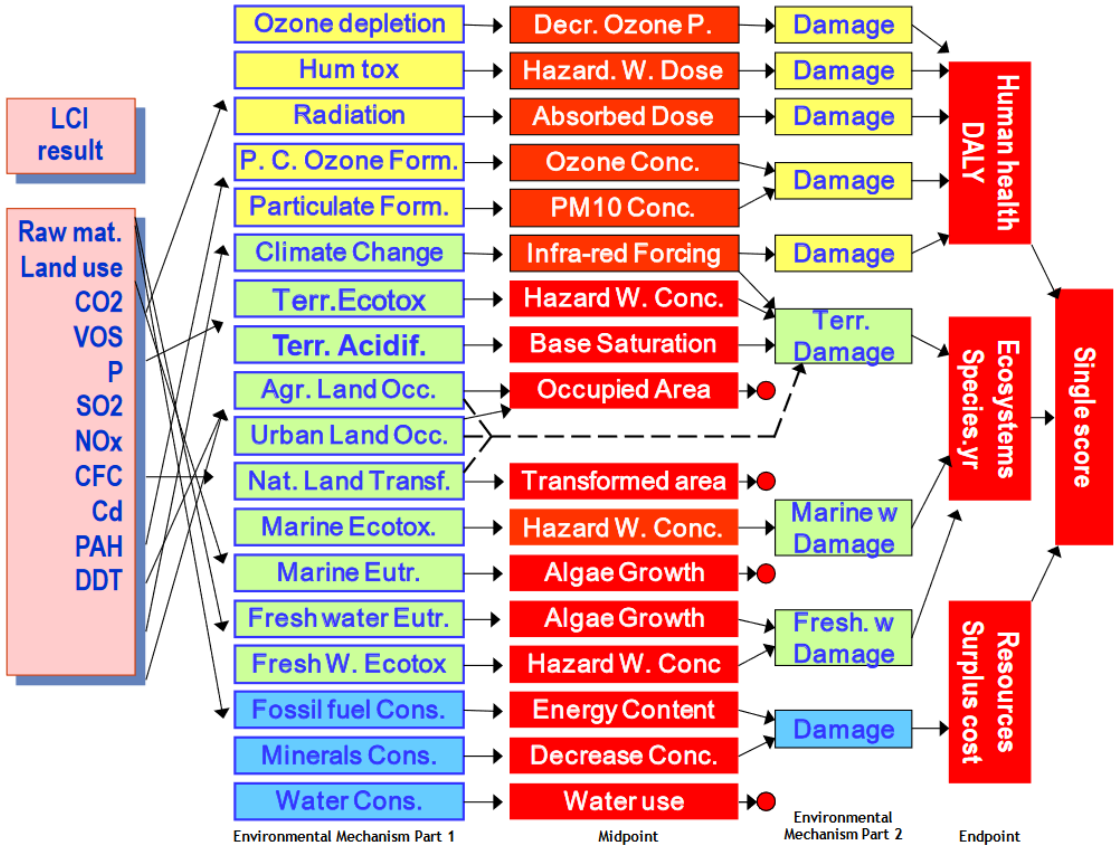
Task 5.2.2 – LCA: impact category

GWP100 [kg CO_2-Eq]

A relative measure of how much heat a GHG traps in the atmosphere.

Global Warming Potential “relates to the capacity to influence changes in the global average surface-air temperature and subsequent change in various climate parameters and their effects”.
European Commission

Task 5.2.2 – LCIA methodology



ReCiPe 2008 midpoint (H)

RIVM and Radboud University, CML and PRé

H – hierarchist perspective

Task 5.2.2 – Functional unit

Object of study

retrofitting materials and works

Function

to reduce the energy bill and the emission of contaminants associated to energy consumption of residential buildings by reducing heat and cooling needs and by producing clean and free energy in situ.

Functional unit

1 m² of retrofitted façade wall

all the products and activities implied in the intervention are normalized accordingly

Task 5.2.2 – LCA baseline

PLUG-N-HARVEST - reference scenario
Components and materials' characteristics, amounts and origins as defined by the project.

Conventional retrofitting
Based on the most common equivalent solutions for each pilot region (standard providers).
Components and materials' characteristics and amounts defined after the PLUG-N-HARVEST product, based on the assumption of **equal performances.**

Life span: 50 years (ISO 15686)

Task 5.2.2 – LCA baseline

Conventional retrofitting
Based on the most common equivalent solutions for each pilot region (standard providers).
Components and materials' characteristics and amounts defined after the PLUG-N-HARVEST product, based on the assumption of **equal performances.**

- Different providers for each pilot.
- PV system: **roof mounted PV panels** and inverter.
- PV panels area: calculated with PVGIS.
- ETICS and windows areas: same as contemplated for the PLUG-N-HARVEST scenario.
- Refurbishment: façade is painted every 15 years (except Aachen's pilot).
- Replacement of PV panels every 30 years.
- Replacement of inverter every 30 years.

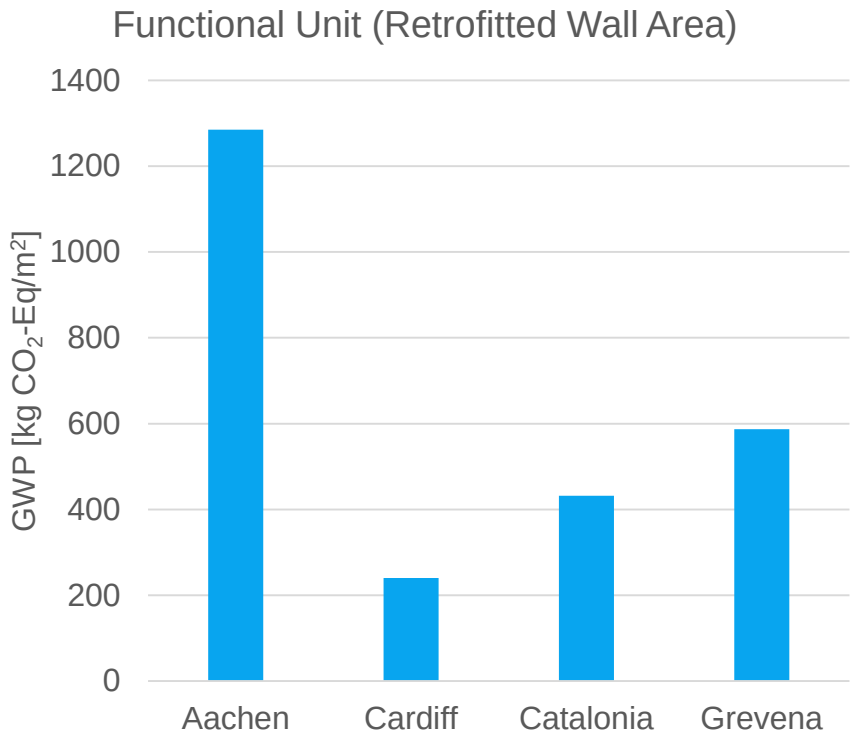
Task 5.2.2 – Life Cycle Inventory (LCI)

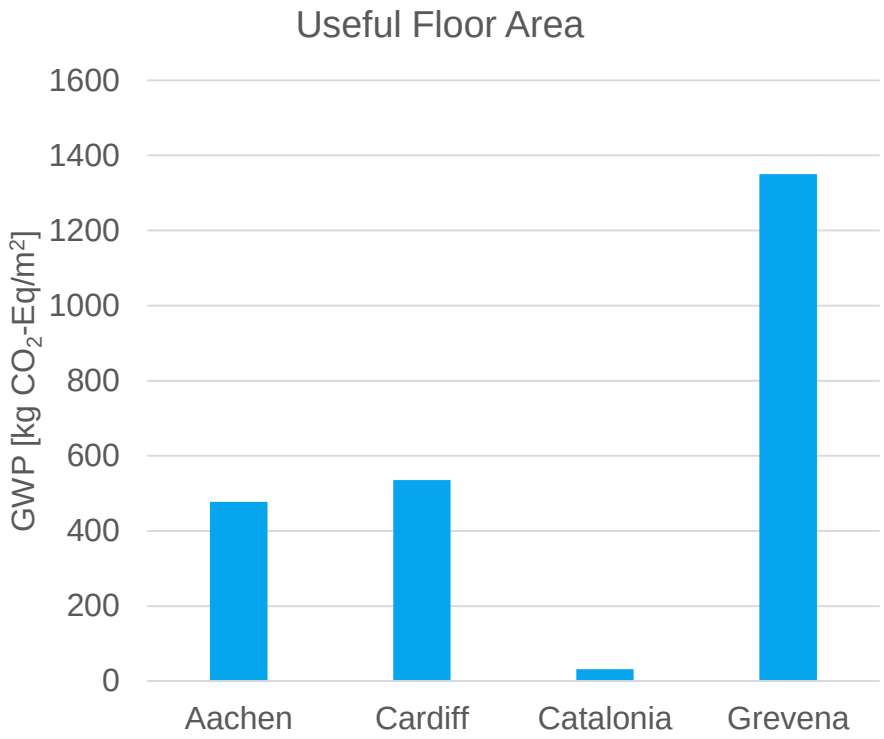
Definition of all the inputs and outputs of the product systems

Data collection, validation and adaptation to functional unit

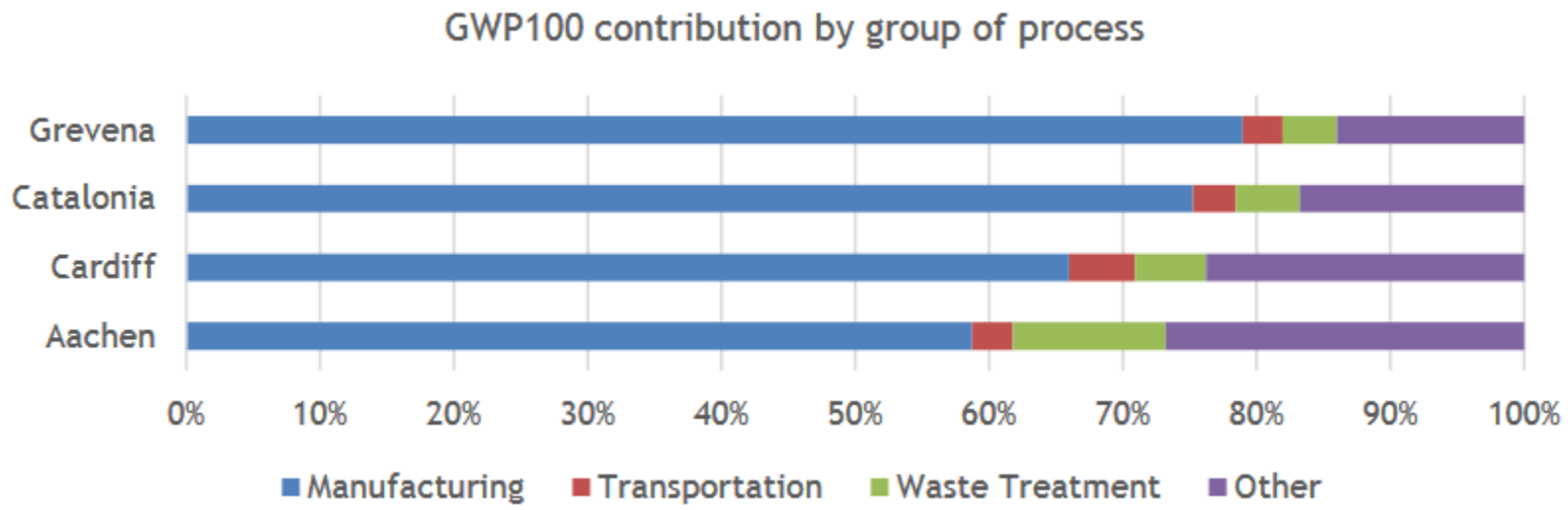
- Input from partners
- Online research
  - Providers catalogues
  - Products datasheets
  - Environmental Product Declarations (EPD)

Task 5.2.2 – Life Cycle Impact Assessment (LCIA)



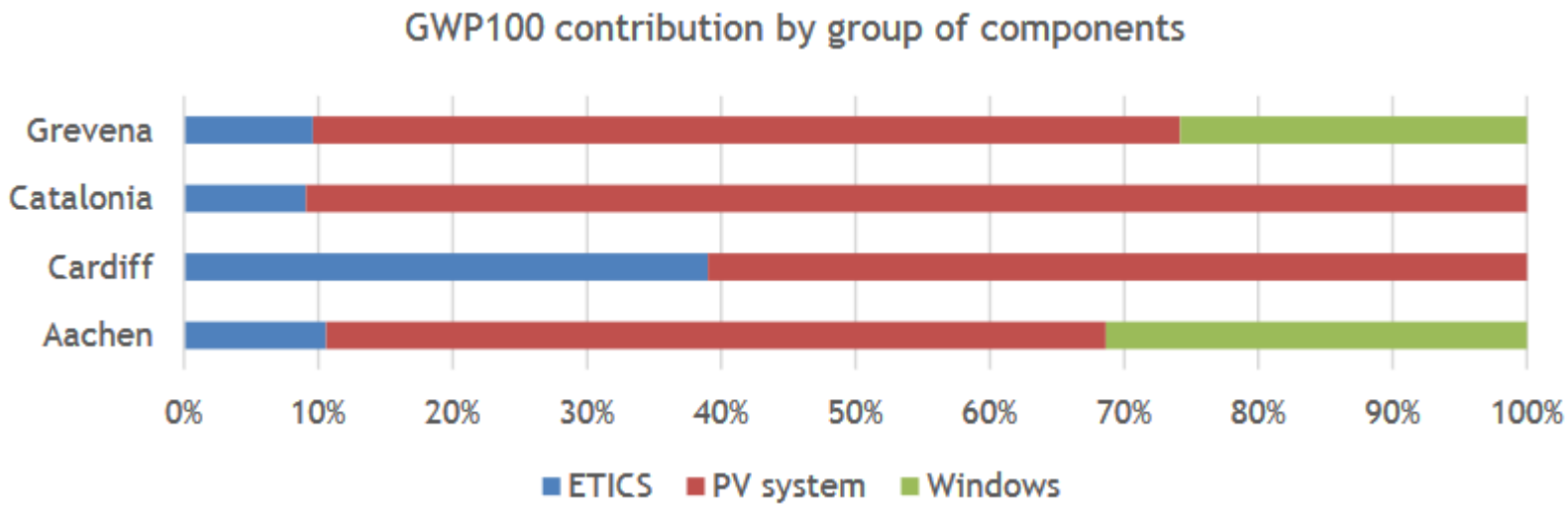


Task 5.2.2 – Interpretation and conclusions



Manufacturing processes the most critical

Task 5.2.2 – Interpretation and conclusions



PV system components are particularly impactful

Task 5.2.2 – Interpretation and conclusions

KPI 8 GHG Payback – Catalonia's demo-case calculation example (Conventional retrofitting)

$$GHG\ Payback[years] = \frac{GWP50\ (D6)\ [kgCO_2eq]}{CO_2\ Emissions\ (D5)\ \left[\frac{kgCO_2eq}{year}\right]} \quad (1)$$

GHG Payback = 7.2 years

$$GHG\ Payback[\%] = \frac{GWP50\ (D6)\ \left[\frac{kgCO_2eq}{50\ years}\right]}{CO_2\ Emissions\ (D5)\ \left[\frac{kgCO_2eq}{year}\right]} \quad (2)$$

GHG Payback = 14.4%

WP5 – Circular Economy Business Model & Exploitation Plan

T5.3 LIFE CYCLE COSTING ANALYSIS

TASK RESPONSIBLE: CERTH
PRESENTER(S): NIKOS MARGARITIS

MEETING: 7TH PLENARY MEETING, BRUSSELS, 26 FEBRUARY 2020

Task 5.3 Life Cycle Costing analysis

- Task Leader: CERTH
- Task activities:
  - Carry out a Life Cycle Costing (LCC) modelling
  - Provide and assessment of the long-term cost effectiveness of each component
- Deliverables:
  - D5.3a Report On Life Cycle Cost Analysis (due May 2020)
  - D5.3b Report On Life Cycle Cost Analysis (due August 2021)
- Status of task: ongoing (incipient stage, started January 2019)

D5.3 Report On Life Cycle Cost Analysis: Progress so far

- Building the methodological approach for all cost categories
- Development of functionalities for each cost category
- Identification of models for cost estimation
- Template for selection of required data
- Preliminary definition of “business as usual retrofitting” scenarios and “PnH” scenarios
- Determination of KPIs to be estimated

D5.3 Report On Life Cycle Cost Analysis: Methodology and key issues

- Main categories: construction, operation, maintenance, refurbishment and disposal
- Energy savings and externalities costs: to be in line with Life Cycle Analysis (in Task 5.2)
- Cost effectiveness of each component
- Functional unit: €/m2/year
- Approach to the scalability at district scale level

D5.3 Report On Life Cycle Cost Analysis: Models for cost estimations

0.6 power factor model $$Cost2 = Cost1 * \left(\frac{Capacity\ 2}{Capacity\ 1}\right)^{R}$$

R: Scale Factor (Indicative values: R: 0.4-0.9

Lang Model $$TPV = (n) * (DEC)$$

TPC : Total plant cost , n:Lang factor , DEC: Delivered equipment cost (Indicative values n: 3.1 – 4.74)

Hand Model $$IC = (m) * (DEC)$$

IC : Total installed cost of component , m: Hand factor ,DEC: Delivered equipment cost (Indicative values m: 2-4)

D5.3 Report On Life Cycle Cost Analysis: Indicative LCC functionalities

Electricity cost $$C_{el} = \sum_i \sum_j (P_j * H_j * N_j * EP) - E_o * EP$$

i:installations
j: Components used in the installation i,
Pj:Nominal power j (KW);
Hj:operation time j (h/yr);
Nj:Number of components j;
EP:electricity price (€/KWh);
Eo: Self consumptions (KWh);

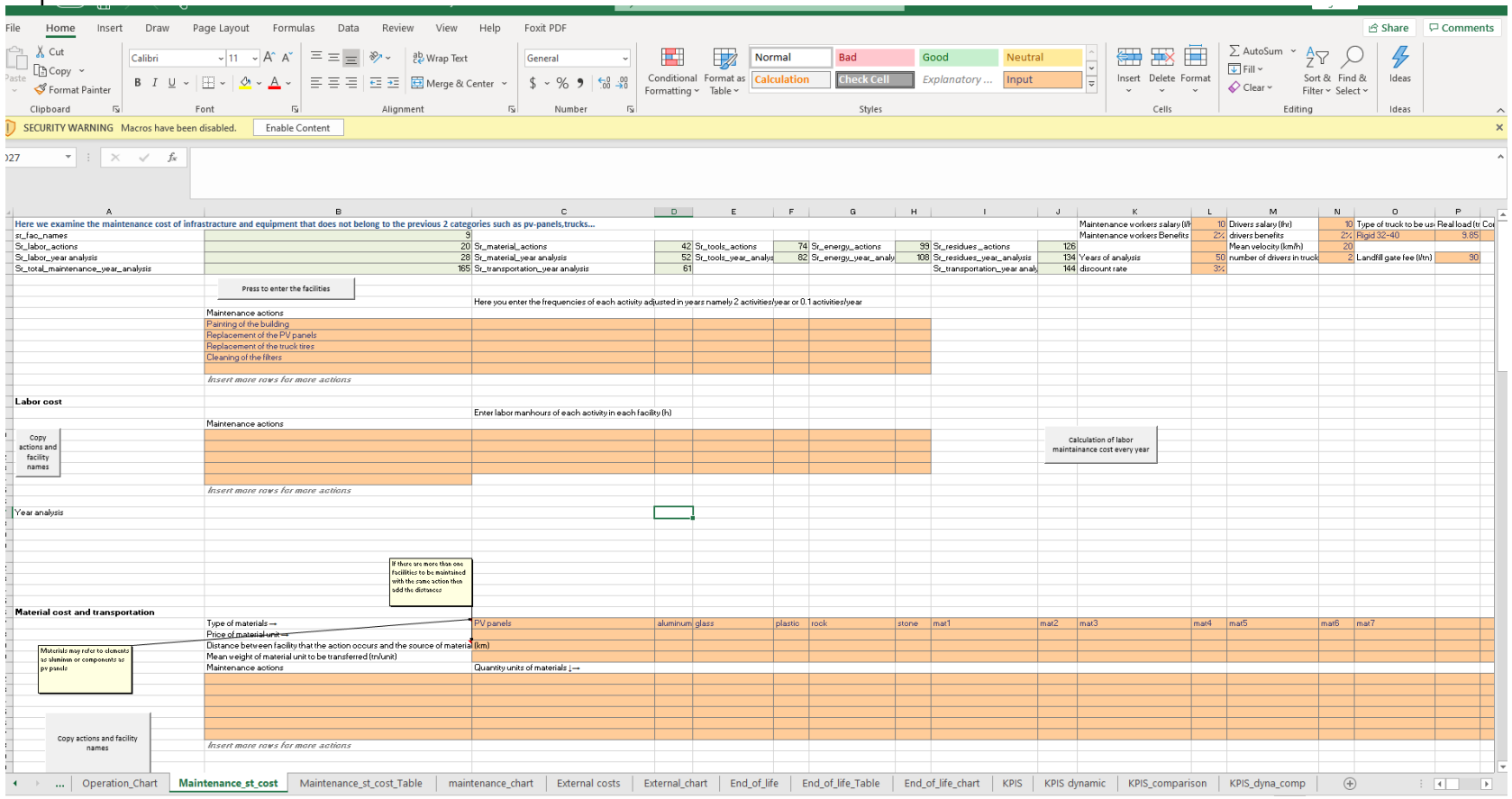
Fuel costs $$C_f = \sum_i \sum_j \frac{P_j * H_j * N_j * FP_j}{(LHV_j * \rho_j * \eta_j)} * 3600$$

i:installations;
j:Components used in installation i;
Pj:Nominal power j (KW);
Hj: Operational time j (h/yr);
Nj: Number of components j;
FPj: Fuel price j (€/m^3);
LHVj :Lower heating value j (KJ/Kg);
ρ_j:density of fuel j (kg/m^3);
η_j: efficiency rate j;

D5.3 Report On Life Cycle Cost Analysis: Data required for each pilot for both of scenarios

- Description of the business as usual retrofitting scenario
- Investment cost per component (PV cost, battery cost, infrastructure costs etc)
- Operational costs (energy costs, labour costs)
- Maintenance costs per components (values, life time)
- Disposal costs per component (fraction of recyclable materials, disposal cost for common disposal practices)

D5.3 Report On Life Cycle Cost Analysis: Development of a tool for LCC calculations



- Main functionalities for LCC categories
- Performance of graphs
- Calculation of KPIs

WP5 – Circular Economy Business Model & Exploitation Plan

T5.4 DEVELOPMENT OF FINANCIAL BUSINESS MODELS AND IMPLEMENTATION FOR DEMO CASES

TASK RESPONSIBLE: AIGUASOL
PRESENTER(S): ARNAU GONZALEZ, TONI HERENA

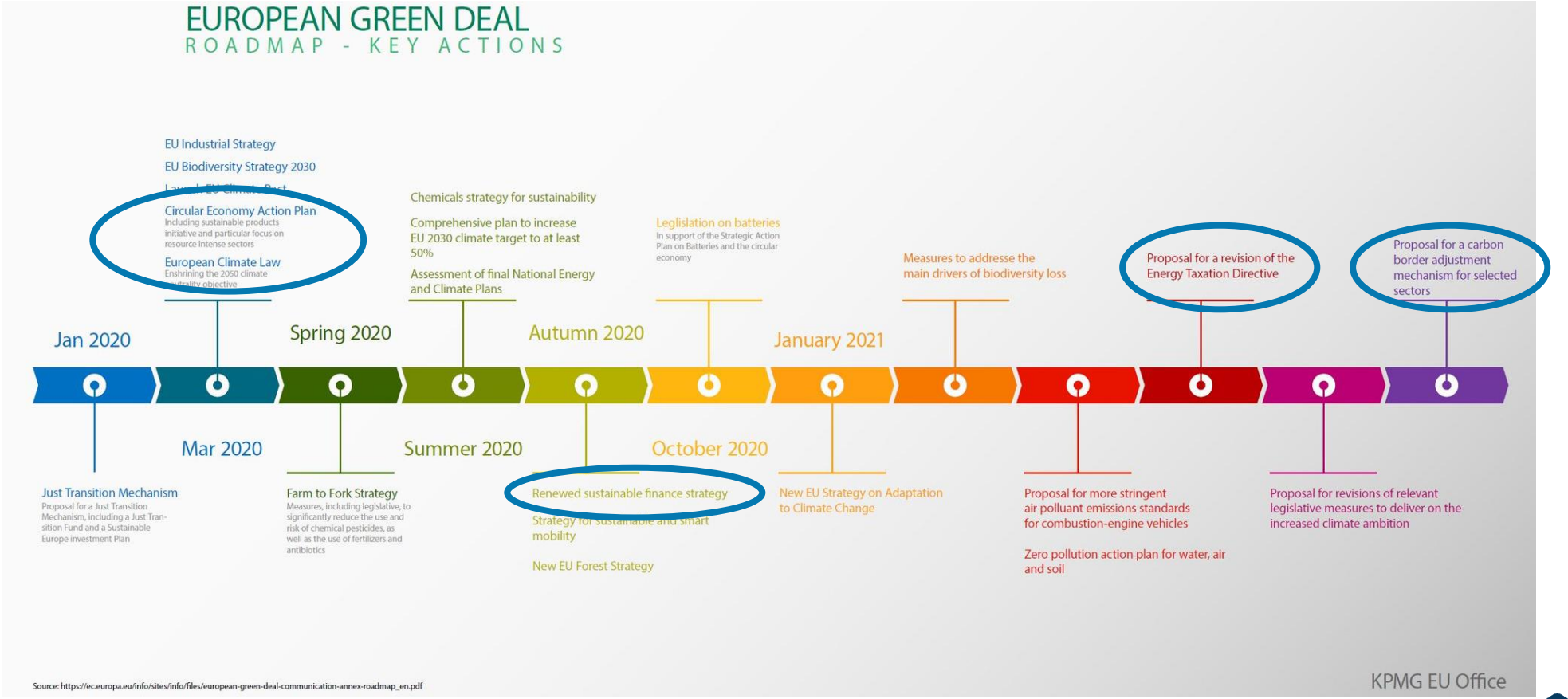
MEETING: 7TH PLENARY MEETING, BRUSSELS, 26 FEBRUARY 2020

Task 5.4 Development of financial Business Models and implementation for demo cases

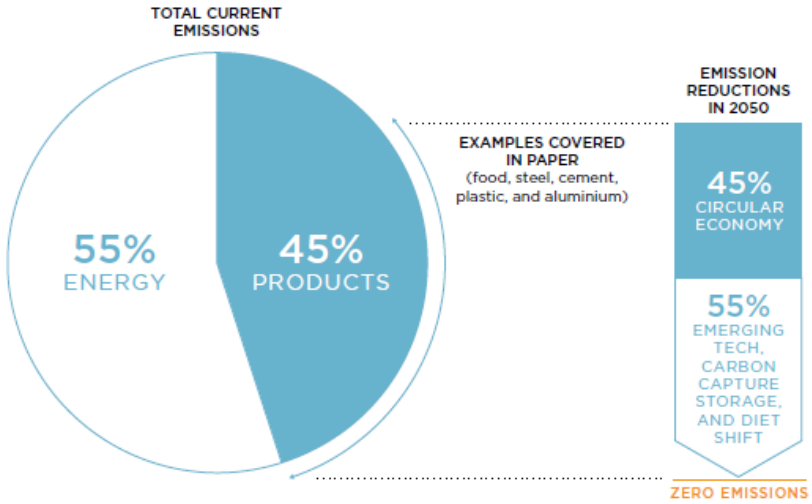
- Task Leader: AIGUASOL
- Task activities:
  - Adaptation of financial business models to demo cases
  - Analysis of risks and benefits considering the technical, energetic and economic real results obtained
  - Study of scalability at district level scale
- Deliverables:
  - D5.4a Report On Financial Business Models (due May 2020)
  - D5.4b Report On Financial Business Models (due August 2021)
- Status of task: ongoing

D5.4 Report On Financial Business Models

Outcome of COP25 Madrid: EU climate change tackling



Circular Building Solutions contribute to fight climate change



45% of the hard-to-abate emissions are linked to the way we use and produce products.

- Circular economy applied to food and industry (steel, aluminum, cement and plastic) could help reduce global emissions by around 9.3 Gt CO2e in 2050.
- A circular scenario could reduce global CO2 emissions by 38% in 2050 , by reducing the demand of 4 materials (steel, aluminum, cement and plastic)

Ellen MacArthur Foundation, Completing the Picture: How the Circular Economy Tackles Climate Change (2019)

D5.4 Report On Financial Business Models

Business model strategy

Compare financial analysis for 3 different business models

- BAU Solution
- CE Business models (PPS or similar)
- Carbon valuing
  - Circular C total balance assessment, both quantitatively and qualitatively
  - Circular C impact monetization approach (true value calculation method) - non financial value
  - Circular C financial value (residual value, cost of emissions, climate change liability cost, etc.)

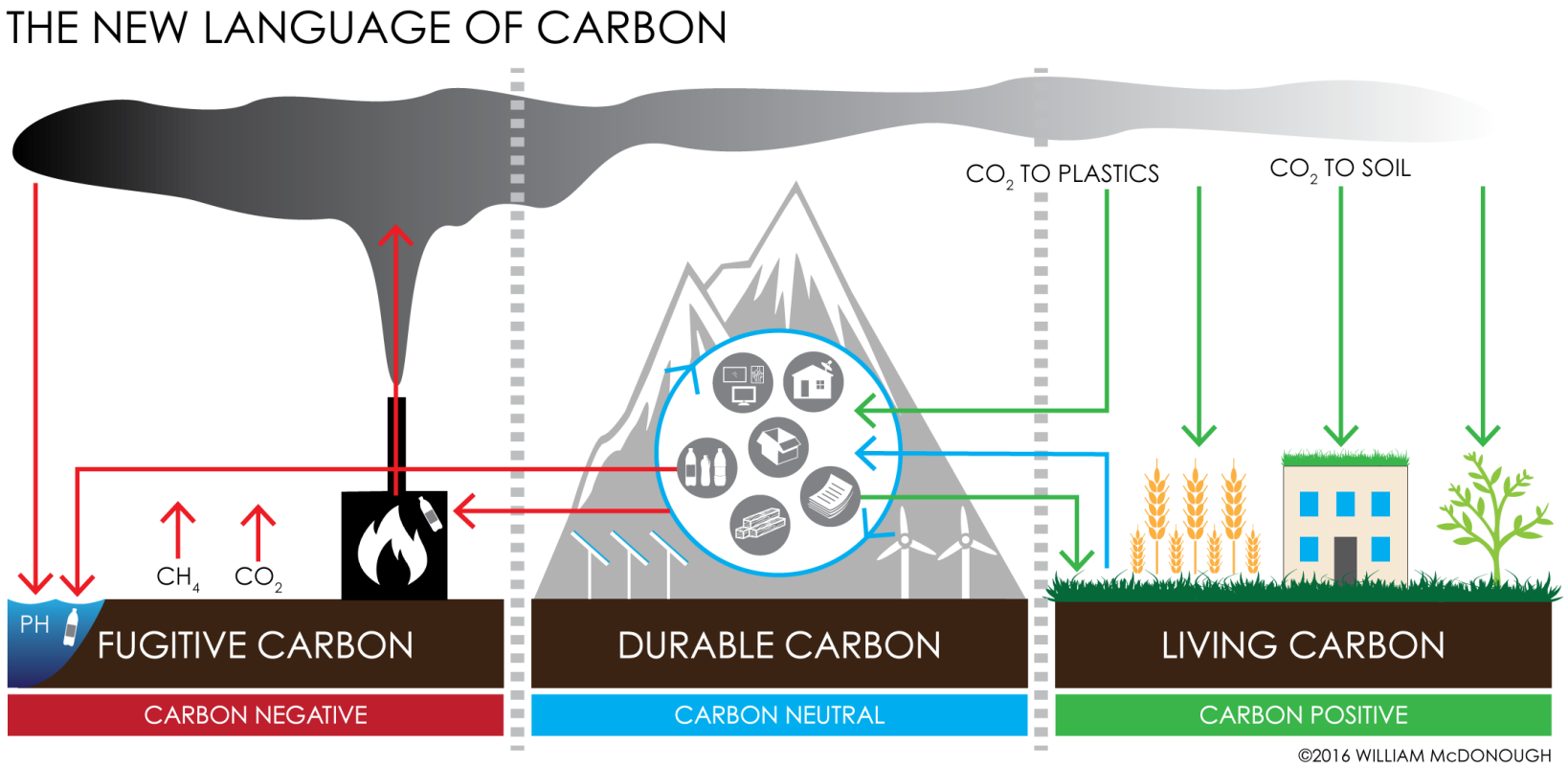
Financial indicators

- Net Present Value (NPV)
- Profitability (IIR)
- Residual value (RV)
- Pay-back
- Emission taxes
- CAPEX – OPEX - Revenues

Circular carbon valuing

- Emitted vs avoided emissions
- Carbon stock
- All stages of the project:
  - A: Production and construction Stage
  - B: Operational/Use Stage
  - C: End of life Stage

D5.4 Report On Financial Business Models



Design to ensure that carbon ends in the right place

- New relationship with carbon
- Support healthy carbon life
- Ecosystems with durable / living carbon.
- Reverse climate change
- Carbon emission taxation
- Capture carbon value
- Recognize carbon as an asset

Circular business strategies

Generate the proper information to **select the apropiate materials** that allow the development of Plug-n-Harvest circular business

- Safe and trust
- PnH Material Database
- Select cyclable materials
- Track to retain product value
- PnH Material Passport
- Circular business model

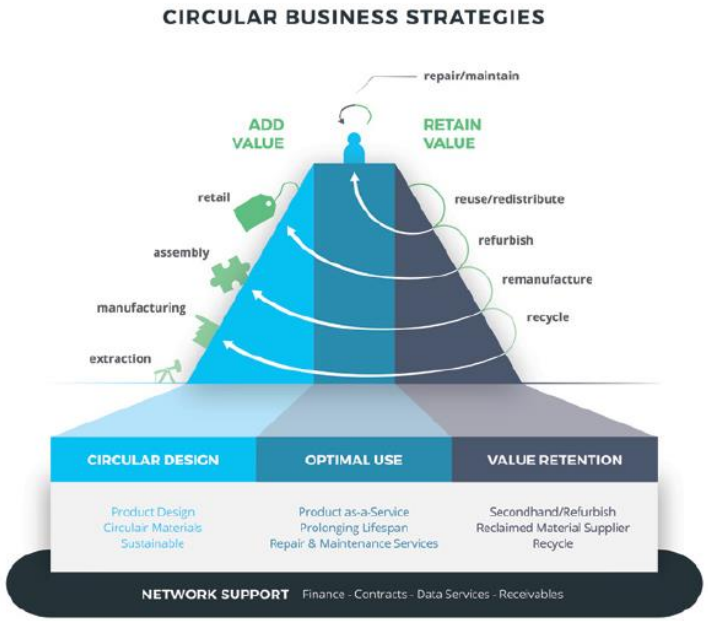
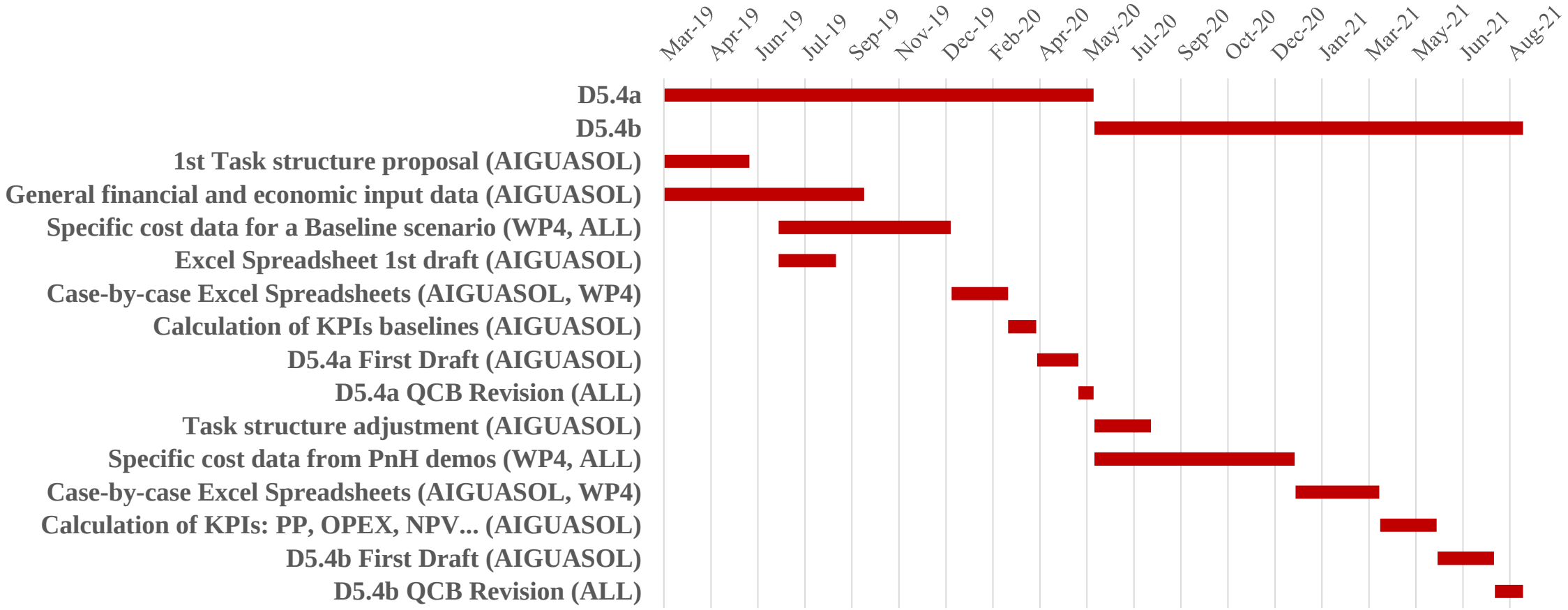


Figure 2 - Circular business strategies on the Value Hill. Source: Achterberg, Hinfelaar, and Bocken (2016)

Task 5.4 Next steps



WP5 – Circular Economy Business Model & Exploitation Plan

T5.5 STANDARDIZATION MODELS AND ANALYSIS

TASK RESPONSIBLE: CERTH
PRESENTER(S): CHRISTOS RAVANIS

MEETING: 7TH PLENARY MEETING, BRUSSELS, 26 FEBRUARY 2020

Task 5.5 Standardization Models and Analysis

- Task Leader: ALUMIL/CERTH
- Task activities:
  - Identification of the necessary activities to facilitate acceptance and utilization of the developed solutions by the market
  - Provision of starting information for other WPs to ensure compatibility and interoperability with already existent solutions through standards
  - Use standardization as a dissemination tool
- Deliverables:
  - D5.5a Report On Standardization Models (due Aug 2018, submitted Dec 2018)
  - D5.5b Report On Standardization Models (submitted September 2019)
  - D5.5c Report On Standardization Models (due August 2020)
  - D5.5d Report On Standardization Models (due August 2021)
- Status of task: ongoing

WP5 – Circular Economy Business Model & Exploitation Plan

T5.6 EXPLOITATION STRATEGY & BUSINESS PLANS

TASK RESPONSIBLE: AIGUASOL
PRESENTER(S): ARNAU GONZALEZ, TONI HERENA

MEETING: 7TH PLENARY MEETING, BRUSSELS, 26 FEBRUARY 2020

Task 5.6 Exploitation Strategy and Business Plans

- Task Leader: AIGUASOL
- Task activities:
  - Definition of a plan for the exploitation and commercialization of the results using outputs from the rest of WP5
  - Identification of project exploitable results and related target groups
  - Development of the PLUG-N-HARVEST business model, including marketing and pricing strategy, cost-benefit analysis, risk analysis and risk management activities
- Deliverables:
  - D5.6.1a Market Analysis & Business Plans (submitted)
  - D5.6.2a Exploitation Plans (submitted)
  - D5.6.1b Market Analysis & Business Plans (submitted August 2019)
  - D5.6.2b Exploitation Plans (submitted August 2019)
  - D5.6.1c Market Analysis & Business Plans (due August 2020)
  - D5.6.2c Exploitation Plans (due August 2020)
  - D5.6.1d Market Analysis & Business Plans (due August 2021)
  - D5.6.2d Exploitation Plans (due August 2021)
- Status of task: ongoing

THANK YOU