eneuron

optimising local energy communities

The Outcome of Technical, Regulatory, Environmental and Economic Impacts Assessment (First Version)

WP 7, D 7.1

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This project has received funding from the European Union's Horizon 2020

research and innovation programme under grant agreement N° 957779.

Technical references

Project Acronym	eNeuron
Project Title	greEN Energy hUbs for local integRated energy cOmmunities optimizatioN
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Project Duration	November 2020 – October 2024 (48 months)

Deliverable No.	D7.1
Dissemination level*	PU
Work Package	WP7 - Evaluation of results: replicability and scalability
Lead beneficiary	7 (DERlab)
Contributing beneficiary/ies	7 (DERlab), 1 (ENEA), 6 (TECNALIA)
Due date of deliverable	31 October 2022
Actual submission date	14 November 2022

*PU = Public

PP = Restricted to other programme participants (including the Commission Services)

RE = Restricted to a group specified by the consortium (including the Commission Services)

CO = Confidential, only for members of the consortium (including the Commission Services)

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05	10/11/2022	ENEA	Marialaura Di Somma **(Reviewer)**

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“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement No 957779”.

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Executive Summary

This deliverable is the first release of "The outcome of technical, regulatory, environmental and economic impacts assessment" which is part of the Work Package (WP) 7 "Evaluation of results: Replicability and scalability". This document focuses on explaining the methodology for the eNeuron solutions' impact assessment from four dimensions: technical, regulatory, environmental and economic. In the technical dimension, the methodology followed for the key performance indicators (KPIs) identification as well as the description and formulation of the preliminary KPI list is exposed. Moreover, in the regulatory dimension, the steps followed for the recognition of regulatory limitations and overcoming strategies are defined. In the environmental dimension, the Life-cycle analysis (LCA) methodology based on the main guidelines of the International Reference Life Cycle Data System (ILCD) and ISO standard is described. Likewise, the economical dimension bases its methodology on both a Life-cycle Cost (LCC) and Life-cycle Cost Benefit (LCCB) analysis. Additionally, a sensitivity analysis of the main economic parameters complements the assessment due to the variety of technology and factors involved in the project. Thus, each dimension of the impact assessment follows a specific methodology which, when carried out in parallel, ensures an integral evaluation.

In the technical aspect, the focus lies on evaluating the impact of the solutions in terms of KPIs, so then the methodology explained in subsequent sections is addressed to describe the process for their identification. Furthermore, the formulation of each KPI from the preliminary list is detailed in order to give an idea of the parameters to be calculated in the final version of the deliverable. This content is complemented by the description of the preliminary KPI list including their formulation.

In the regulatory aspect, local governments implement policies according to the interpretation of European directives and their respective national regulations which leads to differences in the regulatory frameworks among member states. Keeping this on mind, a regulatory assessment with an emphasis on a local level becomes more convenient. The methodology exposed in following sections gives an overall idea of the steps to be followed for performing the regulatory analysis. This is complemented by an overall recap of the main regulatory barriers at European level identified in early stages of eNeuron project (WP2 with deliverable D2.3 '*Limitations and shortcomings for optimal use of local resources*').

In the environmental aspect, the methodology for the impact assessment is based on the Life-Cycle Analysis concept. In this case, the assessment will be performed according to the guidelines and framework of the international standard ISO 14040. Thus, the study covers several stages in the data treatment including classification, characterisation, normalisation and assessment. Moreover, in order to define the scope of the study and reduce the complexity of the assessment, a cradle-to-gate analysis is carried out at an early stage. This analysis allows to exclude phases and elements out of the study objectives while simplifying the calculations. In addition, this deliverable includes a model structure of the spreadsheets shared with the pilots for the LCA data collection as preliminary outcome.

Lastly, in the economic aspect, the present progress of the Life-cycle Cost analysis methodology, although in definition yet, is presented. Starting from a traditional cycle of the costs of an energy system, the benefit concept is added in order to provide a more complete cost-benefit analysis of the impact of the eNeuron solutions application. Due to the difficulties of getting and managing actual economic figures (too large types of energy technologies and a wide range of power and energy dimensions for the energy systems considered), a sensitivity analysis approach is adopted. This sensibility approach identifies what LCC and LCCB indicators are sensitive to the application of the eNeuron solutions and the related parameters that would provide reference and measurement of that sensitivity. This is the present activity being carried out in the task and this document presents the preliminary list of LCCB indicators as well as the identification of some parameters that could provide evidence of their sensitivity to eNeuron application. The feasibility of measuring these sensitivity parameters during the simulation, validation through laboratory tests and demonstration phase will be also analysed in the next activities of the task.

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Abbreviations and Acronyms

Acronym	Meaning
CAPEX	Capital Expenditures
CF	Characterisation factor
DER	Distributed Energy Resource
EC	Energy Community
EMS	Energy Management System
EV	Electric Vehicle
ILCD	International Reference Life Cycle Data System
ILEC	Integrated Local Energy Communities
ISO	International Standards Organization
KER	Key Exploitable Results
KJR	Key Joint Result
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
LCC	Life-Cycle Cost
LCCB	Life-Cycle Cost Benefit
LCI	Life-Cycle Inventory
LCIA	Life-Cycle Impact Assessment
LCOE	Levelized Cost of Energy
LEC	Local Energy Community
mEH	micro-Energy Hub
O&M	Operations and Maintenance
OPEX	Operational Expenditures
P2P	Peer-to-peer
PV	Photovoltaic
SCADA	Supervisory Control and Data Acquisition
SCIS	Smart Cities Information System
V2B	Vehicle to building
V2G	Vehicle to grid
V2H	Vehicle to home
WP	Work Package

1 Introduction

The task T7.1 “Cross-comparison of demonstration results and assessment of technical, regulatory, environmental and economic impact” seeks for assessing the eNeuron project impacts from the technical, regulatory, environmental and economic points of view. Each of these aspects are evaluated independently as describes below.

The technical assessment is performed through specific KPIs that are identified. The KPIs are categorised in two groups consisting of: Project KPIs to assess the contribution to the optimal design, operation and scheduling of local energy communities (LECs) integrating both distributed energy resources and multiple energy carriers; and global KPIs to assess the technical contribution of the project concept to the European decarbonising targets, the integration of local energy sources and activation of local demand-response.

Moreover, in the regulatory assessment, the current regulatory frameworks of the pilot countries are analysed bottom up, in order to identify the barriers for implementing the technical solutions and propose strategies to overcome them.

Furthermore, the assessment of the environmental impact implements a life cycle analysis (LCA) methodology. This procedure follows the main guidelines of the International Reference Life Cycle Data System (ILCD) Handbook and ISO 14040-14044 and includes five phases: goal definition, scope definition, inventory analysis, impact assessment and interpretation.

Lastly, the economic assessment focuses on the economic impact of the solutions proposed in the project. In close cooperation with other work packages, this analysis aims to identify the main economic implications of both the simulations and laboratory test on the one hand, and of the different demonstration pilots on the other. Thus, a life cycle cost analysis (LCC) is carried out in order to ensure that the impact of ILEC integrating distributed energy resources and multiple energy carriers is fully addressed.

1.1 eNeuron in a nutshell

LECs are schemes in which the users participate in the decision-making process related to the energy flow management with the aim of maximizing their benefits while assuring to meet their energy needs. This new paradigm implies a transition from a traditional centralised electricity generation towards a decentralised generation with the implementation and integration of electricity and heat generation technologies (including non-conventional renewable energy sources), energy storage systems, flexible demand and electric mobility.

The project *greEN Energy hUbs for local integRated energy cOmmunities optimization* (eNeuron) address the challenge of optimising the design and operation of LECs. The complexity in this task lies not only on the wide range of potential actions by operators, developers, asset owners and end-users, but also in the potential conflict between the interest of these actors. Moreover, additional complications may arise in the LEC optimisation task when considering the interaction between different energy carriers (e.g., electricity, heat, etc.). Thus, eNeuron project focuses on the development of innovative toolboxes for this optimisation tasks with an emphasis on the integration of multiple energy carriers at different scales, and the identification of the potential benefits for the consumers and stakeholders throughout the adoption of an Energy Hub (EH) concept.

Moreover, the solutions proposed in eNeuron project represents benefits for all stakeholders involved in the LECs. For instance, prosumers (e.g., residential, commercial, etc.) can benefit by reducing the energy costs while contributing to the transition towards a low-carbon decentralised energy generation. On the other hand, distributed system operators can benefit by avoiding grid congestions and deferring network investments, while policy-makers can use the outcomes from the regulatory analysis to evaluate changes in local regulations related LEC technologies.

Thus, eNeuron project aims to contribute to EU targets and the energy transition process by providing innovative mechanisms for the main actors involved in LECs to deliver an optimal integration of multi energy carriers. Therefore, the solutions developed can promote development and implementation of this new energy paradigm at European level.

1.2 Purpose of the Document

This report is the first release of the outcomes from the WP7-Evaluation of results: Replicability and scalability related to the task T7.1-Cross-comparison of demonstration results and assessment of technical, regulatory, environmental and economic impact. This first version aims to explain the different methodologies to be implemented at each dimension of the impact assessment. Thus, the report gives the reader a detailed picture of the methodologies followed and serves as a preamble of the quantification of the impact assessment, as well as, some preliminary outcomes each dimension considered in the evaluation.

1.3 Structure of the Document

The document is structured in four main chapters. The first chapter introduce the purpose of the document and its structure. The second chapter presents the methodology to be followed for the impact assessment with four sections dedicated to each dimension considered in the study.

A first section is focused on the technical assessment's main outcomes. Here, the scope of the technical assessment and the methodology for the KPIs identification are explained. The second section exposes the regulatory assessment process including the actions to be performed in each step. In the next two sections, the LCA and LCC methodology are detailed as methodologies in which are focused the environmental and economic assessments, respectively. In the third chapter, some preliminary outcomes from the impact assessment are detailed, including the preliminary KPI list, an overall summary of the European regulatory framework, the spread-sheets designed for collecting the LCA and a preliminary analysis of the economic variables involved in the LCC and LCCB analysis. Finally, in the fourth chapter, main conclusions are stated as well as the next steps in the activities related to the task covered by this deliverable.

2 Methodology for Impact Assessment

The methodology for the impact assessment is divided according to the four dimensions covered by the analysis: Technical, regulatory, environmental and economic. The following subsections are dedicated to describe each procedure individually.

2.1 Technical Assessment

2.1.1 Scope of the technical assessment

The development of new technological solutions, such as the proposed in eNeuron project, implies the quantification of benefits and contributions of its implementation according to the defined target and objectives [1]. Therefore, the indicators play an important role not only because they allow a quantifiable estimation of the impact of the solutions but also facilitate the comparison against the existing and proposed novel solutions [1]. Thus, a key performance indicator (KPI) is a measure either financial or non-financial used in a project with the purpose of demonstrating its successfulness in terms of the objective initially established [2]. In eNeuron project, the technical assessment will be realised through specific KPIs that will be identified, described, calculated and analysed at the end of the process. Those indicators will include both “Project KPIs”, which will assess the project contribution to the optimal design, operation and scheduling of LECs, and “Global KPIs” which will assess the technical contribution of the project concept to the European decarbonising targets.

Additionally, The KPIs analysis will be extended to include multiple domains so as to cover different kind of project objectives (e.g., technical, environmental, economic, etc.). Thus, the KPIs can be classified according to the following domains as suggested in [1].

- **Technical**: KPIs dedicated to measure the impact form a technical point of view. The variables considered in this domain depend largely on the nature of the project. For instance, in projects related to smart grid solutions and RES, the technical domain would measure the performance in terms of energy consumption, peak load reduction or RES share in the energy mix.

- **Economic**: financial KPIs addressed to measure the cost-benefit repercussion of the investment related to the implemented solutions. Here are included, among others, variables such as the average cost of energy consumption, the average estimation of cost savings, levelized cost of energy, etc.

- **Environmental**: KPIs that measure the environmental impact of a technology implemented or a novel process. Calculations may imply the quantification of the carbon footprint of the manufacturing, transportation, installations, operational and management stages. A typical KPI in this domain is the quantification of the CO_2 emission reduction.

- **Social**: indicators that evaluate the impact of the solutions in the society and end-users affected. A good example for this dimension is, for example, the degree of users' satisfaction after the project implementation.

- **Legal**: KPIs that measure the legal infrastructure and integration of the proposed solutions to the existing regulatory framework.

Within the technical assessment, KPIs from technical, economic and environmental dimension are considered, while legal KPIs will not be measured since a dedicated regulatory framework assessment will be performed separately. Likewise, KPIs from the social dimension will be discussed in the end-user engagement analysis as part of the Task 7.2 "*End-user's engagement and assessment of social impacts*" and its respective deliverables: D7.3 "*The outcome of end-user engagement and social impacts assessment (first version)*" and D7.4 "*The outcome of end-user engagement and social impacts assessment (final version)*".

2.1.2 Methodology for KPIs identification

The quantitative evaluation of the proposed solutions demands the implementation of representative KPIs [1]. In this case, the eNeuron methodology followed for the KPIs identification and description is based on the BRIDGE's Scalability and Replicability Task Force proposal [3]. The steps for the determination of the KPIs are illustrated in Figure 1.

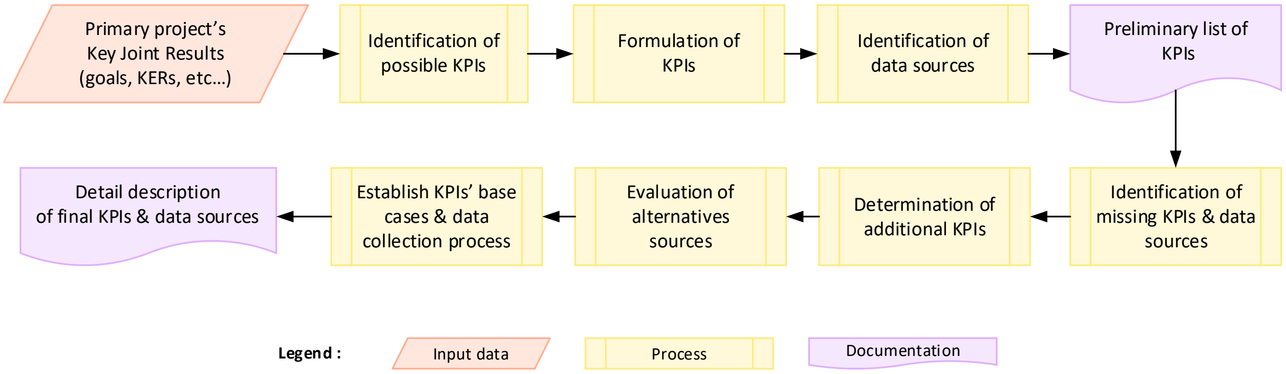

Figure 1: Methodology for the identification of the KPIs based on BRIDGE Task Force

As initial inputs, the methodology proposes to use the Key Exploitable Results (KERs) stated at early stages of the project and focuses the KPI identification process on them. In other words, the formulation of the KPIs is pretended to assess the repercussions of the project from the point of view of the KERs. In addition, the selection also considers the project's objectives, use cases and business models defined in other work packages in order to cover all relevant aspects involved in the project. The aforementioned elements are referred as the Key Joint Results (KJRs) and help not only to structure a more complete KPI list, but also more adequate to the interests of the project.

The identification of possible KPI begins once the KJRs are established. As starting point, an initial KPIs list is built by collecting indicators from other projects in the same topic lines. Subsequently, the KPIs are categorized according to their dimension (e.g., technical, economic, etc.) to be easy of analyse. In the next step, the mathematical formulation of the KPIs and the source of the data required to evaluate them are defined.

After the preliminary KPI list is defined, a revision process from all partners is performed in order to verify whether there are KJRs whose evaluation is still not covered by any of the indicators. Therefore, it can be identified alternative KPIs the required data for their calculation which can quantify the KJRs initially not covered.

Once the modifications in the preliminary list are made and the missing KPIs and data sources are added, a final list is finally established. Lastly, the base case scenario for each KPI as well as the data collection process are determined. Moreover, for the determination of KPIs, the following main criteria are considered.

- Relevance: Significant importance for the evaluation process, in terms of a strong link to the sub-themes of the framework and significance for the underlying theory of change
- Measurability: Capability of being measured, preferably as objectively as possible
- Comparability: Comparability between the different demo site cities involved in the project
- Clarity: Ease of understanding, communicability, capacity to tell narratives
- Availability: Expected data and data source availability

2.2 Regulatory Assessment

2.2.1 Concept of a regulatory assessment

In overall, a regulatory assessment is understood as a study in which data is collected and analysed to assess the repercussions of a process within a legal framework. In the literature, it is common to find the term ‘regulatory impact assessment’ which considers both quantifiable and unquantifiable regulatory impact, and is performed with the aim of providing evidence for decision-making evaluations [4]. Thus, regulatory impact assessments are crucial for a good governance since they improve the policy-making process by tackling key shortcomings identified during the assessment [5]. Among the advantages of performing this kind of analysis are included: a most cost-efficiency policy design, identification of weak aspects, legal loopholes and limitations for the implementation of new procedures and solutions. Therefore, regulatory assessments are instruments used in several ambits and can be extended to any study that attempts to formulate recommendations for improving an existing regulatory framework.

In a broader definition, the regulatory assessment is considered as a tool that supports policymakers and governments in general to make changes in the current regulatory framework. Therefore, the assessment reveals which aspects from the regulation can be improved in favour of the implementation of novel technology advances and the society improvement as well. In the case of eNeuron project, the scope of the regulatory assessment will be focused on the following aspects:

- Description of the local regulatory framework of each pilot country covered by the project (i.e., Poland, Norway, Portugal and Italy) and analysis of the current challenges that they may face for the transposition of the EU framework LECs-related directives.

- Identification of regulatory barriers, shortcomings and limitations for the implementation of the multi-energy technologies associated to the eNeuron solutions. Hereby, the analysis will cover those policies related to operation and implementation of non-conventional renewable energy generation technologies, hydrogen production, EV mobility integration and any other.

- Comparison of the current LECs-related policies between the pilot countries in order to study strengths and weakness of their regulatory frameworks and analyse the heterogeneity of regulations among EU members.

- Formulation of strategies and measures that can be considered by policy-makers as potential modifications in the current regulatory framework of each pilot country in order to counter-attack the barriers identified during the assessment.

2.2.2 Methodology for regulatory assessment

The regulatory framework analysis allows the identification of gaps and barriers that LECs functionalities may face in their implementation and operation. In eNeuron project, the barriers will be studied at a European level with focus on the pilots' countries and the assessment aims to provide the necessary recommendations for the policies-maker bodies to take into consideration when formulating changes in the policies related to the implementation of LECs. Apart from the identification of the regulatory barriers, the assessment will also include the evaluation of the trends and challenges associated to the transposition of LEC-related of the EU framework directives in the pilot countries taking as reference the literature available and similar studies (e.g., [6]).

Once said this, the regulatory assessment methodology is inspired in a five-step approach from the legal and regulatory framework analysis carried out in the project 'Citizen Financing for Energy Efficiency' (CitiZEE) [7]. These five steps are shown in Figure 2 and described below.

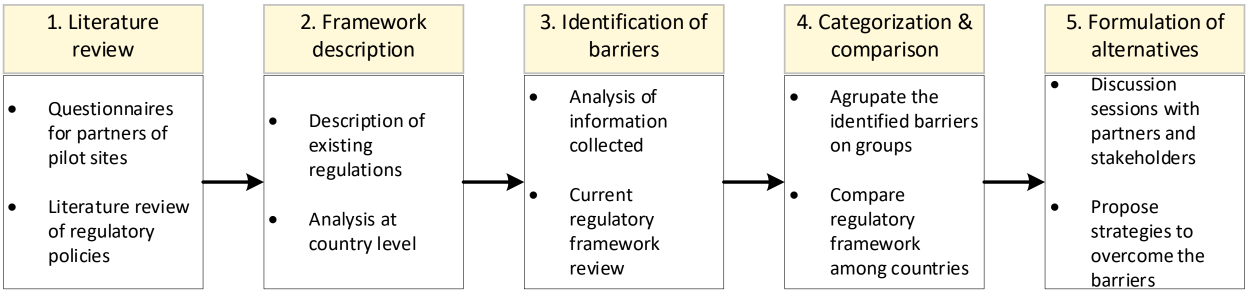

Figure 2: Methodology for the regulatory assessment based on the 5-steps approach methodology proposed by CitiZEE project [7]

Literature review: in a first step, information about the policies which regulate the operation and implementation of LECs-related multi-energy technologies is collected. In order to achieve this, a review of the main regulatory barriers at European level described in the WP2 "*Limitations and shortcomings for optimal use of local resources*" is initially performed. Subsequently, a literature review of the legal framework related to the development of LECs in the pilot countries is carried out. Likewise, additional information about limitations for implementing eNeuron solutions are collected through questionnaires spread among the partners from the pilot sites.

Framework description: in this step, an overall description of the national regulatory framework on LECs for each pilot country is developed. Both the literature collected in the previous step and the information provided by the pilot partners in the questionnaires will be taken as main sources for this description.

Identification of barriers: once the regulatory framework is well-described, the identification of the main barriers and limitations for the implementation and operation of LECs and their related technologies is carried out. Likewise, this analysis will be based on the feedback from the questionnaires and the literature collected. Moreover, the shortcomings identified at European level will be studied in the local grounds to determine additional legal restrictions for LECs at each pilot country. Also, additional limitations for the implementation of the eNeuron solutions will be determined through follow-up discussions with all project partners.

Categorization and comparison: Subsequently, a categorization of the regulatory barriers and limitations identified is performed according to, e.g., legal/non-legal related aspects. Therefore, the categorization of the barriers makes the formulation of counterattack strategies easier in the next step. Additionally, a comparison of the legal framework and regulatory barriers for the pilot countries will be carried out.

Formulation of alternatives: in the last step, a deep analysis to find viable solutions to overcome the identified regulatory barriers is performed. Consult with stakeholders and the advisory board members of the project can also be included as part of the analysis process.

The five-steps methodology to be followed for the regulatory assessment is a simple but well-structured process which lead to an integral analysis that includes: literature review, description of the framework, analysis and comparison of barriers and the formulation of recommendations. Moreover, the final outcome after the implementation of this methodology will include bottom-up recommendations tailor-made to the local regulations of the pilot countries based on both the barriers identified at European level (according to the analysis performed in WP2 "*Limitations and shortcomings for optimal use of local resources*") and at a local level. Additionally, the assessment will provide recommendations to the decision-making bodies for the formulation of incentives within the regulatory frameworks which can foster the implementation and integration of LECs.

2.3 Environmental Assessment

2.3.1 Introduction and definition of life cycle analysis

Life Cycle Analysis (LCA) is widely recognized as the most advanced approach to obtaining verified and comparable information on the environmental performance of products and services on a qualitative and quantitative basis. LCA is standardized internationally in the ISO 14040 series [8].

ISO 14040 and 14044 provide the indispensable framework for life cycle assessment (LCA). This framework, however, leaves the individual practitioner with a number of choices that can affect the legitimacy of the results of an LCA study. To ensure consistency and assure data quality, the International Reference Life Cycle Data System (ILCD) has established guidelines for life cycle assessment data and studies. These guidelines complement the general framework provided by ISO 14040 and 14044:2006. Thus, ISO 14040 defines LCA as "the compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system during its life cycle" [9].

LCA is a tool for analysing the environmental burden of products at all stages of their life cycle. It quantifies all the emissions and resources consumed and the related environmental and health impacts, as well as resource depletion issues, associated with any good or service or process ("products") [10].

Thus, LCA is a tool for analysing the consequences of the production and use of products or the provision of services with regard to the consumption of raw materials and energy, the release of gaseous, liquid or solid substances into the environment, throughout the entire life cycle of the processes involved "from cradle to grave".

Therefore, LCA is a technique developed for better understand and address possible impacts associated with products, services, and technologies [11] that:

- Provides increased awareness of the importance of environmental protection
- Can assist in identifying opportunities to improve the environmental performance of products at various points in their life cycle

- Selects relevant indicators of environmental performance, including measurement techniques
- Informs decision-makers in industry, government and non-government organizations.

LCA addresses the environmental aspects and potential environmental impacts throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal [11].

LCA is therefore a vital and powerful decision support tool, complementing other methods, which are equally necessary to help make consumption and production more sustainable in an effective and efficient manner.

Through a systematic overview and perspective, the shifting of a potential environmental burden between life cycle stages or individual processes can be identified and possibly avoided. Therefore, LCA helps to avoid, for example, causing waste-related issues while improving production technologies, increasing land use or acid rain while reducing greenhouse gases, or increasing emissions in one country while reducing them in another.

A system may have several possible functions and the one(s) selected for a study depend(s) on the goal and scope of the LCA. LCA is a relative approach, which is structured around a functional unit. This functional unit defines what is being studied, i.e., the quantification of the identified functions (performance characteristics) of the product. ISO 14040 defines the functional unit as "quantified performance of a product system for use as a reference unit" [11].

All subsequent analyses are then relative to that functional unit, as all inputs and outputs in the Life Cycle Inventory (LCI) and consequently the Life Cycle Impact Assessment (LCIA) profile are related to the functional unit. The primary purpose of a functional unit is to provide a reference to which the inputs and outputs are related. This reference is necessary to ensure comparability of LCA results.

LCA is an iterative technique. This approach within and between the phases contributes to the comprehensiveness and consistency of the study. LCA studies comprise four phases:

- Goal and scope definition
- Inventory analysis
- Impact assessment
- Interpretation

Goal and scope definition: the goal of an LCA states the reasons for carrying out the study, the intended application and audience and whether the results are intended to be used in comparative assertions. The scope, including the system boundary and level of detail, of an LCA depends on the subject and the intended use of the study. It should be well defined to ensure that the depth and detail of the study are sufficient to address the stated goal. This is the preliminary phase in which the purpose of the study, functional unit, boundaries of the system studied, data requirements, assumptions and limitations are defined. The choice of the functional unit is fundamental in order to represent, in an unambiguous and comparable manner, the quantity of the product or service whose effects on the system are being analysed.

Inventory analysis (LCI): it is an inventory of input/output data with regard to the system being studied. It involves data collection and calculation procedures to quantify relevant inputs and outputs of a product system. Data for each unit process, within the system boundary, can be classified under major headings, including: energy inputs, raw material inputs, ancillary inputs, other physical inputs, products, co-products and waste, emissions to air, discharges to water and soil, and other environmental aspects [11]. Its purpose is to identify and quantify resources, energy consumption and emissions into the environment for the process under consideration.

Impact assessment (LCIA): the purpose of this phase is to provide information to help assessing a product system's LCI results to better understand their environmental significance. The impact assessment phase of LCA is aimed at evaluating the significance of potential environmental impacts using the LCI results. This process involves associating inventory data with specific environmental impact categories and category indicators, thereby attempting to understand these impacts. The LCIA phase also provides information for the life cycle interpretation phase [11]. It is the study of the environmental impact resulting from the process, activity, or product, which aims to establish the extent of the alterations generated as a result of the consumption of resources and releases to the environment calculated in the inventory phase.

This phase consists of four stages: classification, characterisation, normalisation, and assessment. In the classification phase each impact category is classified according to the environmental issues to which it can potentially contribute, i.e., acidification of water, depletion of the ozone layer, increase in the greenhouse effect. These categories are associated with damage categories such as human health, ecosystem quality and depletion of natural resources. In the characterisation phase a quantitative analysis of the various impacts is carried out. Each substance contributes differently to the same environmental issue; consequently, the quantities of each input and output are weighted, that is, multiplied by a weight factor that measures the intensity of a substance's effect on that particular type of environmental problem. In the normalisation phase the previously obtained values are normalised, i.e., divided by a reference value so that they can be compared against the same reference value. The objective of the assessment phase is to express, through a numerical value, the environmental impact associated with a product over its life cycle. The normalised values are then multiplied by weight factors, which express the importance associated with each environmental issue [12].

Interpretation: this is the final phase of the LCA, in which the results of an LCI or an LCIA, or both, are summarized and discussed as a basis for conclusions, recommendations and decision-making in accordance with the goal and scope definition. Life cycle interpretation is also intended to provide a readily understandable, complete and consistent presentation of the results of an LCA, in accordance with the goal and scope definition of the study [11]. The interpretation phase aims, among other things, to propose the required changes to reduce the environmental impact of the industrial processes under consideration. It is divided into two sub-phases: analysis of the improvements and final interpretation of the results. In the first sub-phase, possible options for reducing the environmental impact of the systems under consideration are evaluated. The second one is often limited to a simple presentation of emissions, combined with some qualitative considerations.

2.3.2 Key features of an LCA

The following list outlines the main features of the LCA methodology [11].

- LCA assesses, in a systematic way, the environmental aspects and impacts of product systems, from raw material acquisition to final disposal, in accordance with the stated goal and scope

- The relative nature of LCA is due to the functional unit

- The depth of detail and time frame of an LCA may vary to a large extent, depending on the goal and scope definition

- LCA must be compliant with ISO 14040 and ISO 14044, but there is no single method for conducting LCA

- LCA addresses potential environmental impacts; LCA does not predict absolute or precise environmental impacts due to:

    - Relative expression of potential environmental impacts to a reference unit
    - Integration of environmental data over space and time
    - Inherent uncertainty in modelling of environmental impacts
    - Fact that some possible environmental impacts are clearly future impacts

- The LCIA phase, in conjunction with other LCA phases, provides a system-wide perspective of environmental and resource issues for one or more product system(s)

- LCIA assigns LCI results to impact categories; for each impact category, a life cycle impact category indicator is selected and the category indicator result is calculated; the collection of indicator results (LCIA results) or the LCIA profile provides information on the environmental issues associated with the inputs and outputs of the product system

- Life cycle interpretation uses a systematic procedure to identify, qualify, check, evaluate and present the conclusions based on the findings of an LCA, in order to meet the requirements of the application as described in the goal and scope of the study

Life cycle interpretation uses an iterative procedure both within the interpretation phase and with other phases of an LCA.

2.3.3 Life cycle impact assessment methodology: IMPACT 2002+

Various methodologies are available to evaluate the life cycle impact assessment (LCIA). Their objective is to evaluate the significance of potential environmental impacts using the LCI results. This process involves associating inventory data with specific environmental impact categories and category indicators [11].

The category indicator can be located at any point between the LCI results and the damage category (where the environmental effect occurs) in the cause-effect chain. Two kinds of methodologies have evolved [13]:

a) Classical impact assessment methodologies (e.g., CML, EDIP) that restrict quantitative modelling to relatively early stages in the cause-effect chain, and classify and characterise LCI results in so-called “midpoint categories” by quantifying midpoint characterisation factors (CFs)

b) Damage oriented methodologies such as ReCiPe, Eco-indicator 99, EPS that try to model the cause-effect chain up to the damage and quantify endpoint CFs

The first task force of the Life Cycle Impact Assessment Initiative program [14] suggests utilizing the advantages of both approaches by grouping similar category endpoints into a structured set of damage categories. The concept also works with midpoint categories, each midpoint category relating to one or several damage categories. The LCIA methodology IMPACT 2002+ addresses this new challenge by presenting an implementation working both at midpoint and damage.

LCI results with similar impact pathways are allocated to impact categories at midpoint level, also called midpoint categories. The term “midpoint” expresses the fact that this point is located somewhere on an intermediate position between the LCI results and the damage on the impact pathway. All types of LCI results are usually linked via several midpoint categories to three damage categories: human health, ecosystem quality, and resources. Thus, the analysis of impacts is divided into four stages:

Classification: qualitative stage, in which the inventory data are divided into groups of themes or categories of environmental impacts. These can be traced to three broad areas of general protection: resource depletion, human health, and environmental conservation;

Characterisation: in which the impacts are quantified and aggregated to identify the harm related to the substance emitted or resource used;

Normalisation: which divides the values obtained in the previous step by the harm suffered in 1 year by the average European citizen (or world population) in the same category, in order to make categories that have different units of measurement comparable;

Assessment: which assigns a value in terms of importance to each impact and can be done following different cultural perspectives.

The impact categories that are chosen represent the environmental impacts that will be considered in the LCA. Each impact category has a category indicator related to that environmental impact. The characterisation model is the conversion of LCI results into common units and the clustering of the results within the impact category. The midpoint categories reflect the damage that the impact categories may cause. For this reason, there are many LCIA models and methods.

In the LCA analysis carried out within the eNeuron project, IMPACT 2002+ will be used for the LCIA methodology. It links all types of life cycle inventory results via 14 midpoint categories to four damage categories: human health, ecosystem quality, climate change and resources (see Figure 3). IMPACT 2002+, developed at the Swiss Federal Institute of Technology (EPFL), does not consider water and land transformation, damage categories are measured as “endpoints” and impact categories are measured as “midpoints” (ecosystem effects, human health and resource depletion) [15], [16].

Global warming (impact category) and thus climate change (damage category) do not take into account the absorbed CO_2 and biogenic emissions. These are considered carbon-neutral because carbon is generated by natural processes. Other midpoint categories were adapted from existing methods (Eco-indicator 99 and CML 2002) or accredited institutions lists (IPCC GWP, US EPA OPD and Ecoinvent 2000) [17].

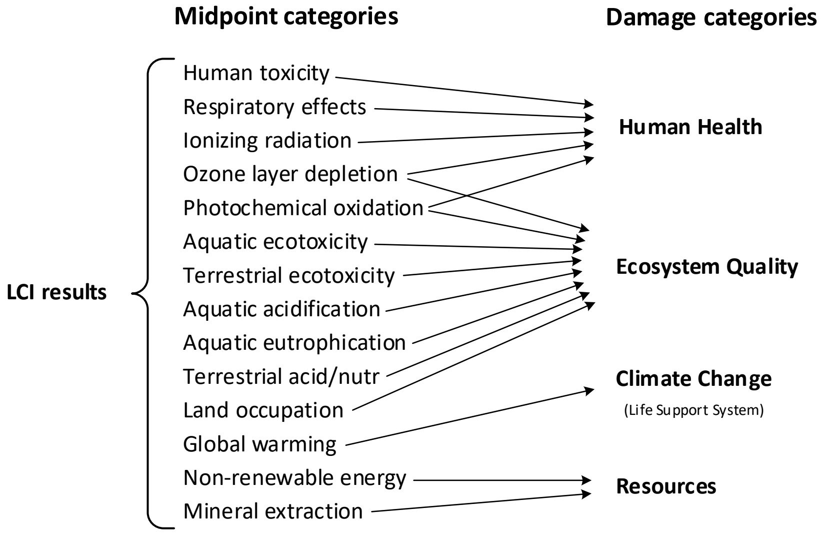

Figure 3: General outline of the IMPACT 2002+ framework, linking LCI results across midpoint categories to damage categories [18]

In the damage assessment, the method assigns an evaluation factor of 1 for the four damage categories. The impact categories are measured in terms of equivalent substance quantities (midpoint). The damage categories (excluding climate change, which is measured by the quantity of equivalent substance) have as a unit the effect of the damage on human health, ecosystem quality and resources (endpoint).

Table 1: Normalisation factors for the four damage categories

Damage categories	Normalisation factors	Unit
Human Health	0.0071	DALY/pers/yr
Ecosystem Quality	13700	PDF × m^2 × yr/pers/yr
Climate Change	9950	Kg CO_2/pers/yr
Resources	152000	MJ/pers/yr

For Europe, the damage factor brought back in the Ecoinvent database is normalised by dividing the total impact of each substance in the specific category, per person per year. Table 1 shows the normalisation factors for the four damage categories. The total damage is expressed in Ecopoints (Pt).

2.3.4 Reasons for studying only the operational phase in eNeuron project

LCA is conducted by defining product systems as models that describe the key elements of physical systems [11]. The system boundary defines which unit processes shall be included within the LCA. The selection of the system boundary shall be consistent with the goal of the study. The criteria used in establishing the system boundary shall be identified and explained. The deletion of the life cycle stages, processes, inputs or outputs is only permitted if it does not significantly change the overall conclusions of the study. Any decisions to omit life cycle stages, processes, inputs or outputs shall be clearly stated, and the reasons and implications for their omission shall be explained [19].

Resources need not be expended on the quantification of such inputs and outputs that will not significantly change the overall conclusions of the study. The choice of elements of the physical system to be modelled depends on the goal and scope definition of the study. The criteria used in setting the system boundary are important for the degree of confidence in the results of a study and the possibility of reaching its goal [11].

LCA technique with proper justification could be applied in studies that are not LCA or LCI studies. Examples are: cradle-to-gate studies, gate-to-gate studies and specific parts of the life cycle (e.g., waste management, components of a product).

The gate-to-gate analysis is from factory entry gate to exit gate, and the product use/disposal phase is not included in the system boundary. The cradle-to-gate analysis includes gate-to-gate scope as well as the raw material extraction, manufacture, and transportation (see Figure 4).

The system boundaries determine which processes are to be included in the LCA and thus how far an analysis goes. In this sense, therefore, an analysis can also be limited to a "cradle to gate" not to a "cradle to grave" study, i.e., including only a part of the life cycle. It is even possible to proceed by considering only a single phase: this can be done to simplify the analysis in the case of very complex systems or to exclude phases outside the objective of the study.

The work of this subtask focuses on the assessment of the environmental impacts of the solutions implemented in the demo pilots. It was determined to evaluate the effect of the eNeuron toolbox on the four pilot configurations from an energy perspective. Therefore, in light of this consideration, a comparison will be made between ex-ante and ex-post application of the eNeuron toolbox. For this reason, only the operational phase will be considered. This happens because eNeuron toolbox (when applied to the pilot cases) affects only the operational phase of the several technologies involved in the pilots.

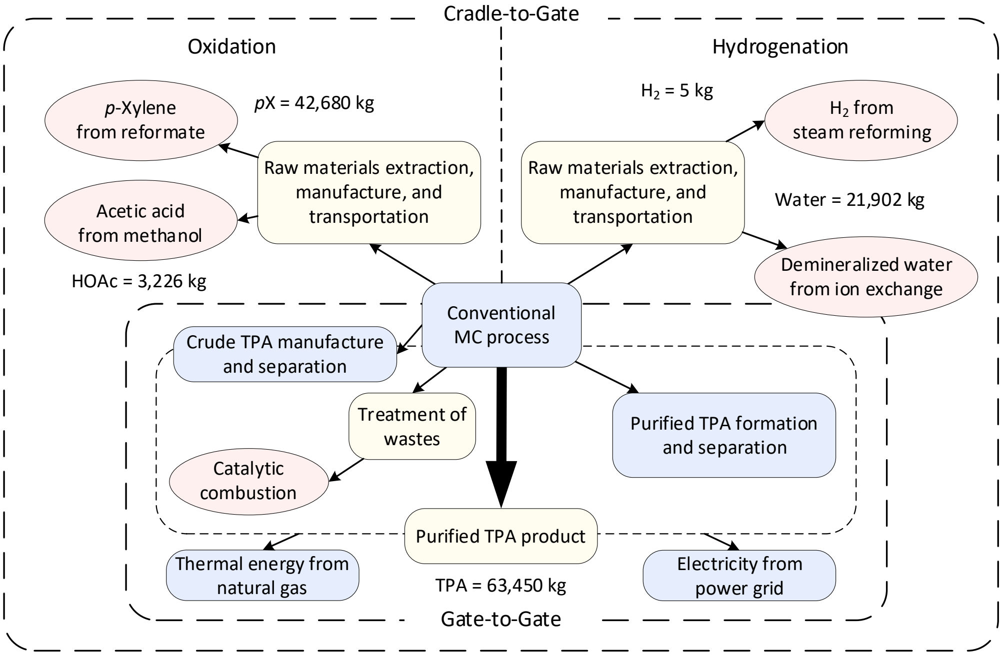

Figure 4: Example of Cradle-to-Gate and Gate-to-gate analysis [20]

2.3.5 LCA software tool selected

SimaPro has been among the leading LCA software solutions for over 30 years, used by companies, consultancies, and universities in more than 80 countries. SimaPro is used primarily in the academic field and by experienced LCA consultants. The software is used for various applications:

sustainability reporting, carbon and water foot-printing, product design, generating environmental product declarations and determining key performance indicators. The version of SimaPro used for this study is the 9.2.

Developed by PRé Sustainability, it allows to collect, analyse and monitor the sustainability performance data of products and services. Thus, SimaPro allows to [21]:

- Easily model and analyse complex life cycles in a systematic and transparent way
- Measure the environmental impact of products and services across all life cycle stages
- Identify the hotspots in every link of supply chain, from extraction of raw materials to manufacturing, distribution, use, and disposal

SimaPro is a widely used LCA tool for industrial applications, and in most cases, it is considered to be one of the expert versions for useful LCA application. With this tool, decisions related to the product life cycle and design can be made effectively. Overall, these decisions will boost companies to meet the requirements of regulatory bodies. This tool was developed considering the scientific information related to almost every product and material. The information provided in this tool is transparent to an extent and mostly avoids the black-box process [22].

By using SimaPro, users can make appropriate decisions by carrying out the analysis, based on the accuracy of obtained results. SimaPro offers a systematic and transparent approach to model life cycle processes through the collection, analysis and monitoring of any product data along with its sustainability performance. Additionally, it allows the measurement of the environmental impacts as per the impact categories throughout the product life cycle. These features also enable modellers to identify hotspots in the supply chain.

2.4 Life cycle cost (LCC)-based economic assessment

The Life Cycle Cost (LCC) analysis to be developed will focus on the economic impact that the solution proposed by eNeuron project will have, mainly on prosumers within the ILEC. In close cooperation with WP5 '*Validation of energy hub solutions through simulation and testing in a lab environment*' and WP6 '*Pilot roll out and real-world testing*', this subtask will identify the main economic implications of both:

- The simulations and laboratory test carried out in WP5
- The different demonstration pilots developed in WP6

Next sections explain the steps followed until now for the development of such analysis, from a theoretical summary of the applied methodology until the specific concepts which will have to be considered for the LCC calculations.

2.4.1 Life cycle cost methodology

Many works in the scientific literature explain the LCC methodology and how it should be applied (refers from [23] to [27]). In brief, this type of analysis allows to determine the most cost-effective option of owning a facility or running a project among several alternatives. It is especially useful when there are different alternatives of initial investment and operating costs, and all alternatives meet the performance necessities [23]. All costs arising from owning, operating, maintaining, and disposing of a project must be considered for the analysis [24].

According to the reviewed references, this type of analysis should not be used for the budget allocation but for determining the overall costs of the considered alternatives. LCC is a useful tool when the decision of higher initial investment costs is considered in order to reduce future costs. In addition, it is a more suitable mechanism to determine the long-term cost effectiveness of a project than other alternative methods which only focus on the short-term related costs of the project (e. g. payback method) [24].

When performing an LCC analysis, the economic impact of the available alternatives is determined, quantified and expressed in monetary terms [23]. As stated in [24], the LCC is a straightforward method of accounting for present and future costs of a project over its life-cycle.

As a guideline, [24] provides a detailed list of key steps, which are summarized below, to be followed in an LCC analysis:

- Identification of the problem and definition of the objective
- Identification of different alternatives
- Establish common assumptions and parameters
- Estimation of times and costs for each alternative
- Discount future costs to present value
- Comparison of LCC alternatives
- Assessment of uncertainties of input data and non-monetary savings or costs

The LCC analysis performed in this intermediate report focuses on the estimation and assessment of costs of the considered and deployed solutions within eNeuron project.

A general formula for the LCC considering a present-value model would be as shown in equation 2.1 [24].

$$LCC = \sum_{t=0}^{N} \frac{C_t}{(1+d)^t} \tag{2.1}$$

Where:

LCC: total LCC in present-value of a given alternative [EUR]

C_t: sum of all relevant costs, including initial and future costs, minus any positive cash flows, occurring in year t [EUR]
N: number of years considered in the analysis [-]
d: discount rate used to adjust cash flows to present value [-]

In order to compare cash-flows incurred at different times during the life-cycle of a project, they have to be made time-equivalent. The LCC method converts them to present values by discounting them to the base date. The discount rate represents the investor's minimum acceptable rate of return [25].

When developing an LCC analysis, one of the main doubts is to determine which of the numerous costs associated with acquiring and operating a facility should be included in the analysis. Only the costs that are relevant for the decision, so they change from alternative to alternative, should be considered [24].

Different classifications of costs to be considered in an LCC analysis exist. The classification provided in [23] considers all the costs related to obtaining, owning and disposing of the facility (see Figure 5).

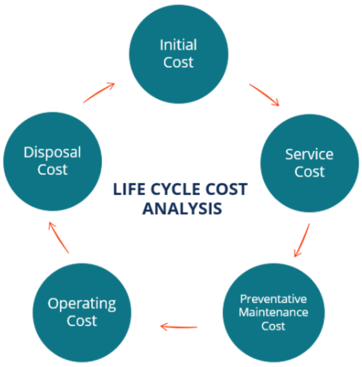

Figure 5: Costs classification in a LCCA [23]

A basic formulation gathering these costs could be the one shown in equation 2.2 [25]

$$LCC = Capital + Lifetime\ operating\ and\ maintenance\ costs + Disposal\ costs - Residual\ value \tag{2.2}$$

Taking this formulation as the basis for the analysis to be developed in this report, subsection 2.4.2 explains how the life cycle costs will be calculated. When acquiring the required data, the results obtained from the work developed by different tasks within the project and the interdependency among them will be considered.

2.4.2 Life Cycle Cost (and Benefit) analysis in eNeuron

The analysis to be performed focuses on the economic impact that the solutions proposed in the eNeuron project could have over the participants in an ILEC. With that purpose, as a first step, the main economic implications of both the simulations and laboratory tests on the one hand, and of the different demonstration pilots on the other, have to be identified. In addition, the analysis has to consider and include the results and considerations assumed by other tasks in the project, in order to ensure that the impact of ILEC integrating distributed energy resources and multiple energy carriers is fully addressed. Figure 6 shows how such results and interdependencies may impact on the LCC analysis and may evolve as the project runs.

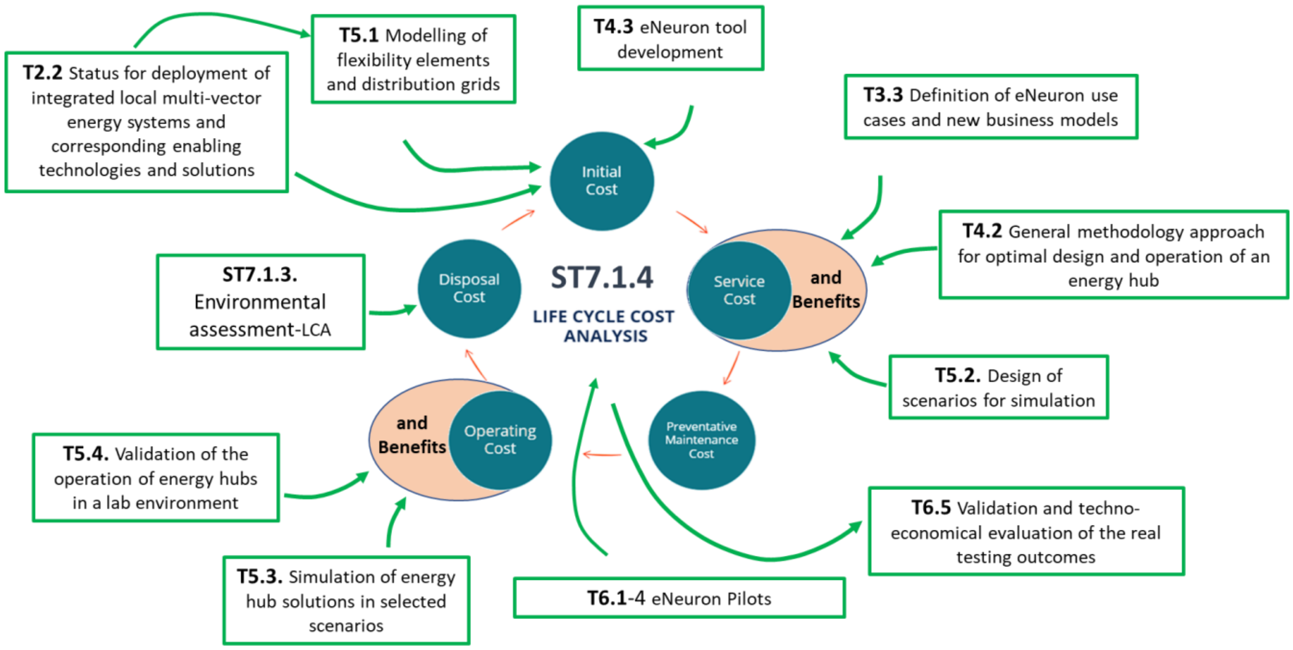

Figure 6: Interdependency of tasks for the LCC analysis

In Figure 6, the “Benefit” concept is also included being aware that the eNeuron impact shouldn’t be evaluated only by the criterion of costs. It can be easily understood that the integration of prosumer’s energy systems into an eNeuron-based energy community will imply relevant additional costs that would be compensated with the benefits of those energy resources playing in the energy community framework.

That’s the reason the LCC analysis will be completed with some Cost-Benefit Analysis considerations as shown in Figure 6 assuming benefits coming from the services and operating phases. So, in some way a sort of Life-cycle Cost and Benefit (LCCB) analysis will be carried out.

As a preliminary step, the eNeuron tasks expected to have an impact, or which could provide useful information as inputs of the costs to be considered in the analysis, have been identified:

- Initial cost:
    - **T2.2**: Status of local multi-vector energy system deployment, architectures, involved actors and interactions between them. As result, a set of guidelines in terms of technological solutions aimed at meeting the goal of establishing effective ILEC is provided.
    - **T4.3**: The software and hardware device are developed within this task. The costs and resources employed in such development will be used as a reference input for the analysis.
    - **T5.1**: Several components are modelled in order to be used in the simulations, including distributed generation units, energy storage systems and thermal components to be able to design hybrid models of the energy hubs.

- Service cost:
    - **T3.3**: Use cases and the business model alternatives are defined in this task. A path of how different concepts and needs could co-exist may also be drawn.
    - **T4.2**: A methodology for designing the optimal resource mix within a ILEC is designed by this task. The identified business models and how the market will interact with the developed eNeuron approach in a real time basis is taken into consideration.
    - **T5.2**: Scenarios derived from the use cases and business models previously defined for the simulation are designed.

- Operating and Maintenance cost:
    - **T5.3**: Simulations of the eNeuron functionalities are run. Results will be evaluated and used as inputs for the development of other tasks.
    - **T5.4**: Validation of the operation of energy hubs at laboratory level.

- Disposal cost:
    - **ST7.1.3**: Assessment of the environmental impacts of the solutions implemented in the demo pilots.

2.4.3 Sensitivity analysis methodology

eNeuron project is considering a wide sort of energy systems not only from the side of the energy carriers and technologies involved, but also from the side of the diverse ranges of power and energy that could be expected in those systems. In addition to this, the difficulties of getting feasible economic figures from the pilots, made convenient and practical to take the following decisions:

- Not to consider all the eNeuron technologies: Possibly pilot technologies plus those additional ones that could be considered more relevant and probable in energy communities would be selected.

- Not to apply actual and detailed economic figures but applying a kind of sensitivity-based approach by considering relative values for the LCCB economic variables comparing pre-post-eNeuron solutions effect.

- To select a LCCB model covering the most relevant type of costs and benefits according to the eNeuron concept and the defined pilots.

- To take the pilots as the main reference for the technologies considered, as mentioned above, and the LCCB-based economic considerations related to those technologies deployed in the pilots.

Most cost data for an LCCB analysis are likely to be estimated. Moreover, every decision related to investments typically involve uncertainty about their real costs and potential savings, especially for projects which involve a long-term duration. The uncertainty and risk included when calculating the LCCB can be valued subsequently. The technical literature provides several methods, which are categorised as deterministic and probabilistic approaches, to measure such uncertainty. The deterministic approaches measure the impact on project outcomes of changing one key value or a combination of values at a time. The results obtained will show how the change in the input values change the outcome, remaining constant the rest of inputs. There are several deterministic techniques for the assessment of the uncertainty (e. g. breakeven analysis, risk-adjusted discount rate, sensitivity analysis, etc.) [24].

In the specific case of eNeuron, the selected technique to assess the uncertainty of the LCCB analysis is the sensitivity analysis. This type of analysis allows to determine which input values could have a considerable impact in the outcome of the analysis. It also allows to determine the lower and upper bounds of the considered measures of economic evaluation [25]. The sensitivity analysis aims to identify the range of critical variables for which the outcome is positive [26].

The sensitivity analysis can be used to test different scenarios, for example using more optimistic and pessimistic values than the expected ones. The main advantage of this type of analysis is that it can be performed with less resources and time than other more sophisticated techniques. Moreover, the results of a sensitivity analysis are easily understandable. On the contrary, one of the main disadvantages identified in [24], is that the sensitivity analysis does not provide any information of the likelihood of different outcomes, so, the decision of one alternative or another will be selected on the basis of equal likelihood of a scenario occurs. However, in spite of this, the sensitivity analysis is expected to provide important and very valuable additional information.

The methodology for performing a sensitivity analysis can be summarized as follows [25], [26]:

- Identify and vary the uncertain input values which have the greatest impact on a specific measure of economic evaluation, one at a time

- Recalculate the economic measure under evaluation and determine how the variability in the input affects the obtained outcomes

- Analyse new results testing different scenarios and draw conclusions

Since the data acquisition may be time-consuming and complicated, given the wide range of energy systems and their characteristics to be considered, the LCCA will be based on a sensitivity analysis approach rather than performing a detailed economic calculation with actual numerical values. Relative values for the LCCA economic variables will be assigned and, as a result, a comparison between the post eNeuron effects and the current business-as-usual situation may be provided.

Likewise, the technologies deployed in the pilots are taken as main references for the analysis and the LCCB analysis will focus on such technologies.

The main objective of this sensitivity analysis is to determine under which circumstances the deployment of the eNeuron approach implies an improvement for a prosumer in the ILEC. Through the sensitivity analysis, the range of critical input variables which become the outcomes in positive might be determined.

With this sensitivity approach, a preliminary identification of LCCB indicators has been made covering a traditional LCC but adding benefit indicators matched to the corresponding costs indicator. For each LCCB indicator, a reference formula is assigned identifying the parameters that could provide evidence and measurement of the relative impact of the eNeuron application. This process is on-going at present and preliminary outcomes are presented in section 3.

3 Preliminary Outcomes

In this section, the preliminary outcomes related to the impact assessment of each dimension considered are presented. On the technical dimension, the preliminary KPI list, including the formulation and definition of each indicator is detailed. In the regulatory dimension, an overview of the regulatory barriers at European level identified in early stages of eNeuron project (WP2 "*Limitations and shortcomings for optimal use of local resources*") is presented. Moreover, in the environmental dimension, an example of the spreadsheets prepared for the pilots to collect the data required for the LCA calculations is exposed. Lastly, in the economic dimension, a preliminary description of the economic variables that will be considered in the LCC and LCCB analysis is exposed.

3.1 Technical assessment: preliminary KPI list

In the following tables, a description of the preliminary KPI list identified so far is presented. In this stage, the KERs and project objectives stated at the beginning of the project in deliverable, D1.5 "*Project Handbook*" [28] were initially considered. The KPI description presented below will be the base for the formulation of the final list in further stages of the project. Therefore, some modifications, either in the addition of missing KPIs or adjustments in the preliminary ones may be performed according to subsequent discussions and the consideration of business models and use cases (once those becomes finally defined). The final KPI list as well as their calculation and results analysis will be covered in the second release of this deliverable, D7.2 "*The outcome of technical, regulatory, environmental and economic impacts assessment (final version)*".

No. ID	KPI 1
Name	Reduction in primary energy demand and consumption
Dimension	Technical
Definition	The primary energy demand/consumption of a system encompasses all the naturally available energy that is consumed in the supply chains of the used energy carriers. To enable the comparability between systems, the total primary energy demand/consumption can be related to the size of the system (e.g., conditioned area) and the considered time interval (e.g., month, year). In this case, demand is defined as "design consumption" (consumption stands for actual/monitored energy consumption). In smart cities information systems (SCISs), energy consumption is reported at three phases: for refurbished buildings (baseline, design, monitoring) and for new buildings (reference energy consumption based on regulations and similar buildings, design demand based on simulations, and monitored consumption).
Calculation	$P_{Ec} = T_{Ec} \times P_{EFt} + E_{Ec} \times P_{EFe}$

	$\%\ change\ demand = \left(\frac{P_{Ec_{before}} - P_{Ec_{after}}}{P_{Ec_{before}}}\right) \times 100$ P_{Ec} : primary energy consumption/demand (monitored/simulated) [kWh/month; kWh/y] $P_{Ec_{after}}$: primary energy consumption/demand (monitored/simulated) after the implementation of eNeuron solutions [kWh/month; kWh/y] $P_{Ec_{before}}$: primary energy consumption/demand (monitored/simulated) before the implementation of eNeuron solutions [kWh/month; kWh/y] T_{Ec} : thermal energy consumption/demand (monitored/simulated) [kWh/month; kWh/y] E_{Ec} : electrical energy consumption/demand (monitored/demand) [kWh/month; kWh/y] P_{EFt} : primary energy factor for thermal energy (weighted average based on source/fuel mix in production) [-] P_{EFe} : primary energy factor for electrical energy (weighted average based on source/fuel mix in production) [-]
Units	%
Data	Primary energy consumption/demand (including thermal, electrical)

No. ID	KPI 2
Name	Electricity network energy losses
Dimension	Technical
Definition	The transport of electrical energy through the distribution or transmission network is associated with a certain amount of losses. Therefore, the amount of energy being produced has to be a few percentage points higher than consumption levels. When the marginal electricity production is based on fossil fuel, as is the case most of the time in most European countries, the losses result in additional CO_2 emissions.
Calculation	$\%\ losses = \left(\frac{E_I - E_D}{E_I}\right) \times 100$ E_I : amount of injected energy [kWh] E_D : amount of energy delivered to the customers [kWh]
Units	%
Data	Energy injected/delivered to the customers

No. ID	KPI 3
Name	Flexible energy traded and managed
Dimension	Technical

Definition	Measure the energy from the flexible assets traded through the market versus the energy consumption of the ILEC in a time frame. It is calculated as target flexibility as a percentage of ILEC annual energy consumption.
Calculation	$\% \, flexible \ energy = \left(\frac{E_{TF}}{E_C}\right) \times 100$ E_{TF} : target flexibility [kWh] E_C : ILEC annual energy consumption [kWh]
Units	%
Data	Annual Energy Consumption, target energy from the flexible assets

No. ID	KPI 4
Name	Flexible energy unlocked
Dimension	Technical
Definition	Measure the flexible energy that was available versus the flexible energy that was unlocked and traded. It is calculated as target flexibility as a percentage of the ILEC flexibility baseline.
Calculation	$\% \, flexible \ energy \ unlocked = \left(\frac{E_{TF}}{E_{FB}}\right) \times 100$ E_{TF} : target flexibility [kWh] E_{FB} : ILEC flexibility baseline [kWh]
Units	%
Data	Flexible energy that was available, flexible energy that was traded

No. ID	KPI 5
Name	ILEC Self-sufficiency
Dimension	Technical
Definition	Measure the self-sufficiency of the ILEC in terms of not needing import of energy by the upper grid. It is calculated as the energy self-generated respect to the ILEC annual energy needs, taking as reference a period of time after the implementation of eNeuron solutions.
Calculation	$\% \, Self - sufficiency = \left(1 - \frac{E_I}{E_D}\right) \times 100$ E_I : annual Import of energy after implementation of eNeuron solutions [kWh/a]

	E_D : ILEC annual energy needs [kWh/a]
Units	%
Data	Annual imported energy, annual energy needs (in the ILECs)

No. ID	KPI 6
Name	Increase in self-sufficiency
Dimension	Technical
Definition	Measure the increase in self-sufficiency of the ILEC comparing it with the baseline import prior to eNeuron solutions implementation. It is calculated as annual import of energy as a percentage of the ILEC annual energy needs versus the annual import of energy as a percentage of the ILEC annual energy need prior to the eNeuron solutions.
Calculation	$\%\ change\ self - sufficiency = \left(\frac{E_{I_{before}} - E_{I_{after}}}{E_{I_{before}}}\right) \times 100$ $E_{I_{after}}$: annual import of energy after the implementation of eNeuron solutions [kWh] $E_{I_{before}}$: annual import of energy before the implementation of eNeuron solutions [kWh]
Units	%
Data	Annual imported energy, Annual energy needs (in the ILECs) prior/after the implementation of eNeuron solutions

No. ID	KPI 7
Name	Reduction of O&M costs for network operators, RES operators and facility managers
Dimension	Technical and Economic
Definition	Defined as the reduction of O&M costs for different actors in the ILEC. It is calculated as the annual O&M costs for different actors as a percentage of the annual O&M costs before the implementation of eNeuron solutions.
Calculation	$\%\ change\ OM\ costs = \left(\frac{OM_{before} - OM_{after}}{OM_{before}}\right) \times 100$ OM_{after} : annual O&M costs after the implementation of eNeuron solutions [EUR] OM_{before} : annual O&M costs before the implementation of eNeuron solutions [EUR]
Units	%

Data	Annual O&M costs prior/after the implementation of eNeuron solutions

No. ID	KPI 8
Name	Reduction in total annual cost for ILEC
Dimension	Technical and Economic
Definition	Reduction in total annual cost for local energy communities (energy cost + annualized investment cost + O&M costs) as compared to conventional energy supply system (power grid, conventional boilers and electric chillers).
Calculation	$AC = C_E + I + OM$ $\% \; reduction \; costs = \left(\frac{AC_{conv} - AC_{LEC}}{AC_{conv}}\right) \times 100$ C_E : energy cost [EUR] I : annualized investment cost [EUR] OM : operational and maintenance costs [EUR] AC_{LEC} : total annual cost in ILEC after the implementation of eNeuron solutions [EUR] AC_{conv} : total annual cost from conventional energy supply system [EUR]
Units	%
Data	Energy cost, annualized investment cost, O&M costs, energy from conventional supply system

No. ID	KPI 9
Name	Reduction in daily and annual CO_2 emissions
Dimension	Environmental
Definition	Reduction in daily and annual CO_2 emissions as compared to conventional energy supply system (power grid, conventional boilers and electric chillers). As Norwegian pilot has an almost 100% Hydro mix i.e., CO_2 emissions free, a benchmarking towards continental energy mixes can be performed.
Calculation	$\% \; CO_2 \; emissions \; reduction = \left(\frac{e_{conv} - e_{LEc}}{e_{conv}}\right) \times 100$ e_{LEC} : CO_2 emissions in ILEC after the implementation of eNeuron solutions [kt $CO_{2\text{-eq}}$] e_{conv} : CO_2 emissions from conventional energy supply system [kt $CO_{2\text{-eq}}$]

Units	%
Data	CO_2 emissions data from environmental assessment

No. ID	KPI 10
Name	Overall energy savings for the ILEC
Dimension	Technical
Definition	This KPI evaluates how much energy is saved during a time frame in a community after implementing project solutions. It is calculated as the reduction in the consumption of local energy communities' consumers in a time frame (e.g., annual) after the implementation of eNeuron solutions.
Calculation	$\%\ consumption\ reduction = \left(\frac{EC_{before} - EC_{after}}{EC_{before}}\right) \times 100$ EC_{after} : energy consumption of the ILEC consumers during a year after the implementation of eNeuron solutions [kWh/y] EC_{before} : energy consumption of the ILEC consumers in the year before the implementation of eNeuron solutions [kWh/y]
Units	%
Data	Energy Consumption of the ILEC consumers

No. ID	KPI 11
Name	Network and assets down-time reduction
Dimension	Technical
Definition	This KPI evaluates how the down-time of network and the integrated assets is reduced in a community after implementing the project solutions. It is measured through the System Average Interruption Duration Index (SAIDI) which is the average duration of interruptions per consumers during the year. The index is compared prior and after the implementation of eNeuron solutions in the ILEC.
Calculation	$SAIDI = \frac{t_i}{N}$ $\%\ downtime\ reduction = \left(\frac{SAIDI_{before} - SAIDI_{after}}{SAIDI_{before}}\right) \times 100$

	$SAIDI$: system average interruption duration index [minutes or seconds/consumer] t_i : total duration of sustained interruptions in a year [minutes or seconds] N : number of consumers in ILEC [-] $SAIDI_{before}$: SAIDI before the implementation of eNeuron solutions [minutes or seconds/consumer] $SAIDI_{after}$: SAIDI after the implementation of eNeuron solutions [minutes or seconds/consumer]
Units	%
Data	Total duration of sustained interruptions in a year prior/after the implementation of eNeuron solutions, number of customers

No. ID	KPI 12
Name	Increase of penetration of RES in the local generation mix
Dimension	Technical
Definition	This KPI evaluates the percentage of RES increase in generation mix of a community after implementing project solutions.
Calculation	$\% \, RES \, share \, increase = \left(\frac{E_{RES_{before}} - E_{RES_{after}}}{E_{RES_{before}}} \right) \times 100$ $E_{RES_{after}}$: share of RES in generation mix after the implementation of eNeuron solutions [kWh/y] $E_{RES_{before}}$: share of RES in generation mix in the previous year before the implementation of eNeuron solutions [kWh/y]
Units	%
Data	RES share in generation matrix prior/after the implementation of eNeuron solutions

No. ID	KPI 13
Name	Reduction in global damage
Dimension	Environmental
Definition	The global damage of pilot plants, composed of damage to human health, ecosystem quality and resources will be compared with global damage of pre-existing energy situation. Will be considered the global damage in the operation phase. The categories of damage (Human

	Health, Ecosystem Quality and Resources) have as their unit of measure the effect of damage on human health, on the quality of the ecosystem and resources (end point). For Europe, the damage factor is normalized by dividing the total impact of each substance of the specific category, per person per year. Total damage is expressed in points (Pt).
Calculation	$GDF = HH + EQ + R$ $\% \; GDF \; reduction = \left(\frac{GDF_{before} - GDF_{after}}{GDF_{before}}\right) \times 100$ GDF : normalized total global damage factor [Pt] HH : normalized global damage in human health [Pt] EQ : normalized global damage in ecosystem quality [Pt] R : normalized global damage in resources [Pt] GDF_{before} : normalized total global damage factor before eNeuron solutions implementation [Pt] GDF_{after}: normalized total global damage factor after eNeuron solutions implementation [Pt]
Units	%
Data	Global damage data prior/after the implementation of eNeuron solutions (results from environmental assessment)

No. ID	KPI 14
Name	Variation in the Net Present Value (NPV) calculated for the energy systems taking part of the mEH/EH
Dimension	Economic
Definition	This KPI is determined by calculating the costs of the considered energy resource (investment, O&M costs) and benefits (energy deal) for each period of the considered time. Benefits can be estimated at the simulation and laboratory stages and calculated for the demo sites.
Calculation	$NPV = \sum_{j=0}^{n} \frac{B_j - C_j}{(1+i)^j}$ $\% \; \Delta NPV = \left(\frac{NPV_{before} - NPV_{after}}{NPV_{before}}\right) \times 100$ NPV: net present value [EUR] B_j : total Benefits/incomes in the period j [EUR] C_j : costs (investment, O&M expenditures) in the period j [EUR] i : rate of interest [-] j : period [year or month]

	n : number of periods considered [-] NPV_{before} : net present value before eNeuron solutions implementation [EUR] NPV_{after} : net present value after eNeuron solutions implementation [EUR]
Units	%
Data	Costs, rate of interest, total benefits/incomes (results from economic assessment)

No. ID	KPI 15
Name	Internal Rate of Return (IRR) calculated for the energy systems deployed in the mEH/EH
Dimension	Economic
Definition	The Internal Rate of Return (IRR) is the critical interest rate (where Net present value (NPV) is zero in order to an investment to be economically sustainable. It will also take into account the costs of the considered energy resource (investment, O&M costs) and benefits (energy deal) for each period of the considered time. Benefits can be estimated at the simulation and laboratory stages and calculated for the demo campaigns.
Calculation	$$\sum_{j=0}^{n} \frac{B_j - C_j}{(1+IRR)^j} = 0$$ B_j : total Benefits/incomes in the period j [EUR] C_j : costs (investment, O&M expenditures) in the period j [EUR] IRR : internal rate of return [-] n : number of periods considered [-]
Units	-
Data	Total benefits/incomes, costs (results from economic assessment)

3.2 Regulatory assessment: regulatory barriers at European level (overview)

In earlier stages of the eNeuron project, the main regulatory limitations and barriers at European level for the implementation of the LEC technological solutions were identified and detailed in the deliverable D2.3 "*Limitations and shortcomings for optimal use of local resources*" [29] as part of the WP2 activities. As starting point of the regulatory assessment, these barriers are summarized in the tables below.

Table 2: Summarize of regulatory barriers in generation technologies identified at European Level [29]

Generation type	Limitations / Shortcomings
Thermal	• Standards related to operation, testing and safety of burners and boilers are designed for devices that use natural gas, but do not consider the utilisation of other elements such as hydrogen • Regulations related to the de-carbonisation of boilers are non-uniform throughout Europe. While some countries incentive the installation of RE-based heating systems, others do not define policies • For Heat Pump (HP) there are local regulations (specially in urban zones) that prevent the installation of external units due to noise, vibration, external air heating, aesthetics • Non-existent low quality or non-unified legislations for geothermal energy hinder its dissemination and scaling up (e.g., ground source HP utilisation) • Unpredictable and fragmented policy environments (thermal, electricity), as well as, lengthy and expensive procedures influence negatively the development of co-generation in the EU. Inappropriate evaluation methods to measure environmental benefits of co-generation • No common EU framework for connection of stationary fuel cells to the electricity grids. Lack of long-term support approaches (e.g., financial)
Electrical	• Complex administrative processes for getting implementation permission and connection of local generation (in general for all technologies) • Lack of common directives between EU countries about ownership and operational aspects of Energy Communities • Uncertainty in the support schemes for PV installations due to constant changes in legislations that drive the investments away • Diversity of regulations at different scales for all generation technologies
Hydrogen	• Unclear definition and classification of Hydrogen as well as no common EU framework for the regulation of its generation and interconnection

	- Limitation for installing electrolysers at domestic level in ECs when considered as industrial activity (in some countries)

Table 3: Summarize of regulatory barriers in energy storage and mobility identified at European Level [29]

Aspect	Limitation/Shortcoming
Energy Storage	- Lack of appropriate markets to enhance the development of storage systems and services - Unclear or complex policies related to network connection and market participation in some countries - Imprecise regulations about energy storage systems ownerships, management and divergence on interests for the technology deployment along EU countries
Mobility	- Non-uniformity on EV policies across EU countries (tax incentives, emissions targets, etc…) - Difficult interoperability due to lack of standardization for EV charging station - Unclear policies for DSO’s expenditures recovery due to demand increment for EV mobility - Unsettled policies for integration of EV mobility (e.g.; V2B, V2H or V2G schemes) and charging point protocols

3.3 Environmental assessment: spreadsheets for data collection

Spreadsheets were prepared for the four pilots in order to collect the data required to run the simulations with the SimaPro software. In each sheet input and output data for all technologies will be reported as well as the materials used for each component of the various technologies. Thus, data are requested for thermal and/or electrical production of the technologies. As exemplification, Table 4 presents the spreadsheet structure for the Norwegian pilot.

During the second stage of the project, the required data will be collected from pilots and simulations will be performed, by reporting the results in deliverable D7.2 “*The outcome of technical, regulatory, environmental and economic impacts assessment (final version)*” to be released at the end of the project.

Table 4: Structure of spreadsheets prepared for the four pilots (example for Norwegian pilot)

Pilot	Input	Technologies in pilot	Output	Unit
Norwegian	Electricity	Energy Storage System (Li-ion Battery)	Energy	
		Electrolyser	Hydrogen	
		Heat pump	Heating	
		Electric boiler	Heating	
		EV charging stations	Electricity	
	Hydrogen	Fuel cell	Electricity	
	Solar	PV panels	Electricity	

Li-ion BESS		
	Ex ante	Post
Type of material for component A		
Type of material for component B		
Type of material for component C		
Type of material for component …		
Weight (kg) of component A		
Weight (kg) of component B		
Weight (kg) of component C		
Weight (kg) of component ….		
Total weight (kg) of the machine		
Storage capacity		
Power		

Information about the properties of each pilot component

PV panels		
	Ex ante	Post
Area of the single panel (m^2)		
Number of panels		
Total surface of the panels (m^2)		
Type of installation (roof, ground, facade)		
Type of panel (monocrystalline, polycrystalline, and thin-film, etc.)		
Max electrical power of the panel (kWp)		
Normalized electric energy production (kWh)		

Data prior/post implementation of eNeuron solutions

3.4 Economic assessment: preliminary analysis of economic variables

In this section, a summarized analysis of the identified economic variables usually considered in the LCC analysis is presented as the preliminary methodological outcome of the economic assessment. At this intermediate stage, the identification and description of the LCC variables are presented as well as the sensitivity parameters are identified. Consecutively, it is detailed both indicators and sensitivity parameters associated to the Life-cycle cost benefit. Note that the pending information in the analysis will be developed in the final release of this deliverable, D7.2 "*The outcome of technical, regulatory, environmental and economic impacts assessment (final version)*".

The defined LCC variables cover the life-cycle of a considered energy system in terms of economic magnitudes according to the phases identified in Figure 5. The tables presented below go further in the analysis of the possible impact of the eNeuron solutions on those LCC economic variables, especially in the following aspects.

- **Sensitiveness for eNeuron**: analysing if the considered variable is sensitive to the deployment of the eNeuron solutions on the energy system under study

- **Related benefit variable**: identifying if the implementation of the eNeuron solutions brings benefits in the considered LCC phase

- **Relevant parameters**: identifying which parameters in a given variable equation are sensitive to the implementation of eNeuron solutions and evaluating the relevance and feasibility of measuring their sensitivity

- **Parameter feasibility**: identifies which eNeuron project phases (i.e., simulation, validation and pilot's implementation) can provide evidences and measures of a given sensitive parameter

Thus, the following tables are completed with the corresponding formulation preliminarily considered and relevant additional information.

No. ID	LCC 1
variable	Investment per kilowatt
Description	The incurred costs by the solutions deployed in eNeuron should be quantified, taking into account the different technologies, grid models, scenarios, etc. In case that the specific values are not finally provided, there are references which analyse the required investment per kilowatt for different technologies (e.g., [27], [30], [31]). Therefore, useful information could be gathered from the literature
Sensitiveness for eNeuron	Not relevant apart from complementary investment required to integrate an existing energy asset in the eNeuron framework

Related benefit variable	Not relevant benefit initially identified.
Relevant parameters	Investment payback period. The reference [27] provides information of installed costs for several technologies, specifically the detailed breakdown of utility-scale solar PV total installed costs. The main concepts included in this breakdown are: • Hardware: modules, inverters, racking and mounting, grid connection, wiring, monitoring and control. • Installation: mechanical and electrical installation, inspection • Soft costs: system design, customer acquisition.
Parameter feasibility	Pilot
Calculation	$$I = \frac{\sum_{i=1}^{n} Costs_i}{IC}$$ I: investment per kilowatt [EUR/kW] $Costs$: incurred costs by the solutions deployed in eNeuron [EUR] IC: installed capacity [kW] n: life of the system - economic life [years]
Additional considerations	It is not considered the possibility of buying and transporting an energy system knowing that is going to be use in an energy community framework. However, additional infrastructure would be required for the integration in an energy community framework. For simplification, these costs are included in the installation costs. [27] provides the total installed cost for commercial and residential PV installations. Other considered technologies in the report: Biomass, onshore and offshore wind, geothermal, etc. (sizes > 1 MW). From the literature, [30] also provides information on the cost per kW for several technologies while [31] provides information about costs

No. ID	LCC 2
Variable	Levelized Cost of Energy (LCOE)

Description	The Levelized Cost of Electricity (LCOE) refers to the average lifetime levelized cost of electricity generation. As in the variable “investment per kilowatt” LCC 1, values of references for different technologies can be obtained from the literature (e.g., [27])
Sensitiveness for eNeuron	Not relevant apart from complementary investment required to integrate an existing energy asset in the eNeuron framework
Related benefit variable	Not relevant benefit initially identified
Relevant parameters	Investment payback period, electricity generated, discount rate, system lifetime and expenditures associated to O&M, investment and fuel
Parameter feasibility	Simulation
Calculation	$LCOE = \dfrac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$ I_t: investment expenditures in the year t [EUR] M_t: operations and maintenance expenditures in the year t [EUR] F_t: fuel expenditures in the year t [EUR] E_t: electricity generation in the year t [kWh] r : discount rate [-] n: life of the system - economic life [years]
Additional considerations	The literature provides reference LCOE values by country for residential and commercial sector solar PV (e.g., [27]) and for other technologies

No. ID	LCC 3
Variable	Transportation costs
Description	These costs would be related to the adaptation needed in the considered energy systems to be integrated in the eNeuron framework
Sensitiveness for eNeuron	Not initially relevant unless the deployment of the eNeuron solutions would require any relocation of the energy systems.
Related benefit variable	Not relevant benefit initially identified.
Relevant parameters	Still under analysis (to be defined)

Parameter feasibility	Pilot
Calculation	Still under analysis (to be defined)
Additional considerations	The costs due to the implementation of eNeuron solutions, including costs specific to the solution and those caused on the existing energy systems, are still under study.

No. ID	LCC 4
Variable	Installation costs
Description	These costs would be related to the adaptation needed in the considered energy systems to be integrated in the eNeuron framework
Sensitiveness for eNeuron	Required ICT-based and electrical interconnection to the energy community
Related benefit variable	No benefits would be expected in this installation phase due to the implementation of the eNeuron solutions
Relevant parameters	Still under analysis (to be defined)
Parameter feasibility	Pilot
Calculation	Still under analysis (to be defined)
Additional considerations	Installation processes would be different in a, e.g., self-consumption approach than in an energy community approach; and would also depend strongly on the already existing Supervisory Control and Data Acquisition (SCADA) and the energy management systems (EMSs).

No. ID	LCC 5
Variable	Commissioning cost
Description	This kind of costs would be related to the adaptation needed in the considered energy systems to be integrated in the eNeuron framework
Sensitiveness for eNeuron	Required ICT-based and electrical interconnection to the energy community

Related benefit variable	No benefits would be expected in this installation phase due to the implementation of the eNeuron solutions
Relevant parameters	Time of deploying (including unboxing, installing, commissioning and cleaning area)
Parameter feasibility	Pilot
Calculation	Still under analysis (to be defined)
Additional considerations	Alike the installation costs, commissioning costs may vary a lot depending on the already available SCADAs and EMSs to be integrated with the eNeuron solution

No. ID	LCC 6
Variable	Required ICT cost
Description	The ICT costs refers to the communications and information technologies. Specifically, in the case of a prosumer, an ICT-based adaptation would be necessary to participate in the LEC and markets. It should be analysed the ICT requirement for each one of the N participants during the period of time T under consideration (e.g., the ILEC manager should develop the required software, as for example, the aggregation module [32])
Sensitiveness for eNeuron	The implementation of eNeuron solutions would likely increase ICT costs due to the deployment of ICT infrastructure that could be required in the existing energy systems
Related benefit variable	Still under analysis (to be defined)
Relevant parameters	ICT-based adaptation for each DER
Parameter feasibility	Pilot
Calculation	$Costs_{ICT} = \sum_{t=1}^{T} \sum_{i=1}^{N} ICTcost_{i,t}$ $Costs_{ICT}$: costs related to communications and information technologies [EUR] N: number of participants [-] i: equipment for each one of the N participants [-] T: period of time under consideration [-]
Additional considerations	No further considerations

No. ID	LCC 7
Variable	Operational Expenditures (OPEX)
Description	The OPEX includes the recurrent costs which are incurred during the lifetime of the facility. In the specific case of a prosumer, the only additional recurrent cost due to the integration in the ILEC would be the cost of maintaining the required communications [32]. The formula considers the OPEX for each one of the N participants during the period T under consideration
Sensitiveness for eNeuron	Expected to increase
Related benefit variable	Still under analysis (to be defined)
Relevant parameters	Recurrent cost of the required communication
Parameter feasibility	Pilot
Calculation	$$OPEX = \sum_{t=1}^{T} \sum_{i=1}^{N} Costs_{R_{i,t}}$$ $OPEX$: operational expenditures [EUR] $Costs_R$: recurrent costs [EUR] N: number of participants [-] T: period of time under consideration [-]
Additional considerations	It is necessary to analyse the recurrent cost to operate and maintain the installed equipment [32]

No. ID	LCC 8
Variable	OPEX for service procurement
Description	The OPEX for service procurement is calculated as the product of the total activated energy per participant multiplied by the variable cost of the facility. This variable cost includes the operation and maintenance costs, other external administrative costs, management costs, etc. [32].

Sensitiveness for eNeuron	Expected to increase
Related benefit variable	Provided energy for ancillary service by the unit at a specific time, energy generation cost
Relevant parameters	Recurrent cost of the required communication
Parameter feasibility	Simulation
Calculation	$$OPEX_{sp} = \sum_{t=1}^{T} E_t \times VC_t$$ $OPEX_{sp}$: OPEX for service procurement [EUR] E_t: Total activated energy for the procurement of a specific service by each provider in the period t [kWh] VC_t: variable cost of the provider (e.g., O&M costs) in the period t [EUR/kWh]
Additional considerations	This variable measures the cost for services procurement consisting of the cost of the energy provided [32]

No. ID	LCC 9
Variable	Number of transactions in the ILEC
Description	This variable analyses the number of cleared bids at time period considered
Sensitiveness for eNeuron	Expected to increase
Related benefit variable	Income due to energy transactions trade
Relevant parameters	Number of offered/cleared bids for each service
Parameter feasibility	Simulation, Validation, Pilot
Calculation	$$NT = \sum_{t=1}^{T} NB_t$$ NT: number of transactions [-]

	NB_t: number of cleared bids in the period t [-] T: period of time under consideration [-]
Additional considerations	This indicator measures the number of transactions in order to determine the number of offered and cleared bids for each service during the period under consideration [32]

No. ID	LCC 10
Variable	Volume of energy traded in the ILEC
Description	This variable accounts for the volume of transactions in energy at time t. It is important to jointly analyse the number and volume of transactions, in order to identify any link between the number of cleared bids and the volume of flexibility managed in such transactions
Sensitiveness for eNeuron	Expected to increase
Related benefit variable	Income due to the energy volume exchanged with a specific price
Relevant parameters	For each participant: energy offered in a period of time or energy cleared in a period of time
Parameter feasibility	Simulation, Validation, Pilot
Calculation	$$VT = \sum_{t=1}^{T} E_{c_t}$$ VT: volume energy traded [kWh] E_{c_t}: cleared energy in the period t [kWh] T: period of time under consideration [-]
Additional considerations	This variable is related to the number of transactions in the ILEC (LCC 9) but, in this case, it is considered the amount of traded energy instead of the number of cleared bids [32].

No. ID	LCC 11
Variable	Disposal Costs
Description	The cost of disposal every asset i of a facility should be considered when determining the total costs of such a facility deployment. In the specific case of the PV technology, extensive bibliography sources on this issue are available (e.g., [33], [34]). In general, it is cheaper to

	landfill the solar panels than recycle them, so, governments are addressing how to manage the end of lifetime for materials in a sustainable way [34]. Therefore, specific recycling programs and policies are in progress.
Sensitiveness for eNeuron	Not relevant since this variable is not affected by the implementation of eNeuron solutions
Related benefit variable	No applicable
Relevant parameters	Still under analysis (to be defined)
Parameter feasibility	Pilot
Calculation	$Cost_{facility} = \sum_{i=1}^{N} Cost_{asset_i}$ $Cost_{facility}$: Disposal cost of a facility [EUR] $Cost_{asset}$: disposal cost of the asset i [EUR] N: number of assets [-]
Additional considerations	The disposal costs are those related to the last phase of the systems under LCC analysis.

No. ID	LCCB 1
Variable	Revenue from energy services
Description	This variable provides the value of the income generated from trading with energy services provided by the energy system under study to other entities (e.g., DSOs)
Sensitiveness for eNeuron	Expected to increase
Related cost variable	LCC variables related to the operation of the energy systems (OPEX)
Relevant parameters	Amount of energy exchanged Energy prices related to every energy exchanged
Parameter feasibility	Simulation, Validation, Pilot
Calculation	Still under analysis (to be defined)

Additional considerations	Revenue refers to the income generated from the provision of energy-based services at a specific price. In this case, a differentiation between the energy exchange motivated by the contribution to a service provision (e.g., aggregated to response to a flexibly market launched by a DSO) and the one performed among peers (e.g., in a P2P-based local market) is performed.

No. ID	LCCB 2
Variable	Revenue from energy trading
Description	This variable provides the value of the income generated from trading with energy exchanges provided by the energy system under study
Sensitiveness for eNeuron	Expected to increase
Related cost variable	Number of transactions in the ILEC (LCC 9) and volume of energy traded in the ILEC (LCC 10)
Relevant parameters	Amount of energy exchanged Energy prices related to every energy exchanged
Parameter feasibility	Simulation, Validation, Pilot
Calculation	Still under analysis (to be defined)
Additional considerations	Revenue refers to the income generated from the exchange of energy at a specific price. In this case, a differentiation between the energy exchange motivated by the contribution to a service provision (e.g., aggregated to response to a flexibly market launched by a DSO) and the one performed among peers (e.g., in a P2P-based local market) is performed

Conclusion

As next steps in the technical assessment, the identification and determination of missing KPIs will be performed taking into consideration those KJRs (project objectives, KERs, business models, use cases, etc…) that have not been covered within the preliminary list presented in this first release. Once the additional KPIs are determined and the data collection process for their calculation is defined, the final KPI list will be completed. In a next stage, the collection of the data is performed during the operational phase of the pilots for later be processed so as to calculate the KPIs. Afterwards, the results of the calculation will be presented and analysed in terms of the impact of the eNeuron solutions.

Moreover, the regulatory assessment process will take as basis the regulatory limitations at European and local (country) level identified in previous stages of the project. Having this information and with additional literature collected, an analysis on how to overcome these barriers will be performed in order to find out strategies which allow the implementation of eNeuron solutions. The formulation of solutions will consider not only strategies suggested in similar projects and studies, but also the expertise from stakeholders and all partners involved in the WP7, especially the demo pilot's partners.

Furthermore, the environmental assessment base on a Life-cycle analysis will take a starting point a simplification process in order to focus the analysis on variables relevant for the project objectives. Also, the international standard guidelines stated in ISO 14040 will define the methodology framework for this evaluation and the respective calculations will be performed through the use of a specialised LCA software.

Lastly, in the economic assessment, once defined the sensitivity-based LCCB indicators framework completing what has been presented in this deliverable, will perform a Life-cycle cost and benefit analysis in which will indicate the most cost-effective alternatives for the implementation of the project's solutions at the simulation, validation and demonstration stages. In addition, preliminary selection of variables that will be considered during the analysis has been presented including their mathematical formulation. Moreover, a sensitivity analysis will be performed with the purpose of evaluating under which circumstances the solutions implemented in the pilots lead to an improvement from the end-user perspective.

Thus, in the final release of this deliverable, D7.2 '*The outcome of technical, regulatory, environmental and economic impacts assessment (final version)*', the results of the impact assessment calculations at each dimension will be presented. Based on these results, a detailed analysis of the repercussions of the implementation of eNeuron solutions in the pilots will be performed in a dedicated section for each dimension considered. Therefore, all calculations and analysis to be performed in the impact assessment will throw quantitative evidence of the effectiveness of implementing eNeuron solutions and its replicability potential at European level.

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