CHESTER

Compressed Heat Energy Storage for Energy from Renewable sources

D1.1 QUALITY ASSURANCE PLAN

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Type of Deliverable		
R	Document, Report	X
DEM	Demonstrator, pilot, prototype	
DEC	Websites, patent fillings, videos, etc.	
OTHER		
ETHICS	Ethics requirements	
ORDP	Open Research Data Pilot	

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V1	12-04-2018	Silvia Alonso	New format and WP efforts added
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V3.0	28-06-2018	Silvia Alonso	Minor changes

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Glossary, Abbreviations and Acronyms

CHEST	Compress Heat Energy and STorage
PSC	Project Steering Committee
RES	Renewable Energy Source
HT	High Temperature
HTHP:	High Temperature Heat Pump
TES	Thermal Energy Storage
LCA	Life Cycle Approach
ORC	Organic Rankine Cycle
SEMS	Smart Energy Management System
SVV	Sliding Volume Valve
KPI	Key Performance Indicator
DH	District Heating
PO	Project Officer
ISAMPE	Standard Innovation Management Process

1. Introduction

1.1 Purpose and Scope

This document is aimed at ensuring the quality of the different CHESTER's activities.

The following procedures and specifications are detailed in the following sections:

- Deliverables review process in order to guarantee their quality, involving as well CHESTER's partners in the process
- Detailed work plan for each WP
- Methodology for the reporting technical progress
- Internal Communication Procedure
- Templates for the different kind of documents to be developed in CHESTER

2. Procedure for Deliverables Review

The procedure will consist of the steps below. ***<u>The numbers of days indicated below refer to the NUMBER OF DAYS BEFORE THE DELIVERY DATE TO THE EC</u>***. They are not working days but natural days, so the precise dates should be analysed and agreed between the involved parties in each case. Please note that this review process only took effect on deliverables due Month 4 (July 2018) or later.

The review procedure uses the official delivery month as a baseline and tracks backwards in time to identify deadlines for the different quality assurance activities (reviews). The responsible partners for each stage of the review process are indicated in the Annex A Section.

1. INTERNAL PROCESS WITHIN WP (since the process is still internal, these steps are just indicative):
    a. [50 days] The Author sends the **TABLE OF CONTENTS** and the **DISTRIBUTION OF COMMITMENTS** to WP partners
    b. [25 days] The Author has compiled all the contributions and sends the new **HIGH QUALITY DELIVERABLE** to the reviewer
2. REVIEWER (these dates for deadlines must be strictly fulfilled)
    a. [15 days] The Reviewer checks that the HIGH QUALITY DELIVERABLE is really good.
        i. The Reviewer gives his/her OK to Author and to WP leader about the HIGH QUALITY DELIVERABLE, potentially indicating comments for its improvement
        ii. Otherwise it rejects it immediately to the Author and WP leader with copy to TECNALIA (the reviewer's task is not to improve the document, just to check its quality), indicating the reasons for this decision (see "A LOW QUALITY DELIVERABLE")
3. IMPROVEMENT BY AUTHOR
    a. [5 days] The Author sends the improved **HIGH QUALITY DELIVERABLE v2** to TECNALIA, after having assessed the hints by the Reviewer and considered them together with the WP leader
4. REVISION BY TECNALIA
    a. At this point the quality of **HIGH QUALITY DELIVERABLE v2** should be excellent. TECNALIA will read it just to verify it
5. Delivery Date: TECNALIA uploads the deliverable to the EC Repository

Case of a LOW QUALITY DELIVERABLE at Step2

ACTIONS IN CASE ANY OF THE PARTICIPANTS IN ANY STEP OF THE REVIEW PROCESS CONSIDERS THAT THE QUALITY IS NOT SUFFICIENT FOR IMPROVING IT THROUGH AN ACCEPTABLE AMOUNT OF COMMENTS

1. REVIEWER (these dates for deadlines must be strictly fulfilled)
    a. [25-15 days] The Reviewer declares that the DELIVERABLE has not the sufficient quality, **indicating the reasons for this decision** to the author, WP leader and TECNALIA
    b. TECNALIA will inform and keep informed the EC Officer of the situation and expectations for this deliverable
    c. TECNALIA, the Reviewer, the Author and the WP leader will hold a phone conference to analyse the issues and agree on a new deadline for delivery to the EC
    d. Considering the new deadline, the whole process and previous steps 1 to 5 will be adapted
    e. TECNALIA, the Author and the WP leader will hold a phone conference in the midterm before the deadline to analyse the right progress

Publications of joint project results, e.g. conference papers, brochures, public documents, etc., need approval of the involved partners and/or Coordinator.

3. Procedure for Progress Reporting

The methodology for reporting progress in the individual tasks (or subtasks, if existing), against the Detailed Work Programme itself, will be as follows:

1. Every two months a Web conference will be held (1 hour duration, in principle).
   a. It will be compulsory for all the partners, but specially for WP leaders
   b. The tentative periodic date will be the second Wednesday of the month, starting in June, at 11.00h. The precise date will be agreed in the previous Web conference
2. TECNALIA will remind the partners of each next meeting, 2 weeks in advance
3. TECNALIA will propose the agenda 3 days before the Web conference
4. The progress reporting will be realized in every CHESTER' General Assembly, where progress of each individual WP will be presented and discussed as necessary
5. WP leaders will distribute their updated progress reports to all the partners, 1.5 weeks before the GA meeting (or will ensure an updated version on CHESTER's collaborative space) Work Packages' Progress Reporting.

4. Detailed Work Plans

4.1 Introduction

The preliminary Detailed Work Plans corresponding to the different WPs are included hereafter. They correspond to a methodology agreed by CHESTER, and according to a basic structure and format unified for all the WPs (Figure 1). Each WP leader has been free to propose Sub-Tasks for managing specific activities, or to include additional tables or any other kind of information, such as the deliverables, that can help them visualize the different commitments and activities to be performed.

The Detailed Work Plans documents in detail the project work breakdown and the related elements that support the project's schedule. The actual schedule performance will be then periodically compared to planned performance in order to implement corrective action when actual performance deviates from planned or required performance. This internal monitoring will be facilitated by the project management structure. The Coordinator will monitor overall project progress with the help of the Work Package Leaders (WPLs). WPLs will report progress made on technical tasks since last report at every Project Steering Committee (PSC) meeting every 6 months.

Besides, every partner should submit interim Financial Statement *(“**CHESTER-PROGRESS REPORTING_[DATE].xls**”,)* to the Coordinator for financial monitoring every 6 months. Even though this is not a contractual obligation, it is strongly recommended, especially for partners with less management experience in European projects. The Coordinator will review, consolidate and inform WP Leaders. These reports will allow monitoring the progress, gathering the information periodically and will be the base of the Periodic and Final Reports.

Although this QAP document is not going to be updated after its delivery and acceptance by the EC, the Detailed Work Plans will be living documents, available in CHESTER' Portal, so they will be modified as needed throughout CHESTER's development.

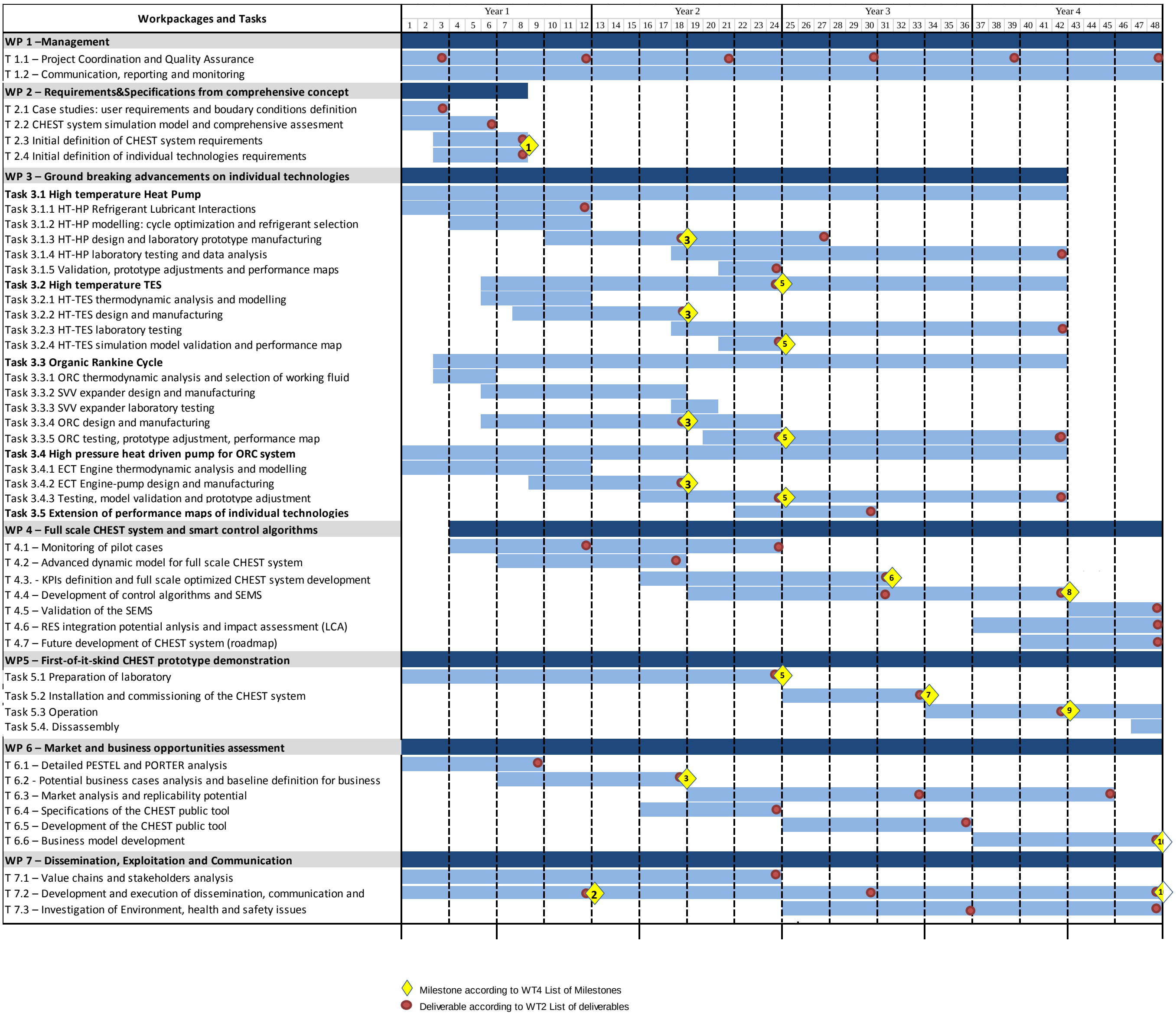

Figure 1. Gantt of the CHESTER project

1.1 WP1

WP1: Project coordination and quality assurance
Leader: TECNALIA / Timeline: 1-48

Description of the work:

- overall strategic and operational management
- ensure the coherence of all developments
- financial and administrative management
- manage public face of the project encouraging the networking with other projects and platforms

Table 1. Contributions of partners in WP1 (PM)

Tasks	TECNALIA	DLR	IREN	USTUTT	PLANENERGI	AIGUASOL	ECT	UGENT	UPV	ULSTER	PNO	GOIENER	Sum
T1.1 (timeline: 1-48) *Project coordination and quality assurance*	28	0,5	0,25	0,25	0,5	0,5	0,25	0,25	0,25	0,25	0,5	0,25	*31,75*
T1.2 (timeline: 1-48) *Communication, reporting and monitoring*	20	0,5	0,25	0,25	0,5	0,5	0,25	0,25	0,25	0,25	0,5	0,25	23,75
Sum	48	1	0,5	0,5	1	1	0,5	0,5	0,5	0,5	1	0,5	55,5

1.1.1 T1.1

Detailed description of the task work:

- manage the work progress
- Quality Assurance Plan
- Innovation Management Plan

Table 2. Contributions of partners in T1.1 (Task details and PM)

T1.1 **Project coordination and quality assurance**	TECNALIA	DLR	IREN	USTUTT	PLANENERGI	AIGUASOL	ECT	UGENT	UPV	ULSTER	PNO	GOIENER	Sum
Stabish the overall strategic and operation management	10	0,25			0,25	0,25					0,25		11
Quality Assurance	12	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	14,75
Financial and administrative management	6												6
Sum	28	0,5	0,25	0,25	0,5	0,5	0,25	0,25	0,25	0,25	0,5	0,25	*31,75*

1.1.2 T1.2

Detailed description of the task work:

- to perform fluent communication within the Consortium and with the EC
- internal and external monitoring of the project
- ensure the quality production of deliverables and reports

Table 3. Contributions of partners in T1.2 (Task details and PM)

T1.2 **Communication, reporting and monitoring**	TECNALIA	DLR	IREN	USTUTT	PLANENERGI	AIGUASOL	ECT	UGENT	UPV	ULSTER	PNO	GOIENER	Sum
Reporting	5	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	7,25
Public face management	5	0,25			0,25	0,25					0,25		5,5
Project monitoring	10												10
Sum	20	0,5	0,25	0,25	0,5	0,5	0,25	0,25	0,25	0,25	0,5	0,25	23,75

1.2 WP2

WP2: Requirements & specifications from comprehensive conceptual assessment
Leader: PLANENERGY / Timeline: 1-8

Description of the work:

- to establish the initial specifications of the project and the requirements for WP3, WP4 and WP5
- to assess from a holistic approach the CHEST system integrated into future smart energy systems
- to specify the requirements and specifications that the CHEST system and the individual technologies need to fulfil

Table 4. Contributions of partners in WP2 (PM)

Tasks	TECNALIA	DLR	IREN	USTUTT	PLANENERGI	AIGUASOL	ECT	UGENT	UPV	ULSTER	PNO	GOIENER	Sum
T2.1 (timeline: 1-3) *Case studies: user requirements and boundary conditions definition*	0,5	0,5	1,5	0,5	2,5	2						1	8,5
T2.2 (timeline: 1-6) *CHEST system simulation model and boundary conditions definition*	1	3	0,5	1,5	5	0	0,5	1	1			0,5	14

T2.3 (timeline: 2-8) *Initial definition of CHEST system requirements*		**1,5**	**1**	**1**	**2,5**	**0,5**							**6,5**
T2.4 (timeline: 3-8) *Definition and specification of some reference electricity grid and communication networks*	**2,5**	**1**			**1**		**0,5**	**1**	**2**	**0,5**			**8,5**
Sum	**4**	**6**	**3**	**3**	**11**	**2,5**	**1**	**2**	**3**	**0,5**		**1,5**	**37,5**

1.2.1 T2.1

Detailed description of the task work:

- for each of the 7 sites a technical report will be elaborated making it possible to calculate and optimize the pilot cases in the modelling in WP4
- the user requirements to the CHEST system for each of the main actors will be defined
- the existing boundary conditions (electricity tariffs and markets, electricity regulation methodology, DH temperatures...) will be described for each case study for the present situation, 2030 and 2050

Table 5. Contributions of partners in T2.1 (Task details and PM)

T2.1 **Case studies: user requirements and boundary conditions**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
For each of the 7 sites a technical report will be elaborated	**0,5**	**0,5**	**0,5**	**0,5**	**1**	**1**						**0,5**	**4,5**
User requirements to the CHEST system for each of the main actors			**0,5**		**0,5**	**0,5**						**0,5**	**2**
Boundary conditions			**0,5**		**1**	**0,5**							**2**
Sum	**0,5**	**0,5**	**1,5**	**0,5**	**2,5**	**2**						**1**	**8,5**

1.2.2 T2.2

Detailed description of the task work:

- to perform the simulations that will allow to define the specifications of the overall system and individual components
- starting point: the model of the CHEST cycle, as developed by DLR
- update of the CHEST model and definition of performance
- development of a system simulation model for the CHEST system integrated into the energy system
- profiles for: RES production, electric and thermal grids, electric and thermal consumption
- simulations/Calculations using the user requirements and T2.1's boundary conditions

Table 6. Contributions of partners in T2.2 (Task details and PM)

T2.2 **CHEST system simulation model and boundary conditions definition**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Perform the simulations		**1**			**0,5**								**1,5**
Model of the CHEST cycle, as developed by DLR		**2**			**0,5**								**2,5**
Update of the CHEST model and definition of performance	**0,5**				**0,5**		**0,5**	**0,5**	**0,5**				**2,5**
Development of a system simulation model for the CHEST system integrated	**0,5**			**0,5**	**0,5**			**0,5**	**0,5**				**2,5**
Profiles for: RES production, electric and thermal grid			**0,5**									**0,5**	**1**
Simulations/Calculations using the user requirements and T2.1's				**1**	**3**								**4**

boundary conditions													
Sum	**1**	**3**	**0,5**	**1,5**	**5**		**0,5**	**1**	**1**			**0,5**	**14**

1.2.3 T2.3

Detailed description of the task work:

- system requirements defined taking into account the requirements from model calculations in T2.2
- system requirements if district heating is not an option (ambient air cooling, cooling in rivers, lakes and sea)

Table 7. Contributions of partners in T2.3 (Task details and PM)

T2.3 **Initial definition of CHEST system requirements**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
System requirements definition from model calculations in T2.2		**1,5**	**1**	**1**	**2,5**	**0,5**							**6,5**
Sum	**0**	**1,5**	**1**	**1**	**2,5**	**0,5**							**6,5**

1.2.4 T2.4

Component requirements will be defined taking into account the requirements from model calculations in T2.2. The main outputs will be:

- HTHP: Response time, preferred temperatures at cold and warm side
- ORC/Heat engine: Response time and preferred temperatures at cold and warm side
- HT storage: Charge and discharge response time
- expected charge/discharge cycles/year and related demands according component life time if the CHEST system shall have a ***lifetime of 40 years.***

Table 8. Contributions of partners in T2.4 (Task details and PM)

T2.4 **Initial definition of individual technologies requirements**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Component requirements (WP3) from model calculations in T2.2	**2,5**	**1**			**1**		**0,5**	**1**	**2**	**0,5**			**8,5**
Sum	**2,5**	**1**	**0**	**0**	**1**	**0**	**0,5**	**1**	**2**	**0,5**			**8,5**

1.3 WP3

WP3: Ground breaking advancements on individual technologies
Leader: TECNALIA / Timeline: 1 - 42

Description of the work:

- to carry out the research and development work to deliver the ground breaking advancements on the individual technologies
- main outputs: component prototypes and experimentally validated performance maps
- all the prototypes will be integrated into the whole CHEST system prototype that will be built in WP5
- research the up scaling issues on the mentioned technologies (technology and cost)

Table 9. Contributions of partners in WP3 (PM)

Tasks	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
T3.1 (timeline: 1-42) *High temperature Heat Pump*	***25***								***19***	***17***			***24***
T3.2 (timeline: 6-24) *High temperature thermal energy storage*	***2***	***22***						***0,5***					**22**
T3.3 (timeline: 3-24) *Organic Rankine Cycle (ORC)*	***2***							***20***					**14**

T3.4 (timeline: 1-42) *High pressure heat driven pump for ORC system (ECT Engine-pump)*	***2***						***12***						**17,5**
T3.5 (timeline: 22-30) *Extension of performance maps from laboratory scale to real size technologies*	***3***	***2***	***1***				***1***	***3***	***5***	***2***			**20**
Sum	**34**	**24**	**1**	**0**	**0**	**0**	**13**	**23,5**	**24**	**19**	**0**	**0**	**138,5**

1.3.1 T3.1

Detailed description of the task work:

Subtask 3.1.1 HP thermodynamic analysis and modelling: selection of most suitable refrigerant and thermodynamic cycle

- the definition of the most suitable thermodynamic cycle for the HT-HP considering different refrigerants options
- pre-select the most suitable working fluids
  - thermodynamic efficiency
  - material compatibility
  - ASHRAE safety group (flammability and toxicity)
  - chemical stability
- regarding thermodynamic cycles different alternatives will be analysed
  - the most promising: two-stage compression
- the different parameters of the cycle will be optimized. Most important issues:
  - cycle architecture definition (simple/double stage, cascade structure, etc)
  - subcooling optimization (key variable in the control strategy to optimize the cycle efficiency)
  - adjustment of evaporator superheat to the properties of the refrigerant
  - definition of control strategies
- design the laboratory prototype, define the design specifications of the HT-HP solution for different potential applications and boundary conditions, and evaluate the HT-HP features in the operation range of different applications

Subtask 3.1.2 HP Refrigerant Lubricant Interactions

- the most appropriate lubricant for the refrigerant(s) selected in T3.1.1. will be identified
- assess the refrigerant-lubricant solubility and miscibility across the proposed temperature ranges as well as ensuring that the transport properties are sufficient
- develop small scale facilities
  - measure and simulate a range of oil-refrigerant mixtures
  - evaluate lubrication, transport and any potential loss in performance due to refrigerant-oil properties circulating, particularly in the evaporator, where transport issues tend to be noted

Subtask 3.1.3 HT-HP design and manufacturing of the laboratory scale prototype

- to analyse the compressor. The main points:

  - suitability, availability and behavior of the compressor technology/type depends on its size
  - for the cooling of the compressor: different alternatives will be analysed, new design specifications of the motor may be required due to higher refrigerant density at those temperatures
  - detailed modelling
  - provide strong relationships with main compressor suppliers
- manufacturing of the laboratory prototype manufacturing which includes the components selection, installation, wiring and monitoring equipment selection. The main activities are:
  - compressor selection and confirmation of the key parameters for the HT-HP prototype (according to the outcomes from T3.1.1):
  - analysis and selection of the heat exchangers
  - analysis and selection of the expansion device (able to fulfil the control specifications defined in T3.1.1)
  - analysis and selection of components for the lubrication system loop and definition of pipes diameters
  - definition of monitoring equipment
  - control system, including refining of the control strategy, definition of specific control algorithms, selection of software and hardware and programming
  - electrical installation

Subtask 3.1.4 HP laboratory testing and data analysis

- heat pump prototype be tested in the test rig of TECNALIA
- testing conditions: under a range of different temperature levels, heat flow rates and power input
  - protocols for safe start-up and shutdown, emergency cases, etc. will be tested
- validate the work developed in T3.1.2: several samples of refrigerant-lubricant mixture will be collected and, among other issues, the degradation level will be analysed in laboratory

Subtask 3.1.5 HP simulation model validation, prototype adjustment and performance maps

- the thermodynamic cycle model developed in T3.1.2 will be validated based on the experimental results obtained from T3.1.4
- once the heat pump model is validated, new simulations will be run to identify the possible performance optimization scenarios and apply them where necessary
- the required adjustments will be made to the prototype and definitive performance maps of laboratory HT-HP prototype will be concluded

Table 10. Contributions of partners in T3.1 (Task details and PM)

T3.1 **High temperature Heat Pump**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Subtask 3.1.1 HP thermodynamic analysis and modelling: selection of most suitable refrigerant and thermodynamic cycle	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8**	**2**	**0**	**0**	**13**
Modelling of large scale applications									**8**				**8**
Thermodynamic analysis linked with the HT-HP laboratory prototype	**3**												**3**
Link with the on-going work in T3.1.2										**2**			**2**
Subtask 3.1.2 HP Refrigerant Lubricant Interactions	**0,5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8**	**0**	**0**	**8,5**
Develop small scale facilities - identify refrigerant										**8**			**8**
Link with other subtasks	**0,5**												**0,5**
Subtask 3.1.3 HT-HP design and manufacturing of the laboratory scale prototype	**12**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**4**	**0**	**0**	**22**
Compressor selection and confirmation of the key parameters	**2**								**2**	**1**			**5**
Analysis and selection of the heat exchangers	**3**												**3**
Analysis and selection of the expansion device									**2**				**2**

Analysis and selection of components for the lubrication system										3			3
Definition of monitoring equipment	2												2
Control system, including refining of the control strategy	4								2				6
Electrical installation	1												1
Subtask 3.1.4 HP laboratory testing and data analysis	4	0	0	0	0	0	0	0	1	2	0	0	7
Heat pump prototype be tested in the test rig of TECNALIA	3								1				4
Protocols for safe start-up and shutdown, emergency…	1												1
Validate the work developed in T3.1.2										2			2
Subtask 3.1.5 HP simulation model validation, prototype adjustment and performance maps	5,5	0	0	0	0	0	0	0	4	1	0	0	10,5
The thermodynamic cycle model developed in T3.1.2 will be validated	3								1				4
New simulations will be run to identify the possible performance optimization	1								2				3
The required adjustments will be made to the prototype - performance maps	1,5								1	1			3,5
Sum	25	0	0	0	0	0	0	0	19	17	0	0	61

1.3.2 T3.2

Subtask 3.2.1 High temperature TES thermodynamic analysis and modelling

A detailed thermodynamic model of the HT-TES system will be used for predesign of the storage system and dimensioning of sub-components. The main activities for this are:

- Adapt existing simulation model: the high temperature TES system will likely be a **cascaded type system that consists of a latent heat storage unit using nitrate salts as the storage material and a pressurized hot water storage for sensible heat storage**. This unique layout is, according to current knowledge, necessary to:
    - follow the preheating and evaporation temperature profile of the ORC at best
    - lose as little exergy as possible
    - and, hence, lead to a high round trip efficiency
- dimension the sub-components based on numerical simulations
- find the best fitting phase change material with an applicable melting temperature
- predesign the heat exchanger that is integrated in the latent heat storage
    - compute a preliminary performance map of the storage system that shows the inlet- and outlet temperatures depending on the state of charge

Subtask 3.2.2 High temperature TES design and manufacturing

- Detailed engineering, design and manufacturing of the high temperature TES system:
    - based on the predesign and dimensioning resulting from T3.2.1
    - includes the installation of the monitoring equipment

Subtask 3.2.3 High temperature TES laboratory testing

- test the high temperature TES system in a DLR laboratory
- experimental analysis of the component interaction, performance and behaviour under all relevant operating modes (inputs from WP2)
- technical improvements and adjustments of the prototype will be implemented

Subtask 3.2.4 High temperature TES simulation model validation and performance map

Based on the experimental results of T3.2.3 and the results of the experimental analysis of the heat pump and ORC gained in tasks 3.1.3 and 3.3.3:

- validate the thermodynamic model developed in T3.2.1
- detect possible performance optimization of the high temperature TES system in the interplay with the ORC and heat pump
- adjust if necessary laboratory prototype

- finalize the preliminary performance map of T3.2.1

Table 11. Contributions of partners in T3.2 (Task details and PM)

T3.2 **High temperature thermal energy storage**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Subtask 3.2.1 High temperature TES thermodynamic analysis and modelling		**5**						**0,5**					**5,5**
Subtask 3.2.2 High temperature TES design and manufacturing		**7**											**7**
Subtask 3.2.3 High temperature TES laboratory testing		**4**											**4**
Subtask 3.2.4 High temperature TES simulation model validation and performance map	**2**	**6**											**8**
Thermodynamic model and possible performance optimization	**1**	**5**											**6**
Performance map	**1**	**1**											**2**
Sum	**2**	**22**						**0,5**					**24,5**

1.3.3 T3.2

Subtask 3.3.1 ORC thermodynamic analysis and modelling

- theoretical assessment of the ORC and expander performance
  - models developed in this task are essential for sizing and selection of the ORC components later on
  - selection of the working fluid will be of particular interest
- due to the various load variations in the CHEST system, the **transient behaviour of the heat exchangers** requires investigation
  - transient heat exchanger models developed at UGENT will be adapted to the CHEST concept
    - models will be implemented in Python
    - effect on the whole system will be analysed: optimal size of the heat exchangers, robust and fast control with a high efficiency of the ORC
    - an existing semi-empirical model of a single screw expander will be adapted to include the sliding volume valve (SVV) for improved off-design performance
    - both the transient heat exchanger model and the SVV expander model will be integrated into a complete ORC simulation

Subtask 3.3.2 SVV expander design and manufacturing

- An innovative sliding volume valve (SVV) will be installed in a single screw expander. The expander has a proposed shaft power output of 10 kWe. This work is done in close co-operation with BEP-Europe. BEP-Europe will adapt one of their single screw expanders to include the SVV in dialogue with UGENT on the basis of the results from T3.3.1

Subtask 3.3.3 SVV expander laboratory testing

- the novel prototype of the SVV screw expander will be tested on an existing UGENT test-bench
  - specifically designed for small scale expander testing
  - wide range of operating conditions
  - set of experiments will be made with the SVV at nominal condition
  - different set points of the SVV will be applied to make sure the expander works according to the specifications
  - correct operation during on-line SVV variations will be examined
- with the data from this task, the semi-empirical model from task 3.3.1 will be validated

Subtask 3.3.4 ORC design and manufacturing

- based on the dimensioning and optimization in T3.3.1, the ORC components will be selected and modified if required
- the manufacturing and design will be done by BEP Europe (expander manufacturer)

- the installation will include the monitoring and control system with sensors (pressure, temperature, flow) in all points relevant for the analysis in WP5 of the overall CHEST system
- protocols for steady-state operation at different setpoints and safe start-up and shutdown, emergency procedures will be implemented
- a theoretical investigation considering several volumetric expanders in parallel (with or without an SVV) will be investigated
    - qualitative comparison with turbine technology
        - performance maps for the turbine are compiled from literature
    - results of this study will feed T3.5. about the extension of performance maps

Subtask 3.3.5 ORC testing, prototype adjustment, performance map

- The ORC prototype will be tested in the laboratory of UGENT, where an appropriate heat source (thermal oil heater) and cooling loop are already present
- very and correct performance under the set-points required for the CHEST system
- validate against the experimental results of the thermodynamic cycle model developed in T3.3.1
    - then new simulations will be run to identify the possible performance optimization scenarios and apply them where necessary
    - the required adjustments will be made to the prototype and definitive performance maps will be recorded
- the ORC module, with the new SVV expander, will then be shipped to DLR (WP5)

Table 12. Contributions of partners in T3.3 (Task details and PM)

T3.3 **Organic Rankine Cycle (ORC)**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Subtask 3.3.1 ORC thermodynamic analysis and modelling								5					5
Subtask 3.3.2 SVV expander design and manufacturing								2					2
Subtask 3.3.3 SVV expander laboratory testing								2					2
Subtask 3.3.4 ORC design and manufacturing								6					6

Subtask 3.3.5 ORC testing, prototype adjustment, performance map	**2**							**5**					**7**
Correct performance verified - thermodynamic cycle validated	**1**							**4**					
Definitive performance maps	**1**							**1**					**2**
Sum	**2**							**20**					**22**

1.3.4 T3.4

Subtask 3.4.1 ECT Engine thermodynamic analysis and modelling

- select working fluid of the engine
- lay theoretical background
    - for maximizing the engine thermal efficiency and power
    - for the determination of the design parameters providing the required power of the ORC high-pressure pump (T3.3.1)
- special attention to the heat regeneration, because of non-ideal properties of the working fluids
- working fluid:
    - high thermal expansion, low compressibility in the liquid phase
    - nontoxic, environmental acceptable, stable and not corrosive
    - first option: working fluid for the ORC
    - Otherwise light hydrocarbons and refrigerants
    - or a compound working fluid (mixtures) will be designed
- to optimize the engine performance: comprehensive, predictive models of the main engine components (heater, cooler, and regenerator) and a dynamic model of the whole engine will be developed
    - finding a compromise between low heat losses, high heat exchange rates, low pressure drops, small dead volumes, high heat capacity of the solid phase and small footprint

Subtask 3.4.2 ECT Engine-pump design and manufacturing

- based on the experience obtained in the previous projects and theoretical results of T3.4.1
- production drawings and engine manufacturing: by a specialized machine-building company
- the engine will contain many standard parts such as sealing rings, connectors, tubing, fittings, etc.
- engine’s designed parts: heat exchangers, displacer, engine body, etc.
    - standard parts (sealing rings, connectors, tubing, fittings, etc.) will be selected and ordered

Subtask 3.4.3 ECT Engine-pump laboratory testing, simulation model validation and prototype adjustment

- an experimental set-up for testing of the engine will be developed and built
- measure and record all the process parameters (pressures, temperatures, frequency of the displacer reciprocation, flow rates)
- tests will be performed at different operating regimes and go in parallel with the theoretical research towards optimization of the engine performance
- learn about and demonstrate the engine capabilities for the CHEST system

- the engine will also be combined with a hydraulic motor producing shaft power which can be used to generate electricity and/or drive centrifugal pumps
- the experimental data will be used for validation of the model, which will be applied for the prototype adjustment (increasing the energy efficiency and power density
- eventually the engine performance map will be provided

Table 13. Contributions of partners in T3.4 (Task details and PM)

T3.4 **High pressure heat driven pump for ORC system (ECT Engine-pump)**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Subtask 3.4.1 ECT Engine thermodynamic analysis and modelling							**3**						**3**
Subtask 3.4.2 ECT Engine-pump design and manufacturing							**5**						**5**
Subtask 3.4.3 ECT Engine-pump laboratory testing, simulation model validation and prototype adjustment	**2**						**4**						**6**
Record process parameters, tests performed, demonstrate capabilities for CHEST	**1,5**						**3**						**4,5**
Definitive performance maps	**0,5**						**1**						**1,5**
Sum	**2**						**12**						**14**

1.3.5 T3.5

Detailed description of the task work:

- deliver to WP4 (T4.2) the performance maps of the real size individual technologies, which will be got based on the experimentally validated performance maps of laboratory scale prototypes
    - Key technological as non-technological aspects will be considered such as the effect of the isoentropic efficiency, suitability and features of available technology types for each component depending on the size, etc.

Table 14. Contributions of partners in T3.5 (Task details and PM)

T3.5 **Extension of performance maps from laboratory scale to real size technologies**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Thermodynamic model and possible performance optimization	**1**		**1**					**1**	**5**	**1**			**9**
Performance map	**2**	**2**					**1**	**2**		**1**			**8**
Sum	**3**	**22**					**1**	**3**	**5**	**2**			**17**

1.4 WP4

WP4: Full scale CHEST system and smart
Leader: AIGUASOL / Timeline: 3 - 42

Description of the work:

- Techno-economic assessment of full scale CHEST system in real applications based on monitoring data of pilot sites
- Development of algorithms and control strategies based on ANN to efficiently operate the full scale CHEST system
- Development of Smart Energy Management System (SEMS) to visualize and control the CHEST system into real applications
- CHEST potential assessment to provide economically feasible system support functions to the future energy system through pilot testing of the SEMS in real applications
- RES integration potential quantification
- Roadmap elaboration for future perspectives of the CHEST system

Table 15. Contributions of partners in WP4 (PM)

Tasks	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
T4.1 (timeline: 3-24) *Monitoring of pilot cases*	*2*		*3*	*3*	*1*	*10*						*1*	*20*
T4.2 (timeline: 6-18) *Advanced dynamic model for full scale CHEST system integration into energy networks*	*1*	*1*	*1*	*6*	*1*	*8*			*2*			*1*	*21*

T4.3 (timeline: 16-31) *Key Performance Indicators definition and full scale optimized CHEST system development*	***5***	***0,5***	***1,5***	***12***	***2***							***2***	***23***
T4.4 (timeline: 18-42) *Development of control algorithms and Smart Energy Management System*	***1***	***1***	***1,5***	***3***	***2***	***16***						***1***	***25,5***
T4.5 (timeline: 42-48) *Validation of the SEMS*	***1***		***1***	***5***	***1***	***2***						***0,5***	***10,5***
T4.6 (timeline: 37-48) *RES integration potential analysis and impact assessment from life cycle perspective*	***3***			***2***	***4***	***4***						***1,5***	***14,5***
T4.7 (timeline: 40-48) *Future development of CHEST system (Roadmap)*	***1***	***1***	***1***	***4***	***1***		***0,5***	***0,5***	***1***			***1***	***11***
Sum	**14**	**3,5**	**9**	**35**	**12**	**40**	**0,5**	**0,5**	**3**			**8**	**126**

1.4.1 T4.1

Detailed description of the task work:

- two case studies with highest realization potential will be selected (D2.1). For each pilot case:
    - the parameters that have to be measured (to be used directly or for indirect calculations) and the most appropriate monitoring procedures will be identified
    - communication protocols will be defined
    - the measured data at an appropriate time resolution are, among others:
        - available and demanded electric power and heat
        - temperatures of heat sources
        - weather data
    - the most appropriate interface and platform will be developed for monitoring data acquisition
- evaluation of monitoring data: the measured data will be used to develop load and availability profiles of electricity and thermal energy
    - these profiles will then be implemented in the CHEST integrated model in T4.2
    - the monitoring platform will serve as basis for the SEMS interface to be developed in T4.4.
    - monitoring platform ready for collecting monitoring data from the selected pilot sites
    - annual energy profiles available

Table 16. Contributions of partners in T4.1 (Task details and PM)

T4.1 **Monitoring of pilot cases**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Two case studies selected			**1**	**1**	**1**	**2**							**6**
Communication platforms	**1**		**1**	**1**		**4**							**7**
Monitoring	**1**		**1**	**1**		**4**							**7**
Sum	**2**		**3**	**3**	**1**	**10**							**20**

1.4.2 T4.2

Detailed description of the task work:

- an advanced dynamic model for the full scale CHEST system integration into the energy system will be designed and developed
    - based on the work performed in WP2
    - to be used to model the behaviour of all the components of the system as a whole with a high level of detail in order to optimize the CHEST system design
    - to evaluate its integration into real applications in terms of efficiencies, economics and ecology
    - will be the basis for the SEMS
- individual technologies will be represented according to the inputs received from WP3
- the boundary conditions and their implementation in the TRNSYS model will be defined
    - each pilot case requires a different set of boundary conditions
    - these sets must be implemented into the model and the necessary adjustments must be done in the source codes of the related types
- the model (so far focused on technical approach -in WP2) will be complemented with economic data
    - a suitable interface between the simulation results (thermodynamic) of the TRNSYS model and the economic data must be implemented
- the interfaces for the implementation and interaction with external boundaries (power grid, thermal network, demand-side, other RES…) will be defined, adjusted and integrated into the model
- the developed model its highly flexible and adjustable structure and relatively quickly to be adjusted to the pilot case's specific characteristics
        - to avoid the need to develop a specific model for each case
        - and to optimize the required resources for this task

Table 17. Contributions of partners in T4.2 (Task details and PM)

T4.2 **Advanced dynamic model for full scale CHEST system integration into energy networks**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Model design in TRNSYS		**1**	**1**	**5**		**6**			**2**				**15**
Boundary conditions for each pilot	**1**			**0,5**		**1**						**1**	**3,5**

Interfaces for the implementation and interaction with external boundaries				**0,5**	**1**	**1**							**2,5**
Sum	**1**	**1**	**1**	**6**	**1**	**8**			**2**			**1**	**21**

1.4.3 T4.3

Detailed description of the task work:

- focused on the integration of the optimized CHEST system into the energy system
  - research work mainly based on dynamic simulations (model developed in T5.2)
  - KPI will be defined:
    - *savings of primary energy and CO2 emissions*
    - *increase of energy efficiency*
    - *share of renewable energy*
    - *energetic and economic payback time*
- analysis and optimization of the different operation models of the CHEST system
  - scenarios in the future energy system (WP2) and different boundary conditions
    - the project case studies will be used (represent a wide variety of real situations)
    - the best operation strategies will be defined to effectively operate the CHEST system, at optimal cost and minimum energy use and environmental impact
    - analysis to provide outputs to WP5: optimum control strategies for the CHEST laboratory prototype
  - dimensioning of the CHEST system in different case studies, besides specific results for particular sites, the study will allow to conclude key features for the design of CHEST systems for future potential projects
- techno-economic assessment of the CHEST system in different pilot cases

Table 18. Contributions of partners in T4.3 (Task details and PM)

T4.3 **Key Performance Indicators definition and full scale optimized CHEST system development**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Analysis and optimization of the different operation models	**3**	**0,5**		**8**									**11,5**
Dimensioning of the CHEST system in different case studies	**1**		**1**	**2**	**1**							**1**	**6**

Techno-economic assessment of the CHEST system in different pilot cases	**1**		**0,5**	**2**	**1**							**1**	**5,5**
Sum	**5**	**0,5**	**1,5**	**12**	**2**							**2**	**23**

1.4.4 T4.4

Detailed description of the task work:

- the SEMS for the full scale CHEST system will be developed
    - operation strategy of the CHEST system at each moment
    - operated at the best way considering
        - the interactions with the electric grid (supply and demand side)
        - the interaction with the DH network and the integration of other sources
    - forecast of electricity price and demand, heat demand and weather
    - developed and applied to at least 2 pilot cases (selected and monitored in T5.1)
- development of the SEMS platform
- implementation of the model developed in T4.2. and results of T4.3. about the optimized CHEST system and operation strategies
- use of predictive algorithms and their implementation into the control system (programming)
- development of the interface to visualize the operation of the CHEST system
- implementation of KPIs defined in T4.3 and their calculation
- the SEMS will provide the operation strategy of the CHEST system at each moment and will visualize the main KPIs
- the user will be able to see, besides the investment cost of the system
    - how it is performing at each moment
        - energy balance of the system
        - charging/discharging mode
        - operation costs, …etc.
    - the associated benefits
        - energy savings, economic savings, reduction of CO_2 emissions, etc.
- analysis of the potential of heat-electrical storage integration of the CHEST depending on site conditions
- control strategies implemented in the CHEST laboratory prototype (WP5)
- validation when fully operative

Table 19. Contributions of partners in T4.4 (Task details and PM)

T4.4 **Development of control algorithms and SEMS**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Development of the SEMS platform			**1**	**1**	**1**	**5**						**1**	**9**
Implementation model developed in T4.2. and results of T4.3: operation strategies	**1**					**5**							**6**
Interface to visualize the operation of the CHEST system		**1**				**2**							**3**
User monitoring of CHEST operation						**2**							**2**
Analysis of the potential of heat-electrical storage integration of the CHEST			**0,5**	**2**	**1**	**2**							**5,5**
Sum	**1**	**1**	**1,5**	**3**	**2**	**16**						**1**	**25,5**

1.4.5 T4.5

Detailed description of the task work:

- analysis and validation of the CHEST system functionalities by testing the developed SEMS into pilot cases
  - this will show how the developed SEMS control strategy works in the specific boundary conditions of the different pilot cases
  - all the possible beneficiaries of the future CHEST system in the pilot cases will be involved in this pilot testing of the SEMS
  - comparison between the current situation of the pilot cases without a CHEST system and the case with an integrated CHEST system with SEMS control strategy
  - conclusion on the benefits for the specific pilot cases

Table 20. Contributions of partners in T4.5 (Task details and PM)

T4.5 **Validation of the SEMS**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Analysis and validation by testing the developed SEMS into pilot cases				**4**		**1**							**5**
Comparison situation with/without CHEST - benefits for the specific pilot cases	**1**		**1**	**1**	**1**	**1**						**0,5**	**5,5**
Sum	**1**		**1**	**5**	**1**	**2**						**0,5**	**10,5**

1.4.6 T4.6

Detailed description of the task work:

- potential of the CHEST system to increase the RES penetration in the grid will be concluded based on different scenarios foreseen and on different renewable generation profiles, mainly for electricity generation from wind and PV
- potential of other competing technologies will be also considered, based on
    - technical features (concluded in WP4)
    - potential market niche for the CHEST (inputs from WP6)
- development of a deep environmental impact assessment based on life cycle approach (LCA)

Table 21. Contributions of partners in T4.6 (Task details and PM)

T4.6 **RES integration potential analysis and impact assessment from life cycle perspective**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Potential analysis based on the foreseen scenarios	**1**			**1**	**3**	**2**						**1**	**8**
Potential of other competing technologies				**1**	**1**	**1**						**0,5**	**3,5**
Development of environmental impact assessment based LCA	**2**					**1**							**3**
Sum	**3**			**2**	**4**	**4**						**1,5**	**14,5**

1.4.7 T4.7

Detailed description of the task work:

- the future perspectives of the CHEST system will be evaluated in terms of optimization and further development
    - roadmap:
        - technological progress overview: increased efficiency and flexibility, system integration, etc.
        - required R&D work for the next decades
    - other technologies, their development stage and potential
    - other on-going roadmaps
    - network connection codes

Table 22. Contributions of partners in T4.7 (Task details and PM)

T4.7 **Future development of CHEST system (Roadmap)**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Roadmap: technological progress overview, increased efficiency and flexibility		1	1	2			0,5	0,5	1			1	7
Required R&D work for the next decades	1			1									2
Other technologies and roadmaps				1									1
Network connection codes					1								1
Sum	1	1	1	4	1		0,5	0,5	2				11

1.5 WP5

WP5: First-of-its-kind CHEST prototype
Leader: DLR / Timeline: 1 - 48

Description of the work:

- successfully build and operate a laboratory CHEST system showing:
    - its capability to handle various operation modes
    - its potential suitability for performing as an efficient heat and electricity storage and management system
- indispensable basis for every potential further development or upscaling to real pilot demonstrations in subsequent projects
- complete preparation of the test site at DLR in order to minimize any time risks
- delivery of the components “heat pump”, “ORC” and “ECT engine-pump” developed
- assembly of the components
- test series for a comprehensive characterization of the system performance (inputs from WP2)

Table 23. Contributions of partners in WP5 (PM)

Tasks	TECNALIA	DLR	IREN	USTUTT	PLANENERGI	AIGUASOL	ECT	UGENT	UPV	ULSTER	PNO	GOIENER	Sum
T5.1 (timeline: 1-24) *Preparation of laboratory*	*1*	*18*					*0,5*	*0,5*	*1*	*0,5*			*21,5*
T5.2 (timeline: 24-33) *Preliminary installation of high temperature TES*	*4*	*13*					*1,5*	*1,5*	*1*	*1*			*22*

T5.3 (timeline: 33-48) *Operation*	***4***	***12***	***1***				***1***	***1,5***	***1***	***1***			**21,5**
T5.4 (timeline: 46-48) *Disassembly*	***1***	***2***					***0,5***	***0,5***					**4**
Sum	**10**	**45**	**1**				**3,5**	**4**	**3**	**2,5**			**69**

1.5.1 T5.1

Detailed description of the task work:

- preparation of laboratory space, electrical connections, cooling water net
  - preparation of the electricity supply for the compressor and the pumps
  - load absorption of the heat engine
  - connection to the existing cooling water net at DLR
- preparation of safety devices and exhaust air system
  - Some of the potential working fluids for the heat pump and ORC cycle can be hazardous substances. They can to some extent be toxic, inflammable or explosive.
  - Although modern basic safety equipment is already installed in the laboratory, checking the additional requirements for the chosen working fluids is mandatory.
  - Potentially, specific safety devices such as an eye shower or an adequate exhaust air system must be installed.
- preparation of data acquisition and control system:
  - the data acquisition and control system will be planned and installed
  - interfaces between the component controllers and the superordinate controller of the whole system will be coordinated between the involved partners
  - real time visualization of the operation and an online access for all partners
  - the procedure for data collection and monitoring data analysis will be established
- planning of system layout and pipe connections between the components:
  - three-dimensionally system layout
  - pipe connections between the components at the sub-system boundaries will be coordinated between the involved partners
- design and installation of temperature controlled heat source and heat sink:
  - heat sink and heat source (temperature-controlled buffer tanks) → designed and installed
      - connection of the cold buffer tank to the cooling network (cooling capacity of 150kWth at 12°C)
    - installation of electric heater
      - 100kW for heating the hot buffer tank to 100°C
      - temperature controlled mixing valves for return addition will be installed on both sides (to cover the temperature range for all possible operation modes)
- preliminary installation of high temperature TES:
  - everything prepared for the subsequent installation of the components developed by the other partners

Table 24. Contributions of partners in T5.1 (Task details and PM)

T5.1 **Preparation of laboratory**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Preparation of laboratory space, electrical connections, cooling water net		7											7
Preparation of safety devices and exhaust air system		1											1
Preparation of data acquisition and control system	0,5	3							0,5				4
Planning of system layout and pipe connections between the components	0,5	2					0,5	0,5	0,5	0,5			4,5
Design and installation of temperature controlled heat source and heat sink		2											2
Preliminary installation of high temperature TES		3											3
Sum	1	18	0	0	0	0	0,5	0,5	1	0,5			21,5

1.5.2 T5.2

Subtask 5.2.1 Installation of the heat pump

- HP will be installed by TECNALIA and DLR at the prepared laboratory site at DLR connected to the other components and to the prepared data acquisition and control system

Subtask 5.2.2 Installation of the ORC

- the ORC will be installed by UGENT and DLR at the prepared laboratory site at DLR connected to the other components and to the prepared data acquisition and control system

Subtask 5.2.3 Installation of the ECT Engine-pump

- the ECT engine will be installed by ECT and DLR at the prepared laboratory site at DLR connected to the other components and to the prepared data acquisition and control system

Subtask 5.2.4 Commissioning of the CHEST system

- the components will be filled with working fluid and operation readiness will be individually checked
- whole CHEST system commissioned
    - test procedure developed and followed to ensure the operation readiness of the whole system including data acquisition and control

Table 25. Contributions of partners in T5.2 (Task details and PM)

T5.2 **Preliminary installation of high temperature TES**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Subtask 5.2.1 Installation of the heat pump	**4**	**2**							**1**	**1**			**8**
Subtask 5.2.2 Installation of the ORC		**4**						**1,5**					**5,5**

Subtask 5.2.3 Installation of the ECT Engine-pump		**3**					**1,5**						**4,5**
Subtask 5.2.4 Commissioning of the CHEST system		**4**											**4**
Sum	**4**	**13**					**1,5**	**1,5**	**1**	**1**			**22**

1.5.3 T5.3

Subtask 5.3.1 Set up test procedures

- test procedures covering all operating modes will be defined by the involved partners (ramp-up, partial charge and discharge trials)
- in parallel to the conduct of the tests in T5.3.2 (to be able to react to trial results)

Subtask 5.3.2 Conduct test procedures

- Test trials will be conducted in accordance to procedures planned in T5.3.1

Subtask 5.3.3 Data analysis and finalized performance maps

- all data generated during the test trials will be prepared and analysed focus on the data characterizing the performance of:
    - the whole CHEST system
    - their components
- provide the finalized performance maps of the components and the whole CHEST laboratory prototype

Table 26. Contributions of partners in T5.3 (Task details and PM)

T5.3 **Operation**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Subtask 5.3.1 Set up test procedures	1	4											5
Subtask 5.3.2 Conduct test procedures	2	4	0,5				0,5	0,5	0,5	0,5			8,5
Subtask 5.3.3 Data analysis and finalized performance maps	1	4	0,5				0,5	1	0,5	0,5			8
Sum	4	12	1				1	1,5	1	1			21,5

1.5.4 T5.4

Detailed description of the task work:

- at the end of the project the CHEST system will be disassembled and components will be shipped back to the partners

Table 27. Contributions of partners in T5.4 (Task details and PM)

T5.4 **Disassembly**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Components back to the corresponding partners	**1**	**2**					**0,5**	**0,5**					**4**
Sum	**1**	**2**	**0**	**0**	**0**	**0**	**0,5**	**0,5**					**4**

1.6 WP6

WP6: Market and business opportunities assessment
Leader: PLANENERGI / Timeline: 1 - 48

Description of the work:

- identify the legal requirements and constraints affecting the future implementation of the CHEST system in different EU countries
- analyse and quantify the market
    - gain insight into the potential for replication of the CHEST system
- identify new market mechanisms, roles and potential beneficiaries
    - develop economically feasible business models for a successful market deployment of the CHEST system into future smart energy systems
- quantify environmental, economic and social impacts from life cycle perspective
- develop a public and friendly tool dedicated to show the potential of CHEST system to its potential users
    - to be used in pre-design phases

Table 28. Contributions of partners in WP6 (Task details and PM)

Tasks	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
T6.1 (timeline: 1-9) *Detailed PESTEL and PORTER analysis*			***1***		***3***	***1***					***0,5***	***2***	***7,5***
T6.2 (timeline: 6-18) *Potential business cases analysis and baseline definition for business models*	***2***		***3***		***2***	***1***						***1***	***9***

T6.3 (timeline: 19-45) *Market analysis and replicability potential*	*2*		*2*		*3*	*1*					*0,5*	*2*	**10,5**
T6.4 (timeline: 16-24) *Specifications of the CHEST public tool*	*0,5*		*0,5*	*1,5*	*0,5*	*3*			*0,5*			*1*	**7,5**
T6.5 (timeline: 25-36) *Development of the CHEST public tool*				*3*	*0*	*9*							**12**
T6.6 (timeline: 37-48) *Development of innovative business models*	*1*	*0,5*	*3,5*	*0,5*	*3*	*1*	*2*	*0,5*	*0,5*	*0,5*	*0,5*	*2*	**15,5**
Sum	**5,5**	**0,5**	**10**	**5**	**11,5**	**16**	**2**	**0,5**	**1**	**0,5**	**1,5**	**8**	**62**

1.6.1 T6.1

Detailed description of the task work:

- political, economic, social, technological, environmental and legal (**PESTEL**) framework analysis of the electric market for the CHEST system integration
  - o study to be applied to the EU countries represented by the Consortium (Spain, Denmark, Germany, Italy, Belgium, The Netherlands)
- Porter analysis to conclude
  - o strengthens and potential benefits of the CHEST system
  - o market forces that can help CHEST enter in the different markets and applications
- analyse the legal and regulation framework of national grid codes to identify the specifications and requirements that should be taken into account
  - o an appropriate consideration of the identified issues on the design level (T4.3), operational strategies (T4.4) and business models (T6.6) is necessary to increase the market implementation potential.
- the final outcomes, once the CHEST system is developed according to identified legal requirements, will be considered in T4.7. "Future development of CHEST system (roadmap)"
  - o legal boundary conditions in different countries identified
  - o market opportunities and requirements for the CHEST system integration in 6 EU countries

Table 29. Contributions of partners in T6.1 (Task details and PM)

T6.1 **Detailed PESTEL and PORTER analysis**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Political, economic, social, technological, environmental and legal (PESTEL)					**1,5**						**0,5**		**2**
Porter analysis					**1,5**								**1,5**
Analyse the legal and regulation framework of national grid codes			**0,5**			**0,5**						**1**	**2**

Market opportunities and requirements for CHEST in 6 EU countries			**0,5**			**0,5**						**1**	**2**
Sum			**1**		**3**	**1**					**0,5**	**2**	**7,5**

1.6.2 T6.2

Detailed description of the task work:

- analyse the competitive advantage of the CHEST system for the different services that it can provide to the energy systems in different EU countries
    - to be applied to the 7 case studies
    - identify the CHEST value by running national or regional scenario calculations
        - CHEST will be compared to the alternatives, for instance
            - hydrogen production
            - storage
            - use in fuel cells in periods more than 24 hours with too low fluctuating electricity production
            - definition of potential business cases at system level
- initial economic assessment related to the CHEST system integration into the energy system
- economic baseline definition for the CHEST market implementation

Table 30. Contributions of partners in T6.2 (Task details and PM)

T6.2 **Potential business cases analysis and baseline definition for business models**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Analyse the competitive advantage of the CHEST - applied to the 7 case studies	**1**		**1**		**1**	**0,5**						**1**	**4,5**
Compared to alternatives: H2…			**1**			**0,5**							**1,5**
Economic assessment and market baseline	**1**		**1**		**1**								**3**
Sum	**2**		**3**		**2**	**1**						**1**	**9**

1.6.3 T6.3

Detailed description of the task work:

- preliminary market analysis; mainly potential of “technological market”
- comprehensive market analysis, considering market and economic boundary conditions
    - to conclude the potential market in which the CHEST system can be economically feasible, identifying the required boundary conditions

Table 31. Contributions of partners in T6.3 (Task details and PM)

T6.3 **Market analysis and replicability potential**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Preliminary market analysis	0,5		0,5		1							1	3
Comprehensive market analysis, considering market and economic boundary conditions	1,5		1,5		2	1					0,5	1	7,5
Sum	2	0	2	0	3	1	0	0	0	0	0,5	2	10,5

1.6.4 T6.4

Detailed description of the task work:

- define the list of specifications for the "CHEST tool"
  - will require to define precisely the potential target(s) of the tool and to understand clearly its expected functionality
    - inputs from potential users should collected and feedback of similar tools in the market
    - definition of the boundary conditions for the approach of calculations and solutions
  - according to the inputs collected by the tool interface
    - the corresponding software to make the required calculation will be called
    - it will provide the solutions of several metrics and KPIs (defined in T4.3) in an output interface

Table 32. Contributions of partners in T6.4 (Task details and PM)

T6.4 **Detailed PESTEL and PORTER analysis**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Define clearly its expected functionality	0,5		0,5	1	0,5	2						0,5	5
Inputs collected by the tool interface and calculations requirements				0,5		1			0,5			0,5	2,5
Sum	0,5	0	0,5	1,5	0,5	3	0	0	0,5	0	0	1	7,5

1.6.5 T6.5

Detailed description of the task work:

- implementation of the tool on any computing language appropriate to create a web site running platform
    - tool based mainly in the performance maps developed in WP4
    - according to the specifications of the previous section
    - implemented in a friendly-user web-site interface
    - includes the selected models developed (WP4)
    - allows specifying the parameters needed for the calculations and generate the desired outputs
- tool to be implemented in a web site platform
    - to maximize the widespread dissemination and engagement of stakeholders all around EU
    - friendly-user platform easily usable for people from both energy field and industrial sector
    - alfa-tests of the tool will be performed by the partners working in this task

Table 33. Contributions of partners in T6.5 (Task details and PM)

T6.5 **Development of the CHEST public tool**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Implementation of the tool in a web site platform				**3**		**9**							**12**
Sum				**3**		**9**							**12**

1.6.6 T6.6

Detailed description of the task work:

- implement/simulate the new market mechanisms developed within the CHESTER project including the aggregator.
- In the different case studies, the main actors will be:
    - DH utilities with thermal storages
        - DH utilities could install and operate the CHEST system
        - Incomes will come from frequency regulation, sold electricity and sold heat
        - New possibilities:
            - integration and utilization of more excess heat
            - electricity production without smoke
    - BRP
        - get bids by DH utilities
        - functions as aggregator
    - Industries and geothermal plants with excess heat
        - can make a business model as third party supplier in a DH system
            - since more excess heat could be utilized in a DH network connected to a CHEST system
            - in the new context low temperature excess heat could become valuable as heat source (for HT-HPs)
    - Unflexible electricity producers with excess heat (waste incineration plants, biogas plants, biomass CHP, …)
            - can add flexibility to their systems, utilize own electricity production themselves in periods with low prices and produce extra electricity in periods with high prices
    - Flexibility users (RES producer, DSO, TSO, Traders):
        - RES developers (wind, solar) might in the future have periods where electricity prices are near zero
            - some are developing storage systems to avoid that situation
            - these systems can have a CHEST and add flexibility to the wind or PV plant
        - DSOs and TSOs might invest in CHEST as they invest in pumped hydro or batteries
            - CHEST works very much as a pumped hydro plant integrated in a DH system
            - only difference: connection to DH. Excess heat could come from transformer stations
- CHEST investment costs will be considered
    - different revenues from the implementation of the strategies for the various users
    - thorough effort for a financial analysis of the feasibility of the concept in the different cases

Table 34 . Contributions of partners in T6.6 (Task details and PM)

T6.6 **Development of innovative business models**	TECNALIA	DLR	IREN	USTUTT	PLANENERGI	AIGUASOL	ECT	UGENT	UPV	ULSTER	PNO	GOIENER	Sum
Implement/simulate CHESTER's market mechanisms	0,5		1,5	0,5	2	1	1	0,5	0,5	0,5			8
Analysis of revenues for the different stakeholders		0,5	1		0,5		1				0,5	1	4,5
Financial feasibility for the different business cases	0,5		1		0,5							1	3
Sum	1	0,5	3,5	0,5	3	1	2	0,5	0,5	0,5	0,5	2	15,5

1.7 WP7

WP7: Dissemination, exploitation and communication
Leader: PNO / Timeline: 1 - 48

Description of the work:

- promote the up-scale and use of the newly developed technologies amongst specifically identified EU and International organisations providing opportunities for stakeholders to deliver feedback on the project results to identify future collaboration
- facilitate a short time to market of the project results
- design and execute effective dissemination, exploitation and communication strategies for the benefit of the EU industry, the EU research area, and the public at large
- identify the major environmental, health and safety hazards and develop mitigation plans for a robust operation of the developed system and technologies

Table 35. Contributions of partners in WP7 (PM)

Tasks	TECNALIA	DLR	IREN	USTUTT	PLANENERGI	AIGUASOL	ECT	UGENT	UPV	ULSTER	PNO	GOIENER	Sum
T7.1 (timeline: 1-25) *Value chains and stakeholders analysis*											*10,5*		*10,5*
T7.2 (timeline: 1-48) *Potential business cases analysis and baseline definition for business models*	*3,5*	*3,5*	*2*	*3*	*1*	*2*	*2*	*1,75*	*3*	*3*	*3*	*3*	*30,75*
T7.3 (timeline: 25-48)	*0,5*	*0,5*	*1*	*0,5*	*0,5*	*0,5*	*0,5*	*0,25*	*0,5*	*0,5*	*3*	*0,5*	*8,75*

Market analysis and replicability potential													
Sum	**4**	**4**	**3**	**3,5**	**1,5**	**2,5**	**2,5**	**2**	**3,5**	**3,5**	**16,5**	**3,5**	**50**

1.7.1 T7.1

Detailed description of the task work:

- systematic stakeholder analysis
    - relying on a proven methodology developed by PNO
    - identify the most important stakeholder groups within and around the CHESTER value chain
    - assess their position towards the project's results, to set up engagement strategies
    - identification of the value chain segments that could benefit from the project results
    - identification of relevant stakeholders belonging to the identified value chain segments based on the exploration of different databases such as
        - CORDIS database where innovators and potential end users will be identified
        - patent databases where innovators and potential investors and end users will be identified
        - desktop research, e.g. recent scientific publications, market reports, press releases where relevant stakeholders will be identified
- Relevant stakeholders will be interviewed or invited to participate in a survey
    - designed to measure stakeholder characteristics: interest, attitude, influence, knowledge, …
    - based on the outcome of the interview/survey, more targeted dissemination and exploitation actions will be implemented and engagement strategies will be built with key stakeholders

Table 36. Contributions of partners in T7.1 (Task details and PM)

T7.1 **Value chains and stakeholder's analysis**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Value chains and stakeholders analysis											**11**		**11**
Sum											**11**		**11**

1.7.2 T7.2

Detailed description of the task work:

- dissemination and communication strategy
  - targeted dissemination and communication strategy and plan will be developed and implemented based on the outcome of the stakeholder analysis (T7.1)
- website: will be established and regularly maintained
  - Secured documents repository platform restricted to the project partners
  - public website where dissemination and communication materials will be posted
- participation in Meetings, industrial workshops, congresses, conferences: at least 12 national and international conferences, congresses, fairs…
- project events: Several dissemination and exploitation workshops will be organized
  - comprehensive overview on the achievements of the project at various industry and public levels:
  - organize together to other partners an exploitation workshop
    - aim of spreading the results of the project to relevant industrial stakeholders and potential end users
    - contact with clients of ECT, AIGUASOL, DLR, IREN, PLANENERGI, and other stakeholders (electricity conversion, energy storage…)
  - at least 1 workshop sessions organised by PNO together to other partners
    - engage identified relevant stakeholders from academia and industry in the project activities around mid-term
    - disseminate the achievements
  - at least 4 Open day events organised by GOIENER, IREN, PLANENERGI, PNO
    - in different countries
    - to inform the public at large on the potential of CHESTER converting electricity and in providing energy storage solutions, particularly pupils and undergraduate students will be targeted to promote scientific carriers in this domain
- Scientific publications: the most interesting results from a scientific and technological point of view will be submitted to peer reviewed journals for publication
  - review papers will be also prepared on specific topics, and submitted for publication o suitable international reviews
    - will be selected on the basis of the article topic among conventional peer reviewed Journals and Open Access publications
    - publishing on Open Access will provide the additional benefit of strengthening the reputation of these journals
    - priority in selecting international conferences for presenting CHESTER results, international peer reviewed journals
      - pre-prints of all publications will be made available to Project partners in a reserved area of the Project website or effective knowledge sharing before dissemination
      - at least 12 articles in journal or conference proceedings
- Dissemination materials: Press releases, flyers and newsletters
    - all partners should provide inputs for those dissemination materials on regular basis
    - partners will be using social media such as LinkedIn posts, twitter, etc.

- UGENT, UPV, ULSTER, and USTTUT: prepare Lectures for students
- CHESTER will contribute, upon invitation by INEA, to common information and dissemination activities to increase the visibility and synergies between H2020 supported actions

Table 37. Contributions of partners in T7.2 (Task details and PM)

T7.2 **Development and execution of dissemination, communication and exploitation strategies**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Dissemination and communication strategy											0,5		0,5
Website: established (M3) and regularly maintained	0,5	0,5	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	1	0,2	3,8
Participation in Meetings, industrial workshops, congresses, conferences	1	1	0,8	0,8	0,8	0,8	0,8	0,3	0,8	0,8		1,3	9,2
Project events: workshops (>1+1) and open days (>4)	1	1	1	0,5		1	1	0,3	0,7	0,7	0,5	1,5	9,2
Scientific publications (>12)	1	1		1,2				0,7	1	1			5,9
Dissemination materials: Press releases, flyers and newsletters											1		1
Lectures for students				0,3				0,25	0,3	0,3			1,15
Sum	3,5	3,5	2	3	1	2	2	1,75	3	3	3	3	30,80

1.7.3 T7.3

Detailed description of the task work:

- set of activities addressing environmental, health and safety issues and risks to guarantee safe and secure operation of CHESTER solutions
  - starting point: system definition, and identification and preliminary analysis of the potential hazards of the proposed solutions
  - issues to identify
    - system function and elements including human, technical and operational elements
    - system boundary
    - interfaces including human interfaces such as user-machine interface
  - the system environment to analyse
    - energy and thermal flow
    - shocks, vibrations
    - electromagnetic interference
    - operational use
  - system definition: not only the normal operation mode, but also degraded or emergency mode
- a set of questionnaires will be prepared by PNO for interviewing the CHESTER partners
    - to investigate the major potential hazards and their potential environmental, health and safety issues based on a failure mode and effects analysis
  - study
    - identification of the major hazards, impacts, potential cause, ways to prevent them
    - recommended actions and contingency plans to mitigate their risks

Table 38. Contributions of partners in T7.3 (Task details and PM)

T7.3 **Investigation of Environment, health and safety issues**	**TECNALIA**	**DLR**	**IREN**	**USTUTT**	**PLANENERGI**	**AIGUASOL**	**ECT**	**UGENT**	**UPV**	**ULSTER**	**PNO**	**GOIENER**	**Sum**
Set of activities addressing environmental, health and safety issues	**0,25**	**0,25**	**0,75**	**0,25**	**0,25**	**0,25**	**0,25**		**0,25**	**0,25**	**2**	**0,25**	**5**

Set of questionnaires and study for interviewing the CHESTER partners	**0,25**	**0,25**	**0,25**	**0,25**	**0,25**	**0,25**	**0,25**	**0,25**	**0,25**	**0,25**	**1**	**0,25**	**3,75**
Sum	**0,5**	**0,5**	**1**	**0,5**	**0,5**	**0,5**	**0,5**	**0,25**	**0,5**	**0,5**	**3**	**0,5**	**8,75**

2. Templates for the different documents

Templates for Deliverables, Meetings Agendas and Minutes, and Presentations, have been designed and agreed by CHESTER Partners. All those templates are available in CHESTER Collaborative workspace (see section 3.2).

3. Internal Communication Procedure

Communication is fundamental to keep all the partners informed about the project status. In the project communication will be performed by the following means:

- Face-to-face meetings
- Electronic meetings (Telephone, Skype, WebEx or GoToMeeting)
- E-mail

All official communication with the Project Officer (PO) or the EC Services related to the CHESTER project will be provided through the Coordinator.

Any oral communication that is relevant to the project shall be documented in minutes of meetings. Minutes are mandatory for WP, SC, STC, DCT and review meetings, and have to be uploaded to the collaborative workspace in a dedicated folder for meeting minutes.

The appropriate template should be used. Any supporting documents (e.g. presentations), should be included in a subfolder created for that purpose.

3.1 Important Contacts and Mailing Lists

This section contains contact points that you might frequently require during the execution of the project.

3.1.1 Strategic and technical issues on project level

For all technical and strategic issues on project level please contact the Project Coordinator.

3.1.2 Administrative issues

For all administrative issues (e.g. management processes for internal and external reporting, processes for the review of deliverables, the CHESTER Portal…) please contact the Project Coordinator.

3.1.3 Issues related to dissemination

For all issues related to dissemination please contact the Dissemination Leader, and put the Project Coordinator in CC.

3.1.4 Mailing lists

Mailing lists for each individual WP will be kept up to date by the WP leaders. The overall contacts information and e-mail addresses are "***CHESTER_ContactList_[DATE].xls***", where "***DATE***" corresponds to the day when the last version has been issued, which the coordinator will keep up to date and distribute as new changes occur.

The WP leaders will be responsible to update the mailing lists corresponding to their WPs.

3.2 Collaborative workspace

To ensure an efficient project communication, the Consortium has set up a collaborative workspace which will be used to store and exchange all relevant documents, considering the dissemination level of documents and the access rights of different user groups. These include:

- Deliverables
- Internal documents:
  - Meeting minutes and supporting documentation from project meetings and

conference calls

  - Technical notes
  - Progress reports
  - Contacts lists
  - Others considered useful by the Coordinator or the WPLs

- Templates to be used when preparing:
  - Deliverables
  - Technical notes
  - Meeting minutes
  - Presentations
  - Internal WP progress reports
  - Internal Partner Financial statements
- • Major documents and reports as:
  - Periodic Reports
  - Final Report
  - Other documents requested by the PO or the EC
  - Other documents suggested and/or approved by WPLs
  - Other documents requested/or approved by the GA

The collaborative workspace is a cloud platform that helps to securely store, share, manage, view and comment on any kind of document.

3.3 Tracking of meetings and other events

3.3.1 CHESTER Calendar

CHESTER' calendar is managed by the Coordinator, who will send the agenda and invitations as defined in the Consortium Agreement. Organizers of workshops or WP meetings should send the corresponding invitations to the corresponding targets, and the Project Coordinator should be included in CC, in order to give an overview of these meetings and the possibility to take part.

3.3.2 Relationship to other projects and initiatives

Since the Grant Agreement foresees the obligation to liaise with the research community and beyond, it is essential to define the relationship to other projects, policy makers, etc. A responsible interface will be appointed, who will report about activities in the respective initiative that might be of concern for the development within the CHESTER project. All this will be defined in detail in WP7.

4. Innovation management

Innovation management is the process for maximising the capability of project outputs of being successful in the form of future products, services or processes, by combining creativity and a technical and market wise perspective.

An effective innovation management system needs to include the innovation from the idea generation to the market results, especially on a project like CHESTER, where the incipient sector needs a step change towards industrialisation.

CHESTER will implement TECNALIA's Standard Innovation Management Process ISAMPE, a derivative of ISAEP model 1. ISAMPE comprises:

- **Identification**. Improving the mechanisms for finding, capturing and communicating information about technologies (both internal and external) which may affect product development, production processes, opportunities and threats
- **Selection.** Determining the portfolio of products and services and the associated production process technologies and their impact on environmental sustainability
- **Acquisition (and Development)**. Technologies can be acquired either by internal development, external acquisition or co-development with partners
- **iMpulse** to innovation learning and improvement. The culture of learning expands to become a culture of continuous improvement with a focus on results
- **Protection**. The effective protection of early stage technologies (freedom to operate, patent, industrial secret …) is an important part of the innovation management system
- **Exploitation (and Transfer).** Technologies need to be effectively exploited if they are to deliver long-term growth. It can also be the case that new technologies might themselves lead to previously unforeseen product or market opportunities and could potentially change the business strategy

Identification and selection of the exploitable results has been done during the proposal stage and will be periodically updated within W7. A first version of the exploitation plan will also be available (D7.1). It contains the fundamental protection, exploitation and transfer strategies per exploitable result.

The innovation management process has been further strengthened thanks to the common support services to boost exploitation of research results, a pilot service from the EC. Precisely, a joint working session to streamline the exploitation strategy and go to market action plan (Exploitation Strategy Seminar) was facilitated by an expert consultant along the first GA meeting of the CHESTER project.

The outcomes of the innovation management process will be the focus of D7.4. Plan for exploitation (month 18, 30 and 42).

Annex A - List of reviewers and Deliverables

Deliverable Number	Deliverable name	Lead participant	Reviewer	Dissemination level	Delivery date
D1.1	Quality Assurance Plan	TECNALIA	--	PU	3
D2.1	Case studies: user requirements and boundary conditions definition	PLANENERGI	TECNALIA	PU	3
D2.2	Description of CHESTER simulation model and results	PLANENERGI	AIGUASOL	PU	6
D2.3	Requirements of the overall CHEST system	PLANENERGI	AIGUASOL	PU	8
D2.4	Requirements of individual technologies that form the CHEST system	TECNALIA	DLR	PU	8
D6.1	Detailed PESTEL and PORTER analysis of the CHEST system	PLANENERGI	DLR	PU	9
D3.1	Refrigerant/lubricant interactions testing in high temperature heat pumps	ULSTER	UPV	PU	12
D4.1	Start-up and commissioning of the monitoring procedures and environment for data collection from selected pilot cases	AIGUASOL	ECT	PU	12
D7.1.	Dissemination, Communication and Exploitation plans	PNO	TECNALIA	PU	12
D8.1	H – Requirement No.1	PNO	TECNALIA	CO	12
D8.2	POPD – Requirement No.2	PNO	TECNALIA	CO	12
D3.2	Detailed design of the high temperature heat pump laboratory prototype	UPV	TECNALIA	PU	18
D3.3	Detailed design of the high temperature TES laboratory prototype	DLR	GOIENER	PU	18
D3.4	Detailed design of the ORC laboratory prototype including SVV expander	UGENT	--	PU	18
D3.5	Detailed design of the ECT engine-pump laboratory prototype	ECT	ULSTER	PU	18
D4.2	Development of the full scale integrated CHEST model	AIGUASOL	USTUTT	PU	18
D6.2	Business cases definition and baseline for business models	PLANENERGI	PNO	PU	18
D3.6	Results of experimental prototype testing and performance maps of the high temperature heat pump	TECNALIA	--	CO	24
D3.7	Results of experimental prototype testing and performance maps of the high temperature TES	DLR	USTUTT	CO	24
D3.8	Results of experimental prototype testing and performance maps of the ORC	UGENT	PLANENERGI	CO	24

D3.9	Results of experimental prototype testing and performance maps of the ECT engine-pump	ECT	--	CO	24
D4.3	Report on monitoring of the selected pilot cases and development of annual energy profiles	AIGUASOL	--	PU	24
D5.1	Laboratory test site completely prepared	DLR	USTUTT	PU	24
D6.3	Specifications of the CHEST public tool	AIGUASOL	IREN	PU	24
D7.2.	Value Chain and stakeholder's analysis report	PNO	PLANENERGI	CO	24
D3.10	Design specifications and optimization of heat pumps for high evaporation and condensing temperatures	UPV	UGENT	PU	27
D3.11	Extended performance maps of individual technologies that form the CHEST system	UPV	AIGUASOL	CO	30
D6.4	Market technological potential	PLANENERGI	AIGUASOL	PU	33
D4.4	Operation modes and control strategies to be implemented at CHEST laboratory prototype	AIGUASOL	PLANENERGI	PU	31
D4.5	Full scale CHEST system optimization and techno-economic assessment	USTUTT	DLR	PU	31
D5.2	Installation and commissioning of components and whole CHEST prototype	DLR	TECNALIA	PU	33
D6.5	Development of the CHEST public tool	AIGUASOL	PLANENERGI	PU	36
D7.3.	Intermediate report on the major environmental, health and safety hazards and mitigation plants	PNO	TECNALIA	CO	36
D8.3	EPQ – Requirement No. 3	PNO	TECNALIA	CO	36
D3.12	Results of additional experimental prototype testing and final performance maps of the high temperature heat pump	TECNALIA	ULSTER	CO	42
D3.13	Results of additional experimental prototype testing and final performance maps of the high temperature TES	DLR	--	CO	42
D3.14	Results of additional experimental prototype testing and final performance maps of the ORC	UGENT	UPV	CO	42
D3.15	Results of additional experimental prototype testing and final performance maps of the ECT engine-pump	ECT	TECNALIA	CO	42
D4.6	Smart Energy Management System for efficient operation of the CHEST system	AIGUASOL	USTUTT	PU	42

D5.3	Report on operation and data analysis of the CHEST lab prototype	DLR	PLANENERGI	CO	42
D6.6	Market replicability potential	PLANENERGI	UGENT	PU	45
D4.7	Pilot testing of the SEMS and validation of CHEST functionalities	USTUTT	AIGUASOL	PU	48
D4.8	RES integration potential and environmental impact assessment	PLANENERGI	DLR	PU	48
D4.9	Roadmap for future development of CHEST system	USTUTT	TECNALIA	PU	48
D6.7	Development of business models	PLANENERGI	IREN	PU	48
D7.4	Dissemination, Communication and Exploitation campaigns report	PNO	TECNALIA	PU	48
D7.5	Report on the major environmental, health and safety hazards and mitigation plans	PNO	GOIENER	CO	48