Ref. Ares(2023)5686105 - 21/08/2023

This Project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement N. 957752

Smart integRation Of local energy sources and innovative storage for flexiBle, secure and cost-efficIent eNergy Supply ON industrialized islands

D 3.1 – Report on the integration with the 3 island environments

Lead partner: NORCE NORWEGIAN RESEARCH CENTRE AS

Project Contractual Details

Project Title	Smart integration of local energy sources and innovative storage for flexible, secure and cost-efficient energy supply on industrialized islands
Project Acronym	ROBINSON
Grant Agreement No.	957752
Project Start Date	01-10-2020
Project End Date	30-09-2024
Duration	48 months
Website	www.robinson-h2020.eu

Deliverable Details

Number	D3.1		
Title	Report on the integration with the 3 island environments		
Work Package	3		
Dissemination level	Public		
Due date (M)	24	Submission date (M)	30.09.2022
Deliverable responsible	Peter Breuhaus		
Contributing Author(s)	Mario L. Ferrari, Lorenzo Gini, Mohammad Mansouri, Daniele Molognoni		
Reviewer(s)	Rene Vijgen		
Final review and quality approval			

Document History

Version	Date	Name	Comments[1]
1.0	15.09.2022	D.3.1_Robinson_Draft 0.docx	Document for review
1.1	15.09.2022	Robinson_D3.1_integration	Document reviewed
1.2	20.08.2022	D3.1_ROBINSON_V1.2	Error on page 19 corrected for re-submission

[1] Creation, modification, final version for evaluation, revised version following evaluation, final

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Executive summary

Deliverable 3.1 of the ROBINSON project corresponds to Task 3.1 that is entitled as "Analysis of the integration with the 3 island environments". This document focuses on the integration aspects of a highly integrated energy system (such as the one proposed in ROBINSON) into island environments and implications of those aspects on the development of an energy management system (EMS). This task links the outcomes of WP1 (Islands requirements, barriers, and system specifications) and WP2 (Technologies adaptation and development) with WP3 (EMS for European Islands simulation and integration).

This report presents the following topics:

- A summary of boundary conditions of different islands involved in ROBINSON
- Integration aspects at energy system component level including the components that are going to be installed in the demonstrator island, the development process related to the EMS platform, communication protocols and issues to integrate the EMS in the laboratory and the demo site, as well as initial details related to cybersecurity and data integrity
- Integration and replication aspects at different island environments

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AD	Anaerobic digestion
BES	Bio-electrochemical system
CHP	Combined heat and power
EMS	Energy management system
ID	Identifier
IP	Internet protocol
I/O	Input/Output
LHV	Lower heating value

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LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
mGT	Micro gas turbine
NG	Natural gas
OPEX	Operational expenditure
P&ID	Piping and instrumentation diagram
PLC	Programmable logic controller
SCADA	Supervisory control and data acquisition
TCP	Transmission control protocol
Vol	Volume
WP	Work package
XML	Extensible markup language

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1. Introduction

The ROBINSON project “Smart integRation Of local energy sources and innovative storage for flexiBle, secure and cost-efficIent eNergy Supply ON industrialized islands” aims at developing an integrated energy system concept for island application which is going to be demonstrated on the island of Eigerøy and shall be replicated on two follower islands (Crete of Greece and Western Iles of Scotland). The energy systems composed of various primary energy sources, components and user profiles needs to be managed by an energy management system (EMS) in a real-time mode. This tool will be essential for the system performance and operation to reduce the operational expenditure (OPEX) or to optimise other objective functions, such as minimising the CO_2 emissions or maximizing the energy efficiency. In this context is special attention devoted to the industrial symbiosis, considering possible internal recycling of energy sources.

The energy management system to be developed within the course of the project must comply with two basic boundary conditions:

1. Being a generic system, which can be applied to various locations and thus cover a wider range of boundary conditions.
2. Being adjusted towards the needs and requirements of the demonstrator on the island of Eigerøy.

For development of the energy management system differences between islands in terms of their existing energy systems, available infrastructure, boundary conditions, etc. need to be considered. As part of Task 3.1, this report focuses on two major aspects to be covered within work package three:

- Description of the requirements and challenges during development of a generic energy management system
- Expected necessary adaptation to the different boundary conditions of the demonstrator and the two follower islands

2. Generic energy management system

2.1. EMS description

The generic EMS to be developed within the project aims at covering a concept as highlighted in the project proposal (Figure 1). It needs to cover the utilisation of various local energy sources (e.g., wind, solar, biomass etc.) in terms of their contribution the three energy vectors electricity, thermal energy, and gas. It also must consider the possible interaction with a connection to the electrical grid of the mainland. Furthermore, the EMS needs to balance energy generation, demand and storage capacities across the different energy vectors, which also includes the aspect of energy flux planning and scheduling, probably including demand management. The EMS being developed as generic tool will be demonstrated at the site on Eigerøy.

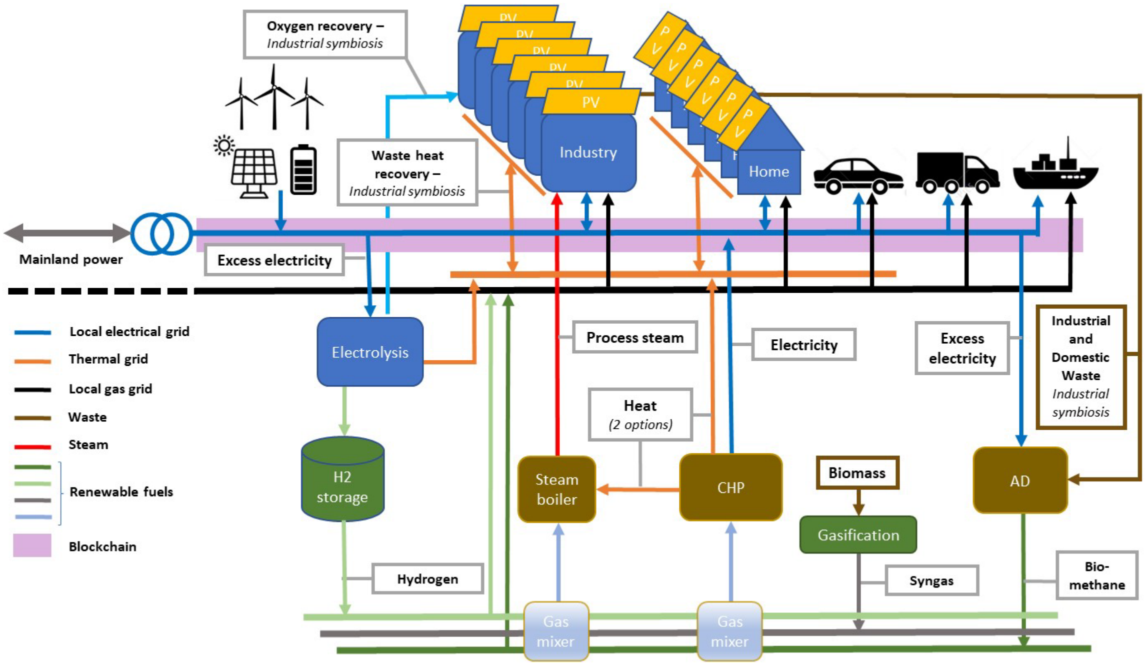

Figure 1 – Concept of the integrated energy system of ROBINSON

2.2. Requirements of an EMS

The general requirements of the EMS resulting from the need of integrating existing and already installed components, as well as those that will be developed and commissioned, can be listed as follows:

- The main requirement towards the EMS is to reliably manage the entire energy system with its different components and their specific characteristics to ensure matching available energy from generation and storage, with the demand. This needs to be performed at lowest cost and emission.
  - EMS challenges result from the fact that for example fluctuating renewables (e.g., solar and wind) need to be coordinated with available dispatchable energy (e.g., CHP) that use fuel produced by different sources of different characteristic. For example, the anaerobic digester assisted with a bioelectrochemical system (AD-BES) unit has a

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very high level of inertia (production and reproduction cycle of fuel generating microbes), a gasifier unit is more dynamic but still is slow (re-)acting relative to wind or sun, while an electrolyser has the capability of fast load changes.
    - Charging and discharging of storage capacities of energy storage devices need to be managed in terms of rates and stored capacity
    - Energy demand scheduling might be considered for an even better match of generation and demand while at the same time reducing costs and emission.
- Smooth communication and exchange of data and information with a wide range of technological development levels if installation of components is performed in different years.
- Flexible structure to allow for an easy adaptation of the EMS to different boundary conditions, as well as to changing boundary conditions. An example in this context might be the significant change of energy costs and prices during the first 24 months of the ROBINSON project. This resulted in changed business cases for equipment to be installed and thus requiring their consideration within the EMS development.
- The EMS needs to contribute to the resilience of the energy system and to reduce the danger of interruptions in energy supply.
- Data security and privacy needs to be considered on a high level given that potential competing businesses will be connected, thus having a high interest to protect their operational data against access from competitors.
- Cyber security and the protection of the energy system against attack from the outside needs to be also considered especially as the EMS forms the central element of controlling and managing the integrated energy system of islands.

2.3. Platform development for the EMS

The platform development is performed using the Matlab/Simulink environment. The solution to be integrated on site will be then transformed to an environment which matches the locally available standard and could avoid additional licence costs.

Communication between the EMS and the components / prime movers will allow for various protocols (e.g., OPC, Modbus, Profibus, wireless etc.) as the components are expected to use different protocols.

Data to be transferred are focusing on the exchange of data and information being necessary to manage the system. These are general information on:

- The load status, i.e., - the current level of local energy generation or demand
- Operating conditions such as start-up, shut down, idle, in service etc.
- Expected future load pattern in terms of demand and generation. For both is information on the expected weather an essential additional information.
- The condition of storage reservoirs in terms of the charging status

State-of-the-art technologies to ensure data privacy as well as cyber security will be implemented.

2.4. EMS development for the demonstrator

The following three chapters describe the development of the EMS for the demonstration site at Eigerøy. It was agreed amongst project partners that the Ems will be installed on the premises of the partner Prima Protein, as most of the equipment will be located on or close at their location.

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2.4.1. EMS platform for Eigerøy

As describe above is the EMS algorithm developed in MATLAB/Simulink environment, integrating it with single prime mover models (D3.2).

Figure 2 presents the EMS flow chart strategy for achieving the final EMS tool. For the installation at the demonstrator site will be the EMS software ported from MATLAB/Simulink to LabVIEW, which will be used to generate executable file running on the Prima Protein PLC. Using a LabVIEW RunTime is free and does not require any licence.

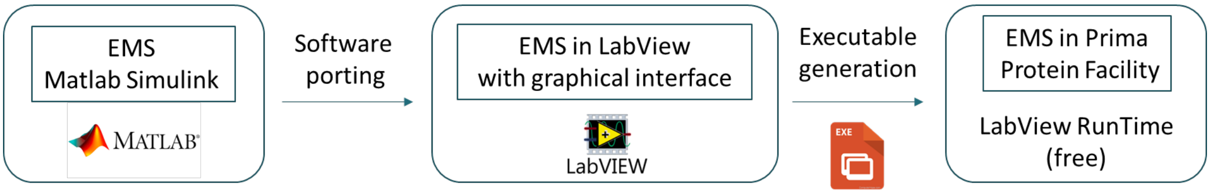

Figure 2 – EMS flow chart development

The overall system simulation and the laboratory cyber-physical tests will allow for testing and debugging before the real environment application.

2.4.2. Communication protocol and issues

The ROBINSON PLC will be installed in the server room of Prima Protein to store relevant data and run EMS controlling prime movers (Figure 3). The EMS will receive signals from the facility and all components the be managed by the system. It includes both decisions making parameters (e.g., H_2 storage pressure, electrical and thermal demands, etc) and monitoring parameters (e.g., electrolyser voltage, wind turbine speed, etc). Starting from current operation and the decision-making parameters, the EMS defines the control signal to the prime movers (sample time: 1 second), minimising the target function in the day horizon. In details, Table 1 presents the communication protocols between the prime movers and the ROBINSON PLC.

Table 1 – Communication protocols

Prime mover	Communication protocol
CHP	Modbus TCP, IP / Slave ID
Electrolysers	Modbus TCP, IP / Slave ID
Steam boiler	ProfiNet (internal com)
Wind turbine	Wireless communication
AD-BES	Modbus TCP, IP / Slave ID
Gasifier	Modbus TCP, IP / Slave ID

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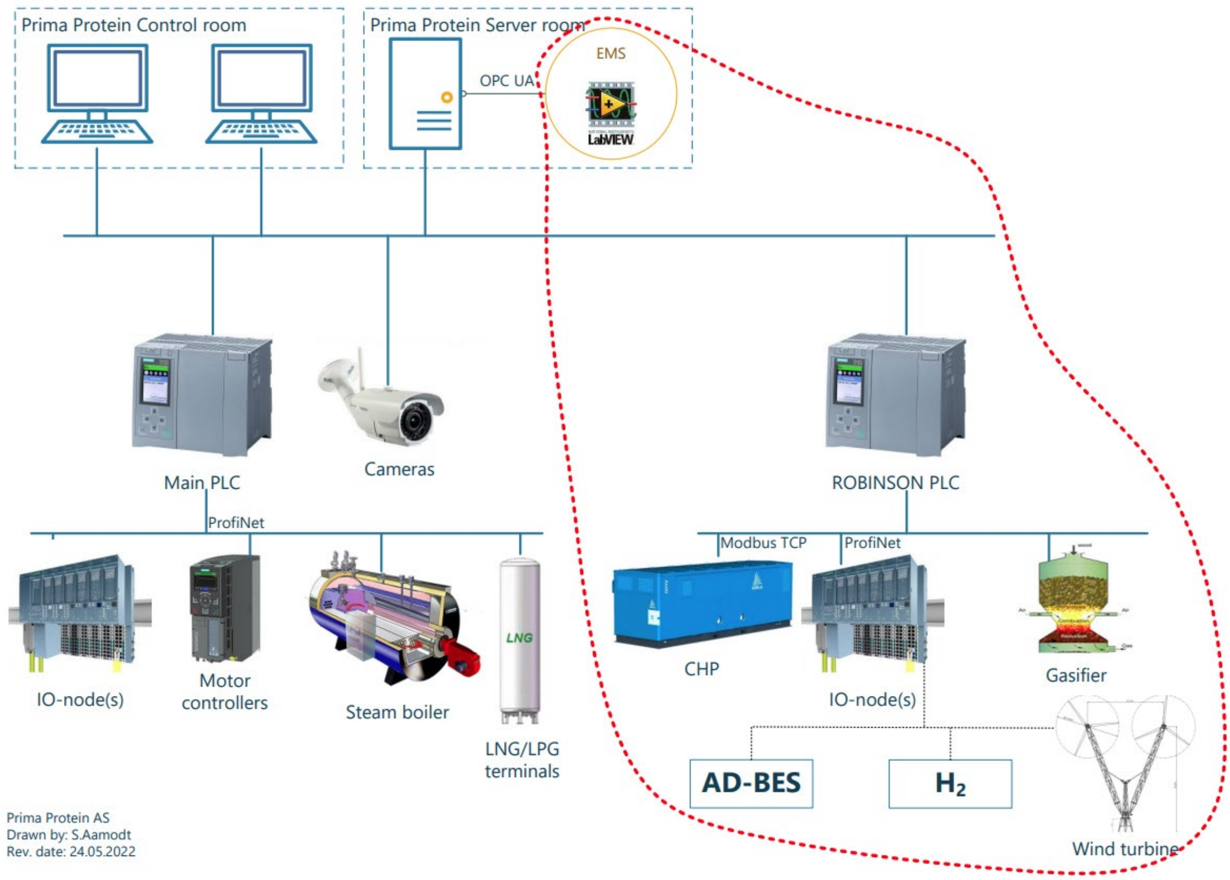

Figure 3 – Overview of the communication in Prima Protein demo site

2.4.3. Preliminary consideration on data integrity and cybersecurity

Data integrity and cyber security are subject of a separate specific task (T2.4). However, preliminary meetings were performed to consider data integrity and cybersecurity issues for the laboratory tests already. In this context, special attention has been devoted to defining preliminary implementation solutions for the data integrity aspects through the blockchain technology. Specific integration with the ongoing developments of T2.4 will be carried out.

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3. Adapting to the island environments

This chapter covers the integration of the above-described components into the energy systems of the demonstrator island and the two follower islands. It covers the aspects of integrability, and highlights issues of integration based on the experience of the first 24 months of the project.

3.1. Summary of islands boundary conditions

As outlined in the report “D1.1 - Islands documentation and mapping report” the demonstrator island is Eigerøy and the two follower islands (Western Isles and Crete) differ significantly in terms of size, population, and structure (Table 2).

Table 2 – Basic information on the islands

Name	Eigerøy	Western Isles (or the Outer Hebrides)	Crete
Country	Norway	Scotland	Greece
Location	South west coast of Norway 58°26’37,608”N 5°57’11,581”Ø	A chain of islands off the west coast of Scotland	Approximately 160 km south of the Greek mainland
Size	20 km^2	3,059 km^2	8,336 km^2
Population	About 2.500 within about 800 households	More than 26.000 within about 12.500 households	About 635.000 in about 214.150 households
Climate	Influenced by the coast with relatively high temperatures in winter and low temperatures in summer, wind speeds are high	The climate is mild and oceanic. High wind speed.	The climate is mainly Mediterranean

Given restriction in terms of available budget and to limit the risk of a blackout, the EMS will cover not an entire island but a part of it. At Eigerøy will be the demonstrator installed on and close to the premises of Prima Protein as a decentralised energy system. The same concept is going to be considered for the follower Western Isles and Crete. The concept behind this approach is twofold:

- Building a renewable and local energy source-based energy system for the island(s) via the concept of several inter-connected decentralized energy cells.
- Allowing for a stepwise expansion of the concept to cover the entire island(s). By doing so is it possible to consider locally varying boundary conditions (e.g., in terms of available sources and resources) as well as keeping control over costs.

The following chapters describe the integrated EMS of the three islands with the bulk part on the demonstrator island which includes a description of the prime movers. Similar ones will be applied to

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the follower islands also. It can be expected that several characteristics of component might be similar but impacted by size or maybe different feedstock (e.g., gasification unit or bio-gas generation unit).

3.2. The demonstrator in Eigerøy

In addition to the previously published information in the reports "D1.4 - Optimised layout description" and "D2.2 - Description and documentation of the models and characteristics collected" further data have been collected, with several inputs from the in parallel ongoing activities on component adaptation and development (WP2 of the project). Collected information is related to performance and constraints of the environments and for a detailed prime mover characterisation to model the overall system and EMS development. In parallel, ahead of the official start of WP4, work on the P&ID is ongoing. Via regular update meetings are interconnections and prime mover feedings defined. This is an ongoing dynamic process resulting from the new green and sustainable trends as well as the recent significant changes in energy costs impacting the potential investments of Prima Protein and Dalane Energi. A first outline of the location of components at the demonstrator site is shown in Figure 4. Uncertainties and changes of the current status relative to the project proposal resulting from the changes boundary conditions for investments are related to:

- Increase size of the electrolyser unit and selling surplus hydrogen for transport (fuel for sea and heavy transport). This is already defined and decided.
- Increased size of the gasification unit to replace a significant larger part of LNG for steam generation. This is currently in evaluation.
- Evaluating the installation of a local "district heating" grid for further increased utilisation of otherwise wasted heat.
- Installation of a small-scale wind turbine which was uncertain due to local resistance against wind turbines. As a result, was the business case at stake but it might change again due changed energy prices and reducing resistance.

The bullets above indicate the need for a flexible architecture of the EMS to ensure an efficient consideration and integration of changes in boundary conditions and prime movers.

For single component modelling, steady-state and dynamic data are used to emulate part-load and transient behaviour. The mixed fuel compositions, feeding CHP and Boiler, plays a key role in EMS. Energy Management System aims to contain OPEX and/or CO_2 emissions of the micro-grid, guaranteeing safe operations, and matching user electrical and thermal demand. CHP and Boiler models consider the inlet fuel composition for computing the fuel consumption and power heat generation.

The entire system and EMS are planned to be developed and tested first in modelling phase and later in cyber-physical environment. The Prima Protein industry operations present intermittent load, altering start-up/full load/shutdown correlated to the fishing and/or sea conditions; besides from the beginning of December up to the end of February the protein production is stopped. Starting from D1.3 electrical and thermal energy consumptions, typical factory operation days were selected to simulate its regular operation and start-up/shutdown.

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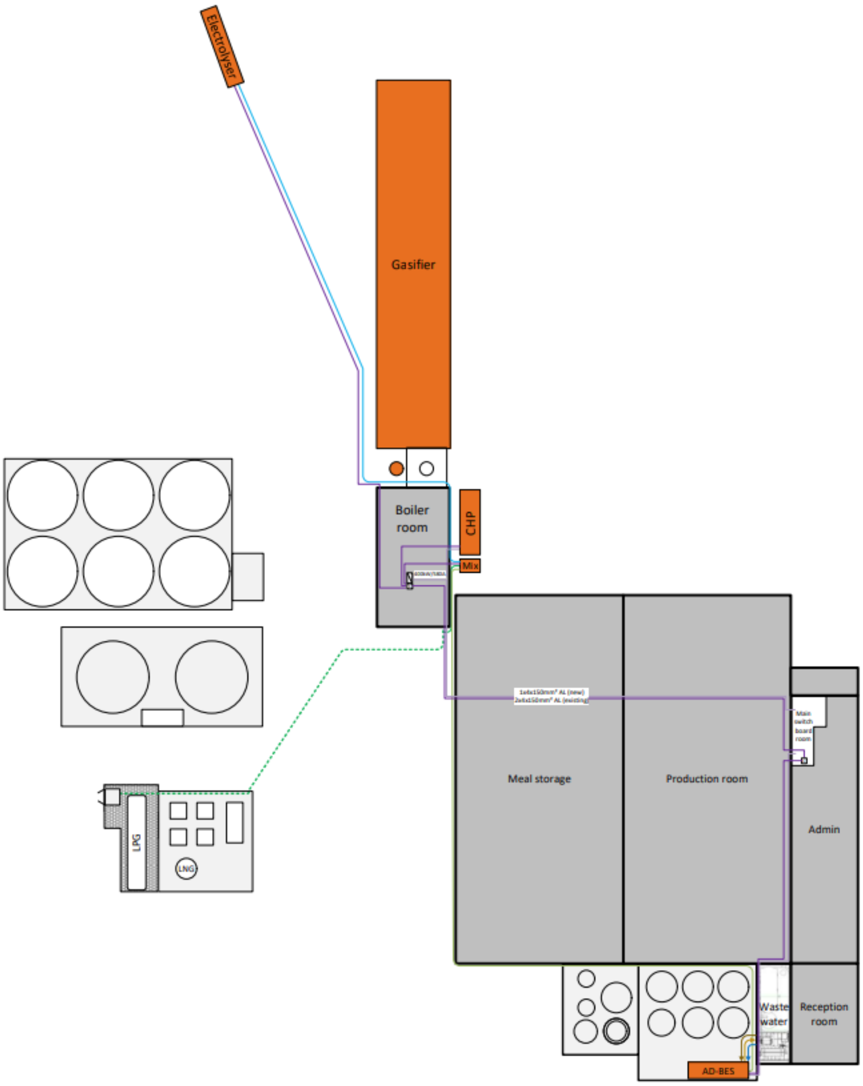

Figure 4 – Location of equipment in Prima Protein demo site

The weather conditions data were classified to have a typic day profile of wind, solar radiation, and ambient temperature each month. The electricity and LNG prices will remain extremely volatile, however by now typical trends and valued have been considered, the final system target would be integrating on-line updating tool for monitoring and updating these input data[2]. The EMS makes energy strategy decision using these data.

3.3. Components and their implications on the EMS

This section presents technical insights on technologies that we will be install in the ROBINSON demo site, providing single specification and grid integration aspects.

[2] See: https://www.nordpoolgroup.com/en/Market-data1/#/nordic/table

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3.3.1. CHP

The CHP unit will be manufactured by Aurelia Turbine. The fuel flexibility represents the main challenge for the high efficiency A400 mGT (Figure 5). It should be able to burn NG or syngas as main fuel, including the possibility to mix hydrogen (up to 30% in volume) and biogas from AD-BES.

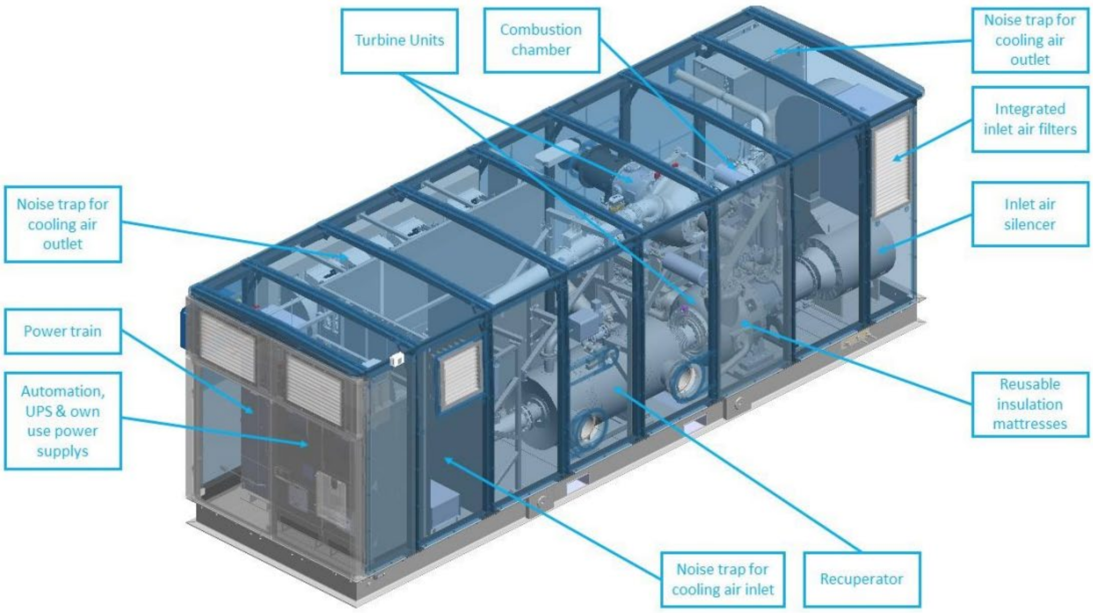

Figure 5 – Internal Arrangements of components

The innovative cooling technologies allows the mGT to reach 40% electrical efficiency.

When a generator is connected in parallel with the grid there is a possible requirement from the network operator that the generator take part in dynamic grid stabilisation control. The A400 can control the active power. This is essentially to prevent the problems as large instabilities in the grid were introduced by large numbers of small capacity distributed generation plants, and to prevent inter area fluctuation of voltage and frequency. This means that the generator actively changes the power factor, active power, and VAR exchange with the grid to positively support the grid during these fluctuations. The limits for this are given by the network operator. The despatch of the equipment in these conditions is normally under direct control of the network operator via comms over power interface.

3.3.2. Gasifier

There are currently two different types of gasifiers in evaluation due to different requirements of integrating them into the process. Option one is a gasifier that delivers syngas that can be used in e.g., a CHP unit, while the second option is a tightly integrated gasifier plus a boiler unit that directly produces process steam. These two operations are described with more details below.

3.2.1 Syngas gasification unit of SYNCRAFT

Option one that might be applied is a gasification unit providing syngas. The syngas can be used as fuel in a downstream CHP unit or in a boiler. As such, this option can represent a generic solution applicable to wide range of local boundary conditions. The unit in evaluation is a gasifier produced by

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Syncraft (for the schematics see Figure 6[3]). Note that in ROBINSON, the gas engine in Figure 6 will be replaced by a A400 mGT.

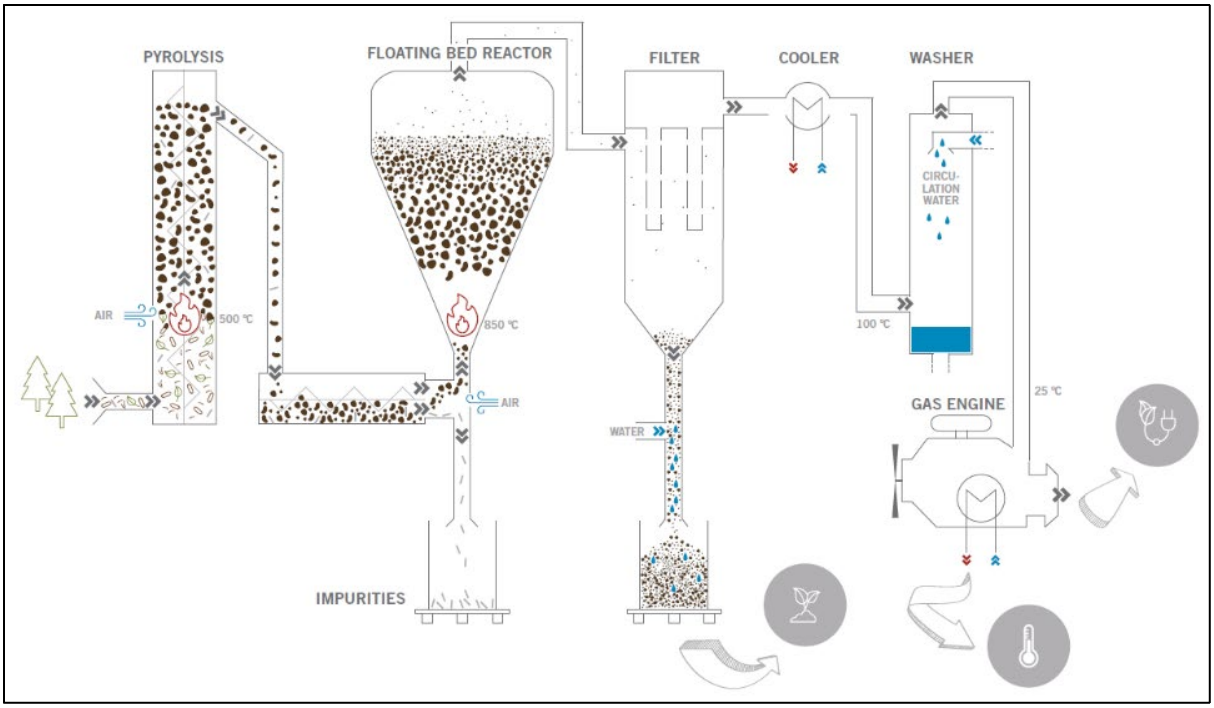

Figure 6 – Schematics of the SYNCRAFT gasifier integrated with a gas engine

The SYNCRAFT technology is based on a staged co-current fixed-bed gasifier and the actual gasification reactor is operated against gravity as shown in Figure 6.

Due to the high thermal inertia of the unit, it might be necessary to consider a buffer tank for the syngas to cover changes and fluctuations in the fuel demand. It needs to be noted that the gas buffer tank cannot be considered as a storage means because of its size and is mainly to ensure delivering the necessary flow to the downstream conversion unit (that can be for example a CHP unit). The control parameter is the volume flow rate (or mass flow rate) of the syngas that is needed for operation of the gas turbine-based CHP unit. This parameter governs operating the rest of the gasification equipment.

3.2.2 Integrated gasification and steam boiler unit of Dall Energy

An alternative especially useful for the demonstrator on Eigerøy can be a closely integrated concept of a gasification and gas combustion. This concept has been used by the Dall Energy's biomass furnace that combines updraft gasification and gas combustion. Combining updraft gasification and gas combustion into one unit offers several advantages to operation and maintenance, emissions reduction, and turndown ratio[4]. In addition, such a solution can replace an even larger share of LNG

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[3] Source: SYNCRAFT, 2021, The wood gasification technology, Accessed online 11 August 2022, https://en.syncraft.at/wood-power-plants/overview.

[4] Dall J., Bentzen K., 2016, Fuel flexibility and low emissions in biomass-fired power plants, Engineering & Technology Reference, pp. 1-6, https://digital-library.theiet.org/content/reference/10.1049/etr.2016.0036

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that is used on Eigerøy than the solution of a gasifier providing fuel for the CHP only, as described above. This integrated solution might be better suited due the large difference in electricity and steam demands at the demonstrator site. Furthermore, due to significantly increasing prices of fossil fuels in the recent months, the business case of such a concept might be even more attractive. Nevertheless, one needs to perform a detailed techno-economic analysis evaluating which option is more suitable, as like fossil fuels, the prices for woodchips, also manufacturing costs have been increased sharply in the recent months. Figure 7 indicates the schematics of the gasification (furnace) side of the Dall Energy technology.

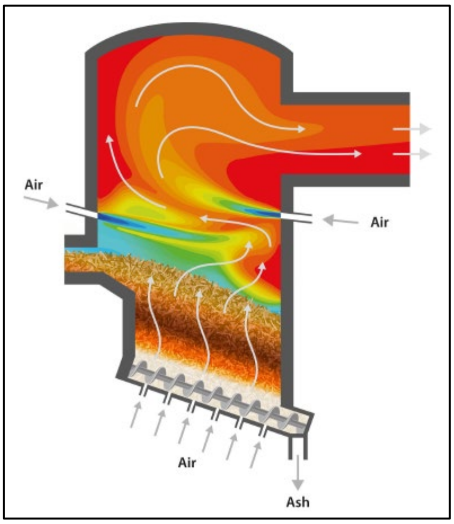

Figure 7 – Schematics of the gasification side of Dall Energy technology[4]

The main configuration of the integrated gasification and steam boiler plant, as per the installed plant in the district heating system of the of Sindal, Denmark, is illustrated in Figure 8. As shown in this figure, first the biomass is partially combusted in the gasification part of the plant. The produced syngas is further combusted using the tertiary air in a so-called “after-burner”. The thermal energy in the flue gas is transferred to water resulting in steam production.

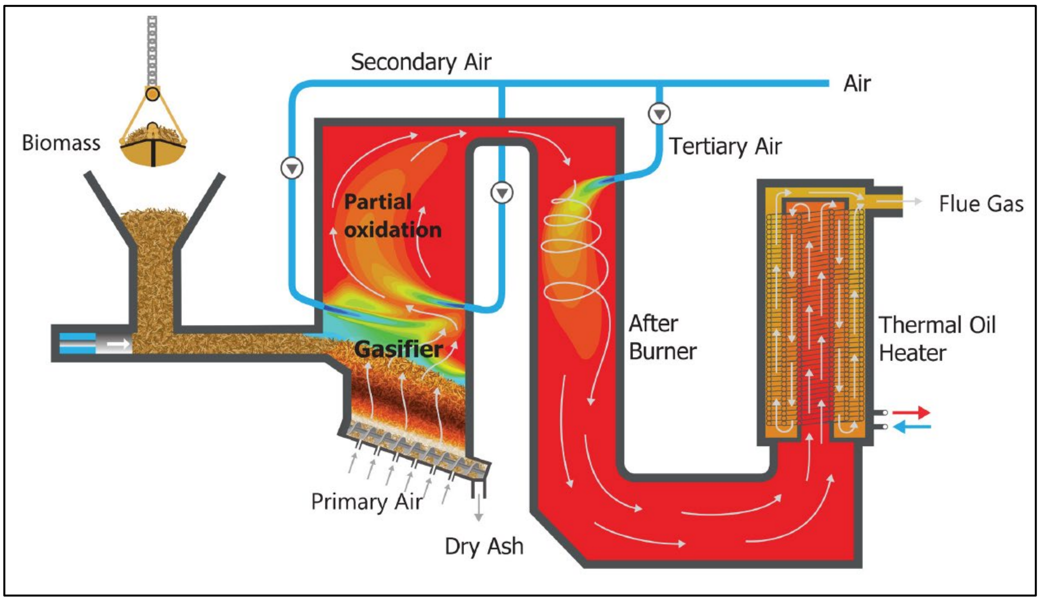

Figure 8 – Main configuration of the integrated gasifier and boiler technology of Dall Energy[4]

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The unit is typically operated between high (100%) and low (20%) operating loads as also pointed out as upper and lower operating loads in the environmental technology verification report of the Dall Energy's biomass furnace[5]. To avoid unnecessary shut-down of the integrated gasifier and boiler unit, hence reducing the impact of frequent shut-down and start-up cycles on the lifetime and on service and maintenance costs, there are currently two scenarios under evaluation:

1. Evaluating the possibility of integrating the heat from the unit into a district heating, while the demonstrator site does not require any steam.
2. Evaluating the possibility of extracting the syngas from the integrated gasifier/boiler unit and make it available as fuel for the CHP unit.

However, both solutions are currently under evaluation, but the decision on which approach to implement is expected to impact the design of the energy management system.

3.3.3. AD+BES

The prototype (currently under design) will be composed by a main anaerobic digestion (AD) reactor (around 1 m^3) and a side-stream stack of single-chamber bioelectrochemical system (BES) modules, performing electromethanogenesis (120-140 l) (Figure 9). The prototype will be containerized in an ISO30 unit.

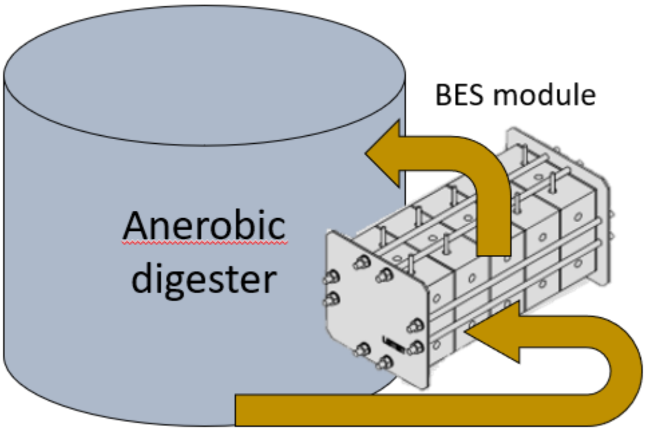

Figure 9: General concept of the AD+BES unit

Wastewater will be fed from PRIMA buffer tank (30 m^3) to the AD reactor in a step-batch mode. The feeding rate is estimated in approx. 128 kg/d, which can be fed in a window of 4 hours (i.e., a flow rate equal to 32 kg/h). A continuous recirculation flow is foreseen between AD and BES reactors. For the thermal requirements of the AD-BES system (to be kept at 35°C), a combined thermal and electrical heater was conceived, to be installed within the recirculation loop, which will allow a better exploitation of the available energy sources (i.e., recovered heat for hot water utilities and retrieved electricity). The expected system productivity lies around 1 Nm^3/d of biogas. The results from the lab

[5] ETA-Danmark, 2012, Environmental Technology Verification report of Dall Energy Biomass Furnace, Accessed online 11 August 2022, http://www.etv-denmark.com/files/air/Dall%20E%20TEST%20REPORT.pdf

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scale tests performed by LEITAT indicate that the composition of CH_4 in the product stream is higher than 80% v/v, therefore near to biomethane specifications. This biogas will be stored in a buffer tank, without further post-treatment, and delivered to the gas fuel mixing station at a pressure of 1,2 bar.

3.3.4. Electrolyzer

The electrolyser splits water into hydrogen and oxygen as well as carrying out the post-processing necessary to make sure the hydrogen released contain no residual electrolyte or water.

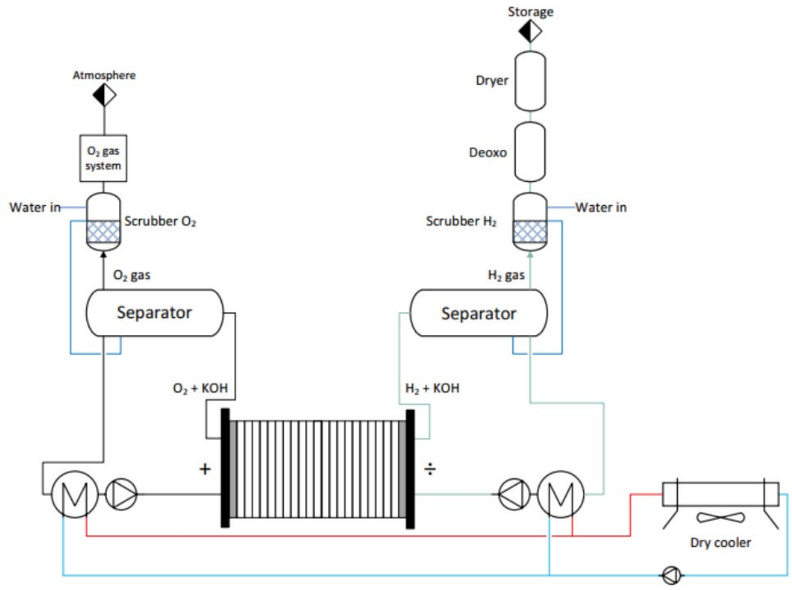

Figure 10 – Schematic of the functioning for A90 Alkaline electrolyser, Green Hydrogen System

Two Alkaline electrolysers, A90 Green Hydrogen System, will be installed by Dalane Energi in the ROBINSON demo site, 500 kW electrical power each (compression up to 35 bars included). The Figure 10 presents the complete electrolyser system including stack, separators, scrubbers, heat exchangers, etc. Table 3 and Table 4 present technical specification and technical description. The A90 electrolysers present 77% efficiency at full load.

Table 3 – Technical specification HyProvideTM

Item	Specification	Nomination
Plant capacity	0,86	[MW]
Hydrogen, maximum capacity of plant	180	[Nm3/h]
Hydrogen, maximum capacity of plant	388	[kg H2/day]
Hydrogen, delivery pressure maximum	35	[bar (g)]
Hydrogen purity	>99.998	[%]

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Table 4 – Technical description of HyProvideTM

HyProvide™ A90 Process Module Equipment per Process Module	Specification	Nomination
H2 production (max)	90	[Nm3/h]
H2 production (max)	194.0	[kg/day]
H2 purity	99.998	[% (vol.)]
System pressure maximum	30-35	[bar (g)]
Process temperature	90	[°C]
Dynamic range A90	16-100	[%]
Hydrogen delivered according to	SAE J2719/ISO 14687	NA
Oxygen production (max)	45	[Nm3/h]
Oxygen purity	>97	[% (vol.)]
Lifetime	>100.000 hours in normal use for process module	NA
Ambient temperature Process Module	+5 / +35	[°C]
Pre-tested	FAT	NA
Process Control	1 Module	NA
Deoxo	1 Module	NA
Separators	2 Modules	NA
Dryer	2 Modules	NA
Software to control and operate the system, locally and remote.	HyProManager	NA

3.3.5. Gas mixer

The CHP main fuel (syngas from gasifier or NG) will be mixed with H_2 and AD-BES biogas for feeding the CHP unit with an H_2 share of up to 30%. The EMS will, based on the composition of three the fuels LNG, Syngas and biogas identify the allowable additional H_2 mass flow for achieving the target composition ratio. The selection of the fuel to be mixed and used in the CHP aiming at optimizing OPEX.

3.3.6. Wind turbine and related issues

The targeted location of the wind turbine is a strategic windy position close to the location of Prima Protein. However, currently there are discussions on the ownership ongoing due to earlier resistance of residents in the area and the uncertainty of the getting the relevant permissions for installation. However, the EMS aims to maximize the exploitation of renewable energies, running the V-Twin 100 wind turbine for as long as possible.

The V-Twin 100, by RES-T company, integrate the WP100 Platform that is specially designed for control of small and medium sized wind turbines (Figure 11). The basic variant, WP100 Controller – 00, has a set of various on-board I/O channels that makes it possible to use the controller as standalone (w/o additional I/O modules) to control fewer complex systems. At the same time, it is possible to connect up to 3 WP-Line I/O modules when more I/O channels needed.

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The on-board grid interface makes it possible to calculate main grid parameters by precise and reliable DSP algorithms according to IEC 61400-21 standard. The controller is equipped with two high-speed interfaces that work as separate network interfaces. The controller also features safety chain relay logic. The WP100 Controller– 31 with built-in multiport Ethernet switch (among others, includes fiber optic 100BASE-FX port) can be extended with more I/O groups via Backbone interface. The WP100 Controller–32 has built-in GPS receiver and can provide geographic coordinates and accurate time for the system.

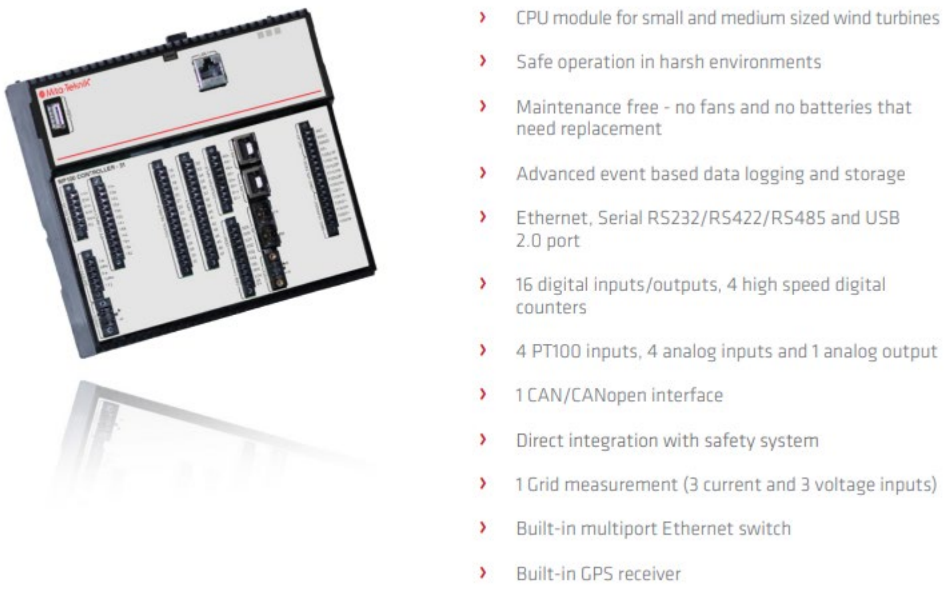

Figure 11 – WP100 Controller

The ENSOTEST software will manage the communications for monitoring and control[6].

Worldwide standard for communication between wind energy components as wind turbines or wind power plant servers and SCADA Systems that monitor or control the energy production.

Key features:

- Interoperability between SCADA systems and controllers from different vendors
- Independent of applications or hardware solutions
- Vendor independent configuration based on standard XML files
- Standardized data models for easy description and access to the information
- Standardized controlled way to define model extensions to the system
- Reduce integration cost and data harmonization effort

The information model with several logical nodes holds the information of the wind turbines, meteorological station, and complementary active and reactive power functions in the wind power plant. Any vendor using this standard series must use the logical nodes predefined selecting the data objects available in their model (Figure 12).

[6] See: https://www.ensotest.com/iec-61400-25/iec-61400-25-communications-for-monitoring-and-control-of-wind-power-plants/

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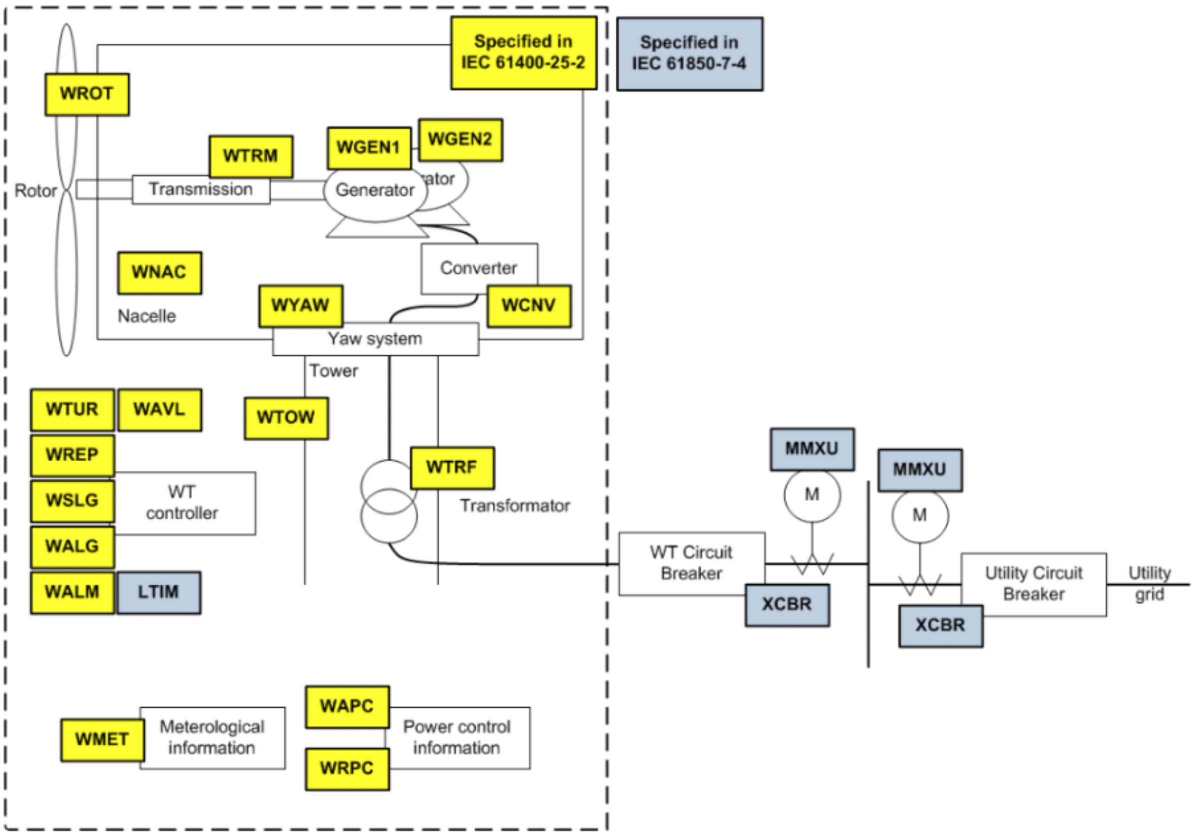

Figure 12 – ENSOTEST software

The device information model structure is a hierarchy where the naming and the structure is defined (Figure 13).

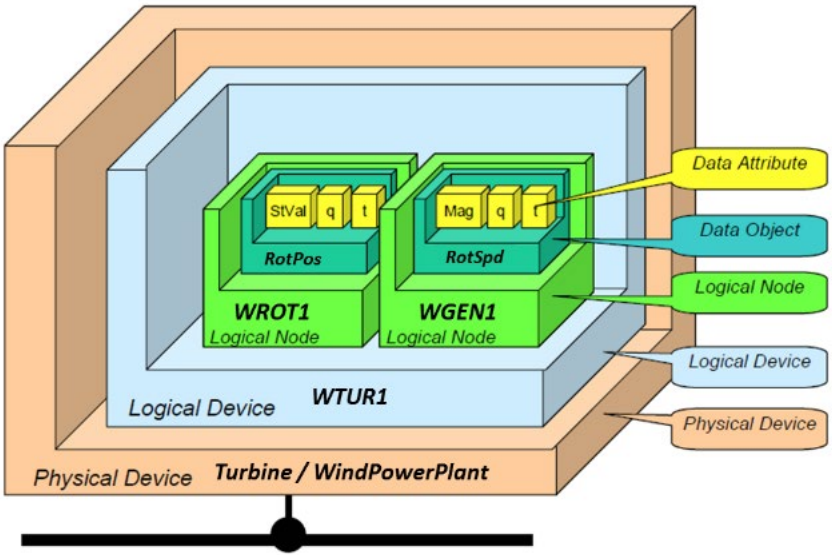

Figure 13 – Device information model structure, ENSOTEST software

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3.4. Replication: Crete, a follower island

The Crete replication case study have considered many techniques similar to Eigerøy case (D1.3), keeping the same non dimensional operating features but scaling up/down their size according to the local boundary conditions. Instead of considering the energy system of the entire island, there are two possible follower sites on Crete identified for the installation of the ROBINSON decentralized and integrated energy systems concept (Figure 14). The table lists potential stakeholders in this area on Crete.

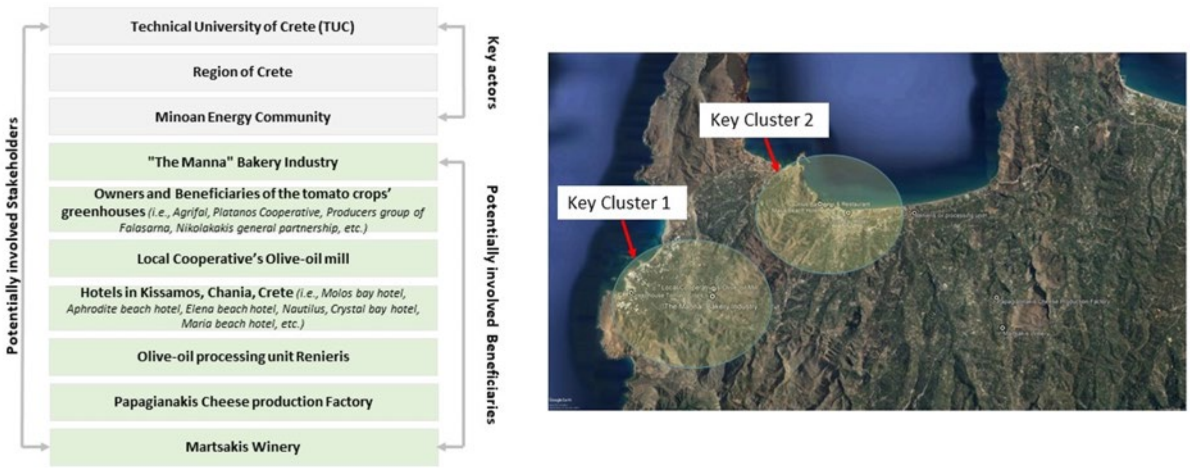

Figure 14 – Potential follower sites on the island of Crete

The scaling of information of the components to be installed and demonstrated on Eigerøy using available manufacturer data allows to emulate Crete system and test its EMS. However, discrepancies resulting from different boundary conditions need to be considered. These impact especially the feedstock towards the AD-BES plant as well as to the gasification unit. Feedstock to the AD-BES will be residues from local agricultural activities which are predominantly connected to growth of tomatoes and olives. Given the building structure on Crete differs the feedstock towards the gasification unit as less waste wood from demolished old houses will be available but could be replaced by feedstock olive plantations (e.g., wood) and olive oil production (olive stones). In this context it the seasonal dependent availability of the feedstock to be considered which will be different from the situation at the demonstrator site on Eigerøy. The difference in type of feedstock and availability of the feedstock might impact the generation of biogas and syngas in terms of the amount and the quality/composition. Seasonal availability of the feedstock impacts also aspects such as storage capacity and & or service and maintenance activities.

Replicating activates of the EMS are already started and a close cooperation with stakeholders on Crete is established to cover potential mismatching of the estimated size and the user requests. At the time of reporting was for example the local CHP downsized from 3.5 MW electrical power and 4.5 MW thermal power (see D1.1 – Islands documentation and mapping report) to 290 kWe and 375 kWth, at nominal operating point). Another significant difference is the energy demand, especially in terms of the required thermal energy demand and the replacement of an almost all year heating into a heating (winter) and cooling (summer) demand. It is also reflected by the electrical demand pattern which shows that peak demand in summer is significantly higher than in winter (Figure 15), which is also subject to tourist season.

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These differences impact the dimensions of the various components as well as potentially impact the EMS and maybe its integrated cost functions.

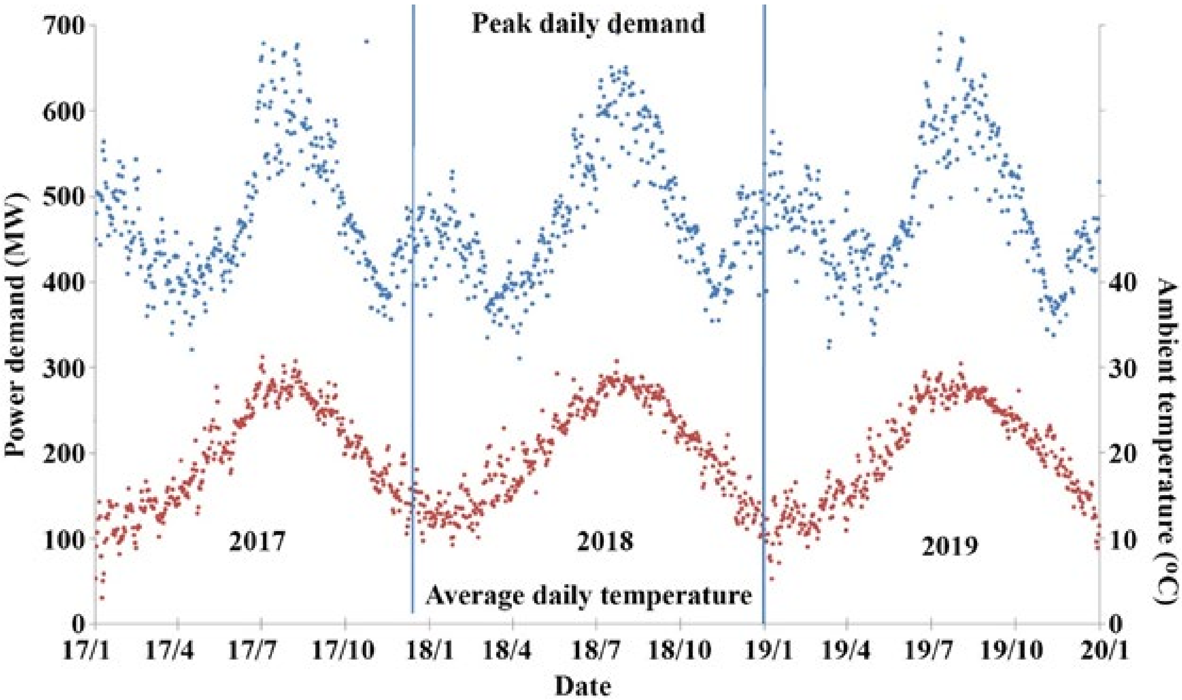

Figure 15 - Daily peak power demand on Crete for 2017 – 2019

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3.5. Replication: Western Isles, a follower island

The energy systems on the Western Isles are also expected to be developed ins stepwise process. As first phase starts from the process flow of OHLEH Creed company which is a project partner and located close to Stornoway, being the largest settlement of the Western Isles (Figure 16). Figure 17 shows the location of the company.

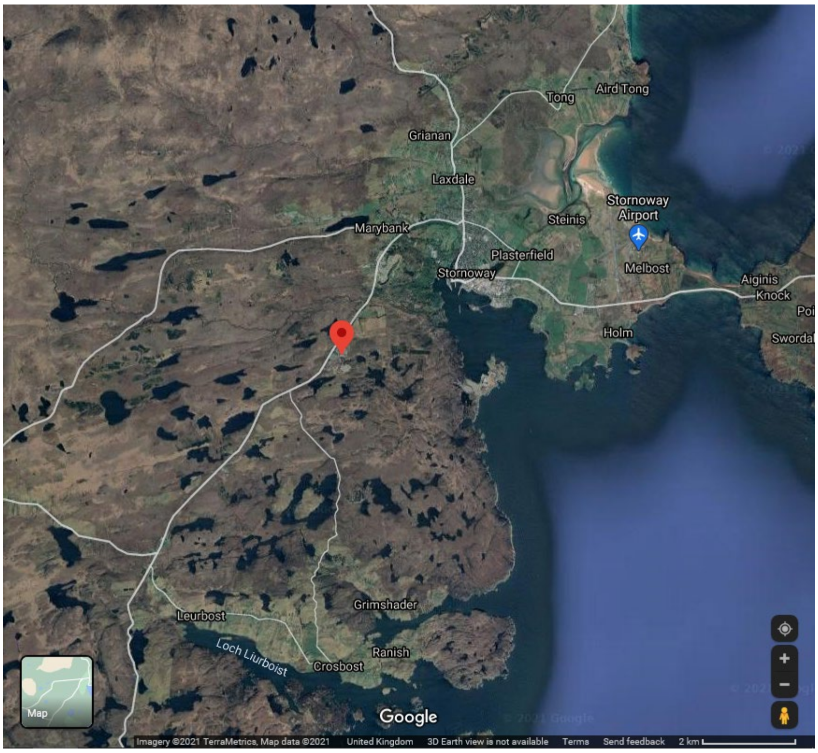

Figure 16 – Location of the OHLEH Creed company close to the settlement of Stornoway (Western Isles)

Figure 17 – OHLEH Creed aerial view

The overall system was modelled and an innovative energy management system solution for optimising (i.e., reducing) OPEX and CO_2 emissions was proposed. The energy concept of ROBINSON will be demonstrated at that Creed site to act as the seed for expanding the concept and apply it to the whole of the Western Isles.

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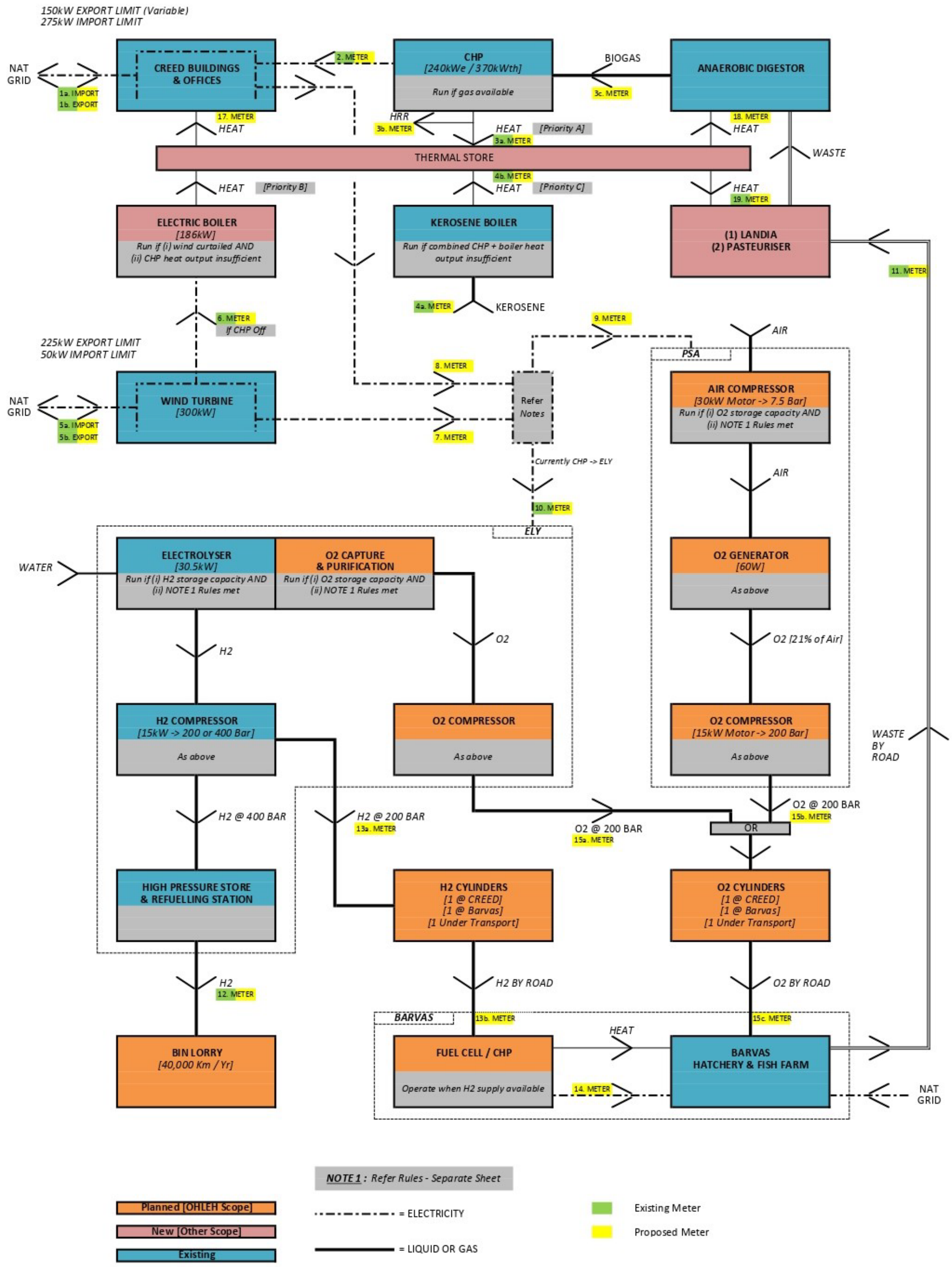

Figure 18 – Existing and proposed meters in Western Isles

Figure 18 shows schematically the current and expected energy fluxes, to visualise the interaction of the various prime movers. The concept considers the power, fuel and thermal energy generation, storage capacities (thermal and gas) and their interaction with the consumers.

As indicated in 2.2 above is the tight integration of the different energy vectors (electricity, thermal energy, and gas) and the inclusion of local energy storage aiming at balancing energy generation and demand. This shall consider the difference in availability of energy, the wide range of characteristics

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of the components inside the energy system while at the same time forming a reliable and resilient system.

While the demonstrator uses an anaerobic digestor supported by a bioelectrical system, is currently the one on the Western Isles an un-supported one. The produced biogas is fed to the CHP which is a reciprocating engine, thus having a different operational characteristic and fuel flexibility than the CHP of the demonstrator site in Eigerøy. The engine delivers electricity to the Creed Building and thermal energy to the storage (Figure 18). The WT located at the premises of Creed generates power which is fed into Creed's micro-grid. It is used to run the electrolysers which produce green hydrogen while oxygen is used in nearby hatchery. A gasification unit is not (yet) part of their energy system but might be considered in future. As no process steam is needed, the energy system of the Western Isles does not include a steam boiler and required heat of lower temperature level is covered making use of waste heat from the CHP and electrolyser while the decoupling of generated heat and heat demand is achieved by the integration of the thermal energy storage reservoir.

4. Summary

This is a deliverable related to the component integration issues, as preliminary activity for the EMS development. Attention is therefore mainly focused covering requirements, identification of different boundary conditions for integrated energy systems at the three involved islands and to collect missing details of the components of Eigerøy (for both simulations and demonstration) and for the replication activities (Western Isles, and Crete). However, as some component development activities are still ongoing, and as changing boundary conditions on the energy market impact business cases, further adaptation and updating need to be expected.

Special attention has been devoted to the platform development and the selection of the platform environment. It is decided to use the Run Time tool in LabView environment and to the communication protocols are defined (mainly Modbus). Finally, integration aspects related to the replication (Crete and Western Isles) are evaluated to identify synergies, as well as differences that need to be addressed when replicating the concept of Eigerøy. Details relevant for the execution of modelling and simulations are collected and in the process of being applied during follow up activities (e.g., T3.2).

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