HYDROUSA

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Water in the context of circular economy

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Guidance methodology for replication assessment

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Brief Description	The deliverable D7.2 details the guidance methodology to pave the way for the HYDRO replicability assessment. Specifically, D7.2 includes a general methodology to address technical, economic, social and legislative feasibility of HYDROs implementation in any replication site.
Keywords	Feasibility Assessment, Guidance Methodology, Decentralized Solution Replicability

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4	30 June 2020	Francesco Fatone, Giulia Cipolletta and Cagri Akyol	Final revision

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EXECUTIVE SUMMARY

This deliverable provides a guidance methodology to study and assess the technical and economic feasibility to transfer and/or replicate the adapted HYDRO(s) in different geographical, social and institutional frameworks. Thanks to D7.2 methodology, the results of the feasibility studies enable a homogeneous and harmonized framework to be used by different HYDROUSA partners, or outside the HYDROUSA consortium. Therefore, the WP7 results can even properly support the exploitation manager (WP8) to assess the business potential and opportunities of HYDROUSA solutions.

Even according to the Global Water Partnership approach, D7.2 allows to define: (A) the local enabling environment; (B) the local institutional arrangements in terms of regulation and compliance and water supply and sanitation services for each replication site.

The main domains that are addressed to study and assess the transferability and replicability are as follows:

- **Technical** (indicators/information are related to sizing criteria, mass flow analysis and resource requirements for evaluation of reliability, efficiency and flexibility, etc)
- **Economic** (indicators/information are related to Cost and Benefits analysis, Return of Investments, etc)
- **Geographic/Environmental** (indicators/information are related to the local environmental conditions and sensitivity such as water stress, etc)
- **Social** (indicators/information are related to social benefits and community needs, and are identified with the support of local stakeholders)
- **Institutional/Legislative/Regulatory** (indicators/information are related to regulatory framework, permitting pathways, etc ...).

In the context of the D7.2 guidance, the data collection and data processing routes are clearly schematized both within the HYDROUSA consortium and within local stakeholders.

In order to support the HYDROUSA Replication Site Managers, specific and detailed guidance documents/templates for data collection are also provided. Thanks to the gathered homogeneous format of information, the decision on the selection of the most relevant HYDRO(s) for the local framework will be supported.

Specifically, HYDROUSA Replication Site Managers will:

1) **Fill the "HYDRO Roadmap for legislative and institutional data collection" Excel spreadsheet** to summarize the local institutional framework and enabling environment for HYDRO implementation
2) **Write a "Feasibility Study" technical report** to determine the pressures/obstacles to HYDRO implementation at technical, economical, geographical/environmental, social and institutional/legislative/regulatory level.

The aim of this particular D7.2 is to provide methods, extensive and detailed support and general homogeneous criteria to: (a) select the HYDRO(s) that better fit(s) the replication site conditions; (b) evaluate and assess the technical and economic feasibility of the HYDRO(s) by quantifiable indicators. In order to provide the best guidance and to support decisions of the HYDROUSA Replication Site Managers, the following supporting documents are also provided within D7.2:

1) n.6 files of HYDRO Brochures, for HYDRO 1, HYDRO 2, HYDRO 3, HYDRO 4, HYDRO 5 and HYDRO 6
2) n.5 files of HYDRO Roadmap for data collection, for HYDRO 1 and 2, HYDRO 3, HYDRO 4, HYDRO 5 and HYDRO 6
3) n.5 files of HYDRO Design and Sizing criteria file, for HYDRO 1 and 2, HYDRO 3, HYDRO 4, HYDRO 5 and HYDRO 6
4) n. 1 Template of Feasibility Study Report
5) n. 1 Template of subcontract agreement between the Replication Site Manager and the Subcontracted Replication Manager

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ABBREVIATIONS

CAPEX	Capital Expenditure
CW	Constructed Wetland
MCDA	multi-criteria decision analysis
OPEX	Operative Expenditure
PP	Payback Period
UASB	Upflow Anaerobic Sludge Blanket
UV	UltraViolet

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1 INTRODUCTION

D7.1 clearly highlighted that the current EU legislations do not provide specific guidelines on closed water loops at small and decentralized/community level. Although a shift to decentralisation is generally recommended at different legislative levels, a clear enabling environment is often lacking.
Therefore, even according to the Global Water Partnership approach, the replication studies need to stand as a starting point for each replication site before evaluating the possible suitable HYDRO solutions:

A- The local enabling environment in terms of:
- a. Policies
- b. Legal framework
- c. Investments and financing structures

B- The local institutional arrangements in terms of:
- a. Regulation and compliance
  - i. Regulatory bodies and enforcement agencies
  - ii. Local authorities
  - iii. Monitoring and evaluation bodies
  - iv. (Possible) impact assessment committees
- b. Water supply and sanitation services
  - i. Public sector water utilities
  - ii. Private sector water and water-service providers
  - iii. Community-based water supply and management organizations
  - iv. Private water and water-loop managers (e.g. for tourist facilities)

Considering the legislative structure of each Country or Region, HYDROUSA Replication Site Managers will provide information on their own local framework of the (A) **enabling environment** and (B) **institutional arrangement** that can govern, regulate, finance, implement and exploit the HYDROUSA water loops.

The aim of this particular D7.2 is to provide methods, support and general homogeneous criteria to: (a) select the HYDRO(s) that better fit(s) the replication site conditions; (b) evaluate and assess the technical and economic feasibility of the HYDRO(s) by quantifiable indicators.

1.1. Chain of Responsibility and Internal Communication Channels for Data Collection

In order to provide a clear overview of the chain of responsibility/roles, following figures are internally identified:

SITE MANAGERs = All the HYDROUSA Partners responsible for the implementation of the 6 HYDROs in the Greek Islands, as defined by the Grant Agreement. Contacts of Site Managers are identified as follows:

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Table 1.1 Site Managers List

DEMO SITES	SITE MANAGERs	RESPONSIBLE
HYDRO1 + HYDRO2	NTUA ISOF ALCN	D. Mamais, C. Noutsopoulos T. Elarabi, J. Kisser A. Pantera
HYDRO3	DEL	A. Eleftheriou Y. Vasilakos
HYDRO4	NTUA	K. Monokrousou, C.Makropoulos A. Eleftheriou
HYDRO5	PLANET	A.Zecca, A.Villa
HYDRO6	ELT ALCN	N. Bedau, J. Kisser

TECH PROVIDERs = All the HYDROUSA Partners responsible for developing the HYDROUSA Technologies of the 6 HYDROs in the Greek Islands. Tech Providers contacts are identified as follows:

Table 1.2 Technology Providers List

DEMO SITES	TECH PROVIDERs	RESPONSIBLE
HYDRO1 + HYDRO2	AERIS IRIDRA ALCN AGENSO	O.Prado, R. Montes-Martínez F. Masi, A. Rizzo J. Kisser, P. Karlsson Z. Tsiropoulos, E. Anastasiou C. Noutsopoulos, C. Lytras
HYDRO3	DEL AGENSO	A. Eleftheriou, I. Vasilakos Z. Tsiropoulos, E. Anastasiou
HYDRO4	NTUA AGENSO	K. Monokrousou, A. Eleftheriou Z. Tsiropoulos, E. Anastasiou
HYDRO5	PLANET RANDKE ALCN AGENSO	A. Bianciardi, A.Villa M. Radtke J. Kisser, P. Karlsson Z. Tsiropoulos, E. Anastasiou
HYDRO6	ELT ALCN	N. Bedau J. Kisser

HYDROUSA Replication Site Manager = HYDROUSA Partner responsible for the replicability of the HYDROs in the replication sites defined in Task 7.3, 7.4 and 7.5 of WP7 (according to the Grant Agreement). HYDROUSA Replication Site Manager are identified as follows:

Table 1.3 HYDROUSA Replication Site Managers List

HYDROUSA Replication Site Manager	Contact Person	Replication Site	
EUROPE			
UNIVPM/ASA	Francesco Fatone	Italy	Tuscan Arcipelago
UNIVPM	Francesco Fatone	Bulgaria	Sofia Region
UNIVPM	Francesco Fatone	Turkey	Southern Mediterranean areas
SEMIDE	Eric Mino	France	Porquerolles Island
SEMIDE	Eric Mino	Croatia	Zlarin island
ICRA	Gianluigi Buttiglieri	Spain	Balearic islands (Cabrera)
ICRA	Gianluigi Buttiglieri	Spain	Balearic islands (Formentera)
ICRA	Gianluigi Buttiglieri	Spain	Canary Islands (El Hierro)
ICRA	Gianluigi Buttiglieri	Spain	Canary Islands (La Graciosa-Lanzarote)
ICRA	Gianluigi Buttiglieri	Spain	Canary Islands (South East Gran Canaria)
ICRA/CWP	Gianluigi Buttiglieri/Amores Bravo Xavier	Portugal	Algarve
MEMIRA	Memnon Papageorgiou	Cyprus	Limassol/Geroskipou coastal town
SEMIDE	Eric Mino	Malta	
MENA			
SEMIDE	Eric Mino	Tunisia	Kerkennah archipelago
SEMIDE	Eric Mino	Palestine	Jenine and Khan
SEMIDE	Eric Mino	Lebanon	Beqaa valley
UNIVPM	Francesco Fatone	Israel	Galilee
UBRUN	Evina Katsou	UAE	Abu Dhabi
NTUA	Constantinos Noutsopoulos	Morocco	Fès-Meknès region
ISOF, HUSD	Omar Eldahan/Jane Hannah	Egypt	Al-Wahat
FAR EAST			
UNIVPM	Francesco Fatone	China	Shaanxi province
UNIVPM	Francesco Fatone	Australia	Queensland
UNIVPM	Francesco Fatone	Mexico	Poncitlán Municipality
UNIVPM	Francesco Fatone	Chile	Rural areas
UBRUN	Evina Katsou	Malaysia	Malaysia
UBRUN	Evina Katsou	Argentina	Buenos Aires

External/Subcontracted Local Replication Managers = External local replication responsible/support, possibly subcontracted by the HYDROUSA Replication Site Manager in order to provide information on the local site and, if needed, information required in this document. Following discussions with the replication sites, replication Managers who might be possibly subcontracted are identified as follows.

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Table 1.4 Subcontracted Replication Managers List

EUROPE					
beneficiary	**country**	**replication sites**	**supporting organizations/authorities**	**External/local replication responsible/support**	**contact e-mail**
UNIVPM	Italy	Tuscan Arcipelago	Asa	Camillo Palermo	C.Palermo@asa.livorno.it
UNIVPM	Bulgaria	Sofia Region	Bulgarian Water Association	Irina Ribarova	ribarova.irina@gmail.com
UNIVPM	Turkey	southern Mediterranean areas	Istanbul University	Gozde Ozbayram	gozde.ozbayram@istanbul.edu.tr; c.akyol@staff.univpm.it
SEMIDE	France	Porquerolles Island	Parc national de Port-Cros	Giulia AZZOLINI	giulia.azzolini@portcros-parcnational.fr
SEMIDE	Croatia	Zlarin island	Tourist office and council of Zlarin island + SMILO association	Sylvain Petit	sylvain.petit@paprac.org
ICRA	Spain	Balearic islands (Cabrera)	National Park of Cabrera	Maria Francisca Lopez (Managing Director of Natural Spaces and Biodiversity) Ainhoa Ibarrola José Romero Casado	mflopez@dgmambie.caib.es aibarrola@dgmambie.caib.es
ICRA	Spain	Balearic islands (Formentera)	Consell Insular de Formentera	Ana Maria Fernández Antonio Sanz (conseller de medi ambient) Verónica Aguilar (secretary)	anamfernandez@conselldeformentera.cat mediambient@conselldeformentera.cat veronicaaguilar@conselldeformentera.cat
ICRA	Spain	Canary Islands (El Hierro)	Centro de iniciativas y turismo (CIT) El Hierro	Amós Lutzardo Castañeda	citelhierro@gmail.com
ICRA	Spain	Canary Islands (La Graciosa-Lanzarote)	Water consortium of Lanzarote (Consorcio del Agua de Lanzarote)	Mareiva Marrero, Domingo Pérez	gerencia@consorcioagualanzarote.com, administracion@consorcioagualanzarote.com

ICRA	Spain	Canary Islands (South East Gran Canaria)	Southeast County of Gran Canaria (Mancomunidad del Sureste de Gran Canaria)	Delia Caballero	agenda21.fefi@surestegc.org
ICRA/CWP	Portugal	Algarve	Portuguese Water partnership (Parceria Portuguesa para a Água)	João Simão Pires	jsp@ppa.pt
MEMIRA	Cyprus	Limassol/Geroskipou coastal town	Geroskipou Municipality		info@geroskipou-municipality.com
SEMIDE	Malta		MEW-Energy & Water Agency	Sapiano Manuel at MEW-Energy & Water Agency	manuel.sapiano@gov.mt
MENA					
SEMIDE	Tunisia	Kerkennah archipelago	NGO Al Majarra	Mohamed nejib Kachouri	mohamednejibkachouri@gmail.com
SEMIDE	Palestine	Jenine and Khan	Palestinian Water Resources Authority	Subhi Samhan	subhisamhan@yahoo.com
SEMIDE	Lebanon	Beqaa valley	Society for the Protection of Nature	Bassima Khatib	bkhatib@spnl.org
UNIVPM	Israel	Galilee	Agrobics	Isam Sabah	isabbah@gal-soc.org
UBRUN	UAE	Abu Dhabi	Khalifa University	Shadi Wajih Hasan	swajih@masdar.ac.ae
NTUA	Morocco	Fès-Meknès region	Sidi Mohamed Ben Abdellah University	Recherche Scientifiques	kaoutar.sekkat@usmba.ac.ma
ISOF, HUSD	Egypt	Al-Wahat	SEKEM farm in Al-Wahat	Mamdouh Abouleish - CEO ISIS Organic for Food Industries Ltd	info@sekem.com
FAR EAST					
UNIVPM	China	Shaanxi province	International S&T Cooperation Center for Urban Alternative Water Resources Development	Xiaochang C. Wang- Director	xcwang@xauat.edu.cn
UNIVPM	Australia	Queensland	University of Queensland	Ilje Pikaar - Lecturer Environmental Engineering	i.pikaar@uq.edu.au

UNIVPM	Mexico	Poncitlán Municipality	CIATEJ, Mexico	Luis Alberto Arellano Garcia - Technical Manager CIATEJ	larellano@ciatej.mx
UNIVPM	Chile	rural areas	University Adolfo Ibanez	Dafne Crutchik	dafne.crutchik@uai.cl
UBRUN	Malaysia	Malaysia	University of Nottingham in Selangor (Malasya)	Sara K. Yazdi - Assistant professor	ResearchSupportOffice@nottingham.edu.my
UBRUN	Argentina	Buenos Aires	Instituto Tecnológico de Buenos Aires	Daniel Ryan, Vanina Ros, ITBA	dryan@itba.edu.ar; vaninadaros@gmail.com

The above actors will cooperate with UNIVPM to support the work in the Tasks 7.3, 7.4, 7.5

According to the main actors mentioned earlier, the chain of responsibility/roles for data collection is schematized below:

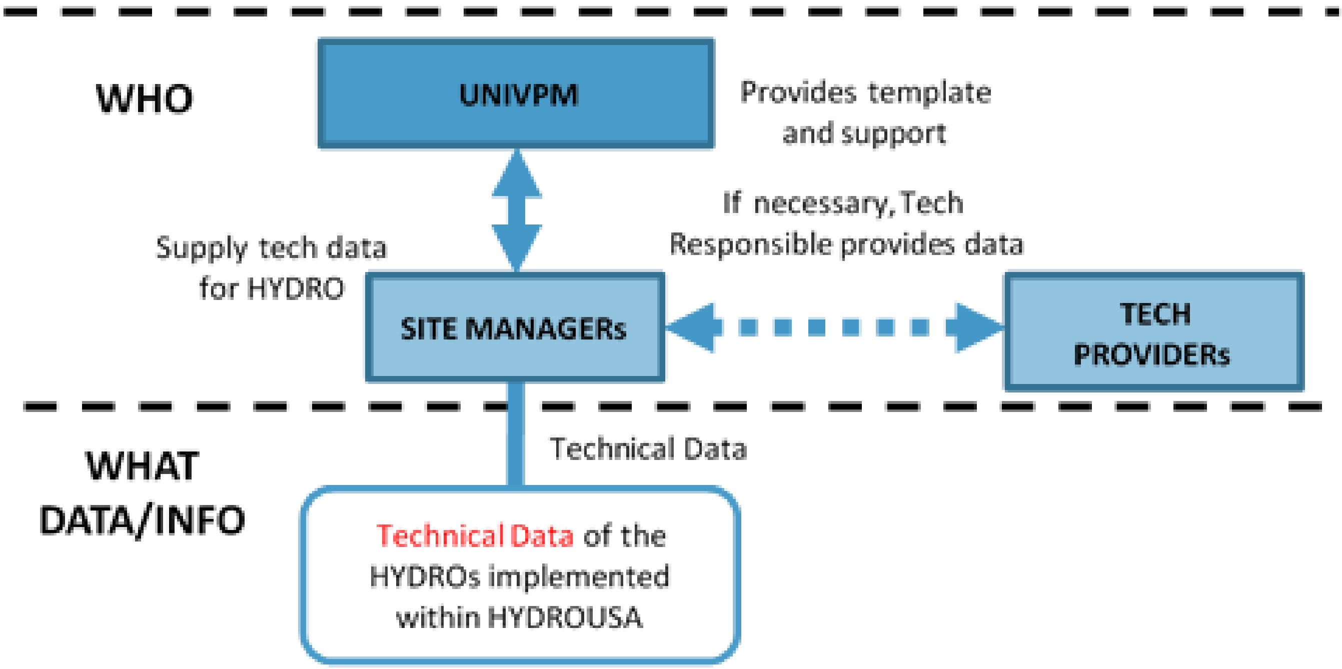

Figure 1.1 Responsibility Chain for Technical Data Collection[1]

[1] Technical Data refer to specific indicators (surface requirement, energy consumption…etc) per PE served or per m3 of flow treated or per kg of crop cultivated or per m2 of land footprint etc…

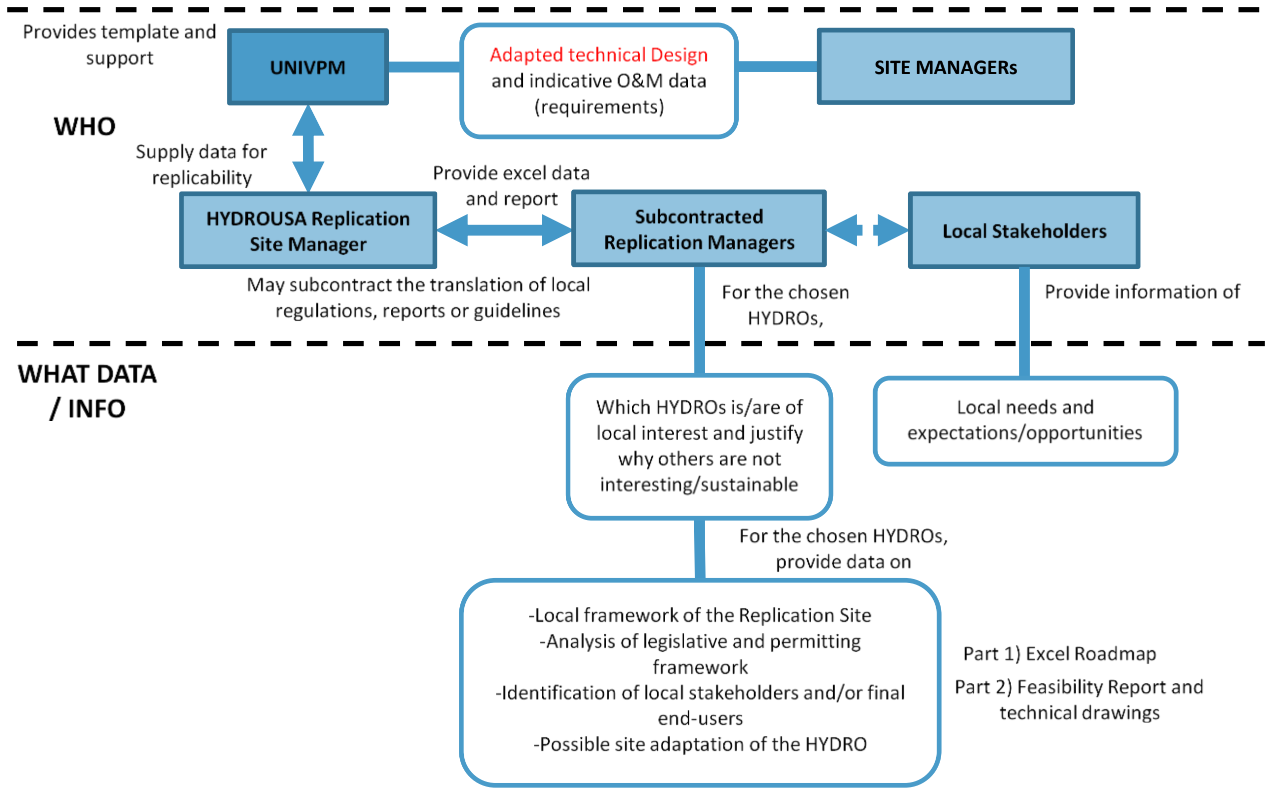

Figure 1.2 Responsibility Chain for HYDRO Replicability assessment and Data Collection[2]

In order to support the HYDROUSA Replication Site Managers, specific guidance documents/templates for data collection were elaborated and are hereby provided. Thanks to this information, the decision on the selection of the most relevant HYDRO(s) for the local framework will be supported.
Specifically, HYDROUSA Replication Site Managers will in collaboration with the External/Subcontracted Replication Managers:

1) **Fill the "HYDRO Roadmap for legislative and institutional data collection" Excel spreadsheet** to summarize the local institutional framework for HYDRO implementation
2) **Write a "Feasibility Study" technical report** to determine the pressures/obstacles to HYDRO implementation at social, institutional, technical and economical level.

[2] Adapted Technical Data refer to the data related to the "modified" HYDRO to best fit the needs of the replication site (e.g. HYDRO 1 excluding composting system, when compost recovery is not needed/valuable etc…). In this context, HYDROUSA replication site managers should get data from the subcontracted replication manager. Then, HYDROUSA replication site managers should fill the form that is needed to deliver the preliminary design, with the support of subcontracted replication manager if needed. UNIVPM will receive data and support HYDROUSA replication site managers.

To deliver the above-mentioned output, Replication Site Managers are provided with:

1) n.6 files of **HYDRO Brochures**, one for each HYDRO. In each file, a brief description, block flow diagram and main technical features of the HYDRO are reported. These files aim at providing all the necessary information for the choice of the HYDRO in the future replication site;
2) n.5 files of **HYDRO Roadmap for legislative and institutional data collection**. In these files, all the required legislative and permitting pathway information are collected. The excel spreadsheets includes guided tables to be filled. In addition, an example of data collected for the Italian case has been attached to each excel document as support for filling the tables;
3) n.5 files of **Sizing criteria for HYDRO design**. These files contain sizing criteria and main technical requirements of the HYDROs. Specifically, excel documents were elaborated to support the HYDROUSA Replication Site Managers in defining technical aspects for the feasibility study;
4) **Feasibility Study Report Template**. This document provides a detailed guidance to write the Feasibility Assessment Study for the selected HYDRO in the specific local context;
5) **Template of subcontract agreement**. This document defines the terms between the Replication Site Manager and the Subcontracted Replication Manager to perform the Hydro feasibility study.

As an example, the above-mentioned documents are provided in the Annex 8. For brevity, only the documents for HYDRO 1 are reported in this Deliverable.

2 TECHNICAL HYDRO BROCHURES

Six integrated brochures (see Annex 8, chapter 8.1 for HYDRO 1 Example) were prepared to provide an overall picture of all the HYDROs. Information collected can be used by the Replication Site Manager and Subcontracted Replication Manager to select the HYDRO(s) to be thereby replicated. In these files, the general overview of the HYDROs is summarized as follows:

- **System Description**: a schematic general overview of the HYDRO solution;
- **Technical Specifications**: main design and continuously updated operation data of the Greek pilots that are actually under the implementation phase within the HYDROUSA Project;
- **Recovered resources**: quantified description of valuable resources/products recovered by the HYDROs implementation;
- **Benefits**: direct and indirect advantages of the HYDRO solutions, at technical, social and economic level.

At the early stage, operating data are referred to the HYDRO design phase. Data will be continuously updated when the HYDROs are fully implemented in the Greek demo sites. Therefore, the identification of the most appropriate HYDROUSA solution for a replication site will be optimized in line with the current knowledge of the implemented HYDROs.

The identification of the most appropriate HYDRO solution for each local replication site is the first step of defining the feasibility assessment of HYDROUSA water loops.

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3 ROADMAP FOR LEGISLATIVE AND INSTITUTIONAL DATA COLLECTION

Since the local regulatory context is a crucial factor for the HYDRO replicability, each HYDROUSA Replication Site Manager is responsible of analyse the national/regional legislative and authorization factors.
In this context, an excel file **"HYDRO Roadmap for legislative and institutional data collection"** was prepared for each HYDRO according to the structure described below in this section.
Specifically, once the HYDRO is chosen, the expected contribution from the HYDROUSA Replication Site Manager will be to fill the excel spreadsheet related to the selected HYDRO.

Specifically, collected data to be reported in the spreadsheet are:

- National (and regional/local if implemented) regulations to authorize the construction and operation the HYDRO;
- National (and regional/local if implemented) regulations, guidelines, technical standards on the reuse of the recovered resources (Outputs) defined in the HYDROUSA Project;
- Technical requirements that Outputs should ensure in specific applications (e.g. quality parameters, prescription on the use, minimum required treatment, necessity to label and certify the by-products, necessity to contract the end-users, etc.)
- Financing strategies or incentives can be applied for the construction and/or recovery/reuse of by-products. In this case, please provide information on the financial methods
- Practical suggestions to cope with the lack of clear pathways (if detected) for closed water loops at small and decentralized/community level.

To facilitate effective data gathering, a detailed guidance to navigate the Excel file **"HYDRO Roadmap for legislative and institutional data collection"** is given below.

The file is composed of different sheets:

a. **"HYDRO n°….":** in this sheet HYDROUSA Replication site Managers can find a general overview of the HYDRO. The work sheet is divided into three relevant sections of the HYDRO:

Table 3.1 Sections of the HYDRO Roadmap excel file

INPUT (I)	HYDRO SOLUTION	OUTPUT (O)
In this section, influents to the HYDRO solution are highlighted	In this section, simplified P&Id of the HYDRO is reported and a link for the main block flow diagram of the HYDRO solution is provided. For the implementation of the HYDRO in a specific local context, a table is reported with the required information on permitting procedures.	In this section, arrows from the HYDRO solution highlight the different outputs as recovered resources. For each of the recovered resources, a link to data/info collection tables is given.

b. **"O n°…_….." (one sheet for each output of the HYDRO)**: in each sheet, a table with the required main information on the legislative references (including quality requirements, parameters, limits and prescriptions etc…) and necessary permits/authorizations are reported.

HYDROUSA Replication Site Managers are kindly invited to fill the tables (in all sheets) with the relevant legislative and institutional information to analyse the enabling environment for the specific outputs. In this perspective, the tables can be modified with new rows and/or columns if necessary.
In addition, the information on the main permitting procedures/authorization/certifications for the reuse of the recovered resources need to be provided. For each permitting procedure, partners will provide detailed legislative references and related responsible authorities for issuing the permits.
As further guidance and example for the compilation of the table, HYDROUSA Replication site Managers may also refer to the **"EXAMPLE ITALIAN CASE" sheet,** by clicking on the link on the page;

c. **"Permitting Pathway":** in this sheet, the main information on the permitting pathway for the construction and management of HYDRO solution is required. Specifically, both an example of necessary authorization and indication on how to collect the required information are suggested in tables;

d. **"Block Flow Diagram":** after providing the local legislative framework, HYDROUSA Replication Site Managers are kindly invited to analyse the main flow scheme of the HYDRO and, if necessary, to consult the tech provider and to adapt it to the technical requirements and to the local legislations. In fact, modifications/updates might be necessary whether further treatments are needed to comply with local legislation and standard;

e. **"EXAMPLE ITALIAN CASE":** in this sheet, HYDROUSA Replication site Managers can find a practical example on the preliminary information collected for the replication of HYDRO 1 in the Italian site.

An example of the excel file for HYDRO 1 is reported in Annex 8, chapter 8.2.

4 SIZING CRITERIA FOR HYDRO DESIGN

The HYDROUSA Replication Site Managers should carry out the preliminary design of the chosen HYDRO with the support of "**Sizing criteria for HYDRO design"** files, which aim:

a. to define the main technical characteristics of the applied technologies/sub-HYDROs, to determine the mass and energy balances (below, an example of the design file of Upflow Anaerobic Sludge Blanket-UASB is given for HYDRO1);
a. To list all the required technical equipment and devices;
b. To obtain data for the HYDRO footprint in terms of required area and energy consumption;
c. To define capital and operative expenditures, in order to determine the payback period.

Design Data UASB				
Parameters	Units	Typical	Used for HYDRO 1 in Greek Case Study	**Insert Data according to Replication Site Case Study**
Influent Wastewater Charateristics:				
Population equivalent to be served	PE		500	
Flowrate	m3/d	-	100	
COD concentration	mg/l	500	578	
BOD5 concentration	mg/l	300	331	
TSS concentration	mg/l	320	272	
Organic Load	kg COD/d	-	57.8	
pH	-	-	7.3	
Conductivity	µS/cm	-	1164	
TKN	mg/l	40	42	
Ammonia Concentration	mg/l	25	32	
Temperature	°C	-	23	
Operative Parameters:				
HRTdesign	h	5 ÷ 10	10	
Volume tot	m3	-	42	
n° of operative lines	n°	-	2	
Volume of each line	m3	-	20.8	
OLR	kg COD/m3 d	0.8-2	1.39	
HRToperative	h	-	10	
Vup	m/h	0.5 - 1.5	0.6	
Area (each reactor sectional area)	m2	-	3.47	
Diameter	m	-	2.10	
Each Reactor height	m	-	6.0	
Liquid upflow velocity at the bottom of the GLS separator (VUP,GLS)	m/h	< 4	1	
Sliq (each reactor Liquid Area)	m2	-	2.08	
Sliq (each reactor separation Area)	m2	-	1.39	
dsep (each reactor separation diameter)	m		1.33	
Stoichiometrically methane production	m3CH4/kgCODRemoved	0.35	0.35	
COD removal	%	70 - 80	70	
COD removed	kgCOD/d	-	40.5	
Daily methane production	m3CH4/d	-	14.2	
Methane percentage in the Biogas	%CH4/biogas	60	60	
Daily Biogas production	m3biogas/d	-	23.6	
Stoichiometrically Sludge production	kg sludge/kg CODRemoved	0.06 - 0.07	0.062	
Sludge production	kg sludge/d	-	2.51	
TS% of sludge	mgTSS/l	-	20000	
Q excess sludge	m3/d	-	0.125	
UASB Balance				
Qout	m3/d	-	99.9	
CODin	kgCODin/d	-	57.8	
CODout	kgCODout/d	-	17.3	
	mg/l	-	174	
TSS in	kgTSS/d	-	27	
TSS removal	%	60 - 70	67	
TSS removed	kdTSS/d	-	18	
TSSout	kgTSSout/d	-	9	
	mg/l	-	90	
Energy Conversion factor	kJ/kWh	3600	3600	
Energy content of methane at standard conditions	kJ/m3CH4	35846	35846	
Energy production	kW/m3		1.4	
	kW/d		141.0	

Figure 4.1 Design data of UASB – HYDRO 1 - example

The design files were prepared following the HYDROs and sub-HYDROs sizing criteria described in the available technical Deliverables, written for the Greek case studies (D2.1, D2.3, D3.1, D3.2, D3.6). Hence, Replication Site Managers, with the support of Technical Provider, can use the file as a guidance to design the future HYDRO by using the data referred to the specific replication site.

The design files for HYDRO 6 is less detailed than the others, as the submission of technical Deliverable is planned at Month 24 (D2.5).

At this stage, the design files aim to define a rough pre-sizing of the HYDRO to assess the replicability of the future site in the local context. Moreover, these technical documents are actually under revision by the HYDROUSA Site Managers, so the current versions might slightly vary from the final ones.

5 FEASIBILITY ASSESSMENT REPORT

Once the previous steps are finalized, each HYDROUSA Replication Site Manager is asked to write the Feasibility Assessment Study (technical report) for the selected HYDRO, following the provided template (Annex 8 chapter 8.4).
This document aims to provide a detailed guidance to analyse all the key aspects for the HYDRO replicability in a specific local Context.

Firstly, an overview of the HYDRO implementation (hereafter called as "project") and the relevant data of the local context need to be analysed. In this regard, the local social and environmental conditions and constraints should be generally summarized. Specifically, the local resource security priorities should be clarified, so the demand estimation for a specific resource recovery and reuse and benefit that could be derived from the project should be quantitatively reported. Furthermore, relevant geographic/environmental indicators/information related to the local environmental conditions and sensitivity should be reported in the Feasibility Report.
All the required information are detailed in the **"Feasibility Study Report Template"**.

Each HYDRO will stand as a starting point within its own local context for the identification of the most suitable measures that can enable environmental protection and conservation of cultural and landscape values.

Once the project is locally contextualized, the policy and institutional analyses should identify the enabling or disabling conditions for the exploitation of the HYDRO. In this perspective, the data on national and regional legislation are, then discussed and further integrated with all relevant mandatory local regulations or rules of practice.

Then, the technical feasibility of the HYDRO is assessed. Specifically, the local design criteria for HYDRO flows and loads are defined to size and preliminary draw the best available HYDRO layout.

Finally, the economic feasibility is analysed. An evaluation of the costs associated to the project and local market analysis of the recoverable resources is reported to determine the economic feasibility of the project.

According to literature review, the multi-criteria decision analysis (MCDA) method can be used to assess overall feasibility. It represents a useful tool to evaluate complex decisions where trade-offs between competing objectives are involved (Meerholz A. & Brent A.C., 2013).

Here MCDA method is used to combine information about the implementation of the HYDRO. It covers different criteria (scoring) with subjective evaluation about the importance of the evaluation criteria in the decision-making context (weighting) (Saarikoski et al., 2017).

According to literature studies (Giorgini, 2003; Meerholz A. & Brent A.C., 2013; Marleni N. et al., 2020), assessment criteria are:

- Social feasibility
- Policy feasibility
- Technical feasibility
- Economic feasibility

Further sub-criteria were identified to evaluate the feasibility of the HYDRO in a specific context (e.g. Social, Legislative, Technical and Economic).
For each sub-criterion and considering the local context, a score is assigned (e.g. Low, Medium, High).

As a result, equation 1 should be used to define the Feasibility Score of the HYDRO in a specific site.

$$S = \sum_{i=1}^{n} s_i \qquad \textit{(Equation 1)}$$

where:
S= the overall Feasibility Score
i = the sub-criteria of interest, i = 1, …, n
s_i =the score given for a specific sub-criteria.

As feasibility studies are often applied to specific projects in defined social and geographical contexts, higher weights are usually attributed to the technical and economic aspects. However, considering the innovative aspects of the HYDROUSA Project and the results of D7.1, the attention has to be paid on the analysis of social and policy frameworks. This is mainly due to the importance of both social acceptance and policy support for the HYDROUSA water loops exploitation. Applied weights are thus:

- Social feasibility 30%
- Policy feasibility 30%
- Technical feasibility 20%
- Economic feasibility 20%

Once the scores are obtained for Social, Legislative, Technical and Economic criteria, a value function (Equation 2) should be used to define the overall feasibility score (v(x)) as follows (Meerholz A. & Brent A.C., 2013):

$$v(x) = \sum_{x=1}^{n} W_i \cdot S_i \qquad \textit{(Equation 2)}$$

where:
S_i = the score with respect to a criteria i
n = the number of criteria
i = the criteria of interest, i = 1, …, n
W_i =the relative importance (weight) of a criteria i, $W_i > 0$.

The final contribution of each HYDRO solution in different replication sites is expected to be as follows:

Table 5.1 Overall Feasibility Score

FINAL RESULTS			
Feasibility Criteria	Main Feasibility Sub-Criteria	Weight	Score
Social Feasibility	Stakeholder and public participation, Social Benefits, Social Acceptance	30%	*Specific SCORE of the chosen HYDRO for the replication site*
Policy Feasibility	Strategies and Action plans, Targets and Quality standards, Permitting Pathway	30%	*Specific SCORE of the chosen HYDRO for the replication site*
Technical Feasibility	Efficiency	20%	*Specific SCORE of the chosen HYDRO for the replication site*
Economic Feasibility	Financial pathway, Payback Period	20%	*Specific SCORE of the chosen HYDRO for the replication site*
OVERALL FEASIBILITY	**-**	**100%**	**SCORE from 1 to 100**

Replication Site Managers will follow the structure (see Annex 8, chapter 8.4) and provide all the necessary data to elaborate the final document which will represent the Feasibility study for the HYDRO replicability.

6 CONCLUSIONS

This deliverable reports a methodological guidance for replicability evaluation and assessment of HYDRO solutions.

The main purpose is to provide the HYDROUSA Replication Site Managers with deep knowledge and details for the selection of the best fit HYDROs and the following feasibility assessment. The replication managers are guided in all the steps and relevant templates are provided. Thanks to this guidance, HYDROUSA consortium will also get harmonized information to feed and support the exploitation strategy and commercialization roadmap.

Due to the lack of standard for the replicability assessment, scientific literature has been considered to propose indicators to quantify the social technical, regulatory and economic local feasibility.

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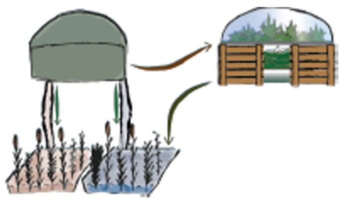
8 ANNEX

8.1 HYDRO Brochure

HYDRO 1

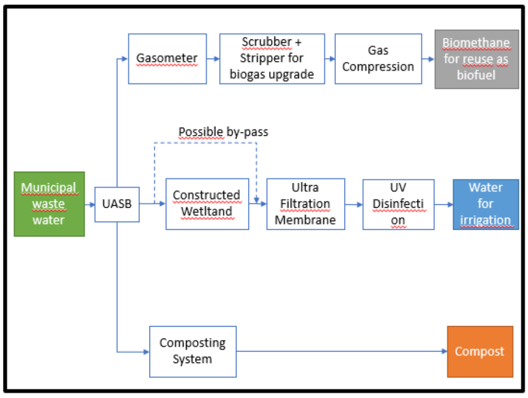
a sewage treatment system applied in decentralised areas with high seasonal loads to recover energy and recycle water and nutrients



System Description

HYDRO1 consists of a sewage treatment system applied in decentralised areas with high seasonal loads. HYDRO1 combines anaerobic processes (Upflow Anaerobic Sludge Blanket (UASB) reactor) with constructed wetlands and disinfection to treat domestic wastewater as a completely circular solution, where water, nutrients and the produced sludge are going to be reused. Furthermore, the anaerobic process recovers energy in the form of biogas.

HYDROUSA establishes the optimal operating conditions under which organic load removal and biogas production are maximized. The excess sludge from the UASB gets mixed with biomass and co-composted in an innovative in-vessel composting system, coupled with a novel plant biofilter to treat the odours. According to legal constraints the UASB effluent will be either treated in a series of saturated and unsaturated constructed wetlands (CWs), filtered and disinfected for reuse in agriculture, or will be directly used for fertigation after disinfection. The produced biogas may be used for energy production in CHP generators or can be upgraded to methane to be valorised as a fuel. A simplified layout of HYDRO 1 is shown in Figure 1.



Technical Specifications

UASB

Pretreatment requirements: grease and grit removal
Municipal wastewater temperature range = 15–35 °C
Hydraulic Residence Time = 7 – 10 h
Organic loading = 2 - 10 kgCOD/m³/day
Area required = 0.25 m² per m³/day of wastewater treated
Upflow velocity = 0.5–1 m h^{-1}
Organic pollution removal as COD = 70 – 80%
Solids removal as TSS = 70 – 80%
Biogas production = 0.24 m³ biogas per m³ of wastewater treated
Sludge production = 25 g DS per m³ of wastewater

Post-treatment

Ultrafiltration membrane

TSS removal = 96 – 99%
Total and Fecal Coliforms reduction = 3 – 6 log
Rate of flux = 60 – 180 l $m^{-2}h^{-1}$
Energy consumption = 0.2 – 0.3 kWh m^{-3} of wastewater treated

UV Lamp

Estimated lamp life = 8000 – 12,000 hours
Max Energy consumption = 0.03 kWh m^{-3} of wastewater

Constructed Wetlands

Area required = 8.5 m² per m³/day of wastewater treated
Organic pollution removal as COD = 90%
Solids removal as TSS = 75%
Nitrogen removal = 10-20% (one stage wetland);
50-70% (two-stage wetland)
E. coli removal = 90 – 99%
Sludge production = none

Benefits

No wastewater discharge into the sea at dry weather
High quality wastewater effluent that meets Directive 91/271 effluent criteria
Cheaper Production of reclaimed water for restricted and unrestricted irrigation
Recycling nutrients in agriculture
Low energy consumption < 0.3 kWh/m³ of wastewater treated
Energy recovery from wastewater = 0.6 kW_e/ m³ of wastewater treated
Low O&M costs < 0.5 €/m³ of wastewater treated
Pay back period < 9 years

Figure 8.1 HYDRO 1 Technical Brochure

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8.2 HYDRO route for data collection

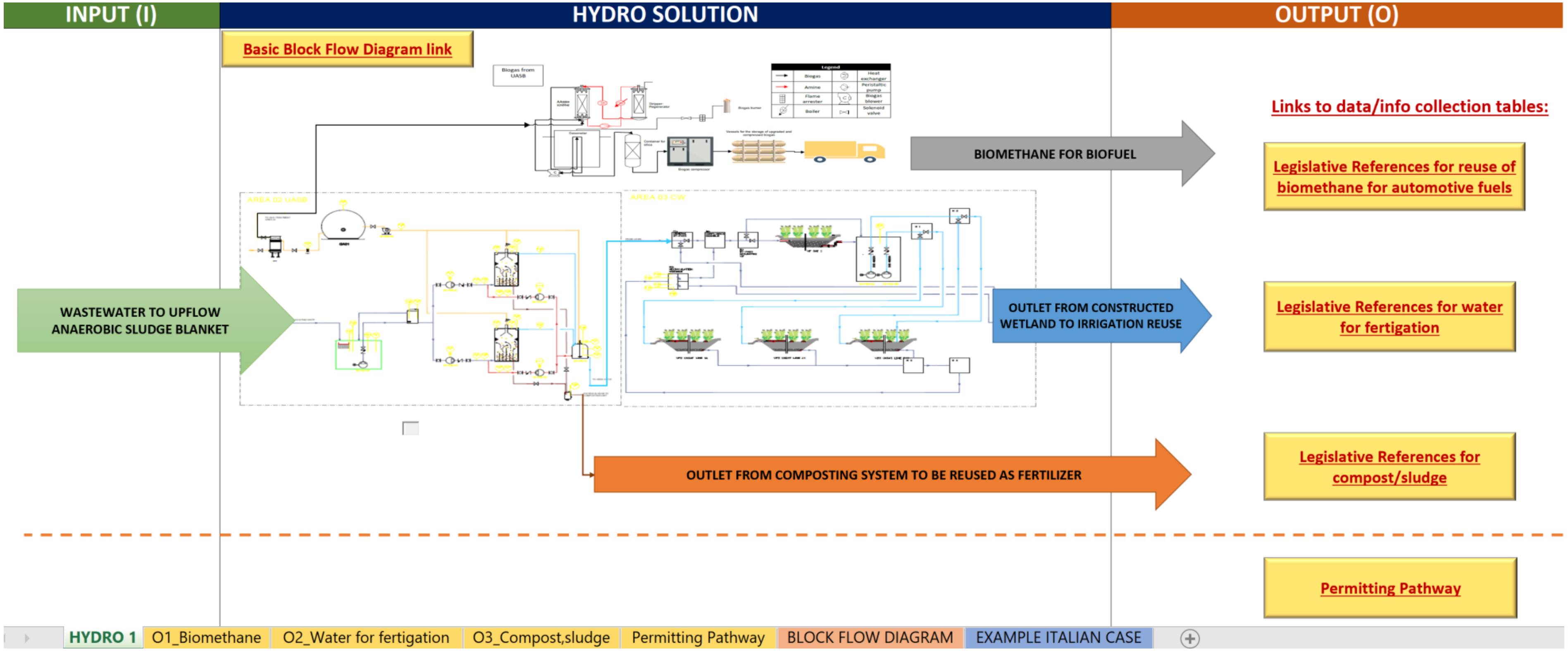

Figure 8.2 HYDRO1 Roadmap

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Please fill the table below with main information required in each column. Relevant information for the regulation of this output can be also highlighted, by adding new columns and raws. As guidance for the compilation of the table, please refer to the ITALIAN CASE in the link at the side.

EXAMPLE ITALIAN CASE

Insert here the Legislative References (e.g. Law/Decree/Regulation/Standard n°__of __/__/___) on reuse of biomethane for automotive fuels			PERMITTING PATHWAY FOR UTILIZATION OF THE BY-PRODUCT	Notes/Improvements/Lack of actual legislation
Quality of the methane	**Prescriptions on the use**	**Minimum required treatments**		
Chemical Parameters (unit and values) to be respected as limits for reuse	Descriptions of: 1- specific conditions for utilization of the methane	Processes and treatments (i.e. desulphurization, scrubbing etc...)needed to ensure compliance with methane in terms of quality, according to the reuse	For example: 1-Need to certify the product (i.e. labelling or certification etc...); 2-Need to identify end-users; 3-Need to involve Authorities/get authorized by legislative Bodies. Please give detailed legislative references	

Figure 8.3 O1_Biomethane

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EXAMPLE ITALIAN CASE

Insert here the Legislative References (e.g. Law/Decree/Regulation/Standard n°__of __/__/___) on water for fertigation			PERMITTING PATHWAY FOR UTILIZATION OF THE BY-PRODUCT	Notes/Improvements/Lack of actual legislation
Quality of the water	**Prescriptions on the use**	**Minimum required treatments**		
Chemical and Microbiological Parameters (unit and values) to be respected as limits for reuse	Descriptions of: 1- specific conditions for utilization of the fertigation liquid	Processes and treatments (i.e. primary treatments, secondary treatments, disinfection etc...) needed to ensure compliance with reclaimed water with quality, according to the reuse	For example: 1-Need to certify the product (i.e. labelling or certification etc...); 2-Need to identify end-users; 3-Need to involve Authorities/get authorized by legislative Bodies. Please give detailed legislative references	

Figure 8.4 O2_Water for fertigation

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EXAMPLE ITALIAN CASE

Insert here the Legislative References (e.g. Law/Decree/Regulation/Standard n°__of __/__/___) on Compost/Sludge				PERMITTING PATHWAY FOR UTILIZATION OF THE BY-PRODUCT	Notes/Improvements/Lack of actual legislation
Quality of the Compost/Sludge		Prescriptions on the use	Minimum required treatments		
Matrices allowed for compost/soil improver for agricultural uses (Specify even if they are allowed for organic farming)	Chemical and Microbiological Parameters (unit and values) to be respected as limits for reuse	Descriptions of: 1- specific conditions for utilization/spreading of the compost/soil improver (i.e. times and doses)	Treatments (i.e. transformation, stabilization etc...) for compost/soil improver/sludge	For example: 1-Need to certify the product (i.e. labelling or certification etc...); 2-Need to identify end-users; 3-Need to involve Authorities/get authorized by legislative Bodies. Please give detailed legislative references	

Figure 8.5 O2_Compost Sludge

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Please fill the table below with main information required in each column. Relevant information on the permitting pathway can be also highlighted, by adding new columns and raws. As guidance for the compilation of the table, please refer to the ITALIAN CASE in the link at the side.

EXAMPLE ITALIAN CASE

PERMITTING PATHWAY FOR THE CONSTRUCTION AND MANAGEMENT	Notes/Improvements/Lack of actual legislation
For example: 1-Need to obtain authorization for construction, building and management of the plant (HYDRO SOLUTION);	

For 100 m3/d of wastewater, consider a global area of about 1300 mq.

An example of table can be summarized in the following way.

List of Administratitive Body/Relevant Institution responsible for authorization		Remarks about the authorization (e.g. Purpose, procedures, approval conditions etc...)
n°	**Name of the Administration**	**Example**
1	Administration "......"	Authorization for....It signs the permit after the approval of Institution....
2	Administration "......"	It approves, if there is no negative evaluation by any body....
3	Administration "......"	...
4	Administration "......"	...
5	Administration "......"	...
6	Administration "......"	...
....	Administration "......"	...
n	Administration "......"	...

Figure 8.6 Permitting Pathway

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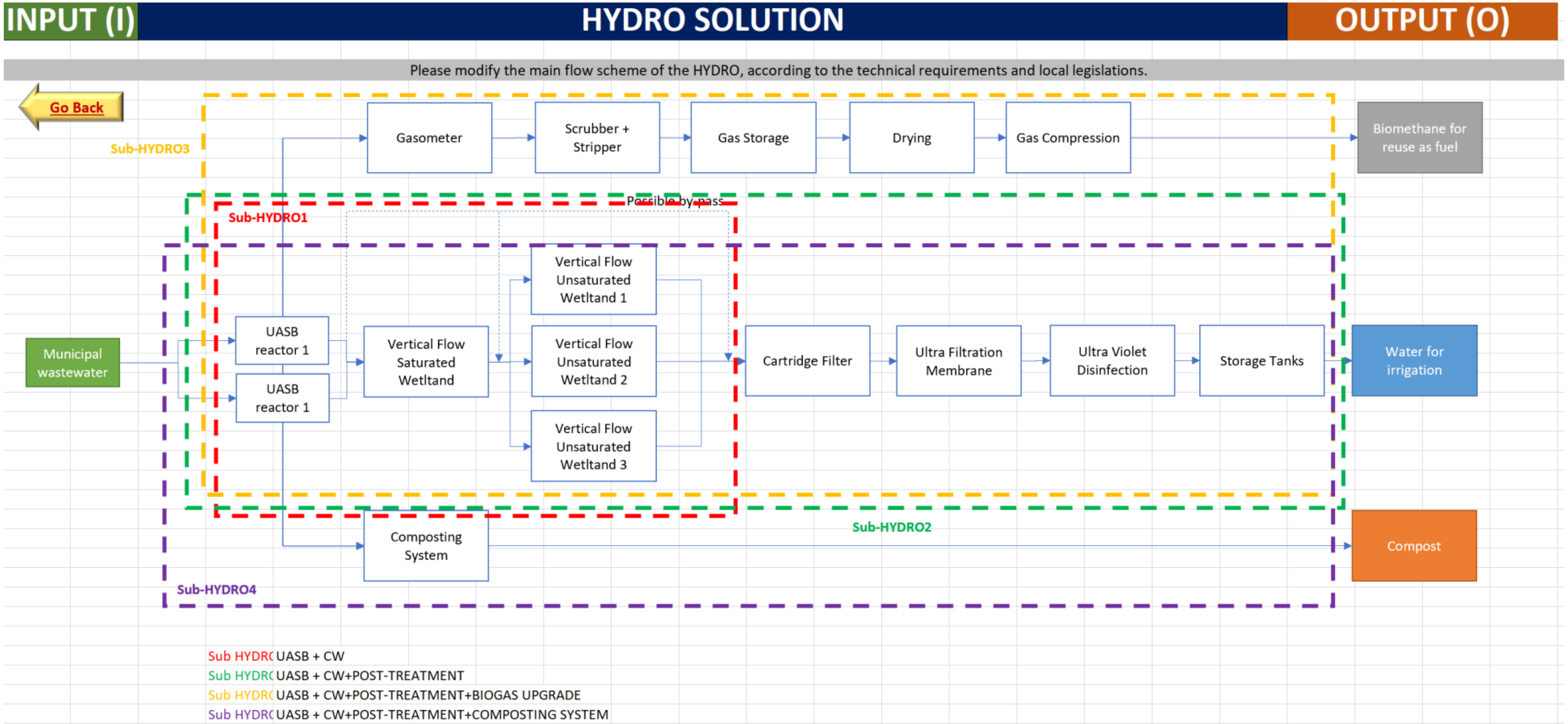
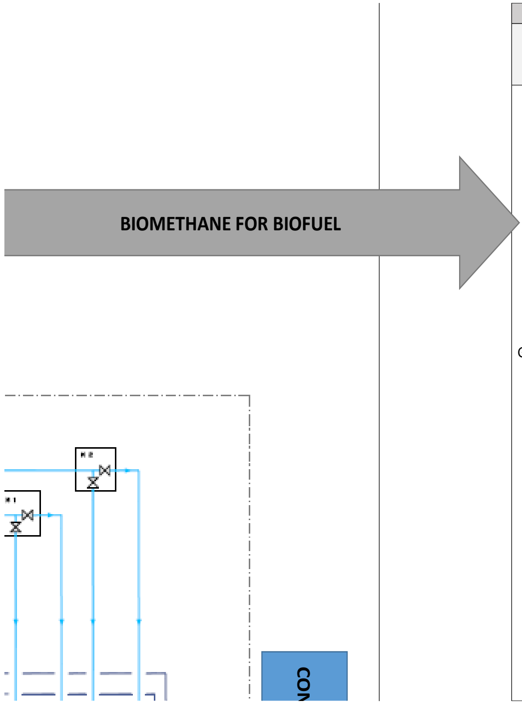


Figure 8.7 Block Flow Diagram



EN 16723-2 (on GNL, biomethane and blends for automotive fuels)						AUTHORIZATION PATHWAY FOR UTILIZATION OF THE BY PRODUCT	Notes/Improvements/Lack of actual legislation
Field of application	Parameter	Unit	Limits Based on st. ref. Conditions 15°C/15°C	Limits Based on normal ref. Conditions 25°C/0°C	Reference standars for methods		
			Min.	Max.	-		
GNL, **biomethane** and their blends of H and L Group families, according to EN 437, used for automotive fuels	Total volatile Silicon (as Si)	mgSi/m3	-	0.3	EN ISO 16017-1:2000 TDS-GC-MS	Once the biofuel is produced, the producer is responsible for its quality and the subscription of contracts with the end-users (i.e. ACNG/fuel station) to be sent to the GSE (Authority for the energy)	The regulation refers only to centralised plant, no indication for domestic or community biogas production/management is given
	Hydrogen	% mol/mol	-	2	EN ISO 6974-3, EN ISO 6974-6, EN ISO 6975		
	Hydrocarbon dew point temperature (from 0.1 to 7 Mpa)	°C	-	-2	ISO 23874, ISO/TR 11150, ISO/TR 12148		
	Oxygen	% mol/mol	-	1	EN ISO 6974 series, EN ISO 6975		
	Hydrogen sulphid + Carbonyl sulphide (as sulfur)	mg/m3	-	5	EN ISO 6326-1, EN ISO 6326-3, EN ISO 19739		
	S total (including odorization)	mgS/m3		10[a] 30[b]	EN ISO 6326-5, EN ISO 19739		
	Methane Number	Index	65		See EN 16726 - Annex A		
	Compressor oil*			Free from impurities other than level of compressor oil and dust	ISO 8573-2		
	Dust impurities*				ISO 8573-4		
	Amine*	mg/m3		10	VDI 2467 Blatt 2:1991-08		
	Water dew point °C at 20000 kPa	Class A	-10		ISO 6327 (applicability at 20000 kPa)		
		Class B	-20				
		Class C	-30				
	*To avoid problems with lubrificating oil filter should be used (cartridge type). The cartridge should retain 99% of the solid particulates ≥ 5μm and						
	[a]Automotive industry needs for sulfur content including odorization						
	[b]Values the gas industry can provide including odorization						

Figure 8.8 Example of Biomethane Legislation for Italian case

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OUTLET FROM CONSTRUCTED WETLAND TO IRRIGATION REUSE

	DM (Ministerial Decree) 185/2003 (reuse of reclaimed water); DM 86/99 (Good agricultural practices); (Respect of limits defined in the European Proposal for a Regulation on minimum requirements for water reuse)						AUTHORIZATION PATHWAY FOR UTILIZATION OF THE BY PRODUCT	Notes/Improvements/Lack of actual legislation
	Quality			Prescriptions on the use		Minimum required treatments		
OPTION A: reuse of water according to DM 185/2003		**Parameter**	**Unit**	**Limit Value**	Art. 3 (1) Allowed purposes of reusing:				
	Phisical-Chemical Parameters	pH	-	6-9.5	**a) irrigation:** for the irrigation of crops intended both for the production of food for human and animal consumption and for non-food purposes, as well as for the irrigation of green areas or for recreational or sporting activities		NONE	The Province releases the authorisation to reuse water	The UASB effluent would not respect the discharge limit for Nitrogen as according to DM 185/2003.
		SAR	-	10					
		Coarse Materials	-	Absent					
		TSS	mg/l	10					
		BOD5	mgO2/l	20					
		COD	mgO2/l	100					
		Ptot	mgP/l	2	**b) civil:** for washing roads in urban centers; for powering the heating or cooling systems; for the feeding of dual distribution networks, separated from those of drinking water, to the exclusion of the direct use of this water in buildings for civil use, with the exception of waste systems in toilets				
		Ntot	mgN/l	15					
		N-NH4	mgNH4/l	2					
		Conductivity	µS/cm	3000					
		Alluminum	mg/l	1					
		Arsenic	mg/l	0.02					
		Barium	mg/l	10					
		Berillium	mg/l	0.1					
		Borum	mg/l	1	**c) industrial:** such as fire, process, washing and thermal cycles of industrial processes, to the exclusion of uses that involve contact between the recovered waste water and food or pharmaceutical and cosmetic products				
		Cadmium	mg/l	0.005					
		Cobalt	mg/l	0.05					
		Chromium tot	mg/l	0.1					
		Chromium VI	mg/l	0.005					
		Iron	mg/l	2					
		Manganese	mg/l	0.2	Nitrogen fertilization plans				
		Mercury	mg/l	0.001	Crop Type	Limits of Nitrogen requirement [kg/ha]			
		Nickel	mg/l	0.2	Wheat	180 - 140			
		Copper	mg/l	0.1	Barley	120			
		Lead	mg/l	1	Oat	100			
		Selenium	mg/l	0.01	Rye	80			
		Tin	mg/l	3	Rice	160			
		Tallium	mg/l	0.001	Corn	280			
		Vanadium	mg/l	0.1	Broad bean, bean and pea	20			
		Zinc	mg/l	0.5	Potato	150			
		Cyanides tot	mg/l	0.05	Sugar beet	150			
		Sulphides	mgH2S/l	0.5	Rape	180			
		Sulphites	mgSO3/l	0.5	Sunflower	100			
		Sulphates	mgSO4/l	500	Soy	20			
		Active chlorine	mg/l	0.2	Garlic and onion	120			
		Chlorides	mgF/l	250	Carrot	150			
		Fluorides	mg/l	1.5	Turnip	120			
		Animal / vegetable fats and oils	mg/l	10	Asparagus	180			
		Mineral oils	mg/l	0.05	Chard	130			
		Total phenols	mg/l	0.1	Artichoke	200			
		Pentachlorophenol	mg/l	0.003	Savoy cabbage and cabbage	200			
		Total aldehydes	mg/l	0.5	Broccoli	150			
		Tetrachlorethylene, trichlorethylene	mg/l	0.01	Cauliflower	200			
		Total chlorinated solvents	mg/l	0.04	Fennel	180			
		Trialomethanes	mg/l	0.03	Salad	120 - 180			
		Total aromatic organic solvents	mg/l	0.01	Celery	200			
		Benzene	mg/l	0.001	Spinach	120			
		Benzo (a) pyrene	mg/l	0.00001	Cucumber	150			
		Total nitrogen organic solvents	mg/l	0.01	Watermelon	100			
		Total surfactants	mg/l	0.5	Strawberry	150			
		Chlorinated pesticides (each)	mg/l	0.0001	Aubergine	200			
		Phosphate pesticides (each)	mg/l	0.0001	Melon	120			
		Other total pesticides	mg/l	10 (80% of samples)	Sweet pepper	180			
	Microbiological parameters	Escherichia coli	UFC/100mL	100 max point value	Tomato	160			
		Salmonella		Absent	Zucchini	200			

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OUTLET FROM CONSTRUCTED WETLAND

	DM (Ministerial Decree) 185/2003 (reuse of reclaimed water); DM 86/99 (Good agricultural practices); (Respect of limits defined in the European Proposal for a Regulation on minimum requirements for water reuse)				AUTHORIZATION PATHWAY FOR UTILIZATION OF THE BY PRODUCT	Notes/Improvements/Lack of actual legislation
	Quality		Prescriptions on the use	Minimum required treatments		
OPTION B: comparison of UASB supernatans to domestic wastewater	If water is reused on cultivated soil, the irrigation is allowed only for UN-EDIBLE products (**Regional Law of Tuscany Region: Regulation-8 september 2008, n. 46/R)**	Use of supernatants, as it is, **ONLY** if it can be comparable to domestic wastewater and does not cointain hazardous substances	The influent wastewater **MUST** be comparable to domestic wastewater; absence of hazardous substances; further, dispersion on soil is considered a treatment itself (Regulation 8 september 2008, n. 46/R)		**Actually not required. An utilisation plan might be presented to the Municipality if water reuse is managed by a company and not only by a private citizen. Absence of indication on permitting pathways for community management**	Italian regulation lacks indications on water reuse for community application (i.e. private houses). In case of single private use, no authorisation nor communication to Municipality are required. If the system would refer to a community, the authorisation of the Municipality/ASL (Local health Agency) might be necessary to spread water on the soil, since it is considered a treatment itself. The latter case is not clearly regulated by actual legislation, further a risk approach has to be implemented through Water Safety Plan. No quality parameters for irrigation are identified, thus the reference law for water reuse is DM 185/2003 (see HYDRO 1 for effluent parameters limits).

Figure 8.9 Example of reclaimed water reuse Legislation for Italian case

OUTLET FROM COMPOSTING SYSTEM TO BE REUSED AS FERTILIZER

DM (Ministerial Decree) 218/2013						AUTHORIZATION PATHWAY FOR UTILIZATION OF THE BY	Notes/Improvements/Lack of actual legislation
Quality (minimum requirements)				Prescriptions on the use	Minimum		
Type	Parameter	Unit	Value				
Mixed composted soil improver and soil improver with sludge	Humidity	%	<50		Transformation and stabilization of organic waste which can be made up of the organic fraction of Urban Waste coming from separate collection, from digestate from anaerobic treatment (with the exception of waste coming from the treatment of undifferentiated waste), from zootechnical sewage, waste from agro-industrial	The soil improver must be certified by the Ministry of Agricolture	The regulation refers only to centralised plant, no indication for domestic or community composting (of sewage sludge) process/management is given
	pH	-	6 - 8.8				
	Organic Carbon on dry fraction	%	>20				
	Humic and fulvic Carbon on dry fraction	%	>7				
	Organic Nitrogen on dry fraction	% of Ntot	>80				
	C/N	-	<25				
	Tallium on dry fraction	mg/kgSS	<2				
	Plastic, glass and metallic materials content on dry fraction (d>2 mm)	%	<0.5				
	Salmonella	n°/25g	n(1)=5; c(2)=0; m(3)=0; M(4)=0;				
	E.Coli	CFU/1g	n(1)=5; c(2)=1; m(3)=1000; M(4)=5000				
	Germination Index	%	>60 (diluition 30%)				
	Enterobacteriaceae tot	unit/g	< $1*10^2$				
	Fecal Streptococci (Nematodes)	unit/50 g	Absent				
	Fecal Streptococci (Trematodes)	unit/50 g	Absent				
	Fecal Streptococci (Cestodes)	unit/50 g	Absent				
	% on dry fraction of Sludge that can be used for compost production	% w/w	< 35				

(1) n = number of samples to be tested;
(2) c = number of samples whose bacterial load can be between m and M; the sample is still considered acceptable if the bacterial load of the other samples is equal to or less than m.
(3) m = threshold value for the number of bacteria; the result is considered satisfactory if all the samples have a number of bacteria less than or equal to m;
(4) M = maximum value for the number of bacteria; the result is considered unsatisfactory if one or more samples have a number of bacteria equal to or greater than M

Figure 8.10 Example of Compost Legislation for Italian case

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DLGS (Legislative Decree) 99/92 (SLUDGE CASE)

	Quality (minimum requirements) into sludge		
	Parameter	Unit	Value
Annex I B	Cadmium	mg/kg SS	<20
	Mercury	mg/kg SS	<10
	Nickel	mg/kg SS	<300
	Copper	mg/kg SS	<750
	Lead	mg/kg SS	<1000
	Zinc	mg/kg SS	<2500
	Organic Carbon	%SS	>20
	Ptot	%SS	>0.4
	Ntot	%SS	>1.5
	Salmonella	MPN/gSS	>10

	Quality (minimum requirements) into soil		
	Parameter	Unit	Value
Annex I A	Cadmium	mg/kg SS	<1.5
	Mercury	mg/kg SS	<1
	Nickel	mg/kg SS	<75
	Copper	mg/kg SS	<100
	Lead	mg/kg SS	<100
	Zinc	mg/kg SS	<300

Prescriptions on the use of sludge in agriculture. Allowed uses if sludge:
a) is subjected to treated
b) can produce a fertilizing effect and / or soil conditioner and corrective effect
c) does not contain toxic and harmful and / or persistent substances and / or bioaccumulative in concentrations to the soil, crops, animals, humans and the environment in general
d) does not cause an increase of one or more heavy metals concentrations in the soil over the limit values set in Annex I A
e) has, at the time of its use in agriculture, limit values for concentrations of heavy metals and other parameters lower than those in Annex I B
f) can be applied on and / or in the soil in doses not exceeding 15 t / ha of dry matter in the three years, as long as that the soils have the following characteristics:
f-1) cation exchange capacity (c.s.c.) greater than 15 meg / 100 gr
f-2) pH between 6.0 and 7.5
f-3) If pH < 6 and c.s.c. < 15, quantities of sludge used have decreased by 50%
f-4) If pH > 7.5, the quantities of sludge used can be increased by 50%
g) from the agri-food industry can be used in a maximum quantity of up to three times the quantities indicated in letter f). The heavy metal limits cannot exceed values equal to one fifth of those listed in Annex I B.
h) can be used as components of the artificial substrates of flower crops on pallets, in compliance with this standard, for the environmental protection and health of operators in the sector. In particular:
h-1) the sludge used must be dehydrated and their moisture content must not exceed the limit of 80%
h-2) the sludge must have an analytical composition that falls within the limits of Annex I B
h-3) the artificial culture substrate must contain a quantity of sludge not exceeding 20% of the total
Prescriptions on prohibition of the use of sludge in agriculture. Prohibited uses:
a) The use of sludge on agricultural land is prohibited if the conditions above are not verified
b) with reference to the substances listed in the annex to the DPR 1982/915
c) It is forbidden to apply sludge to the soil:
c-1) flooded, subject to floods and / or natural floods, marshy or with surfacing aquifer, or with landslides in progress;
c-2) with slopes greater than 15% limited to mud with a dry matter content of less than 30%;
c-3) with pH less than 5;
c-4) with C.S.C. less than 8 meg / 100 gr;
c-5) intended for pasture, pasture, forage crops, also in association with other crops, in the 5 weeks preceding pasture or forage harvesting;
c-6) intended for horticulture and fruit growing whose products are normally in direct contact with the ground and are usually eaten raw, in the 10 months preceding the harvest and during the harvest itself;
c-7) when a crop is in progress, with the exception of tree crops;
c-8) when the existence of a danger to human and / or animal health and / or environmental protection has been
d) The application of liquid sludge with the rain irrigation technique is prohibited, both for sludge as it is and for diluted with

Minimum required treatment	AUTHORIZATION PATHWAY FOR UTILIZATION OF THE BY PRODUCT	Notes/Improvements/Lack of actual legislation
Are subjected to specific treatment (86/278/CEE ->New Sludge Decree with new limits, parameters and treatments for sludge)	Provinces release the Authorisation to spread sludge, both for the producer and final user	The regulation refers only to centralised plant, no indication for community production or management is given

Figure 8.11 Example of Sludge Legislation for Italian case

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8.3 Sizing/Design Criteria Files

HYDRO 1 Facility n°	TECHNOLOGIES INVOLVED	Legend	
1)	Upflow Anaerobic Sludge Blanket	(blue)	Design Data which should be provided by the site manager
2)	Constructed Wetland	(light green)	Assumed Data for
3)	Membrane/Sand Filtration + UV Disinfection		
4)	Composting system		

Design Data UASB					
Parameters	Units	Typical	Used for HYDRO 1 in Greek Case Study	**Insert Data according to Replication Site Case Study**	Notes
Influent Wastewater Charateristics:					
Population equivalent to be served	PE		500		
Flowrate	m3/d	-	100		
COD concentration	mg/l	500	578		
BOD5 concentration	mg/l	300	331		
TSS concentration	mg/l	320	272		
Organic Load	kg COD/d	-	57.8		
pH	-	-	7.3		
Conductivity	µS/cm	-	1164		
TKN	mg/l	40	42		
Ammonia Concentration	mg/l	25	32		
Temperature	°C	-	23		
Operative Parameters:					
HRTdesign	h	5 ÷ 10	10		Set as hypothesis
Volume tot	m3	-	42		
n° of operative lines	n°	-	2		
Volume of each line	m3	-	20.8		
OLR	kg COD/m3 d	0.8-2	1.39		
HRToperative	h	-	10		
Vup	m/h	0.5 - 1.5	0.6		
Area (each reactor sectional area)	m2	-	3.47		
Diameter	m	-	2.10		
Each Reactor height	m	-	6.0		
Liquid upflow velocity at the bottom of the GLS separator (VUP,GLS)	m/h	< 4	1		Set as hypothesis
Sliq (each reactor Liquid Area)	m2	-	2.08		
Sliq (each reactor separation Area)	m2	-	1.39		
dsep (each reactor separation diameter)	m		1.33		
Stoichiometrically methane production	m3CH4/kgCODRemoved	0.35	0.35		
COD removal	%	70 - 80	70		
COD removed	kgCOD/d	-	40.5		
Daily methane production	m3CH4/d	-	14.2		
Methane percentage in the Biogas	%CH4/biogas	60	60		
Daily Biogas production	m3biogas/d	-	23.6		
Stoichiometrically Sludge production	kg sludge/kg CODRemoved	0.06 - 0.07	0.062		
Sludge production	kg sludge/d	-	2.51		
TS% of sludge	mgTSS/l	-	20000		Set as hypothesis
Q excess sludge	m3/d	-	0.125		
UASB Balance					
Qout	m3/d	-	99.9		
CODin	kgCODin/d	-	57.8		
CODout	kgCODout/d	-	17.3		
	mg/l	-	174		
TSS in	kgTSS/d	-	27		
TSS removal	%	60 - 70	67		
TSS removed	kdTSS/d	-	18		
TSSout	kgTSSout/d	-	9		
	mg/l	-	90		
Energy Conversion factor	kJ/kWh	3600	3600		Set as default data
Energy content of methane at standard conditions	kJ/m3CH4	35846	35846		Set as default data
Energy production	kW/m3		1.4		
	kW/d		141.0		

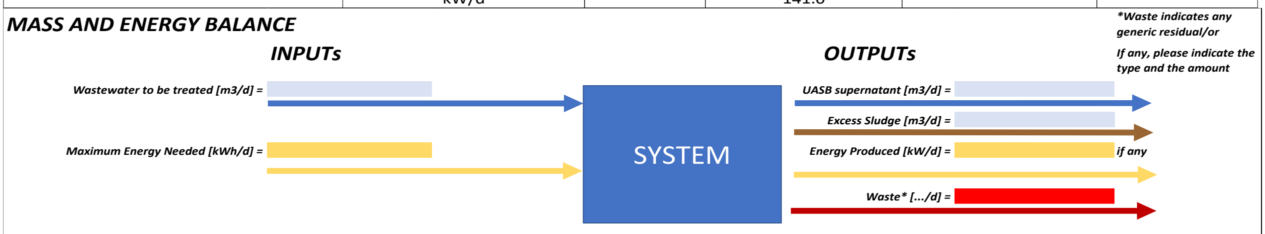

Figure 8.12 Design and Mass/Energy Balance of UASB

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Technical minimum requirement to Technology replicability:						
FOOTPRINT						
Paramenter to analyse	**Unit**	**Specification**	**TOTAL**	**Notes**		
Equipment area requirement	*m2*	area to be irrigated				
		tanks				
		....				
Specific area equirement	*m2/(m3treated/d)*	m2 per m3/day of wastewater treated		From Greek Case Study		
Total area requirement	*m2*	**Considering all of the equipments (tanks. pumps. piping. etc...)**	0			
INPUTS (Requirements)						
Influent Flowrate	*m3/d*					
Energy Consumption	*kWh/d*	**Energy for:**	**kW absorbed**	**h/d**	**kWh/d**	**Notes**
		pumps			0	
		....			0	
		TOTAL requirements				
Specific Energy consumption	*kWh/m3 treated*	Specific kWh consumed/day per m3/day of wastewater treated	-	-		From Greek Case Study
Reagents Consumption	*l/d*	Considering reagents both for operation and maintenance (cleaning)	None	None	None	
OUTPUTS EXPECTED						
Effluent Flowrate from Post-treatment	*m3/d*				0	
COSTS (CAPEX)						
Cost of units	€	tanks			0	
	€	pumps			0	
	€	....			0	
Construction/Installation of units	€	Preparation of site			0	
	€	Land purchase			0	
	€	Installation			0	
Total CAPEX	*€*					
TOTAL CAPEX	*€/PE*		-	-		From Greek Case Study
COSTS (OPEX)						
Reagents	*€/y*	Considering reagents both for operation and maintenance (cleaning)			0	l/y*€/l
Energy costs	*€/y*	Considering cost of electricity [average between day and night, during week and week-end]		0.170	0	kWh/y * €/kWh(=0,17 average in Europe for non-household elecrticity)
Human Requirement	*€/y*	Considering personnel both for operation and maintenance			0	Hour of work required/y * €/h
Maintenance	*€/y*	Considering substitution of pieces etc...			0	Quantity of unit to change/y * €/unit
Insurance	*€/y*				0	
ANNUAL TOTAL OPEX	*€/y*				0	
ANNUAL TOTAL OPEX	*€/y/PE*					From Greek Case Study

Figure 8.13 Technical Requirements for UASB

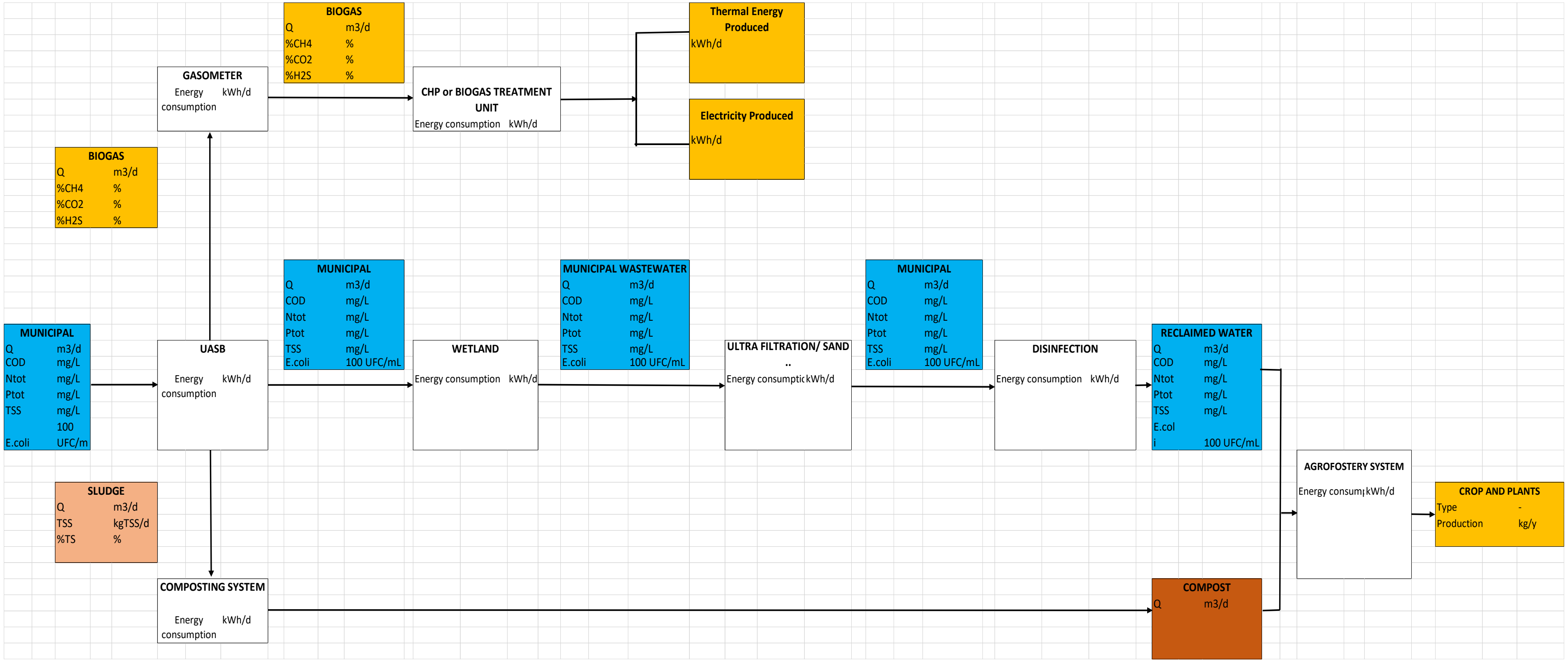

Figure 8.14 Integrated HYDRO 1 Mass Balance

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TOTAL HYDRO CAPEX summary								**Comments**
Total CAPEX						**#RIF!**	€	
TOTAL HYDRO OPEX summary								
System Operation						#RIF!	€/year	
Insurance	External services					0	€/year	
Certification/permit fees	External services					0	€/year	
Yearly OPEX						**#RIF!**	**€/year**	
Revenue & costs saving streams								
		Unit	**Quantity**	**Item value***	**Unit**	**Revenue**	**revenue unit**	* from Local market analysis
Treated wastewater for irrigation		m3/year			€/m3	0	€/year	
Biogas		MWh/year			€/MWh	0	€/year	
Fertilizers		kg/year			€/kg	0	€/year	
Waste water treatment tax		m3/year			€/m3	0	€/year	
Annual food production from crop cultivation		kg/year			€/kg	0	€/year	
Yearly revenues						**0**	€/year	
Payback period		year	**#RIF!**	CAPEX/(yearly revenues - OPEX)				

Figure 8.15 Summary of HYDRO 1 Costs and Business Model

8.4 Feasibility Study Report Template

SUMMARY

REPORT TEMPLATE

1. Project Strategic Context

When assessing preliminary feasibility studies, the project's scope and background should be analysed to outline the context of the feasibility study (Feasibility Study, 2019). Please specify:

- The importance of the HYDRO implementation in local water and water-related resources management for the local replication site
- How HYDRO implementation can close the water loop in a decentralized site and provide a sustainable solution to manage water and water-related resources

1.1. Scenarios analysis and related benefits

In this step, the data on the local background of the replication site should be stated. For instance:

- Water and water-related resources availability
- Local needs of the community

- Social and/or economic challenges to be faced (e.g. water scarcity, economic growth, human safety, wastewater problem, biodiversity and nutrient loss etc.) (LaStampa, 2019; HYDROUSA, 2020)

Considering the above topics, please specify how the selected HYDRO can determine significant improvement in the resource's management.

Please state also the reasons for not choosing the other HYDROs.

2. Characterization of the replication site

The location of the project is a key factor to evaluate the environmental impacts and the correlation between the local community needs. In this section, please provide information on the local environmental characteristics (e.g. climate conditions, hydro-geological information, slopes etc) which may affect the design of the HYDRO.

2.1. Description of the area

The site description, characterization of the area where to place the HYDRO should contain the main relevant information in terms of:

- Extension of the area
- Orographic (e.g. slopes and altitude) and hydro-geological characteristics
- Climatic conditions if relevant for the project (e.g. solar irradiation, temperatures, rainfalls etc)
- Description of nearby existing infrastructures – if it is relevant to the project (e.g. wastewater treatment plant, sewer systems, industrial complex etc) – and close end-users.

To better identify the chosen location, a (Google) map extraction of the future replication site with GPS coordinates and a .dwg file of the area(s)) need to be included.

2.2. Environmental constraints

Once the area is identified, please detail the possible environmental constraints. The results of the replication site's restrictions help i) to highlight possible "environmental fragilities" in terms of water, soil, flora and/or fauna (Environmental Feasibility, 2020) and ii) to identify any potential risks connected to the project (Designing Buildings, 2020).

Specifically, the necessary information should cover the following aspects (Vincoli alla proprietà, 2013):

- **possible restrictions due to local legislation** (e.g. the presence of sensitive or specially protected water bodies, specific noise, vibration and dust emission levels,
- **hydrogeological constraints**, to ensure a good water regime in terms of flood prevention and land stability ,.
- **forestry restrictions**, for the protection and conservation of the forests to ensure a high quality of life and biodiversity
- **constraints related to protection of water bodies** ecological status against pollution
- **natural/wildlife constraints**, for the protection of ecological, geological, biological and aesthetic values (e.g. natural parks and protected areas)

When characterising the area, HYDROUSA Replication site Managers should also consider the impact of the project with respect to the above-mentioned category of constraints.

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3. Social Analysis and final end-users' identification

Social Feasibility aims to provide a framework to analyse, prioritize and incorporate social information and engagement into the design and delivery of projects, while involving a wide range of stakeholders (Dept of Economic Affairs, Ministry of Finance, Govt of India, 2007).
Furthermore, the assessment of social aspects aims to evaluate the influences that the project might have on the society (Modern Academy, 2019). This aspect of the feasibility study does not only include the evaluation of possible benefits towards the community, but also the analysis of all information instruments which could create awareness and public engagement.
In the context of HYDRO implementation, social feasibility assessment could contribute to provide information about the necessary instruments to arise awareness and to support the dialogue between public and private institutions, key actors and citizens.

Table 8.1 Social Analysis score attribution sub-criteria

SCORE			
Feasibility Sub-Criteria	**LOW (1-6)**	**MEDIUM (7-13)**	**HIGH (14-20)**
Stakeholder and public participation	Low level of social interest (policymakers and stakeholder engagement) (e.g. low Institutions engagement and low citizen interest)	Partial level of social interest and stakeholder engagement (e.g. high Institutions engagement but low citizen interest or vice versa)	High level of social interest and stakeholder engagement (e.g. high Institutions engagement and high citizen interest)
Feasibility Sub-Criteria	**LOW (1-5)**	**MEDIUM (6-10)**	**HIGH (11-16)**
Trainings and qualifications	Low level of training	Medium level of training	High level of training
Public information programmes	Low level of information activities	Medium level of information activities	High level of information activities
Monitoring systems for decentralized systems	Low frequency of monitoring activities	Medium frequency of monitoring activities	High frequency of monitoring activities
Research projects	Low interest in research	Medium interest in research	High interest in research
Assessments of decentralized system status/ ecosystem services	Low level of ecosystem mapping	Medium level of ecosystem mapping	High level of ecosystem mapping

According the above-mentioned sub-criteria, please assign a score to each sub-criteria and report evaluations in table 8.2 below under "score" column.
Besides, an explanation of the reason for the score attribution should be also provided.
As a result, please define the overall Social Feasibility Score of the HYDRO according to equation 1.

$$S = \sum_{i=1}^{n} s_i \qquad \text{(Equation 1)}$$

Table 8.2 Information, awareness-raising and public engagement Instruments; Monitoring and Research Instruments

Feasibility Criteria	**SOCIAL FEASIBILITY**	
Type of instrument	**Example**	**SCORE**
Trainings and qualifications	Training and qualifications (obtaining certificates or proof of qualification) related to sustainable urban development, (socially inclusive) urban regeneration, closing loop infrastructure, nature-based solutions planning. Design, implementation and maintenance.	………….. for each of the box below, please fill it according to the score legend and provide explanation/example for this evaluation
Public information programmes	A series of activities geared toward raising the amount of information available and people's awareness about sustainable urban development, (socially inclusive) urban regeneration, green and blue infrastructure, nature-based solutions etc. and its benefits (brochure, factsheets, events, campaigns, videos..)	
Stakeholder and public participation	Decision-making processes or knowledge-building consultations by policy makers which involve stakeholders with a direct interest in or practical knowledge of the issue being discussed, e.g. Townhall meetings, citizen councils, workshops for stakeholders, stakeholder advisory groups, multi-criteria analysis, household surveys	
Monitoring systems for decentralized systems	Manual or automatic system (technological or by hand) which collects data about activities, products used, timing, etc.	
	Monitoring and reporting of infrastructure areas	
	Monitoring and mapping of activities relevant to sustainable urban development, (socially inclusive) urban regeneration, green and blue infrastructure	
Research projects	Research related solutions for sustainable urban development, (socially inclusive) urban regeneration, green and blue infrastructure, including development of more efficient solutions (e.g. green roofs and facades)	
Assessments of decentralized system status/ ecosystem services	E.g. national overviews on the status of sustainable urban development, (socially inclusive) urban regeneration, green and blue infrastructure and related ecosystem services including mapping (e.g. Mapping and Assessment of Ecosystem Services - MAES)	
OVERALL SCORE	**From 1 to 100**	

4. Policy analysis and institutional framework

This section should describe the regulatory instruments at different institutional levels (From National to Local, Paragraphs from "*4.1 Regulatory Instruments for decentralized community systems*" to "*4.4 Identification of the permitting pathway*") to exploit the selected HYDRO solution in the replication site, from its practical implementation to the final-products valorisation at community level (Krott, M., 2005). Considering the fragmentation of the policy framework and how this could affect the replicability of the HYDRO, it is essential to obtain information on the whole permitting pathway for the HYDRO implementation.

Next, according to the site characteristics described at Paragraph 2, partners should list and describe:

- The permitting pathway for the construction and management of the HYDRO
- The permitting pathway for use/reuse of the HYDRO by-products

If any of the above regulatory instrument is missing, Partners should highlight this lacking for the HYDRO exploitation.

<u>A synthetic picture of the policy framework is represented by the excel file "HYDRO-Roadmap for data collection", referred to the chosen HYDRO.</u>

Once the institutional framework is clearly identified, Partners are asked to critically evaluate the Policy asset to synthetize (through the attribution of a score) the overall adequacy of the regulatory system for decentralised HYDRO systems.
Partners should refer to the criteria listed in the Table 8.3, providing a subjective score for each policy instruments taking into account the indications reported in the table below.

Table 8.3 Policy Analysis score attribution sub-criteria

SCORE			
Feasibility Sub-Criteria	**LOW (1-4)**	**MEDIUM (5-8)**	**HIGH (9-12)**
National/ regional planning law or regulations	No ad-hoc regulation for small-systems are implemented in the context of HYDRO output	Regulation in the context of HYDRO output are implemented, but ad-hoc regulation for small-systems are not implemented	Ad-hoc regulation for small-systems are implemented in the context of HYDRO output
Feasibility Sub-Criteria	**LOW (1-4)**	**MEDIUM (5-8)**	**HIGH (9-11)**
National/ regional strategies and action plans	No Strategies to promote the management and reuse of HYDRO recoverable resources are implemented	Strategies promote the management and reuse of some HYDRO recoverable resources	Strategies promote the management and reuse of all HYDRO recoverable resources
Planning/ zoning	Bans to HYDRO plants realisation in the chosen replication site	HYDRO plants realisation is subjected to restrictions/prescriptions in the chosen replication site	No restrictions to HYDRO plants realisation in the chosen replication site

Targets	No targets are implemented in the context of HYDRO output	Targets are implemented in the context of some HYDRO outputs	Targets are implemented for all HYDRO outputs
Standards	Clear limits for the reuse of all HYDRO outputs	Limits for the reuse of some HYDRO outputs	Defined standards for the reuse of all HYDRO outputs
Bans	Legal barriers detected for all HYDRO output management/ HYDRO implementation	Legal barriers detected for some HYDRO output management	Legal barriers not detected for HYDRO output management
Permits/ quotas	Simplified procedures to get permits for small HYDRO systems and reuse of recovered resources are not implemented	Simplified procedures to get permits for small HYDRO systems and reuse of recovered resources are implemented just for some aspects of HYDRO management	Simplified procedures to get permits for small HYDRO systems and reuse of recovered resources are implemented and cover all HYDRO management aspects
Environmental impact assessments	Simplified authorization procedure for small HYDRO systems and recovered resources management are not implemented	Simplified authorization procedure for small HYDRO systems and recovered resources management are implemented for some aspects (i.e. Plants realisation but not for by-products reuse)	Simplified authorization procedure for small HYDRO systems and recovered resources management are implemented
Public Procurement	HYDRO system is not in line with objectives of Green Public Procurement (GPP)	HYDRO system is partially in line with objectives of (GPP)	HYDRO system is fully in line with objectives of (GPP)

According the above-mentioned sub-criteria, please assign a score to each sub-criteria and report evaluations in table 8.4 below under "score" column.
An explanation of the reason for the score attribution should be also provided.
As a result, please define the overall Policy Feasibility Score of the HYDRO according to equation 1.

Table 8.4 Regulatory Instruments. Laws, action plans and quality standards

Feasibility Criteria	POLICY FEASIBILITY	
Type of instrument	**Example**	**SCORE**
National/ regional planning law or regulations	Spatial planning law, environmental regulation and/or law, directives focusing on water cycle.	…………… for each of the box below, please fill it according to the score legend and provide explanation/example for this evaluation

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National/ regional strategies and action plans	National strategies for sustainable development, water cycle wastewater treatments, green and blue infrastructure etc.	
Planning/ zoning	Comprehensive planning of the different uses to be conducted in areas of an urban settlement designated by certain categories (eg., residential, commercial, industrial, green areas), e.g. Comprehensive land use plans, zoning applications, non-conforming use applications, eminent domain	
Targets	Targets focused on decentralised systems, water loop cycle, recovery resource, sustainable urban development, (socially inclusive) urban regeneration, green and blue infrastructure etc., eg targets to establish green and blue areas (in ha, in specific areas, type of areas; budget spent etc.). Targets focused on these could be part of sustainable development strategies or action plans, strategies or similar	
Standards	Legal or regulatory requirements for all persons or businesses to whom it applies to maintain a certain level of environmental quality confine actions to a certain type of practice or limit, or to rehabilitate resources. e.g. a certain area of private homes must be green area, in a certain area the effluent from WWTP should satisfy certain limits, by-products (fertilizer) for reuse should have certain characteristics, etc. Legal or regulatory requirement for the utility to maintain a certain level of environmental quality, limits, or to rehabilitate resources. e.g. **Mandatory:** Environmental standards by law, directives, plans, etc. **Voluntary:** Agreements between private citizens and Municipality regarding the management and reuse of the HYDRO by-products.	
Bans	A legal or regulatory prohibition of a certain type of activity or use of a material/ product.	
Permits / quotas	A license or authorization issued by a competent Authority allowing the utility to perform certain activity or to have a certain portion / amount of a product. e.g. Authorizations for water reuse, for biomethane production, plant construction, sludge reuse, soil fertilizer use, etc. Requirements such as maintenance of pre-development hydrology or pollutant loading reduction requirements are tied to stormwater permits.	

Environmental impact assessments	Legal or regulatory process which an individual or business must undergo before application for approval to perform a certain action. Environmental Impact Assessment (EIA), audits, inspections	
Public Procurement	Green Public Procurement (GPP)	
OVERALL SCORE	**From 1 to 100**	

5. Stakeholders and policymaker's identification

Stakeholder Analysis is a key aspect to identify all those "actors" who can positively or negatively affect the outcomes of the project (Sustainable Sanitation and Water Management Toolbox, 2020).
This analysis aims to:

- highlight the interests of stakeholders in relation to the project's objectives,
- identify the feasibility other than in purely financial terms (e.g. including social factors),
- evaluate relationships between different interested parties.

Considering the Social and Policy Analysis exploited at Paragraphs 3 and 4, the identification of the stakeholders and policymakers should be listed according to the:

- definition of the local stakeholder/policymaker in the "Example" column;
- attribution of the stakeholder/policymaker category in the related column (Sustainable Sanitation and Water Management Toolbox, 2020):
    - **(P)Primary** for direct beneficiaries and direct related person (e.g. end users, farmers, etc.)
    - **(S)Secondary** such as intermediaries in the process of delivering aid to primary stakeholders (e.g. professionals, advisers, practitioners, consultants, experts, governmental, NGO and private sector organisations etc.)
    - **(E)External** stakeholders such as decision, policy makers (politicians, senior civil servants, district level bodies, governmental bodies, etc.)
- Description of the expected benefits for the stakeholders/policymakers involvement ("Needs and expectations" column).

Table 8.5 Relevant Stakeholders identification

RELEVANT STAKEHOLDERS		CATEGORY	NEEDS AND EXPECTATIONS
Stakeholders' group	**Example**	**P/S/E**	
At National authorities	…please insert here actor involved…		
At Regional/Local authorities			
Decentralized government services (Health, Education, Water, Environment etc.)			
Education (e.g. universities, training centre, schools)			
Communication (e.g. Media)			
Water authority			
Civil society (e.g. users, private citizens etc.)			
Water utility			

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 776643

6. Technical analysis

The technical analysis determines if the HYDRO solution, that is designed according to the site characteristics, will achieve the KPI of the HYDROUSA project.

6.1. HYDRO scheme implementation

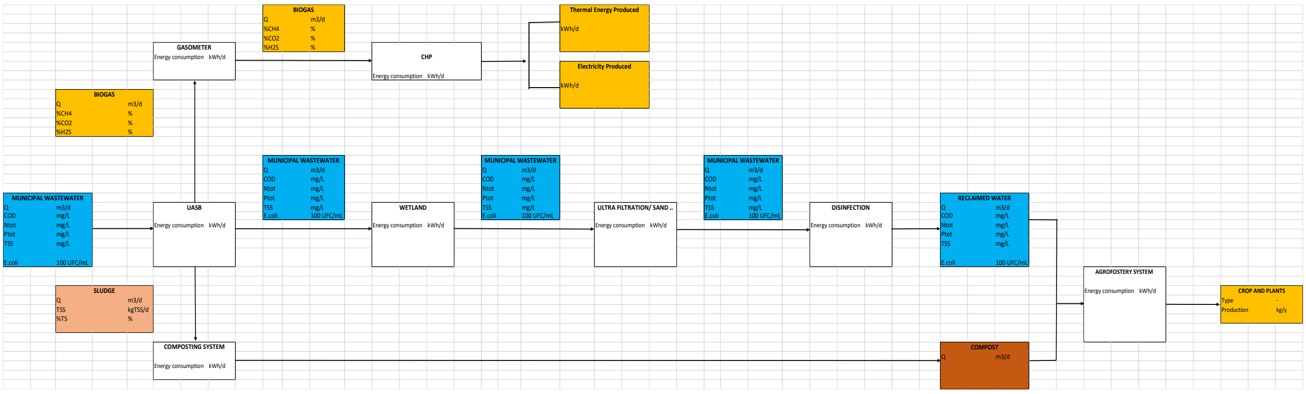
The social and policy analysis might determine a change in the HYDRO layout. According to the main project objectives and after a preliminary evaluation of the possible environmental/legislative constraints, general layout of the HYDRO should be outlined. Specifically, if the whole HYDRO won't be implemented, a description and discussion of the chosen SUB-HYDRO should be included in the assessment.

6.2. Design Data and Sizing Criteria for HYDRO replicability

The HYDROUSA Replication Site Manager should carry out the preliminary design of the chosen HYDRO with the support of "Sizing Criteria" files, which aims:

a) to define the main technical characteristic of the applied technologies/sub-HYDROs that helps to determine the mass and energy balance
b) to list all the required technical equipment and devices
c) to obtain data for the HYDRO footprint in terms of required area and energy consumption
d) to define the capital and operative expenditures, in order to determine the payback period.

Figure 8.16 Example of HYDRO Mass Balance



Technical requirements of the HYDRO should be summarized and reported in the table below. This inventory, as divided into macro-categories, will provide a general overview of the necessary resources (e.g. land, energy, chemical reagents etc.) to construct, install and run the HYDRO.

Specifically, the footprint of the necessary area, energy consumption and chemical consumption for each sub-HYDRO should be reported. To complete the table, the excel sheet "**Sizing criteria for HYDRO design"** of the chosen HYDRO can be used as reference (In fact, the design files were prepared following the HYDROs and sub-HYDROs sizing criteria described in the available technical Deliverables D2.1, D2.3, D3.1, D3.2, D3.6, written for the Greek case studies).

Collected data will be then used for the next economic analysis (see chapter 7).

Table 8.6 HYDRO expected technical requirement

Technical requirement for HYDRO replicability				
FOOTPRINT				
Paramenter	**Unit**	**System**	**Value**	**Remarks**
System area requirement	*m2*	System 1:………………….		
		System 2:………………….		
		……….		
		System n:…………………….		
Total area requirement	*m2*	**Considering all of the equipment (tanks. pumps. piping. etc...)**		
ENERGY				
Paramenter	Unit	Specifications	**Value**	**Remarks**
Maximum Energy Consumption	*kWh/d*	System 1:……………….		
		System 2:……………….		
		……….		
		System n:…………………		
Total energy consumption	*kWh/d*	**Considering all of the equipment (tanks. pumps. piping. etc...)**		
REAGENTS				
Paramenter	Unit	Specifications	**Value**	**Remarks**
Maximum Reagents consumption	*l/d*	reagents 1:……………. for……		
		reagents 2:………………for……		
		……………………		
		reagents n:……………. for……		

6.3. Graphic design

The Feasibility Study will be provided with technical drawings:

- **HYDRO Planimetry**, with main process units, tanks and piping;
- **Block Flow Diagram** of the selected HYDRO;

6.4. Results of technical analysis

According to the HYDRO design and characteristics, the technical outcomes should be evaluated.

Table 8.7 Technical Analysis score attribution sub criteria

	SCORE				
HYDRO	**Feasibility Sub-Criteria**	**Definition of Sub-Criteria**	**LOW (1-33)**	**MEDIUM (34-66)**	**HIGH (67-100)**
1+2	Efficiency	Reuse wastewater with high nutrient content (m3/y)	<5000	5000<x<10000	≥10000
		Compost production (tons/y)	<5	5<x<10	≥10

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Research and Innovation Programme
under Grant Agreement No 776643

		Recovered energy from Biogas (MWh/y)	<5	5<x<10	≥10
3	Efficiency	Rainwater harvested (m3/y)	<25	25<x<50	≥50
4	Efficiency	Rainwater and run-off collected (m3/y)	<125	125<x<250	≥250
		Water stored in the aquifer (m3)	<250	250<x<500	≥500
		Drinking water production (m3/y)	<5	5<x<10	≥10
5	Efficiency	Harvested rainwater (m3/y)	<37.5	37.5<x<75	≥75
		Freshwater produced (l/d)	<100	100<x<200	≥200
		Salt produced (kg/d)	<1	1<x<2	≥2
6	Efficiency	Water recovered from atmospheric vapour (m3/y)	<15	15<x<30	≥30
		Harvested rainwater	<25	25<x<50	≥50
		Reclaimed water	<15	15<x<30	≥30

According the above-mentioned sub-criteria, please assign a score to each sub-criteria and report evaluations in table 8.8 below under “score” column.
An explanation of the reason for the score attribution should be also provided.
As a result, please define the overall Technical Feasibility Score of the HYDRO according to equation 1.

Table 8.8 HYDRO Technical Efficiency

TECHNICAL FEASIBILITY		
Feasibility Criteria	Feasibility Sub-Criteria	Score
Technical Feasibility	Efficiency (according to KPIs of HYDROUSA Project)	
OVERALL SCORE	**From 1 to 100**	

7. Economic analysis

This section highlights the economic evaluation of the HYDRO solution exploitation. All the aspects that will be further analysed aim to provide a clear economic and financial framework that represents the key steps for the project investment decision. Specifically, the “value” of the project will be assessed in terms of the benefits that could be derived from HYDRO implementation. Cost-Benefit Analysis (CBA) will be delivered for the proposed project to compare the potential revenues against the costs involved for HYDRO implementation and maintenance (CAPEX and OPEX).

7.1. Identification of the financing pathway

Financial analysis defines the key points for the economic viability of the proposed project. Firstly, different economic pathways to manage the HYDRO replication need to be identified and described (e.g. subsidies, funds, water-sector tariff). Then, please provide information on the possible economic instruments in the “Example” column according to the description.

Table 8.9 Economic Instruments

Economic instrument	Type of instrument	Example
Pricing	**Taxes and charges/fees**: Compulsory payment to the fiscal authority for a service from a regulatory authority: e.g., charge for new development sites as a means of recovering costs for e.g. urban regeneration or green and blue infrastructure investments such as recreation programs ("fee in lieu")	
	Reduced taxes/charges e.g. if a landowner provides a certain (green/unsealed) area of its property for water to infiltrate and therewith reduced run-off of rainwater or stormwater drainage	
	Trading of permits for using a resource or trading (Building or development permits, etc.) of permits for pollution / emission levels	
	Tariffs: A price paid by users to a service provider for a given quantity of service or a schedule of rates or charges of a business or a public utility that provides a product or service which may affect the quality of green and blue areas	
Payments/ Subsidies	**Payments to landowners** or private actors for practices (e.g. installing green roofs of natural water retention areas)	
	Financing targeted research projects (e.g. developing more efficient urban sustainable solutions)	
	Payments for insurances which can cover the risk associated with the performance of newer green technologies	
Voluntary agreements/ Cooperation	**Individual voluntary agreements**: negotiated voluntary arrangement between parties to adopt agreed practices by governmental bodies in order to influence the development of products or the adoption of production processes that benefit the GI/reduce environmental degradation. These are not linked to payments. Voluntary agreements linked to subsidies are included under payments category.	
	Public-Private Partnerships: Contractual instruments between public and private actors that enhance the ability of the public sector to provide public services thanks to the involvement of the private sector. These are a sub-form of voluntary agreements and can include multiple public and private actors. E.g. flood protection projects,	

	coastal defences. These can be structured in many different ways:	
	• private sector has control over all assets, including investment, maintenance, and operations decisions, although some specific, strategic decisions remain subject to regulatory oversight;	
	• concessions in the form of long-term contracts...[where] the private sector has full responsibility for the operation of the asset, usually recouping investment costs with service provision revenues (i.e. tariff collections); In this case also solutions for taking into consideration the fragmented nature of land ownership and how this could be tackled through incentives such as the sharing of benefits (e.g. agroforestry cultivations) should be reported.	
	• management and lease agreements, the private sector takes control on operations for shorter time, but also bears less financial risks, and initial capital investment is assured by the public.	
Private sector	**Loans** (from Investment and commercial banks) (especially low interest loans) to invest in green and blue infrastructure projects, such as green stormwater technologies or restoration projects or urban regeneration projects	
	Bonds (from Capital market) e.g. Financing of adaptation measures via an investment instrument with returns, green Bonds for investing in sustainable and nature-based adaptation solutions	
	Crowdfunding e.g. Crowdfunding platform established by the city council that allows citizens to propose and finance their ideas for the city such as urban farming for residents of a social housing quarter, edible streets etc.	
Liability schemes	Offsetting schemes where liability for environmental degradation leads to payments of compensation for environmental damage. E.g. Eco-accounts, wetland destruction, brownfields funds, habitat banking)	

7.2. Cost estimation for HYDRO implementation (CAPEX)

To estimate the total costs to realise the HYDRO, the capital expenditure (CAPEX) defined in the excel file “**Sizing criteria for HYDRO design**” should be summarized and reported in the table below.

Table 8.10 CAPEX Summary Table

CAPEX				
Paramenter	Unit	Specifications	**Value**	**Remarks**
Cost of HYDRO implementation	€	Preparation of site (Earth works, excavation etc.…)		
	€	Legal affairs/permit purchase /product certification/staff training etc…		
	€	Land purchase		
	€	Unit supply and installation of system 1		
	€	Unit supply and installation of system 2		
	€	Unit supply and installation of system 3		
	€	……………		
	€	Unit supply and installation of system n		
Total CAPEX	€			

7.3. Cost estimation for HYDRO maintenance (OPEX)

To estimate the total costs for HYDRO operation and maintenance, the operating expenditure (OPEX) defined in the excel file "**Sizing criteria for HYDRO design"** should be summarized and reported in the table below.

Table 8.11 OPEX Summary Table

OPEX				
Paramenter	Unit	Specifications	**Value**	**Remarks**
Reagents	€/y	Considering reagents both for operation and maintenance (cleaning)		
Energy costs	€/y	Considering cost of electricity [average between day and night, during week and weekend]		
Staff	€/y	Considering personnel both for operation and maintenance		
Maintenance	€/y	Considering substitution of pieces etc…		
Insurance	€/y			
TOTAL ANNUAL OPEX	€/y			

7.4. Revenue & costs saving streams

The financial feasibility of the project is determined by the project profits (Woodruff, J., 2019) and specifically estimated by using the Payback Period Method.
According to the possible marketable HYDRO by-products (e.g. crops, fertilizers, Biogas etc.) and to their local market values, yearly revenues can be determined and thus, payback period can be calculated as reported in the table below.
Specifically, Partners can determine the Payback Period by filling the table in the excel file "**Sizing criteria for HYDRO design"**.

Table 8.12 Business Model for HYDRO Replicability

Revenue & costs saving streams						
Parameter (below examples are provided)	Unit	Quantity	Unit	Market value	Unit	**Value**
Treated wastewater for irrigation	m3/year		€/m3		€/y	
Biogas	MWh/year		€/MWh		€/y	
Fertilizers	kg/year		€/kg		€/y	
Wastewater treatment tax	m3/year		€/m3		€/y	
Yearly revenues					€/y	
Payback period	CAPEX/ (yearly revenues - OPEX)				y	

The achieved result must be compared to the KPI of the HYDROUSA Project (according to the grant agreement, see figure below) to evaluate the economic feasibility of the HYDRO implementation. Specifically, the feasibility score must be evaluated considering the HYDROUSA Project KPI of 9 years.

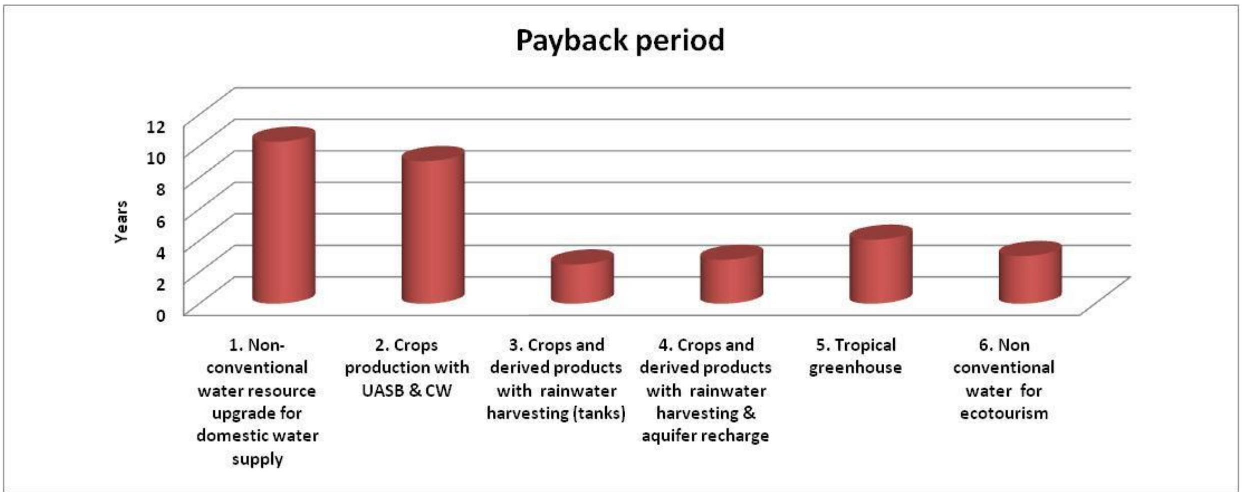

Figure 8.17 Grant Agreement HYDRO Payback Period

Table 8.13 Economic Analysis score attribution criteria

SCORE			
Feasibility Sub-Criteria	**LOW (1-33)**	**MEDIUM (34-66)**	**HIGH (67-100)**
Payback Period (PP)	PP ≥ 9 years	9 years < PP ≤ 5 years	PP < 5 years

According the above-mentioned sub-criteria, please assign a score to each sub-criteria and report evaluations in table 8.14 below under “score” column.
An explanation of the reason for the score attribution should be also provided.
As a result, please define the overall Technical Feasibility Score of the HYDRO according to equation 1.

Table 8.14 HYDRO Payback Period

ECONOMIC FEASIBILITY		
Feasibility Criteria	Feasibility Sub-Criteria	Score
Economic Feasibility	Payback Period	
OVERALL SCORE	**From 1 to 100**	

8. Conclusion

To define the overall feasibility of the HYDRO and to suggest the necessary improvements for the water loops exploitation, Partners must fill the score matrix below in order to determine the overall score of the HYDRO according to the Equation 2.

Table 8.15 Matrix of Feasibility Study

	FINAL RESULTS		
Feasibility Criteria	Main Feasibility Sub-Criteria	Weight	Score
Social Feasibility	Stakeholder and public participation, Social Benefits, Social Acceptance	30%	*...report here score from section...*
LegalFeasibility	Strategies and Action plans, Targets and Quality standards, Permitting Pathway	30%	*...report here score from section...*
Technical Feasibility	Efficiency	20%	*...report here score from section...*
Economic Feasibility	Financial pathway, Payback Period	20%	*...report here score from section...*
OVERALL FEASIBILITY	**-**	**100%**	**SCORE from 1 to 100**

8.5 Subcontract Document Template

Between

The HYDROUSA Replication Site Manager ____ represented by the ____________________________________, Partner of the HYDROUSA Project (n.776643) and WP_____ Leader

And

The ____
represented by the ______________________________________, named Collaborator below,

GIVEN THAT

- The HYDROUSA Replication Site Manager _______________________________________ has to fulfil the following objective in the HYDROUSA project, Task 7.3, 7.4 and 7.5 of the Work Package 7: "Transferability and replication of HYDROUSA services";

- as part of the HYDROUSA project, it is required to carry out the following activity: "Assessment of the transferability and replicability of the HYDROUSA regenerative solutions in Europe, Middle East and North African, Australia, America and Asia";

- it is required to give an assignment to an external subject, under the collaboration contract, due to the complexity of finding and collecting information on local legislative and institutional framework to conduct feasibility study;

- the characteristics of the external service are temporary and high qualification;

THE FOLLOWING IS STIPULATED:

ART. 1 (OBJECT OF THE ASSIGNMENT)

The HYDROUSA Replication Site Manager __________________________________, as identified above, subcontracts the activities specified in this article to the Collaborator ____, who accepts the assignment.

Specifically, the activities include the identification and English translation of local regulations and relevant reports or guidelines to best engage local stakeholders of the replication site. Furthermore, the Collaborator is committed to support the HYDROUSA Replication Site Manager in collecting the relevant information in the context of HYDRO feasibility study.

The required data and information for HYDRO replicability might concern:

- **HYDRO strategic context and local background of the replication site:**
  Project's scope and background should be analysed to outline the context of the feasibility study, highlighting:
  - The importance of the HYDRO implementation in local water and water-related resources management for the local replication site
  - How HYDRO implementation can close the water loop in a decentralized site and provide a sustainable solution to manage water and water-related resources.

- **Characterization of the replication site and identification of environmental constrains:**
  An exhaustive description of the local replication site has to be given, in order to evaluate the environmental impacts and the correlation among the local community needs. Furthermore, once the area is identified, possible environmental constraints have to be detailed to highlight "environmental fragilities" to identify any potential risks connected to the project;

- **Social Analysis and final end-users' identification**
  In the context of HYDRO implementation and promote HYDRO exploitation, a description of the social feasibility assessment is a key factor to identify the necessary instruments to arise awareness and support the dialogue between public and private institutions, key actors and citizens.

- **Policy analysis and institutional framework**
  All the regulatory instruments have to be described at different institutional levels, from HYDRO implementation to the final-products valorisation at community level (e.g. National and/or regional planning laws, regulations, strategies and action plans).
  Furthermore, a detailed description of the following aspects has to be done according to the site characteristics:
  - The permitting pathway for the HYDRO construction and management
  - The permitting pathway for the use/reuse of the HYDRO by-products

  If any of the above regulatory instrument is missing, the Collaborator should highlight this lack for the HYDRO exploitation. Also, a list of the stakeholders and policymakers should be provided.

- **Technical Analysis and graphical drawing**
  The Collaborator should provide all the necessary information to support the HYDROUSA Replication Site Manager to preliminary design and draw the HYDRO(s). Specifically, local site data (e.g. climate conditions such as solar irradiation, temperatures and rainfalls; hydro-geological and orographic information such as slopes and altitude; extension of the area etc.) should be provided;

- **Economic Analysis and financial pathway identification**
  Subcontractors should describe the financial asset of the HYDRO to evaluate its financial exploitation.

For more information please refer to "Feasibility Study Report Template".
The work is related to the Project: "HYDROUSA - Demonstration of water loops with innovative regenerative business models for the Mediterranean region".
The HYDROUSA Replication Site Manager will have the right to technical supervision of the activity carried out by the Collaborator by providing him with the guidelines of the correct execution of the service.

ART. 2 (DUTIES OF THE COLLABORATOR)

The way of performing the service will be determined by mutual agreement between the parties and the Collaborator. The Collaborator will autonomously organize his own activity except for the deadlines which must be pre-agreed with the HYDROUSA Replication Site Manager.
The Collaborator is required to carry out the activity referred to in art. 1 with the necessary diligence.
The Collaborator is also required to comply with the general guidelines provided by the HYDROUSA Replication Site Manager and to communicate with him about the points highlighted in this contract.
The HYDROUSA Replication Site Manager will carry out periodic checks on the results of the activity carried out by the Collaborator with reference to the subject of this contract.

ART. 3 (DATE AND DURATION OF THE CONTRACT)

The activity described in this contract will have a duration of n. __________ months from ____________________.
The starting date and/or the duration might vary with respect to the specific activities of the project agreed between the parties.

ART. 4 (OBLIGATION OF CONFIDENTIALITY)

The Collaborator undertakes not to disclose any information to third parties regarding the HYDROUSA activities carried out during its collaboration. The purpose of this obligation is that any information, that has not been published or otherwise publicly known, cannot be disclosed and used.
It has to be noticed that none of these provisions will prevent the Collaborator from sharing information to third parties for an effective and efficient fulfilment of his obligations towards the HYDROUSA Replication Site Manager.

_________place________, _____date______

The HYDROUSA Replication Site Manager | The Collaborator

_________________________________ | _________________________________