D17.1 Contingency Plan

Electrochemical oxidation of cyclic and biogenic substrates for high efficiency production of organic chemicals

ELOXYCHEM

eloxychem-horizon.eu
HORIZON-CL4-2023-TWIN-TRANSITION-01
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Executive Summary

The Contingency plan for the ELOXYCHEM project describes how quality assurance and risk management will be organised and followed up. Roles and responsibilities are described for project participants with focus on periodic follow-up of risks. An outline of the identified risks at the start of the project is given with focus on managerial, technological and exploitational risks.

The motivation for the risk management work is to support the overall objective of the ELOXYCHEM project which aims to contribute to Europe's twin transition in the chemicals sector through the application of advanced electrochemical technologies for production of key classes of chemicals: aliphatic monocarboxylic acids, dicarboxylic acids and, to a small extent, cyclic ketones.

The overall objective involves a series of sub goals, each associated with individual risks.

1. Achieve technological breakthroughs for electrochemical conversion processes to produce platform chemicals which reduce energy usage by up to 60% compared to conventional thermochemical processes.
2. Validate concepts through design, build & commissioning of a continuous flow pilot system.
3. Demonstrate the industrial viability of electrochemical processes to produce platform chemicals which are more energy efficient, sustainable and cost-effective than fossil-based processes.
4. Optimise the process economics while increasing the use of renewable energy through the integration of digital technologies.
5. Reveal the versatility of the process for different feedstocks, especially for future bio-based sources.

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List of Abbreviations

Abbreviation	Description
CA	Consortium Agreement
CAPEX	Capital Expenditures
C	Criticality
C*P	Risk Potential
DSP	Down Stream Processing
HSE	Health, Safety and Environment
I	Intervention
iDAQ	Intelligent Data Acquisition Engine
IDE	Project partner IDENER
IP	Intellectual property
IPR	Intellectual property rights
LCA	Life Cycle Assessment
MEG	Project partner Megara resins
ML	Machine Learning
Mxx	Month xx of the project period
OEM	Original Equipment Manufacturer
P	Probability
PV	Photovoltaic
RES	Renewable Energy Systems
Risk	An incident that may have negative consequences for a given objective or entail a loss of value in the form of life, health, material assets, the external environment, reputation, infrastructure, financial loss, etc. Risk can be expressed as a function of the probability that an incident will occur and the impact that results if it does occur. Incidents with positive outcomes are regarded as opportunities.
TEA	Techno-Economic Analysis
WP	Work Package
ZPR	Project partner Z-prime

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1. Introduction

This report, addressing the project deliverable D17.1 “Contingency Plan”, offers a comprehensive look into the risks and quality management strategies that have been considered and implemented for the ELOXYCHEM project.

To cover all contingencies throughout the ELOXYCHEM project the following general principles for risk management processes are followed:

- The aim of risk management is to contribute towards a proactive approach to uncertainties that may represent a threat to the projects' abilities to meet the objectives, or which are factors that may influence the ability to exploit commercial opportunities.
- Risk management provides decision support in the process to determine whether a risk can be regarded as acceptable, or if measures should be evaluated to mitigate said risk.
- Risk management shall involve the processes of risk mapping, risk analysis and risk evaluation with subsequent risk mitigation as a basis for initiating actions to address the risk in question.
- Risk assessments shall be repeatable and carried out systematically and collaboratively, thus enabling the knowledge and opinions of all those involved to be considered. A risk assessment shall utilise the best available information, supplemented with further investigation if required.

2. Roles and Responsibilities

Project coordinator:

- establishing a risk management policy and evaluating periodically whether there is a need for revision of the policy or amendments to related procedures.
- establishing a framework for the practical implementation of risk management processes

Work package leaders:

- mapping WP-related risks and monitoring risk mitigating measures.
- reporting significant risks to the project coordinator.

All project members:

- reporting significant risks to the subsequent WP leader

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3. Quality and Risk Management

An evaluation and monitoring of the risk related to the successful implementation of ELOXYCHEM during project execution and beyond will be done. To do so, they were divided into three different categories (Administrative, Technological, and related to the exploitation) for better control and mitigation. Furthermore, a quantification methodology based on the expertise of the exploitation manager (IDE), and aligned with the approaches available in the literature.[1] This methodology focuses on two risk characterisation parameters: probability and criticality. Both parameters go from 1 to 10, being the lowest and highest probability and criticality, respectively. They are used to obtain a derived indicator by multiplication: the risk potential. Finally, another parameter is defined, the intervention, to quantify the capacity (or need) of the consortium to solve the risks. This parameter also goes from 1 (low capacity) to 10 (high capacity). All the risks, including their quantification, are listed in Table 1-3.[2]

Finally, combining the risk potential and intervention leads to four different risk classes: (1) Low risks (no mitigation required), (2) Low/medium risks (mitigation actions are needed and the risk is under control with them), (3) Medium/high risks (mitigation actions are needed, but they are not enough), and (4) High risk (there are no feasible mitigation actions). The distribution of the ELOXYCHEM risks among these four classes leads to the ELOXYCHEM risk map (Figure 1), which is an easy tool to quickly identify the more dangerous risks.

Based on this map, it can be concluded that the majority of the risks were classified as low/medium risk (under control). This means that they are not critical since the mitigation measure is expected to be enough to minimize them. However, during the first months of the project, a new risk was identifed (number 27), which can imply important limits in the electrochemical reactor performance. Despite its potential negative effect, the consortium is confident in finding a technical solution, which is currently under evaluation (intervention>5), to reduce its potential. All in all, its real effect may not be precisely quantified until the first lab-scale experiments are run. This risk assessment will be updated in the following Exploitation/Contingency plan versions.

[1] https://onlinelibrary.wiley.com/doi/epdf/10.5325/transportationj.51.4.0428?saml_referrer
[2] Note that this quantification and risk identification is updated using the exploitation questionnaires developed in D14.1.

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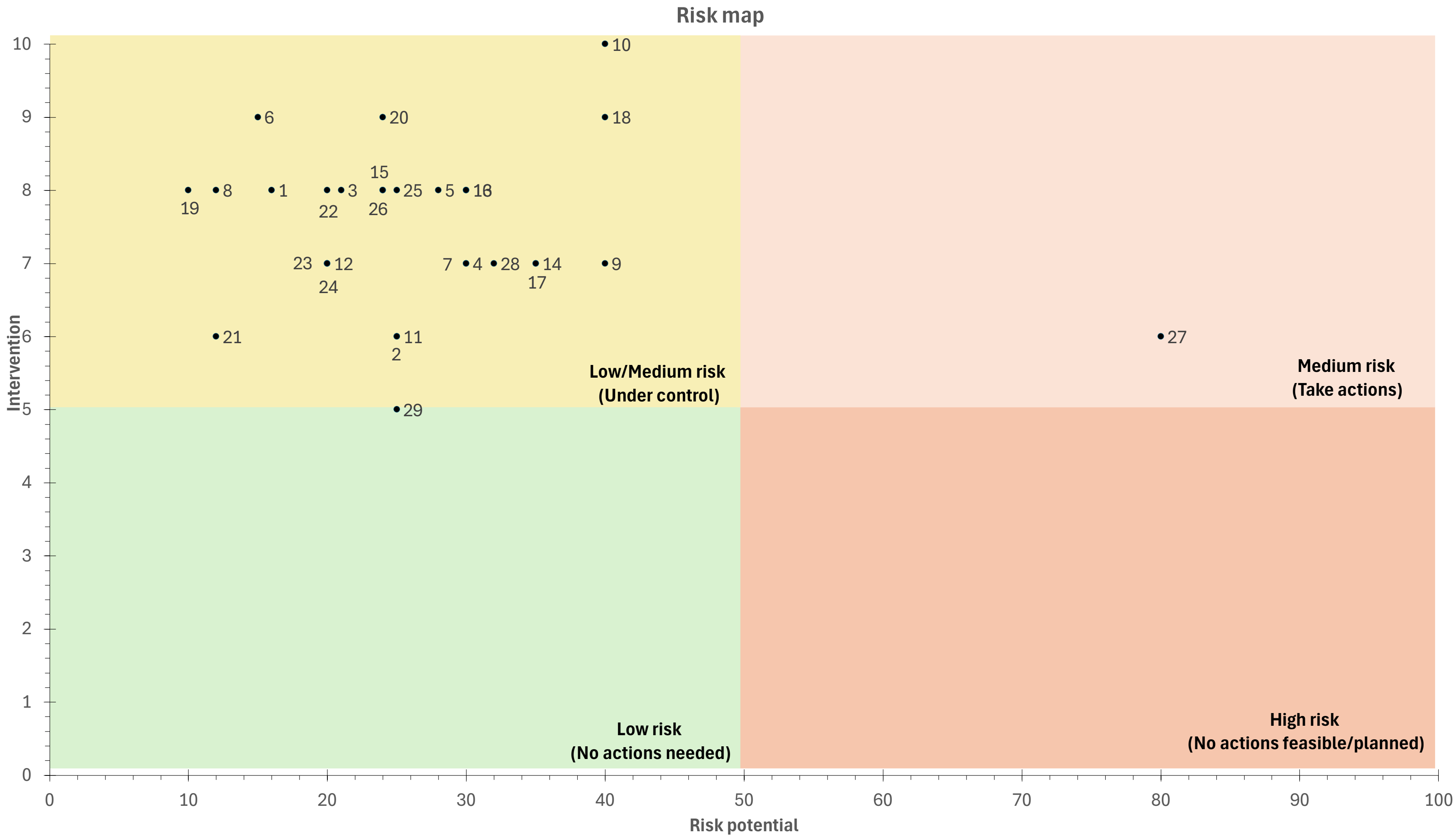

Figure 1. ELOXYCHEM risk map.

3.1 Administrative risks

Table 1: Overview of identified risks related to the management of the project.

Risk number	Description of risk	WP	Probability (P)	Criticality (C)	Risk potential (C*P)	Risk-mitigation plan	Intervention (I)
1	A partner not committed, underperforming or even leaves the project	All	2	8	16	The partners are well-established, highly motivated and committed. Include clear partners' liabilities and procedures for conflict resolution within the CA. Seek replacement partner or redistribute tasks if necessary.	8
2	Key staff leaves the project	All	5	5	25	Assign WP co-leads to take over responsibility and maintain continuity of work whilst replacement is sought. Consortium partners have depth of expertise to deputise.	6
3	Delay in the work plan and in the delivery of project outcomes	All	3	7	21	The experienced coordinator will ensure communication among partners and close monitoring of project execution through consortium meetings. Project will benefit from the institutional experience of the WP leaders. Management	8

Risk number	Description of risk	WP	Probability (P)	Criticality (C)	Risk potential (C*P)	Risk-mitigation plan	Intervention (I)
						structures/procedures are designed to optimise project monitoring and overcome delay.	
4	Delay in equipment procurement, subsequent delays in construction & commissioning	11	5	6	30	Pilot plant design and procurement to be completed by M26 (halfway through the project). Use experience of partners in equipment supply chains to identify and mitigate potential bottlenecks early on.	7
5	Issues on data provisioning and sharing	All	4	7	28	Clearly communicate with partners the logic, type, extent of the data required to generate the assessment models	8
6	Travel restrictions due to pandemics, war, climate events or other unexpected events	All	3	5	15	Move project meetings, training and engagement activities online, start domestic activities early until cross-border travel restrictions lift and activities requiring travel can happen.	9
7	Conflicts on the exploitation roadmap definition (e.g. revenues share, ownership)	14-16	5	6	30	Partners will seek internal/external professional support if required to negotiate and ensure an agreement is met among partners. Initial IP rights	7

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Risk number	Description of risk	WP	Probability (P)	Criticality (C)	Risk potential (C*P)	Risk-mitigation plan	Intervention (I)
						assigned and conflict resolution actions in place.	
8	Building on results of still ongoing R&I projects and without full visibility on background IP ownership	2-4	4	3	12	Carefully positioned deliverables & milestones within WPs 2-4 which allow for the assessment of the situation and adjustments in later WPs. Inclusion of partners background, IPR ownership and clear procedures for IPR conflict resolution in the CA.	8
9	Construction and integration of the demo plant exceed budget allocation	11	5	8	40	Careful revision of equipment costs considered along design and construction of demo plants. Budget re-allocation considered among partners if needed to fulfil project objectives. Potential to partner with manufacturers (e.g. glassy carbon electrodes) who may co-invest to generate large scale business opportunity	7
10	The pilot plant will be ready in month 24 after related deliverable submission deadline (ex.	10	10	4	40	Close collaboration with SINTEF to define the architecture and implementation for the control and monitoring of the pilot plant in WP11. If	10

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Risk number	Description of risk	WP	Probability (P)	Criticality (C)	Risk potential (C*P)	Risk-mitigation plan	Intervention (I)
	D10.1 in Month 18)					the implementation extends beyond month 18, preliminary information will be included in D10.1, while a complete version will be done in a subsequent deliverable.	

3.2 Technological risks

Table 2: Overview of identified risks related to technical aspects of the project.

Risk number	Description of risk	WP	Probability (P)	Criticality (C)	Risk potential (C*P)	Risk-mitigation plan	Intervention (I)
11	Electrodes show shorter working lifetime than expected	2-4	5	5	25	Identification of the optimal operating environment for electrode stability. Application of low-cost forms for glassy carbon electrodes with varying morphologies to optimise lifetime.	6
12	Stability issues with the electrolyte limit performance	2-4	4	5	20	Limit the current density and alter the electrolyte components which undergo side reactions.	7

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Risk number	Description of risk	WP	Probability (P)	Criticality (C)	Risk potential (C*P)	Risk-mitigation plan	Intervention (I)
13	Gas/liquid mixing is insufficient, causing a low oxygen concentration in the electrolyte and limiting the reaction performance.	2-4	5	6	30	Installation of high intensity gas/liquid mixing units. Modify temperature/pressure of process to maximise oxygen solubility. Select additional solvents with a high oxygen solubility that are compatible with the electrochemical requirements and the DSP. Increase area of electrode at increased CAPEX	8
14	Flow processes are not efficient in conversions	2-4	5	7	35	Reduce flow rate, increase effective electrode surface area or perform sequential electrochemical oxidations	7
15	Electrochemical conversion process generates excessive heat	2-4,7-8, 11	4	6	24	Extent of heat generation will be identified in WP2 and 3, appropriate measures such as cooling of the electrodes itself or the circulating liquid will be implemented in the flow systems.	8
16	Short chain diacids as likely by-products need to be separated.	2-4	5	6	30	Adequate efficient work-up procedures need to be developed for diacids of interest, such as distillation and recrystallisation	8

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Risk number	Description of risk	WP	Probability (P)	Criticality (C)	Risk potential (C*P)	Risk-mitigation plan	Intervention (I)
17	Safety concerns cannot be mitigated to allow for technical operation.	1-4, 11	5	7	35	HSE analysis completed in first year to advise reactor designs. To handle critical mixtures operations, the electrolysis will be conducted in narrow gap cells which limit the volume of reactants. By numbering up the cells, the same productivity can be met. Machine Learning utilised to determine explosion risk criteria.	7
18	Initial yield and purity lower than expected	2-6	5	8	40	Perform the process with partial conversion, design downstream processing for recovery of starting material and product. Conduct post-process purification.	9
19	Waste residues pose environmental risk	2-4	2	5	10	Alter electrochemical conditions to avoid by-products and other contaminates. Post-process water treatment can be applied.	8

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Risk number	Description of risk	WP	Probability (P)	Criticality (C)	Risk potential (C*P)	Risk-mitigation plan	Intervention (I)
20	Scale-up risks (e.g., inhomogeneous current distribution, hydraulic constraints, heat imbalances, safety issues)	5,6,9, 11	4	6	24	Modular design of the electrochemical reactor and applying existing experiences, methods, and rules for scaling up an electrochemical process from lab to pilot plant. Perform evaluation of heat formation, liquid distribution and pressure drop when scale is increased and incorporate in the design.	9
21	Scalability in flow is initially insufficient	5,6, 11	4	3	12	Continue with small scale and increase reaction time, revise reactor design to optimize residence time and flow pattern in the cell	6

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Risk number	Description of risk	WP	Probability (P)	Criticality (C)	Risk potential (C*P)	Risk-mitigation plan	Intervention (I)
22	Multiple vendors generate multiple communication protocols, lack of access to equipment and machinery monitoring and control data limits control and ML	10	5	4	20	ZPR iDaQ technology deployed to communicate with the equipment. Communication through partners to OEMs to provide information. Alternatively, deployment of external sensors and data acquisition systems to compensate for the lack of information and use of simulated data through theoretical expert knowledge to cover missing but essential data from the process.	8
23	CAPEX costs escalate, making the process uneconomic	7,8, 11, 12	2	10	20	Revise reactor and electrode design, making the cell smaller, and then increase volume through numbering up approach.	7
24	Not possible to undertake the electrochemical process using 100% RES	13	4	5	20	Model Wind & PV renewable energy integration. Develop strategies for integration hydropower. Design processes for variable production.	7
25	Availability and quality of data for TEA/LCA	7,8, 13	5	5	25	Early development of data inventory. Data quality will be evaluated, missing data identified early and can be retrieved. Literature data will be utilised.	8

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Risk number	Description of risk	WP	Probability (P)	Criticality (C)	Risk potential (C*P)	Risk-mitigation plan	Intervention (I)
26	Lack of (free) data to simulate the renewable energy integration	2-4, 13	8	3	24	Tailored internal tools developed by IDE that enable the use of simulated power profiles for solar panels and wind turbines located at any place and at any date.	8
27	Hindered oxygen mass transfer in the reactor	5-9-11	8	10	80	Review of different flow patterns in the reactor to optimize O_2 diffusion and minimize the required surface area	6

3.3 Risks related to exploitation

Table 3: Overview of risks identified related to the exploitation of project results.

Risk number	Description of risk	WP	Probability (P)	Criticality (C)	Risk potential (C*P)	Risk-mitigation plan	Intervention (I)
28	Additional value created not sufficient for value chain(s)	12; 14-16	4	8	32	Initial TEA undertaken has shown that current process can yield products of value to EVONIK and MEG. Assessment of side stream products done early to boost commercial potential. See additional higher value oxidative processes.	7

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29	Existing patents/prior art impedes commercialisation or protection of foreground IP	14-16	5	5	25	Extensive patent/literature searches have been conducted with no indication of existing patents/prior art which impedes commercialisation or protection of expected key IP. Tech-Futures Analysis carried out during the project (Tasks 14.6/15.6/16.6).	5

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