

PERFORM (PoWER platFORM)

Project overview

Projects and Hubs4Circularity Forum
9 June 2022

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PERFORM
Power platFORM



*This project has received funding from the European Union's
Horizon 2020 Research and Innovation Programme under
Grant Agreement N. 820723*

SPiRE
Sustainable Process Industry through
Resource and Energy Efficiency

PERFORM Project

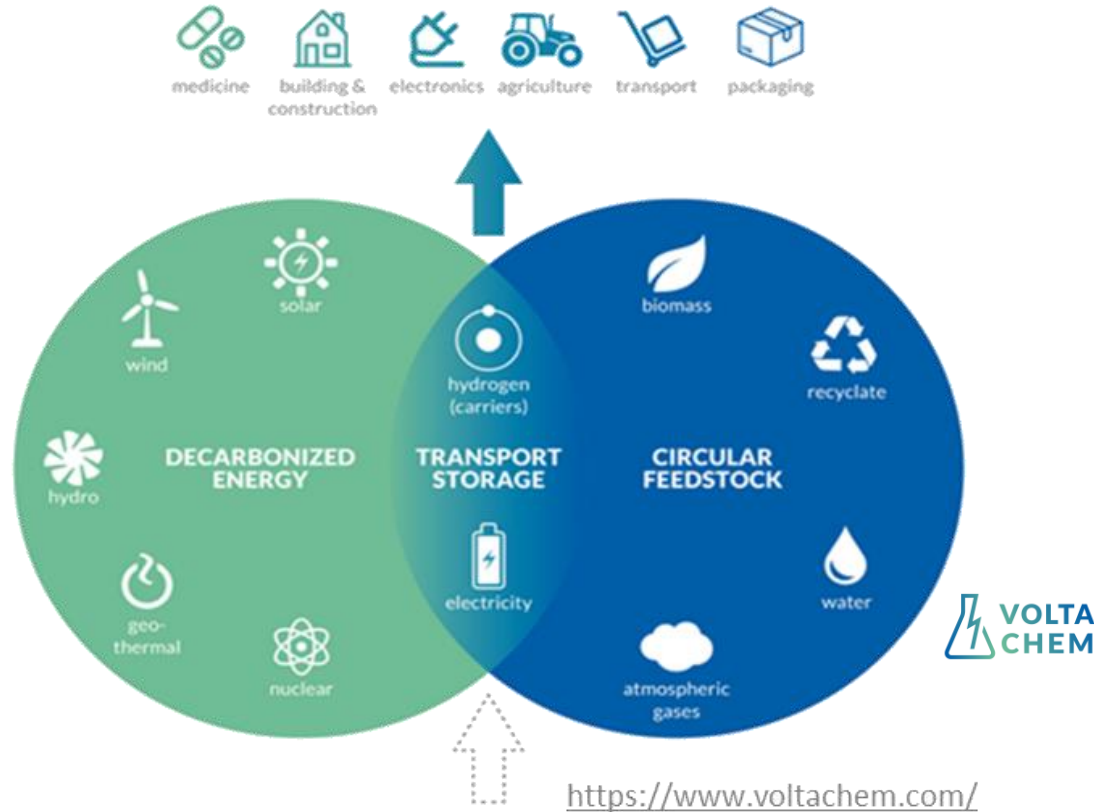
Introduction

- Project info:
 - 4 years funding by HORIZON 2020, call H2020-NMBP-ST-IND-2018-2020, Topic: CE-SPIRE-02-2018:
Processing of material feedstock using non conventional energy sources
 - January 2019 – June 2023 (6 month extension due to COVID-19)
- Overall objectives:
 - Development and construction of a highly versatile and modular TRL5-6 electrochemical **PowerPlatform** for the valorization of biobased chemicals (1 m² electrode surface area, 250 g/h)
 - **Demonstration** of improved flexibility by showcasing two processes based on different feedstocks at variable throughputs and electricity input
 - **Dissemination and exploitation** of the major innovation outcomes, during the project; providing open-access infrastructure for integrated electrochemical processes development to be available to the research community after the project ends.



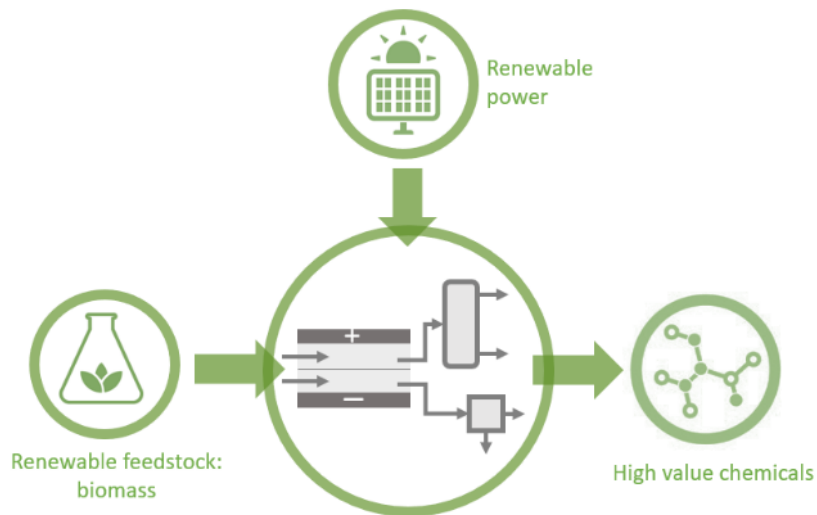
Motivation

- **Project targets 2 global trends:**
 - Energy transition and Electrification
 - Shift to bio-based feedstocks
- Paris agreement 2015 → 1.5/2 °C target
- European Green Deal: becoming carbon neutral by 2050 and decoupling economic growth from fossil resource use

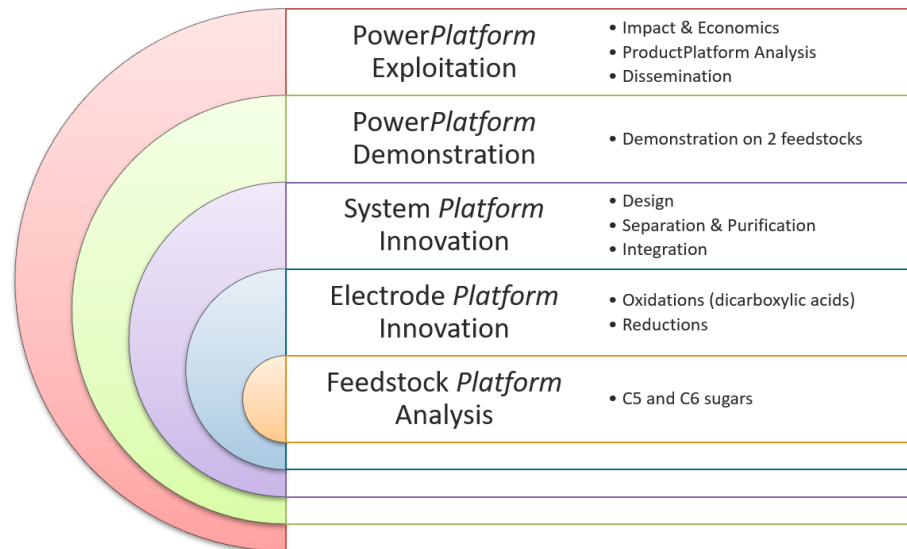


Project concept

Development of highly efficient and integrated electrochemical system for transformations based on bio-based feedstocks: TRL 2-3 → TRL5-6

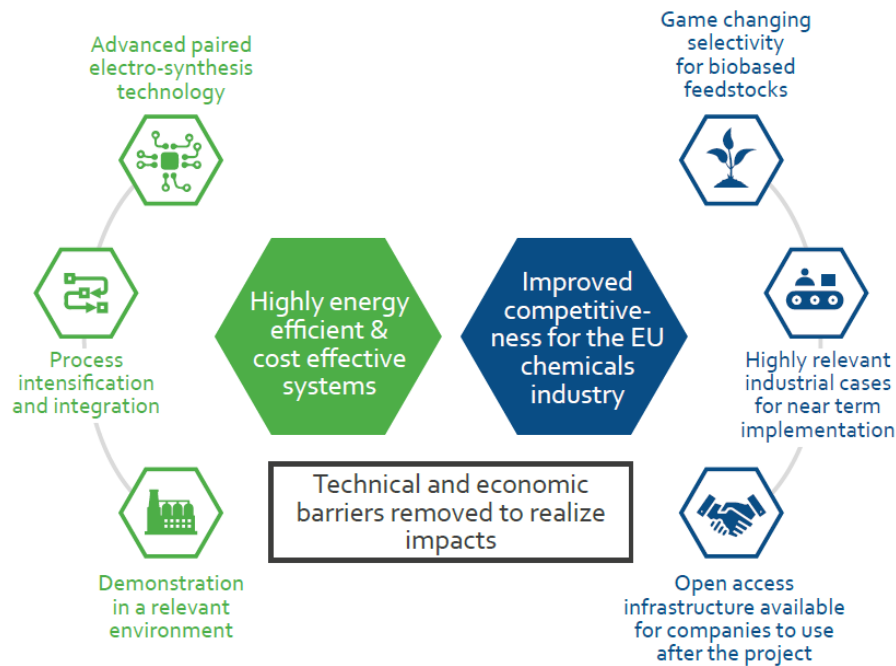
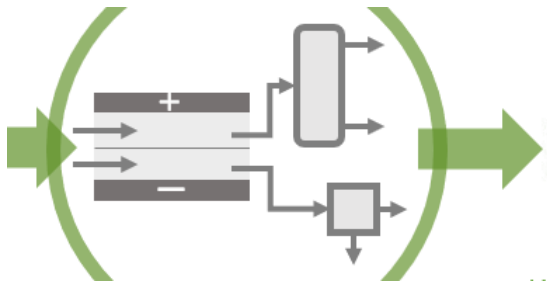


- Integrated electrocatalytic reactor & DSP
- Paired/Tandem electrochemical conversions
- Open access flexible & modular Power Platform



Key innovations

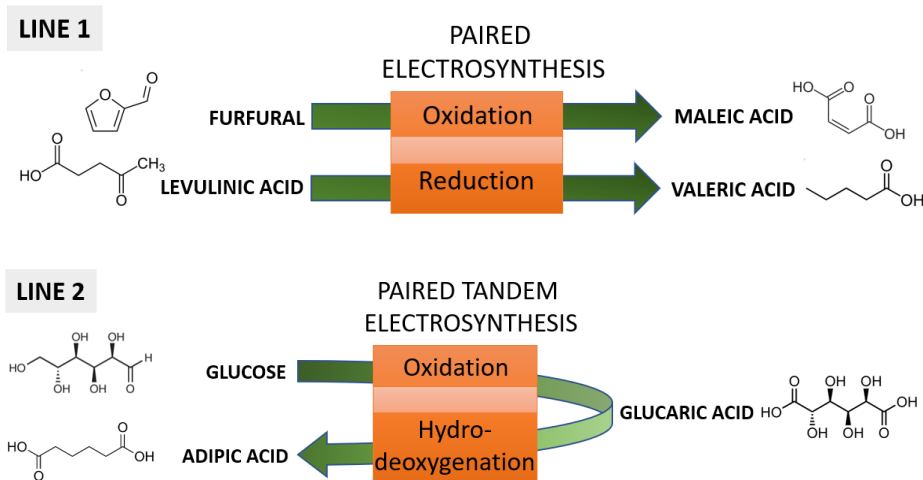
1. Paired electro-synthesis for efficient conversion of bio-based chemicals
2. Upscaling of novel electrode production
3. Electrochemical process intensification
4. Integrated electrochemical process system design



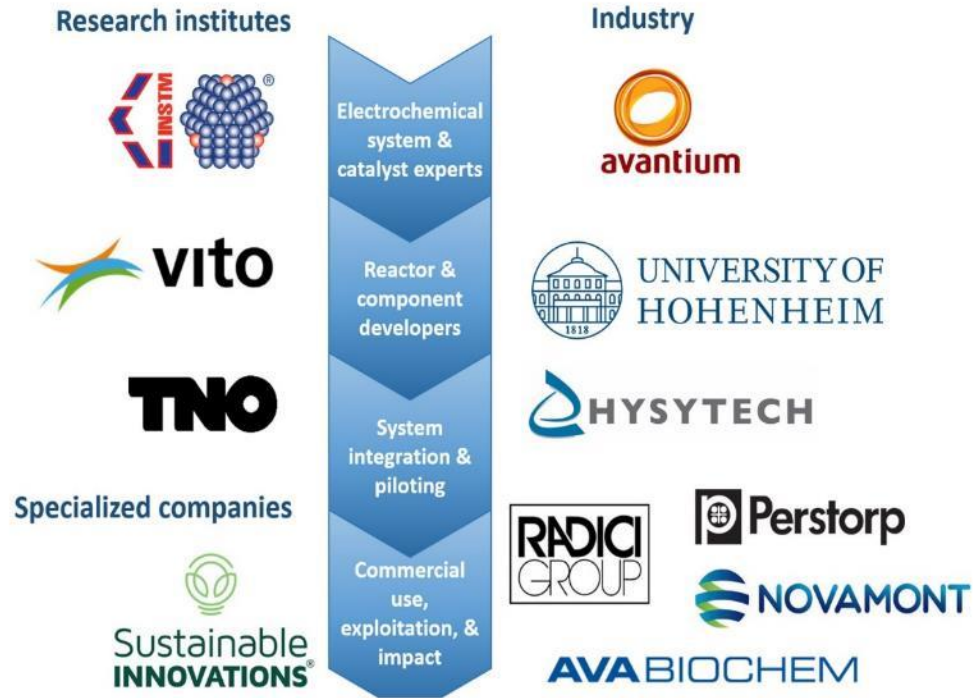
Showcases

Chemical building blocks from bio-based feedstocks

- Feedstock:
 - Furfural, glucose
- Products:
 - Line 1: Maleic & Valeric acids
 - Line 2: Adipic acid (via glucaric acid)
- Applications:
 - Polymers and plastics
 - Synthetic lubricants
 - Perfumes, cosmetics



Strong international consortium: 11 partners in 7 countries

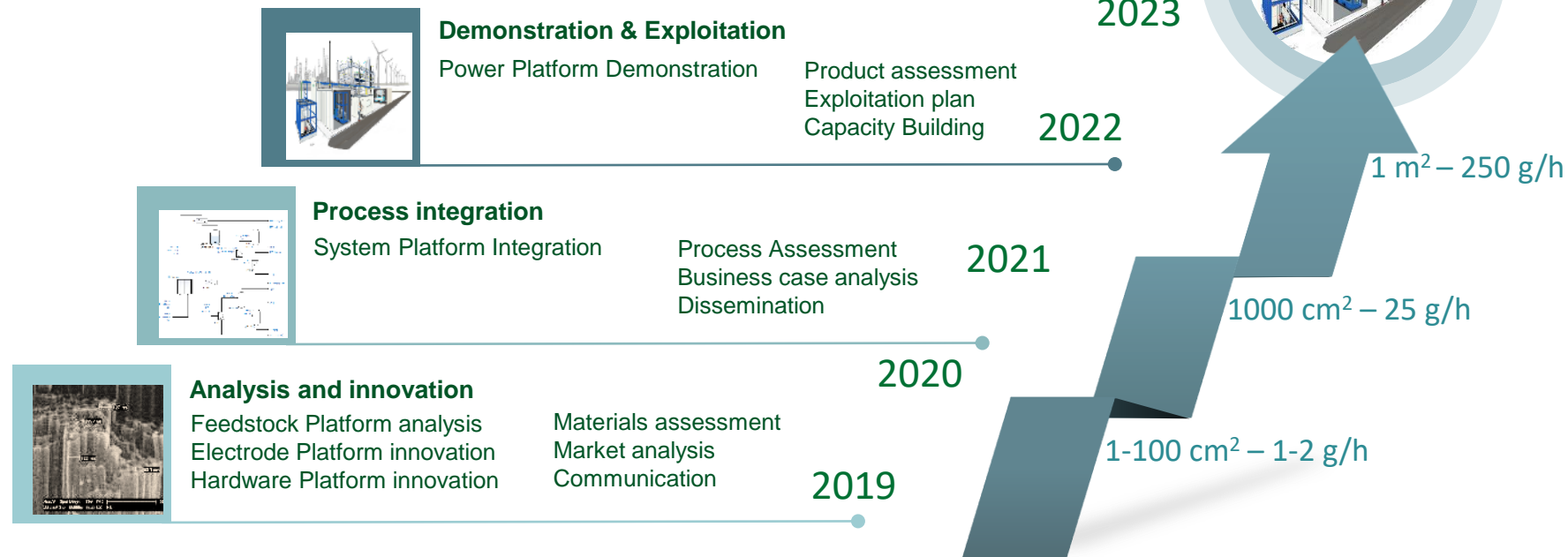


Expected impact

Main KPI's

- Electrochemical Pilot - The surface area of the electrodes will be up to 1 m² , capable of converting up to 250 g/h of biobased feedstock allowing for fast scale-up, reaching TRL6. Will be open access infrastructure.
- Increased energy efficiency compared to non-coupled electrochemical processes by 50%. Decreased energy use by 25% compared to related non-electrochemical processes.
- Electrocatalysts/electrodes with Faradaic efficiency > 80% and overpotential < 0.2 V for the selective oxidations of furfural and glucose. Demonstrate performance at TRL 5 with selectivity > 80%.
- Downstream Processing: separation of carboxylic acid products from the electrochemical reaction mixtures with recovery >90% and with purity > 95% in crude form, that can be further purified to 99.9%.
- Techno-economics and benchmarking to assess the business case (energy efficiency, resource efficiency, decrease in CO₂ emissions, decreased OPEX and CAPEX)
- Dissemination, communication, and exploitation for the realization of the full potential of the PERFORM project results.

Main activities & Development phases



Dissemination, communication, exploitation, capacity building

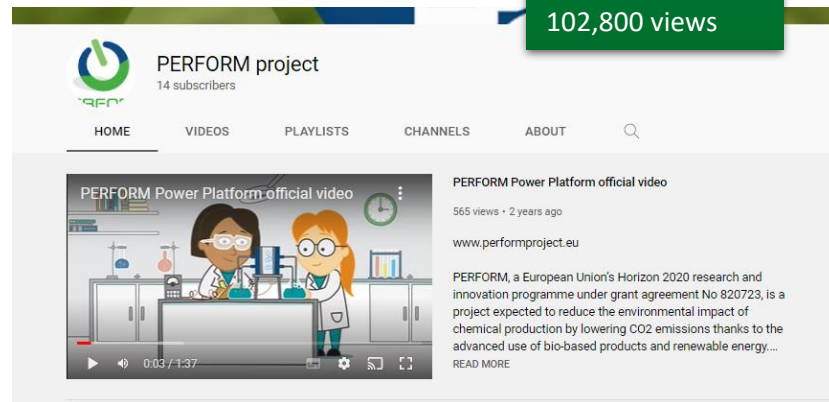
OBJECTIVES

- To enable potential future exploitation of the results to their full potential by disseminating the results to the relevant stakeholders.
- To ensure that the findings of the project are widely communicated to the public in general.
- To document undertaken and proposed dissemination and communication activities.
- To ensure the project results reach the relevant stakeholders who will use and implement them.

MAIN ACHIEVEMENTS M38

- Market assessment, market approach workshop
- KER updated and refined
- Exploitation & IP workshop
- Clustering with related projects (DESTINY, LIBERATE, SIMPLIFY)
 - Webinar, Horizon Results Booster
- PERFORM nominated to 3 awards
- 1 paper published
- 4 Newsletters released
- 8 events attended

Social media M38
301 post, 5 videos
549 followers
102,800 views



Project Innovation Highlights

Feedstock



- **Analytical methods** developed to characterize feedstock compositions and purity
- **Feedstock pre-treatment** methods developed to remove organic and inorganic contaminants, e.g. salts, acid.



(Zambezi in Grant Agreement)

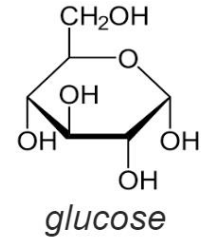
Non-food biomass



Agricultural residues



Forestry residues

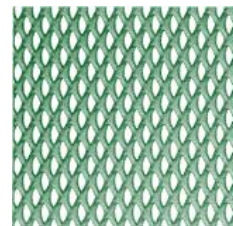
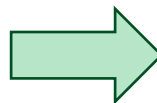
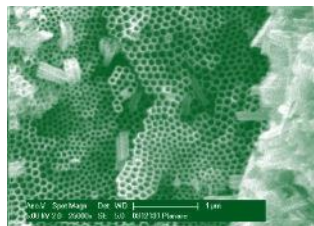
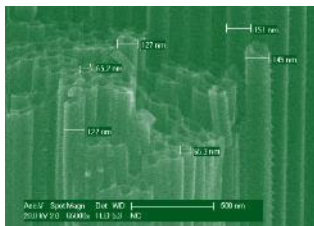
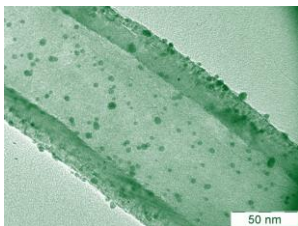


- **Industrial grade feedstocks** available on the market for the demonstration

Catalysts and electrode development

Objectives:

- Selective & efficient conversion ($S > 80\%$, $FE > 80\%$)
 - High productivity ($CD > 100 \text{ mA/cm}^2$)
 - Stable electrode materials
- Proven production of target molecules with selectivity and Faraday efficiencies of 50-90%
 - But: adipic acid electrolysis is challenging
 - Novel cathode and anode materials developed (PbO_2 , Pb, Au, ...)
 - Reactions optimized at lab scale
 - 3D electrodes are being manufactured

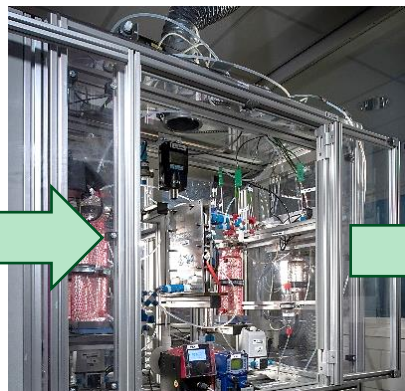


Scale up from lab to pilot scale

Reactor scale up

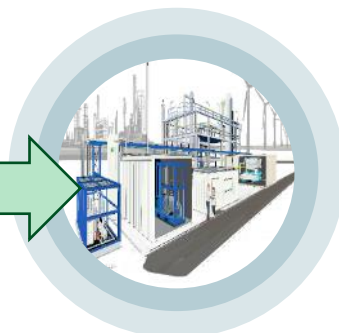


1-100 cm² – 1-2 g/h



1000 cm² – 25 g/h

Pilot PerformPlatform
Stack Reactor



1 m² – 250 g/h

1000 cm² Reactor designed, constructed & tested.
Productivities 50-100 g/h (100 mA/cm²)

TNO

HYSYTECH

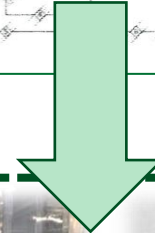
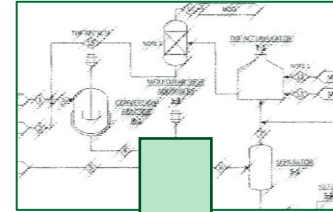
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avantium

Process development

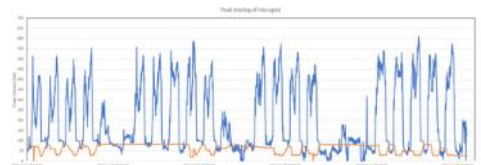
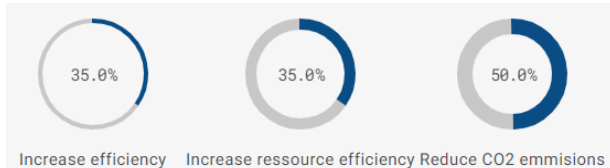
Objective: Separation of carboxylic acid products with recovery >90% and with purity > 95% in crude form, that can be further purified to 99.9%.

- Process designed and optimized at lab scale for both showcases
- Samples generated for industrial partners
- PowerPlatform is under construction, to be tested in 2022 & 2023, goal is a continuous process demo for >200 hrs.

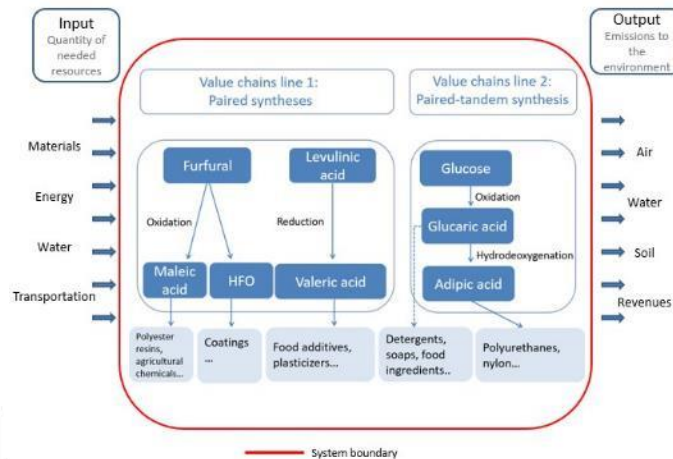


Process assessment

- Environmental Life Cycle Assessment; Costing; Impact analysis.
- Optimization and scale up the technology beyond Perform project
- Application testing of produced chemicals (samples produced and tested by partners)



D. Kolokotsa, Energy Storage, 2019



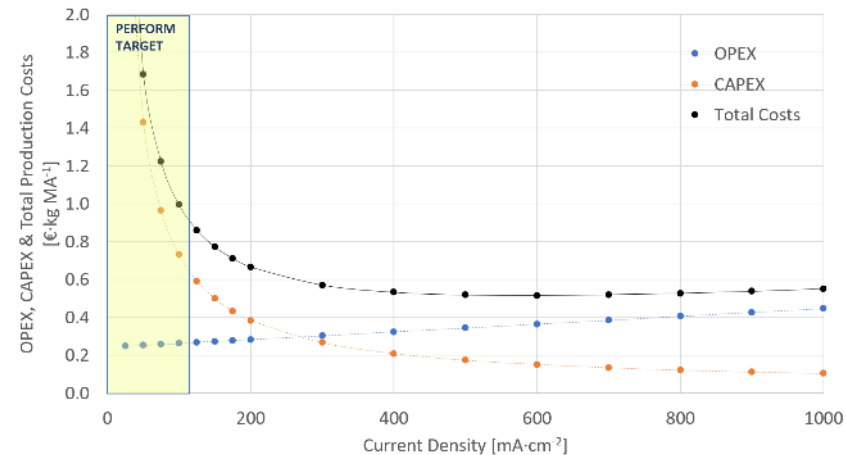
AVABIOCHEM



Business case analysis

Objectives:

- Provide continuously Techno-Economic Assessment (TEA) along the project to guide the development
- Final TEA and benchmarking after pilot tests & plant design
- Market assessment
- Average market price
 - VA 0.8-0.9 €/kg
 - MA 1.1-1.2 €/kg
 - AA 1.6-1.7 €/kg
- **Preliminary TEA shows potential for positive business case if target performance achieved!**



Progress summary and outlook

- Electrochemical conversion and integrated DSP demonstrated at lab scale
- Flexible Pilot Perform Platform (TRL5-6) designed, under construction to demonstrate electrochemical conversion on kg/day production scale:
 - For conversion of bio-based feedstocks to Maleic, Valeric, Glucaric and Adipic acids
 - Flexible electrochemical reactor stack with various electrode testing possibilities
 - Modular & Integrated DSP (Electrodialysis, nanofiltration, extraction & distillation, crystallization, ...)
 - Skid based, open access platform available for industry & research parties after the project





PERFORM- POWER PLATFORM



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Research institutes



Electrochemical
system &
catalyst experts



Reactor &
component
developers



System
integration &
piloting

Specialized companies



Sustainable
INNOVATIONS

Commercial
use,
exploitation, &
impact

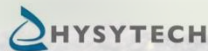
Industry



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