SMAR3TS

Staff Mobility to Action Resilient, Restorative, and Regenerative Transitions & Societies

Funded by
the European Union

I3X – Guiding Principles

SMAR3TS

- Innovate3X-Igniting Impactful Initiatives, or I3X, should aim to accelerate the understanding/scoping of a challenge (technological, market, societal etc), and the emergence/development of possible solutions. This can be interpreted as e.g. increased technological or societal readiness, once the I3X is completed.
- I3X should have a sufficient scale and scope (i.e. not being too narrowly-defined), and should require multi/cross/inter/trans disciplinary capabilities.
- I3X should align to the core concepts of SMAR3TS – Resilience, Restoration, Regeneration (either R or all Rs).
- I3X should align to (at least) one WP – WPs are the main coordination mechanism of the project, hence I3X should be connected to WPs.
- Any partner can initiate an I3X. Yet, shaping the I3X should be done collectively, and in collaboration with WP leader and SMAR3TS Team.
- At this stage, we are looking for initial I3X, which will be further defined during the Kick Off Meeting – and where engagement across the consortium will be assessed.
- Overall, it is expected that each I3X will lead and enable about 10 person-months of secondment, across the consortium (i.e. not only between the initiator of the I3X and possible contributors), possibly more.
- I3X will serve as guiding instruments for secondments, as well as for events (i.e. hackathons, workshops, showcase)

I3X – About the initiator

Name of Organization: LUT University
Research Group/Department: School of Energy Systems
Country: Finland

1. Background info

Short description of your organization:
LUT University, Lappeenranta campus, Finland.

Website: https://www.lut.fi/en

2. Research Group/Company Department

Short description: LUT's Sustainability Science – School of Energy Systems research group, together with expertise in thermochemical waste conversion, applies Life Cycle Assessment (LCA) to emerging hydrogen production routes, complementing LUT's existing LCA work on Power-to-X and biomass-based fuels with a waste-derived feedstock pathway.

Link to the website: https://www.lut.fi/en/about-lut/faculties/lut-school-energy-systems
Contact info: Professor Jouni Havukainen, LUT School of Energy Systems, Jouni.Havukainen@lut.fi

3. Expertise and available technologies within SMAR3TS project

1. ***Expertise*** *of your research group/department and available technologies:*

LUT's Sustainability Science – Sustainability of energy system research group, together with expertise in thermochemical waste conversion, applies Life Cycle Assessment (LCA) to emerging hydrogen production routes, complementing LUT's existing LCA work on Power-to-X and biomass-based fuels with a waste-derived feedstock pathway.

2. ***Current status*** *of available technologies (incl. TRL) / problematization/solution development (SRL) and expected TRL/SRL to reach:*

LCA tools, sustainability assessment tools and methods

3. *Examples of engagement in* ***Research, Development & Innovation (RDI) partnerships and industry partnerships:***
Engagement in several EU R&I projects (e.g., Compass - Comprehensive Offshore Management Platform for Assessing SuStainability, Butterfly - Biomass Utilized To The Extended portfolio of Renewable Fuels with Large Yields, Mussalo, Sunny - SUstaiNable eNergy sYstems for refugee and host communities in Africa) and nationally-funded projects: JustH2Transit - Climate neutral, justified and sustainable H2 transition, Hygcel - Hydrogen and Carbon Value Chains in Green Electrification.

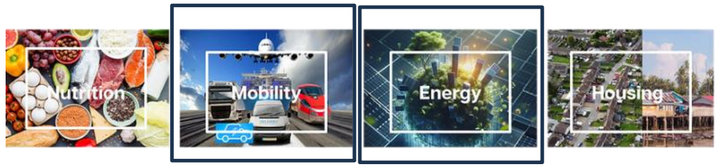
4. Examples of strategically relevant Innovate3X (I3X) Initiatives

Preliminary description of work that needs to be done, which will be further refined and shaped throughout the secondments:

I3X-17: Clean Hydrogen Production from Municipal Solid Waste
I3X-18: Life Cycle Assessment and Sustainability of Biomass-Based Renewable Fuels

I3X – Alignment to R3 and to WPs

SMAR3TS domains:



1) Specify here: *one or several SMAR3TS domains that are relevant to the work of your organization/research and innovation team.*

I3X-17 – **Energy** (energy systems, sustainability, P2X) and **Mobility** (sustainable fuel supply)
I3X-18 – **Energy** (energy systems)

2) Specify here: *alignment of the work of your organization/research and innovation team with one or several SMAR3TS focus areas on Resilience, Restoration, and Regeneration. Share examples.*

I3X-17: Life Cycle Assessment and Sustainability of Biomass-Based Renewable Fuels

- **Resilience**: Diversifying fuel supply with locally sourced biomass reduces dependence on imported fossil fuels and strengthens regional energy security.
- **Restoration and Regeneration:** Sustainable use of residues and waste streams for fuel production supports circular economy principles and can reduce net greenhouse gas emissions when feedstock sourcing is managed responsibly.

I3X-18: Clean Hydrogen Production from Municipal Solid Waste

- **Resilience**: Diversifying hydrogen production away from a single feedstock or technology route, using locally available waste streams that are not exposed to electricity price or import volatility, and reinforces accordingly resilience of energy systems.

- **Restoration and Regeneration:** Quantifying the benefit of valorising waste that would otherwise be landfilled or incinerated, supporting evidence-informed circular economy decisions and reduced landfill methane emissions.

I3X Description

Note: *there can be several Innovate3X (I3X) descriptions, just duplicate this template slide*

1) I3X-17: Life Cycle Assessment and Sustainability of Biomass-Based Renewable Fuels

1. Description of Current Stage

Specify here: *What is your research group/department currently working on? Which initiatives/projects are underway under I3X? How does this work contribute to resilience, restoration, and regeneration?*

LUT's Sustainability Science and Solutions – Energy Systems research groups combine life cycle modelling with expertise in biomass conversion technologies, including biogas upgrading (membrane separation, biomethanation), pyrolysis and gasification, and the sustainable use of solid biomass and waste-derived fuels for heat, power, and chemicals production.

R&I stages:

☒ Pilot / Proof of Concept – demo how waste and biomass are utilized to produce fuels and chemicals.

2. Necessary skills and capabilities, across disciplines:

Specify here: *What gaps or barriers need to be addressed to move forward? Which new skills, knowledge, expertise, interdisciplinary approaches or collaborations are required?*

- Life cycle assessment (LCA) methodology, particularly for bioenergy and biofuel systems
- Knowledge of biomass conversion technologies (gasification, pyrolysis, biogas upgrading)
- Feedstock and land-use sustainability assessment
- Techno-economic modelling of bioenergy value chains
- Comparative/benchmarking analysis across fuel pathways

3. Examples of challenges that need to be addressed

Specify here: *Please outline which challenges remain unresolved. You may answer in bullet points.*

- **Evaluate** the sustainability of different biomass feedstocks (forestry residues, agricultural residues, waste streams) used for fuel production in Finland.
- **Assess** the environmental performance of biogas upgrading routes, including hydrogen-based biomethanation, compared with conventional upgrading.
- **Compare** life cycle emissions of biomass-based fuels against fossil fuels and Power-to-X e-fuels on a consistent basis.
- **Identify** where biomass and e-fuel pathways are complementary versus competing for feedstock, land, or infrastructure.
- **Support** development of guidance for industry and policy on sustainable scale-up of biomass-based fuel production.

I3X Description

Note: *there can be several Innovate3X (I3X) descriptions, just duplicate this template slide*

1) I3X-18: Clean Hydrogen Production from Municipal Solid Waste

1. Description of Current Stage

Specify here: *What is your research group/department currently working on? Which initiatives/projects are underway under I3X? How does this work contribute to resilience, restoration, and regeneration?*

LUT's Sustainability Science and Solutions – Energy Systems research groups have expertise in thermochemical waste conversion, apply Life Cycle Assessment (LCA) to emerging hydrogen production routes, and complement LUT's existing LCA work on Power-to-X and biomass-based fuels with a waste-derived feedstock pathway.

R&I stages:

☒ Idea / Conceptualization

☒ Pilot / Proof of Concept

2. Necessary skills and capabilities, across disciplines:

Specify here: *What gaps or barriers need to be addressed to move forward? Which new skills, knowledge, expertise, interdisciplinary approaches or collaborations are required?*

- LCA methodology and software (e.g. SimaPro, openLCA, LCA for expert)
- Knowledge of thermochemical waste conversion (gasification, tar cracking) processes
- Waste characterisation and feedstock variability analysis
- Comparative LCA across hydrogen production routes (electrolysis, biomass, waste-derived)
- Techno-economic and environmental data analysis

3. Examples of challenges that need to be addressed

Specify here: *Please outline which challenges remain unresolved. You may answer in bullet points.*

- **Build** an LCA model of the MSW steam gasification and tar-cracking pathway, from waste collection through to purified hydrogen output.
- **Quantify** emissions and resource use associated with tar cracking and syngas cleaning, and their contribution to the overall footprint.
- **Compare** the environmental performance of waste-derived hydrogen against electrolysis-based (Power-to-X) and biomass-based hydrogen routes on a consistent functional-unit basis.
- **Assess** how MSW feedstock variability (composition, moisture, collection logistics) affects life cycle results and uncertainty.
- **Develop** impact pathways from the industrial process of diverting waste away from landfill or incineration, and their effect on the overall environmental balance.