SMAR3TS

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

Funded by
the European Union

# I3X – About the initiator

**Name of Organization**: University of Vaasa
**Research Group/Department**: Efficient Powertrain Solutions (EPS) / School of Technology and Innovations
**Country**: Finland

## 1. Background info

*Short description of your organization: The University of Vaasa is a leading Nordic university in energy technology, smart energy systems and sustainable business, located in one of Europe's strongest energy innovation clusters. UVA works closely with industry, cities, startups and policymakers to ensure that energy research becomes real-world solutions.* UVA combines expertise in energy transition, business renewal, and leadership of societal transformation. University of Vaasa combines expertise in energy transition, business renewal, and leadership of societal transformation. The university is part of EnergyVaasa - the largest energy technology hub in the Nordics. ***Website***: www.uwasa.fi

## 3. Expertise and available technologies within the SMAR3TS project

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

The Department of Efficient Powertrain Solutions (EPS) works on the interface between fundamental research and industry application with focus on domains that are strategically important for Finland's economy, that is the marine, non-road and stationary power generation sectors. The EPS research group is experienced in coordinated powertrain development. We do fuel analytics in our own fuel laboratory and engage in the development of new fuels and their interaction with the aftertreatment systems. Combustion modes for alternative fuels are explored with simulation and modelling tools to secure optimum performance with near zero emissions, by handling the calibration complexity dilemma efficiently. Models further allow co-optimizing the powertrain as a system utilizing coordinated emission-energy management strategies. Combustion and powertrain control is developed utilizing rapid prototyping directly linking the plant models with engine control unit via Hardware in the loop methodologies. Final concept validation is conducted in own cutting-edge testing facilities.

## 2. Research Group/Company Department

*Short description*: The research group supports the end-to-end process of powertrain development from fuel to energy and emission management while its research focuses on combustion engines.
*Link to the website*: https://www.uwasa.fi/en/research/groups-and-focus-areas/efficient-powertrain-solutions *Contact info*: Maciej Mikulski, Professor, maciej.mikulski@uwasa.fi

## 4. Examples of strategically relevant Innovate-3X Initiatives

*Provide a preliminary description of work that needs to be done, which will be further refined and shaped throughout the secondments.*

*Examples:*

1. **Optimising the regeneration processes in the pyrometallurgical industry.**
**Status**: Industrial and market validation needed.

2. **Reducing engine vibrations through the identification of governing excitations and enabling noise-based control**
**Status**: Toolchains and methods created. Benchmarking of the new methods in real-world operation scenarios is needed

3. **New insights into engine noise with fundamental studies on combustion-derived pulsating flow propagation**
**Status**: Engine exhaust and airpath noise covered. Correlations of combustion noise with fuel properties and different combustion modes remain unexplored

4. **Selective electrolysis for preparation of ammonia (SE-NOx to NH3) from nitrogen oxide (NOx) containing fluids**
**Status**: Concept validation in an industrial application is needed. Improving process efficiency is needed, particularly in engine applications.

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## 3. Expertise and available technologies within SMAR3TS project (continues)

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

Cutting-edge accelerated testing methodology, deeply integrating hardware and simulation (TRL 8). In house rapid combustion and aftertreatment prototyping models (over 7 unique predictive tools) (TRL5- 7); Scalable and automatically parameterised powertrain digital twins (TRL7); Ultra fast multi-input multi-output predictive combustion controllers for advanced fuel flexible operation (TRL 5); Reactivity controlled compression ignition technology (TRL7); Argon Power Cycle (TRL 3)

*Examples of engagement in* ***Research, Development & Innovation (RDI) partnerships and industry partnerships***

Business Finland (BF) financed the project “Flexible Clean Propulsion Technologies”, “ in collaboration with 9 companies. BF financed project iHAPC, collaboration with 5 companies.
JointLab established with Wärtsilä, University of Oulu and VTT Technical Research Centre of Finland, 2024. Engine technology and competence center in build-up with AGCO Power, 2025.

# 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.*

The suggested I3X are related to the domains of **energy** (renewables, hydrogen, storage and smart grids) and **mobility** (electric and hydrogen transport).

***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.*

*The suggested I3X support* ***restoration*** *and contributes to* ***regeneration****.*

*More specifically:*

***Resilience*** *– more secure, locally balanced and crisis-proof energy systems;*
***Restoration*** *– replacing fossil fuels with clean energy;*
***Regeneration*** *– creating circular, community-based and future-proof energy ecosystems.*

# Innovate-3X: Future fuels and integrated combustion concepts

***Note:*** *there can be several Innovate-3X descriptions, just duplicate this template slide*

## 1) Innovate-3X: Future fuels and integrated combustion concepts

### 1. Description of Current Stage

***Specify here:*** *What is your research group/department currently working on? Which initiatives/projects are underway under Innovate-3X? How does this work contribute to resilience, restoration, and regeneration?*

*Several technologies are developed simultaneously. Mainstream directions are:*

- *Development of Reactivity Controlled Compression Ignition (RCCI) technology to facilitate full fuel flexibility between LNG/H2 and Ammonia; Multi-fuel capability is the key feature that will secure resilience of next-generation energy systems.*
- *Extrapolating combustion power plants into a complete energy balancing system with zero emission and zero resource consumption. This is done via advanced closed-loop combustion concepts utilizing complete recirculation of combustion products into valorised energy streams – supports all aspects from resilience to regeneration.*

### 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?*

- New Skills in system level analysis involving cross-domain modeling (electro-thermal, electro-hydraulic etc.)
- Deep expertise in NVH phenomena, needs to be cross-coupled with powertrain development methods
- Infrastructural development towards other energy system components (electrolyzers, fuel cells, gas compression and liquification, heat recovery and related domain expertise)

### 3. Examples of challenges that need to be addressed

***Specify here:*** *Please outline which challenges remain unresolved. You may answer in bullet points.*
Challenges can be related e.g., to market and business model, technology adoption, sustainability assessment, regulation, policy, technologies, data availability, methods & analysis, technical or methodological gaps, ecosystem building or community development, societal & cultural acceptance of innovations, impact, etc.

***Examples of questions that can help you clarify the challenges:***

- Technological – handling thermal loading and oil-induced pre-ignition of zero-carbon fuels; handling impurity removal from closed-loop combustion systems
- *Control development – handling transient events in reactivity-controlled combustion, handling control complexity with variable valve actuation*
- *Energy stream valorisation – from all energy system components*
- *Methodological gaps in acoustics not fitting modern development methods and hard to unify into a coordinated development framework with energy and emission aspects*
- *Legislation – extremely difficult processes of approving hydrogen-operated systems on laboratory and in real-world scenarios*

# Innovate-3X: Building Resilient Hydrogen Energy Ecosystems for Europe's Regions

***Note:*** *there can be several Innovate-3X descriptions, just duplicate this template slide*

## 2) Innovate-3X: Building Resilient, Hydrogen Energy Ecosystems for Europe's Regions

### 1. Description of Current Stage

***Specify here:*** *What is your research group/department currently working on? Which initiatives/projects are underway under Innovate-3X? How does this work contribute to resilience, restoration, and regeneration?*

SMAR3TS partner **University of Vaasa (UVA), Finland,** is working to enable **Europe's regions, industries and communities** to move toward **secure, climate-neutral and affordable energy ecosystems**.

Across Europe, energy systems are under increasing pressure from **climate change, geopolitical instability, rising demand and ageing infrastructure**. At the same time, **renewables, hydrogen and digital technologies** offer powerful new ways to create **clean, flexible and locally controlled energy** — but these opportunities are not yet connected into **coherent, workable ecosystems**.

This I3X Challenge focuses on **turning emerging energy technologies into real, functioning regional energy solutions** that can be used by **cities, ports, industrial parks and energy communities**.
The goal is to move from **fragmented pilots** (solar here, hydrogen there, batteries somewhere else) to **integrated, resilient energy ecosystems** that deliver: reliable electricity, clean fuels, local value creation and climate-neutral growth.
The **Innovate3X (I3X)** invites innovators, researchers and practitioners to work together through **funded secondments** to **design, test and scale these next-generation energy ecosystems**.

### 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?*

This I3X brings together researchers and innovators who can connect **technology, markets, and innovation practices for the energy sector.**

**To develop solutions, research and innovation talent should be knowledgeable of one or several areas, e.g.:**

- Renewable energy and smart grid
- Hydrogen and clean fuel
- Digital and data-driven energy innovations
- Business model and investments
- Energy policy and regulation
- Community and stakeholder engagement

### 3. Examples of challenges that need to be addressed

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

**Participants may work on challenges such as:**

- Designing **energy systems for regions, ports, cities or industrial parks** that use renewables and hydrogen together
- Reducing **energy costs and risks** through better local energy solutions
- Creating **business models** for energy communities and clean-energy hubs
- Using **digital tools** to manage energy supply and demand
- Increasing **public acceptance** of new energy infrastructure
- Enabling **policy and investment decisions** for clean energy systems