RESILIENCE

Some facts about **RESILIENCE**:

- **Focus:** Electrified, microwave-assisted valorisation of **CO_2 and CH_4** via **e-DRM** (dry reforming) and **e-NOCM** (non-oxidative methane conversion).
- **Approach:** Development of **microwave-compatible catalysts** (e.g., hierarchical porous carbons and Ni on ceria-doped mesoporous supports) alongside **microwave reactor design**, process optimisation, and **LCA/LCC**.
- **Targets:** Improve performance (**~+20% selectivity, ~+30% yield**) while reducing **reactor heating energy demand by ~40%**.

RESILIENCE Consortium

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Process intensification of Carbon dioxide and methane valorization by microwave heating

The chemical industry is a major global emitter, and the EU’s 2030 climate target requires rapid decarbonisation through electrification powered by low-carbon electricity.

RESILIENCE addresses this need by developing microwave-based electrification for two highly endothermic industrial reactions: dry reforming of methane (e-DRM) and non-oxidative methane conversion (e-NOCM), enabling the valorisation of CO_2 and CH_4. The project combines catalyst synthesis and characterisation with the design and construction of microwave-heated reactors, process optimisation, and life-cycle and cost assessments.

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Background

The chemical industry is economically vital but a major GHG emitter, and decarbonisation requires a shift toward **electrified chemical processing** powered by low-carbon electricity. Microwave heating is highlighted as a promising route because it can deliver **direct, rapid and potentially selective heating** of catalysts, but it demands dielectric-aware materials and reactor designs, especially for scale-up. These needs are acute for endothermic CO_2/CH_4 conversion routes such as **DRM**, where high temperatures and **coking/sintering** still limit catalyst stability.

Objectives

1. **Hierarchical Porous Carbons (HPCs) for the microwave-heated e-NOCM**
   Ice/silica templating will yield hierarchical carbon monoliths, while MOF-derived N-doped single-site TM carbons boosting conductivity.
2. **Ni loaded Ceria doped alumina for microwaves heated e- DRM process**
   Development of ceria-doped alumina or mesoporous silica supports via EISA (Pluronic templates) and introducing Ni either in situ or post-synthesis.
3. **Design and implement microwave heated reactors for e-NOCM and e-DR**
   To increase the selectivity of the studied reactions by 20% and the yield by 30%, via optimization of both reactors and catalysts.
4. **To evaluate the energy efficiency of the developed electrified processes**
   The project targets a 40% reduction in reactor heating energy consumption for both reactions.

Impact

- Climate impact: Enables valorisation of CO_2 and CH_4 into useful products, supporting net GHG reduction pathways beyond abatement.
- Electrification impact: Demonstrates a practical route to electrified, renewable-powered chemical processing via microwave heating.
- Energy efficiency: Targets ~40% lower reactor heating energy demand, reducing thermal losses and improving overall process efficiency.
- Process intensification: Aims for ~+20% selectivity and ~+30% yield, reducing by-products and downstream separation burden.
- Industrial relevance: Addresses two highly endothermic, industrially encountered reactions (e-DRM and e-NOCM) with scalable reactor concepts.
- Technology impact: Delivers microwave-compatible catalysts (HPCs, single-atom/N-doped carbons, Ni on ceria-doped mesoporous supports) and microwave reactor designs tailored for stability and performance.
- Economic impact: Potential for lower operating cost through improved energy use; supports future modular deployment and flexible operation (fast start/stop).
- Decision-ready sustainability: Provides LCA/LCC evidence to quantify environmental and cost trade-offs and guide scale-up priorities.

Grant information

- **Grant ID**: 26272
- **Decision of the HFRI Director**: Ref. No. 113394/04-10-2025
- **Start date**: 03 November 2025
- **Duration**: 36 months (until 02 November 2028)

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