Topics in the call 2023

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Clean Hydrogen Partnership

Topics in the call 2023

Renewable Hydrogen Production

Renewable Hydrogen Production Overview

Main Focus

- Cost reduction and efficiency increase for renewable hydrogen production routes:
  - Going low in TRL for LT & HT electrolyser concepts
  - Ringfencing support to AEL
  - Revisiting PEC & PC devices

What is new

- Waste to H_2
- Valorising O_2 and heat from electrolysis

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Renewable Hydrogen Overview

Topic	Type of Action	Ind. Budg (M€)
HORIZON-JTI-CLEANH2-2023-**01-01**: Innovative electrolysis cells for hydrogen production	RIA	2 x 3
HORIZON-JTI-CLEANH2-2023-**01-02**: Innovative Solid Oxide electrolysis cells for intermediate temperature hydrogen production	RIA	3
HORIZON-JTI-CLEANH2-2023-**01-03**: Advances in alkaline electrolysis technology	RIA	2.5
HORIZON-JTI-CLEANH2-2023-**01-04**: Photoelectrochemical (PEC) and/or Photocatalytic (PC) production of hydrogen	RIA	2.5
HORIZON-JTI-CLEANH2-2023-**01-05**: Waste to Hydrogen demonstration plant	IA	10
HORIZON-JTI-CLEANH2-2023-**01-06**: Valorisation of by-product O2 and/or heat from electrolysis	IA	10
HORIZON-JTI-CLEANH2-2023-**01-07**: Hydrogen use by an industrial cluster via a local pipeline network	IA	15

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Renewable Hydrogen - Topics

HORIZON-JTI-CLEANH2-2023-01-01: Innovative electrolysis cells for hydrogen production

Thinking outside the box for disruptive components and cell concepts in LT electrolysers (TRL 2 → 4)

- Improve efficiency (<48kWh/kg) and life time, reduce CRMs
- Innovative cells using multi disciplinary approach: material science, nano-engineering, bio-hybrid catalysts
- Diaphragms, membranes/membrane-less electrolysers that can operate down to 5% of nominal load @ < 0.4% H_2 in O_2
- 8 potential innovations listed, more than one to be explored

HORIZON-JTI-CLEANH2-2023-01-02: Innovative Solid Oxide electrolysis cells for intermediate temperature hydrogen production

550- 700ºC aiming for dynamic operation of SOEL (TRL 2 → 4)

- Hot start up in 4min, cold start-up in 6h; current density of 1.2A/cm^2
- New cell & stack designs replacing costly ceramics, reducing CRMs; CFD & multi-physics modelling
- 5 cells of > 25cm^2; > 1,000h

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Renewable Hydrogen - Topics

HORIZON-JTI-CLEANH2-2023-01-03: Advances in alkaline electrolysis technology

Improvements in performance, reduction in cost from materials to BoP components, control, systems (TRL 3 → 5)

- Improve at least one KPI, maintaining the others at present levels
    1. Current density > 1.2 A/cm^2 @ <2V per cell; efficiency increase <48 kWh/kg @ <2V
    2. CAPEX < 150€/kW; OPEX< 35€/(kg/d)/y
    3. Deg <0.1%/1,000h
    4. Avoid PGMs and other CRMs

HORIZON-JTI-CLEANH2-2023-01-04: Photoelectrochemical (PEC) and/or Photocatalytic (PC) production of hydrogen

Prove the potential of PEC&PC to cheap H2 in centralised/decetralised systems (TRL 2/3 → 5)

- Single component for solar harvesting and catalytic reaction – no PV cells and electrolyser cells connection
- PEC: 15% solar / PC 5% to H_2 conversion eff @ >500 cm^2
- Demo for 500h with stable STH efficiencies

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Renewable Hydrogen - Topics

HORIZON-JTI-CLEANH2-2023-01-05: Waste to Hydrogen demonstration plant

Develop a pilot plant to demonstrate waste to H2 conversion (TRL 5 → 7)

- Wastes without any recycling potential – mainly organic; range of moisture (<50%) and calorific value (2-5kWh/kg)
- various conversion techs are possible
- 3MW reactor; 4,000h/a operation; 180,000kg/a @ location with H_2 end user
- Funding plan to be provided

HORIZON-JTI-CLEANH2-2023-01-06: Valorisation of by-product O2 and/or heat from electrolysis

Utilise O2 and heat in non-energy intensive industries (TRL 7 → 8)

- Innovative EL; BoP integration with industrial process
- Optimal & dynamic operation to balance H_2, O_2 and heat demand – impact on durability
- 15MW, 1 year, 4,000h operation
- Go-no go decision; detailed funding plan

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Renewable Hydrogen - Topics

HORIZON-JTI-CLEANH2-2023-01-07: Hydrogen use by an industrial cluster via a local pipeline network

Install a large electrolyser and a new or repurposed 100% hydrogen pipeline network to fully or partially decarbonise at least two industrial processes of a single industrial zone (TRL → 8)

- Demonstrate operation of a number of processes from a small H2 pipeline
- Electrolyser > 10MW, pipeline of sufficient capacity
- Pipeline: capital investment 1 M€ /km, transmission pressure 100 bar, H2 leakage 0%
- Synergies with existing projects of the Horizon Europe Process4Planet or Clean Steel partnerships are encouraged – Funding plan

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Topics in the call 2023

Hydrogen Storage and Distribution

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Hydrogen Storage and Distribution Overview

Main Focus

Hydrogen Storage

- Scaling up underground storage for both salt caverns and depleted gas fields
- Next generation on-shore liquid hydrogen storage.

Hydrogen Distribution

- Facilitating the re-purposing of steel pipelines to transport hydrogen
- High pressure supply chain for gaseous hydrogen transport

What is new

- Liquid Hydrogen Refuelling Stations

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Hydrogen Storage and Distribution Overview

Topic	Type of Action	Ind. Budget (M€)
HORIZON-JTI-CLEANH2-2023-**02-01**: Large-scale demonstration of underground hydrogen storage	IA	1 x 20
HORIZON-JTI-CLEANH2-2023-**02-02**: Pre-Normative Research about the compatibility of transmission gas grid steels with hydrogen and development of mitigation techniques	RIA	1 x 4
HORIZON-JTI-CLEANH2-2023-**02-03**: Novel insulation concepts for LH2 storage tanks	RIA	1 x 2
HORIZON-JTI-CLEANH2-2023-**02-04**: Demonstration of high pressure (500-700 bar) supply chain	IA	1 x 5
HORIZON-JTI-CLEANH2-2023-**02-05**: Demonstration of LH2 HRS for Heavy Duty applications	IA	1 x 5

Hydrogen Storage- Topics

HORIZON-JTI-CLEANH2-2023-02-01: Large-scale demonstration of underground hydrogen storage

Hydrogen underground storage in salt caverns or depleted gas fields

- Demonstration in an underground storage facility that has potential of at least 1,000 tonnes H2
- For caverns: At least 100 injection & withdrawal cycles at various pressures/volumes.
- For gas field: At least 1 injection & withdrawal cycle
- Evaluate the performance integrity, environmental impact and safety of the hydrogen storage.
- Qualify the purity of the recovered hydrogen and ensure T&D from/to storage site

HORIZON-JTI-CLEANH2-2023-02-03: Novel insulation concepts for LH2 storage tanks

Novel insulation to enable the safe, cost and energy efficient storage of large quantities of LH2

- Concept definition, material selection and integrity evaluation.
- Concept should be scalable to similar LNG tanks for on-shore storage and shipping
- Testing at laboratory scale to evaluate the viability of the concept at relevant conditions
- Concept design and cost estimation targeting onshore containment tank CAPEX of 70€/kg in 2024

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Hydrogen Distribution- Topics

HORIZON-JTI-CLEANH2-2023-02-02: Pre-Normative Research about the compatibility of transmission gas grid steels with hydrogen and development of mitigation techniques

Facilitating the re-purposing of the natural gas grid to 100% H2

- Gap analysis & proposal for a testing approach covering the most representative EU steel grades.
- Deliver harmonised testing protocols and test them confirming that results are comparable between different laboratories
- Deliver to standardisation bodies a matrix of gas grid steel behaviour in the presence of hydrogen across various network conditions
- Investigate and propose mitigation techniques to limit hydrogen uptake and embrittlement.

HORIZON-JTI-CLEANH2-2023-02-04: Demonstration of high pressure (500-700 bar) supply chain

Demonstration of the entire high-pressure concept from the filling centre to trailers and finally the HRS

- Demonstrate a complete logistic scheme with a distribution radius at relevant scale
- It should demonstrate the distribution capability to two HRSs minimum;
- It should encompass an innovative compressor capable of filling trailers at pressures of 500 to 700 bar enabling trailer payloads of 1,000 to 1,500 kg
- A techno-economic assessment should be included, demonstrating the economies of scale due to the high-pressure

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Hydrogen Distribution- Topics

HORIZON-JTI-CLEANH2-2023-02-05: Demonstration of LH2 HRS for Heavy Duty applications

Development, construction and operation of a liquid hydrogen refuelling station with a flowrate of at least 5 tonnes per hour

- Development of a demonstrator with proven scalability in railroad, aircraft or maritime applications
- Development of a model to forecast boil-off gas generation during operations
- Techno-economic analysis of the performance of these systems including energy consumption (in kWh/kgH2), CAPEX, OPEX;
- Development of a metrology system or methodology for measuring or evaluating the quality and quantity of delivered hydrogen (Potential synergies with EURAMET to be explored)
- Development of operations protocols, including for fuelling, venting or flaring, stand-by and emergency;
- Explore potential synergies with the topic HORIZON-CL5-2023-D5-01-07: ‘Hydrogen-powered aviation’ and with the activities of ZEWT partnership.

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Topics in the call 2023

HYDROGEN END USES: TRANSPORT APPLICATIONS

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Hydrogen End Uses: Transport Applications Overview

Main Focus

- Aviation, maritime and non road applications;
- Adaptation of fuel cells and stacks to the specific needs of non-road applications;
- Increased power, lifetime and modularity;

What is new

- Development of dedicated fuel cells systems for non-road mobile machinery;
- Large power at stack level for maritime applications;
- Clean Aviation JU cooperation/synergies;

Transport Applications Overview

Topic	Type of Action	Ind. Budget (M€)
HORIZON-JTI-CLEANH2-2023-03-01: Real environment demonstration of Non-Road Mobile Machinery (NRMM)	IA	5 x 2
HORIZON-JTI-CLEANH2-2023-03-02: Development of a large fuel cell stack for maritime applications	RIA	7.5
HORIZON-JTI-CLEANH2-2023-03-03: Ultra-low NOx combustion system for aviation	RIA	8

Transport Applications- Topics

HORIZON-JTI-CLEANH2-2023-03-01: Real environment demonstration of Non-Road Mobile Machinery (NRMM)

New design for optimal integration of FC systems

- Develop and demonstrate FC propelled machinery;
- Sectors considered: construction & mining and/or agricultural & farming;
- NRMM performance to be the same of diesel engine and demonstrate resilience to dust, humidity, shocks and vibrations;
- FC CAPEX < 800 €/kW, Availability 80% by the project end;

HORIZON-JTI-CLEANH2-2023-03-02: Development of a large fuel cell stack for maritime applications

Focus on higher power and lifetime

- PEM or SO technologies to be addressed;
- To be achieved: PEM power range 250-500 kW and SO 100-250 kW – at stack level ;
- On-line diagnostic and prognostics to ensure 40.000 h of lifetime;
- At least 2.000 hours of testing to demonstrate resilience to maritime specific conditions;

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Transport Applications- Topics

HORIZON-JTI-CLEANH2-2023-03-03: Ultra-low NOx combustion system for aviation

Development of ultra-low NOx combustion technologies

- Direct burn hydrogen combustion with low NOx;
  - Innovative fuel injection system;
  - Demonstration of the low NOx technology (NOx reduction of at least 30% compared to state-of-the-art reference engine);
  - Reliable and safe operation across all operating ranges;

- Cooperation with the Clean Aviation JU;

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Topics in the call 2023

Hydrogen end uses: Clean Heat & Power

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Hydrogen end uses: Clean heat & power Overview

Main Focus

- Next generation fuel cells for stationary applications able to run under 100% H_2 and other H_2-rich fuels - Reducing CAPEX and TCO
- Combustion of H_2 in retrofitted Gas Turbines

What is new

- Fundamental research on combustion of unconventional H_2 blends
- Demonstration activities on the retrofitting of burners and furnaces so that they are able to run up to 100% H_2

Clean Heat & Power - Overview

Topic		Type of Action	Ind. Budget (M€)
Fuel Cells	HORIZON-JTI-CLEANH2-2023-**04-01**: Development and validation of high power and impurity tolerant fuel cell systems ready to run on industrial quality dry hydrogen	RIA	4
Gas turbines, boilers and burners	HORIZON-JTI-CLEANH2-2023-**04-02**: Research on fundamental combustion physics, flame velocity and structure, pathways of emissions formation for hydrogen and variable blends of hydrogen, including ammonia	RIA	3
	HORIZON-JTI-CLEANH2-2023-**04-03**: Retrofitting of existing industrial sector natural gas turbomachinery cogeneration systems for hydrogen combustion	IA	6
	HORIZON-JTI-CLEANH2-2023-**04-04**: Hydrogen for heat production for hard-to-abate industries (e.g. retrofitted burners, furnaces)	IA	6

Clean Heat & Power - Overview

HORIZON-JTI-CLEANH2-2023-04-01: Development and validation of high power and impurity tolerant fuel cell systems ready to run on industrial quality dry hydrogen

Efficient and reliable high power output systems operating on industrial quality hydrogen (TRL 3 → 5)

- Renewable hydrogen fueled fuel cell system: ≥100 kW, operation with industrial quality dry hydrogen (95% pure), customised for various applications, modular design, impurity tolerant, >5,000 hours validation (cold ironing of ships and ground power supply in ports are potential use cases)
- Electrical efficiency of the system 52%, 98% availability, CAPEX 2,000 €/kWe (100 MWe/annum production volume)

HORIZON-JTI-CLEANH2-2023-04-02: Research on fundamental combustion physics, flame velocity and structure, pathways of emissions formation for hydrogen and variable blends of hydrogen, including ammonia

Fundamental knowledge about unconventional hydrogen blends combustion in Dry Low Emission (DLE) gas turbines (TRL 2 → 4)

- Gaining insights of unconventional hydrogen blends combustion (like $NH_3/H_2/N_2$ blends)
- Assessment of the technological feasibility, safety, and risk of using new blends in DLE gas turbines for power generation and transport applications, including environmental, social, and economic risk/benefit balance
- Preparing gas turbines to run on 100% hydrogen, maintaining low NO_x and N_2O emissions, while enhancing gas turbine ability to handle hydrogen content fluctuations (>±15% H2/min)

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Clean Heat & Power - Overview

HORIZON-JTI-CLEANH2-2023-04-03: Retrofitting of existing industrial sector natural gas turbomachinery cogeneration systems for hydrogen combustion

Decarbonizing power generation from gas turbines → GT able to burn up to 100% H_2 (TRL 5 → 7)

- Enhancement of gas turbine flexibility, H_2 content in gas turbine fuel in the range 0 – 100%vol, H_2 fuel content during the start-up phase up to 100% vol, etc.
- Targeted gas turbine size for cogeneration applications is at least 10 MW_e, 60 (not continuous) fired hours
- Field test, safety plan, sustainability and circularity, legislative barriers, synergies

HORIZON-JTI-CLEANH2-2023-04-04: Hydrogen for heat production for hard-to-abate industries (e.g. retrofitted burners, furnaces)

Towards 100% hydrogen-fired industrial burners and furnaces to provide high temperature heat (TRL 5 → 7)

- Develop and validate an integrated hydrogen burner system within heating furnaces in energy intensive industrial applications; focus on flame monitoring, buoyancy effects, flame stability & flashback, emissions, odorants, colourants
- 100% fossil fuel substitution, NO_x emissions < legislation, maintain the quality of the final products
- Demo: period >6 months, operating for at least 100h at 100% H_2, furnace thermal output >1 MW_{th}
- Field test, safety plan, sustainability and circularity, synergies

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Topics in the call 2023

Cross-cutting Issues

Alberto Garcia Hombrados

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Cross-cutting Issues Overview

Main Focus

- Raising the environmental sustainability of FCH systems by developing rules on how to measure the life cycle environmental performance of several FCH products categories
- Underpinning the build of a highly skilled workforce in FCH technologies and applications
- Assessing the potential effects of a hydrogen economy on the climate

What is new

- Development of Product Environmental Footprint Category Rules for several FCH Products
- Establishment of a large alliance of universities, educational institutions, and schools
- Assessment of the number, sources, release rates, etc. of hydrogen releases expected from the hydrogen value chain

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Cross-cutting Issues Overview

Topic	Type of Action	Ind. Budget (M€)
HORIZON-JTI-CLEANH2-2023-05-01: Product environmental footprint pilot for a set of FCH product categories	CSA	1.5
HORIZON-JTI-CLEANH2-2023-05-02: European hydrogen academy	CSA	3
HORIZON-JTI-CLEANH2-2023-05-03: Pre-Normative Research on the determination of hydrogen releases from the hydrogen value chain	RIA	3

Cross-cutting Issues - Topics

HORIZON-JTI-CLEANH2-2023-05-01: Product environmental footprint pilot for a set of FCH product categories

Development of Product Environmental Footprint Category Rules (PEFCRs) for several FCH product categories

- PEFCRs for ≥ 3 FCH product categories, ≥ 3 case studies within each category (≥ 9 case studies in total).
- ≥ 1 product category on H_2 production, ≥ 1 product category on H_2 end-uses, ≥ 1 product category on another step of the H_2 chain.
- Build on lessons learned from similar activities with other tech., involve stakeholders, and provide datasets (LCI) into the "Hydrogen Node" of the Life-Cycle Data Network (LCDN) managed by the JRC.

HORIZON-JTI-CLEANH2-2023-05-02: European hydrogen academy

Setup a large alliance of universities, educational institutions, and schools

- Network capable to provide certified educational training, update the teaching materials, and supply the education/ training needed in the different educational levels (focus on "formal" education, from school education to higher education).
- Collect, revise, organize, translate, and develop content and training activities on FCH tech. at all education levels, and assess the coverage of FCH education/ training at EU and MS level, identify missing building blocks, obstacles/ barriers, etc.
- Provide free (digital) access through an online portal, create ≥ 10 high-quality free-access books, a repository/ reference library of materials, school-level workbooks, network of training laboratories, digital tools, develop novel approaches for creating learning materials/ online activities on FCH tech., etc.
- Strong cooperation with the ERASMUS+ project GreenSkills4H2, links/ synergies with existing platforms/projects.

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Cross-cutting Issues - Topics

HORIZON-JTI-CLEANH2-2023-05-03: Pre-Normative Research on the determination of hydrogen releases from the hydrogen value chain

Further understanding of the (human-made) hydrogen releases expected from the hydrogen value chain

- Identify, quantify, and prepare an inventory of the types of H_2 releases along the H_2 chain in 2030 and 2050.
- Identify the most critical elements along the H_2 chain links regarding potential H_2 releases.
- Develop and validate methodologies and test methods/ protocols to gather data on H_2 releases from the critical elements.
- Develop simulation tools to quantify and characterize the (total) potential H_2 releases from the whole H_2 chain considering different scenarios of deployment/ integration in the energy mix.
- Identify mitigation measures, engineering solutions, technologies, R&I actions to minimize the releases.
- Provide recommendations to support the development of EU/ international standards.
- Strong cooperation with the project resulting from the Horizon Europe Work Programme 2023-2024 Cluster 5, HORIZON-CL5-2023-D1-01-03: Climate impacts of a hydrogen economy, links/ synergies with EU and International entities and institutions on climate, atmospheric and meteorological expertise, and metrology.

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Clean Hydrogen Partnership

Topics in the call 2023

Hydrogen Valleys

EUROPEAN PARTNERSHIP

Hydrogen Valleys

Main Focus

- Demonstrate large and small-scale hydrogen valleys that can be sustained and grow with time and replicated elsewhere
- Hydrogen as an enabler for sector coupling and integration of renewable energy
- Covers the complete value chain of hydrogen
- Contribute to EU competitiveness by supporting a European value chain

What is new

- Increased focus on innovation at system level
- Topics less prescriptive on the volumes of hydrogen allocated to each sector and application (up-to applic

Hydrogen Valleys

Topic	Type of Action	Ind. Budget (M€)
HORIZON-JTI-CLEANH2-2023-**06-01**: Hydrogen Valleys (large-scale)	IA	1 x 20
HORIZON-JTI-CLEANH2-2023-**06-02**: Hydrogen Valleys (small-scale)	IA	2 x 9

Evidences of commitment: to be submitted in the system as an annex of the proposal

Hydrogen Valleys- Topics

HORIZON-JTI-CLEANH2-2023-06-01: Hydrogen Valleys (large-scale)

Develop and demonstrate a large-scale Hydrogen Valley with innovative approaches at system level

- Production of ≥ 4,000 tonnes of renewable H2 per year using new hydrogen production capacity (GOs)
- ≥ 2 hydrogen applications from ≥ 2 sectors (energy, industry, transport)
- Costs of renewable energy plants (e.g. PV or wind plant) or related costs for operation of the Hydrogen Valley (e.g. electricity for electrolyser) are not eligible for funding

HORIZON-JTI-CLEANH2-2023-06-02: Hydrogen Valleys (small)

Develop and demonstrate a large-scale Hydrogen Valley with innovative approaches at system level

- Production of ≥ 500 tonnes of renewable H2 per year using new hydrogen production capacity (GOs)
- Supply more than one end sector or application (mobility, industry energy)
- Costs of renewable energy plants (e.g. PV or wind plant) or related costs for operation of the Hydrogen Valley (e.g. electricity for electrolyser) are not eligible for funding

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Hydrogen Valleys- Topics

Common elements applicable to Hydrogen Valley Topics

- Present the **Hydrogen Valley beyond the investments/actions** to be **supported directly** by the topic
- Contain clear **calendar with key phases of the implementation** of the action, ≥ 2 years of operations
- Demonstrate the **replicability and scalability** of the concept -> facilitate deployments of Hydrogen Valleys in other locations in Europe
- Develop a **long-term vision** on how the Hydrogen Valley developed is expected to grow
- Demonstrate **collaboration & synergies with other Hydrogen Valleys (**e.g supported by the JU)
- Provide a **funding plan** to ensure implementation of the project in synergies with other sources of funding + a **commitment from partners to provide own funding** (when relevant)
- **Evidence of the commitment** and role of public authorities (Member States, Regions and Cities) and of any other necessary stakeholders to implement the Hydrogen Valley
- **Professional communication activities** to reach to local citizens and increase public engagement of hydrogen ecosystems

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Topics in the call 2023

Strategic Research Challenges

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Strategic Research Challenges Overview

Main Focus

- Generate continuous innovation and long-term knowledge on early-stage research:
  - Multidisciplinary investigations, gathering the expertise across the EU research community
  - Covering most relevant research challenges identified in the SRIA
  - Development of multi-functional materials for hydrogen storage tanks
  - Understanding degradation mechanism and improve the stability of electrolysers

What is new

- Addressing sustainability and circularity
- Public annual progress reports

Strategic Research Challenges Topics overview

Topic	Type of Action	Ind. Budget (M€)
HORIZON-JTI-CLEANH2-2023-**07-01:** Advanced materials for hydrogen storage tanks	RIA	10
HORIZON-JTI-CLEANH2-2023-**07-02**: Increasing the lifetime of electrolyser stacks	RIA	10

Strategic Research Challenges Topics

HORIZON-JTI-CLEANH2-2022-07-01: Advanced materials for hydrogen storage tanks

Early-stage research (TRL 2 - 4) on materials for hydrogen storage in tanks for static storage and mobility applications

- Increase the storage size, gravimetric capacity, operating pressure, lifetime, safety and reduce in capital cost in line with SRIA KPIs
- Hydrogen storage as high-pressure gas, liquid and cryo-compressed, while materials as hydrogen carriers are out of the scope
- 4 tanks (TRL-4): aboveground (>300kg H_2), road transport (>150kg H_2) and onboard (heavy-duty (>40kg H_2) and aviation (>100kg H_2))
- Sustainable, high-performance materials enabling recyclability and circular design

HORIZON-JTI-CLEANH2-2022-07-02: Increasing the lifetime of electrolyser stacks

Early-stage research (TRL 2 – 4/5) on improving electrolysers stability over long-time operation

- Understanding of the degradation mechanisms of electrolyser (alkaline, PEM, SO, AEM, PCC) at stack level in line with SRIA KPIs
- Durability tests >10,000 hours (extrapolation to >40,000 hours) without compromising the performance
- Collaboration with JRC for developing harmonised testing protocols