Inputs to CERN Environmental Report 2023-24

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IPT/KT

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Reminder:

Inputs to CERN Environmental Report 2021-22

Highlight 1: CERN/KT preliminary strategy on Environmental Applications defined in 2021

RENEWABLE AND LOW-CARBON ENERGY

Production
Transformation
Distribution
Storage

CLEAN TRANSPORTATION AND FUTURE MOBILITY

Aviation
Shipping
Rail
Automotive

CERN KNOWHOW

Superconductivity
High Field Magnets
High Vacuum
Cryogenics
Materials
Artificial Intelligence
Advanced Sensors
Rad-Tol Systems
Thermal Control
Radioprotection
...

SUSTAINABILITY AND GREEN SCIENCE

Power Management
Heat Management
Industrial Processes

CLIMATE CHANGE AND POLLUTION CONTROL

Monitoring
Modelling
Mitigation

Highlight 2: examples of projects signed in 2021-22 and under implementation in the 4 areas of focus

RENEWABLE AND LOW-CARBON ENERGY

Helping a company in Spain (Applus+) to develop cryogenic testing facilities to support the development of systems for green hydrogen storage and transportation

CLEAN TRANSPORTATION AND FUTURE MOBILITY

Supporting civil aviation (Airbus) to assess the feasibility and interest of using superconducting power distribution systems in future electric/hybrid airplanes

CLIMATE CHANGE AND POLLUTION CONTROL

Collaborating with the European Space Agency (ESA) to develop Artificial Intelligence algorithms to analyse Earth Observation images for climate monitoring

SUSTAINABILITY AND GREEN SCIENCE

Partnering with industry (ABB) to improve energy efficiency of CERN cooling and ventilation infrastructure by up to 15% using smart sensors and digital twins

Report 2021-22

Highlight 3: CIPEA (CERN Innovation Programme on Environmental Applications) launch and results in 2022

In March 2022, CERN launched the CIPEA programme to encourage CERN experts to come up with new ideas for environmental applications.
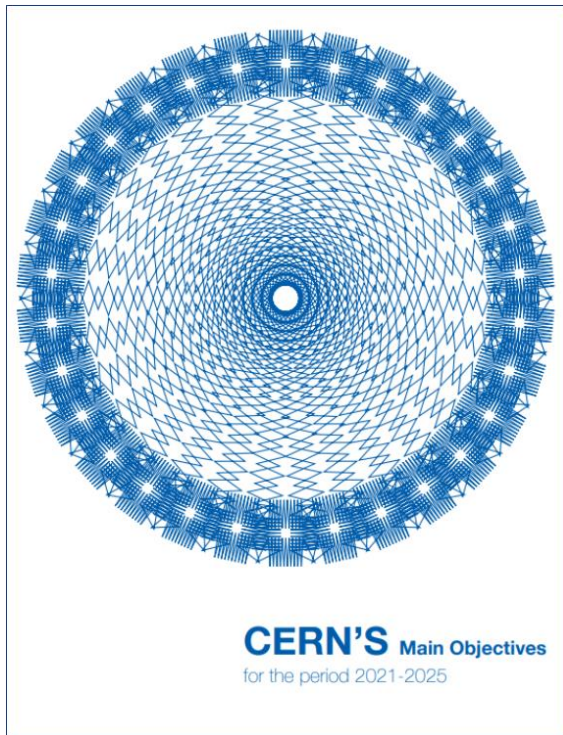
In June 2022, the CIPEA Innovation Day welcomed 15 innovative project proposals, such as:

- Accelerator systems for improving clean-techs production and reducing polluting emissions;

- Vacuum and RF technologies for renewable energy large-scale distribution and new industrial heating;

- Machine-learning algorithms for climate modelling;

- Innovative systems for reducing greenhouse gas emissions at CERN and beyond.

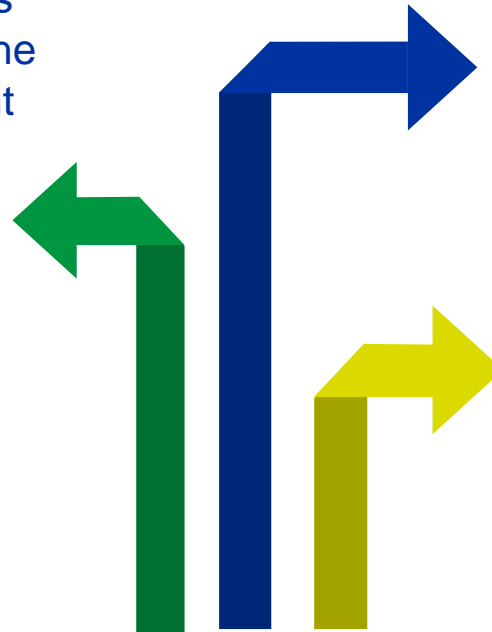**In September 2022, 7 CIPEA projects were selected to receive support from the KT Fund**

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Identify and develop CERN's technologies that may contribute to mitigating the impact of society on the environment

Minimise the Laboratory's impact on the environment

Pursue actions and technologies aiming at energy saving

CERN'S Main Objectives
for the period 2021-2025

Knowledge Transfer
Accelerating Innovation

CIPEA CERN Innovation Programme
on Environmental Applications

CIPEA – Concept Evolution

CIPEA today is a label for all CERN projects (supported by KT) aiming at achieving positive environmental impact beyond CERN (global level)

Currently counting 30 projects in total - Classification

- **Origin**:

    - 10 issued from internal proposals

    - 20 issued from external requests

- **Funding**:

    - 9 supported by the KT Fund
      (out of which 4 supported also by external funding)

    - 10 supported only via external funding (companies)

    - 2 supported by external public funding (EU, ESA)

    - 9 currently in negotiation with external companies

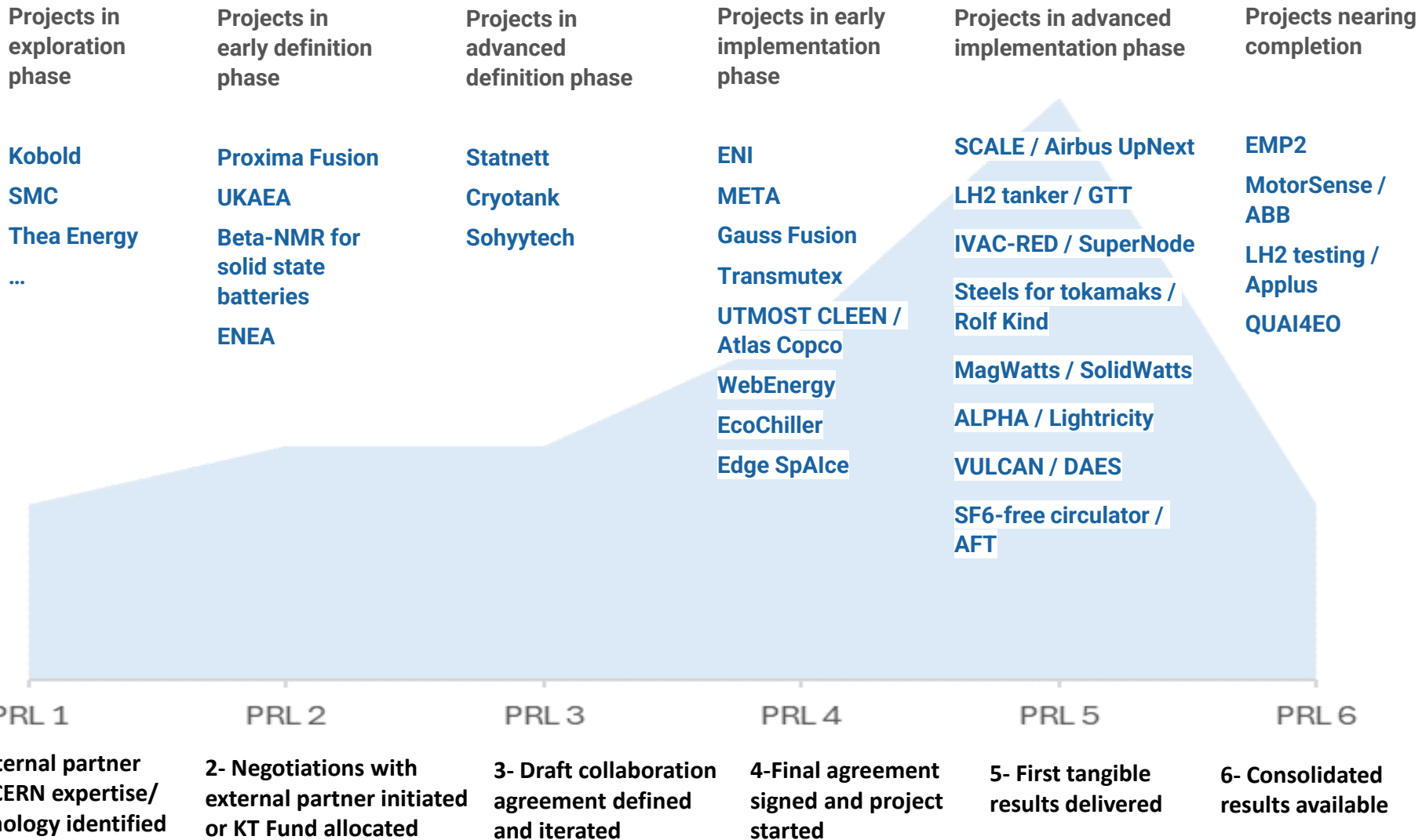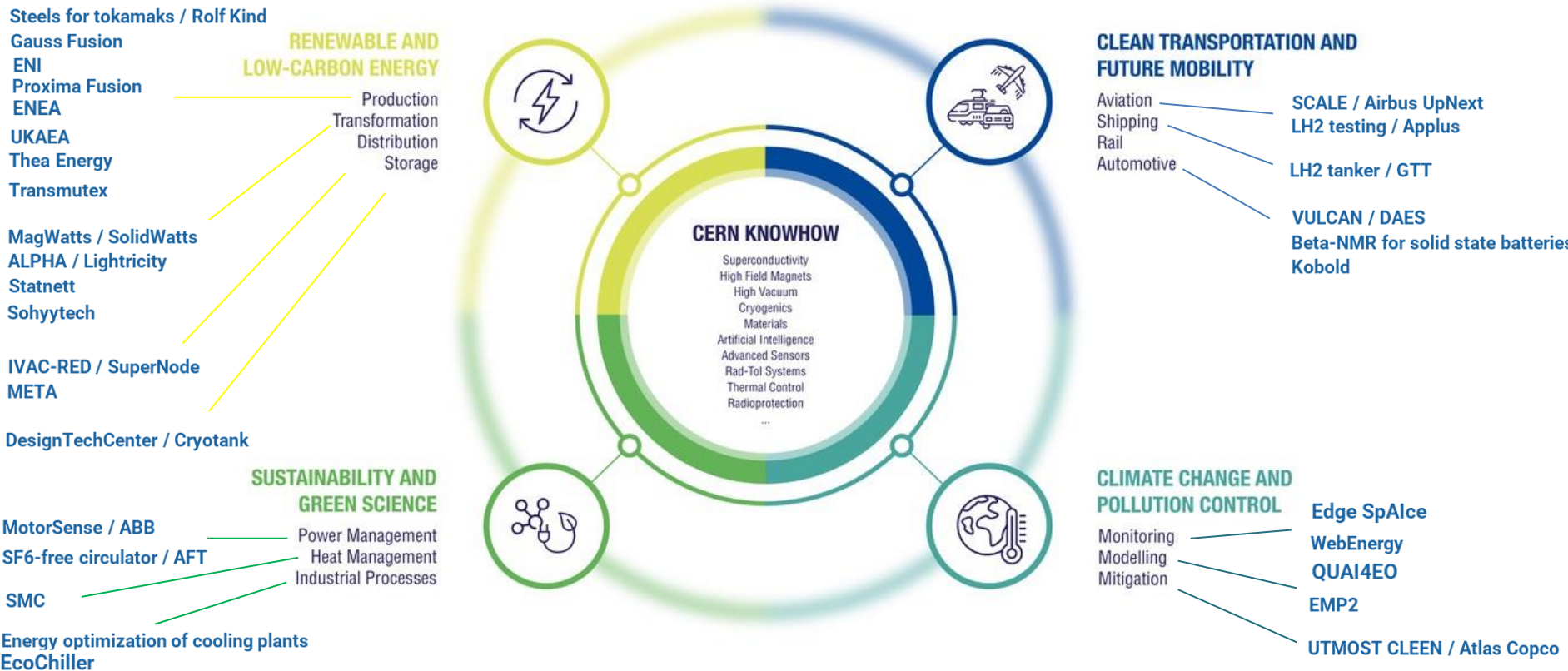- **Key areas distribution**:

    - Renewable and Low Carbon Energy: 15

    - Clean Transportation and Future Mobility: 6

    - Climate Change and Pollution Control: 5

    - Sustainability and Green Science: 4

    All subcategories covered

- **PRL (Project Readiness Level)**: Classification in 6 different levels - see next slide

CIPEA – Project Readiness Levels

Projects in exploration phase

Kobold

SMC

Thea Energy

...

Projects in early definition phase

Proxima Fusion

UKAEA

Beta-NMR for solid state batteries

ENEA

Projects in advanced definition phase

Statnett

Cryotank

Sohyytech

Projects in early implementation phase

ENI

META

Gauss Fusion

Transmutex

UTMOST CLEEN / Atlas Copco

WebEnergy

EcoChiller

Edge SpAIce

Projects in advanced implementation phase

SCALE / Airbus UpNext

LH2 tanker / GTT

IVAC-RED / SuperNode

Steels for tokamaks / Rolf Kind

MagWatts / SolidWatts

ALPHA / Lightricity

VULCAN / DAES

SF6-free circulator / AFT

Projects nearing completion

EMP2

MotorSense / ABB

LH2 testing / Applus

QUAI4EO

PRL 1 PRL 2 PRL 3 PRL 4 PRL 5 PRL 6

1- External partner and CERN expertise/ technology identified

2- Negotiations with external partner initiated or KT Fund allocated

3- Draft collaboration agreement defined and iterated

4-Final agreement signed and project started

5- First tangible results delivered

6- Consolidated results available

CERN | Knowledge Transfer Accelerating Innovation

CIPEA — CERN Innovation Programme on Environmental Applications

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CIPEA Projects in Environmental Key Areas

With sub-categories tentative distribution

Steels for tokamaks / Rolf Kind
Gauss Fusion
ENI
Proxima Fusion
ENEA

UKAEA
Thea Energy

Transmutex

MagWatts / SolidWatts
ALPHA / Lightricity
Statnett
Sohyytech

IVAC-RED / SuperNode
**META**

DesignTechCenter / Cryotank

MotorSense / ABB
SF6-free circulator / AFT

SMC

Energy optimization of cooling plants
EcoChiller

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CLIMATE CHANGE AND POLLUTION CONTROL

Monitoring
Modelling
Mitigation

Edge SpAIce
WebEnergy
QUAI4EO
EMP2
UTMOST CLEEN / Atlas Copco

CIPEA - Poles of Competence in Environmental Applications

Compact Magnetic Confinement Fusion Energy Systems

SC Lines for On-board and Grid Power Distribution

Accelerator Driven and Advanced Nuclear Reactors

Liquid Hydrogen Storage and Handling Systems

Engineering Systems Optimized for Low Emissions and Energy Efficiency

Instruments and Facilities for Remote and In-situ Environmental Monitoring

Fast, Low-power Computing Techniques based on AI

AI Platforms for Global Phenomena Modelling and Climate Simulations

CIPEA On-going Projects Examples

Fusion Systems

**Magnetic confinement fusion devices –
System design and components testing**

Supporting system level R&D and component testing for fusion systems

- Design, modelling and testing of critical components for magnetic confinement fusion devices
- Assessing the mechanical properties of steels for tokamaks casing at cryogenic temperatures

Impact: Accelerating availability of unlimited affordable low-carbon fusion energy
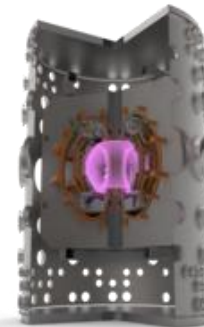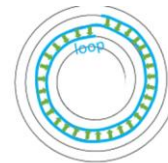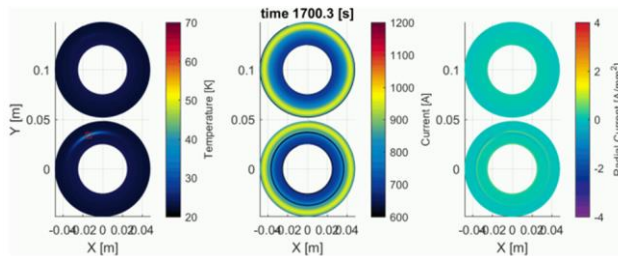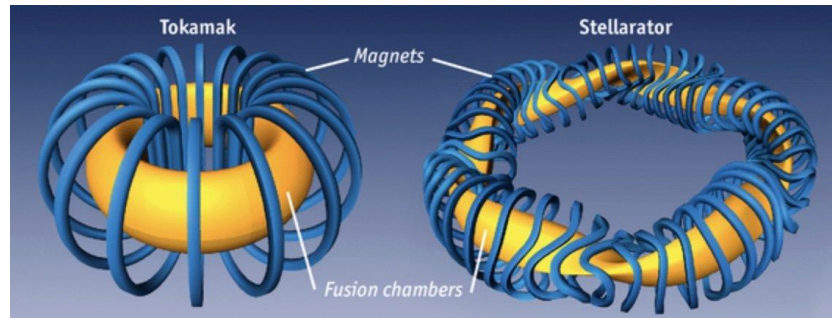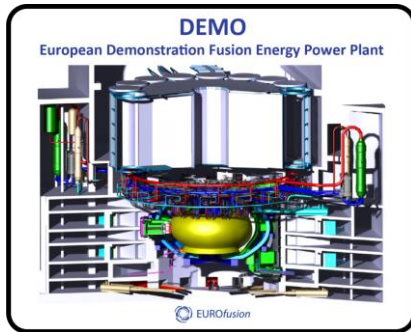
https://home.cern/news/news/knowledge-sharing/future-colliders-and-fusion-reactors

Cryostats for SC powerlines

IVAC-RED: Insulation VACuum of superconducting cables for Renewable Energy Distribution

Vacuum compatibility of materials for long-range superconducting cables

- Permeability and outgassing measurements of candidate materials for the insulating system of superconducting cables

- Development of dedicated test rig

Impact: Minimizing losses, cost and footprint of long-range renewable energy power transmission, for both terrestrial and submarine applications
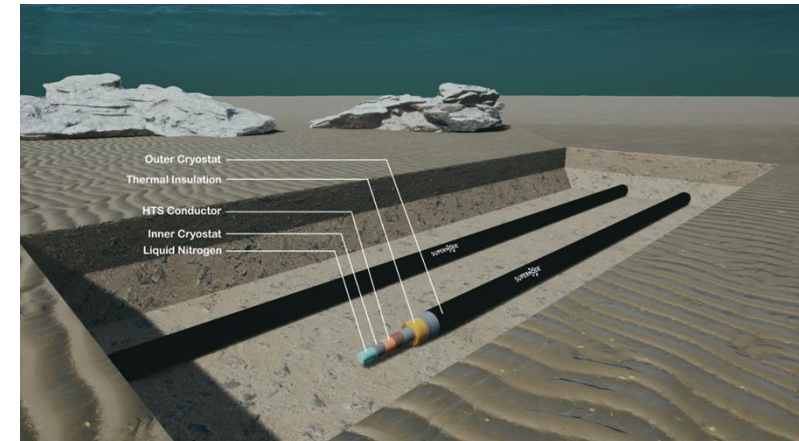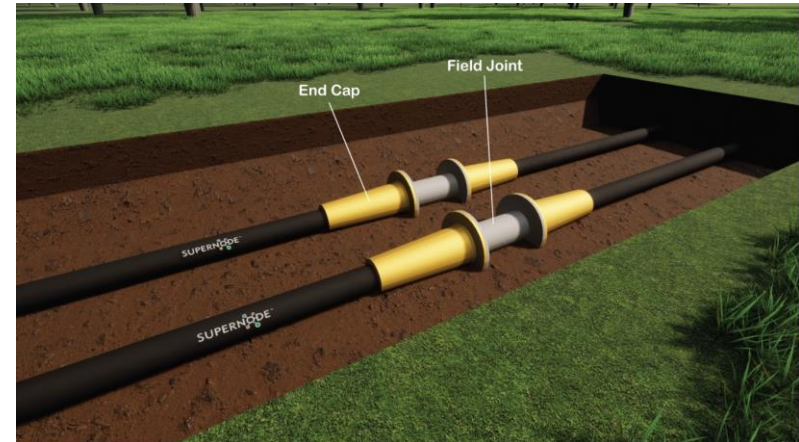
SUPERNODE™
Connecting the Future

https://home.web.cern.ch/news/news/knowledge-sharing/supernode-and-cern-collaborate-new-solutions-renewable-energy

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CIPEA | CERN Innovation Programme on Environmental Applications

HTS for Electric Planes

SCALE: Super-Conductors for Aviation with Low Emissions

SCALE: Demonstration of SC power distribution systems for future LH$_2$ planes

- SCALE aims to promote the adaptation and adoption of superconducting technologies in airborne electrical distribution systems

- The demonstrator consists of a DC link (cable and cryostat) with two current leads. The cooling system is based on gaseous helium.

Impact: Support critical decisions on advanced technologies for clean aviation with the ambition to:

➢ Halve weight and volume of components

➢ Reduce voltage to below 500V

➢ Increase system efficiency (+5-10%)
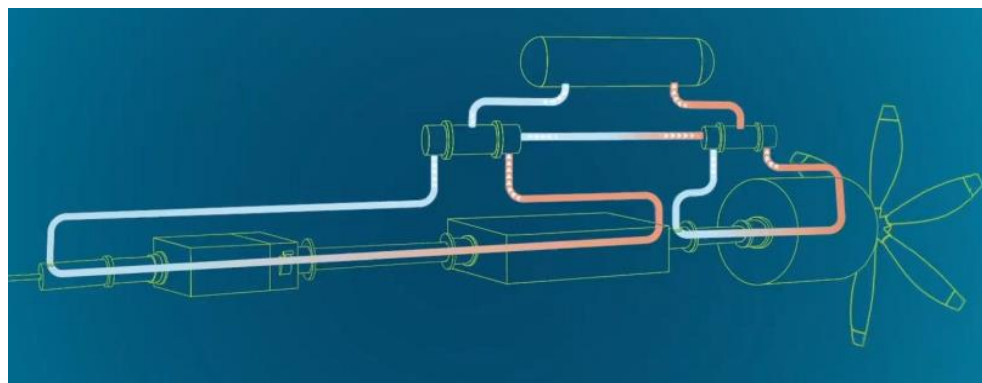
AIRBUS
Airbus UpNext

https://kt.cern/news/press-release/knowledge-sharing/cern-and-airbus-partnership-future-clean-aviation

Joint press release

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Liquid Hydrogen storage

Development of large LH$_2$ tanks for maritime transportation

Supporting the development of tanks for long-range maritime transport of LH$_2$

Project to help GTT adapting procedures/designs for LNG to innovative LH2 tanks related to:

- Materials specifications and quality control
- Welding procedures to ensure leak-tightness
- Materials test for vacuum insulation layer
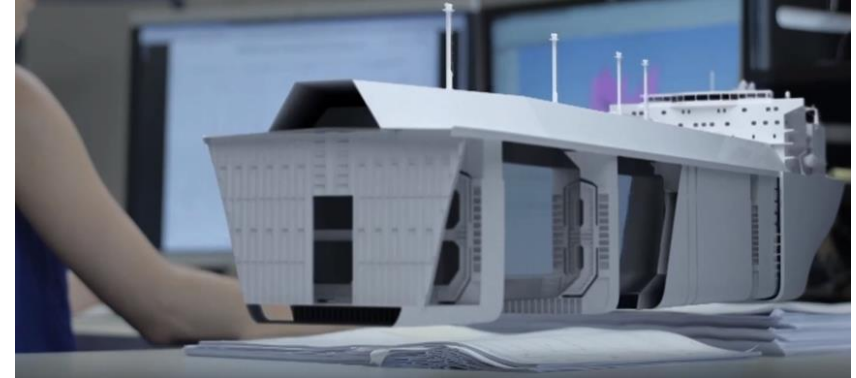
Impact: Develop technologies to enable the maritime transport of liquid hydrogen to connect producers and consumers across the world enabling a green hydrogen economy.

GTT
Technology for a sustainable world

[CERN and GTT enabling liquid hydrogen maritime transportation - Video](#)

EMP2
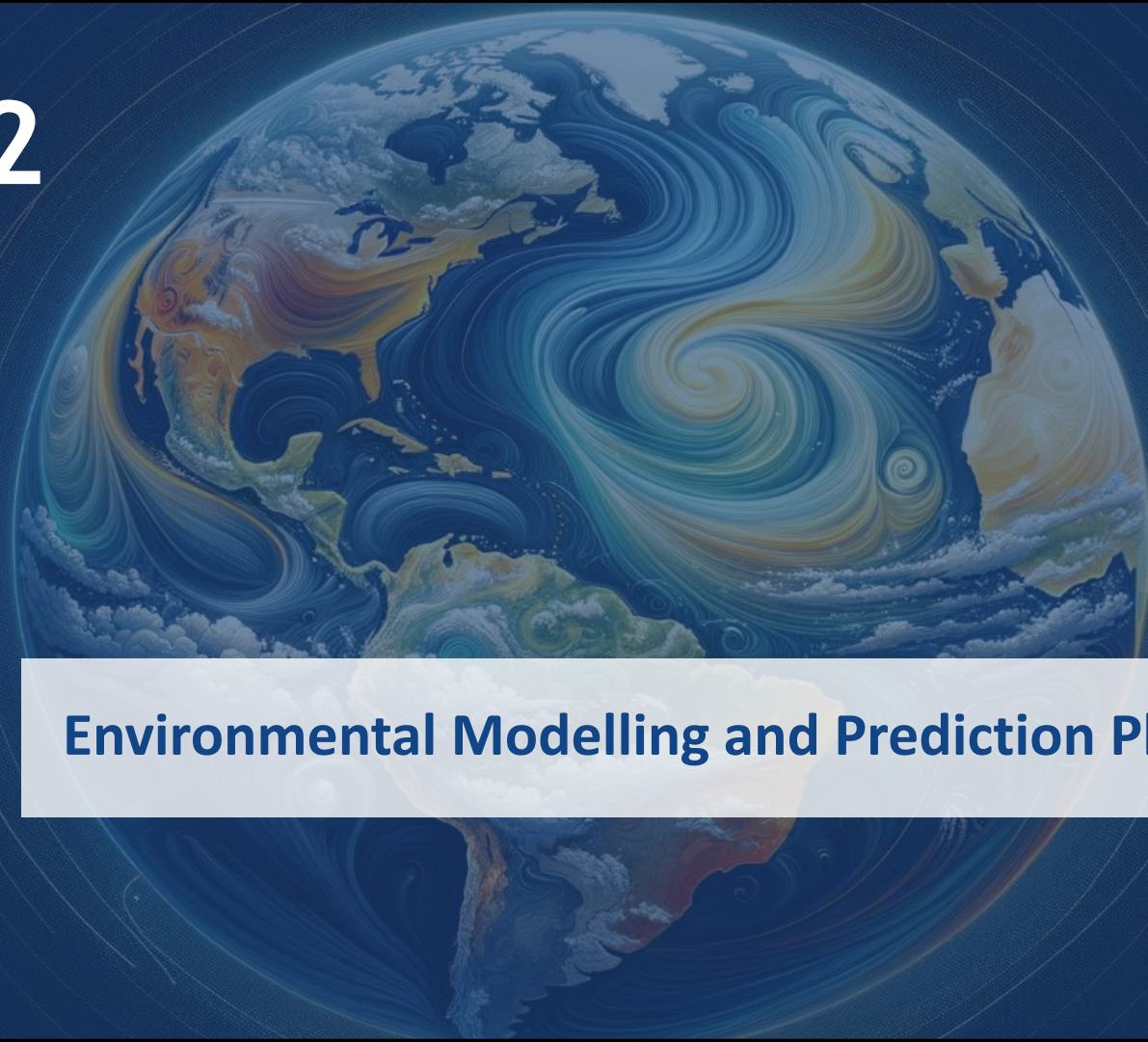
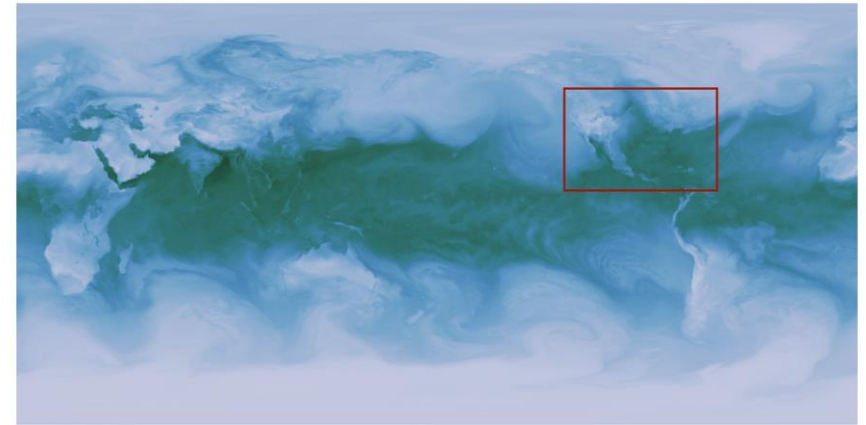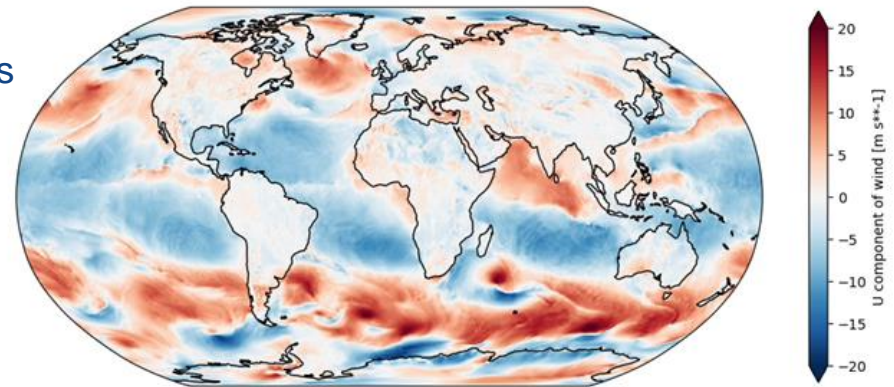**Environmental Modelling and Prediction Platform**

Environmental Modelling and Prediction Platform

- Development of a proof-of-concept Machine Learning digital twin of the dynamics of the atmosphere

- Trained on hourly data over 40 years from Copernicus (Wind, Temperature, Humidity & Precipitation)

Impact: Very robust predictions that can improve traditional numerical weather modelling, specifically:

- ➢ Nowcasting (weather forecast up to 6h)

- ➢ Downscaling of (extreme) weather phenomena (32km → 6km)

- ➢ Correction of precipitation measurements bias

JÜLICH
FORSCHUNGSZENTRUM

ECMWF

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UTMOST CLEEN / CLEER

Electron Beam Flue Gas Treatment System

Development of Electron-Beam-Flue Gas-Treatment

UTMOST CLEEN: Ultra-Thin Membrane Overlay STacks to Channel Low Energy ElectroNs to Atmosphere

Development of a compact and durable Electron Beam Flue Gas Treatment (EBFGT) technology

- Phase 1: UTMOST CLEEN: Development of key components such as ultrathin beam windows
- Phase 2: UTMOST CLEER: Development of Demonstrator System for specific application

Impact: Significant cut in greenhouse gas emissions from hard-to-abate transportation systems (ships) and industries (semiconductors) through pre-release exhaust gas purification.

➢ Reduce SOx emission by up to 95%
➢ Reduce NOx emission by up to 80%

Strategic Partnership Negotiation On-going
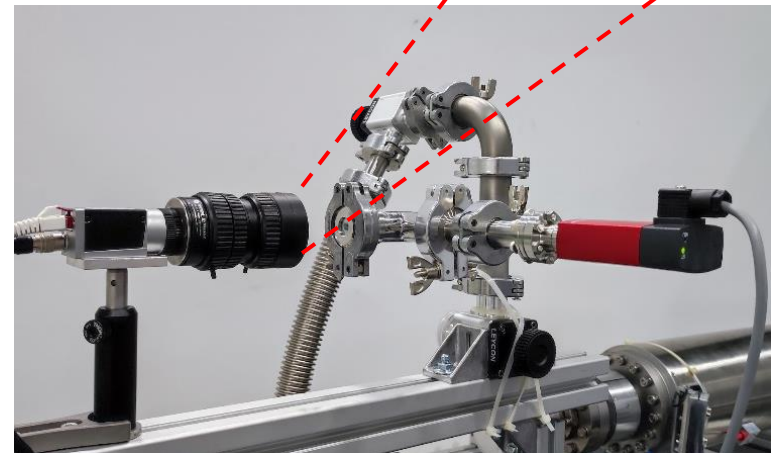
SF6-free RF circulator for photo injectors

Development of a vacuum-compatible high-power waveguide circulator

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CIPEA | CERN Innovation Programme on Environmental Applications

SF6-free RF circulator for photo injectors

Development of a vacuum-compatible high-power waveguide circulator operable without SF6

➤ Performing outgassing and brazing studies to identify suitable vacuum-compatible ferrite

➤ Testing existing circulators with eco-friendly alternative gases

Impact: Eliminate need of SF6 gas (Global warming potential: 23'500) in all accelerator applications requiring RF circulators (including medical hadron facilities).

CERN's need: 3 units.

Potential benefits also for circuit breakers industry.

AFT *microwave*
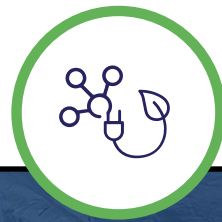
MotorSENSE

Reducing electricity consumption in cooling and ventilation using smart sensors and digital twins

Energy savings in driven pumps and fans using smart sensors and digital twins

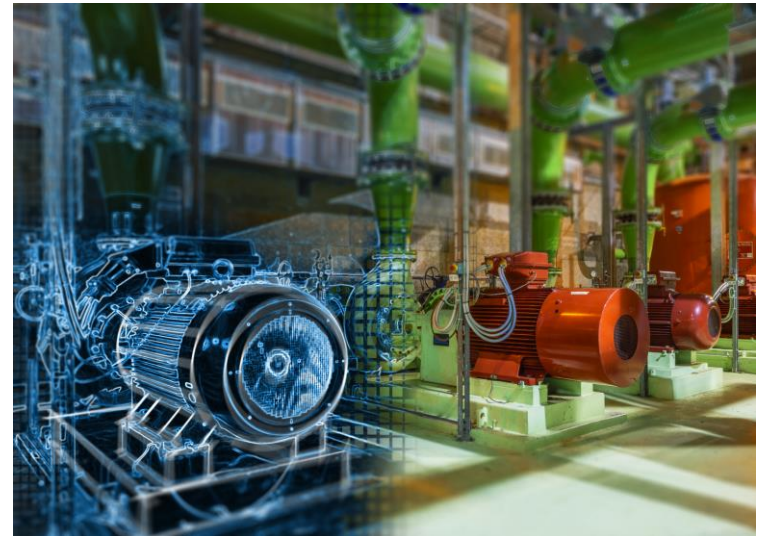**Reducing electricity consumption in cooling and ventilation using smart sensors and digital twins**

➢ Selection of >800 low-voltage motors and installation of >100 smart sensors

➢ Measurement of output power, speed, vibration levels and estimation of operating efficiency

➢ Improvement and optimisation of smart sensors algorithms

➢ Development of digital twins
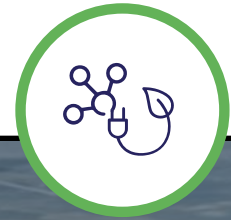
➢ Recommendations for energy saving

Impact: Identification of 17.4% energy-saving opportunities at CERN (up to 31 GWh). Same approach can be applied to any infrastructure with similar cooling and ventilation requirements.

ABB

https://home.cern/news/news/knowledge-sharing/abb-and-cern-identify-174-energy-saving-opportunity-laboratorys-cooling

Thanks for your attention!

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