Topic idea submitted to IHI - Reference Number: TI_001227

Are you submitting the idea:
☒ **in your personal capacity?**
☐ **on behalf of an organisation?**

1 Title of your idea

Please provide a short title that accurately reflects the objective(s) of your idea:
Advanced indoor air purifier utilizing genetically modified algae and bio-photovoltaic systems.

2 Scope

Explain the specific challenges/problems to be addressed by your idea and how these affect relevant stakeholders, taking into account what is already known and/or available in the field:
The project addresses the critical need for improving indoor air quality and generating sustainable energy in urban and industrial environments. High levels of indoor air pollution significantly impact human health, causing respiratory and cardiovascular diseases. Existing air purifiers primarily filter pollutants without enhancing oxygen levels. This project proposes an advanced air purifier that integrates genetically modified Chlorella vulgaris and encapsulated cyanobacteria within bio-photovoltaic (BPV) modules. The device not only filters pollutants but also produces an oxygen surplus, enhancing air quality and generating renewable energy.

Chlorella vulgaris, a microalgae known for its high photosynthetic efficiency and robust oxygen production, forms the core of the air purification system. The chloroplasts of Chlorella vulgaris are genetically modified using CRISPR/Cas9 to express genes such as Heat Shock Proteins (HSP) and Superoxide Dismutase (SOD), enhancing their tolerance to environmental stresses and protecting against oxidative damage. Additionally, key enzymes in the photosynthetic pathway, like RuBisCo, are optimized to improve carbon assimilation and reduce energy losses. The chloroplasts are treated with biocompatible nanomaterials to enhance light-harvesting efficiency and structural stability, further boosting oxygen production.

In parallel, the system incorporates microbial fuel cells (MFC) containing encapsulated cyanobacteria within BPV modules. The cyanobacteria are encapsulated in coacervate micro-droplets, creating a micro-compartmentalized environment that stabilizes the microorganisms and optimizes photosynthesis and electron transfer. This encapsulation protects the cyanobacteria from ultraviolet (UV) radiation, particularly at the wavelength of 254 nm, which triggers the production of the neurotoxin BMAA, ensuring the system's safety and efficiency.

Please indicate which IHI specific objective(s) (SO), as described in the IHI Strategic Research and Innovation Agenda (SRIA), your idea addresses:

["SO1: contribute towards a better understanding of the determinants of health and priority disease areas"
"SO2: integrate fragmented health research and innovation efforts bringing together health industry sectors and other stakeholders, focusing on unmet public health needs, to enable the development of tools, data, platforms, technologies and processes for improved prediction, prevention, interception, diagnosis, treat- ment and management of diseases, meeting the needs of end-users "
"SO4: exploit the full potential of digitalisation and date exchange in heath care"
"SO3: demonstrate the feasibility of people-centered, integrate health care solutions"]

Please select the keywords that are most relevant to your idea:

["Non-communicable diseases"
"Cardiovascular diseases"
"Mental health"
"Prevention"
"Disease management"
"Health technology"]

In alignment with the IHI specific objective(s) selected above, specify the objectives of your idea:

The project aims to develop an advanced indoor air purifier that utilizes genetically modified algae and bio-photovoltaic (BPV) systems to significantly improve indoor air quality and generate sustainable energy. This innovative device not only filters pollutants but also adds an oxygen surplus, substantially enhancing air quality. Additionally, it is designed to be energy self-sufficient, reducing reliance on non-renewable energy sources and lowering operational costs.

The anticipated impacts align with the specific objectives selected in point 9:

SO1: Contribute towards a better understanding of the determinants of health and priority disease areas.
The project will provide new insights into how indoor air quality affects health outcomes, particularly in non-communicable diseases like cardiovascular and respiratory conditions. By analyzing the effects of improved air quality on these health parameters, the project will contribute valuable data to public health research and help identify priority areas for intervention.

SO2: Integrate fragmented health research and innovation efforts, bringing together health industry sectors and other stakeholders.
This prototype bridges multiple fields, including biotechnology, environmental science, and energy technology, fostering a multidisciplinary approach to health innovation. By collaborating with academia, industry, and healthcare providers, the project aims to create a unified research effort that addresses the complex challenge of indoor air pollution and sustainable energy production.

SO3: Demonstrate the feasibility of people-centered, integrated health care solutions.
The air purifier is designed to be user-friendly and integrated into everyday living spaces, providing a direct benefit to individuals by improving the quality of the air they breathe. This focus on user-centric design ensures that the solution is accessible and practical, promoting widespread adoption and enhancing public health.

SO4: Exploit the full potential of digitalisation and data exchange in health care.
The air purifier system can incorporate digital sensors and data analytics to monitor air quality in real-time, providing valuable information to users and health professionals. This data can be used to adjust the purifier's settings for optimal performance and to track long-term health benefits, making full use of digital health technologies to enhance care.

3 Expected impacts to be achieved by your idea

Briefly describe the expected impacts to be achieved by your idea, ensuring that they contribute to IHI general and relevant specific objectives, as described in the IHI SRIA:

Impacts *are wider long-term effects on society (including the environment), the economy and science, enabled by the outcomes of R&I investments. Impacts generally occur sometime after the end of the project, e.g. successful implementation of digital solutions supporting people-centred care.*

IHI general objectives: *1. contribute towards the creation of an EU-wide health research and innovation ecosystem that facilitates translation of scientific knowledge into innovations, notably by launching at least 30 large-scale, cross-sectoral projects, focussing on health innovations; 2. foster the development of safe, effective, people-centred and cost-effective innovations that respond to strategic unmet public health needs, by exhibiting, in at least 5 examples, the feasibility of integrating health care products or services, with demonstrated suitability for uptake by health care systems. The related projects should address the prevention, diagnosis, treatment and/or management of diseases affecting the EU population, including contribution to 'Europe's Beating Cancer Plan'; 3. drive cross-sectoral health innovation for a globally competitive European health industry and contribute to reaching the objectives of the new Industrial Strategy for Europe and the Pharmaceutical Strategy for Europe.*

The project aims to develop an advanced indoor air purifier that utilizes genetically modified algae and bio-photovoltaic (BPV) systems to significantly improve indoor air quality and generate sustainable energy. This innovative device not only filters pollutants but also adds an oxygen surplus, substantially enhancing air quality. Additionally, it is designed to be energy self-sufficient, reducing reliance on non-renewable energy sources and lowering operational costs. The anticipated impacts include the improvement of human health and well-being through the reduction of indoor air pollutants, leading to a decrease in respiratory and cardiovascular diseases and enhancing overall population health and well-being, especially in urban and industrial settings where pollution levels are high. The project introduces technological innovation and environmental sustainability by integrating genetically enhanced algae and encapsulated cyanobacteria within BPV modules, representing a novel and sustainable approach. These organisms are genetically optimized to increase photosynthetic efficiency and resilience to environmental stresses, ensuring continuous oxygen and energy production, thereby reducing the overall environmental footprint and contributing to climate change mitigation. The air purifier is designed to be energetically self-sufficient, thanks to BPV modules that generate renewable energy, reducing the need for external electrical power, lowering operational costs, and promoting energy sustainability. The project's support for research and innovation is evident in its contribution to the creation of a health research and innovation ecosystem, facilitating the translation of scientific knowledge into practical innovations. Collaboration with research institutions and private industry will leverage the latest scientific discoveries and advanced technologies to develop effective and scalable solutions. The social and economic impact of the project is substantial, as improving indoor air quality will positively affect worker productivity and well-being, reduce sick leave, and enhance quality of life. Moreover, the adoption of sustainable technologies will stimulate the green economy and create new job opportunities in the renewable energy and environmental technology sectors.

4 Why should your idea become an IHI call topic?

Explain why collaboration through a cross-sectoral and multidisciplinary public private partnership is needed in particular:

Why does it require collaboration among several industry sectors (*e.g.* pharma, vaccines, biotech, medical devices, in vitro diagnostics, radiotherapy, medical imaging health ICT)?

Why does it require collaboration between private (industry) and public partners (*e.g.* academia, healthcare practitioners, patients, regulators)?

Collaboration through a cross-sectoral and multidisciplinary public-private partnership is crucial for the success of this project for several reasons. The need to involve various industry sectors, such as biotechnology, medical devices, in vitro diagnostics, healthcare technology, and others, stems from the complexity and innovative nature of the project. Integrating advanced technologies such as genetic modification of algae, encapsulation of cyanobacteria, and bio-photovoltaic systems requires

expertise ranging from molecular biology to materials engineering and environmental sciences. Each sector contributes its own expertise, technological resources, and infrastructure, which are essential for developing, testing, and implementing effective and safe solutions.

Furthermore, collaboration between private and public partners is essential to ensure that the project is not only technologically sound but also complies with regulatory standards and meets the real needs of end-users. Academic institutions provide scientific know-how and basic research capacity, while industrial partners offer the necessary resources for large-scale production and commercialization. Healthcare practitioners and regulators ensure that the final product is safe, effective, and compliant with current regulations, facilitating its acceptance and dissemination in the market.

Why is the contribution of industry needed to achieve the expected impacts?

***Contribution of industry**: Large companies that are members of the IHI industry partners (i.e. COCIR, EFPIA, EuropaBio, MedTech Europe, Vaccines Europe) contribute to the programme, primarily through 'in-kind' contributions (e.g. their researchers' time, laboratories, data, compounds). At least 45% of each project's total costs have to be in-kind contribution.*

The contribution of industry is fundamental to achieving the expected impacts of the project for several reasons. Large companies that are members of the IHI industry partners, such as COCIR, EFPIA, EuropaBio, MedTech Europe, and Vaccines Europe, primarily provide in-kind contributions such as researchers' time, laboratories, data, and chemical compounds. These resources are essential for developing and validating the proposed technologies, allowing for an accelerated research and development process and reducing associated costs.

The industry has the necessary infrastructure for large-scale production and implementation of innovative solutions. Additionally, industry involvement ensures that the project is market-oriented, increasing the chances of commercial success. Companies can also facilitate access to global distribution networks and sales channels, ensuring that the final product reaches consumers quickly and efficiently.

At least 45% of each project's total costs must be covered by in-kind contributions provided by industrial partners. This commitment ensures that companies are actively involved in the project, providing not only financial resources but also expertise, innovation, and production capacity. Without this support, it would be difficult to achieve the desired levels of innovation and impact, making public-private collaboration an indispensable component for the project's success.