Science & Technology

FORESIGHT

from society to research

National Research
Council of Italy

Science & Technology

FORESIGHT

INTERDEPARTMENTAL PROJECT « SCIENCE AND TECHNOLOGY FORESIGHT »

Mission

The Science and Technological Foresight Project seeks to define a medium to long-term vision – 5 to 30 years – in order to elaborate coherent research strategies, and to address serious socially relevant problems related to environment, health, food, energy, security and transportation.
The holistic approach followed in analysing the topics and the active participation of internationally aknowledged experts from universities, research centers, public and private sectors in the foresight activities are two key characteristics of the project. In particular, the experts will attend a series of "Face to Face" (F2F) workshops, each of them focused on specific correlated, sub-topics.
The F2F workshops are invitation only events, organized in such a way as to guarantee to participants from a range of backgrounds and positions the conditions necessary for a free and open debate. This approach is designed to facilitate convergence towards common positions related to research priorities, knowledge gaps and funding needs, and to address the social acceptability of future products and services and resultant market potential.

Working Method

The organization of the F2F workshops has four operational phases: the definition of the program of workshops, the preparation of preliminary documents, the selection of experts – interested in confronting problems in all their complexity and the preparation of the reports following each work-shop. The identification of the participants, crucial to the success of the F2F workshops requires time, credibility and a wide network of contacts. This interactive and reciprocal exchange leads to the consolidation of a collective intelligence which goes beyond the linear view of cause and effect towards the development of a systemic, collective and integrated vision.
Using the dedicated web platform (www.foresight.cnr.it) those who wish to can join the Foresight Network, and contribute to the project with concepts, ideas, questions and observations.

Acknowledgements

The Science and Technology Foresight Project is supported by the National Research Council of Italy (CNR), by Area Science Park (Trieste) and by the Italian Ministry for Education and Research (MIUR) with the collaboration of the American Institute on Science for Global Policy (ISGP), of Aspen Institute Italia and of Nova-Sole24Ore.

National Research Council of Italy

AREA SCIENCE PARK

Ministero dell'Istruzione, dell'Università e della Ricerca

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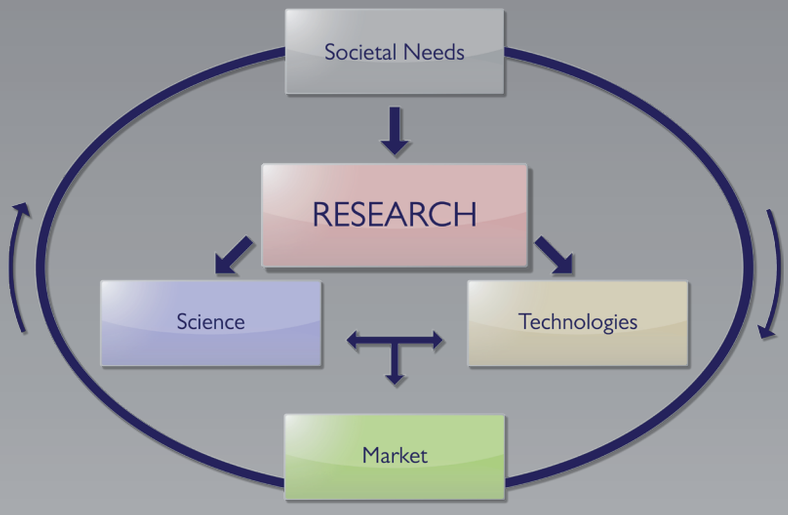
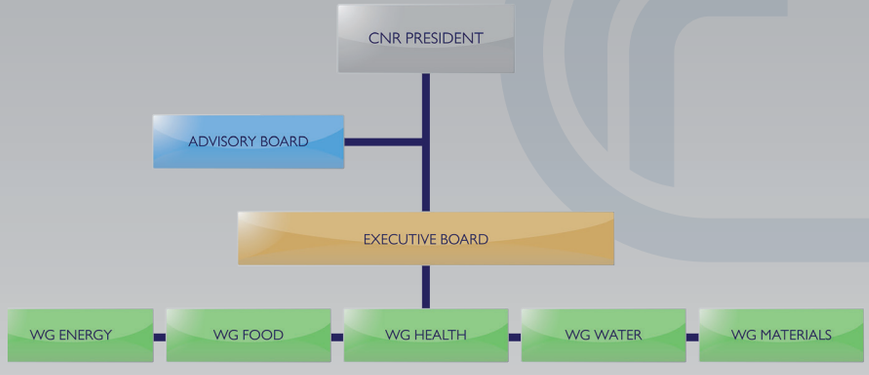
The approach of the Science and Technology Foresight, while driven by societal needs and interested in identifying innovative technologies, puts the scientific research at the center. The outputs that reach the market should have long term disruptive impacts on the society.





The Advisory Board proposes initiatives to the Executive Board and promotes all project activities within the CNR scientific network. It gathers all CNR Department Directors.

The Executive Board defines the strategic plan and the work programme of the Project, coordinates the Thematic Working Groups activities and validates the strategic documents. It gathers all Working Group Coordinators.

The Thematic Working Groups (WG) design and organise the scientific initiatives according to the Executive Board decisions, including the organisation of the exploratory and Face to Face workshops. The WGs are coordinated and constituted by CNR researchers.

SUMMARY OF RESULTS AND FUTURE ACTIVITIES

The following events have been organised in the last four years:
- 6 Exploratory workshops
- 3 Face-to-Face workshops

The results were presented at several international conferences and published on the website www.foresight.cnr.it

The future work programme foresees the organization of face-to-face workshops, the participation to international events and the establishment of new collaborations.

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WG ENERGY

"NEXT GENERATION ENERGY STORAGE TECHNOLOGIES"

MISSION

Distributed energy generation using renewable power sources and energy storage technologies are of significant importance for the future energy system. Energy storage is considered the key technology in transitioning the global energy economy away from fossil fuels to renewables. An efficient storage is necessary to increase the use of renewables and can contribute to reduce the carbon footprint of the electricity grid. Energy storage technologies can overcome the temporal mismatch between energy supply and demand and avoid that excess of renewable energy is curtailed by the grid operators. In general, the storage technologies contribute to improving the overall efficiency of the energy system. However, in order to effect this transition in applications such as distributed generation, electric power grid and transportation, leading energy storage technologies must be economically competitive, reduce the use of critical raw materials and achieve substantial increases in both efficiency and longevity relative to today's performance. The mission of the Foresight WG "Energy Storage" is to address the challenges of the energy storage sector and related environmental issues in particular the identification and setting of priorities for the topics of future research programmes.

Renewable power generation.

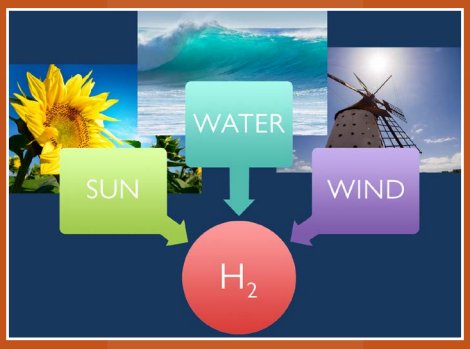
Fuel Cell prototype.

MAIN OUTCOMES

The Foresight workshop "Next Generation Energy Storage Technologies: Challenges and Opportunities (Taormina, Italy, 2-3 December 2015)" and the scoping workshop on STEM materials (Rome, 23-24 March 2017) have pointed out the need of exploring scientific gaps and perspectives in two specific research directions: "Carbon Dioxide Management and Valorisation" and "Green Hydrogen Generation and Use on a Wide-scale". These research directions concern two relevant energy cycles:

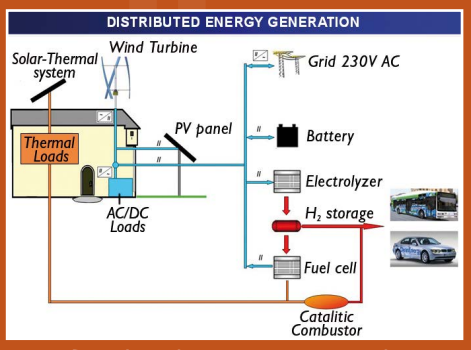
i) A carbon-neutral cycle involving conversion of CO_2 from various sources/emissions into a renewable fuel, using the excess of renewable energy. In this framework, CO_2 is used as substrate to produce methanol, dimethyl ether, syngas, ethanol etc. as sustainable fuels.

ii) The hydrogen cycle involving production of "green" hydrogen from water, using the surplus of renewable energy; in this cycle, water is used as substrate to generate H_2 as large-scale energy carrier.



Hydrogen energy vector.

Home wall lithium batteries for energy storage.



Distributed generation approach.

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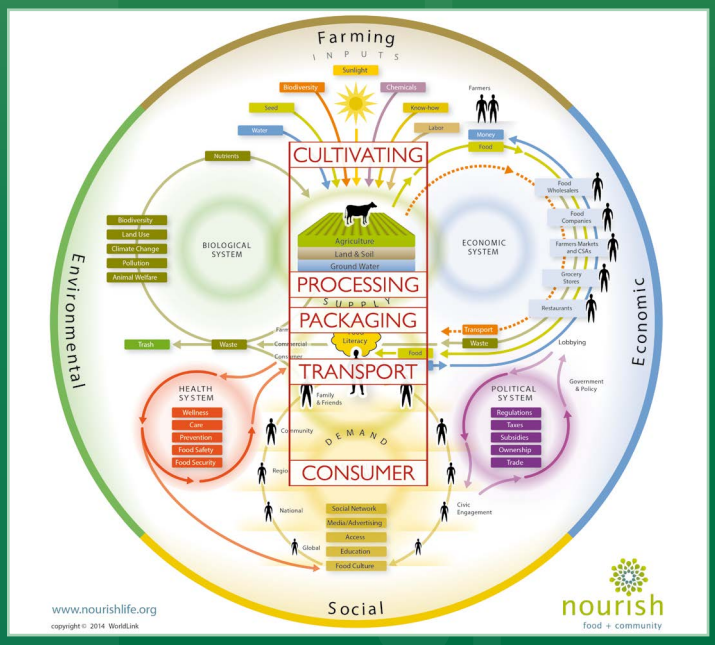
WG FOOD

"CONVERGING TECHNOLOGIES for SUSTAINABLE and HEALTHY FOOD"

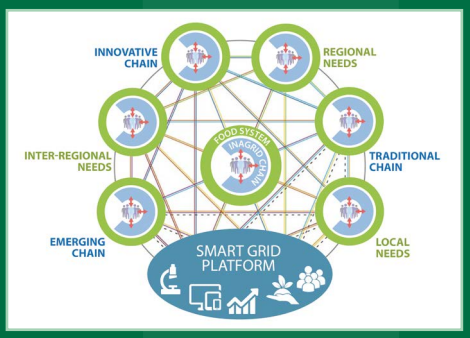
MISSION

In the coming decades, there will be the need to propose a new approach to the challenge of providing, in a sustainable way, food security and healthy food to a growing population. Malnutrition is prevalent in many parts of the world and predictions are that it will get worse as the population grows. However, there are estimates that caloric production capacity today could easily meet the need in 2050 if we could only match capacity and nutritional quality to the need. Much of the mismatch is because of a wrong quantity/quality ratio, or because areas of need are separated from areas of production. Innovation has the potential to allow more capacity to be produced nearer to the areas of need, supporting local realities and variations (crops, climate, population, culture) according to specific demands. In this framework, a further challenge comes from the effects of global climate change. An interdisciplinary forward looking approach, which considers food systems and the food chains embedded within those systems, will be necessary to address these challenges. In collaboration with a group of international experts we developed the concepts of a "**SmartGrid for Food Systems**" and of "**Diversified Adaptable Food**", which support the engagement in research and the development of technologies to address common issues, and connect food systems in order to avoid finding individual solutions for each problem.



A food chain within a food system

MAIN OUTCOMES



A SmartGrid connecting food systems

Within the topic "Converging technologies for sustainable and healthy food" we organized two international workshops focused on "Diversified Adaptable Food" (May 2015) and "SmartGrid for Food Systems" (May 2017). Invited international experts, policy makers, politicians, and NGOs reached a consensus on the following criteria: supply and variety should match nutritional, social, and economical needs; resources use (soil, water, energy, genetic resources, human resources) needs to be optimized in terms of efficiency and sustainability; agricultural ecosystems and ecosystem services need to be supported; priority should be given to food quality and not only quantity. Focusing on existing and emerging technologies as well as innovative processes, a SmartGrid needs to be developed to: monitor and evaluate local and regional key supply chain data; connect capacities and needs through distribution networks at various levels; connect different food systems (nodes of the SmartGrid) through monitoring and predicting response to future climatic, environmental and socioeconomic conditions; adapt production processes and technologies to resources.

The results of the workshops have been presented at several international conferences (see foresight.cnr.it/working-groups/wg-food).

We are planning a 3rd workshop in collaboration with the WG Health, focused on identifying knowledge gaps in the relationship between health and nutrition and innovation priorities regarding proper technological applications. In collaboration with **Global Good Fund**, we will focus on **nutrition during the first 1000 days of life.** This is the time of greatest development and of greatest vulnerability, and it provides exceptional opportunities to make an impact through optimal nutrition.

Nutrition ⟷ Health

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WG HEALTH

"TOWARDS the MEDICINE of the FUTURE"

MISSION

It's now time to move from a reactive medicine, focused on treating the disease after it occurs, to a more predictive and preventive medicine with customized therapies and services able to promote individual health and wellbeing. At present, to determine the best course of actions, the "one size fits all" approach is centered on clinical studies that look at broad groups of patients from different backgrounds and with different risk factors.

We are now poised to transition to a new medical paradigm, where the single individual is at the center of a holistic approach. The emerging revolution in healthcare will lead to a medicine with new dimensions: more predictive, preventive, personalized and participatory (P4) Medicine.

Quantifying the wellness and demystifying the disease are the big challenges of the future medicine. Within this frame, the health systems will face radical changes towards a less invasive, more predictive and preventive medicine with tailored therapeutic approaches, thus impacting not only on individual wellbeing but also on social-economic costs.

The aim of WG Health is to identify medical needs, bottlenecks, knowledge gaps and new/emerging technological solutions to overcome the current obstacles, to elaborate scenarios addressing the urgent societal challenges of wellness and healthcare and to design a time-dimensioned Science & Technology roadmap for an innovative medicine based on individual needs.

MAIN OUTCOMES

After a first explorative workshop on "Theranostics for Personalised Medicine" aimed at assessing the impact and potentialities of disruptive and emerging technologies on improving the quality of healthcare in the medium-long term, a second face-to-face (F2F) workshop on "Theranostics for P4-Medicine" was organized. A roadmap for the medicine of the future, starting from the patients' needs, was designed with the participation of Medical Doctors, representatives of public and private research institutions, stakeholders and policy-makers.

The independent international experts agreed that a "creative assembling" of available tools and technologies to develop "personalized smart systems", providing diagnostic and therapeutic options (theranostics) and whole person fingerprint, is the key for the novel P4 medicine. A strong emphasis was put on the need to re-contextualize the concept of disease, viewed as phase transition from equilibrium to disequilibrium states, and on the assessment of the impact that both environmental factors, including exposome, and lifestyle, including nutrition that can modify the gut microbiota biodiversity, have on individual health.

A strong link with WG Food priorities highlights the need to consider the impact of personalized nutrition on personalized healthcare.

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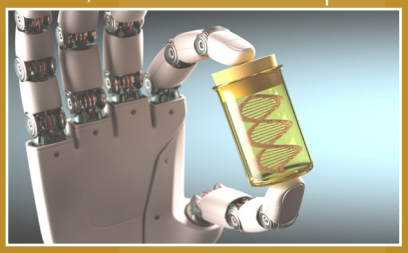
WG MATERIALS

"STEM MATERIALS[1]"

MISSION

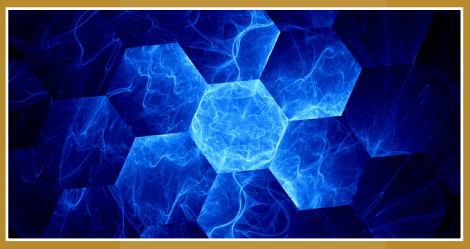
In nature, living organisms consist of a limited number of primary components and chemical bonds, organized in complex systems capable to adapt to diversified environmental conditions. Materials are very rarely adaptable, and often require a large number of components to achieve high performances in specific functions. A comparison between organisms and materials shows that even the approach to their respective life-cycles is largely different, the first renewing themselves in a continuous interaction with the environment, the latter mainly preserving from alterations.

Indeed, materials able to perform different functions and to respond to external inputs will become increasingly important. They will play a fundamental role in the additive production to the extent that they are designed and structured to perform and adapt, without any additional device. Reversing the current manufacturing processes, introducing materials able to perform as sensors and actuators, according to external environmental conditions for fulfilling different requirements, is still a challenge. These intelligent materials should be adaptable in any context and condition, and possibly consist of *primitive units*, containing the minimal and sufficient number of components to perform a basic function. Their *combinations* can respond to specific requests of multi-functionality and adaptability.

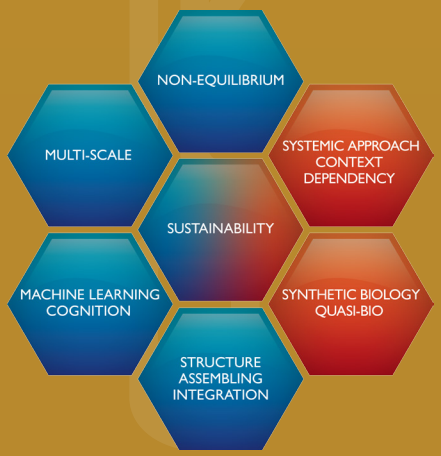


The group aims at identifying the main research gaps and setting priorities towards the development of a breakthrough in this field.

MAIN OUTCOMES



The natural evolution has already selected a machine for building materials, capable to adapt to environmental conditions with widespread functional capacity: the organic cell.
Chemical synthetic biology, as the artificial design and engineering of new "quasi-biological" materials, is providing unprecedented outcomes, but the identification and a general description of simple and "minimal cells/units", providing the union between the informational genome and the three dimensional structure in which it resides, are still lacking.
Recent results in quantum simulations and material science have already allowed to design and to produce new ad-hoc materials, paving the way towards the identification of a "material code". Greater computational capabilities could allow more accurate descriptions of the complex systems, which may provide clues in identifying a paradigm for primitive units and their combinations.
While experiments and analogies seem to drive the advances in this research, the group will address different options to achieve 1) a general and breakthrough mathematical framework for primitive units, as a sort of ribosome of Materials, and their combinations and/or 2) an accurate and flexible empirical framework to satisfy any request for functionality and performance of materials.
In this regard, central (leading/major…) aspects have been selected in order to identify the main research gaps which should be filled towards the "Stem materials" (see figure).



[1]*The adjective "stem", commonly attributed to cells, refers to the use of primitive units which, even if not able to differentiate spontaneously in several other types, undergo a process of transformation aimed to make them capable of adapt to specific requirements.*

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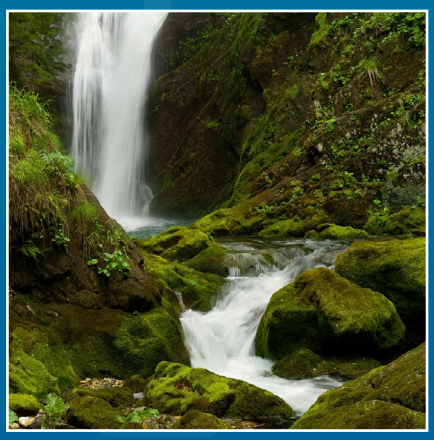
Science & Technology Foresight

WG WATER

"The FUTURE of WATER: AVAILABILITY, DISTRIBUTION AND PROVISIONING"

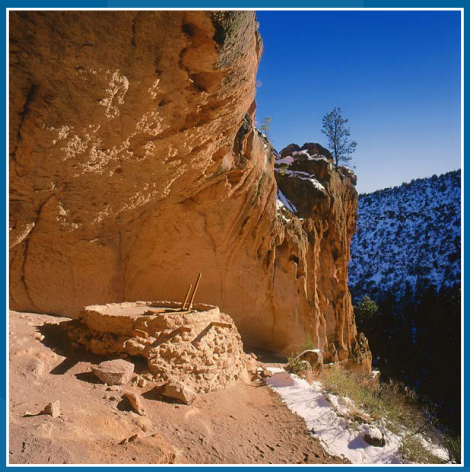
MISSION

Natural resources on Earth are finite, and some of them - such as water - control the fate of societies and human life. If water is scarce, droughts and famine can appear. If water is too much, floods and landslides are expected. Water quality, then, is a crucial element for human health and wellbeing: Organic, chemical or radioactive pollution can make entire water reservoirs unfit for drinking and/or agricultural purposes. For all these reasons, there is widespread consensus that water is one of the essential resources of future decades, whose distribution and availability are exposed to the vagaries of global and climate change. New and more efficient management and distribution systems are required, together with improved ability to desalinize sea water. The increasing human population will put larger pressures on natural water resources, including shallow and deep aquifers. As a result, discussions are ongoing on public versus private water management (a topic with significant implications on environmental policies and the type of society we aim at), on the best approaches to technology transfer to developing countries, and on the contrast between the needs and views of different interest groups. Central to any foresight exercise, the issue of future water quality, quantity, availability and management is a complex arena where science, technology, policy and ethics meet each other, not without clashes. It is to the scientists to develop indications on the best strategies to address these problems, helping to build the future we want.



MAIN OUTCOMES

The topic of future water quantity and quality is central to ongoing discussions at all policy and science levels, as well as to many European and international research, technology and management projects. Here, we adopt a long-term view and address the issue of water in its broadest sense, from changes in precipitation owing to climate and land-use change, to water pollution, effects on soil and ecosystems, the expected dangers of flooding and droughts, the identification of the best management strategies and the related geopolitical hazards.



In April 2016, an exploratory workshop on the theme of future water quality, quantity and management has been organized. As a result, a report and a roadmap on future water has been prepared, and a first Face to Face workshop, discussing the most relevant water questions will be organized.

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