

Overview

The general strategic approach and baseline of the Institute in the General Thematic Area of Clean Energy & Environmental Impacts monitoring and reduction is to perform high quality applied R&D and develop / sustain the respective infrastructure in a concerted effort to take advantage of Greece's climatic conditions and rich potential for Renewable Energy Sources (RES, particularly solar) development and exploitation. Further strategic aims are related to:

- the need to serve the growth of the existing energy – environment industry in the country in a safe and efficient manner (e.g. power generation and chemical industry, hydrocarbons industry, solar thermal manufacturing sector, energy / environmental service providers (mostly SMEs), etc);
- the need to study climate change (through measurements and modeling) and mitigate its effects on a regional scale.
- the need to monitor, analyze and assess the indoor and outdoor air quality, provide detailed characterization of pollution sources and their radiological and health impacts under various conditions (urban, industrial, etc).
- the need to develop analytical protocols and risk assessment methods for existing and new POPs (Persistent Organic Pollutants), to monitor levels in food, environment and population (blood and breast milk), to evaluate human exposure and examine public health issues related to POPs.

Major Objectives / Activities

- [Solar Energy Systems - Renewable Energy Storage – Alternative Fuels and Energy Carriers](#)
- [Air Quality and Climate Change studies](#)
- [Dioxin and dioxin-like compounds analysis and human exposure assessment](#)
- [Safety and Security](#)
- [Other Associated Concepts and Horizon 2020 Priorities](#)

Specific tasks and deliverables

Resources – Critical mass assembly

□ Participating Laboratories / Groups:

- [Solar and Other Energy Systems Laboratory](#)
- [Environmental Research Laboratory](#)
- [Environmental Radioactivity Laboratory](#)
- [System Reliability and Industrial Safety Laboratory](#)
- [Mass Spectrometry and Dioxin Analysis Laboratory](#)

Major accomplishments in this thematic area can be found in the [latest Scientific Report of INRASTES](#).

▣ **Solar Energy Systems - Renewable Energy Storage – Alternative Fuels and Energy Carriers**

Emphasis on Renewable Energy Storage as the only realistic means to achieve high RES penetration and flexibility in RES usage with grid stability:

- Concentrated Solar Power, Solar Thermal Processes at medium / high temperatures and Thermal storage (Phase Change Materials);
 - New energy carriers for efficient long-term storage and transport of energy:
 - Hydrogen for stationary and mobile applications; H₂ production from RES; Efficient and safe H₂ storage in solid materials; Hybrid RES-H₂ integrated systems; Safety assessment of hydrogen and fuel cell applications.
 - CaO looping for on-site renewable energy storage and long distance renewable energy transport.▣
- Solar fuels production using CO₂ as raw material as a way to mitigate carbon emissions (CO₂ and H₂O splitting and conversion to solar fuels, thus moving from Carbon Capture and Storage (CCS) to the Carbon Capture and Utilization concept (CCU)).

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□ **Air Quality and Climate Change studies**

- Evaluation of climate change using global climatic models; dynamic downscaling from global to regional / local scale, in order to assess the environmental (e.g. air quality, land cover), social and economic effects of climate change in the area of Greece and Eastern Mediterranean.
- Determination of air pollution from airborne particulate matter (PM) including a unique in the region (SE Europe) research station for the measurement of climate change related aerosol parameters, integrated into the global database for atmospheric and climatic parameters as part of the Global Atmosphere Watch programme (WMO).
- Assessment of indoor/outdoor air quality and pollutants emissions from industries (measurements of physical properties and chemical analysis of airborne particulate matter, volatile organic and inorganic compounds, isokinetic sampling from industrial stacks.
- Receptor modeling for the identification and quantitative assessment of pollution sources.
- Studies of innovative photocatalytic materials for the removal/oxidation of air pollutants in the urban and indoor environment
- Development and maintenance of state-of-the-art software for simulating atmospheric dispersion and transformations of air pollutants (photochemical, radioactive) in complex terrains from local to regional scales, and for diagnostic and prognostic meteorology.

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Dioxin and dioxin-like compounds analysis and human exposure assessment

The Mass Spectrometry Laboratory has emerged as the National Certified Dioxin Reference Lab holding contracts with the Greek Food Authority as well as providing for-profit services to the major food and agricultural industries of the country. It is accredited according to ISO/EN 17025 by ESYD and participates in the United Nations Laboratories Network for the control of dioxin and dioxin-like compounds in food, feed, biological samples and air.

Main research achievements include:

- Development of new methodology for the determination of dioxins and dioxin-like compounds using GC-MS/MS. Development of analytical methodologies for the determination of persistent organic pollutants (POPs), belonging to the group of dioxins, in environmental, biological and food samples.
- Investigation of the consequences of forest or landfill fires on the environment and agricultural/animal farming products. □ Dioxin contamination of food products and the environment after public landfill fire and forest fire. Preparation of a plan for the management of such cases and application for the protection of public health.
- Environmental problems related to dioxins and dioxin-like toxic compounds in industrial zones. Evaluation of soil and food products for their dioxin content.
- Research on the levels of dioxins and dioxin-like compounds in the blood of professionally exposed individuals.
- Risk assessment of infant dietary exposure to dioxins and dioxin-like compounds. Examination of the contribution of breast feeding, formula milk and solid food to total dietary exposure during the first year of life, based on the results of 10 years of national programs for the control of dioxins in food. □ □
- Development of specific and sensitive analytical methodology for the determination of perfluorinated compounds in various matrices including food, food packaging materials and biological fluids, and correlation with possible health effects.

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□ **Safety and Security**

The long term goal is to establish a Research Reference Facility for Critical Infrastructure Protection (RRFCIP), in order to provide a unique in the country test-bed facility in the field of Critical Infrastructure Protection. It will setup an environment where industrial (and SME) partners will interact with both R&D entities and emergency responders / operators to catalyze the transformation of CIP related research into highly innovative products and services. It is of note that INRASTES is one of the main members of the National Emergency Response Plan's Nuclear Technology Team, in charge of producing prognoses of radionuclides atmospheric dispersion in cases of nuclear or radiological emergencies.

The relevant R&D priorities include:

- Safety of industrial installations with advanced modeling tools; Study of the interaction of human factors in safety and security operations; Enhancing safety in the process industry through virtual reality tools.
- Consequence assessment of Hydrogen and Fuel Cell applications, using the CFD methodology. Releases from both compressed (CGH₂) or liquified (LH₂) hydrogen storage in unconfined, semi-confined or confined environments. Support of Regulation, Codes and Standards. Consequence assessment using the CFD methodology in other application areas, e.g. CO₂ transport, natural gas, LNG, LPG, ammonia, chlorine, Argon installations, etc.
- Decision Support in Nuclear Emergencies: development and maintenance of state-of-the-art software (meteorological and dispersion models) that is included in the European Decision Support System for nuclear emergencies RODOS.
- Risk assessment of interconnected and interdependent heterogeneous critical infrastructures from multiple threats including malevolent acts, technological accidents and natural hazards.
- Nuclear Security which is related to the protection of nuclear / radiological installations providing a holistic concept of operations from prevention (risk assessment) to site physical protection and response to potential incidents. This area will be linked to issues for border protection and illicit transportation of dangerous materials.
- Studies for preparedness and resilience against CBRN terrorism. Radiological dispersion ("dirty bombs") in urban and indoor environments.
- Development and application of unmanned platforms easily deployable both to GRR-1 and off-site applications, using advanced sensor systems and radiation monitoring equipment inherently linked to dispersion and dose assessment models.
- Training (theoretical and hands-on) to interested organizations in the field of protecting critical infrastructures and nuclear / radiological installations.

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□ **Other Associated Concepts and Horizon 2020 Priorities**

Besides the general request for safe, clean and efficient energy processes, the above outlined framework of activities relates closely to additional Concepts and Priorities at international level and particularly with regard to Horizon 2020. These include among others:

- Smart Cities and Green Mobility;
- Transition from the Carbon Capture and Storage (CCS) approach to Carbon Capture and Utilization (CCU);
- Green Autonomous Energy Systems for non-connected to the grid applications (e.g. Green Islands and Isolated Communities);
- Climate Change Impacts at Regional level and Mitigation;
- Novel efficient and clean Energy carrying systems for on-site storage and long distance energy transport.

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□ **Specific tasks and deliverables**

- Solar-energy systems and techniques for the exploitation and storage of solar thermal energy at high and low temperatures, as well as methods for the characterization and certification of energy products.
- R&D on hydrogen production from concentrated solar (thermochemical water splitting, photocatalytic processes); Performance and simulation of hybrid RES-H₂ systems integrating the whole chain (renewable energy powered electrolysis, storage tank, H₂ re-electrification devices (fuel cells) or H₂ internal combustion units); H₂ storage in physisorbing and weakly chemisorbing solid materials (carbon based, MOFs, nanostructured composites, doping and scaffolding techniques); Computational Fluid Dynamic (CFD) tools development and validation for H₂ safety assessment. Stationary (autonomous power systems, etc) and transport (mobile and portable) applications.
- Tracer technology for advanced characterization of underground (hydrocarbon or water) reservoirs. Multi-scale (from nano- and meso-scopic simulations to macroscopic property estimation) simulation of multi-phase transport processes in porous and composite media for the assessment of performance in connection to structural parameters and properties in energy, environmental and biomedical applications (inorganic and biological membranes, CO₂ separation and capture, gas sorption and selective separations, etc.).
- Integrated methodologies and computational tools for the assessment and management of risks related to technological systems, extreme weather phenomena, as well as new emerging technologies such as nanotechnology. Methodologies for quantitative occupational risk assessment and methods for the optimum selection of mitigation measures in any working environment.
- Risk assessment and consumer protection from dioxins and new persistent organic pollutants such as flame retardants and perfluorinated compounds. Exposure to POPs, belonging to the group of dioxins and perfluorinated compounds and public health. Identification of exposure routes, quantification of human levels and creation of National Reference Database (levels in blood, breast milk, etc) for the Greek population. Correlation with observed health outcomes. Risk assessment of dietary intake of dioxins and dioxin-like compounds through consumption of Greek farmed fish and evaluation of the safety of Greek farmed fish for public health. This study will be based on the results of 10 years of national programs and collaboration with major Greek aquaculture facilities.
- Simulation models of atmospheric dispersion of hazardous pollutants and methodologies for the determination of optimal response to emergencies. Software on an operational basis for weather and air quality prognosis and for studies on climate change and its local impact. Inverse modelling computational methods for the determination of location and intensity of an unknown hazardous substance release combining observations and model results.
- Methods for the determination of air pollution from airborne particulate matter (PM) including a research station for the measurement of PM parameters, integrated into the global database for atmospheric and climatic parameters (GAWEBAS).
- Aerosol technology for detailed physical, chemical, optical and radiological characterization of airborne nanoparticles with applications in radiation protection, atmospheric science, human health, climate change and nanomaterial research.
- Computational Fluid Dynamics (CFD) Code research and development (ADREA-HF) for realistic local scale 3D transient simulation of release, dispersion and combustion phenomena of multi-component, multi-phase mixtures of the released substances with air, for variable atmospheric conditions and any layout geometrical complexity. Turbulence modeling either using RANS or LES models.

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□ **Resources – Critical mass assembly**

- Experience and infrastructure (in terms of expert staff and advanced facilities) developed over the last decade as a result of European and National projects.
- Currently running projects on solar and hydrogen technologies and newly (within 2013) approved for funding projects (EC, QNRF, GSRT) on new energy carrying systems, hydrogen stationary applications, gas capture /separation and transport using hydrates.
- Proposal submitted to GSRT for the establishment (and inclusion in the national RI roadmap) of an advanced RI on Concentrated Solar Power for sustainable energy production and storage, solar fuels and thermochemical processes.□ This national level facility will play a major role in integrating and sustaining a set of activities ranging from solar thermal to CO2 capture and conversion to solar fuels production. The efficient conversion of CO2 into high?energy?density fuels for stationary applications and land, sea, and air transportation would increase the viability of renewable energy sources, including concentrating solar thermal.
- Intense service provision to public and private entities in the fields of food safety / air quality / materials characterization / solar energy systems qualification / occupational risk assessment / safety studies.
- The recently started Regional Potential Development (RegPot) ENTEC project, a large scale undertaking awarded to the Environmental Laboratories of INRASTES in recognition of their excellence in research and service provision and with the aim of enhancing their R&D potential by upgrading and expanding their infrastructure, employing high level staff and acquiring advanced tools in the fields of climate change, air quality, energy technology impacts assessment and mitigation.

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