European Cooperation in the field of Scientific and Technical Research - COST -

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COST 087/14

MEMORANDUM OF UNDERSTANDING

Subject :	Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action CM1404: Chemistry of Smart Energy Carriers and Technologies (SMARTCATS)

Delegations will find attached the Memorandum of Understanding for COST Action CM1404 as approved by the COST Committee of Senior Officials (CSO) at its 191th meeting on 12-13 November 2014.

MEMORANDUM OF UNDERSTANDING
For the implementation of a European Concerted Research Action designated as

COST Action CM1404
CHEMISTRY OF SMART ENERGY CARRIERS AND TECHNOLOGIES (SMARTCATS)

The Parties to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 4114/13 "COST Action Management" and document 4112/13 "Rules for Participation in and Implementation of COST Activities", or in any new document amending or replacing them, the contents of which the Parties are fully aware of.

2. The main objective of the Action is to create a European-wide network for addressing the "grand challenge" of matching the most promising Smart Energy Carriers with the advanced technologies for fuel flexible, low-carbon intensity and distributed energy generation strategies.

3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 84 million in 2014 prices.

4. The Memorandum of Understanding will take effect on being accepted by at least five Parties.

5. The Memorandum of Understanding will remain in force for a period of 4 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of Section *2. Changes to a COST Action* in the document COST 4114/13.

A. ABSTRACT

The primary aim of this COST Action is to create a Europe-wide network of world leading academic and research institutions and key industries to promote the use of Smart Energy Carriers (SECs) on a large scale in order to increase fuel flexibility and carbon efficiency of energy production and to support distributed energy generation strategies. The approach to accomplish this aim is twofold. On the one hand, academic/research organizations will devote strong efforts to bring together fundamental/advanced numerical and diagnostic tools to improve the understanding of combustion kinetics and by-products formation of SECs at micro/meso-scale levels. On the other hand, the intended exchange between academic and industrial partners will support the optimization of tools developed in the Action exploiting the way that SECs could be utilised at the macro-scale in advanced combustion technology devices. This interaction will lead to the identification of standards and criteria for the development of a searchable database and internet tool devoted to integration of experimental and numerical combustion chemical/physical data which will provide easy access to information relevant to SECs components.
Keywords: Innovative and sustainable fuels, Detailed and reduced chemical kinetic models, Pollutants diagnostics and reduction, Advanced combustion technologies, Flow-chemistry interaction.

B. BACKGROUND

B.1 General background

A safe, secure and environmentally-friendly energy supply is among the highest priorities and concerns of contemporary society. Combustion of conventional and alternative fuels which accounts for about 80% of total gross energy production in Europe, has to develop because of:
- a complex geo-political situation with multiple influences on fuel availability and security of supply
- the long-term objective of building up a low carbon society
- the opportunity offered by the growth of cyber-physical applications and their effect on smart energy distribution and utilization grids
- the ecological drives or incentives.

On this basis, the greatest challenge that the combustion-based energy industry has to face in the next few years is the urgent need for:

- maximum *fuel flexibility* of combustion technologies;
- minimization of *greenhouse gas (GHG) emissions*;
- adjustment of *distributed energy production*.

Fuel flexibility has been for a long time a common requirement of combustion system design, primarily for covering commercial needs (e.g. adapting power plants to local fuel availability). Nowadays fuel flexibility is a prerequisite to face a fast changing fuel market and an increasing number of energy carriers available in the local market, mainly due to the increased penetration by renewable and unconventional energy sources. Mitigation of *Greenhouse Gas Emissions* to the atmosphere is a central priority of the EU Framework Programme for Research and Innovation Horizon 2020. It currently appears that a multifaceted approach, encompassing highly efficient low-carbon technologies coupled with medium-term emission containment (e.g. Carbon Capture and Storage/Utilization), will have to be pursued in order to avoid potentially catastrophic climatic consequences. The realization of a *new energy production and distribution system* based on smart grid concept is often seen as a possible straightforward option for developed countries. Also, the ecology movement would be more prone to accept the build-up of a strongly delocalized energy system as an alternative and a more eco-compatible development model.

All these factors call for the characterization, specification and proper utilization of new "*Smart Energy Carriers*" (SECs). This category includes conventional and novel energetic molecules from alternative or conventional (re)sources, selected on the basis of their best available production and/or utilization technologies. Accordingly, to be considered "smart" an energy carrier and related technologies must be energetically and CO_2 efficient and able to provide the most suitable energy mix to meet the intermittency of renewable energies, to exploit varying and locally diverse sources and to satisfy the requirements for eco-compatibility and sustainability. SEC**s** are strong candidates as possible solutions for energy storage, transfer and transformation from renewable (wind, solar, biomass, wastes) and unconventional sources (e.g. shale gas). SEC**s** include a wide range of compounds like aliphatics, oxygenates (alcohols, esters, ethers) as well as olefins, naphthenes and their mixtures with diluents (CO_2 and H_2O). As a consequence, energy conversion systems have to face an increasing variety of smart carriers that change their characteristics depending on the available source. Even though tailor-made fuel technologies are under development, feedstock and fuel processing variability influences fuel properties in a complex and sometimes unpredictable way.

To meet the aforementioned needs, advanced combustion technologies for energy and power generation in the industrial, domestic and transport sectors are required. Such technologies have to be fuel-flexible and able to achieve high efficiencies, often operating under conditions (low/high temperatures, extreme lean/rich/diluted charges, high pressures, fuel blends for reactivity control) that are significantly different from those of conventional combustion modes. A new knowledge has to be built to make SEC**s** and new combustion technologies usable in an efficient and sustainable way.

WHY A COST ACTION: The growing volatility of world's economies and politics which has characterized the past decades, in combination with increasing environmental concerns, has strongly affected and modified the fuel portfolio. Energy conversion technologies, from small/domestic-scale to large-scale power conversion systems to engines, must be able to respond in a timely fashion to this variability while satisfying, efficiently and sustainably, the energy needs. Generation of detailed data in combustion science requires the collaboration of scientists and engineers working on diverse fundamental and applied experimental techniques and employing diverse analysis methods. At the same time, the development of advanced combustion systems for use in practice sets requirements on the type and accuracy of combustion data. The formation of an extensive network facilitates collating all the data, and at the same time provides a critical forum to assess the needs of the end users.

Europe has a highly productive and scientifically visible combustion community, encompassing several groups with strong expertise in experimental, theoretical, and numerical simulation approaches. Advanced fuel and combustion chemistry research projects are often funded in Europe. What is missing is a systematic European-funded effort supporting contacts and networking. While EU and national programs are funding advanced fuel and combustion chemistry research, none of these covers European networking. The SMARTCATS Action aims at filling this gap, building an effective network aimed at preserving the role of the European economy and its energy industry, exploiting the benefits of COST Actions. A COST Action is the *best available framework* to establish a virtual knowledge centre with great flexibility and rapidity covering the chemical and technical expertise dealing in the conversion of SECs.

B.2 Current state of knowledge

Chemistry plays an ever-increasing central role in the combustion process of advanced energy conversion technologies. Knowledge of chemical mechanisms is the key issue to ensure that energy conversion systems fit to the requirement of efficiency and environmental sustainability. Over the past fifty years, great efforts have been devoted to an understanding of the mechanisms of fossil fuel combustion at a molecular level, from simple to more complex systems. Countless experimental data have been collected on reference experiments on molecules that represent standard fossil fuels and numerous detailed numerical models have been developed. These models currently attain a certain level of reliability even though there are significant uncertainties even for fundamental global properties (such as laminar flame speeds). Moreover, there are significant differences between existing mechanisms from different research groups – both in the number and type of elementary chemical reactions they employ and in the quality of their predictions against both global combustion parameters and speciation profiles.

Looking at a wider palette of SEC candidates (especially to bio-derived oxygenated fuels), their detailed chemical mechanisms are still in the early stages of their development. For example, large amount of data in the literature concerns linear and branched C1-C5 alcohols, a class of molecules candidates for building SECs. With the support of recent advances in experimental diagnostics, semi-predictive models have been made available. However, more accurate kinetic parameters and experimental results are desired for engine conditions, including higher more energy-dense alcohols. Particular attention has been devoted to 2,5 dimethylfuran (DMF), a promising second-generation biofuel candidate with a high octane number. Based on quantum chemical calculations, mechanism has been developed that represent the initial DMF consumption and reproduce only the main features of its oxidation.

A further issue relates to pollutants formation. The changes in fuel palette modify the major chemical routes to unwanted combustion products. In spite of their oxygen content a surprisingly high sooting tendency of some furans was noted, while computational studies did not show a significant effect of these fuels on NO chemistry. On the other hand NOx chemistry is strongly affected by diluent species (CO_2 and H_2O). Moreover, during lean combustion of oxygenated fuels toxic oxygenates tend to increase. It has been noted that in this context the role of trace species (present in bio-derived fuels) becomes very important not only as pollutants but also as potential inhibitors or promoters of the combustion process. Such issues are currently largely unexplored and significant experimental, theoretical and modelling work is required.

New technologies are indeed designed to operate under conditions – such as low temperatures (e.g. Low-Temperature Combustion), extreme lean and/or rich mixture, stoichiometries (Rich Quench Lean), high dilution (e.g. MILD/flameless combustion), high pressures, homogeneous and kinetically-controlled (e.g. Reactivity Controlled Compression Ignition) etc. – that are significantly different than those encountered in conventional combustion modes. For example, recently it has been well assessed that the presence of diluents, required for temperature control and pollutant mitigation or the use of low-energy fuel leads to failure of the consolidated kinetic models in predicting efficiency and environmental impact. This problem is also connected to the reduction of the large size of detailed kinetic mechanisms used to allow the simulation of complex systems with a reasonable computational load. Significant shortcomings still persist in these reduced mechanisms when predicting fuel oxidation not only in advanced combustion technology systems but also under standard conditions.

B.3 Reasons for the Action

The fast and tumultuous evolution of world political and economic scenarios, even more pressing in the last decade and worsened by high environmental concerns, strongly influence and repeatedly modify the global fuel portfolio. Energy conversion technologies, from small/domestic scale to large power conversion systems as well as to engines, have to provide practical answers to such a variable market while satisfying the energy needs with efficiency and sustainability.
There is not a unique approach capable of addressing such a formidable challenge. The only feasible strategy is to build a competent and knowledgeable network of leading scientists and laboratories sharing their tools and expertise in chemistry and technology of the SEC's oxidation. The natural flexibility and speed of information exchange in a networked community will enable proper coordination and synergy of the many isolated efforts and will ease technological transfer toward industrial stakeholders.
The objectives of the Action are perfectly in line with the decarbonisation of the energy system, through increased efficiencies, renewable sources and new energy production technologies, fostered by the Horizon 2020 Programme. As a matter of fact, SECs (unconventional, renewable and bio-based fuels) are key to the realization of a low CO_2 producing, low emission and truly efficient energy production and utilization chain.
This Action aims at providing a collaborative academic/industrial framework that has the potential to fill the gap towards effective, large scale utilization of SECs, gathering together many groups across Europe and worldwide, working individually on smart carrier kinetics and on advanced combustion technology.
The objectives will be pursued by integrating advanced diagnostic tools, predictive models and standardized validation experiments at the micro-scale (elementary kinetics and thermochemistry), the meso-scale (physicochemical properties and metrics in controlled laboratory environments) and the macro-scale (utilization at an industrial level) under a common platform, both for a better understanding of the new chemistry of the SECs and for their utilization on a large scale.
The final outcome of the activity will be included in a database of advanced detailed and reduced models with their experimental validation data. This body of knowledge aims to become a reference for:

- the tune-up of existing technologies to allow them to use new energy carriers;
- future development of both fundamental and applied research as well as the design of innovative combustion systems.

B.4 Complementarity with other research programmes

SMARTCATS will complement and valorise knowledge generated within the Heat Flux Burner network which deals with the development and application of a novel experimental methodology for the accurate determination of a fundamental combustion property (the laminar flame speed) of conventional and alternative fuels.

The SMARTCATS project complements research performed in the 2G-CSafe European Research Council Advanced Researcher Grant representing its upgrading to a wider European dimension (with the involvement of a large number of European laboratories, with the extension to a much larger range of combustion technologies, types of fuels, experimental devices and computational methods).

Similar complementarities exist with the BioRedKat and BioEng projects. The ESF BioRedKat project final objective is the design of an optimized catalyst for biofuel (ethanol) combustion. The BioEng project quantifies performance and emissions from internal combustion engines operated on 2nd generation biofuels aiming to enhance the development of Nordic R&D institutions and businesses in the field. SMARTCATS aims to expand and favour coordination of activities and results of these projects on a wider European scale.

C. OBJECTIVES AND BENEFITS

C.1 Aim

The main objective of the Action is to create a European-wide network of high calibre academic, research and industrial partners capable of addressing the "grand challenge" of matching the most promising SECs with the advanced energy conversion technologies for the 21st century. This is by itself a relevant objective to keep European science and technology at the forefront of the world scene. In this sense the expected deliverables of this Action will be both validated numerical models, based on novel chemical kinetics tools (models, mechanisms and kinetic database), and advanced diagnostics ready to be applied to technological processes design and control. This Action is expected to significantly increase the already outstanding level of basic and applied knowledge of the European research institutions and industries in the field of combustion and energy.

C.2 Objectives

At the scientific level the secondary objectives of this Action are:
Improvement of kinetic models: Extend experimental databases (elementary reaction rate and validation data) over unconventional conditions typical of innovative combustion processes. Extend the detailed chemistry and thermochemistry oxidation knowledge from fossil toward unconventional and bio-based energy carriers. Optimize chemical kinetic models for simulation of SECs combustion processes (high-pressure, high inlet temperature, massive dilution, multi-component fuels, etc.).
Improvement and development of new diagnostic tools: Develop/optimize innovative diagnostic tools and procedures for identification and quantification of chemical intermediate/markers in SECs combustion. Adapt advanced diagnostics to complex systems (e.g. engines, furnaces, household applications, etc.).
Pollutants monitoring and control: Compile inventories of pollutants emitted from the combustion of SECs in practical systems. Increase understanding of the kinetics of combustion by-product for a sustainable use of SECs. Assess control strategies for the mitigation of pollutant formation and emission. Develop tools to detect and quantify chemical, physical and morphological properties of combustion-generated pollutants, particularly of particulate matter.
Data collection, sharing and use: Define specific set of prerequisites and goals for the establishment of an efficient and scalable architecture of a combustion chemistry, experimental and numerical database. Identify a widely accepted, from both experimentalists and modellers, set of "model experiments" and measurables to be assumed, after a detailed side-by-side experimental and numerical validation procedure, as a representative dataset. Define widely accepted criteria for objective evaluation of accuracy and reliability levels of combustion chemistry datasets.
Knowledge transfer towards technology application: Integrate detailed kinetic mechanisms in large scale numerical simulations. Develop reliable, widely applicable and affordable turbulence/chemistry interaction models. Develop methodologies to constructively couple simulations and experiments, to provide estimates of the uncertainty related to numerical predictions.

At network level the objectives of this Action are (not in order of relevance):
Scientific Cooperation: bring together the leading European research groups across combustion-

related disciplines.

Strong Industrial Cooperation: on the ground of strong industrial participation in the Action, ensure an intense knowledge transfer between the two sectors with increased benefits for European technological excellence.

Promotion of entrepreneurship: on the basis of strong industrial participation, the SMARTCATS Action will act as an incubator of new ideas and inspirer of entrepreneurial activities.

Submission of New Common Proposals: SMARTCATS will provide the framework for initiating possible common proposals for the EU Framework Programme Horizon 2020.

Increase of Competitiveness: promote the competitiveness of European academic and industrial partners in the field of SECs at a global level.

Interaction with Policy Makers: increase awareness of policy makers to the output of the Action and the potential risks and benefits of introducing SECs in the European energy market.

Interaction with European platforms: make the acquired knowledge and experiences on the use of SECs available for interested European platforms to support strategic development and identify research and innovation bottlenecks and opportunities.

Scientific Training: train young scientists and engineers from the industry in a strongly interdisciplinary field of science easing the establishments of a cooperative attitude.

Dissemination: establish dissemination channels to communicate the output of the Action to the wider scientific and engineering communities.

Improve the gender balance: attempt to make the field more attractive to female researchers by highlighting the leading role played by women in this Action and ensuring that all committees etc. adhere to the most positive gender balance possible.

C.3 How networking within the Action will yield the objectives?

The COST framework will be fully exploited to support the accomplishment of the Action objectives: meetings, seminars, workshops, training schools, dissemination towards academia, industry and the general public, creation of public website, use of social media, exploitation of Short-Term Scientific Missions (STSMs) to foster collaboration between groups and enhance skills particularly among Early Stage Researchers (ESRs). Scientific Missions of ESRs to industrial groups will be actively promoted. This will increase the entrepreneurial skills of ESR and augment the possibility for the Action to become an incubator for future start-ups and spin-offs. Every effort will be made to achieve gender balance.

The set-up of a collaborative network and the definition of requisites of a thermochemical database are the specific objectives of this Action. To this aim the usage of advanced communication and sharing tools (also by exploiting social media and networks) will be strongly promoted to multiply the opportunity of interaction and accompany the establishment of long term multi-lateral collaborations.

C.4 Potential impact of the Action

The successful completion of the Action will have a positive impact on European society, on European industry and on the European scientific and technological community. The high participation of industry in the SMARTCATS Action strengthens its technological and strategic impact.

Benefit for scientific research: Defragmentation of European research efforts. Increase the competitiveness of research communities through collaboration. Preparing highly professional and entrepreneurial young researchers. Develop efficient means to evaluate and exploit combustion chemistry data. Improve the accuracy of theoretical, experimental and numerical tools in the field of combustion chemistry.

Benefit for industry: Enhanced knowledge transfer between research and industrial communities. Advancing European industrial competitiveness in the industrial, power and transport sectors. Facilitate the development of more efficient and cleaner combustion devices and processes.

Benefit for society: Consolidation of new knowledge on sustainability potential of new, smart and alternative energy carriers and related technologies. Provision/development of tools for policy makers and all relevant stakeholders for better definition of energy supply policy. Quantification of the environment and human health impact deriving from the use of smart/alternative fuels.

C.5 Target groups/end users

Target groups:

Scientists and engineers, particularly Early Stage Researchers, who are either active or who have an interest in the fields of fuel processing and utilization, energy conversion and environmental protection. Since no single laboratory or research group in Europe currently has the capability to study the whole issue in all its infinite variety, the formation of strong persisting links across national boundaries and across disciplines is a vital element of this Action.

End users:

The end users of this Action will be scientists and engineers working in automotive, propulsion, power generation and manufacturing industries of Europe. These industries are economically extremely important to the European economy and are under a constant unremitting challenge both from competitors in the Far East and from new regulations framed by legislators.

D. SCIENTIFIC PROGRAMME

D.1 Scientific focus

The main objective of the SMARTCATS Action is to integrate advanced diagnostic tools, predictive models and standardized validation experiments at the micro-scale (elementary kinetics and thermochemistry), the meso-scale (physical-chemical properties and metrics in controlled laboratory environments) and the macro-scale (utilization at an industrial level) under a common platform to improve the understanding of SECs and novel combustion technologies from the small/domestic to the large/industrial scale.

SMARTCATS fosters the establishment of a collaborative and open network between Action members and the free exchange of information obtained under publicly or privately funded research projects. These will be accomplished through: annual meetings to monitor/review the progress of the Action, seminars, workshops and training schools in order to provide scientific and technical training and to facilitate exchange of knowledge, exploitation of Short-Term Scientific Missions (STSMs) aiming to foster collaboration between research groups and enhance knowledge and skills particularly among Early Stage Researchers (ESRs), dissemination towards academia, industry and the general public also with Newsletters distribution, creation and maintenance of a public website promoting SMARTCATS activities, development of an interactive internal knowledge and communication platform also exploiting the possibilities offered by social media. Every effort will be made to ensure maximum participation of ESRs and achieve gender balance.

D.2 Scientific work plan methods and means

A significant *innovation and originality* in the SMARTCATS Action relies that it considers a holistic approach to the advancement of knowledge on SECs potentials and drawbacks, covering all aspects of the problem from more fundamental to applied ones. In addition, SMARTCATS aims to achieve this result by exploiting combined theoretical, numerical and experimental investigations in the micro-, meso- and macro-scale in the framework of an extensive network, bringing together researchers from academia and industry. There is also significant originality in the integration of

tools and methodologies from the Information and Communication Technology (ICT) community to create and exploit valuable databases that will be utilized long after the completion of the Action. Nevertheless, the core of this Action remains in the development of oxidation kinetic mechanism for new classes of fuels having the potential to become SECs capable to sustainably meet the future energy demand. It addresses this task starting from the already relevant competences of involved research institutions and exploiting the capabilities of increasingly powerful diagnostics tools, in particular for their capabilities to identify and quantify pollutant emissions.
The success of this Action will be measured by the capacity of realizing a significant transfer of knowledge and competences toward their practical application. This transfer must necessarily be guided, through the definition of appropriate standard and tools, by the final users of the chemical and diagnostic tools that are the designers and the manufacturers of combustion systems and plants. The huge amount of experimental and numerical data cannot be efficiently transferred without resorting to advanced information and communication tools. A specific part of this Action is devoted to the analysis and definition of requisites, to the identification of available commercial tools and, in particular, to the realization of a cyber network among scientist and engineers interested to the study and application of SECs.

According to this methodology the SMARTCATS work programme is structured in five Working Groups (WG) whose main objectives and expected results are reported in the following.

WG1. Smart Energy Carriers gas phase chemistry: from experiments to kinetic models
The work in WG1 aims to improve the knowledge on detailed chemistry and thermochemistry for the combustion, pyrolysis, and oxidation of fuels, such as:
- Natural gas mixtures (compressed natural gas, liquefied natural gas, syngas natural gas, bio-methane),
- Simple molecules (large normal and iso-paraffins, alcohols, esters, saturated and unsaturated cyclic ethers (e.g. derivatives of furans)) which can be present in 1st and 2nd generation biofuels,
- More complex molecules, such as the polymers which can be obtained from wood as lignin, cellulose, and ligno-cellulose, and derived molecules, such as γ-valerolactone,
- Complex mixtures of molecules actually found in 1st and 2nd generation biofuels, such as fatty acid methyl esters (FAME), hydrotreated vegetal oils (HVO), or biomass to liquid fuels (BTL, obtained by gasification followed by Fischer-Tropsch synthesis), or in the proposed surrogates, i.e. mixture of simple molecules whose oxidation mimics that of the real fuel.
The oxidation chemistry of some of these biofuels, like FAME, has been already investigated but

for others the knowledge is only partial, as in the case of HVO and lignin. Chemical characterization is indeed a difficult task mainly in the case of biomass derived fuels. Lignin, as an example, is a complex racemic polymer, whose composition varies according to biomass source. The Action aims to fill the gap with the improvement of the existing detailed kinetic models as well as the development of new ones, thanks to the availability of new experimental data and the easier accessibility to quantum chemistry computation for thermodynamic and rate constant estimation. One of the main difficulties in all these cases is related to the large dimensions of the resulting detailed kinetic models, due to the high molecular weight of the species and the lack of symmetry, inherent in such molecules. A general approach will be to start from automatic generation and subsequently adopt proper simplifying rules, like chemical lumping, to control the total number of species, which could make the global scheme impossible to manage. Several software programs already exist in Europe for the automatic generation of mechanisms for components of HVO and FAME. Their possibilities need to be extended. Experimental investigations will be performed in well characterized laboratory combustion environments for ignition (shock tubes and rapid compression machines), flames (laminar premixed and diffusion), and pyrolysis/ oxidation (plug and stirred flow reactors). Experimental data at higher pressures are particularly needed, such as ignition delay times (at pressures > 40-50 atm) and flame speeds (at 20 atm or more). Also the effects of multicomponent mixture, and of diluents, especially CO_2 and H_2O, and Exhaust Gas Recirculation will be considered.

These models require thermodynamic and kinetic parameters of included elementary reactions. The key strategy will be the establishment of close collaborations between experimentalist and theoreticians. Theoretical analysis will use modern quantum chemical methods (e.g. density functional theory or coupled cluster methods). Kinetic data are to be obtained from advanced statistical rate theories (e.g. Rice-Ramsperger-Kassel-Marcus theory and master equations). A particular effort will be devoted to use these theoretical methods to derive data for molecules of increasing size.

In addition to their comparison against a range of experimental studies, a critical part of the evaluation of chemical mechanisms for the prediction of combustion products is uncertainty analysis. This investigates the uncertainty in the model output given defined uncertainties in the model input parameters. These can include for example, reaction rate constants, as well as thermodynamic and transport properties of key species. If enough information is available about the model inputs, uncertainty analysis can be used to provide error bars on model predictions.

WG2: Chemistry for control of by-products in Smart Energy Carrier conversion

WG2 aims to **i**ncrease knowledge on the formation of organic and inorganic combustion by-products in order to improve the sustainability of SECs. The use of unconventional fuels in combustion processes may significant alter quality and quantity of the emitted pollutants with respect to standard fuels. The pollutant tendency of smart energy carriers will be studied by tracing pollutant species typically formed in combustion (carbon monoxide, unburned hydrocarbons (UHC), polycyclic aromatic hydrocarbons (PAH), aldehydes, NOx soot and nano-particles) as well as other classes of pollutants possibly originating from SECs.

The introduction of alternative biofuels, sometimes with significant oxygen content, can result in significant aldehydes emission. Oxygenated pollutants emissions will be more pronounced in the case of advanced technologies operating at low temperatures and premixed conditions. Likewise, trace impurities typically contained in biomass-derived biofuels may either condense into the formation of highly toxic by-products such as chlorinated dioxins and furans, whose chemistry by the way is also poorly understood, or can cause operational problems such as deposit formation.

WG2 will aim towards:

1. increased understanding of pollutants chemistry, through the development of more accurate chemical models and well-targeted fundamental experiments,
2. creation of an inventory of noxious emissions from conventional and advanced combustion devices mainly operating on alternative and sustainable fuels.

The WG2 activity will be focused on the less understood aspects of the pollutant formations that is the formation of soot and nanoparticles. This is an important concern in the combustion of conventional fuels which could be even worsened by the use of alternative fuels. Kinetics of (oxygenated) polycyclic aromatic hydrocarbons, soot and nano-particle formation/destruction in smart carrier conversion as well as their morphological, physical and chemical characterization will be the main issues considered. Although much progress has been made in the last decades, the detailed mechanism of PAH growth and soot inception still remains largely unresolved. The surface chemistry of the soot particles is another topic insufficiently understood. This prevents the development of accurate detailed surface models of particle growth and oxidation as well as the relevant thermochemistry governing the processes of interest. WG2 will aim to consolidate current knowledge and provide directions for further research in those issues.

It is currently ascertained that the soot particle size distribution (PSD) and its chemical composition are more important, at least from environmental and health points of view, than soot particle mass. It is suggested that the combustion of new fuels in novel combustion modes may result in totally different soot typologies. Detailed modelling of soot PSD, chemical composition and morphology based on advanced imaging and analytical experimental techniques and on advanced simulation tools including molecular dynamics and nano-structural representations is an exciting area of research currently at its infancy. WG2 aims to provide a framework of collaboration to support such efforts.

On the other hand, new combinations of trace species and pollutants may become relevant and, possibly, give rise to novel possibilities for active control of combustion by-products. These issues are largely dependent on the interaction of hydrocarbon chemistry with trace elements - currently poorly understood - which will be also an active area of research in WG2.

WG3: Chemical and optical advanced diagnostics for Smart Energy Carriers conversion monitoring

WG3 aims to provide a forum for the development and evaluation of diagnostic tools and procedures ranging from elementary reaction rate determination to real time measurements in practical devices. This WG strengthen the exchange of expertise on advanced diagnostic techniques that are a prerequisite to the investigation of SECs and technologies.

Advanced optical diagnostics combined laboratory combustion devices, such as model flame burners with well-defined boundary conditions, are a key element to analyse combustion processes and to study the complex multi-dimensional interaction between fluid mechanics and chemical kinetics. In the last decades, several optical diagnostics, especially laser-based techniques, have been developed and in recent years systematically improved to allow the study of elementary chemical combustion reactions. Optical techniques provide in principle a tool to observe the spectroscopic states of molecules and atoms with high spectral and spatial resolution. Optical techniques combine the advantages of high spatial and temporal resolution and allow sensitive and selective species measurements with little influence to the reacting system. On the other hand, they often cannot provide a comprehensive chemical analysis of the mixture composition of a reacting system. Consequently, optical diagnostics need to be complemented with sampling procedures coupled to powerful analytical techniques, such as gas chromatography (GC) and mass spectrometry.

Because reacting systems are highly sensitive to perturbations by sample extraction or very high-power lasers, it is important to apply several complementary methods, and assess the relative effects of each technique on the measurement. Furthermore, multiple measurements of different parameters are essential because a multitude of interdependent factors are fundamental to the understanding of chemical kinetics and by-product formation in combustion processes. For these reasons different advanced diagnostics, including both non-intrusive optical techniques, like Rayleigh, Laser Induced Fluorescence, Coherent anti-Stokes Raman Spectroscopy, Raman, Laser Doppler Anemometry,

Particle Image Velocimetry, differential mobility based sizing techniques, and absorption spectroscopy (as the ultra-sensitive and quantitative Cavity Ring-Down Spectroscopy technique), as well as intrusive techniques, including GC, photoionization mass spectrometry (PIMS) and photoelectron-photoion coincidence spectroscopy (PEPICO) will be applied, adapted within the WG3 and further enhanced to address the scientific and technological issues of SMARTCATS with the objective of obtaining combined flow field and scalar field measurements (temperature and chemical species concentrations) with different methods for selected reference cases.
For example, PIMS using vacuum-ultraviolet radiation from a synchrotron source has proven to be an exceptionally powerful tool to investigate the chemistry in laminar premixed flat flames, thermal or photolysis reactors, as well as for determining branching ratios of chemical reactions, including isomers identification. In subsequent and ongoing collaborative efforts, other combustion-related experiments are developed to take advantage of synchrotron radiation. In the case of the implementation of PEPICO, the work is for the first time being conducted at European synchrotron facilities.
The work in WG3 aims to improve the knowledge on advanced combustion diagnostics, with a strong focus on technology transfer from fundamental to complex systems, and focuses on:

- advanced sampling and chemical analysis diagnostics,
- laser-based and mass-spectrometric diagnostics in fundamental combustion devices and chemical kinetics experiments,
- elementary reaction rate measurements, including kinetics experiments on elementary reactions at very low collision energies as they allow to test the most accurate quantum chemical calculations,
- chemical markers for combustion performance characterization,
- combustion and emission measurements in complex systems (engines, furnaces, household applications, etc.).

An additional objective of WG3 will be the analysis of global "integral" combustion properties in model flames and in complex systems. These global parameters, like the laminar burning velocity or the ignition delay time, are enormously important chemical kinetics combustion mechanisms validation in different conditions. Therefore, various flame velocity measurement methods (heat flux burner, spherical bomb, counterflow burners) will be integrated in the framework of WG3 and the expertise of the researchers involved will be combined.

WG4: Standard definition for data collection and mining toward a virtual chemistry of Smart Energy Carriers

WG4 aims towards the identification of the main requirements and tools for the development of

databases, software and mathematical tools for data collection and handling as well as chemistry optimization using data mining techniques. Definition of "crucial" experiments and simulations, uncertainty and sensitivity analysis in combustion modelling will be key issues to be considered. WG4 will significantly improve the state of the art promoting:
- definition of specific sets of prerequisites and goals for the establishment of a combustion database that will allow efficient electronic communication of combustion-related data,
- definition of critical raw, experimental and numerical data that needs to be made available for the evaluation and possible future re-evaluation of derived parameters and the format required for their efficient communication., - definition of crucial experiments needed to provide a consistent match between experimental evidence and model validation,
- active discussion and research involving the sensitivity and establishment of error bounds both in experimental data and modelling results. This will also result in a formulation of requirements for model sensitivity and error bounds,
- development of methods, such as those from data mining, to analyse the vast quantities of already existing data in order to provide new insight into the combustion process.
The path from raw data to a kinetic model involves a large number and a wide range of different types of data parameters. A typical detailed chemical kinetic model (such as those produced in WG1) consists of thousands of pieces of kinetic data in the form of rate constants for each reaction (at least three parameters in Arrhenius format) and temperature dependent thermodynamic data for each species. In turn, each rate constant and each set of thermodynamic data are derived from large sets of experimental or theoretical, e.g. quantum mechanical or statistical mechanical data. A single experimentally-derived Arrhenius rate constant is made up of individual measurements condensed down to a single rate constant and often these come from several experiments over different parameter ranges. Theoretical calculations of Arrhenius constants can involve whole potential energy surfaces consisting of hundreds to thousands of individual molecular calculations, which themselves consist of a multitude of configuration and electronic data. It is a goal of this work package to provide the prerequisites for a platform to handle this large quantity of diverse data.
The experiments to validate these models also provide in a wide range of experimental parameters and data. For example, a typical temperature and pressure dependent ignition delay time experiment consists of pressure and species plots over time from which the first and second ignition times are derived. From this raw data, a single parameter is derived. This raw data can be used to evaluate error bounds of the data. The exact value of ignition can be opened to interpretation and the availability of the raw data can be useful for validation. An open discussion within this Working Group will be to analyse how and in what form the communication of all forms of experimental

data, beyond that published in journals, can be improved.

In terms of data collection, storage and usage there are major challenges to overcome. The field of combustion is unique in that the data itself comes from a varying set of scientific communities, such as theoretical and experimental chemists, physicists and engineers, just to name a few. And each one has their own set of requirements and data.

Within the field of computer science there is a multitude of efficient database storage solutions. There are also efforts by groups within the United States to this end. However, the solution is far from final. The challenge lies in the development of standards which satisfy the needs of the multitude of various user groups within combustion. For this reason an active open discussion is needed within the combustion community with the goal of establishing specific guidelines for the construction of an efficient database that satisfies the users within the combustion community. The members of this COST Action represent a cross section of these researchers and thus an excellent basis for a complete and thorough discussion.

The main challenge of this WG is to provide a forum for all experts in the combustion community to formulate a common set of requirements for a universal combustion database not only capable of efficiently store the vast amount of raw data generated by experiments and modelling but also, more importantly, efficiently accessible for future use and maintenance.

WG5: Integration of fundamental knowledge towards technology application for Smart Energy Carriers exploitation.

The aim of WG5 is to apply/integrate the knowledge tools developed in WG1-WG4 by means of a mutual exchange between academic and industries. This will provide optimized ready to use tools and techniques for an effective use of SECs on large scale.

The research activities of the WG will be driven by the identification of validation test cases, identified in collaboration with the industrial partners to provide scale-bridging information from the laboratory units to the real applications. Such test cases will need to share important similarities with the intended applications (internal combustion engines, gas turbines, furnaces), without the complex interactions characterizing the industrial systems.

Integration of detailed kinetic mechanisms in large scale numerical simulations.

Detailed kinetic models are crucial to properly understand fuel and combustion properties such as ignition, heat release and pollutant formation. Comprehensive chemical schemes for the SECs and the related pollutant formation pathways will be available from both WG1 and WG2. An objective of WG5 will be to develop methodological approaches and tools for the integration of detailed kinetic models into large-scale simulations, taking into account the nature of the combustion regime and the features of the targeted technology. This will require the development and use of efficient reduction techniques.

Validation of the reduced models will be performed not only under conditions where fundamental experimental data exists (WG1 and WG2), but also under typical operating conditions of the combustion device. This will provide quantified estimates about the uncertainty related to the developed models, establishing a mutual exchange with the activities carried out in WG4.

Development of reliable, widely applicable and affordable turbulence/chemistry interaction models

Combustion phenomena take place over a large range of temporal and spatial length scales. Direct resolution of all pertinent scales for practical combustion applications is impossible even with the largest computers currently available. To simulate fluid-dynamics/chemistry interaction it is necessary to use turbulent combustion models. Most of the existing models are based on the assumption that the chemistry is fast compared to the flow. These assumptions are likely to be violated in advanced combustion technologies that are mainly kinetically controlled.

In such cases finite-rate chemistry models (using flamelet- or Probability Density Function-based approaches) and having the ability to handle complex chemistry/flow interactions need to be considered and assessed for both Reynolds-averaged Navier-Stokes and Large Eddy simulations.

Validation of the above combustion models will be based on test cases identified in collaboration with the industrial partners. It is important to stress the scale-bridging nature of such test cases, which implies that they should be relevant enough to the intended use, e.g. engines, turbines and burners, but allowing at the same time the validation of physical sub-models.

Assessment of the uncertainty related to numerical predictions for their use in new design and regulation

Methodologies to constructively couple simulations and experiments (like Validation and Uncertainty Quantification - V/UQ), to provide estimates of the uncertainty related to numerical predictions, can greatly improve reliability of numerical simulations thus enabling a more straightforward transfer of innovative technologies toward practical applications.

The need for consolidating V/UQ techniques in the field of the numerical simulation of reacting flows is quite urgent. Other disciplines (Wind Engineering, COST Action 732) have already tackled this problem. The combustion community, also in view of the multi-scale, multi-physics nature of the problem appears behind on this track.

Assessment of these methodologies will require strong interaction with the WG4, in view of the understanding of the all sources of error/uncertainty, including the experimental error, related to the statistical and bias errors associated to the measurements, the scenario uncertainty, including both uncertain model parameters and boundary conditions, the modelling error, which arises from the non-perfect knowledge of the physical phenomena, and the numerical error, deriving from the numerical approximations adopted in the model (i.e. grid resolution, discretization error, convergence error, etc.).

E. ORGANISATION

E.1 Coordination and organisation

Management and organisation of the Action

The management and organization of this Action will be carried out following the COST Action regulation and procedures. A well-defined and operative structure will be established that will ensure coordination of national research and promote capacity building and dissemination. The Management Committee (MC) organizes, implements and coordinates the activities of the Action. It will be composed from up to two representatives from each signatory country and is responsible for budget planning and allocation of funds, planning of events (i.e. MC and WG meetings, Workshops, Training Schools), defining and overseeing the STSM implementation plan, communicating tasks and milestones, conducting internal evaluation and monitoring of the Action, communicating with the COST Association.

The MC will be supported in these activities by:

1. WG Leaders for each Working Group (WG) that will manage, monitor and report the activities of each WG. WG Leaders will be appointed by the MC, taking due cognisance of gender balance and Early Stage Researcher involvement, with each WG Leader supported by a deputy (WG Vice-Leader). The Action participants will be grouped in 5 Working Groups
2. Early Stage Researcher and Gender-Balance Advisory Committee: consisting of at least two members which has the aim of promoting the participation of young researchers and assuring equality in gender participation.
3. Industrial Advisory Committee: consisting of at least two members that will provide effective means of communication between research and industrial participants and ensure that industrial needs are properly addressed.

4. Website and Dissemination Manager: that will be responsible both for operation of the SMARTCATS website and for the communication of the Action activities to the industry, policy makers and the general public.
5. STSM Manager: that will coordinate the STSMs and be responsible for over-seeing the STSM implementation plan.

The Chair and Vice-Chair of the Action, WG Leaders, the Early Stage Researcher and Gender-Balance Advisory Committee Coordinator, the Industrial Advisory Committee Coordinator, the Website and Dissemination Manager and the STSM Manager constitute the Core Group of the Action. It will provide initial directions for the activities to be approved by the MC and facilitate the task of the MC in coordination.

Coordination of national research

This Action will improve the efficiency of national research by providing the necessary coordination and dissemination activities including training/workshops/conferences and a frequently maintained specific website to achieve:

- Scientific Communication and Interaction: Efficiently exchange of the latest scientific (possibly not yet published) results between the participants.
- Research Coordination: Research planning and coordination between participants, both in the experimental and modelling aspects, at a European level.
- Funding Coordination: The Action will allow the participants to act as a single entity to promote new proposals at both the national and European levels.
- Collaboration: Exchange of researchers, especially Early Stage Researchers through Short-Term Scientific Missions, will foster collaboration between the participants.
- Industrial Cross-Fertilization: Enhanced dissemination and coordination of the fundamental research results of this Action into industrial applications.

Milestones and evaluation of the Action

The milestones of the Action presented on a yearly basis are as follows:

Year 1: 1st MC Meeting (Q1), Launch of SMARTCATS website (Q1), STSM Implementation Plan (Q2), Workshop 1 (Q3), Training School 1 (Q3), General Meeting 1 and MC meeting (Q4).

Year 2: Workshop 2 (Q3), Training School 2 (Q3), General Meeting 2 and MC meeting (Q4).

Year 3**:** Workshop 3 (Q3), Training School 3 (Q3), International Conference (Q4), General Meeting 3 and MC meeting (Q4).

Year 4**:** Workshop 4 (Q3), Training School 4 (Q3), Final General Meeting and final MC meeting

(Q4).
The monitoring and evaluation of the Action will be based on the following quantitative performance indicators:

1. Participation in workshops/training/conferences
2. Number of successfully completed STSMs
3. Number of joint publications
4. Number of joint research proposals
5. Overall gender balance and participation of Early Stage Researchers.

E.2 Working Groups

The activities of COST Action will be organised into five Working Groups:
WG1:Smart Energy Carriers gas phase chemistry: from experiments to kinetic models
WG2: Chemistry for control of by-products in Smart Energy Carrier conversion
WG3: Chemical and optical advanced diagnostics for Smart Energy Carriers conversion monitoring
WG4: Standard definition for data collection and mining toward a virtual chemistry of Smart Energy Carriers
WG5:Integration of fundamental knowledge towards technology application for Smart Energy Carriers exploitation.
Participants can join one or multiple WGs, each of which will have a specific Working Group Leader and a Vice-Leader that will be identified by the MC during its first meeting. Each WG Leader, together with the Vice-Leader, will be responsible for:

- coordinating the activities and monitoring the achievement of the objectives of WG; providing all the information required to have a constantly updated Action website;
- promoting dissemination activities in collaboration with the Dissemination Manager;
- organizing a workshop, an annual meeting or a training school;
- providing the annual and final written reports.

E.3 Liaison and interaction with other research programmes

The SMARTCATS Action will liaise closely and interact with European-funded current and future projects, European-wide organizations and associations that focus on fuel production and processing and on fuel use in the transport and industrial sectors.
SMARTCATS will actively promote links with European projects that work towards increasing the

sustainability and optimizing the properties of 2nd generation biofuels. Such include the BIOFUEL-2G project, co-funded by the EU LIFE+ program, which developed an innovative technology for converting cooking oils to diesel fuel. SMARTCATS will also aim to closely liaise with the European Biofuel Technology Platform (EPTP) which provides a framework for a wide range of activities relevant to the R&D of sustainable advanced biofuels in Europe.

The SMARTCATS Action will also establish collaborative links with EARPA (the Association of Automotive R&D Organisations), ERTRAC (the European Technology Platform which brings together road transport stakeholders) and ECATS (an International Association on Environmentally Compatible Air Transport System). These links will provide the necessary interaction between the more fundamental output of the Action with the needs of the automotive and aviation communities. The Action will also aim at collaborating with existing Clusters Initiatives, such as the CHORUS Cluster for Green Energy. The CHORUS Cluster brings together SMEs and research entities aiming towards the development of synergies and technologies for zero/neutral carbon fuels, CO_2 reduction and smart grids for energy and mobility. Strong links will also be established with the ECCO-MATE MC-ITN project that provides a research and training platform for the development and implementation of novel fuel mixture preparation, injection profiling, air management and staged/low temperature combustion technologies both in marine and light-duty automotive diesel engines. Interaction between the SMARTCATS Action and the above projects/associations/clusters will take the form of information exchange through joint meetings, workshops and seminars as well as the preparation and submission of common research proposals.

E.4 Gender balance and involvement of early-stage researchers

This COST Action will respect an appropriate gender balance in all its activities and the Management Committee will place this as a standard item on all its MC agendas. The Action will also be committed to considerably involve early-stage researchers. This item will also be placed as a standard item on all MC agendas.

About one third of the participants are expected be female. SMARTCAT will also strive to improve the research and professional capacity of early-stage researchers employing the following tools:

Active involvement in SMARTCATS management. Every effort will be made to ensure that a significant percentage of ESR will be appointed as WG Leaders or Vice Leaders.

Active participation in training activities.

Set up a Mentoring Scheme where an early-stage researcher participating in the Action can be paired with a “mentor” - a senior researcher or engineer - that will provide professional and technical advice and guidance.

F. TIMETABLE

All the five Working Groups will be active along the four year of the Action duration.
After the 1st MC meeting, four general meetings, with the participation of all the WG members, will be organized in the last quarter of each year. General meetings will be held jointly with MC meetings to evaluate the progress of the Action.
Specialized workshops aimed at enhancing exchanges between experimentalists, modellers and industrial people will be organized at least once a year, preferably in the second half of the year.
At the end of third year an International Conference will be organized to publicize the Action results.
A detailed dissemination program including training schools, outreach and other dissemination initiatives will be defined by the MC by the end of second quarter.
A tentative timetable is given below:

YEAR	One				Two				Three				Four			
QUARTER	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
MC meetings	X			X				X				X				X
Workshops			X				X				X				X	
Conferences												X				
Training Schools			X				X				X				X	
General Meetings				X				X				X				X
STSM		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dissemination	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Outreach	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

G. ECONOMIC DIMENSION

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: AT, BE, BG, CH, CY, DE, DK, EL, ES, FR, HR, HU, IE, IL, IT, NL, NO, PT, SE, TR, UK. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at 84 Million € for the total duration of the Action. This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

H. DISSEMINATION PLAN

H.1 Who?

An important goal of SMARTCATS is to efficiently disseminate the output of Action activities and to provide access to output and resources to any potentially interested stakeholder. Given the nature of the Action, most of the results will be public. Dissemination activities will be carried out both within and outside the Action. The dissemination strategy will be coordinated and monitored by the MC, and will be adapted/modified during the project and depending on the audience.

The target audience of SMARTCATS will be:

Internal: The Action participants will be informed of the progress and the accomplishments of the Action and of its wider significance with respect to the expected impact at different levels.

External: several external targets can be identified:

- Scientific Community**:** Publications and active participation in international conferences to disseminate scientific results resulting from *the Action*.
- Other network/projects community: Sharing accomplishments of the Action with coordinators and key actors of other networks or projects dealing with complementary topics, to ensure visibility and uptake of results, to receive feedback, share experiences and discuss joint problems and issues.
- Industry: More than 25% of possible participant entities in this Action belong to companies or industries due to great interest toward the aim and objectives of the Action. Further communication towards wider industrial involvement will be an asset of the Action.
- Government: SMARTCATS results will be of interest to government policy makers for the potential of using smart energy carriers to alleviate energy and environmental problems.
- General public: SMARTCATS puts great emphasis on outreach activities aiming to increase awareness of the societal challenges associated to the availability of clean, secure and efficient energy sources.

H.2 What?

1. Direct dissemination initiatives:

Workshops: Specialized scientific workshops with up two days duration. Workshops will be scheduled. Speakers of high scientific/technical calibre will be invited and roundtable discussions will be organized to promote exchanges between researchers and industrial participants.

Training Schools: Training schools covering fundamental aspects of SEC science and technology will be organized each year. Teaching staff will include top specialists from academia and industry. Training schools will be targeted to early-stage researchers and scientists and engineers from industry.

Website: An official website to promote the Action to the general public will be created. An internal, password protected area will be made available to the participants to share provisional models, data and official documents.

2. Publications and Communications

The Action will promote individual and collective publications addressed to scientific/technical as well as more general audiences, such as government, industry, educational institutions and the general public:

Scientific Publications: Publications in peer-reviewed specialized scientific journals will be the primary means of disseminating the relevant scientific results.

Communications in International Conferences and Workshops: Participation in relevant international events will provide the ideal venue for establishing fruitful interaction with the scientific and industrial communities.

Industrially Oriented Magazines: This is an important medium to achieve cross-fertilization with the industrial community, in particular in the transport and energy sectors.

Non-Technical Publications: This channel will be crucial to expand the awareness of the societal challenges faced by the Action and to get in contact with policy makers.

Direct Communication with Industry: This will serve to establish and strengthen existing links between universities and industries, leading to industrially relevant results and joint research projects.

3. Collection and coordination of scientific and educational information

A virtual community, supported by the Action website, will be set up to offer a repository of dissemination materials, but also communication forums inside and outside this Action. Collective efforts to bring together common and collaborative material of the combustion kinetics community will be made:

Bibliographic: Bibliographic references (for example, title, authors and abstract) of, at least, all publications produced during the course of the Action.

Course Material Repository: Individual lectures and entire classes from the academic members to promote the education of young researchers in the fields related to the Action.

Scientific Data Repository: Supplementary data from the Action too detailed to be included in publications, e.g. raw data from measurements or the complete mechanisms developed.

H.3 How?

The Action website will provide the main dissemination platform and will have two important functions:

Archiving: The collective materials, as mentioned in the previous section, will be archived and made available to the Action members and the general public.

Virtual Community: The website will make available web-based tools, such as forums, mailing lists, news, announcements, RSS feeds and even blogs, to enable the formation of a virtual community among the participants and to enhance awareness of passive participants to the activities of the Action.

The Action will be advertised through social media, to improve its social impact and raise the general public interest. Podcasts and video will highlights major results and key events of the Action. A Wiki-type page section will be added where (user-authenticated) reading/editing is welcomed. The website will provide features for equal access and opportunity to people with diverse abilities according to W3C standards. Extra effort will be made to make the information particularly accessible to global search engines. Relevant information, filtered for each level of dissemination will be distributed through mailing lists and RSS feeds.