CENTRE NATIONAL
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FEDERATION DE RECHERCHE FR 0776
ENERGETIQUE, PROPULSION, ESPACE, ENVIRONNEMENT (EPEE)
Directeur : I. Gökalp
1C, Av. de la Recherche Scientifique 45071 Orléans cedex 2
Tel : 33 (0)2-38 25 54 63 ; Fax : 33 (0)2-38 25 78 75
E-mail: gokalp@cnrs-orleans.fr

Space Solar Energy

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Contribution of EPEE – CNRS

Iskender GÖKALP

About EPEE-CNRS

EPEE

–is the acronym for the Research Federation "Energétique, Propulsion, Espace, Environnement" of the CNRS and the University of Orléans

- is directed by I. Gökalp

- It federates 5 laboratories in Orléans and Bourges, and more than 200 research staff

Laboratoire de Combustion et Systèmes Réactifs-LCSR (Dir. M. Cathonnet)

Laboratoire d'Aérothermique (Dir. J-C. Lengrand)

Groupe de Recherche sur l'Energétique des Milieux Ionisés-GREMI (Dir. C. Fleurier)

Laboratoire de Mécanique et Energétique-LME (Dir. S. Burnel)

Laboratoire d'Energétique, Explosions, Structures-LEES (Dir. J. Renard)

- Its facilities are recognised as European Research Infrastructure by the European Commission

- It manages the French National Centre for Technological Research (CNRT) on Future Propulsion (with MBDA, CELERG, Auxitrol, SNECMA, EADS-LV, CNES…)

Expression of Interest for
An Integrated Project for
Advancing Knowledge on Enabling Technologies for
***Sustainable Energy Systems*:**

"Energy, Space, Solar Power, Environment:
Research Actions for a New Society" :

ESSPERANS

Prepared by
Dr. Iskender Gökalp, Directeur de Recherche au CNRS (gokalp@cnrs-orleans.fr)
Director of the Federation of Research "Energétique, Propulsion, Espace, Environnement"
CNRS-EPEE, 45071 Orléans cedex 2, France

Rationale

This integrated project aims to address the research priority **1.1.6.1.ii** ***"Research activities having an impact in the medium and longer term for sustainable development, global change and ecosystems"***. It focuses on new and advanced concepts in renewable energy technologies with a very significant future energy potential for the world and EU energy supply and requiring long term research to make these technologies competitive with conventional fuels.

Its departure point is the following: clean and abundant energy supply for the future is one of the most critical problems facing humanity in the coming decades : first, fossil fuels are "finite" in the mathematical sense, and, new, abundant, clean and renewable future energy sources should be introduced without delay ; second, by ejecting into the Earth atmosphere in about one century a significant fraction of the carbon accumulated during billion years, the equilibrium of the ecosystem is strongly perturbed, and a global and durable solution should be anticipated now in order to stop this trend.

As such, these problems can only be handled by holistic and world scale approaches that require long term research, development and demonstration, as well as mobilising considerable resources, both in expertise and funding. On the other hand, every means to immediately reduce the CO_2 emissions and the energetic dependency on fossil fuels should be introduced. This is particularly crucial for the EU energy supply independence.

Therefore, the integrated project **ESSPERANS is conceived as a cluster of research actions which should be developed following a roadmap leading to the introduction at the Earth scale of clean, abundant, and renewable energy sources.**

Objectives

They are listed below in a kind of chronological order, from medium term to long term objectives; this means that the integrated project ESSPERANS should organise research activities in a progressive way following a technology roadmap to be established in order to develop the enabling technologies at the right time and if possible before (or in collaboration with) USA and Japan. The predicted time frame goes from today to 2040. The cluster of planned research actions aims to:

A] Develop means to immediately reduce the use of fossil fuels

B] Develop the use of Decentralised Energy Resources

C] Develop direct hydrogen combustion technologies

D] Develop CO_2 capture and recycling technologies for very large power systems

E] Develop clean and cost effective production methods of hydrogen

F] Develop clean and cost effective production methods of electricity

[Objectives A, B, C] To contribute to achieve these objectives, which are relatively medium term objectives, ESSPERANS will develop research actions on high efficiency Gas Turbines, focusing on

♥ Gas turbine fuel flexibility, hydrogen / natural gas mixtures-hytane, catalytic combustion, high efficiency hydrogen driven gas turbines
♥ Liquid biofuels, gasification of biomass to produce H_2-rich clean syngas
♥ Hydrogen combustion technology for gas turbines

These research actions could be developed by consortia such as AFTUR (Alternative Fuels for Industrial Gas Turbines, a 5th FP project starting in Fall 2002) composed of 21 partners from 8 member states, and supported by EuMIGT. The AFTUR consortium could be enlarged to other partners, from industry (including energy utilities) and academia.

Research actions on hydrogen combustion technologies will rely on the expertise of European combustion science and technology community, organised in EU member states as sections of the International Combustion Institute (head quarters in Pittsburgh, PA, USA) and also co-ordinated by the Federation of the European Sections of the Combustion Institute, which also include the sections of Russia, Poland, Hungary and Turkey.

It is important to mention here the potential synergy between priority 1.1.6 on Sustainable development, global change and ecosystems, which is addressed in this integrated project and **the priority 1.1.4. on Aeronautics and Space**, through the development of safe H_2 combustion technologies for the implementation of ultra-clean aircraft using liquid hydrogen as fuel (project Cryoplane).

Another research action should focus on

♥ Fuel Cell /Gas Turbine hybrid systems for decentralised energy production

To conduct this kind of research activity, the integrated project ESPERANS should co-operate with Integrated Projects on Fuel Cells especially those active on high temperature fuel cells (SOFC).

[Objective D] To achieve this objective, the integrated project ESSPERANS aims to develop research actions on

♥ CO_2 recycling to produce CO and Oxygen or to produce CH_4

In order to avoid the difficult problem of CO_2 storage after its capture from large scale fossil fuel plants, research actions on recycling CO_2 should be developed in collaboration with integrated projects on CO_2 capture. Several options should be investigated and demonstrated, such as :

♥ Catalytic transformation of CO_2 into CO and Oxygen. The technology for such transformations exists; they should be evaluated in co-operation with appropriate NoEs and Integrated Projects. Again, the potential synergy with priority 1.1.4 on Aeronautics and Space should be mentioned as the capture and transformation of Martian CO_2 into oxygen and CO are today important R&D topics both for ESA and NASA, for Mars mission using *in situ* resources.

♥ The captured CO_2 could be transformed into CH_4 by processing it with H_2. This process obviously needs cost effective hydrogen production (see below).

[Objective E] Clean and cost effective production of H2.

♥ Hydrogen is expected to become a major energy vector, opening important industrial markets on hydrogen production, storage, transportation, its direct combustion or use in fuel cells. Cost effective and clean production technologies will play a crucial role in this process. Electrolysis (or dissociation) of seawater with photovoltaic electricity appears to be the best option. This needs low cost solar cells such as hybrid solar cells and the use of Earth or Space Solar Energy for electricity production (see below). This research action should be conducted together with NoEs and Integrated Projects active in PV technologies.

[Objective F] Clean and cost effective production of Electricity

♥ For the clean and abundant production of electricity in the long term, the only sustainable approach is the transformation of solar energy into electricity. There are two sub options: Earth based or Space based, including their combination. Space Solar Energy necessitates low cost space access technology and therefore should be conducted together with Integrated Projects in space propulsion and transportation.

One of these options is to install very large PV farms on orbit or, for example, on the Moon, to convert the electricity into microwaves or laser beams and to beam it down to Earth, to orbital platforms or to spacecraft, for example, to provide power to satellites, or to spacecraft using electric propulsion for orbit change or planetary missions. Giga-watt scale space solar electricity production units are envisaged and their global feasibility has been assessed in the US by NASA and DoE and in Japan by METI. The European Space Agency has also recently acknowledged this development. Europe should not be absent in the development of this long term technological challenge, which may well be the ultimate solution for sustainable energy supply to the Earth for the next century.

As above, this objective can induce a strong synergy with **the priority 1.1.4 on Aeronautics and Space**, especially to promote a large market for low cost and/or reusable launcher technologies, therefore to support the European space transportation industry and to support the European satellite industry by providing abundant power in orbit. Furthermore, research on the Space Solar Energy objective is expected to induce several innovation spin offs, e.g. in wireless power transmission and laser technologies, where European SMEs can be major players. In this area strong co-operation with Russian institutes should be sought of.

Present partners of the EoI

PARTNER	COUNT.	TYPE	AREAS of EXPERTISE	CONTACT
CNRS-EPEE-LCSR	FR	REC	Energy, Combustion, propulsion	I. Gökalp
CNRS-Aérothermique	FR	REC	Space Propulsion	J-C. Lengrand
CNRS-CORIA	FR	REC	Energy, Combustion, propulsion	M. Ledoux
EADS-LV	FR	IND	Space transportation	H. Hollanders
CEA-RIPAULT	FR	INS	Fuel cells, solar cells, Energy	A. Varoquaux
IFP	FR	INS	Gas Turbines, Energy	E. Lebas
AUXITROL	FR	IND	Sensors, Aeronautics	O. Legras
Prospective2001, EDF	FR	ORG	Energy	L. Deschamps
Univ. Cath. Louvain	BE	UNIV	Combustion, Emissions	J. Vandooren
Univ. Beira Interior	PT	UNIV	Combustion, Propulsion	J. Barata
Tech. Univ.Lisbon	PT	UNIV	Energy, Combustion, Hydrogen	M. Carvalho, M. Heitor
CRES	GR	INS	Biomass, Energy	C. Panoutsou
Agri. Univ. Athens	GR	UNIV	Biomass, Energy	G. Papadakis
Cardiff Univ.	UK	UNIV	Combustion, Energy, Biomass	N. Syred, T. Griffiths
Queen Mary &WC	UK	UNIV	Combustion, Gas Turbines	C. Lawn
UMIST	UK	UNIV	Combustion, Energy	Y. Zhang
Cranfield Univ.	UK	UNIV	Combustion, Energy	J.B. Moss
ENEA	IT	INS	Energy, Combustion, Gas Turbines	G. Giuseppe
Univ. Naples	IT	UNIV	Energy, Combustion	A. Cavaliere
CNR-IRC	IT	REC	Energy, Combustion	F. Beretta
Univ. Roma Tre	IT	UNIV	Energy, Biomass	G. Cerri
Univ. Firenze	IT	UNIV	Energy, Gas Turbines	F. Martelli
Nuove Pignone	IT	IND	Gas Turbines	H. Bornemann
ESA	NL	ORG	European Space Agency	M. Lang
Univ. Twente	NL	UNIV	Energy, Combustion, Biomass	J.B. Kok, E.A. Bramer
KEMA	NL	ORG	Energy, DER, Combustion, CO2	P. Welberg
KTH	SE	UNIV	Energy, Combustion, Gas Turbines	T. Fransson
TPS Termiska Processer	SE	IND	Energy, Biomass, Hydrogen	L. Waldheim
Univ. Lund	SE	UNIV	Energy, Combustion, Gas Turbines	M. Alden, T. Torisson
Univ. Zaragoza	ES	UNIV	Energy, Combustion	J. Ballester
CIEMAT	ES	UNIV	Energy, Solar	P.L. Garcia-Ybarra
Hungarian Acad. Sci.	Hongrie	REC	Energy, Combustion	S. Dobe
RIAME	RU	INST	Space Propulsion	V. Kim

Examples for possible specific contributions of EPEE to a SSE project

Low cost space access

♥ Airbreathing high speed propulsion (with MBDA, CELERG, CNES, ONERA)

♥ Pulsed detonation rocket propulsion (with CELERG, MBDA, CNES, ONERA, SNECMA)

♥ Electric propulsion (high thrust) for orbital transfer (with SNECMA)

Lasers

♥ Laser technologies and laser propulsion (with CILAS)

Solar cells

♥ This film solar cell technology (with CEA)

Microgravity

♥ Large structure deployment tests in microgravity (within the CNES Airbus ZeroG)

Simulation of space conditions

♥ Availability of ultra-vacuum large scale chambers

Space Debris

♥ Mitigation studies and impact studies; production of oxygen atom supersonic beams for impact studies

Plasmas technologies

♥ Atmospheric re-entry studies; rarefied gas dynamics studies; simulation of various atmospheres

Combustion technologies

♥ Hydrogen combustion technologies