NOTICE CONCERNING COPYRIGHT RESTRICTIONS

ENhanced Geothermal Innovative Network for Europe (the ENGINE Co-ordination Action)

P. Ledru[1], P. Calcagno[1], A. Genter[1] , E. Huenges[2], M. Kaltschmitt[3], C. Karytsas[4], T. Kohl[5], A. Lokhorst[6], A. Manzella[7], and S. Thorhallsson[8]

[1]BRGM, France; [2]GFZ, Germany; [3]IE, Germany; [4]CRES, Greece; [5]GEOWATT, Switzerland; [6]TNO, Nederland; [7]CNR-IGG, Italy; [8]ISOR, Iceland

Keywords

Enhanced geothermal system, resource investigation, resource assessment, exploitation, European community, coordination action.

ABSTRACT

The contribution of geothermal energy is a key factor to the successful achievement of the objectives of the European Commission concerning the development of renewable and sustainable energy. The concept of Unconventional Geothermal Resources and in particular Enhanced Geothermal Systems examines ways of increasing the potential of geothermal power generation through (i) exploring new types of reservoirs for heat exchange (Hot Dry Rock, supercritical fluids..), (ii) enlarging the extent of productive geothermal fields by stimulating permeability, (iii) enhancing the viability of current and potential hydrothermal areas by stimulation technology and by improving thermodynamic cycles.

The main objective of the proposed action is the co-ordination of the present research and development initiatives for Unconventional Geothermal Resources and Enhanced Geothermal Systems, from resource investigation and assessment stage through to exploitation monitoring. The Co-ordination Action will provide (1) an updated framework of activities concerning geothermal energy in Europe, including the integration of scientific and technical know-how and practices, the evaluation of socio-economic and environmental impacts; (2) the definition of innovative concepts for investigation and use of Unconventional Geothermal Resources and Enhanced Geothermal Systems; groups of experts will present a "Best Practice Handbook"; (3) a scientific and technical "European Reference Manual" including the information and dissemination systems developed during the Co-ordination Action.

Introduction

The contribution of geothermal energy is a key factor to the successful achievement of the objectives of the European Commission concerning the development of renewable and sustainable energy. The European Commission support for geothermal energy research has been constant since the end of the eighties and has significantly increased in the 6th Framework Program as several projects are directly related to the development of EGS (Schuppers, 2006). The ENGINE project (ENhanced Geothermal Innovative Network for Europe) is a Co-ordination Action that started in November 2005. Its main objective is to co-ordinate present Research and Development initiatives for Unconventional Geothermal Resources and in particular Enhanced Geothermal Systems (EGS), ranging from the resource investigation and assessment stage through to exploitation monitoring. It is meant to complement other Framework Programme instruments in contributing toward integrating research in Europe through well-planned networking or co-ordination activities. Two Specific Target Research Projects are dedicated to the Hot Dry Rock Project at Soultz-sous-Forêts (Fritsch and Gerard, 2006) and to the development of an innovative geothermal exploration approach based on advanced geophysical methods (the I-GET Project, Bruhn et al., 2006). To complete this screening of the 6th Framework Program, the LOW-BIN project aims in improving cost-effectiveness, competitiveness and market penetration of geothermal electricity generation schemes (Karytsas and Mendrinos, 2006). In addition, international co-operation takes place through the Commission participation in the IEA Geothermal Implementing Agreement.

This paper presents a general overview of the challenges faced by the Research and Development partners of the ENGINE network in Europe and defines the main objectives of the project.

State of the Art, Facing Both Old and New Challenges

Considering that 70% of the World's energy needs can be met with water at temperatures less than 200°C and that power plants are becoming increasingly efficient, geothermal energy may represent a major renewable and sustainable source of

energy for Europe. Large wavelength thermal anomalies are characterised across Europe (Genter et al., 2003, Kohl et al., 2003, Genter et al., 2006) and within Ultra Peripheric Regions (Caribbean Islands, Canaries, Traineau et al., 2006). The 200°C isotherm is reached between 2 and 5 km depth in zones of present or recent lithospheric extension in France, Greece, Iceland, Italy, offshore Spain, Turkey or even in intracontinental settings such as Hungary, Lithuania, Romania. These thermal anomalies constitute a source of energy potentially available throughout Europe. However, the use of geothermal energy is limited by the fact that it relies on the relatively uncommon geological concurrence of rocks being simultaneously water-bearing, hot and permeable, and lying at economically accessible depths. Different ways have been tested or are imagined for enhancing and broadening geothermal energy reserves which can be classified into Unconventional Geothermal Resources, i.e. mainly Enhanced Geothermal Systems (EGS) and Supercritical Reservoirs:

- stimulating reservoirs in Hot Dry Rock systems,
- enlarging the extent of productive geothermal fields by enhancing/stimulating permeability in the vicinity of naturally permeable rocks
- enhancing the viability of current and potential geothermal areas by stimulation technology and improving thermodynamic cycles,
- defining new targets and new tools for reaching supercritical fluid systems, especially high-temperature downhole tools and instruments,
- improving drilling and reservoir assessment technology,
- improving exploration methods for deep geothermal resources.

Among these projects, several Hot-Dry-Rock (HDR) sites have been investigated around the globe by the international community. These HDR sites, existing or under development, include Fenton Hill (USA), Rosemanowes (UK), Bad Urach (Germany), Fjallbacka (Sweden), Soultz-sous-Forêts (France), Hunter Valley (Australia), Hijiori and Ogachi, Gross Schonebeck (Germany, Huenges et al., 2006), Basel and Geneva (Switzerland, Hopkirk and Haring, 2006) and Cooper Basin (Australia). They all provide valuable experience input to the ENGINE Co-ordination Action.

Enhancement techniques have already been successfully applied to productive geothermal fields in Larderello (Italy) and Guadalupe (French Caribean Island). Larderello is the oldest geothermal field in operation worldwide (Cappetti, 2006). The first experiment for electricity production was carried out in 1904, and this field has represented the sole example in the world of intensive geothermal energy exploitation up to the end of 50's. On the basis of the positive results of well stimulation and water injection activities, new exploitation strategies have been adopted for the Larderello field, aimed at the resource sustainability. In these recent years the exploitation strategies have been therefore moved from those typical of hydrothermal systems to those related to Enhanced Geothermal Systems.

Beside these pioneer projects, geothermal exploration in Germany has had a sudden development in the Upper Rhine valley (Baumgartner et al., 2006). The Renewable Energy Sources Act (EEG) in Germany has provided new conditions of funding, increasing the rate for geothermal power from 0.089€/kWh to 0.15€/kWh for power production of up to 5MWe. Several geothermal projects aiming at the exploration of different types of reservoirs (hot water aquifers, faults and crystalline rocks) have been launched in the Upper Rhine valley. Exploration work has been started for the hydrothermal projects in Bruchsal, Speyer, Offenbach, Landau and Bellheim. The first wells have been completed and tested in Speyer, Offenbach and Landau. Further projects like Karlsruhe, Riedstadt, Ettenheim, Kehl are still in the planning and early preparation phase.

Geothermal production levels must also be designed to comply with resource sustainability constraints (Megel, 2006). Major cost-reduction must be accomplished to achieve the objectives of the EU for the use of renewable energies. The development of unconventional geothermal resources may also be linked in an "unconventional way" to other industrial activities such as CO_2 storage or hydrogen production. In parallel, the environmental and social aspects of the development of geothermal energy is of great importance as the image of this renewable and sustainable energy must be improved not only in terms of awareness of decision makers, but also acceptance of the general public.

To summarise, by exploring Unconventional Geothermal Resources, research and development institutes face:

- a scientific challenge to understand the distribution of heat and permeability at depth in the uppermost crust. High amplitude and small wavelength anomalies, related to local high conductivity layers or highly radioactive sources, may develop on the large wavelength thermal anomalies and present a great interest for assessment of reservoirs for Hot Dry Rock energy systems.
- a technological and economic challenge to improve and render cost-efficient investigation and development technology in order to make these geothermal systems viable.
- a communication challenge to rally the support of policy makers and investors and, in certain cases, increase the social acceptance of a broader community.
- a challenge to integrate the different, yet parallel, research paths that currently exist, namely one for investigation and resource assessment and another for sustainable exploitation schemes, one for Hot Dry Rocks and another for High Energy Systems.

Objectives of the Project

The proposed Co-ordination Action is aimed at providing an integration of activities related to geothermal energy in Europe, and compiling recommendations from expert groups into a European Reference Manual for the development of Unconventional Geothermal Resources and in particular Enhanced Geothermal Systems. The Co-ordination Action will thus contribute to these society and policy objectives by:

- identifying the gaps and barriers holding back geothermal-energy development (environmental impacts, policy/law/regulatory barriers, etc.) and proposing actions to overcome the bottlenecks (research projects, expert studies, information campaigns, promotion, etc.);
- demonstrating that Unconventional Geothermal Resources and in particular Enhanced Geothermal Systems cover a very large range of reservoir types and heat sources, and that geothermal energy can be considered as a source of energy potentially available throughout Europe;
- defining economic conditions for a reassessment of the profitability of geothermal energy in the framework of " Unconventional Geothermal Resources "; and in particular how geothermal energy can contribute, in the new candidate countries, to their heat and electricity production;
- illustrating how a healthy geothermal energy industry can assist the energy self-sufficiency of Europe and promote the development of local industrial capability;
- proposing a complete economic approach towards geothermal energy, taking into account the sustainability and the environmental benefits.

Organisation of the ENGINE Co-Ordination Action

To promote an efficient network of geothermal activities, the Co-ordination Action will define, organise and manage joint and common initiatives through:

- an Integration Phase, i.e. a bottom-up and federative strategy aimed at providing an updated framework of activities concerning geothermal energy in Europe and developing motivation within the scientific and technical community by exchanging experiences and sharing practices. It will cover all initiatives and bottlenecks encountered during the Investigation of EGS and Unconventional Geothermal Resources, drilling, stimulation and reservoir assessment and Exploitation, economic, environmental and social impact.
- a Synthesis Phase; i.e. an expertise strategy for defining the best practices and priorities for research investment. The expert groups will perform specific studies and strengthen links between the geothermal community and financial and political institutions.

The ENGINE co-ordination action is composed of 31 partners rep, resenting 16 European countries and including 6 private companies. The first group of partners has a broad knowledge covering large aspects of the geothermal energy. It comprises BRGM (France), co-ordinator of the ENGINE project, CFG SERVICES (France), GeoForschungsZentrum Potsdam (GFZ, Germany), ISlenskar ORkurannsoknir (ISOR, Iceland GeoSurvey), Centre for Renewable Energy Source (CRES, Greece), Shell International Exploration and Production B.V. (SIEP B.V., Netherlands).

The second group of partner has a knowledge covering mainly the exploration and drilling and reservoir assessment: the Institute of Geosciences and Earth Resources of National Research Council (IGG, Italy), the Department of Geophysics of the Eotvos University (ELTE, Hungary), the Institute of Earth Sciences, Dept. of Tectonics, of the Vrije Universiteit Amsterdam (VUA, Netherlands), the Groupement Européen d'Intérêt Economique "Exploitation Minière de la Chaleur" (GEIE "EMC", an international consortium operating on the site of Soultz-sous-Forêts, France), the Panstwowy Instytut Geologiczny (PGI, Polish Geological Institute, Poland), Tsentr geoelektromagnitnykh issledovanii Instituta fisiki zemli Rossiskoi akademii nauk (GEMRC IPE RAS, GEoelectromagnetic Research Center of the Institute of the Physics of the Earth, Russian Academy of Sciences , Russian Federation), the Geologijos Ir Geografijos Institutas (IGGL, Institute of Geology and Geography, Lithuania).

A large group of partners has a large experience in drilling and reservoir assessment, exploitation and impact of the geothermal energy, some of them being involved in CO_2 storage. It is composed of the Netherlands Organisation For Applied Scientific Research (TNO, Netherlands), ten laboratories of the French CNRS (France) involved in the HDR Soultz experiment, Geoproduction Consultants (GPC, France), the Chemical Process Engineering Research Institute (CPERI) of the Center for Research and Technology-Hellas (CERTH), the Environmental Research Laboratory of the National Centre for Scientific Research "Demokritos" (NCSRD, Greece), the Institutt for Energiteknikk (IFE, Institute for Energy Technology, Norway), the Deep Heat Mining Association (DHMA, International Consortium), The company Geowatt AG, the Instituto Geológico y Minero de España (IGME Geological and Mining Institute of Spain, Spain), the Leibniz Institute for Applied Geosciences (GGA-Institute, Germany), the University of Oradea (UOR, University of Oradea, Romania), the Geological Survey of Denmark and Greenland (GEUS, Denmark).

Another group of partners are mainly involved in the development and management of exploitation and in impact studies of the geothermal energy: the Institut für Energetik und Umwelt gGmbH (IE, Institute for Energy and Environment, Germany), the Institut vysokikh temperatur Rossyiskoi academii nauk (IVTRAN, Institute for high temperatures, Russian academy of sciences, Russian Federation), the Institute for Geothermal Research of the Daghestan Scientific Centre of Russian Academy of Sciences (IGR DSC RAS, Russian Federation) and 3 private firms, ORME JEOTERMAL A.S., operating in Turkey, Intergeotherm-M Stock Company (Intergeotherm-M SC, Russian Federation), involved in the construction of geothermal plants worldwide and MeSy GeoMessSysteme GmbH (MeSy, Germany) partner of the European HDR Soultz-sous-Forêts project.

The breakdown structure of the project is presented (Figures 1, 2, overleaf). Its duration is estimated to 30 months and it has been funded with 2 Millions €. Among the main actions, 3 general conferences (launching, mid-term and final) will be organised and 7 specialised workshops will present the most innovative concepts, review the best practices, identify gaps and barriers and define new projects on the following items:

- *Defining, exploring, imaging and assessing reservoirs for potential heat exchange*

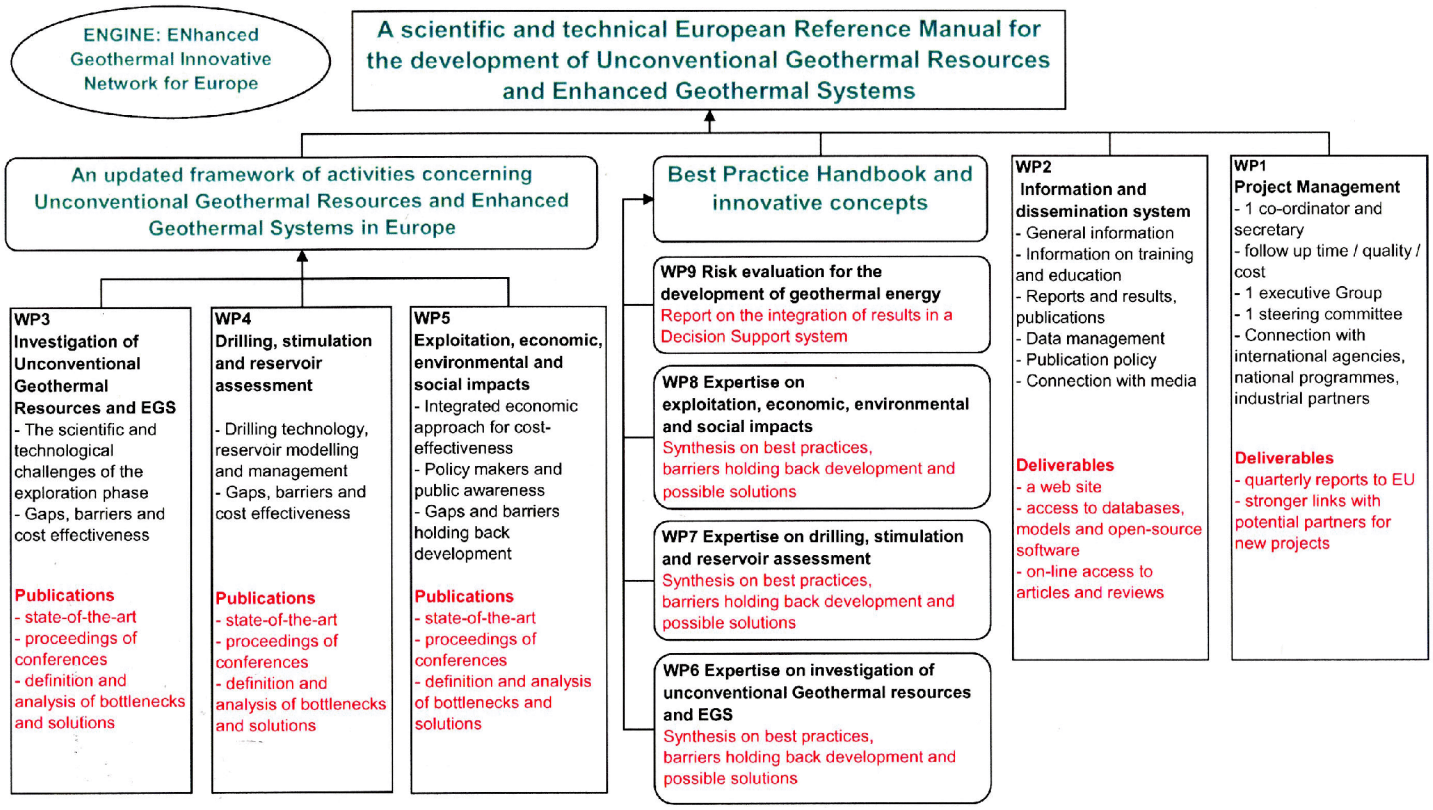

Figure 1. Breakdown of the ENGINE Coordination Action.

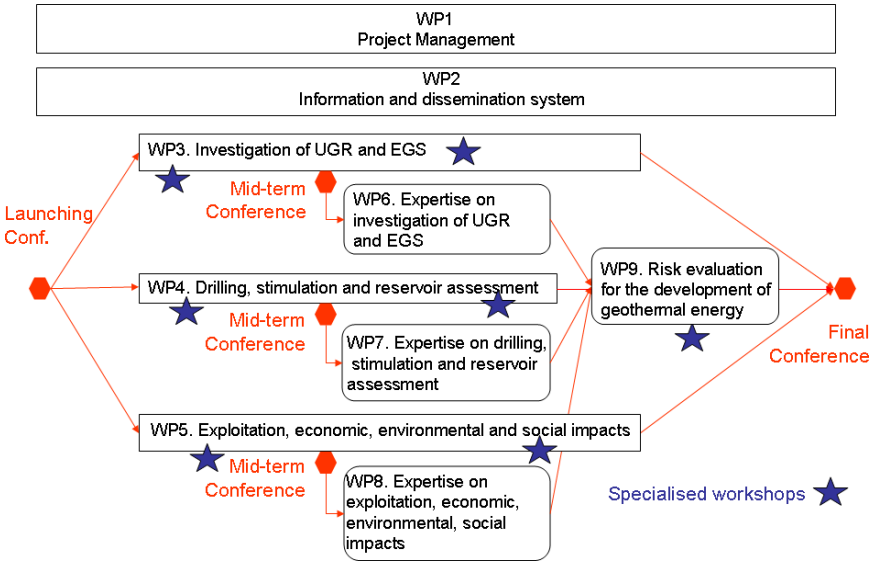

Figure 2. Project network of activity.

- *Exploring Supercritical fluid reservoir: a new challenge for geothermal energy*
- *Induced microseismicity and reservoir stimulation*
- *Drilling cost effectiveness and feasibility of high-temperature drilling*
- *Electricity generation, combined heat and power*
- *Increasing policy makers awareness and the public acceptance*
- *Risk analysis for development of geothermal energy*

A special attention is paid to the information and dissemination system, and especially to the website (http://engine.brgm.fr) as the potential impact of the project will be related to the mobilisation of a large scientific and industrial community and to the establishment of a sustainable institutional and political support.

Expected Results

The main potential impact expected from the Co-ordination Action is to re-establish the institutional and political support that is currently lacking to ensure that geothermal energy reaches its full efficiency and profitability thresholds at European scale. It is first of all necessary to structure the geothermal-energy community towards the definition of innovative research projects. The emergence of such projects requires a capitalisation of the knowledge of the different actors currently playing in the "geothermal field", which implies sharing experiences, exchanging best practices and clearly identifying the gaps and barriers. The expected impact of this Co-ordination Action is that a large scientific research community will be mobilised

that is able to promote such spin-off projects with industrial partners. The Co-ordination Action also intends to play a "transmission role" and constitute an exchange platform. It will provide an opportunity to integrate and synthesise all information about know how, practices, innovations and barriers at the level of the Steering Committee and Expert Groups. This will be particularly helpful during discussions with Executive Directors of international funding agencies or National Policy makers. This knowledge will be disseminated and made available through the information and publication systems, and should arise the interest of other potential scientific and industrial partners. This dissemination will also contribute to the transfer of knowledge towards those requiring more information about the technical and socio-economic know-how for building up the geothermal industry, especially in Central and Eastern Europe. This could speed up the exploitation of both conventional and unconventional geothermal resources in these countries and thus contribute considerably to the short- and long-term goals of the EU to reduce carbon dioxide emissions by increasing the share of renewable energy (Fouillac, 2006).

References

All citations refer to the presentation at the launching conference of the ENGINE project (12-15 February 2006, Orléans). Abstracts, presentations and articles are available on line at the web site http://conferences-engine.brgm.fr/conferenceDisplay.py?confId=0

Baumgartner J., Teza D., Hettkamp T., Homeier G., 2006. Geothermal exploration in the Upper Rhine valley in Germany. From Ledru P. & Genter A. (eds.) 2006, in Actes/Proceedings of the Engine Launching Conference, 12-15 February 2006, Orléans, France, p. 24.

Bruhn D., 2006. Rising open questions on investigation of Enhanced Geothermal Systems, as addressed by the I-GET project. From Ledru P. & Genter A. (eds.) 2006, in Actes/Proceedings of the Engine Launching Conference, 12-15 February 2006, Orléans, France, p. 37.

Cappetti G., 2006. How EGS is investigated in the case of the Larderello geothermal field? From Ledru P. & Genter A. (eds.) 2006, in Actes/Proceedings of the Engine Launching Conference, 12-15 February 2006, Orléans, France, p. 38.

Fouillac C., 2006. Geothermal energy and strategies to reduce greenhouse gas emissions. From Ledru P. & Genter A. (eds.) 2006, in Actes/Proceedings of the Engine Launching Conference, 12-15 February 2006, Orléans, France, p. 11.

Fritsch D., Gerard A., 2006. Current status of the EGS Soultz project: main achievements, results and targets. From Ledru P. & Genter A. (eds.) 2006, in Actes/Proceedings of the Engine Launching Conference, 12-15 February 2006, Orléans, France, p. 21-23.

Genter A., Guillou-Frottier L., Feybesse J.L., Nicol N., Dezayes C., Schwartz S., 2003. Typology of potential Hot Fractured Rock resources in Europe. Geothermics 32, 701–710.

Genter A., Guillou-Frottier L., Debeglia N., Dezayes C., 2006. EGS resource in France and Europe. From Ledru P. & Genter A. (eds.) 2006, in Actes/Proceedings of the Engine Launching Conference, 12-15 February 2006, Orléans, France, p. 44.

Hopkirk R., Haring M., 2006. The Swiss Deep Heat Mining programme: activities and perspectives. From Ledru P. & Genter A. (eds.) 2006, in Actes/Proceedings of the Engine Launching Conference, 12-15 February 2006, Orléans, France, p. 25.

Huenges E., Saadat A., Brandt W., Legarth B., Tischner T., Moeck I., Holl H.-G., Zimmermann G., 2006. Current status of the EGS Gross Schönebeck project within the North German basin: main achievements and perspectives. From Ledru P. & Genter A. (eds.) 2006, in Actes/Proceedings of the Engine Launching Conference, 12-15 February 2006, Orléans, France, p.26.

Karytsas C. Mendrinos D., 2006. The LOW-BIN project of DG-TREN (efficient low temperature geothermal binary power) aiming in improving EGS exploitation costs. From Ledru P. & Genter A. (eds.) 2006, in Actes/Proceedings of the Engine Launching Conference, 12-15 February 2006, Orléans, France, p. 77-78.

Kohl T., Andenmatten N., Rybach L., 2003. Geothermal resource mapping, example from northern Switzerland. Geothermics 32, 721–732.

Megel, 2006 Requirements for the Development of EGS. From Ledru P. & Genter A. (eds.) 2006, in Actes/Proceedings of the Engine Launching Conference, 12-15 February 2006, Orléans, France, p. 67.

Traineau H., Herbrich B., Lasne E., Tournaye D., Genter A., Sanjuan B., 2006 Geothermal development in the volcanic Caribbean islands and EGS perspectives. From Ledru P. & Genter A. (eds.) 2006, in Actes/Proceedings of the Engine Launching Conference, 12-15 February 2006, Orléans, France, p. 73.

Schuppers J. 2006. EC support to geothermal energy research and demonstration. From Ledru P. & Genter A. (eds.) 2006, in Actes/Proceedings of the Engine Launching Conference, 12-15 February 2006, Orléans, France, p. 12.