

NEWSLETTER N°3

Special issue on the GEMINI+ project



Word from the NC2I Chairman & GEMINI+ Coordinator

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Welcome to the NC2I newsletter!

This new edition focuses on the GEMINI+ project which aims to prepare the deployment of High Temperature Gas-cooled Reactors (HTGRs). The name GEMINI results of a partnership between two organisations: the European Nuclear Cogeneration Industrial Initiative (NC2I) and the US Next Generation Nuclear Plant (NGNP) Industrial Alliance. These organisations signed a Memorandum of Understanding in 2014, three years before the launch of **the GEMINI+ project** (September 2017). Therefore, contributions to this newsletter are concentrated on developments in the USA and Europe.

In the meantime, research institutes from Japan and South Korea joined the GEMINI effort, hence the “+” sign in the name of the project. The Japan Atomic Energy Agency (JAEA) and the Korean Atomic Energy Research Institute (KAERI) are active in the project. Moreover, a cooperation between JAEA and the National Centre for Nuclear Research (NCBJ), in Poland, on material research is gaining momentum after several mutual visits. The development of High Temperature Reactors (HTRs) technology was also among subjects of the Poland – South Korea Energy Experts Workshop held in September 2017 in Warsaw (Poland).

The main goal of GEMINI partnership is the deployment of HTRs on both continents, starting from Poland in Europe. Polish Minister of Energy, Krzysztof Tchórzewski, appointed a committee to study the different possible deployment scenarios and validate a report prepared by its members. Among them, representatives of chemical companies and power utilities who might be potential users of HTR reactors. The HTR programme is now among priority projects listed in a governmental document called *Strategy for Responsible Development*. The Polish National Centre for Research and Development (NCRD) recently issued a grant of about PLN18 million (over €4M and almost \$5M) for a joint project supervised by the Polish Ministry of Energy and

organised by the National Centre for Nuclear Research (NCBJ) and the Institute for Nuclear Chemistry and Technology (INCT).

An important tool for developing the HTR technology in Poland will be the creation of a NOvel MATerials for ENergy (NOMATEN) centre by NCBJ. Research carried out by NOMATEN will focus on materials being able to withstand harsh conditions like high temperature, high pressure or high radiation. The project already won the first stage of the prestigious European Horizon 2020 competition called Widespread/Teaming. The European Commission granted €0.4M to prepare a business plan which will be the subject of the second stage competition (possibly granted with over a dozen of million euros). In addition, the project won about €10M from the Polish Science Foundation. NOMATEN is now looking for a director – a world-class scientist expert in material research – and for group leaders. If you are interested to get a position at NOMATEN, look at nomaten.ncbj.gov.pl.

On the European continent, nuclear industry and research institutes reinforce their strategic planning activities in the framework of the Sustainable Nuclear Energy Technology Platform (SNETP). The plan is to evolve towards the creation of a legal entity in order to operate more actively and efficiently. Its three pillars are: **NUGENIA** (Generations II and III), **ESNII** (fast reactors) and **NC2I** (cogeneration). They will preserve their autonomy while externally acting as one entity. In view of these changes, NC2I made an effort to consolidate its mission and vision, which are now presented in the NC2I Vision Paper, published in past August.

Last but not least, NC2I has been active in the preparation of the HTR2018 conference. From 8-10 October, almost 150 contributions will be presented to attendees coming from all around the world. Highlights of this conference will be the beginning of the HTR programme in Poland and the HTR-PM construction in China ●

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GEMINI+

“Via Cogeneration, Nuclear Can Be Better Integrated into Global Energy Systems”



AS A SUSTAINABLE SOURCE OF ENERGY, NUCLEAR CAN TACKLE CLIMATE CHANGE.

Reducing greenhouse gas emissions is today a top priority. Limiting the temperature increase to a maximum of 2°C is extremely challenging, not mentioning the ambition to go beyond, as announced in the 2015 Paris Agreement. Being a sustainable source of energy, nuclear can contribute to tackle this challenge, considering sustainability as the balance between environmental protection, economics and reliability of supply.

Today, nuclear energy is nearly exclusively used to produce electricity. Nevertheless, there is a much wider domain where it might and should contribute to the supply of very low-carbon energy, such as direct heat or cogeneration. This can become very attractive if heat is provided at higher temperatures than the today's reactors, as there is a potential heat market for these levels of temperature. Wind and photovoltaic solar energies only can provide electricity, so they are not in direct competition with nuclear on the heat market. Via cogeneration, nuclear can be better integrated into global energy systems - sometimes called

hybrid systems-, bringing additional flexibility and zero CO₂ produced to compensate for the intermittency of renewable energy systems.

The OECD Nuclear Energy Agency (NEA) launched the Nuclear Innovation 2050 (NI2050) Initiative with the aim to accelerate the development and deployment of innovative technologies in the nuclear sector. Several top priority topics have been selected for which roadmaps are developed, describing what could be done to boost innovation through international cooperation. One of these topics focused on the demonstration of high temperature reactor couples with heat user facility. Once ready, this roadmap will be available to support stakeholders willing to discuss the ways and means for its implementation. ●

Marc Deffrennes
Nuclear Analyst at the NEA Divisions of Nuclear Technology & Economics, and Guest Contributor

GEMINI+

First Steps Towards a Full-size Demonstration of Industrial Nuclear Cogeneration

In line with its strategic objectives of supporting the demonstration of industrial nuclear cogeneration in Europe, NC2I gathered 24 European organisations to answer the 2016 Euratom H2020 call for proposals. The US Next Generation Nuclear Plant (NGNP) Industrial Alliance, the Japan Atomic Energy Research Institute (JAERI) and the Korean Atomic Energy Research Institute (KAERI) joined also forces to be part of the GEMINI+ project.

Launched in September 2017, this 3-year project aims to prove the industrial feasibility of nuclear high temperature cogeneration and to provide a conceptual design of High Temperature Gas-cooled Reactors (HTGRs). A demonstration in Poland – a country who showed its strong interest for the HTGR technology-, is expected to apply the project's results.

Moreover, GEMINI+ will lay the foundations of a licensing framework considering both the requirements of

Europe's nuclear safety directives and international safety standards (including post-Fukushima recommendations). The licensing framework should also address the specific requirements for coupling with industrial process heat applications, and not only with a turbine for electricity generation.

The technical support organisations involved in Work Package 1 already have issued preliminary safety requirements. Indeed, the GEMINI+ project explored some core configurations to make the reactor as compact as possible. This will allow an easy transportation of the vessel in the perspective of a systematic use of modular construction techniques for minimising site construction duration and cost.

On the other hand, the nuclear plant configuration is meant for rejecting all applications (electricity generation, steam distribution outside of the nuclear plant...), to standardise as much as possible the

nuclear plant while making it adaptable to industrial applications. The needs for the industrial domain are much more versatile than those for mere electricity production.

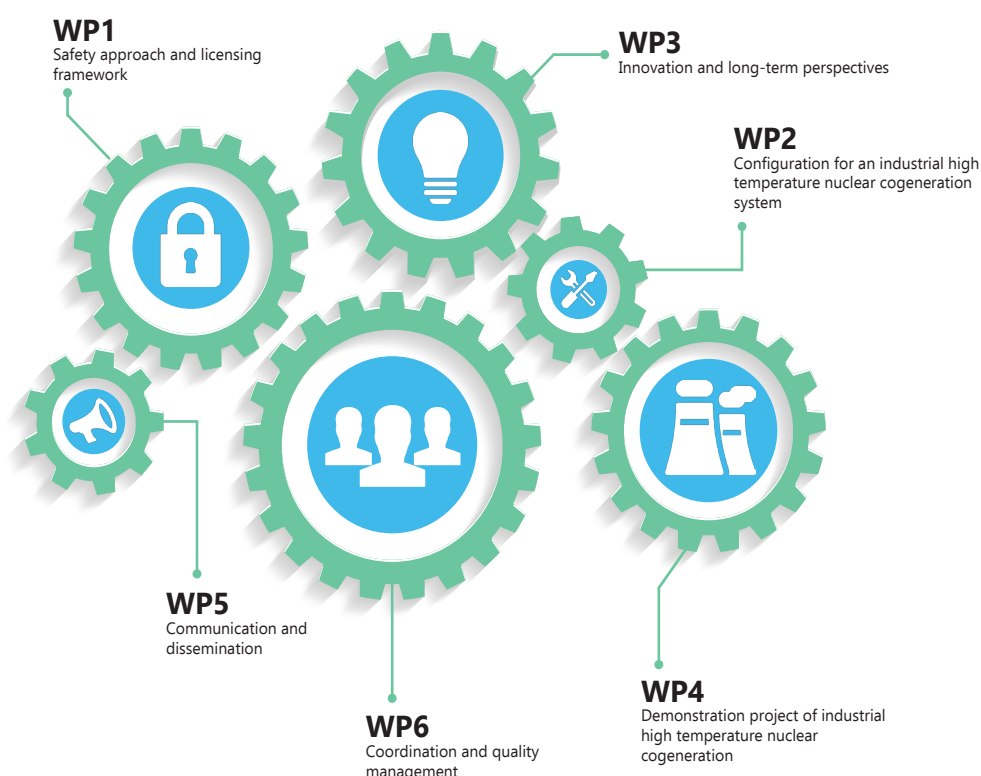
After nearly one year, two possible sites for industrial demonstration of nuclear cogeneration with an HTGR were identified and site studies are being examined.

Anchored in the reality of a real demonstration programme, the GEMINI+ project has the potential to make concrete progress towards a major step for nuclear industry: widen the scope of electricity generation to energy supply, including not only industrial process heat, but also transport energy needs through hydrogen or synthetic fuel production. ●

➡ www.gemini-initiative.com

Dominique Hittner

Technical Coordinator of the GEMINI+ project



Work package organisation
of the GEMINI+ project

NC2I

Active Collaboration with the Generation IV International Forum



The Generation IV International Forum (GIF) is collaborating towards technology demonstration of 6 different reactor types among which the Very High Temperature Reactor (VHTR). Seven countries are involved in the VHTR system: Australia, China, France, Japan, USA, South Korea and Switzerland. Globally, the technology is being advanced through near and medium-term projects, such as HTR-PM, NGNP, GT-MHR, NHDD and GTHTR300C, led by several start-ups, plant vendors and national laboratories.

The active GIF collaboration covers projects on fuel, materials, hydrogen production and code development for which the bigger part of European contributions come from Euratom projects proposed and coordinated by NC2I. Several NC2I members are representing Euratom in various functions in the GIF. A wealth of historical experience was collected and shared in the form of documents, presentations at dedicated workshops, and even including fuel and material samples. In the further course of the project execution, time, effort and scarce facilities (such as irradiation space or hot cell equipment) are being shared thus expediting progress.

Focus is given to licensing requirements for demonstrators of near-term steam production, both for power generation and industrial process heat applications while more aggressive,

longer-term and higher temperature applications are mainly pursued to enable thermochemical production of bulk hydrogen. Based on the VHTR's relatively high technology readiness level, orientations for future R&D target a further increase of the system's market readiness with emphasis on system integration and assessment, safety analysis and demonstration, waste minimisation and cost reductions. ●

Recent achievements:

M.A. Fütterer, Fu Li, H. Gougar, L. Edwards, M. Pouchon, M. Kim, F. Carré, H. Sato, *Recent Advances in the GIF Very High Temperature Reactor System*, Proc. HTR 2018, Warsaw, Poland, October 8-10, 2018.

GIF Annual Report 2017: www.g4if.org

Michael Fütterer

Deputy Head of Unit for Nuclear Safety at the Directorate General Joint Research Center (JRC)

NC21

UCO Based TRISO Coated Particle Fuel Qualification in the USA

The US Department of Energy (DoE) is performing a multiyear and multiphase test and irradiation programme for UCO based TRISO coated particle fuel at Idaho National Laboratory, under the DOE AGR programme. TRISO coated particles using Uranium Oxi-Carbide (UCO) kernel are the basic fuel form that will be used by several high temperature reactor (HTR) designs (Framatome, X-Energy, Kairos Power, and StarCore Nuclear) in the United States.

The industry stakeholders are planning to prepare a Limited Scope Topical Report (LSTR) that will document the generic aspects of the AGR qualification programme. This report will include technical information and experimental data from the AGR programme. The LSTR will be reviewed by the US Nuclear Regulatory Commission (NRC), for safety evaluation and approval. Once validated, each individual HTR designers can use the report as the bases for its reactor specific fuel qualification topical report.

Launched in August 2018, this project has been under planning and for several years and is co-funded by the industry and the US DoE. The LSTR is expected to be ready for the NRC

review in 2019. Upon completion of one estimated year, the NRC review and resolution of all comments a Safety Evaluation Report (SER) will be issued by the NRC signaling approval of the topical.

An annotated outline of the topical report has been prepared and approved by the stakeholders. Electric Power Research Institute (EPRI) will manage the project. Idaho National Laboratory and BWXT will prepare the first draft of the report. The HTGR Technology Working Group members will provide technical input and internal review, and an independent external review team made up of industry experts will provide independently review before the topical is submitted to the NRC. ●

Farshid Shahrokhi

Technical consultant at Framatome Inc.

UK 2016-2021 Nuclear Innovation Programme

The UK's Department of Business, Energy and Industrial Strategy is progressing through its current 2016-2021 Nuclear Innovation Programme. This includes work on advanced nuclear fuels that could provide greater levels of efficiency, covering the development of technology and processes for manufacturing coated particle high temperature fuels.

The Programme also includes the Advanced Modular Reactor (AMR) Feasibility and Development (F&D) project. In this context, AMRs represent a variety of designs that differ from conventional reactors, which use pressurised or boiling water for primary cooling. The project targets proposed reactor types that maximise the amount of off-site factory fabrication and can target:

- The generation of low-cost electricity
- Providing increased flexibility in delivering electricity to the grid over current nuclear power plant

● Providing increased functionality, such as the provision of heat output for domestic or industrial purposes, or facilitating the production of hydrogen

● Offering alternative applications that may generate additional revenue or economic growth

The first phase of the competition launched in late 2016 and the successful entrants include three TRISO fuelled high temperature reactors. ●

Rob Arnold

Department for Business, Energy and Industrial Strategy, UK Government

NC2I

US NRC to Modernise its Licensing Process



Advanced reactor developers in the USA are working with the US Nuclear Regulatory Commission (NRC), the Nuclear Energy Institute (NEI) and the US Department of Energy (DoE) to develop a technology inclusive, risk-informed, and performance-based process for licensing advanced reactors. The NEI Advanced Reactor Regulatory working group meets regularly with the NRC to establish a coordinated plan for rulemaking and regulatory guidance.

An industry prepared guidance document is being developed presenting an efficient process addressing key licensing issues of advanced non-light water reactors (non-LWRs). The document is product from the Licensing Modernisation Project (LMP) led by a nuclear utility and cost-shared by the US DoE. The LMP prepared guidance for establishing licensing technical requirements to navigate through a risk-informed and performance-based design and licensing of non-LWRs. The process acknowledges enhancements in safety achievable with advanced designs and reflects current states of knowledge regarding safety and design innovation, creating an opportunity for reduced regulatory complexity with increased levels of safety and certainty.

The guidance document presents a modern, technology-inclusive, risk-informed, and performance-based (TI RIPB) process for selection of licensing basis events (LBEs); safety classification of structures, systems, and components

(SSCs) and associated risk-informed special treatments; and determination of defence-in-depth (DID) adequacy for non-LWRs. This provides one acceptable means for addressing the aforementioned topics as part of demonstrating a specific design provides reasonable assurance of adequate radiological protection necessary during licensing reviews.

Concurrently, the US NRC is engaged through regular meetings with the industry representatives and is preparing a regulatory guide (RG) that will clarify and endorse as appropriate the process proposed by the industry as one acceptable method for determining the scope and level of detail for parts of applications for licenses, certifications, and approvals of non-LWRs. The NRC has stated that “it finds it appropriate and necessary to define a methodology versus the prescriptive nature of current LWR-centric guidance on content of applications for the guidance to be applicable to a variety of non-LWR technologies.”

Regulatory modernisation is continuing long-term effort and is considered essential element of advanced reactor deployments. It continues to enjoy widespread support from the government, utilities and developer communities. ●

Farshid Shahrokhi
Technical consultant at Framatome Inc.



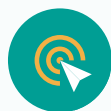
The European Nuclear Cogeneration Industrial Initiative (NC2I) is one of the three SNETP pillars. It aims at demonstrating an innovative and competitive energy solution for the low-carbon cogeneration of heat and electricity based on nuclear energy. The targeted outcome is the commissioning within 10 years of a nuclear cogeneration prototype to deploy this low-carbon energy technology in several energy-intensive industries.



SNETP and NC2I are supported by the SPRINT project which has received funding from the Euratom research & training programme 2014-2018 under Grant Agreement n°662149.



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The research and development activities performed in the GEMINI+ project aim to support the GEMINI Initiative, a transatlantic collaboration between the European Nuclear Cogeneration Industrial Initiative (NC2I) and the American Next Generation Nuclear Plant (NGNP) Industry Alliance

During 36 months, GEMINI+ partners will work together towards the demonstration of high temperature nuclear cogeneration with a High Temperature Gas-cooled Reactor (HTGR).

Launched in September 2017, this European Horizon 2020 project funded under the Euratom programme will provide a conceptual design of a high temperature nuclear cogeneration system that supplies process steam to industry, a licensing framework for this system and a business plan for a full scale demonstration.

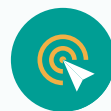
Coordinated by the National Centre for Nuclear Research (NCBJ), in Poland, the GEMINI+ consortium gathers 26 partners from accross Europe and includes partners in Japan, South Korea and the United States.



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