NC2I Nuclear Cogeneration Industrial Initiative

NGNP Industry Alliance
*Clean, Sustainable Energy for the 21st Century*

# The GEMINI Initiative

## *A Trans-Atlantic Partnership to Accelerate the Development of Improved, Intrinsically Safe and Versatile Nuclear Energy Technology*

***Vision Document***

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*This document has been established by the U.S. NGNP Industry alliance and the European Nuclear Cogeneration Industrial Initiative NC2I*

## SUMMARY

No other technology other than the HTGR can, in the relatively near term and with such a high level of safety, address such a broad spectrum of energy challenges – electric power, process heat and hydrogen production for industrial and transportation purposes. The GEMINI Initiative provides a means for addressing and meeting the financial challenges and regulatory compliance work required to successfully deploy this technology. Upon successful implementation, the GEMINI Initiative will strengthen each partner's technology and economic base, increase energy security and significantly advance the protection of our environment.

## VISION

The GEMINI Initiative calls for U.S. and EU partners to work with their governments under a simple, transparent, and accountable arrangement to facilitate the design and regulatory work for the first modern commercial HTGR. The scope of GEMINI includes the definition of HTGR specifications for both the U.S. and EU, design and the completion of regulatory documentation for the review and approval by the appropriate regulatory authority – the NRC in the U.S. and the appropriate authority in the presumed EU host country. Such an arrangement will help provide the confidence necessary to inspire private sector and Government investment to support the successful implementation of the GEMINI Initiative. In turn this will provide the framework for the construction of "sister" or "twin" prototype projects in both the U.S. and EU, and the ultimate widespread commercialization and utilization of this intrinsically safe and versatile nuclear technology.

The GEMINI Initiative:

- Reduces each partner's cost of design and licensing – a notional targeted funding model relies on 1/3 funding each by the U.S. and EU governments[1] and the private sector;
- Combines the best engineering talents from both the U.S. and EU;
- Fully utilizes completed and ongoing research and development work performed in the U.S. and the EU, by government programs and the private sector;
- Strengthens the attractiveness of the HTGR to potential investors by strengthening stability of government investment, lowering costs, and greatly increasing market opportunities;
- Relies on existing design experience and technology, adapts them to the present regulatory frameworks and benefits from new technology developments, particularly in the fields of fuel and graphite;
- Is driven by a financially incentivized U.S. / EU industrial team in partnership with the EU and U.S. governments;
- Enhances public understanding and acceptance of HTGR technology;
- Facilitates an international dialogue with end-user industries, many of them global players;
- Will create jobs and benefit the industrial economy of the partner nations;
- Enables each partner to move forward through its own means to complete construction of a first of a kind modern HTGR by the year 2027;
- Positions each partner to construct and potentially export subsequent modern HTGR plants; and
- Makes significant contributions to the energy security and environmental quality and obligations of both the U.S. and EU.

[1] EU governments are understood as European Union as well as National and Regional Governments.

NC2I and the NGNP Industry Alliance are currently developing an overall project structure and are in discussions with possible sites in the EU and U.S. Both NC2I and the NGNP Industry Alliance encourage the U.S. and EU governments to work together with their respective industries to determine how best to structure their partnership and participation. GEMINI Initiative costs and schedule will be optimized for all involved by an early agreement on the most simple and effective structure possible. Work performed should satisfy the regulatory requirements of both the U.S. and the anticipated host country in the EU.

Final site selection, licensing, and construction of FOAK prototype(s) is left to the partner nations and are outside the scope of GEMINI per se. However, it is important that potential U.S. and EU sites for construction be identified early and involved in each phase. GEMINI Initiative private sector participants will be heavily incentivized to make a return on their investment and hence will work hard with the governments and other stakeholders to ensure the project is a success.

## Context and Background

Nearly 80% of the world's energy demand is consumed in the industrial and transportation sectors, and nearly all of this energy is supplied from the **burning of fossil fuels**. Additionally, approximately 70% of electric power is produced from the burning **fossil fuels**.

**High Temperature Gas Cooled Reactors** (HTGRs) can be strategically deployed in the relatively near term to play a significant role in reducing the world's very heavy reliance on fossil fuels. The need to address this heavy reliance is particularly acute in the EU and Eastern Europe where alternatives to Russian natural gas are desperately needed in both the near and longer-term time frames.

The high temperature capability (750°C presently and higher projections for the future) of HTGRs provides a viable alternative for reducing the massive amounts of natural gas and/or other fossil fuel used in industry, and assisting in the carbon-free synthesis of liquid transportation fuels and hydrogen. Depending on the use, the energy from each 100MW of HTGR-produced heat can eliminate the consumption of 72 millions of cubic meters of natural gas (2.5 million MMBtu) annually. From an environmental perspective, this translates to a reduction of 140 000 tons of CO2 emissions per year when replacing natural gas usage and almost double that amount when replacing coal usage. A 600 MWth reactor would **avoid approximately 1 million tons of CO2 emissions per year**.

Having evaluated the worst-case scenarios, the HTGR's simple design provides an **intrinsic safety feature** that precludes the potential of any significant fuel failure scenario that would result in significant release of radioactive material. Because they require no emergency power sources, cooling water or operator intervention to prevent core damage and significant radioactivity release, HTGRs are immune to extreme natural disasters or other events such as, earthquakes, tsunamis or complete station blackouts. They are "walk away safe", meaning that in a worst-case scenario, no human intervention or response is required to ensure the safety of the public or the surrounding area. Indeed, the safety zone surrounding an HTGR is only a few hundred meters as opposed to two or more miles for a large light water reactor. As a result, no evacuation zone would be required around HTGR. Recent research and development work in the U.S. and EU has further established the unparalleled safety case for these reactors.

Their intrinsic safety features and high outlet temperatures make HTGRs **uniquely versatile**: they can be co-located within new or existing industrial facilities to substitute for fossil fuels for the production of electricity, process heat and steam. Intrinsic safety is a pre-requisite for direct colocation with industrial facilities, and HTGR is considered as the reference nuclear technology for

addressing this requirement. In addition, their high efficiency in electric power production allows them to be located in arid areas with very limited supplies of cooling water.

Of all of the next generation reactor technologies on the horizon, HTGRs are the most developed and have the highest potential for commercialization in the **relatively near term**. Their intrinsic safety features also make them more attractive to a safety conscious public. Currently, HTGR test reactors are operating in Japan and China: both the U.S. and EU have together hosted and operated a total of five HTGRs in the past. Moreover, China is currently building a 2-unit HTGR first-of-a-kind (250 MWth / unit), and preparing for deployment of a commercial HTGR program.

Despite their very low safety risk, the commercial development of modern nuclear reactors represents a difficult undertaking from the financial perspective: the up-front costs are large, timeframes for obtaining regulatory approvals can be long and difficult to predict; additionally, the time for return on investment can be in the range of 15 to 20 years. The costs of preparing regulatory documentation, completing facility and infrastructure design, infrastructure development and obtaining regulatory approvals for HTGR in the U.S. or EU is expected to be approximately $1.5 Billion (€1.1 billion) over 7 years[2]. Therefore, as with any new nuclear energy technology, government support is necessary for design and licensing of HTGRs, particularly in the early phase of development.

The subsequent construction phase of a first-of-a-kind industrial prototype is expected to last 4 years and also cost approximately $1.5 Billion. However the construction phase is expected to require substantially less government support – possibly none depending on market conditions - as the primary up-front and regulatory risks will have been addressed.

## Proposed GEMINI Initiative Timeline

**2014 –2015:** NC2I and NGNP Industry Alliance work with potential demonstration sites in the U.S. and EU to develop a proposed development partnership. In addition, initial discussions begin with the U.S. and EU governments on how to move forward will be taking place.

**End of 2015 – mid-2016:** Project structure and partners largely determined. Substantial non-government cost share will have been determined.

**End of 2016** – Agreement with U.S. and EU governments on cost sharing and moving forward on project scope.

**January, 2017:** Necessary contracts implemented, project oversight mechanisms in place and work begins.

**January, 2023**: Completion of design and licensing requirements in both the U.S. and EU.

**Beyond GEMINI: 2023 – 2027** – Construction of HTGR prototype(s) in the U.S. and EU.

**Mid-2027** – First operation

[2] Based on U.S. estimates

## Organizational Background

### About the NGNP Industry Alliance

The NGNP Industry Alliance is an international consortium headquartered in the United States of America with member organization aligned to promote HTGR technology. In 2012, The Alliance identified and selected the HTGR technology that fits industry needs and has implemented a plan to move it forward. The Alliance has continued to grow since 2010 and is currently comprised of industry-leading membership including potential end users, owner operators, industrial suppliers and nuclear technology companies including: Savannah River Site Community Reuse Organization (SRSCRO) and the Advanced Research Center (ARC), AREVA, ConocoPhillips, Dow Chemical Company, Entergy Corporation, Graftech International Ltd., Mersen, Petroleum Technology Alliance Canada, SGL Group, Technology Insights, Toyo Tanso Co. Ltd., Manufacturing Excellence Consulting, Inc., Westinghouse Electric Company and Wyoming. For more see: www.ngnpalliance.org

2014 Alliance Members

### About the NC2I

The European Nuclear Cogeneration Industrial Initiative (NC2I) was officially created in 2011 as one of three pillars of the European Sustainable Nuclear Energy Technology Platform (SNETP). The objective of the Initiative is to demonstrate 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. NC2I builds on the EUROPAIRS (see: www.europairs.eu) project that identified possible operating windows for the combined system of a very (V)HTR connected to industrial processes. Today NC2I counts eight full members and is supported by the NC2I-R (Research) European project, which is structuring the European public and private capabilities for preparing a nuclear cogeneration demonstrator program. NC2I is currently setting up a Business Group designed to structure the dialogue with energy-intensive industry and market actors. For more see: www.nc2i.eu