The GEMINI Initiative

*Presented by*

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On the basis of a common vision of the specific potential of HTGR for industrial deployment,

The NGNP Industry Alliance, based in the US

The Nuclear Cogeneration Industrial Initiative, based in Europe

decided to launch jointly the **GEMINI Initiative**.
What is the NGNP Industry Alliance?

- Promotes the development and commercialization of modern HTGR technology
  - recent milestones:
    - HTGR application studies of Waterford Louisiana site and of Canadian Oil Sands
    - HTGR assisted coal-to-liquids studies in 2 top U.S. coal states (Wyoming, Kentucky)
    - Worked with U.S. Congress and Administration to maintain strong funding for HTGR development work: approx. $600M since 2006
    - Close coordination with the Idaho National Laboratory
    - Completion of Business Plan in collaboration with U.S. Department of Energy
What is the Nuclear Cogeneration Industrial Initiative?

- NC2I was set up in 2011 as Europe’s initiative for **nuclear cogeneration**, under the Sustainable Nuclear Energy Technology Platform (SNETP)

- HTGR was selected as the reference technology in order to reach **higher temperatures** for industrial applications

- NC2I builds on the German legacy and 15 years of EU R&D programmes

- A **task force** gathers the nuclear developers, and a **business group** is currently being set up to structure a dialogue with end-users and investors
The global energy context: Worldwide concern for climate change

- In Europe, the SET-Plan fixed ambitious targets for reducing CO₂ emissions
  - 40% by 2030

- In US, Clean Power Plan – EPA emission goals, June 2014
  - 30% by 2030
The global energy context: Concern for security of energy supply

- The EU economy is significantly dependent on imported fossil fuel
  - High and volatile energy costs
  - Insecurity of supply due to international conflicts
  - Concern about de-industrialization of Europe: unfavorable energy conditions contribute to relocation of industrial activities from Europe to other regions ("carbon leakage")

- US is currently flushed with cheap natural gas from fracking operation, however
  - Environmental concerns are brewing
  - Export to higher priced markets is expected to normalize worldwide price of natural gas
A shared vision of the assets and challenges for HTGR industrial deployment (1)

• Higher temperature than other present nuclear systems
  ⇒ Possibility to operate in **cogeneration** mode with high **flexibility**
    for adjusting between electricity generation and process heat supply
  ➢ A large market of industrial process heat supply identified in US and EU
  ➢ New market for nuclear, not in competition with Gen III deployment
  ➢ Very significant potential to contribute to
    
    ▷ **Limitation of CO₂ emissions**
      • Industry responsible for 25% of European CO₂ emissions
      • Each 100 MWth of process heat supplied by HTGR would save yearly 140 000 t of CO₂ emissions if replacing natural gas and almost double if replacing coal

    ▷ **Security of energy supply**
A shared vision of the assets and challenges for HTGR industrial deployment (2)

• Unique intrinsic safety features
  ➢ Even in worst case scenario, no significant core degradation and/or radioactive releases outside the reactor in accident condition
    ⇒ Possible co-location with process-heat end-user industries
  ➢ Simplification of the safety design
    ⇒ Asset for competitiveness

• The most mature Generation IV technology
  ⇒ Possibility of early industrial deployment with mostly proven technologies
• Very limited industrial experience of nuclear cogeneration until now, moreover limited to lower temperatures

⇒ Need of **industrial demonstration** of cogeneration with HTGR **as soon as possible** before large scale industrial deployment

• 3 phases for the demonstration program, with different leading actors and different level of financial (not primarily technical) risks

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<tr>
<th>Phase</th>
<th>Leader</th>
<th>Risk Level</th>
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<tr>
<td>Design and licensing</td>
<td>designer</td>
<td>Significant risks</td>
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<td>Construction</td>
<td>operator/end-user</td>
<td>Medium to low risks</td>
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<td>Operation</td>
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• Despite low technical risk, there are high risks in the first phase of the development of a new nuclear system
  ➢ Large up-front costs (~ 1.5 G$ for completing design and licensing of prototype cogeneration HTGR) and long duration (about 7 years)
  ➢ Timeframe for meeting regulatory requirements long and uncertain
  ➢ Return on investment in 15 to 20 years

→ Need to alleviate demonstration risks and make construction projects attractive for investors
Government funding would be needed to de-risk the project and would be in line with the government role:
- Increased safety
- Reduction of CO₂ footprint in industry
- Increased job opportunities
- Industrial energy supply security and diversity

The NGNP Industry Alliance and NC2I decided to launch **the GEMINI Initiative** for facilitating this challenging phase by sharing the development efforts and the risks between US and Europe.
The GEMINI Initiative (1)

• The approach

➢ Convergence of designs between Europe and the US
  ✷ If possible same design
  ✷ At least maximum convergence between both designs (e.g. most components identical, same fuel)
      ➔ To reduce each partner’s cost by sharing tasks
      ➔ To combine the best engineering and research talents and means as well as the industrial capabilities both from the US and EU, including past experience and ongoing activities

➢ Some residual differences may persist in order to address different market needs or regulatory requirements on both sides.

➢ Industry and research organizations in the US and in Europe need to work under a strong international agreement to carry out the design and regulatory tasks, as well as the residual R&D and qualification.
The GEMINI Initiative (2)

• Main actors
  - Nuclear vendors
  - Research Centers
  - Governments
  - Investors

• Main outputs
  - A certified design
  - Supply chain identified
  - Qualified components
  - Sites for demonstration in the US and in Europe
  - Operator / end-users partnership for construction and operation
Basis for the HTGR cogeneration system design (1)

• To use the HTGR modular concept
  ➢ For enhanced safety, economic competitiveness and adaptation to end-users needs

• To benefit from steam networks already in operation on large industrial sites:
  At least for the first applications, the coupling between the nuclear heat source and the process heat applications will be a **standardized “plug-in” coupling**, with the HTGR system substituting a conventional cogeneration plant
No need for HTGR outlet temperature to exceed 700-750°C and process steam to exceed 550-600°C

Possibility to rely on mature designs with steam generators and secondary steam cycle (HTR-Modul, MHTGR, etc.), adapting them to present regulatory frameworks

Use of existing nuclear industry-proven materials for main components – Helium Pressure Boundary and Steam Generator
Basis for the HTGR cogeneration system design (3)

- Nevertheless, as long as no additional risks and delays are induced, to assess the benefit from progress of technology and innovations drawn from the most recent design experiences in Europe and in the US (ANTARES, NGNP...) or emerging from the GEMINI Initiative:
  
  - Recent graphite grades selected by the European and US R&D
  - The fuel developed in the US and being presently qualified in the AGR program
  - Use of advanced technologies (composites for control rod cladding, membranes for He purification, advanced instrumentation, etc.)

\[ \text{Fraction of produced fission products released in the AGR 1 irradiation} < 10^{-7} \]
A first action of the GEMINI Initiative: the TWINS proposal

• In September 2014, NC2I and NGNP Industry Alliance members have proposed a project in the Euratom call for proposal:

**TWINS [Transatlantic Working partnership for Intrinsic Nuclear Safety]**

• Key objectives
  ➢ To select the main design options of the HTGR cogeneration system with the aims of
    ✷ Maximum competitiveness
    ✷ Enhanced safety
    ✷ Maximum convergence between NC2I and Alliance designs
  ➢ To define a safety approach for licensing and have it reviewed by TSOs
  ➢ To elaborate a roadmap for the GEMINI Initiative, sharing its development program between US and EU partners

• Targeted outcome (2017): the technical and funding basis for starting the design and licensing of the prototype plant jointly in the US and in Europe
Moving forward

- Currently the construction of HTR-PM is a major step for modern HTGR technology, paving the way to industrial deployment of modular HTGR

- The GEMINI Initiative focuses on the design and certifications required for bringing HTGR technology to the US and European industrial process heat market

- With the TWINS proposal, GEMINI is making a first step to move forward

- GEMINI partners welcome international support to their initiative