Appendix 1

GIF PRIORITY OBJECTIVES FOR THE NEXT FIVE YEARS

GIF Priority Objectives for the Next Five Years

The GIF Symposium has the objective to give a global view on ongoing activities within the initiative. At the same time, the "Outlook" document illustrates the foreseen path forward. The following text provides a summary of agreed priority objectives for the different systems in order to help focusing and streamlining the GIF R&D activities during the next five years, consistent with GIF objectives. These priority objectives result from an analysis based on the following steps:

1) Review of the potential of the system.
2) Development target for the effective use of its potential.
3) Review of the current stage of development and analysis of technology options, with a view to down selection.
4) Assessment of key R&D issues and priority requirements.

These steps are discussed in the "Outlook" document. The summary presented below is essentially related to step 4) and provides for each system some key R&D priorities.

Very High Temperature Reactor (VHTR)

The VHTR has a long-term vision for operating with core-outlet temperatures in excess of 900 ºC and a long-term goal of achieving an outlet temperature of 1000 ºC. At the same time, the VHTR benefits from a large number of national programs that are aimed at nearer-term development and construction of prototype gas-cooled reactors that have adopted core-outlet temperatures in the range of 750 ºC to 850 ºC. The overall plan for the VHTR within Generation IV is to complete its viability phase by 2010, and to be well underway with the optimization of its design features and operating parameters within the next five years.

1. Core outlet temperatures

Objective:

- Further assess the range of candidate applications for VHTRs with the core outlet temperatures and unit power required, as well as the associated time line.

2. Domains of application and priorities

Objectives:

- Spur the interest of industries to use VHTRs to produce high temperature process heat in various industrial applications, thereby displacing fossil fuels and reducing the production of greenhouse gases.
- Make progress towards resolving feasibility issues (processes, technologies) and more reliably assessing performance;
- Update the definition of priority R&D needs.

3. Hydrogen production

Objectives:

- Make progress towards resolving feasibility issues (processes, technologies) and more reliably assessing performance of hydrogen production processes.
- Update the definition of priority R&D needs and pre-industrial demonstration projects.

4. Materials for the core and cooling systems

Objectives:

- Make progress towards resolving feasibility issues of high temperature design, including the qualification of heat resisting materials and manufacturing issues for key components of the core and the cooling systems (pressure vessel, intermediate heat exchangers).
- Update the definition of priority R&D needs.

5. TRISO fuel particles

Objective:

- Establish performance margins of the uranium-dioxide and uranium-oxicarbide coated particle fuels and establish fission product source terms.

Sodium Fast Reactor (SFR)

The SFR has a long term vision for highly sustainable reactors requiring its development in several important technical directions. At the same time, the SFR benefits from the worldwide operational experience of several sodium-cooled reactors and from a number of national programs aiming at nearer-term restart, development and construction of prototype Generation IV reactors. The overall plan for the SFR within Generation IV is to be well underway with the optimization of its design features and operating parameters within the next five years, and possibly to complete its performance phase by 2015.

1. Advanced fuels

In this area, after the identification of the advanced fuel options, major R&D efforts will be focused on fabrication feasibility and irradiation behavior of minor-actinide bearing fuels. A preliminary selection of advanced fuel(s) should be made.

The assessment of the high burn-up capability of advanced fuel(s) and materials should follow.

Objectives:

- Make preliminary selection of advanced fuels.
- Define priority irradiations beyond the Global Actinide Cycle International (GACID) project.
- Progress towards the resolution of feasibility issues regarding actinide recycling.
- Verify that milestones of the GACID project are realistic.

2. Safety approach

Objectives:

- Progress towards converging safety approaches.
- Revisit re-criticality and potentially positive reactivity coefficient issues, to compare approaches and seek for consensus.
- Assess, among other approaches, the effectiveness of inner-duct structures to mitigate severe accidents while enhancing fuel discharges without the formation of large molten-fuel pool. This assessment may benefit from analyses and conclusions of the EAGLE (Experimental Acquisition of Generalized Logic to Eliminate Re-criticalities) experiment if they can be shared with the international community.

3. In-service inspection

Research and development of in-service inspection approaches is following three parallel paths each of which is highly innovative in its own right. Significant improvements or breakthroughs in the ability to perform in-service inspection of in-vessel sodium components may result from this ongoing work.

Objectives:

- Draw conclusions from related R&D work and set priorities for the future.
- Progress towards resolving in-service inspection and repair feasibility issues.

4. Phenix, Monju and possibly CEFR and BN–800 tests

Objective:

- Summarize lessons learned from planned experiments and start-up.

5. Energy conversion systems

In this field R&D activities cover development and demonstration of sodium-CO_2 Brayton cycle advanced energy conversion systems including: the development and performance testing of compact heat exchangers; development and testing of small-scale sodium-CO_2 turbo-machinery and a complete integrated cycle; sodium-CO_2 interaction testing; CO_2 oxidation and carburization tests; and the analysis of system behavior for SFRs incorporating the sodium-CO_2 Brayton cycle.

Objectives:

- Draw conclusions from related R&D work and define priority research for the future.
- Make progress towards resolving feasibility issues on alternative energy conversion systems with gas or supercritical CO_2.

6. Materials, codes and standards

Objective:

- Develop of codes and standards for high temperature application (for example RCC-MR published by AFCEN is available and has been used for construction of PFBR).

Super-Critical Water Reactor (SCWR)

The SCWR has a long-term vision for water reactors that requires significant development in a number of technical areas. At the same time, the SCWR benefits from the resurgence of interest worldwide in water reactors as well as an established technology for supercritical water power cycle equipment in the fossil power industry. The overall plan for the SCWR within Generation IV is to complete its viability phase research by about 2010 and to operate a prototype fueled-loop by around 2015, thereby preparing for construction of a prototype reactor sometime after 2020.

1. Feasibility of meeting GIF Goals

The SCWR builds on a strong technical foundation from two advanced technologies: advanced Gen III+ water-cooled reactors; and advanced supercritical fossil power plants. The work performed to date does not show any issues regarding the viability of merging these two well-known technologies. However, the feasibility of meeting GIF goals and the estimation of the extent to which GIF metrics can be improved require significant R&D.

Objectives:

- Improve knowledge base to enable optimized designs and accurate assessments against GIF goals.
- Continue R&D needed to design and build a prototype.
- Continue conceptual designs of the various SCWR versions, including fast and thermal neutron spectrum designs using pressure tube and pressure vessel technologies.

2. Critical-Path R&D

Two critical-path R&D projects have been identified and are currently underway: materials and chemistry; and thermo-hydraulic phenomena, safety, stability and methods development.

2.1 Materials and chemistry

Objectives:

- Test key materials for both in-core and out-core components.
- Investigate a reference water chemistry taking into consideration materials compatibility and radiolysis behavior.

2.2 Basic thermal-hydraulic phenomena, safety, stability and methods development

Objectives:

- Continue investigating key areas such as heat transfer, stability and critical flow at supercritical conditions.
- Understand better the different thermal-hydraulic behavior and large changes in properties around the critical point compared to water at lower temperatures and pressures although the design-basis accidents for the SCWR will have similarities with conventional water-cooled reactors.

In addition, non-critical-path R&D areas will continue for specific designs in the areas of advanced fuels and fuel cycles (e.g., using thorium in the pressure-tube design and development of the fast-core and mixed-core options for the pressure-vessel design), and hydrogen production.

Gas-cooled Fast Reactor (GFR)

The GFR has a long-term vision for highly sustainable reactors that requires significant development in a number of technical areas. Unlike the SFR, the GFR does not benefit from operational experience worldwide and will require more time to develop. However, the GFR may benefit from its similarities with the VHTR, such as the use of helium coolant and refractory materials to access high temperatures and provide process heat. The overall plan for the GFR within Generation IV is to be well underway with the viability research within the next few years and to be completed by 2012.

1. Fuel

Work in this field focuses on assessment of multilayer SiC clad carbide fuel pins.

Objectives:

- Identify and demonstrate suitable technologies for pin fuels (low-swelling mixed-carbide fuel, multilayer composite SiC cladding for fuel pins).
- Update irradiation experiments in BR2, and identify other priority R&D needs (e.g., fabrication and behavior at extreme temperature).

2. Experimental demonstration design

The ALLEGRO experimental prototype is an option within the “European Strategic Research Agenda”.

Objectives:

- Update and improve the definition of the experimental prototype ALLEGRO intended to demonstrate GFR key principles and technologies and to offer muti-purpose services such as fast-neutron irradiations and high temperature heat supply.
- Document ALLEGRO so as to support a decision around 2012 of proceeding towards detailed design studies and implementation.

3. Safety

GFR conceptual studies and operating transient analyses are priority R&D areas.

Objectives:

- Demonstrate the safety in case of depressurization accident;
- Study the phenomenology of severe accidents in core with ceramic cladding and structures;
- Confirm GFR safety through further accidental-transient analyses, assessments of innovative design features, and documentation of severe accidents analyses. Especially:
  - assess the merits of a pre-stressed concrete primary pressure boundary; and
  - proceed with tests of GFR fuel samples in extreme-temperature conditions.
- Further update the definition of priority R&D needs.

Lead-cooled Fast Reactor (LFR)

The LFR features a fast-neutron spectrum and cooling by an inert liquid metal operating at atmospheric pressure and relatively high temperatures. The main missions include the production of electricity, process heat, and hydrogen, and actinide management aiming at long-term fuel sustainability. The LFR has development needs in the areas of fuels, material performance, and corrosion control. The overall plan for the LFR is to be well underway with the development of its materials, design features, and operating parameters within the next five years.

1. Heavy liquid metal technology (coolant, materials, components)

Work in this field focuses on progress towards resolving issues related to the feasibility of heavy liquid metal technologies.

Objectives:

- Select and validate candidate structural materials.
- Demonstrate of corrosion control (with surface treatment, oxygen control, etc.).

2. Experimental demonstrations

Whilst the SFR remains the reference technology, the LFR and the GFR are promising alternatives. The LFR has a rather limited operational experience but it has several similarities with the SFR (e.g. fuel cycle). It was thus agreed within GIF that it should benefit from the relevant outcomes of the R&D on the SFR. An experimental reactor with a capacity in the range of 50 to 100 MWth will be needed to gain experience feedback by 2020.

Objectives:

- Update and improve the definition of the experimental prototype LFR.
- Confirm its feasibility and document its merits for testing LFR technologies in support of a decision around 2012 to proceed towards detailed design studies and implementation.

Molten Salt Reactor (MSR)

The MSR has a long term vision for highly sustainable reactors that requires significant development in a number of technical areas. The overall plan for the MSR is to be underway with the development of its design features, processing systems and operating parameters within the next five years.

1. Focus

In the United States, a PB–AHTR (900 MWth) has been selected as the lead commercial-scale plant AHTR concept.

In Europe, since 2005, R&D on MSR is focused on fast spectrum concepts (MSFR) which have been recognized as long term alternatives to solid-fuelled fast neutron reactors with attractive features (very negative feedback coefficients, smaller fissile inventory, easy in-service inspection, simplified fuel cycle…). MSFR designs are available for breeding and for minor actinide burning.

Objective:

- Advance cooperative R&D work to further resolve feasibility issues and assess the performance of the different types of MSRs that have been considered.

2. Materials and on-line chemistry

A wide range of problems lies ahead in the design of high temperature materials for molten salt reactors. The Ni–W–Cr system is promising. Its metallurgy and in-service properties need to be investigated in further details regarding irradiation resistance and industrialization.

Objectives:

- Progress towards resolving feasibility issues and update priority R&D needs about structural materials for MSRs and on-line or batch-wise spent salt treatment processes.
- Plan for associated experiments.