RAPHAEL

Reactor for Process Heat, Hydrogen and Electricity Generation: High-Temperature Reactor - Small Size, Big Potential

In the context of worldwide depletion of fossil fuel resources and CO_2 reduction objectives, Europe must invest in active R&D in order to assess the viability of nuclear fission as a future energy option. Continuing the work initiated by several smaller EC-supported projects since 1998, the RAPHAEL Integrated Project addresses the viability and performance issues of an innovative system for the next generation of power plants, the Very High Temperature Reactor (VHTR), which can supply both electricity and heat for industrial applications.

High-temperature technology

RAPHAEL is focused on the main technology developments needed for VHTR industrial deployment, supporting the results already obtained in the Fifth Framework Programme. It will explore the performance of the individual system elements in challenging conditions of temperatures up to 1000 °C, and integrate the results so as to assess the viability of the whole system.

The RAPHAEL consortium consists of 33 organisations involving most of the leading 'HTR community' from ten European countries, including nuclear engineering firms, companies in the fuel cycle, utilities, nuclear research organisations, universities, engineering schools and a project management professional. In addition, a partner organisation from China is expected to join. Links with other relevant Sixth Framework Programme projects (HYTHEC, GCFR, ExtreMAT) have been established, and collaboration is foreseen with the Generation IV International Forum and other international organisations.

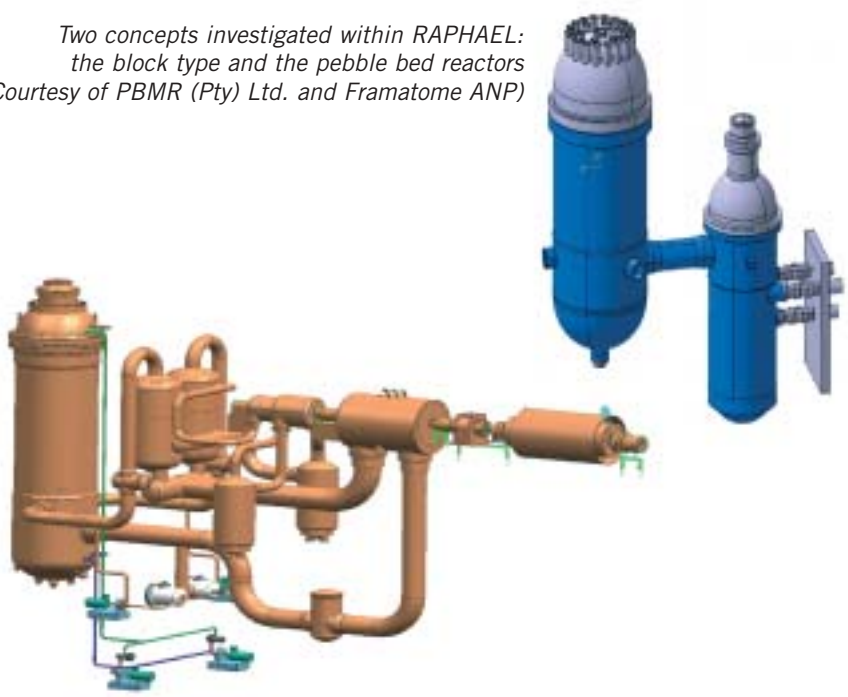
Assessing component performance and system applications

The RAPHAEL project's research will explore the performance of fuel, materials and components, the reactor physics models, the nuclear safety and waste disposal issues, and the overall system integration. This will involve improving the qualification of computer tools and models, exploring the limits of performances of the fuel and the materials, analysing the behaviour of the fuel in accident and final geological disposal conditions, and developing innovative technologies for system components. It will also explore potential interfaces with hydrogen production or process heat exploitation, describing an acceptable nuclear safety approach, and integrating all the results in order to provide preliminary feasibility assessments of concepts of VHTR plants, coupled with hydrogen production processes. In addition, education and training will be organised, and knowledge management and external communication activities undertaken.

New designs for new applications

RAPHAEL will produce performance data for fuel and materials for operation at up to 1000 °C, assessment of the operating performances of high temperature

Two concepts investigated within RAPHAEL: the block type and the pebble bed reactors (Courtesy of PBMR (Pty) Ltd. and Framatome ANP)



components, data for the qualification of computer models for designing and licensing the system, and solutions for the disposal of spent fuel. RAPHAEL's integration team will work with colleagues in the HYTHEC project to describe the interface requirements for an efficient energy transfer that will allow the VHTR to work as an essential source for hydrogen production.

These results will assist the development of a VHTR prototype in the longer term (~15 years) with a possible commercial design that will be available approximately 20 years from now.

New generation reactors with wide application

At present, nuclear fission is used only for generating electricity, which accounts for approximately one-third of the primary energy used in the world. To address the present and future situation with respect to fossil fuels and greenhouse gas emissions, future nuclear systems will need to satisfy much more ambitious goals than those achieved by present nuclear plants. The VHTR technology can enable the nuclear option to address the whole energy spectrum and be consistent with the objectives of sustainability and safety of the next generation of power plants.

Because it produces energy at very high temperatures using a smaller, very safe reactor, the VHTR system, which will make use of technologies developed in RAPHAEL, can offer a wide range of competitive applications for conventional electricity producers (encompassing small or medium-sized utilities) and all industrial heat users. These include applications for CO_2-free hydrogen production, for chemical processes (refinery, aluminium production, etc.), and for lower temperature applications such as desalination or district heating. The VHTR also features inherent safety, waste minimisation solutions, fuel flexibility and cost effectiveness - all key assets regarding public acceptance of nuclear fission and its positive impact on the economy, the environment, and the security of energy supply in Europe. The VHTR development will give opportunities to bring high performance materials and components to the market that can provide spin-off and benefits to large sectors of industry.

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