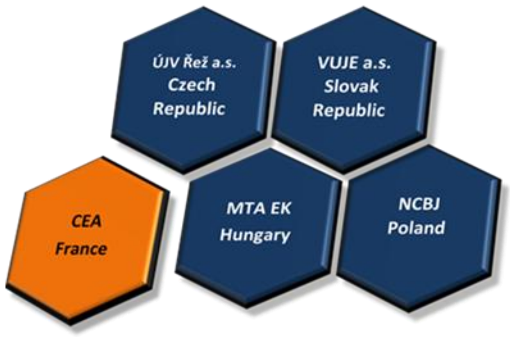
The ALLEGRO Project

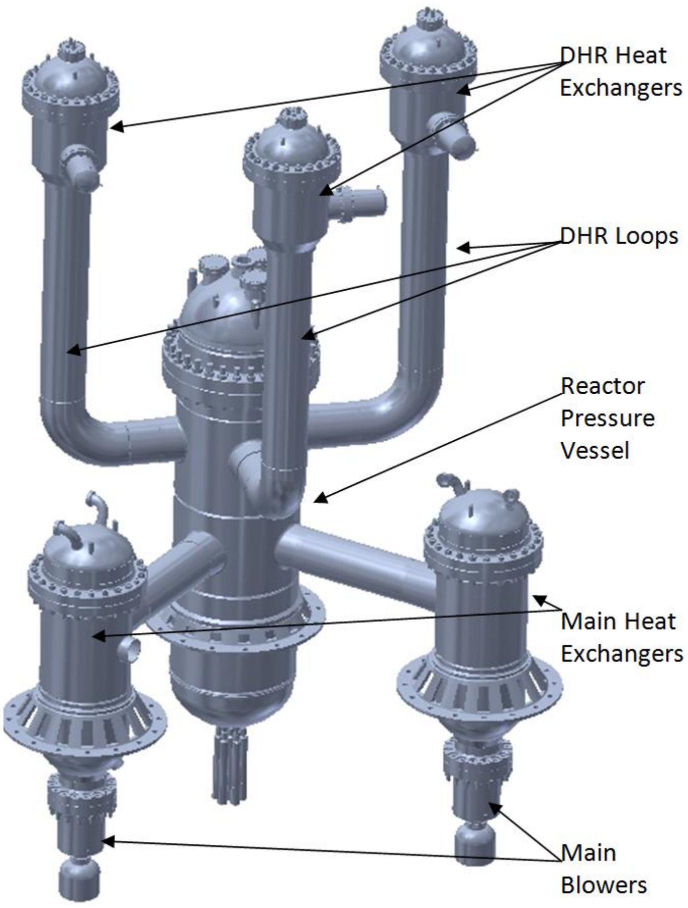
The goal of the ALLEGRO Project is to design, build and operate the first Gas-cooled Fast Reactor (GFR) Demonstrator. The GFR in Europe represents together with the Lead-cooled Fast Reactor (LFR) a longer timescale alternative to the Sodium Fast Reactor (SFR), all of them belonging to the 4th generation of nuclear reactors. The original concept of ALLEGRO was designed in France by CEA with the aim to develop a high temperature (850 °C) fast flux test facility. Because the ceramic fuel is still under development, Stainless Steel cladded MOX or UOX fuel was chosen for the first ALLEGRO core producing helium temperatures of 530 °C.

The ALLEGRO design studies have been shared in the project GCFR 6th FP since 2005 and in the project GoFastR 7th FP since 2010. In 2010 CEA proposed the continuation of the ALLEGRO project to three institutes from Central Europe: MTA EK (Hungary), ÚJV Řež, a.s. (Czech Republic) and VUJE a.s. (Slovak Republic). Later NCBJ (Poland) joined this activity. CEA is continuing the GFR activities as an associated member of the Central Europe consortium.

Central Europe for GFR

Three Central European members of the European Union, the Czech Republic, Hungary and Slovak Republic are traditionally prominent users of nuclear energy. They intend to use nuclear energy on the long run and beside the lifetime extension of their nuclear units, each country decided to build new units in the coming years. In addition, Poland is considering the construction of High Temperature Reactors.





Taking into account the potential advantages of the 4th Generation reactors regarding uranium resources and high level waste management, because of the significant experience in these countries in applying nuclear energy, in order to maintain the competence of their nuclear community by deepening the knowledge on future reactors, to attract leading edge technology development into the region and to share the common responsibility of EU member states in achieving sustainable energy production and contributing to the mitigation of climate change, the idea emerged that one of the countries of the region could host a major European nuclear facility as part of R&D efforts aiming at the development of fast reactors.

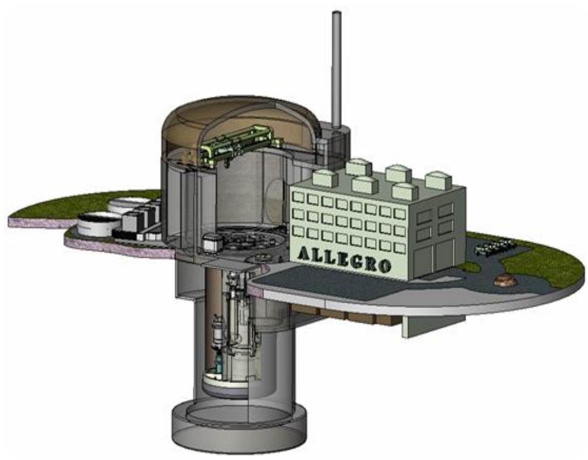
The four respective nuclear research organizations of the region (ÚJV Řež, a.s., Czech Republic, Centre of Energy Research of the Hungarian Academy of Science (MTA EK), Budapest, Hungary, NCBJ, Świerk, Poland and VUJE a.s., Trnava, Slovak Republic) signed a Memorandum of Understanding in 2010, then in 2013 established the V4G4 Centre of Excellence for the coordination of technical, experimental and other ALLEGRO-related issues and for the international representation of the joint effort. In January 2017, CEA joined the consortium as an associated member.

The above mentioned organizations agreed to launch the ALLEGRO Project in July 2015. The first phase of the Project aims to develop the Conceptual Design of the ALLEGRO reactor and answering all safety related and other technical issues. The corresponding roadmap of the design works and safety analysis is under realization and the Conceptual Design has to be completed by 2025. To support these activities a Research, Development and Qualification Roadmap is under elaboration providing a framework of the experimental works needed by the design and safety activities.

Financing of the first phase of the ALLEGRO Project is expectedly supported by national and EURATOM projects. The second phase of the project which includes several steps from licensing till start of operation requires another type of governance and financing and a new model has to be created to realize the second phase.

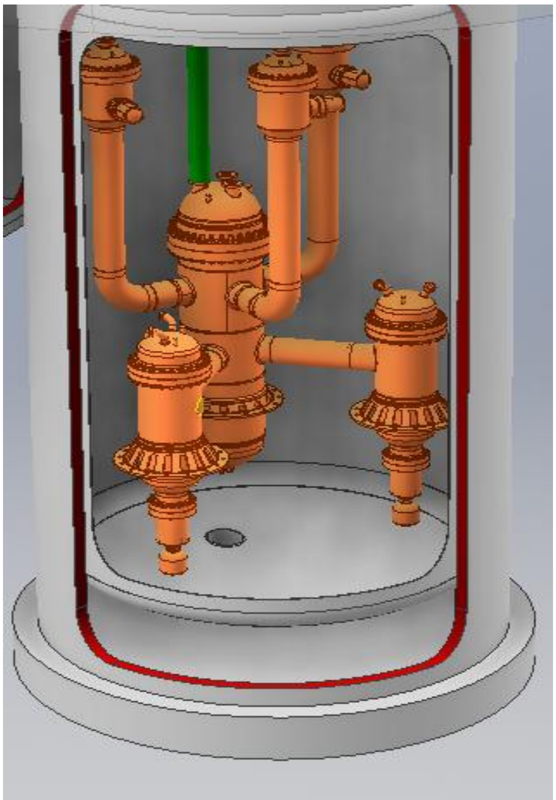
The World and Energy

Today, the world is recognizing the irrefutable role of nuclear power for the security of energy supply and combating climate change. Governments are embracing nuclear power as a fundamental component of their energy strategy in response to security of energy resources concerns, global warming and an ever-increasing demand for energy. Within the European Union, the debate about the place for nuclear energy has been very active over the last few years. Europe, through the Sustainable Nuclear Energy Technology Platform (SNETP), has defined its own strategy and priorities for the fast neutron reactors that are the most likely to meet the energy needs in the long term in terms of sustainability, security of supply and economic competitiveness.



Fast reactors are especially important from the point of view of sustainability of nuclear energy since they represent the main tool for closing the fuel cycle. Closing the fuel cycle has a double purpose: to reduce the amount of high level radioactive waste and at the same time saving natural resources by generating fissile materials to be used in nuclear power plants. The Gas Fast Reactor (GFR) has a potential to deliver high temperature heat for industrial processes and is considered as an alternative reactor type to the Sodium Fast Reactor (SFR). The main research and development areas for GFR technology were identified in the Strategic Research Agenda (SRA) of the SNETP and the Concept paper of the European Sustainable Nuclear Industrial Initiative (ESNII).

The ALLEGRO GFR Reactor Demonstrator



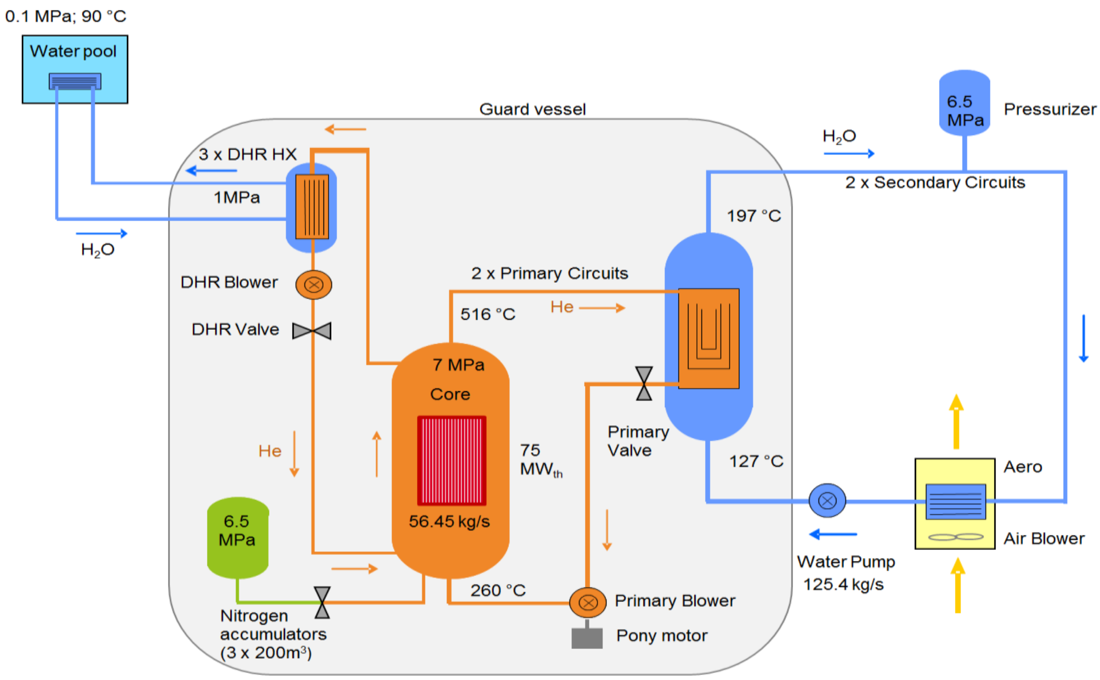
Gas cooled fast reactors (GFR) is one of the six Generation IV reactor concepts and represent one of the three European candidate fast reactor types, the two other being sodium cooled fast reactor (SFR) and lead cooled fast reactor (LFR). There is a considerable experience worldwide on SFR and the European prototype of the future SFRs is under development and will be built in France. Because of the usual uncertainties of R&D success, an alternative solution is also sought for and this may be either GFR or LFR. Technically, GFR is a realistic and promising alternative thanks to its specific advantages connected with high temperatures.

The reactor design

The demonstration of the GFR technology assumes that the basic features of the GFR commercial reactor can be tested in the 75 MWth ALLEGRO. Therefore, most of the main parameters of both reactors are similar to each other.

The original design of the ALLEGRO consists of two He primary circuits, three decay heat removal (DHR) loops integrated in a pressurized cylindrical guard vessel. The two secondary gas circuits are connected to gas-air heat exchangers.

The ALLEGRO reactor would function not only as a demonstration reactor hosting GFR technological experiments, but also as a test pad of using the high temperature coolant of the reactor in a heat exchanger for generating process heat for industrial applications and a research facility which, thanks to the fast neutron spectrum, makes it attractive for fuel and material development and testing of some special devices or other research works.



The fuel design

The 75 MWth reactor shall be operated with two different cores. The starting core with UOX or MOX fuel in stainless steel claddings will serve as a driving core for six experimental fuel assemblies containing the advanced carbide (ceramic) fuel. The second core will consist solely of the ceramic fuel and will enable to operate ALLEGRO at the high target temperature.

Fuel development to satisfy the needs of a GFR is one of the basic goals of the ALLEGRO project. Safety considerations may strongly influence the fuel development.

	MOX Core	Ceramic Pin Core
Power density (MW/m^3)	100	92
I. circuit helium pressure (MPa)	7	7
Core He inlet/outlet temp. (°C)	260/530	400/880
Fissile core mass flow rate (kg.s^{-1})	53.5	36.1
Fuel sub-assemblies (S/A)	Pins w/ hex. tube met. struct.	Pins w/ hexagonal tube SiC struct.
Fuel form	(U, Pu)O_2 pellets in SS clad.	(U, Pu)C pellets in SiCf/SiC tubes
Fuel pellet diameter (mm)	5.42	6.64
Cladding thickness (mm)	0.45	1.08
Fissile core height / diameter (m)	0.86 / 1.12	0.86 / 1.12
Number of fuel pins per S/A	169	90
Pu/U+Pu(%)	25	27.5
Number of fissile sub-assemblies	81	87
Num. of absorber S/A	10 (4+6)	10 (4+6)
Num. of in core steel/exp. S/A	6/0	0
Number of reflector S/A	174	174
Reflector material	Steel	ZrC

Safety

In addition, an LEU UOX alternative core is under development. The main drawback of using gases as coolant in a fast reactor is related to the decay heat removal capabilities in accidental conditions due to the lack of thermal inertia of the system and the poor capabilities of gases to remove heat by natural convection in depressurized conditions. This issue is being investigated in support to the design of ALLEGRO through the improvement of the core design and the safety related systems and components (lower power density, guard vessel, safety injection accumulators, passive feed of main blowers etc.).

Resume

Fast reactors will play a significant role in developing the sustainable use of nuclear energy. Nuclear energy remains a decisive component of electricity production in the 21st century. With the Central European Consortium project ALLEGRO is now becoming a wider European project and it is our hope, that ALLEGRO can fulfill the role as a European GFR technology demonstrator and fast neutron irradiation facility too. In the framework of the Visegrád cooperation (V4) the relevant European governments (of the Czech Republic, Hungary, Slovak Republic and Poland) have already started to discuss hosting the GFR ALLEGRO in the region.