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Other Activities in the Field of Nuclear Technologies and Safety - Innovative Concepts

SPECIFIC TARGETED RESEARCH OR INNOVATION PROJECT

Contract No FI6O-036230

High Performance Light Water Reactor Phase 2

HPLWR Phase 2

HPLWR Public Final Activity Report

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HPLWR Phase 2

Public Final Activity Report / HPLWR-A/F-060

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Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	X
RE	Restricted to a group specified by the consortium (including the Commission Services)	
PP	Restricted to other programme participants (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

EXECUTIVE SUMMARY

Supercritical water is the state-of-the-art coolant for modern coal fired power plants. By increasing the system pressure to supercritical conditions (>22.1 MPa), the size of key components has been reduced and higher plant efficiencies have been obtained. This, in turn, has significantly reduced the construction cost of fossil-fuel power plants leading to lower electricity generation costs for the European market.

The High Performance Light Water Reactor Phase 2 (HPLWR Phase 2) project explores the particular advantages of supercritical water concepts and applies them to the latest Light Water Nuclear Reactor technology. The *objectives of this project*, which has been co-funded by the European Commission, was to assess the feasibility of a Light Water Reactor using supercritical water as a coolant and determine its future potential.

Ten partners from eight European countries were working on critical scientific issues. The consortium consisted of two universities, seven research organisations and one industrial partner.

Partner	Short Form	Country
Karlsruhe Institute of Technology	KIT	Germany
Commissariat à l'Energie Atomique	CEA	France
AREVA NP	AREVA	Germany
Universitaet Stuttgart	USTUTT	Germany
Hungarian Academy of Sciences KFKI Atomic Energy Research Institute	KFKI AEKI	Hungary
Kungliga Tekniska Högskola	KTH	Sweden
Nuclear Research and consultancy Group	NRG	Netherlands
Paul Scherrer Institut	PSI	Switzerland
Ustav jaderneho vyzkumu Rez a.s. (UJV)	UJV	Czech Republic
VTT Technical Research Centre of Finland	VTT	Finland

In addition, three Active Supporters, JRC Petten and TU Delft, The Netherlands, and BME, Hungary were contributing with own research to the project. They were working in the field of neutronics, materials and flow instability.

The project has been coordinated by Karlsruhe Institute of Technology. The email address of the coordinator is coordinator@hplwr.eu. Access to publishable data is maintained through: www.hplwr.eu

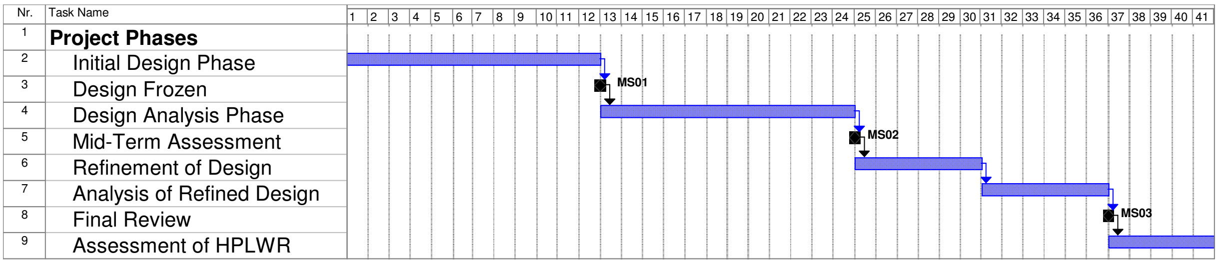
HPLWR 2
High Performance Light Water Reactor Phase 2

Project Plan

The HPLWR Phase 2 project started September 1, 2006. It was organized in 4 stages, as depicted below. The project started with an "Initial Design Phase" (12months) followed by a

"Design Analysis Phase" (12 months). This procedure was repeated in shorter time period (each of them 6 months), i.e. a phase "Refinement of Design" was followed by a phase "Analysis of Refined Design". The final assessment of the results was carried out at the end of the project within the last 6 months.

There were *three major milestones* in this project. After 12 months the design was frozen (Ms01) and assessed for the first time. The second milestone was reached after 24 months, the so-called the mid-term assessment Ms02. The analysis of the HPLWR design was critically assessed by all partners and by the Advisory Board.



The last milestone Ms03 was reached after 36 months where all results of the HPLWR Phase 2 project were available. The HPLWR concept has finally been assessed in the last stage of the project "Assessment Phase" (6 months).

The work was organised in seven work packages of which five were technically oriented (WP1 "Design & Integration", WP2 "Core Design", WP3 "Safety", WP4 "Materials" and WP5 "Heat Transfer"). The remaining WP6 "Education & Dissemination" and WP7 "Management" were more administrative ones.

There are so many results available from the HPLWR project that even a brief description would extend the purpose of this report. Scientific results are explained in great detail in the HPLWR Final Report available on the HPLWR website (http://www.hplwr.eu/public/HPLWR-D7-08_v1.2.pdf).

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1 PROJECT OBJECTIVES AND MAJOR ACHIEVEMENTS

Supercritical water is the state-of-the-art coolant for modern coal fired power plants. By increasing the system pressure to supercritical conditions (>22.1 MPa), the size of key components has been reduced and higher plant efficiencies has been obtained. This, in turn, has significantly reduced the construction cost of fossil-fuel power plants leading to lower electricity generation costs for the European market.

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Objectives

The overall objective of the HPLWR Phase 2 project was to assess the critical scientific issues and the technical feasibility of the High Performance Light Water Reactor (HPLWR) system with a view to determine its future potential. The project implemented research needs and critical scientific issues defined in the roadmap which was derived in the prior EU project also considering the GEN IV roadmap for the development of a Supercritical Water Reactor.

The overall objectives have been transferred into technical objectives, summarized as follows:

- Design of a thermal HPLWR core by evaluating previous concepts, defining fuel assemblies, control rods, and arrangements within the reactor vessel by means of neutronic, thermalhydraulic and stress-analysis codes. The aim was to design a feasible core including a “Hot Channel-Factor” analysis which had been identified to be the critical scientific issue of this project.
- Evaluation of the potential of the HPLWR as a fast reactor to explore the potential for using the reactor as a Plutonium management option, by designing a fast core with computational tools to be adapted and verified.
- Assessment of the reactor safety in order to verify that the HPLWR is as safe as latest LWRs and that it leads to fulfil the European Utility Requirements (EUR) by adapting best LWR safety philosophy and by analysing selective design basis accidents with the improved and verified codes.
- Proposal for selection of materials based on characterization for major in-core and out-of-core components and structures of a thermal HPLWR by performing autoclave tests while concentrating on high temperature materials with improved corrosion and stress corrosion cracking performances.
- Construction and out-of-pile testing of the Supercritical Water Loop for the nuclear research reactor in Rez, Czech Republic. Testing of the loop out-of-pile (basic functioning of loop components, transients, accident management). Preparation of the loop for in-pile material, radiolysis and water chemistry testing in-pile.
- Investigation of the heat transfer and development of a heat transfer correlation.
- Refinement of the HPLWR plant concept respecting the Generation IV technology goals on environmental impact, resource utilization, and proliferation resistance.
- Ongoing economic assessment in order to evaluate the economic potential of the HPLWR including determination of electricity generation cost.

There are so many results available in the HPLWR project that even a brief description would extend the purpose of this report. Scientific results are explained in great detail in the HPLWR Final Report available on the HPLWR website (http://www.hplwr.eu/public/HPLWR-D7-08_v1.2.pdf). Therefore, the major achievements of the HPLWR project are briefly summarized in the following chapters 1.1 – 1.4.

1.1 Month 01-12: Initial Design Phase

In the first year of the HPLWR Phase 2 project, the so-called “Initial Design Phase”, the reactor core was designed according to the KTA-Guidelines (Guidelines of the German Nuclear Safety Authority).

Technical objectives

The technical objectives in the initial design phase were

- To provide a first design proposal of the fuel assembly, spacers, core and core components, reactor pressure vessel and its internals.
- To investigate the feasibility of the fast core option.
- To improve and validate neutronics-thermal hydraulics codes and to perform first sub-channel analyses
- To provide neutron scattering laws for supercritical water
- To provide a first proposal of a safety system
- To improve and update thermal hydraulic system codes for safety analyses
- To perform first autoclave experiments to determine oxidation behavior of candidate materials
- To design a supercritical water loop for in-pile materials tests
- To set-up a materials database
- To validate CFD codes for heat transfer predictions in supercritical water
- To investigate heat transfer deterioration
- To plan an International HPLWR Student workshop

and

- To implement the European HPLWR Phase 2 Project into the research framework on SCWR of the Generation IV International Forum.

All technical objectives given above were focussed on the main milestone at month 12 to have a first design proposal of the reactor core and reactor pressure internals ready and reviewed to be analysed in the 2^{nd} stage of the project (months 13-24).

Major Achievements

A three-pass core has been designed which consists of fuel assemblies with 40 fuel pins and with a water box in the centre and an outer box like in a Boiling Water Reactor. Nine of these assemblies are grouped in a cluster with common foot- and head piece. The “steam” is collected in a steam plenum and guided through co-axial pipes to the turbine. Control rods were designed and their effectiveness has been investigated. The reactor pressure vessel as well as internals was designed for supercritical pressure at 25 MPa. (AREVA, KIT)

First neutronics-thermal hydraulics and subchannel analyses have been performed which show optimisation potential to be worked on in the 2^{nd} phase. Validation calculations were carried out which showed reasonable agreement with Monte-Carlo codes. The codes were used later in the analysis phase. Codes for stability analysis and gap water flow have been validated, too. (KFKI, CEA, KIT, AREVA)

The fast core option has been checked carefully. With the design constraints of 280°C inlet temperature and a homogeneous core configuration, the design success criteria of a void coefficient lower than +1000 pcm could not be reached. It was proposed to stop these studies in the frame of the HPLWR 2 project. (CEA)

The scattering dynamics for the scattering of thermal neutrons at H in H_2O was investigated for water in the liquid, vapour and supercritical state. As a result, it is recommended to take the liquid model for higher density and the vapour model for lower density of super critical light water coolant or moderator. The free gas model is not recommended. (USTUTT)

A first proposal of the safety system has been presented. A Pressure-Suppression Containment with both active and passive safety systems had been selected as starting point. (AREVA)

Thermal-hydraulic system codes have been updated to be used in the supercritical regime. The numerical difficulties to calculate from the supercritical into the two-phase region were solved. The codes have been validated with an Edwards Pipe problem (sudden opening of a rupture disk). The codes show reasonable agreement. (PSI, CEA)

Materials selection for general corrosion tests in autoclaves was done. Specimens (weight gain coupons) for general corrosion tests were prepared from 16 materials including ferritic/martensitic steels, austenitic stainless steels, ODS steels and two nickel base alloys. The initial water chemistry was specified. (VTT, CEA, UJV)

General corrosion tests have been performed at 300, 400, 500 and 650°C in BWR water. A comparison test was performed at 650°C using H_2 chemistry (30 cm3/kg H_2). One test at 600°C in BWR water was added to enable interpolation of the corrosion rates to the expected fuel cladding temperature range. (VTT)

JRC-IE (active supporter) performed tests at 400, 500, 550 and 600°C in BWR water with 0 or 150 ppb O_2 with a different material selection than was tested at VTT (the above mentioned selection of 16 materials was divided between VTT and JRC-IE).

The design of the irradiation channel for the Supercritical Water Loop was completed, together with thermalhydraulic calculations of pseudo-stationary states of the entire loop. (UJV)

The structure of a materials database has been built. It contains corrosion results of VTT tests (generalised and stress corrosion). In order to be more easy to use, it has been implemented on Excel sheets. (CEA)

A literature survey for heat transfer in single tubes was preformed and data were collected and made available for the partners in an excel sheet. In total 14,324 data points were extracted from 14 publications. (KIT)

In order to properly understand and examine heat transfer mechanisms, numerical study of heat transfer deterioration were made using the low-Re RANS approach. Simulation of the existing experiments showed the importance of buoyancy forces for the heat transfer degradation in the region of low coolant flow rates. (KTH)

Single tube heat transfer was investigated using the CFD code CFX11. One-dimensional analysis in the radial direction of a heated tube under supercritical conditions was performed, which allowed easy testing of a new model under those conditions. Comparison of this model implemented in CFX with experimental data of Yamagata and Ornatskii shows a good agreement in the non-deterioration region and in the region of onset of deterioration. (USTUTT)

The CFD code FLUENT has been validated for heat transfer under supercritical conditions. The supercritical water experiment in a vertical tube by Yamagata could be predicted with very good accuracy by application of RANS turbulence modelling with enhanced wall treatment. Comparisons with Herkenrath data show reasonable agreement. (NRG)

Five Doctorate Students were been employed and successfully integrated in the work packages. The project, in general, was very interesting for students at universities. In the first 12 months, about 15 students contributed with theses or other minor tasks to the project as part of their educational work (KIT, USTUTT, KTH)

The project partners disseminated their results at conferences, international workshops, but also at public events like “day of the open door” or “student information days” at universities (all partners)

An International HPLWR Student Workshop was planned to take place at the University of Karlsruhe from March 31-April 3, 2008. Students and young scientists worldwide were invited to join the workshop. (USTUTT, KTH, KIT)

At the end of the 1st year, a design review took place. The result was that the information about the design was mature enough to start the next phase of the project.

1.2 Month 13-24: Design Analysis Phase

An overall objective for the 2nd year of the HPLWR project was to analyse the mechanical design which was frozen after the 1st year. This structure had the advantage that results that could lead to a change of the mechanical design did not enter the project randomly and did not force the analysts to change their input deck continuously.

<u>Technical objectives</u>

The technical objectives in the “Design Analysis Phase” were:

- To demonstrate that temperatures, stresses and deformations of the core, of core components and of the RPV are within design limits,
- To predict the cycle efficiency for full and part load operation,
- To analyse the core with coupled neutronics-thermalhydraulics codes to predict a suitable power and temperature distribution and provide neutronic data,
- To carry out first burn-up calculations,
- To update the safety system if necessary,
- To provide information related to safety by running first transient and accident analyses and reactivity induced accidents with thermo-hydraulic system codes,
- To provide data on corrosion and stress corrosion cracking,
- To construct the Supercritical Water Loop,
- To provide an updated version of the materials data base,
- To demonstrate the capabilities of CFD code for supercritical water applications by analysing single pin and single tube experiments,

and

- To provide a Methodology Identification Ranking Table on Onset of Deterioration Heat Transfer.

All technical objectives given above were focussed on the main milestone (Ms02) at month 24 to have a first analysis of the proposed design available.

Major Achievements

The Reactor Pressure Vessel (RPV), the upper and lower mixing chambers were analysed with respect to stresses and deformations. CFD calculations predicted the heat transfer coefficients serving as input parameter for the stress analysis. All stresses stayed within acceptable limits. Special attention was put on the hot pipe and the thermal sleeve at the outlet of the reactor. The vessel stays below 300°C and the hot pipe can be sufficiently cooled. The upper and lower mixing chamber were assessed with respect to high loadings due to weight, pressure differences and temperature loads, which were found to be uncritical for the components. The results of the stress and deformation analysis were critically assessed by experts. A fist layout of the containment was derived and an active and passive safety system was proposed. The HPLWR data sheet was updated (KIT, AREVA)

The balance-of-plant was analysed with IPSEpro which solves energy and mass balance equations. More realistic pressure drop equations were applied to improve the code, the reheat temperature was adjusted, and a feedwater tank was included which serves as a direct contact pre-heater. Pump efficiencies were adjusted with support of pump manufacturers. The IPSEpro model has been transferred into an APROS model, which enables dynamic calculations of the steam cycle. (KIT)

The honeycomb-structure of the fuel assembly boxes was analysed with FEM. Solid corner pieces were found to be inevitable, but the honeycomb structure could withstand design loads. Deformation due to non-homogeneous power and temperature distributions were analysed independently by means of beam theory and by means of Finite-Element Analyses (FEM). Both analyses showed that one spacer pad at the middle height of the active length mounted at the solid corner pieced of the boxes can limit the deflection within acceptable margins (AREVA, KIT).

Coupled neutronics-thermal hydraulic analyses were carried out for the three-pass core approach. Effectiveness of control rods were evaluated with MCNP. A sensitivity study was carried out with ERANOS-TRACE, showing a positive effect on moderation capabilities if the fuel assembly is insulated and the gap water flow is enhanced. The average radial enrichment was determined with KARATE-SPROD in order to specify a thermal power of a cluster which does not violate the cladding temperature limit. With the same code, the impact of a water layer near the outer periphery of the core was investigated. A 10cm water layer shall flatten the power profile of the superheater 2, thus avoiding hot spots. (KFKI, KIT)

Thermalhydraulic analyses were carried out with C3CLM for the flow inside a fuel assembly. A sensitivity study revealed that corrugated walls have no thermal hydraulic advantage. The temperatures of the coolant are sensitive to the magnitude of the flow sweeping and of the turbulent mixing. Wire wraps provide sufficient inter-subchannel mixing resulting in an almost homogeneous temperature distribution. A simulation of the same problem with Star-CD gave very similar results. (AREVA, KIT)

Thermohydraulic instabilities and coupled neutronic thermohydraulic instabilities were analysed. Orifices need to be installed within the fuel assemblies of an evaporator cluster to avoid density wave oscillations. Ledinegg oscillations do not occur in the HPLWR because of a positive slope of the pressure drop vs. mass flow rate curve. A test facility has been designed to be constructed for experimental verification of the numerical results (KIT, TU Delft)

The volumes of the drywell and of the water pools (core flooding pool and pressure suppression pool) inside the containment were determined. Since no new analyses were available, the proposed safety system remained unchanged. (AREVA)

Input decks were created for RELAP5, CATHARE, SMABRE/TRAB, APROS and KIKO3D-ATHLET. While establishing nominal flow conditions, RELAP calculated reverse moderator flow which was due to an unstable condition in the gap and moderator channels. A first transient was calculated showing no numerical problems with this code and no thread of the cladding temperature. In a later analysis, RELAP showed fuel center line temperatures which were too high. The adjustment of the power in the core could solve this problem. For CATHARE, an input deck was created which contains, beside the nominal assembly, also a “hot” assembly with increased power. The center line temperatures in the evaporator assemblies showed a very high temperature because of a very conservative assumption in application of the hot channel factor of 2. First analyses of SMABRE/TRAB and APROS were carried out. A pump trip was simulated with both codes showing differences in the temperatures of the cladding. A depressurization was calculated, too. The delay of the accident calculations (none of them had performed up to now) were on the critical path. (PSI, CEA, VTT, KFKI)

The consequences of a control rod ejection and a control rod removal transient were calculated with KIKO3D-ATHLET by KFKI. This task was part of their National Hungarian Program. The results showed the reactivity increase was far less than the delayed neutron fraction. The increase of the cladding temperature in the evaporator was mild, but the pressure in the system rose. This analysis gave very useful hints for the design of the automatic depressurisation system. (KFKI)

Materials investigations were an ongoing task. Oxidation experiments of candidate materials for cladding and in core components were investigated. The contact impedance tests were a little delayed but not on the critical path. Corrosion experiments were carried out in a good collaboration of VTT, JRC-IE, and KFKI. Stress corrosion cracking tests started at JRC-IE. The data base was updated. (CEA, VTT)

The construction of the Supercritical Water Loop (SCWL) was continued. The Auxiliary Loop, which contains the heat sink, filtration, water make-up and measuring devices, was finished as planned. This loop was prepared for out-of-pile tests. It was intended to be moved to the LRV-15 reactor hall after passing all tests. (UJV)

Single tube and single pin experiments were successfully calculated using the codes FLUENT and CFX. The comparison with experimental data showed a good agreement in cases of non-deteriorated heat transfer. In case of deteriorated heat transfer (DHT), strong deviations occured. First bundle experiments from KAERI, Korea were simulated. The same trend could be observed: good results for normal conditions, worse results for the deteriorated case. Special emphasis was put on the modelling of the wire and its effect on the flow (partially funded by additional funding from NRG) Heat transfer deterioration showed to be completely suppressed behind a wire. (USTUTT, NRG)

The onset of heat transfer deterioration was investigated using CFX and OPENfoam. The influence of buoyancy on DHT was clearly shown. Other influencing parameters were the thermal conductivity and the rapid change of fluid properties at the pseudo-critical point. A methodology identification ranking table was derived and applied to the HPLWR. Dimensionless numbers were derived to assess whether the assemblies might undergo HTD conditions using the database created in the 1st year. For nominal conditions, no HDT occurs; rather enhanced heat transfer is expected. For a "hot" assembly, conditions can be described as "transition between enhanced and deteriorated" which is a region with high uncertainty. (KTH)

Direct numerical simulations were carried out simulating a laminar flow of supercritical water which gave a good insight on fundamental heat transfer mechanisms (KFKI)

In the 2nd year, about 10 students contributed with theses or other minor tasks to the project as part of their educational work (KIT, USTUTT, KTH)

The project partners disseminated their results at conferences, international workshops, but also at public events. One highlight was the HPLWR own session at the Annual Meeting on Nuclear Technology, Hamburg, organised by Mr Bittermann. (All partners)

The planned International HPLWR Student Workshop took place at the University of Karlsruhe from March 31-April 3, 2008. 26 Students and young scientists worldwide joined the workshop. Eight lectures were given by professors and lecturers from the partners. In total, 22 student contributed with own presentations. The partners greatly appreciated that RWE Power invited the workshop participants for a welcome reception and AREVA invited to a workshop dinner. (USTUTT, KTH, KIT)

During the assessment performed after the 2nd year of the HPLWR project, the analyses revealed that the HPLWR concept is feasible in principle. However, minor design changes were still identified.

1.3 Month 25-36: Refinement of Design- and Analysis of Refined Design Phases

The overall technical objective for the 3rd year of the HPLWR project was to refine the design of the HPLWR within the first six months, if necessary, and to carry out an analysis of the refined design within the remaining six months.

Technical objectives

The technical objectives for the third year were:

- To change the gap water flow inside the RPV to avoid natural convection caused recirculation and to modify the RPV internals accordingly
- To demonstrate that temperatures, stress and deformations of the core, of core components and of the RPV are within design limits under the new flow conditions.
- To design a start-up system for the HPLWR and to carry out simulations to demonstrate the effectiveness of this system

- To design components of the HPLWR steam cycle
- To analyse the updated core with coupled neutronics-thermalhydraulics codes to predict a suitable power and temperature distribution and to provide neutronic data,
- To continue burn-up calculations,
- To update the safety system if necessary,
- To provide information related to safety by running transient and accident analyses and reactivity induced accidents with thermo-hydraulic system codes,
- To provide data on stress corrosion cracking,
- To complete the Supercritical Water Loop and to start the out-of-pile testing,
- To provide an updated version of the materials data base,

and

- To derive a heat transfer correlation for flow inside a bundle equipped with wire wraps.

All technical objectives described above were focussed on the main milestone (Ms03) at month 36 to have the analysis of the refined design available.

Major Achievements

A combined start-up and shut-down system was developed. A procedure was derived to start- and shut down the reactor under loads of 50% (KIT)
For the HPLWR plant, sizes of components were determined, i.e. for the turbine generator set consisting of HP, IP, and LP turbine and for major components and systems like start-up system, feedwater tank, preheater system, reheaters and feedwater and condensate pumps (KIT)

With knowledge of the sizes of components, a plant layout was proposed. The reactor building turned out to be significantly smaller compared to existing boiling water reactors. (AREVA)

The fluence at the RPV wall of the HPLWR was determined, which showed lower values compared to VVER-440 reactors. A life time of 60 years could be achieved easily (AEKI-KFKI)

An economic analysis was started. Fuel cycle costs were estimated. Based on the plant layout, first calculations and sensitivity studies could be obtained for the plant erection and electricity generation costs (VTT, AREVA)

In order to avoid possible buoyancy effects in the gap between the fuel assemblies, the flow path of the moderator/gap water was changed such that the gap water is now flowing upwards inside the core and downwards through the reflector to be mixed with downcomer water at the bottom of the reactor. As a consequence, design changes were necessary in the reflector, in the core support plate, minor ones in the steam plenum and in the lower mixing chamber (KIT)

Core instrumentation was proposed, consisting of temperature and neutron flux measurements. The instruments are mounted on lances to be inserted into the core (AREVA, KIT)

Neutronic analyses of the HPLWR core were carried out comprising of power distribution of a fresh core with uniform enrichment and of an equilibrium core and burnup predictions including reactivity feedback coefficients. In addition, thermo-hydraulic analyses were carried out, i.e. sensitivity analyses of disturbances influencing power distribution and hot channel analyses and predictions of the hottest fuel rod. The coolant flow and temperature in the gaps between assemblies was calculated. Mechanically, bowing analyses of the assembly boxes were carried out to identify spacer pad locations at the outer box walls. Finally, residual heat removal with low coolant mass flow, e.g. during core disassembly (KFKI, USTUTT, KIT, AREVA) was estimated.

A HPLWR safety system was proposed consisting of a high pressure and low pressure coolant injection system, ADS valves, building condenser and a core catcher (AREVA, KIT)

The performance of both coolant injection systems was simulated. Both systems can cool the reactor efficiently. Furthermore, parametric studies of depressurization events were carried out to find e.g. the appropriate size of valves and actuation pressures of the ADS valves. (KIT)

Safety analyses were carried out to give a feedback to the design. Loss-of-feedwater transients were simulated to investigate the temperature evolution within the core. The calculated temperatures were within the acceptance criteria (PSI, CEA)

A series of Reactivity Induced Accidents were simulated. The acceptance criteria were fulfilled. However, in spite of the strong reactivity feedback, the hot channel temperatures were not far from the acceptance criterion limits in some cases (AEKI/KFKI).

To analyze the safety system, a variety of accidents and transients were simulated with the accident codes available. These are Reactor Scram (CATHARE), Loss of Feedwater (a number of parametric studies, considering various flow reductions or number of pumps tripped, run-down times, scram delays, etc.) (APROS, RELAP, CATHARE, SMABRE), Loss-of-offsite power (leading to total loss of feedwater) (RELAP, APROS), Closure of one MSIV (RELAP), Closure of all MSIVs (RELAP, APROS), Main Steam Line Break (2A) (CATHARE, APROS), Small break in MSL (SMABRE), and LOCA with large break (2A) in the FW line (CATHARE). (PSI, VTT, CEA, KIT)

In the materials field, autoclaves were used to carry out stress corrosion cracking tests, oxidation mechanisms, and combined creep and oxidation experiments. The large number of tested materials could have been reduced to 3 candidate materials offering specific advantages. (JRC-IE, VTT)

The materials data were added to the materials data base (CEA)

The auxiliary system of the supercritical water loop in Rez, Czech Republic was completed. It was tested and, after small repairs, the loop could be operated at 25MPa. Out-of-pile testing has almost been finished after the 3rd year.

To investigate the heat transfer and to derive a correlation to be applied to rod bundle flows, different geometries were simulated. The idea was to model heated rods, heated annuli, with and without wire and finally a 4 rod bundle to investigate the influence of the presence of the wire and of the geometry on heat transfer. As a result, wire and geometry factors were derived which shall be multiplied to a base correlation. (KTH, NRG, USTUTT, BME)

After the 3rd year, almost all technical tasks were finished providing a suitable base for the assessment of the concept regarding the goals of the Generation IV International Forum.

1.4 Month 37-42: Assessment Phase

The overall objective of the last six months of the HPLWR project was to finish and summarize the technical tasks and to carry out an assessment of the HPLWR concept with respect to the goals of the Generation IV International Forum.

Objectives

The objectives in the last six months of the project were:

- To derive a layout of the HPLWR plant including an improved containment,
- To repeat steady state coupled neutronics-thermal hydraulics calculations with a higher enrichment,
- To investigate the influence of use of MOX fuel,
- To finish and finally provide information related to safety by running transient and accident analyses and reactivity induced accidents with thermo-hydraulic system codes,
- To provide data on creep tests,
- To continue und successfully finish the out-of-pile testing of the Supercritical Water Loop,
- To provide the final version of the materials data base,
- To write best practise guidelines for CFD simulations,
- To finish the derivation of a heat transfer correlation for flows inside a bundle equipped with wire wraps

and

- To assess the reactor concept.

Major Achievements

The containment of the HPLWR was evaluated and improved regarding weight loads and internal overpressure. Walls were moved for a better load distribution. As a result, the outer diameter of the containment was slightly shortened, the height was slightly increased. The inner volumes were kept constant. Pre-stressed concrete has been foreseen as wall material. (KIT)

For the HPLWR plant, the two-dimensional layout provided by AREVA has been transformed into a three-dimensional CAD file. In addition to the components, the piping between them has been calculated and integrated into the CAD file. Both, the reactor building and the turbine building became available. Both of them still show potential for size reduction. (KIT)
The transformation of the two-dimensional into the three-dimensional layout was supported by AREVA.

An assessment of the HPLWR was carried out from manufacturing point of view. In general, there is no considerably higher complexity of the design compared to LWR. The three pass core arrangement is an unusual design, but does not lead to feasibility problems from the mechanical design point of view considering the current state of knowledge.
Based on newly available data on average enrichment of the HPLWR core, the fuel cycle costs were recalculated. Based on this information, the projected electricity generation costs were updated. Furthermore, an economic assessment was carried out, which showed that the HPLWR plant could be up to 22% cheaper than the 1000MWe reference plant. (AREVA)

The use of MOX was investigated by means of MCNP analyses. The results was that the use of MOX would be favourable for the reactor, especially increasing the burn-up, but some design changes would be required to optimise the core. The use of MOX fuel and stainless steel claddings would be less detrimental compared to a higher U-235 enrichment, because MOX fuel must be reprocessed anyhow. (USTUTT)

The HPLWR core was simulated with a higher enrichment in order to reach a target burn-up of 60 GWd/tHM. An enrichment of 8% (average) was confirmed to reach this value. However, these scoping calculations leave a wide field of improvements. (KFKI)

The core of the HPLWR was assessed neutronically. The core turned out to be feasible although hot spots still exist. The core is operating below but close to the limits defined by the maximum linear heat rate and maximum cladding temperature. These topics should be optimised in a later development stage. The amount of nuclear waste produced is in the order of current LWRs. (KFKI)

The core of the HPLWR was analysed from the thermal-hydraulics point of view. The influence of poisoning, burn-up, box deformations and control rod effects was taken into account to re-calculate hot channel factors. Uncertainties of heat transfer and material properties require a fuel qualification test to reach the target uncertainties. The three pass core concept is considered to be feasible with respect to thermal-hydraulics. (KIT)

An analysis of transients with adjusted hot channel factors was repeated using RELAP. Partial loss of feedwater and complete loss of feedwater with loss of offsite power with starting auxiliary pumps were simulated and showed increased, but not unacceptable cladding temperatures. The pressure drop inside the core was compared with previous predictions. (PSI)

Depressurization events with critical heat flux option and a total loss of feedwater event were performed with APROS. No significant differences appeared in safety system behaviour using critical heat flux option. CHF was found in all simulated cases for about 20s but does not lead to unacceptable cladding temperatures. (KIT)

A control rod ejection event was calculated with TRAB-3D/SMABRE and compared with results from AEKI-KFKI presented before. The comparison showed a quite reasonable agreement. A pump trip event was explained. TRAB-3D/SMABRE still has difficulties to calculate fast depressurization events. (VTT)

The assessment of the safety system was carried out. The codes were compared regarding their applicability to HPLWR conditions. There is no code available, which is perfectly suited for simulations of all accidents or transients. The necessity of a coupled three-dimensional neutronics code was demonstrated. The results of the analyses of various transients and accidents showed that the core can be cooled and that acceptability limits can be matched for an optimised core, which can match design limits under normal operating conditions. The open issues were addressed. (PSI)

A quick summary of JRC SCC tests and development works was given. The slow strain rate tests were finished for different candidate materials (mainly austenitic stainless steels, e.g. AISI 316-L. Constant growth rate texts shall be carried out, for which a new testing device was developed. (JRC-IE)

Creep experiments were performed at VTT. The SCW environment increases strain rate compared to Helium environment for 316NG and 347H. Due to short exposure times, the oxide layers had no impact on the nominal stress levels. 1.4970 steel suffered least from oxidation in supercritical water. The role of the degree of cold work is still open. (VTT)

The Supercritical Water Loop was installed in a test hall at UJV. It was operating out-of-pile and the performance tests could almost be finished. (UJV)

An assessment of results in WP4 showed that there is no perfect material currently available, which can withstand the supercritical conditions up to 630°C. The stainless steel 1.4979 could withstand temperatures up to 550°C. Possible long term solutions would be (1) coatings, but the problems with coating process and protectiveness must be solved. (2) Higher Cr austenitic stainless steels, e.g. SS-310 modifications (~20% Ni). Creep resistant grades available: H2, HR3C. (3) ODSs, because extensive work going on (e.g. EU-GETMAT, Generation 4 and Transmutation Materials) but facing production problems, welding problems, brittleness, etc. To investigate Stress Corrosion Cracking: SSRT tests were done in supercritical water at 500°C and 650°C where austenitic stainless steels 1.4970, 347H and 316NG appeared to be resistant to SCC. Tests on irradiated materials or in the UJV supercritical water loop under irradiation should be carried out. SCW environment seems to increase creep rate compared to Helium environment. Creep is not expected to have impact on thick walled components. (VTT)

Heat transfer simulations in a bare and wired sub-channel under nominal conditions were performed with FLUENT. The adopted CFD set-up followed a best practice guideline. The presence of wire wrap mitigated peripheral surface temperature non-uniformity. The heat transfer coefficient under nominal conditions was larger than under hot-channel conditions. The calculations revealed a small improvement of heat transfer coefficient with wire wrap. (NRG)

A turbulence model study was performed with CFX. A circular tube, a bare rod in a square channel and wire-wrapped rod in a square channel were simulated. Furthermore, an analysis of a quarter-heated rod with wire inside a square channel was compared with C3CLM results from AREVA. An overall agreement was found, but differences revealed the necessity of more detailed analysis work. Wall functions were developed for use in supercritical water conditions. As a first step, the classical wall function was modified by temperature dependent fluid properties. Although not finalized, the wall functions could possibly provide a good step towards CFD simulations within reasonable computational time. (USTUTT)

Conjugated heat transfer studies with convection heat transfer both to the fluid and wall conduction have been carried out. They showed much lower peak temperatures than predicted without heat conduction. The different mechanisms of onset of heat transfer deterioration (HTD) were explained. (KTH)

The work package results were assessed. For the heat transfer database, a lot of experimental tube data are available, which are very useful for CFD code validation: Several experiments from the data base were used. For Heat Transfer Deterioration (HTD), conclusions of the theoretical study on onset HT deterioration were that no clear definition of HTD and very different criteria for onset HTD are proposed in literature, but the physical effects explaining the HTD are quite well understood. A comparison between experiments and CFD predictions for normal or enhanced heat transfer showed: if high near-wall mesh resolution ($y+ < 1$) is used and if SST k-ω based turbulence models with enhanced wall treatment are applied, we get the best agreement. Onset of HTD can be quite well predicted. However, there are still large deviations between experiments and predictions for temperature under HTD conditions. A heat transfer correlation has been derived using correction factors for geometry and presence of wires. Some remaining open points were identified. (NRG)

A general assessment regarding the goals of the project and success criteria was carried out. The success criteria of the HPLWR Phase 2 concept were met completely with two exceptions which had technical reasons. All tasks are fulfilled. The technical deliverables were produced. The final report has meanwhile been published. The partners and Active Supporters of the HPLWR Phase 2 demonstrated their capabilities to successfully work on critical scientific issues to determine the feasibility of the concept with view of the future electricity market.

The results were published mainly on conferences and journals (see Table 1).

2 CONSORTIUM MANAGEMENT

Management Tasks and Achievements

KIT has been responsible for the overall management of the HPLWR Phase 2 Project. KIT acted as Project Coordinator. The following tasks were carried out in the course of the project:

- Acting as the contractor for the European Commission;
- Acting as the intermediary between all participants and the European Commission, since all information related to the project will be transmitted to the European Commission through the Project Coordinator;
- Acting as contact point between the Project Management Board and the Advisory Board;
- Receiving all payments made by the European Commission and distributing the European Commission contribution according to the decisions taken by the Project Management Board;
- Processing the invoicing and exercising the payment to all contractors;
- Monitoring and control of progress using the MS Project software tools (see Deliverable D7-01: HPLWR Project Plan) and information of the Project Management Board and the Work Package Leaders about deviations;
- Providing support for meetings of the Project Management Board, Advisory Board and regular Progress Meetings
- All other administrative and financial matters related to the HPLWR Phase 2 contract;
- Acting as a focal point for all kinds of external and internal requests.

For the communication and overall coordination for the HPLWR Phase 2 Project, an Administration Office was run by KIT. Besides the Coordinator, members were Ms D. Rosanowitsch (Internet), Mr. O. Wittek (Legal Office) and Mr. R. Brannath (Financial Department). Among others, the specific tasks were:

- Establishment and maintenance of the overall project communication activities, including mailings, postal and electronic addresses, web-based communication, etc.;
- Preparation of common documents for the whole project, overall correspondence and working level coordination;
- Contracting, financial matters and overall controlling;
- Registration and central deposit of all deliverables, other products and documents prepared under the project;
- Support for the activities of the Project Management Board and the Advisory Board including the organisation of their correspondence and communication, organisation of the meetings, preparation and distribution of the minutes of the meetings and follow-up on tasks established by them;
- Maintenance of the HPLWR Phase 2-Web site with public and internal sections. www.hplwr.eu

In course of the project, twelve Mandatory Deliverables were produced:

Project Timetable and Status

The HPLWR Phase 2 project has been subdivided into four stages separated by 3 project Milestones:

Title	Duration	Milestone /Result
Stage 1: Initial Design Phase	month 1-12	MS1: Design Frozen
Stage 2: Analysis Phase	month 13-24	MS2: Mid-Term Assessment
Stage 3: Refined Design and Analysis Phase	month 25-36	MS3: Refined results available
Stage 4: Assessment Phase	month 36-42	End of the project

The first milestone MS1 was reached successfully after 12 months. The mechanical design was frozen and has been analysed in the second year. A design review took place at the 4th progress meeting at VTT in Espoo, where all partners agreed to start with a 6 month phase called "refinement of design". Some design modifications needed to be carried out, because the flow path of gap water had been changed. The second milestone MS2 "Mid-Term Assessment" was also reached successfully. The third and the fourth phase were carried out successfully. The HPLWR project was finished with the phase "assessment of the HPLWR concept".

Figure 2 shows the bar-chart of the project. There was no need to change the project structure on the management level.

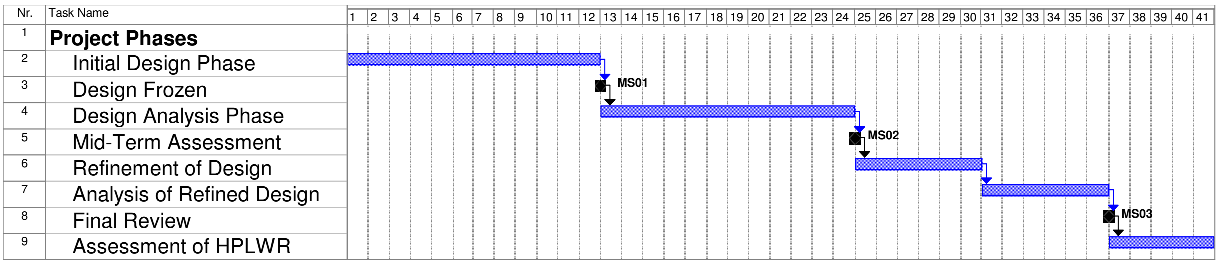


Figure 1: Bar-chart of HPLWR Phase 2

There were changes on the work package level, indicated in the frontline bar-chart for all work packages which is located at the end of this chapter. The changes of the project plan on the work package level (indicated in red) became necessary as result of the research activities. As an example, the fuel assembly, which should be changed after the MS02, remained unmodified. In turn, the related tasks (modification of CAD file, mechanical analysis, etc.) became obsolete.

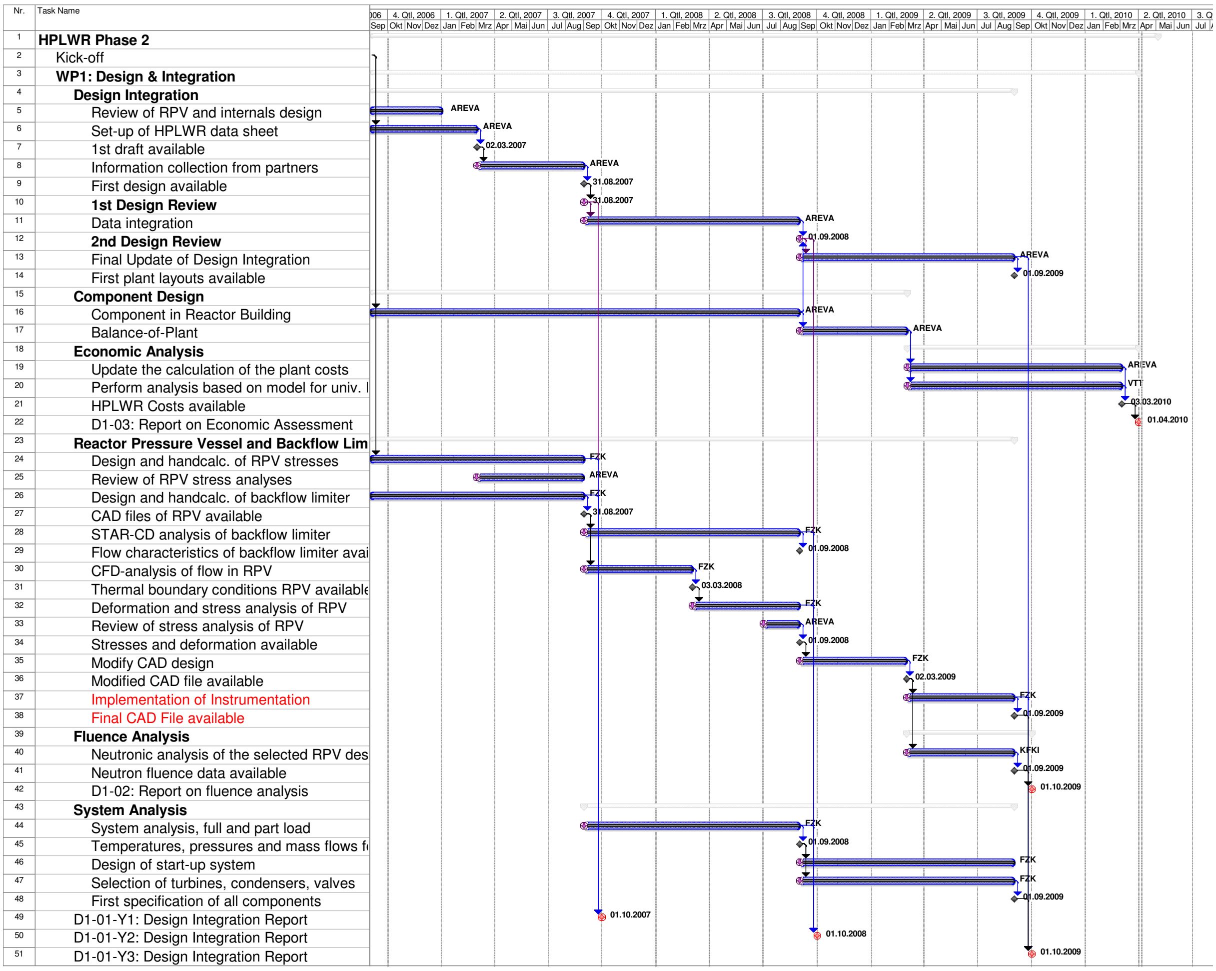
Generation IV International Forum

The HPLWR Phase 2 Project is the European Contribution to the research program on Supercritical Water Reactors within the Generation IV International Forum (GIF). HPLWR work package managers have been members of so-called GIF Project Management Boards. Their task was to define common projects and to carry them out on the GIF level.

The HPLWR Project has been contributing to the GIF Project "Thermalhydraulics and Safety" (WP3 and WP5), for which a project arrangement has been signed. Results of WP4 contribute to the GIF Project "Material and Water Chemistry", for which a project arrangement has been signed as well.

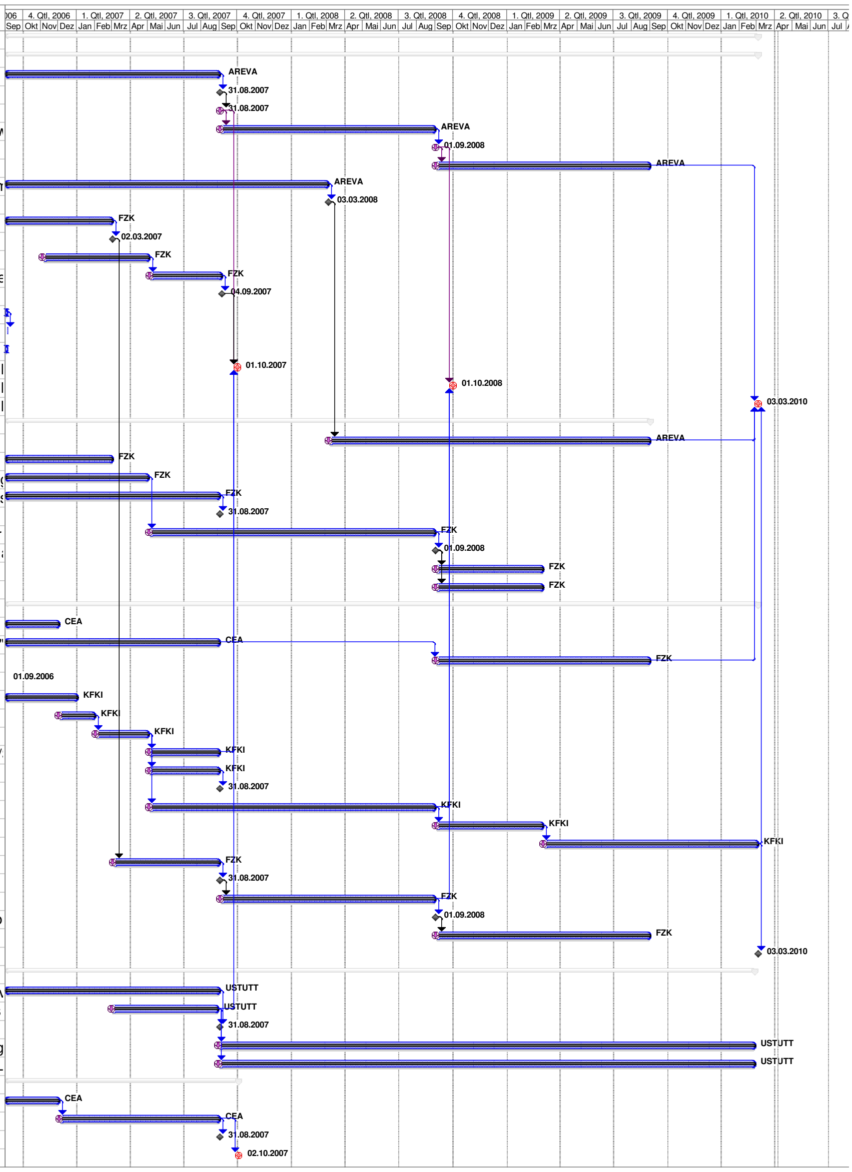
Frontline Bar-chart for all Work-Packages

WP1: Design & Integration



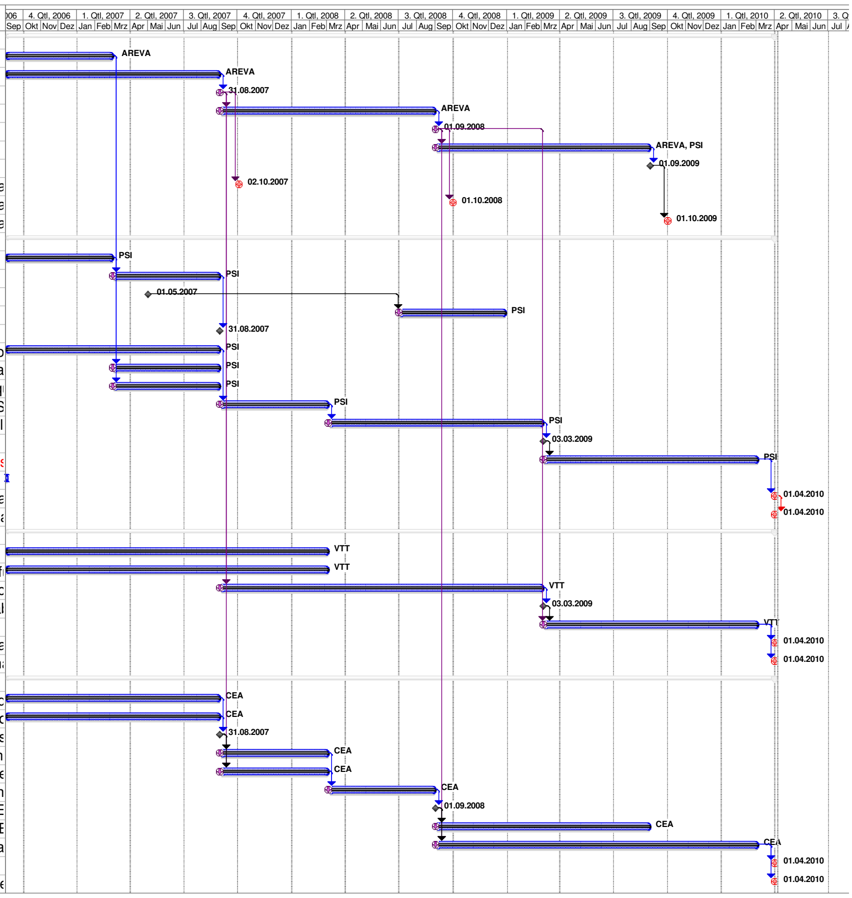
WP2: Core Design

Nr.	Task Name
52	**WP2: Core Design**
53	**Mechanical & Thermal Design**
54	Preliminary FA and Core Design
55	First design proposal available
56	**1st Design Review**
57	Preliminary core analysis and design review
58	**2nd Design Review**
59	Refinement of core design
60	Sensitivity and uncertainty analysis of therm
61	Uncertainty factor available
62	Mechanical design of FA foot piece
63	Core size available
64	Mechanical design of FA head piece
65	Creation of CAD files, upper and lower core
66	CAD files of thermal core available
67	deleted (modify FA)
68	deleted (modified CAD available)
69	deleted (repeat analysis)
70	D2-01-Y1: Thermal Core Design for HPLWI
71	D2-01-Y2: Thermal Core Design for HPLWI
72	D2-01-Y3: Thermal Core Design for HPLWI
73	**CFD and Stress Analysis**
74	Bowing and thermo-elastic instabilities
75	Analysis of mixed convection in the gap
76	Thermal defomation anlysis of Upper Mixing
77	CFD and sub-channel analysis of mixing ins
78	Mixing inside channels available
79	CFD analyses of mixing in upper and lower
80	Mixing in upper and lower mixing chamber a
81	CFD analysis for new moderator flow
82	Flow during outage
83	**Coupled Neutronics/TH Analysis**
84	Generaton of input deck TRIPOLI/FLICA
85	First assembly calculations for "evaporator"
86	Coupled-Caclulations of evap/SH1/SH2
87	D2-03: Report deleted
88	Verification of Power profile (KARATE)
89	KARATE-SPROD code improvement
90	Demonstration calculation
91	Comparison KARATE-SPROD with MCNP/
92	Preliminary core design with KARATE
93	Decision on preliminary core arrangement
94	Analysis of preliminary core design
95	Core refinements
96	Analysis of refined core
97	First MCNP calculations for fresh core
98	Power distribution for fresh core available
99	Coupled neutronics-TH calculations
100	Neutronics-subchannel analysis for given b
101	Repeated coupled core analysis
102	Power distribution of refined core design
103	**Neutron Scattering Laws for SC Water**
104	Improvm. of neutron scattering law, sensitiv
105	Reactivity feedback coefficient calculations
106	Scattering data available
107	Burn up analysis for cells and extended reg
108	Sensitivity and uncertainty analysis for HPL
109	**Fast Core Option**
110	COPERNIC study
111	ERANOS calculations
112	Definition of feasibility domain
113	D2-02: Feasibility study report

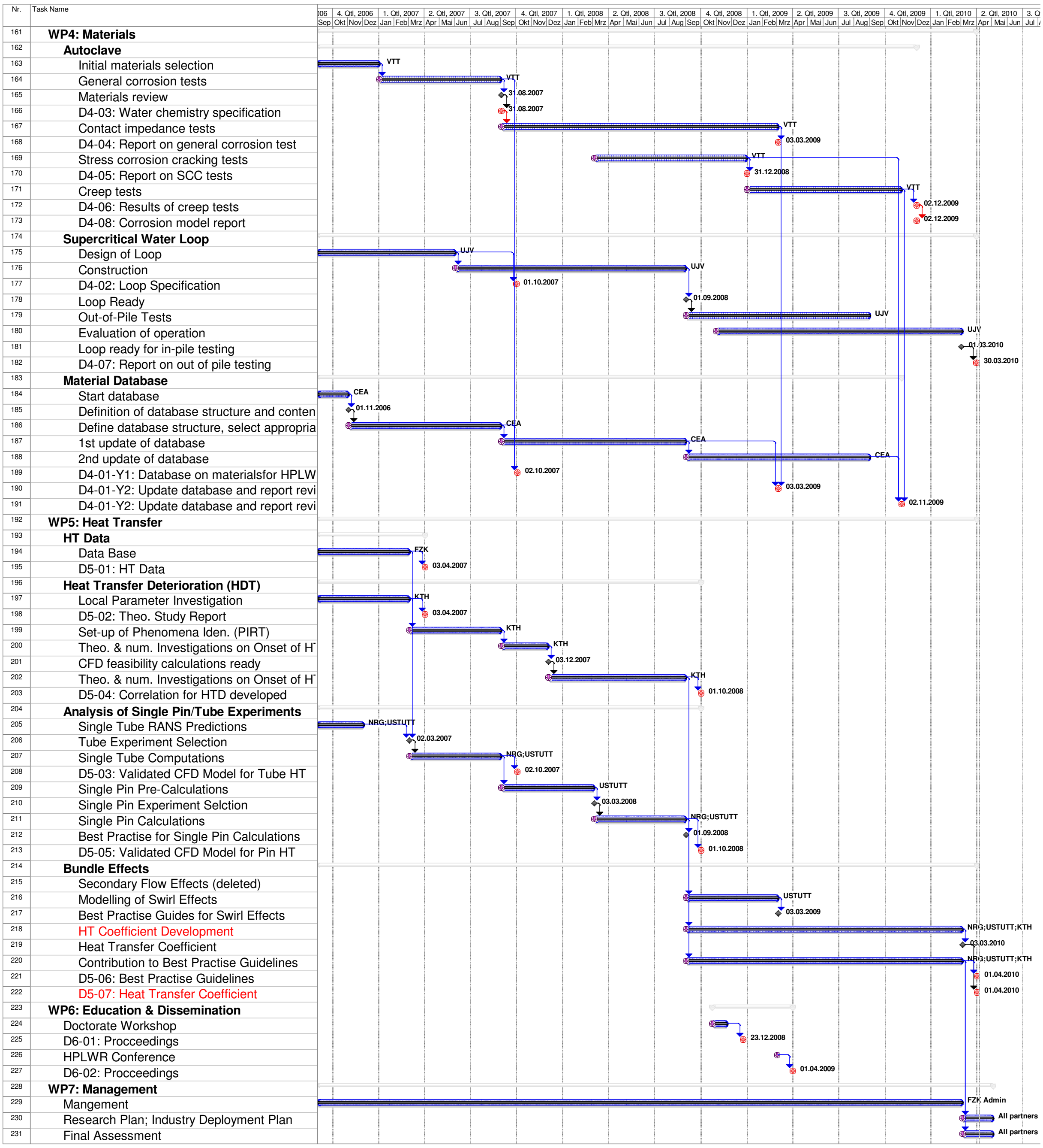


WP3: Safety

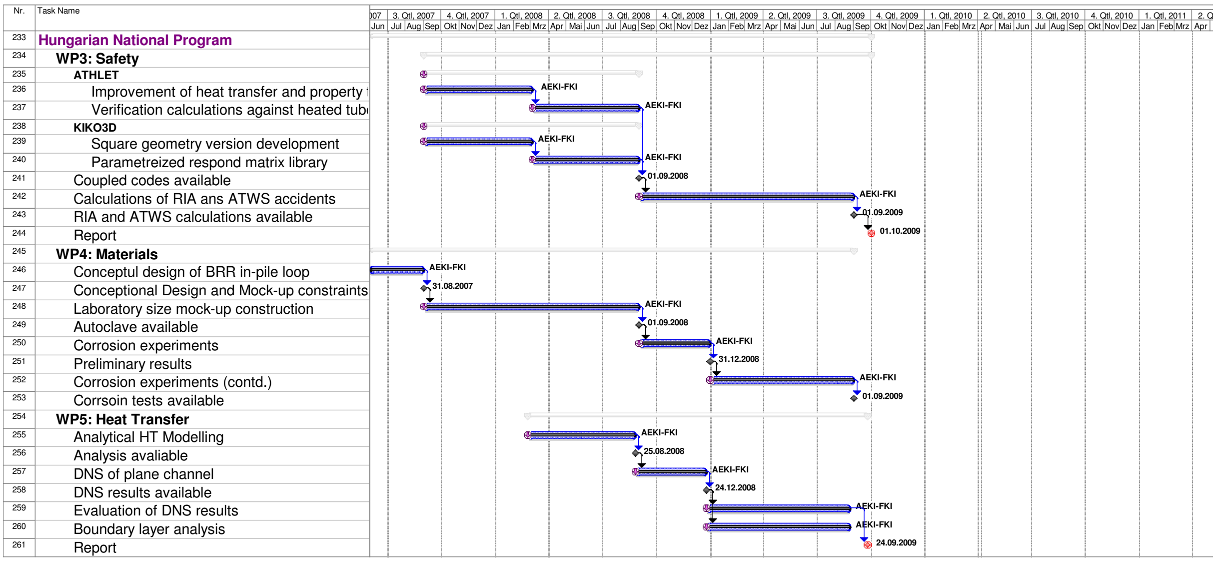
Nr.	Task Name
114	**WP3: Safety**
115	Initial definition of safety concept
116	Design of Safety System
117	**1st Design Review**
118	Update the component and systems design
119	**2nd design review**
120	Improvement of safety concept
121	Safety system available
122	D3-01-Y1: Report on Safety System Configura
123	D3-01-Y1: Report on Safety System Configura
124	D3-01-Y3: Report on Safety System Configura
125	**RELAP calculations**
126	RELAP update (Patch 03)
127	Test calculations
128	Selection of HT correlation from literature
129	Integration and test calculations
130	Exchange of HPLWR Common Design
131	Define and obtain data for RELAP plant mo
132	Contribute to design and optimisation of Sa
133	Identify relevant transient and accident seq
134	Develop RELAP integral plant model incl. S
135	Perform calculations and analyses for 2 sel
136	Decision to repeat calculation
137	Continue transient and accident simulations
138	deleted
139	D3-02: Report on the upgraded transient sa
140	D3-04: Report on accident cases for therma
141	**Reactivity Induced Accidents (TRAB)**
142	Aquisition of geometry and material data
143	Developing the core and circuit as well as f
144	Final selection of the RIA cases. Calculatic
145	Initial selected safety analysis cases availal
146	Detailed analysis of the calculated cases
147	D3-02: Report on the upgraded transient sa
148	D3-04: Report on transient cases for therm
149	**CATHARE calculations**
150	Implementation of models for SC water anc
151	Define required data for model of HPLWR c
152	Exchange of design and retained safety sys
153	Build a CATHARE input deck for the frozen
154	Define common HPLWR design and transie
155	Perform one reference transient calculation
156	Exchange of key-parameters for CATHARE
157	Analysis and comparisons of the CATHARE
158	Perform a reference transient calculation fa
159	deleted D3-03
160	D3-04: Report on thermal core safety studie



WP4 – WP7 (Materials, Heat Transfer, Education & Dissemination, Management)



National Hungarian Project (WP3 Safety, WP4 Materials, WP5 Heat Transfer)



3 IMPACT ON RESEARCH OF SUPERCRITCAL WATER COOLED REACTORS

In course of the European project High Performance Light Water Reactor Phase 2, a conceptual design has been derived for a light reactor operated at supercritical pressure and temperatures (HPLWR). This project is part of the international research on supercritical water cooled reactors, being carried out within the Generation IV International Forum (GIF).

In many fields, the HPLWR project is pioneering. For the first time in history, a conceptual design has been derived, which serves as a basis for future investigations on SCWRs. This conceptual design comprises the mechanical design of the core, reactor pressure vessels and internals, steam cycle and components, like turbines, preheaters, pumps, a pressure suppression containment with safety systems incl. active and passive components, and reactor and turbine building.

This conceptual design shows that a HPLWR can be built in principle. Based on the findings of the project, there is an interest from industry in China, Canada and Japan to continue with the design work.

These components have been analysed by means of neutronics codes, coupled neutronics/ thermohydraulics codes, thermodynamic system codes, computational fluid dynamics codes and finite elements codes for structural analysis.

The analysis showed that some codes still need improvement. The open gaps were clearly identified by HPLWR partners and transmitted to the code developers by the users. International groups, e.g. within GIF, are already benefitting from the project findings and perform analyses with improved codes and methods.

Exemplarily, operational transients and accident have been modelled and simulated. The HPLWR behaves like a Light Water Reactor, but provides a much smoother behaviour in case of reactivity changes. The HPLWR is very likely to later fulfil the European Utility Requirements.

However, more detailed safety analyses shall be carried out. The selected transients and accidents serve as a base for a follow-up project and provide hints for international groups, e.g. within GIF.

Materials have been investigated for use under supercritical conditions. Right now, there is no perfect cladding material available. The HPLWR partners gave a material recommendation for all other components inside the reactor pressure vessel, steam cycle, etc.

It is important to continue the research on materials for supercritical water cooled reactors. The Supercritical Water Loop in Rez is perfectly suited to provide results on corrosion, radiolysis and water chemistry under reactor operation conditions and radiation.

Heat transfer was investigated mainly my means of CFD codes. Under normal heat transfer conditions, the codes predict the experimental (mostly tube data) data, like surface temperatures, quite well.

The surface temperatures and the thermal-hydraulics under "deteriorated" conditions cannot be predicted. Additionally, validation data are missing especially on bundles. Based upon the findings within HPLWR, bundle test facilities in Canada and China are being built right now. A CRP has been launched by the IAEA on heat transfer to which HPLWR partners are contributing with their experience.

Summarizing, the HPLWR Phase 2 project has a very strong impact on the research on supercritical water cooled reactors being carried out in the framework of the Generation IV International Forum.

4 PLAN FOR USING AND DISSEMINATING THE KNOWLEDGE

4.1 Exploitable Knowledge and its Use

The partners of HPLWR Phase 2 state that ***the reactor concept is not yet ready to be built.*** Instead, the main objectives of the project were only to assess critical scientific issues and to assess the future potential of the HPLWR and thus a first theoretical step towards a "product" and exploitable knowledge use.

4.2 Dissemination of Knowledge

The High Performance Light Water Reactor (HPLWR) is one of the six projects being investigated in the Generation IV International Forum and being supported by the European Commission in a funded project called "HPLWR Phase 2". The public and nuclear stakeholders from industry, vendors, utilities, regulators, research organisations and universities have been informed about the reactor and the results of this project. A list of communication and dissemination activities is found in Table 1.

The communication has been targeted on different groups inside the society:

- International scientific community
- Doctorate students, and
- Public at large.

At the current state of the development of the HPLWR concept, the main target groups are the scientific community and students. The scientific community shall be aware of the research activities carried out in the project. For scientists, conferences are the main platform to exchange knowledge and receive feedback.

Two major dissemination events were organised and carried out during the project duration:

- International Student's workshop on High Performance Light Water Reactors and
- 4th International Symposium on Supercritical Water-Cooled Reactors

Both events are summarized as follows:

International Student's workshop on High Performance Light Water Reactors

An important target group is the students and doctorate students. The HPLWR already found its way into the lectures and theses. The HPLWR concept is very innovative and students have been motivated to work on this reactor.

Three partners of the HPLWR project, namely KIT, Prof. T. Schulenberg, KTH, Prof. H. Anglart and USTUTT, Prof. E. Laurien organized the International Students Workshop on High Performance Light Water Reactors, March 31-April 3, 2008 in Karlsruhe, Germany. In morning sessions, lectures were given to the students, in the afternoon students themselves presented their scientific work. There were 22 student presentations having a very high quality. About 26 students attended the workshop, mainly from Germany but also from Finland, India and Canada. Both the project partners and the students highly appreciated the dinner invitations from RWE and AREVA NP.

4th International Symposium on Supercritical Water-Cooled Reactors

The main dissemination event was the 4th International Symposium on Supercritical Water-Cooled Reactors which took place in Heidelberg, Germany. A short summary is given below.

From March 8-11, 2009, the 4th International Symposium on Supercritical Water-Cooled Reactors took place in Heidelberg, Germany. It was organised by the consortium of the European project "High Performance Light Water Reactor Phase 2" (HPLWR Phase 2) with support of the Generation IV International Forum (GIF) and its research partners for Supercritical Water-Cooled Reactors (SCWR). The objectives of the symposium were to enable discussions and exchange of results of design and technology for Supercritical Water-Cooled Reactors, to foster the world-wide research activities and collaborations, to improve the contact between industry (utilities, vendors etc.) and research organizations, and to provide an information platform for political, scientific and industrial stakeholders, as well as for the media and public.

109 participants from 18 countries joined the symposium and thoroughly discussed scientific topics. In particular, representatives of GIF member countries Canada, Japan, Europe, Korea, China and Russia participated, all of them actively working on the development of SCWR concepts. International nuclear organisations, like the IAEA, have sent their representatives.

Three invited lectures were given in a *plenary session*. Dr. Roland Schenkel, Director General, Joint-European Research Centre, European Commission, opened the plenary session. He gave a brief overview on research activities for Generation IV nuclear reactors currently being funded by the European Commission. All six Generation IV concepts are currently addressed by European projects, supported by cross cutting activities like on materials and reactor safety. He emphasised that a sustainable nuclear energy concept requires the development of fast reactors and a full recycling of Pu and other actinides. It will be necessary to prioritize between coolants in view of budget and time constraints and technological challenges. Regarding co-generation of heat and electricity, the Very High Temperature Reactor shall be assessed with industrial partners in Europe. International collaboration will be needed to support long-term R&D and, finally, the construction of prototypes. To foster public acceptance of nuclear energy, the dialogue on the back-end strategies including the geological disposal has to be continued.

Mr. Michael Wenk, Executive Director EnBW Kernkraft GmbH, expressed the expectations of a utility on Generation IV nuclear systems. These shall be a high availability and reliability, short outage times, competitiveness in the electricity generation mix and high safety standards. He summarized that features of Gen IV plants are principally interesting from a utility's point of view, but the way to commercialization is not easy: Gen IV reactors which are based on revolutionary concepts must reach the reliability of today's Gen II/III plants to become competitive. The advanced design features of Gen IV must be so attractive that there will be a competitive advantage at the time the decision has to be taken. A basic driver could be the uranium supply, although no shortage is expected for the next decades from utility's perspective and the electricity production costs depend only to a small fraction on the costs of uranium, whereas the need of Gen IV systems and a closed fuel cycle still mean additional costs. Another driver could be the waste issue. Gen IV can help to reduce effectively the waste burden, but will not make this issue obsolete. Here as well, additional effort will be needed.

Mr. Manfred Erve, Senior Vice President Products and Technology AREVA NP GmbH, explained the vendors point of view in his presentation entitled “Future Potential of Light Water Reactors in the Nuclear Renaissance”. The vendors’ main drivers are safety, reliability, business performance and time to market, taking benefit of existing developments and experience, e.g. by evolutionary development. He indicated a market shift from mostly government driven project in the past to utility and investor driven markets today. Other stakeholders’ main drivers are an improved air plane crash protection, severe accident mitigation, environmental impacts like reduced collective dose, optimized use of resources, minimum waste production and optimized waste management. Comparing SWR1000 and HPLWR, he stated that the HPLWR has assets to become a cost attractive concept due to high performances and compactness. Since the HPLWR design is close to a Boiling Water Reactor design, the SWR 1000 project may provide a good basis for plant design.

The *research programs* of countries investigating the SCWR concepts were presented in a plenary session afterwards. In Japan, as explained by Prof. Yuki Ishiwatari, University of Tokyo, Japan, research is concentrating on two pressure vessel-type concepts, one with a fast neutron spectrum, the other one with a thermal spectrum. Beside the Japanese universities, the companies Toshiba and Hitachi are involved in the development and assessment of particular concepts. Main emphasis today is on core design, plant design, thermal-hydraulics, safety and materials.

Mr. Daniel Brady, Natural Resources Canada, described the Canadian research activities which started recently. Atomic Energy Canada Limited and several Canadian universities are currently working on a pressure-tube version of a SCWR, which can be seen as a further development step of the CANDU-Reactor with a heavy water moderator. The research issues being addressed match the international activities quite well. The importance of collaboration on SCWR research within GIF was explicitly mentioned.

Prof. Thomas Schulenberg, Forschungszentrum Karlsruhe, Germany, reported about the European research activities. The European approach, the so-called High Performance Light Water Reactor (HPLWR) is a pressure vessel-type reactor in the $1000MW_e$ class. Besides research centres and universities from all over Europe, the company AREVA NP is an industrial partner of the project. Recent results of core design, plant design, safety, heat transfer and materials were presented. An assessment of the HPLWR concept is foreseen in 2010.

Prof. Xu Cheng, Shanghai Jiao Tong University, China explained the very ambitious research activities in China. Fundamental investigations on heat transfer, reactor physics and materials are being carried out mainly by Chinese universities. The Chinese nuclear industry, however, indicated interest in the SCWR concept. An experimental reactor to be built by about 2025 is foreseen in the Chinese roadmap for SCWR research.

Dr. Yoon-Yeong Bae, Korean Atomic Energy Research Institute, Korea gave an update of Korean research activities. The Korean design is seen as a further development of the Korean APR1400. The first prototype of a kind could be in operation by about 2025, the first commercial plant by 2030. The present research in Korea is mainly focussing on core design, materials and heat transfer.

After the plenary session, 78 *technical presentations* were given in three parallel sessions over two days, sorted in sessions according to the topics "Design & Integration", "Thermal-hydraulics & Safety" and "Materials & Water Chemistry", which are current projects of the SCWR system research plan worked out by the Generation IV International Forum. The discussion during and between the sessions was very fruitful and stimulated further collaboration between the researchers.

The proceedings of the symposium can be downloaded from www.hplwr.eu.

The 5th International Symposium on Supercritical Water-Cooled Reactors is foreseen to take place in Canada in 2011.

Education of Students and Doctorate Students

An important target group is the students and Doctorate students. The HPLWR already found its way into the lectures and theses.

KIT launched a student and doctorate program for education in light water reactor technologies, such as supercritical water cooled reactors. Starting with a few students in 2005, the HPLWR topic became more and more attractive for students. Since this reactor is the only light water reactor among the six concepts investigated within the Generation IV International Forum, it showed to be a perfect project to learn light water reactor technology.

The following Table summarizes the number of Bachelor, Master / Diploma Theses and Internships, as well as Doctorate Theses related to HPLWR topics which were performed in the course of the project:

Sept. 1, 2006 – Feb. 28, 2010	Bachelor / Master / Diploma Theses / Internships	Doctorate Theses
KIT	28	11 (some together with USTUTT)
USTUTT	4	8 (some together with KIT)
VTT	3	0
BME	7	2
TU Delft	1	0

Public at Large

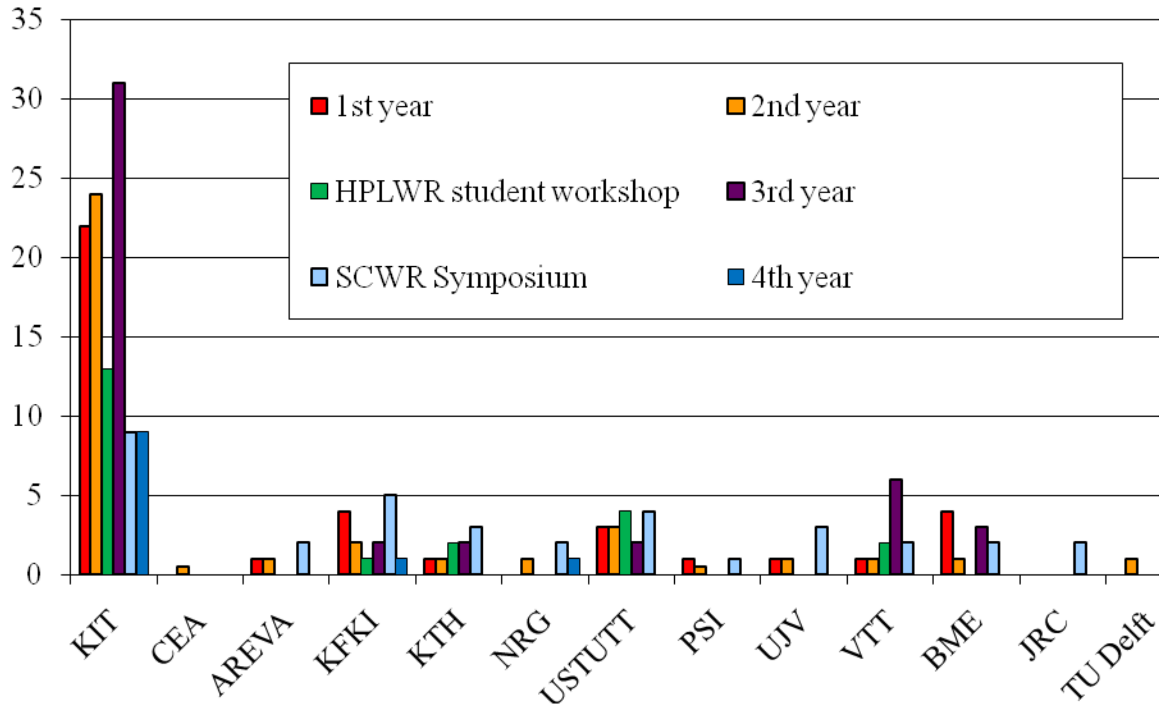
The public at large is addressed by a public website (www.hplwr.eu). Since almost all results are published in scientific papers, a reference list is given below.

A downscaled model of the HPLWR reactor pressure vessel has been built by KIT (Fig. 1). It is used to disseminate the information about nuclear engineering and Gen IV systems to the public. The model was shown to the public at the Hannover Industry fair in April 2009 and will be shown on a permanent exhibition on the "ship of science" in 2010, on which the topic "energy" will be explained by means of models and simple experiments.

Fig. 1: 1:25 model of the HPLWR at KIT booth on Hannover Industry Fair, April 2009

Statistics of Communication and Dissemination Activities

Since September 2006 until the end of the project, 190 dissemination activities (presentations / lectures / papers / posters / …) demonstrated the good visibility of the project. The following graph shows the distribution of these activities for each partner and Active Supporter.



KIT has carried out 119 dissemination activities caused by providing the coordinator, who has the duty to promote the project by definition, and by employing many students writing papers and giving presentations at conferences and workshops.

KFKI, KTH, USTUTT, VTT and BME have carried out more than 10 dissemination activities, the other partners in the order of 1-5.

A list of references can be found at www.hplwr.eu -> publications.

Future Activities beyond the Official End of the Project

Even beyond the official end of the project, dissemination activities will be carried out. Among others, scientific papers have been submitted to:

- Annual Meeting of the German Nuclear Society, May 4-6, 2010, Berlin, Germany
- Annual Meeting of the Canadian Nuclear Society, May 24-27, 2010, Montreal, Canada
- International Congress on Advances in Nuclear Power Plants (ICAPP'10), June 13-17, 2010, San Diego, U.S.A.
- NUTHOS Conference, October 10-14, 2010, Shanghai, China
- 5th International Symposium on Supercritical Water-Cooled Reactors, March 2011, Vancouver, Canada

For the public at large, scientist, social and political stakeholders, it is planned to write:

- The Public Final Summary Report (Deliverable)
- A book about the High Performance Light Water Reactor

Table 1: List of HPLWR Dissemination / Communication Activities (Month 01-42)

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
Sept. 08,.2006	Budapest, Hungary	HPLWR Information Exchange Meeting	KFKI / C. Maraczy	Scientists outside of EU projects	37 participants; guests mainly from Hungary
Sept. 08,.2006	Budapest, Hungary	Press Release of Kick-off Meeting	KFKI	Journalists	
Sept. 14, 2006	University Lappeenranta, Finland	“Supercritical Water Cooled Reactors”, including information about the HPLWR Phase 2 Project, Finnish National Seminar GEN4FIN	FZK / T. Schulenberg	Utilities, Regulators, Ministries, Industry, Academy, Research, Students, Journalists	53 participants
Sept. 23, 2006	FZK – Lecture Room, Germany	HPLWR as part of Gen IV Presentation at “FZK Day of the open Door”	FZK / W. Tromm (Deputy Head of Program Nuclear)	Public	60 participants; very specific questions of interested public
Sept. 23, 2006	FZK – IKET, Germany	HPLWR Posters at “FZK Day of the open Door”	FZK / T. Schulenberg	Public	Has been attractive in particular for students
Sept. 28, 2006	CORDIS Website	Internet contribution on HPLWR for the German CORDIS website	FZK / T. Schulenberg	Public	
Oct. 10-11, 2006	KTH, Stockholm	Contribution to KTH-Workshop: “On the Numerical Simulation of Flow and Heat Transfer within the Fuel-Assembly of the High-Performance Light-Water Reactor”	USTUTT / E. Laurien	Scientific Community, Students	50 participants; attended by 2 FZK Doctorate Students, turbulence models and boiling models were discussed in view of their ability to predict inter-channel exchange and secondary flows in rod bundles
		Contribution to KTH-Workshop: “Preliminary calculations of Coolant Flow in a SCWR Fuel Assembly with the Code ANSYS CFX 10.0”	BME / A. Kiss, A. Aszódi		
Oct. 16, 2006	FZK, Germany	Presentation at Gen IV Workshop in Karlsruhe, organised by ITU	FZK / T. Schulenberg	Scientific Community, Utilities	54 participants from JRC, FZK Utilities. Important political stakeholders: German BMBF and GRS Representatives
Oct. 26-27, 2006	Linthicum,	Presentation on “Current Status on R&D Activities for the High	PSI/ N. Aksan	Presentation at the 2006 Fall Code Application and	38 Participants from US NRC and CAMP member country

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
	Maryland, USA	Performance Light Water Reactor: Safety and Heat Transfer"		Maintenance Program (CAMP) Meeting of U.S. Nuclear Regulatory Commission	representatives
Nov. 27-28, 2006	Aix En Provence, France	*Invited Lecture* at the 1st International Topical Meeting on Coolants and Innovative Reactor Technologies (organized within the framework of CEA-JAEA collaboration and GEDEPEON)	FZK / J. Starflinger VTT / L. Heikinheimo	Representatives of JAEA, colleagues involved in ADS technology, USDOE, SCK, European Commission, ENEA CNRS and CEA, colleagues of GEDEPEON Group (mainly French)	75 participants mainly from CEA, EDF, CNRS. Guests from Japan! Good discussion especially on SCWR water chemistry given by CEA specialist. Action: Invite CEA scientists to give expert contribution to WP4.
Nov. 29 - Dec. 1, 2006	Paks, Hungary	"Application of the KARATE Code System to the HPLWR Supercritical Water Cooled Reactor" (in Hungarian Language), Symposium on Nuclear Technology of the Hungarian Nuclear Energy Society	KFKI / C. Maraczy	Members of the Hungarian Nuclear Energy Society	60 participants from Hungarian research institutes, universities and the Paks NPP, Students interest in HPLWR
		"Coupled neutronics-thermalhydraulics calculations for determining the axial power distribution of the HPLWR (in Hungarian language)"	BME / T. Reiss, D. Horváth, Sz. Czifrus, S. Fehér		
		"Preliminary calculations of Coolant Flow in a SCWR Fuel Assembly using the Code ANSYS CFX 10.0"	BME / A. Kiss, A. Aszódi		
Jan. 11, 2007	Stuttgart, Germany	*Invited Lecture* at Forum Kernenergie Baden-Württemberg: "Zukunftskonzepte für Kernreaktoren (Future Nuclear Reactor Concepts)" (in German Language)	FZK / T. Schulenberg	40 Participants from Ministries, Utilities, Research and Universities	Meeting about the General Future Energy Policy in Germany, Nuclear vs. Solar and Geothermal Energies. Generation IV Concepts were presented and discussed.
Feb. 25-28, 2007	Bernina Switzerland	Lecture on Generation IV Nuclear Systems	FZK / T. Schulenberg	30 Students and Tutors from Universities of Stuttgart and Karlsruhe	

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
March 12-15, 2007	Shanghai Jiao Tong University, China	*The 3rd Int. Symposium on Supercritical Water-Cooled Reactors – Design and Technology*		Scientists of new GIF-Member China	
		"Issues to be considered for the development of Supercritical Water Reactors"	AREVA / D. Bittermann	Scientists and political stakeholders	Up to 150 participants. Chinese Scientists (university and research centres) were very interested.
		"Stability analysis of a heated flow channel with supercritical water"	FZK / T. Ortega Gomez		
		"Review of Design Studies for High Performance Light Water Reactors"	FZK / T. Schulenberg		
		"European Research Project on High Performance Light Water Reactors"	FZK / T. Schulenberg		
		"Supercritical Water Loop Design for Corrosion and Water Chemistry Tests under Irradiation"	UJV / M. Ruzickova		
March 14-16, 2007	Marrakech, Morocco	Conference Paper at PHYTRA1: First International Conference on Physics and Technology of Reactors and Applications. "Application of the KARATE Code System to the High Performance Light Water Reactor"	KFKI / C. Maraczy	150 participants from various fields of reactor technology.	In sessions "*Innovative Reactors and Concepts*" and "*Computational Methods for Advanced Reactors*" generation 3+ and 4 reactors were discussed.
March 22, 2007	Munich, Germany	Invited lecture "Generation IV Development" including HPLWR technologies	FZK / T. Schulenberg	ENEN Training Course on Nuclear Safety at TU Munich	For professionals in nuclear safety
March 26, 2007	Regensburg, Germany	Invited lecture "Reaktorkonzepte der 4. Generation" (in German), including HPLWR technologies	FZK / T. Schulenberg	Public at DPG Conference "Arbeitskreis Energie"	The lecture was so attractive that the classroom was far too small for all students to attend (>200?).
May 13-18, 2007	Nice, France	*International Conference on Advances in Nuclear Power Plants (ICAPP 07)*		Scientific Community	

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
		“European Research Activities within the Project: “High Performance Light Water Reactor - Phase 2” (HPLWR Phase 2)” **Keynote Paper**	FZK / J. Starflinger	40 participants	HPLWR project is clearly visible among the other Gen IV Projects. ICAPP is the ideal conference because 90% of the papers address Gen IV reactors. Partners should select this conference as a main platform for presentation and discussion.
		“CFD Validation of a Supercritical Water Flow for SCWR Design Heat and Mass Fluxes”	NRG / F. Roelofs	20 participants in technical session on heat transfer	Contacts to US universities should be extended, e.g. in the field of heat transfer where single pin experiments will be available soon. Contact to Tractebel (SUEZ) Prof van Hove has been established.
		“Secondary Flows in the Cooling Channels of the High-Performance Light-Water Reactor”	USTUTT / E. Laurien		
		“Preliminary calculations of Coolant Flow in a SCWR Fuel Assembly with the Code ANSYS CFX 11”	BME / A. Kiss, A. Aszódi		
May 14, 2007	Mannheim, Germany	Invited lecture “Kernkraftwerkstechik in Deutschland – quo vadis?“ (in German) including HPLWR technologies	FZK / T. Schulenberg	Public at “Sommerakademie” organized by Alstom	Around 50 participants from turbine business
May 22-24, 2007	Karlsruhe, Germany	*“Annual Meeting of Nuclear Technology 2007”*	German Nuclear Society (KTG)	Nuclear Industry in Germany	
		„Festigkeitsanalyse des Reaktordruckbehälters für einen Leichtwasserreaktor mit überkritischen Dampfzuständen“	EnBW / FZK / K. Fischer		60-80 participants
		„Auslegungsrechnungen für einen Druckwasserreaktor mit überkritischen Dampfzuständen“	EnBW / FZK / B. Vogt		
		“Flow in a HPLWR Fuel Assembly with Wire Wrapped Spacers”	FZK / S. Himmel	Young Scientists at embedded Workshop “Competence in Nuclear	15 participants

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
				Engineering”	
		"Thermal hydraulic Instabilities in a HPLWR Fuel Assembly"	FZK / T. Ortega Gomez	Young Scientists at embedded Workshop “Competence in Nuclear Engineering”	
May 31-June 2, 2007	Budapest, Hungary	International Youth Conference on Energetics : “Coupled neutronics and thermohydraulics analysis for the optimization of the axial enrichment profile of HPLWRs”	BME / T. Reiss, Sz. Czifrus, S. Fehér	Young scientists mainly from Europe	
June 3-6, 2007	St. John, Canada	Presentation “Design Options for High Performance Light water Reactors”	FZK / T. Schulenberg	Scientific Community at Annual CNS Conference	
June 8, 2007	Chalk River, Canada	Invited lecture on FZK activities in the HPLWR development	FZK / T. Schulenberg	Employees of AECL, Canada	Around 40 participants
July 9, 2007	University of Karlsruhe, Germany	Poster of HPLWR reactor pressure vessel at the “information day for future studies”	FZK / T. Schulenberg, A. Class	Contact with about 40 students from Karlsruhe University	Nuclear engineering is more and more interesting for students, especially GEN IV (new!).
July 9-13, 2007	Leipzig, Germany	Presentation “Heat Capacity Model for Turbulent Heat Transfer at Supercritical Pressure, Int. Conf. on Multiphase Flow (ICMF 2007)”	USTUTT / E. Laurien	Scientific Community	
Year 2					
Sept. 4, 2007	CEA Cadarache France	HPLWR Information Exchange Meeting	FZK / J. Starflinger	Scientific Community	In total about 45 Participants. 4 Organisations not involved in the project indicated their interest working on HPLWR.
Sept. 9-13, 2007	Boise, Idaho, USA	*GLOBAL 2007*		Scientific Community	
		Mechanical Design of Core Components for a High Performance	EnBW / FZK K. Fischer		The US is currently more interested in waste management

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
		Light Water Reactor with a Three Pass Core			than in Supercritical Water Reactors. Disappointing discussions, approx. 15 participants in technical session.
		Design and Optimization of a Backflow Limiter for a High Performance Light Water Reactor	EnBW / FZK K. Fischer		
		Mixing Coefficients for Sub-Channel Analyses with Supercritical Water	EnBW / FZK B. Vogt		
		Reactivity Control Mechanisms for a HPLWR Fuel Assembly	FZK / M. Schlagenhaufer		
Sept. 10-13, 2007	Portoroz, Slowenia	Conference: "*Nuclear Energy for New Europe 2007*" Theoretical and Numerical Study of Heat Transfer Deterioration in HPLWR	KTH / D. Palko, H. Anglart	Scientific Community	
Sept. 10-13, 2007	Yalta, Crimea, Ukraine	Conference: *"Seventeenth Symposium of AER "* High Performance Light Water Reactor Core Calculations	KFKI / Cs. Maráczy, Gy. Hegyi, G. Hordósy, E. Temesvári, Cs. Hegedűs, A. Molnár	Scientific Community	25 participants in technical session
September 30-October 4., 2007	Pittsburgh, Pennsylvania, USA	Conference *NURETH-12* "Refined validation of water coolant flow in a supercritical pressure test section with the code ANSYS CFX 11"	BME / A. Kiss, A. Aszódi	Scientific Community	
Oct. 12, 2007	MPA Stuttgart	Presentation "High Performance Light Water Reactors"	FZK / Schulenberg	MPA Seminar, Material Science	30 participants
Oct. 12, 2007	Saclay near Paris, France	Invited Lecture at "International course on the 4th generation reactor" (organizer CEA / INSTN; ENEN)	FZK / J. Starflinger	Young engineers working on Gen IV, university students	20 international participants also from countries like Mexico, Argentina, and Australia. Very good discussions
Nov. 11-15, 2007	Washington, DC	*"ANS Winter Meeting"*			
		Extended Abstract "Flow In A HPLWR Fuel Assembly With Wire Wrap Spacers"	FZK / S. Himmel et al.	Scientists in the US	15 participants in technical session.

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
		Extended Abstract. “Density Wave Oscillations in Coupled Parallel Channels under Supercritical Pressure Conditions”	FZK / T. Ortega Gomez et al.		
Nov. 29-30, 2007	Budapest, Hungary	VI. Nuclear Techniques Symposium: “A Further development of the coupled neutronics-thermalhydraulics program system for the investigation of HPLWRs (in Hungarian language)	BME / T. Reiss et al.	Scientists in Hungary	Published in Nukleon, Vol I., Mai, 2008
Nov. 29-30, 2007	Budapest, Hungary	Presentation: “HPLWR Core Design Calculations”	KFKI/ Cs. Maráczy, Gy. Hegyi, G. Hordósy, E. Temesvári, Cs. Hegedűs, A. Molnár	Members of the Hungarian Nuclear Energy Society	52 participants from Hungarian research institutes, universities and the Paks NPP, Students interest in HPLWR
Dec. 10, 2007	Ruhr-University Bochum, Germany	Invited lecture on Gen IV systems with emphasis on HPLWR	FZK / J. Starflinger	Students and professors	35 participants mainly from university. Contact to German VGB established
Feb. 28-29, 2008	IAEA Vienna	Super Critical Water-cooled Reactor Update	FZK / T. Schulenberg AECL / H. Khartabil	GIF/INPRO/IAEA Interface Meeting	
March 31- April 3, 2008	University of Karlsruhe	**Own event “International Students’ Workshop on High Performance Light Water Reactors”**	FZK / T. Schulenberg USTUTT / E. Laurien KTH / H. Anglart	Students and young scientists	
		Morning Lectures about Design, Neutronics, Heat Transfer, Materials, and Stability	Prof. Schulenberg, FZK Dr. Bernnat, USTUTT Dr. Maraczy, KFKI Prof. Laurien, USTUTT Prof. Anglart, KTH Prof. Ambrosini, Univ. Pisa Prof. em. McEligot, Univ. of Arizona Dr. Heikinheimo, VTT		26 Students, also from India, Canada, Japan, and China. The student papers had a very high quality. AREVA and RWE invited the students for dinner. The partners are thinking of a follow-up student workshop.
		Afternoon student presentation	**22 student papers** available on **www.hplwr.eu**		

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
April 8, 2008	Stuttgart	Presentation: Innovative Kernkraftwerkskonzepte - eine vergessene Option	FZK / T. Schulenberg	3. Stuttgarter Energieforum des Zentrums für Energieforschung Stuttgart	Around 100 participants from industry, government, research or public in general
April 14-16, 2008	FZK Karlsruhe	Presentation: Concept and Thermal-Hydraulic Challenges of the High Performance Light Water Reactor	FZK / T. Schulenberg, J. Starflinger	International Workshop on Thermal-Hydraulics of Innovative Reactor and Transmutation Systems – THIRS	50 scientists discussing thermal-hydraulic issues.
April 24, 2008	Bad Herrenalb, Germany	Manfred Eigen Nachwuchs-wissenschaftler Gespräche der Bunsen-Gesellschaft 2008: Presentation „Technologie der Kernspaltung“ (HPLWR included)	FZK / T. Schulenberg, J. Starflinger	Post-Doc scientists from all over Germany	50 post-docs. Good discussion about the future role of nuclear in Germany. New contact established to: Dr. Hermann Held, Co-Chair of the Research Domain 'Sustainable Solutions', Potsdam Institute for Climate Impact Research (Advisories to Ms Merkel on climate issues)
May 18-23, 2008	Les Embiez, France	Poster at the “7th International Symposium on High-Temperature Corrosion and Protection of Materials”	UJV / M. Ruzickova	Scientific Community	
May 21, 2008	JRC Petten, Institute of Energy	Invited presentation on HPLWR	FZK / J. Starflinger	Scientists from JRC	40 participants from JRC-IE. Discussion about a closer cooperation, e.g. in heat transfer, safety or materials. JRC scientists would like to join project meetings. Offer to work on exergy losses from a scientist.
May 23, 2008	Delft University of Technology, The Netherlands	Invited presentation „Stability of the HPLWR: a critical issue?“	TUD+KIVI / M. Rohde	Dutch nuclear scientists and engineers	80 participants
May 27-29, 2008	Hamburg, Germany	*“Annual Meeting of Nuclear Technology 2008”*	German Nuclear Society (KTG)	Nuclear Industry in Germany, public, students	Own HPLWR session: Session leader: D. Bittermann, AREVA

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
		Das Europäische Projekt HPLWR Phase 2 zur Bewertung eines Leichtwassereaktors mit überkritischen Dampfzuständen	FZK / J. Starflinger, T. Schulenberg		About 60 participants in the HPLWR session. Good discussions and questions from the audience, which seems to be very interested in this kind of reactor. ***Radio interview*** afterwards
		Kernkonzepte für thermische Reaktoren mit überkritischem Wasser	FZK / T. Schulenberg, J. Starflinger, AREVA / J. Heinecke		
		Konstruktionsentwurf eines Reaktors mit überkritischen Dampfzuständen	EnBW / K. Fischer FZK / T. Schulenberg AREVA / W. Meier		
		Hydraulic Analysis of a Backflow Limiter for a High Performance Light Water Reactor	EnBW / K. Fischer USTUTT / E. Laurien, FZK / A. Class, T. Schulenberg,		
		Code-to-Code Comparison for Blowdown Transients at Supercritical Conditions	PSI / A. Manera, CEA / O. Antoni		
		Coupled Analysis of the HPLWR Fuel Assembly	FZK / L. Monti, T. Schulenberg, J. Starflinger		
		Fluid-Dynamics and Heat Transfer Within Rod-Bundles at Supercritical Pressures	USTUTT / E. Laurien		
		CFD Analysis of Turbulent Mixing in Sub-Channels of a Supercritical Water Reactor Fuel Assembly	EnBW / B. Vogt USTUTT / E. Laurien, FZK / A. Class, T. Schulenberg		
		Durchmischung des Kühlmittels im oberen Plenum des HPLWR	FZK / A. Wank, T. Schulenberg	Young Scientists at embedded Workshop "Competence in Nuclear Engineering"	80 participants. Paper and presentation made the 3rd place in "best paper award" and will be published in ATW
May 28, 2008	Hamburg, Germany	Radio interview on HPLWR	FZK, J. Starflinger, T. Schulenberg	Public	20min radio interview by Frank Grotelüschen, science journalist, Hamburg

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
June 8-13, 2008	Anaheim, USA	*"ICAPP 08: International Conference in Advances in Nuclear Power Plants"*		Scientific Community especially in the US	Session chair and presentations
		Progress in the European Project "High Performance Light Water Reactor Phase 2	FZK / J. Starflinger and project partners		2 sessions with about 25 participants in each of them. Discussions were mainly focussed on heat transfer issues.
		Coolant mixing chambers for a HPLWR with three heating stages	FZK / A. Wank, A. Class, T. Schulenberg		
		Determination of Mixing Coefficients in a Wire-Wrapped HPLWR Fuel Assembly using CFD	FZK / S. Himmel, A. Class, T. Schulenberg, USTUTT/ E. Laurien		
		Numerical Simulation of a HPLWR Fuel Assembly Flow with Wrapped Wire Spacers	BME / A. Kiss, A. Aszódi , USTUTT /E. Laurien		
		Summary for Three Different Validation Cases of Coolant Flow in Supercritical Water Test Sections with the Code ANSYS CFX 11.0	BME / A. Kiss, A. Aszódi		
		Thermo-Mechanical Stress and Deformation Analysis of a HPLWR Pressure Vessel and Steam Plenum	EnBW / K. Fischer, Univ. Karlsruhe / T. Redon, G. Millet, FZK / T. Schulenberg		
		Prediction of Overheated Zones along the Wall of Strongly Heated Quasi-Fully Developed Pipe Flow at Supercritical Pressure	USTUTT / E. Laurien, M. Rashid		
		CFD Predictions of Heat Transfer in the Super Critical Flow Regime	NRG / D. C. Visser, J. A. Lycklama à Nijeholt F. Roelofs		15 participants in a thermal-hydraulic session
		Corrosion Studies of Candidate Materials for European HPLWR	VTT / S. Penttilä, A. Toivonen, L. Heikinheimo JRC-IE / R. Novotny		12 participants in a materials session

Date	**Location**	**Activity**	**Responsible Organization / Person**	**Audience addressed**	**Comment**
June, 2008	-	"International Students Workshop on Innovative Light Water Reactors" Atw 53. Jg. (2008) Heft 6 – Juni, S. 380-386	FZK / T. Schulenberg USTUTT / E. Laurien KTH / H. Anglart	German and International Nuclear Community	Summary publication of the HPLWR workshop in ATW
Year 3					
Sept. 20-26, 2008	Interlaken	*International Youth Nuclear Conference 2008*		Young Scientists	
		Mechanical Analysis of an Innovative Assembly Box with Honeycomb Structures Designed for a High Performance Light Water Reactor	FZK / H. Herbell, S. Himmel, T. Schulenberg		About 35 participants; contacts to utility EnBW intensified, possible sponsor of the Heidelberg symposium
		Neutronic and Thermal-hydraulic Modelling of High Performance Light Water Reactor	VTT / M. Seppälä, A. Daavittila, A. Hämäläinen, J. Leppänen, J. Miettinen		
		Simulation of thermal hydraulics at supercritical pressures with APROS	VTT / J. Kurki		
		Heat Transfer Phenomena of Supercritical Fluids	FZK / C. Krau, D. Kuhn, T. Schulenberg		
Sept. 28, 2008	Karlsruhe, Germany	Regionaltag 2008 (Day of the region) (FZK and Univ. Karlsruhe) Lecture: "Kernkraftwerke der 4. Generation" Poster and Hardware Model of RPV and Internals	FZK / T. Schulenberg, J. Starflinger, C. Koehly, M. Schlagenhaufer, S. Himmel	Public	About 35 participants in the lecture, and more than 100 visitors
Oct. 2-3, 2008	Lappeenranta, Finland	*GEN4FIN*		Nuclear industry, stakeholders in Scandinavia	
		SCWR projects in the world; HPLWR core design	FZK / T. Schulenberg		
		Thermal design issues in Gen IV	KTH / H. Anglart		

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
		supercritical-water-cooled reactors			
		Safety concept of the HPLWR	AREVA / D. Bittermann		
		Materials for the SCWR concept	VTT / S. Penttilä		
		HPLWR modelling with TRAB-3D/SMABRE	VTT / M. Seppälä		
Oct. 5-9, 2008	Seoul, Korea	*NUTHOS-7*			
		Investigations of Experiments with Supercritical H2O with the System Code TRACE	FZK / W. Jaeger, V. Sánchez Espinoza, TU Dresden / A. Hurtado		
		Application and Improvements of the System Code TRACE for HPLWR Core Analyses	FZK / L. Monti, T. Schulenberg, W. Jäger, V. Sánchez Espinoza		
		Simulation of Flows at Supercritical Pressures with a Two-fluid Code,	VTT / M. Hänninen, J. Kurki		
		Numerical Study of the Influence of Buoyancy and Thermo-Physical Properties Variations on Heat Transfer to Supercritical Water	KTH / D. Palko, H. Anglart		
Oct. 13-18, 2008	Aomori, Japan	*The 16th Pacific Basin Nuclear Conference (16PBNC)*		Japanese Nuclear Industry, Scientific Community	
		Design Status of the High Performance Light Water Reactor	FZK / T. Schulenberg AREVA / D. Bittermann	Nuclear Community	
		Mechanical Analysis of an Assembly Box with Honeycomb Structure	FZK / H. Herbell, S. Himmel, T. Schulenberg		
		Sub-channel Analysis of a HPLWR Fuel Assembly with STAR-CD	FZK / S. Himmel, A. Class, T. Schulenberg USTUTT / E. Laurien		
		Natural convection in the gap volume	FZK / C. Kunik, B. Vogt, T.		

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
		between fuel assembly boxes	Schulenberg		
		Coupled neutronic / thermal hydraulic analysis of the HPLWR three pass core	FZK / L. Monti, T. Schulenberg, J. Starflinger		
		High Performance Light Water Reactor Core Design Studies	KFKI / C. Maraczy, et Al.		
Nov. 3, 2008	Potsdam, Germany	Invited presentation about HPLWR and Gen IV systems at the Potsdam Institute for Climate Impact Research	FZK / J. Starflinger	Specialists in Climate Modelling	Contacts established. Models of Gen IV Reactors are too coarse in models. Subject of improvement.
Dec. 4-5., 2008.	Budapest, Hungary	7th Symposium on Nuclear Technology Presentation: “3 Years of the NUKENERG Project: SCWR Core Design” (in Hungarian)	KFKI / Cs. Maráczy, Gy. Hegyi, G. Hordósy, E. Temesvári, Á. Brolly,P. Vértes, A. Molnár BME / T. Reiss, S. Fehér, Sz. Cziffrus	Members of the Hungarian Nuclear Energy Society	70 participants from Hungarian research institutes, universities and the Paks NPP
Dec. 4-5., 2008.	Budapest, Hungary	“Advanced calculations of Coolant Flow in a SCWR Fuel Assembly using the Code ANSYS CFX”	BME / A. Kiss, A. Aszódi	Members of the Hungarian Nuclear Energy Society	70 participants from Hungarian research institutes, universities and the Paks NPP, Students interest in HPLWR
Jan 2009	Stuttgart, Germany	HPLWR as part of the magazine “Transmitter” of university of Stuttgart	USTUTT / E. Laurien	Students, University Staff Public	
Jan 6, 2009	Baden, Switzerland	Invited lecture “The HPLWR – a 4th Generation Light Water Reactor”	FZK / J. Starflinger	Members of the “Schweizerische Gesellschaft der Kernfachleute”	More than 50 participants, 30min discussion. Swiss nuclear industry is interested to young scientists, in turn may possibly contribute with their operation expertise
Feb. 11, 2009	Firma Bürkert, Ingelfingen	Invited lecture “Analyse der Durchmischung von überkritischem Wasser in den Mischkammern des HPLWR - High Performance Light Water Reactor“	FZK / A. Wank, T. Schulenberg		

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
March 8-11, 2009	Heidelberg, Germany	***"4th International Symposium on Supercritical Water Cooled Reactors"* organised by the HPLWR Project**	HPLWR project	Scientific Community, Stakeholders, Public	79 presentations and 108 registered participants made the Symposium to a great success.
		EUROPEAN RESEARCH ACTIVITIES AND GENERATION IV NUCLEAR SYSTEM (invited lectures)	R. Schenkel, JRC Director General, European Commission		The invited lectures gave a good overview on research activities, the expectations of possible customers and the position of the vendor. The invited lectures showed that new Generation IV power plants must compete with existing ones in price, reliability etc.
		CUSTOMER EXPECTATIONS FOR GENERATION IV NUCLEAR POWER PLANTS (invited lecture)	M. Wenk, Technical Director, EnBW Kraftwerk GmbH		
		FUTURE POTENTIAL OF LIGHT WATER REACTORS IN THE CONTEXT OF THE NUCLEAR RENAISSANCE (invited lectures)	M. Erve, Director Technical Center, AREVA NP		
		Technical papers			
		EUROPEAN RESEARCH PROJECT ON THE HIGH PERFORMANCE LIGHT WATER REACTOR	FZK / T. Schulenberg, J. Starflinger		37 of 79 presentations from European partners
		GEN4 MARKET SHARE SCENARIOS WITH FOCUS ON SCWR	NRG / F. Roelofs, A. van Heek, Luc Van Den Durpel		
		HPLWR REACTOR DESIGN CONCEPT	FZK / C. Koehly, T. Schulenberg, J. Starflinger		
		TRANSIENT STRESS ANALYSIS OF THE HPLWR PRESSURE VESSEL	FZK / T. Reiss, H. Foulon, A. Wank, T. Schulenberg		
		FLOW AND HEAT TRANSFER OF A HEATED ROD WITH A WRAPPED	USTUTT / E. Laurien, Haijun Wang, Yu Zhu, Hongzhi Li		

Date	Location	Activity	Responsible Organization / Person	Audience addressed	Comment
		WIRE INSIDE A CHANNEL			
		CFD ANALYSES ON THE INFLUENCE OF WIRE WRAP SPACERS ON HEAT TRANSFER AT SUPERCRITICAL CONDITIONS	NRG / L. Chandra, J.-A. Lycklama à Nijeholt, D.C. Visser, F. Roelofs		
		EFFECTIVENESS OF AN INSULATED FUEL ASSEMBLY TO IMPROVE HPLWR CORE PERFORMANCE	FZK / L. Monti, J. Starflinger, T. Schulenberg		
		GENIV MATERIALS AND CHEMISTRY RESEARCH – COMMON ISSUES WITH SCWR CONCEPT	VTT / L. Heikinheimo, AECL / D. Guzonas, FZK / C. Fazio		
		STEAM CYCLE OPTIMIZATION FOR THE HPLWR	FZK / M. Brandauer, M. Schlagenhaufer, T. Schulenberg		
		STEAM CYCLE ANALYSES AND CONTROL OF THE HPLWR PLANT	FZK / M. Schlagenhaufer, J. Starflinger, T. Schulenberg		
		A TURBINE DESIGN CONCEPT FOR THE HPLWR	EnBW / H. Herbell, SIEMENS / M. Wechsung, FZK / T. Schulenberg		
		THERMODYNAMIC ASPECTS OF CYCLES WITH SUPERCRITICAL FLUIDS	UJV / P. Hajek		
		STUDY OF CORROSION IN SUPERCRITICAL WATER	AEKI / Á. Horváth, Gy.Jákli, M. Horváth,A.Csordás, L. Sikó, A. Imre		
		SCC PROPERTIES AND OXIDATION BEHAVIOUR OF AUSTENITIC ALLOYS AT SUPERCRITICAL WATER CONDITIONS	VTT / S. Penttilä, Aki Toivonen, L. Heikinheimo, JRC / R. Novotny		

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		PREDICTION OF HEAT TRANSFER OF UPWARD FLOW IN ANNULAR CHANNEL AT SUPERCRITICAL PRESSURE – WATER AND CO2	USTUTT / Y. Zhu and E. Laurien		
		ON USE OF HYDRIDE FUEL IN HPLWR	JRC / H. Tsige-Tamirat, L. Ammirabile, M. Fuetterer		
		THERMAL NEUTRON SCATTERING ON H IN SUPERCRITICAL H2O	USTUTT / W. Bernnat, A. Conti, J. Keinert, M. Mattes		
		INVESTIGATION OF THE ONSET OF HEAT TRANSFER DETERIORATION TO SUPERCRITICAL WATER	KTH / D. Palko, H. Anglart		
		HEAT TRANSFER DETERIORATION IN APPLICATION TO HPLWR – MECHANISMS IDENTIFICATION AND RANKING TABLE	KTH / H. Anglart		
		HPLWR CORE DESIGN STUDIES	AEKI / Cs. Maráczy, Gy. Hegyi, G. Hordósy, E. Temesvári, A. Molnár		
		CALCULATION OF XENON-OSCILLATIONS IN THE HPLWR	BME / T. Reiss, S. Fehér, Sz. Czifrus		
		2D AND 3D ASSEMBLY BURNUP ANALYSIS FOR HPLWR	USTUTT / W. Bernnat, A. Conti		
		ANALYSIS OF THE CONVECTIVE HEAT TRANSFER TO LAMINAR DUCT FLOW OF SUPERCRITICAL WATER	KTH / A. Simal, H. Anglart		
		IMPLEMENTATION OF IMPROVED HEAT TRANSFER CORRELATIONS IN RELAP5 AND APPLICATION TO THE HPLWR	PSI / M. Sharabi, A. Manera, M. Andreani		

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		THE SAFETY CONCEPT OF THE HPLWR	AREVA / D. Bittermann, FZK / T. Schulenberg, PSI / M. Andreani		
		CONTAINMENT DESIGN PROPOSAL WITH ACTIVE AND PASSIVE SAFETY SYSTEMS FOR A HIGH PERFORMANCE LIGHT WATER REACTOR	FZK / B. de Marsac, J. Starflinger, T. Schulenberg AREVA / D. Bittermann		
		DOWNSCALING THE HPLWR TO AN EXPERIMENTAL FACILITY BY USING A SCALING FLUID	TU Delft / M. Rohde, T.H.J.J. van der Hagen		
		NUMERICAL SIMULATION OF SCWR FUEL BEHAVIOUR UNDER STEADY STATE CONDITIONS	AEKI / E. Slonszki		
		SAFETY ANALYSES OF REACTIVITY INITIATED ACCIDENTS IN A HPLWR REACTOR BY THE COUPLED ATHLET-KIKO3D CODE	AEKI / A. Keresztúri, Cs. Maráczy, I. Trosztel, Gy. Hegyi		
		THEORETICAL INVESTIGATION OF SUDDEN VAPORIZATION AND WATER HAMMER IN SCWR DURING LOSS OF COOLANT ACCIDENTS	AEKI / A.R. Imre, I.F. Barna, I. Farkas, A. Márkus, G. Házi, T. Kraska		
		WATER CHEMISTRY SPECIFICATIONS FOR SUPERCRITICAL WATER COOLED REACTORS – POSSIBLE OPTIONS	UJV / J. Kysela, V. Švarc, M. Růžičková		
		FIRST EXPERIENCE WITH OPERATING THE SUPERCRITICAL WATER LOOP	UJV / P. Hájek, R. Všolák, M. Růžičková		
		IMPROVED NUMERICAL SIMULATION OF A HPLWR FUEL	BME / A. Kiss, A. Aszódi USTUTT / E. Laurien, Yu		

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		ASSEMBLY FLOW WITH WRAPPED WIRE SPACERS	Zhu		
		FLOW PHENOMENA IN THE GAP VOLUME BETWEEN ASSEMBLY BOXES	FZK / C. Kunik, B. Vogt, T. Schulenberg		
		ANALYSIS OF THE FLOW IN THE UPPER MIXING CHAMBER OF A THREE PASS CORE	FZK / A. Wank, T. Schulenberg, E. Laurien		
March 18, 2009	Karlsruhe, Germany	“Operating condition of HPLWR core including thermal-hydraulic feedbacks” KIT PhD Symposium	FZK / L. Monti	PhD Students at university of Karlsruhe	
April 2009	-	“Design Concept of the High Performance Light Water Reactor” in Kerntechnik, 74 (2009) 1-2 pp. 22-27	FZK / T. Schulenberg, J. Starflinger, AREVA / D. Bittermann	Scientific Community	
May 3-7, 2009	Saratoga Springs, USA	*Internat. Conf. on Advances in Mathematics, Computational Methods, and Reactor Physics*		Scientific Community	
		Coupled ERANOS/TRACE system for HPLWR 3 pass core analysis.	FZK / L. Monti, T. Schulenberg		
		Assessment of ERANOS for HPLWR core analyses.	FZK / L. Monti, F. Gabrielli, W. Maschek, T. Schulenberg,		
May 12-14, 2009	Dresden, Germany	Jahrestagung Kerntechnik 2009: Preliminary 3D burn-up analysis of the HPLWR core.	FZK / L. Monti; F. Garbielli, T. Schulenberg	Scientific Community, Stakeholders, Public	1400 participants in total, about 30 in session
May 10-14, 2009	Tokio, Japan	*ICAPP09*		Scientific Community	
		Results of the Mid-Term Assessment of the High Performance Light Water Reactor Phase 2 Project	FZK / T. Schulenberg, J. Starflinger CEA / Ph. Marsault, AVERA / D. Bittermann, AEKI / C. Maraczy,		About 20 participants. Visit of University of Tokio and supercritical water test facilities at Tokai Mura, Japan. Talk wit Prof. Oka and Ishiwatari.

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			USTUTT / E. Laurien NRG / J.A. Lycklama KTH / H. Anglart, PSI / M. Andreani UJV / M. Ruzickova VTT / A. Toivonen		The Japanese colleagues will finish their project in March 2010. A request of assessing the results has been announced.
		Design Concept of the HPLWR Moderator Flow Path	FZK / C. Koehly, T. Schulenberg, J. Starflinger		
		Assessment of Heat Transfer Correlations for Supercritical Water in the Frame of Best-Estimate Code Validation	FZK / V. Jaeger, Victor H. Sánchez Espinoza		
		Calculation of xenon-oscillations in the HPLWR	BME / T. Reiss, S. Fehér, Sz. Czifrus		
April 20-24, 2009	Hannover, Germany	HPLWR model on KIT booth at the Hannover industry fair	FZK / T. Schulenberg, J. Starflinger	Public	The HPLWR is visible as part of the research activities in energy at the KIT main booth
May 31 – June 3, 2009	Calgary, Canada	Annual Meeting of the Canadian Nuclear Society : "RECENT RESULTS OF RESEARCH ON SUPERCRITICAL WATER-COOLED RECATORS IN EUROPE"	FZK / J. Starflinger, C. Koehly, T. Schulenberg AEKI / C. Maraczy, VTT / A. Toivonen, S. Penttilä, NRG / L. Chandra, J.A. Lycklama a Nijeholt	Scientific Community	12 participants in the lecture. The Canadian colleagues proposed to establish a Canadian / EU university exchange program.
June 4, 2009	Chalk River, Canada	Invited Lecture at Atomic Energy Canada Limited	FZK / J. Starflinger	Employees of AECL	60 participants of AECL. Very interested in European research activities on SCWR. Talks with AECL employees about transatlantic contacts
June 4, 2009	Budapest, Hungary	Notice on Supercritical Water Cooled Reactors	KFKI / C. Maraczy	Public	Figyelő (weekly), Issue 23 (in Hungarian)
June 8, 2009	Hamilton, Canada	Invited Student Lecture at McMaster University / Canadian Nuclear	FZK / J. Starflinger	Students at McMaster	25 students. Contacts between universities are expected

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		Society Seminar			
June 12, 2009	Bologna, Italy	Invited Lecture "Development of a coupled ERANOS/TRACE system for HPLWR 3 pass core analyses	FZK / L. Monti	Students at Bologna University	
June 22-24, 2009	Prag, Czech Republic	"European Supercritical Water Cooled Reactor" FISA 2009	FZK / T. Schulenberg, J. Starflinger CEA / Ph. Marsault, AVERA / D. Bittermann, AEKI / C. Maraczy, USTUTT / E. Laurien NRG / J.A. Lycklama KTH / H. Anglart, PSI / M. Andreani UJV / M. Ruzickova VTT / L. Heikinheimo	European Scientists	
		Poster about the HPLWR	FZK / T. Schulenberg, J. Starflinger		
July 9-10, 2009	KTH, Stockholm	Flow and Heat Transfer Simulation of a Wire-Wrapped Fuel Pin inside a Vertical Square Channel	USTUTT/ Y. Zhu, E. Laurien	European and some American Scientists	30 participants approximately half from KTH.
	KTH, Stockholm	Contribution to KTH-Workshop: "Numerical Simulation on a HPLWR Fuel Assembly Flow with One Revolution of Wrapped Wire Spacers"	BME \ A. Kiss, A. Aszódi USTUTT \ E. Laurien, Y. Zhu		
July 14, 2009	Karlsruhe, Germany	HPLWR Poster at the Student information day at Univ. of Karlsruhe	FZK / T. Schulenberg	Students	About 100 flyers regarding nuclear engineering were distributed
July 14, 2009	Karlsruhe, Germany	FZK-Seminar on HPLWR	FZK / J. Starflinger	FZK staff	About 40 participants
August 9-14, 2009	Espoo, Finland,	"Thermal Hydraulic Transient Analysis of the High Performance Light Water Reactor Using APROS and SMABRE" 20th International	VTT / J. Kurki, M. Seppälä	Scientific Community	

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		Conference on Structural Mechanics in Reactor Technology (SMiRT 20)			
Year 4					
Sept. 6-10, 2009	Paris, France	Global 2009		Scientific Community	
		"Reheater Design Concept for the High Performance Light Water Reactor"	EnbW/ H. Herbell, FZK / T. Schulenberg		
		"Plant Control of the High Performance Light Water Reactor"	FZK / M. Schlagenhaufer, J. Starflinger, T. Schulenberg		
Sept. 9-10, 2009	Paris, France	GIF- Symposium "Advanced Supercritical Water and Molten Salt Reactors"	EU / R. Schenkel FZK / T. Schulenberg CEA / C. Renault EU / D. Haas	Scientific Community	
		" Status of Ongoing Research on SCWR Thermal-Hydraulics and Safety"	Y.Y.Bae, L. Leung NRG / J.A. Lycklama FZK / T. Schulenberg, J. Starflinger, PSI /M. Andreani Y. Ishiwatari, Y. Oka, H. Mori, K. Ezato		
Sept 27 – Oct. 2, 2009	Kanazawa, Japan	The 13th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-13)		Scientific Community	
		"Design and Analysis of a Thermal Core for a HPLWR a State of the Art Review"	KIT / T. Schulenberg, KFKI / C. Maraczy AREVA / J. Heinecke USTUTT / W. Bernnart		
		"Mixing of Cooling Water at Supercritical Pressures in the HPLWR –Three Pass Core"	KIT / A. Wank, T. Schulenberg USTUTT / E. Laurien		
		"Preliminary Sub-Channel Wise Analyses of the HPLWR 3 Pass	KIT / T. Schulenberg, L.		

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		Core”	Monti		
		“CFD Analyses on the Influence of Wire Wrap on the Heat Transport in Supercritical Fluid”	NRG / L. Chandra, J.A. Lycklama à Nijeholt, D.C. Visser, F. Roelofs		
Oct. 15-16, 2009	Nyköping, Sweden	Gen IV Seminar	KIT / J. Starflinger	Members of the NOMAGE community	About 40 participants especially from industry. Industry shall be involved in GEN IV developments
Oct. 20, 2009	Rochehaut s/Semois / Belgium	MATRE-I School	KIT / J. Starflinger	Students at MATRE-School	About 50 students
Dec. 3-4., 2009.	Budapest, Hungary	8th Symposium on Nuclear Technology Presentation: “Equilibrium Core Design of the HPLWR Supercritical Pressure Reactor” (in Hungarian)	KFKI / E. Temesvári, Gy. Hegyi, Cs. Maráczy	Members of the Hungarian Nuclear Energy Society	45 participants from Hungarian research institutes, universities and the Paks NPP
Feb. 28, 2010	End of the Project				