



# Summary of 6th International Topical Meeting on High Temperature Reactor Technology HTR2012



The High Temperature Engineering Test Reactor (HTTR) at Oarai



**6th International Topical Meeting on  
High Temperature Reactor Technology  
HTR2012**

**-Nuclear for the future-**

**October 28 – November 1, 2012**

**Venue: Miraikan**

**Tokyo, Japan**

**Organized by:**

Japan Atomic Energy Agency (JAEA)

**Co-organized by:**

Atomic Energy Society of Japan (AESJ)

The Society of Chemical Engineers, Japan (SCEJ)

Division of Energy Engineering

The Japan Society of Mechanical Engineers (JSME)

Power and Energy System Division

Atomic Energy Society of Japan (AESJ)

Computational Science and Engineering Division

**Supported by:**

Japan Atomic Energy Commission

Ministry of Education, Culture, Sports, Science and Technology (MEXT)

Ministry of Economy, Trade and Industry (METI)

This series of meetings is the only international forum focused on high-temperature gas-cooled reactor (HTGR) including heat application technology. Inaugurated in 2002 by the European High Temperature Reactor Technology Network HTR-TN at Patten, the Netherlands, successive meetings were held in Asia (Beijing, China, 2004), Africa (Mmabatho, South Africa, 2006), North America (Washington DC, USA, 2008), and Europe (Prague, Czech Republic, 2010). The attendees included experts from research and industry and decision makers of interest including utilities, user industries, nuclear vendors and governments.

The 6th International Topical Meeting on High Temperature Reactor Technology, HTR2012, aims to accelerate research and development on HTGR and heat application technologies, and make practical use of HTGR systems, through discussing and exchanging latest results and information on above technologies and user requests as well as future perspectives and plans.

### **HTR2012 Local Organizing Committee**

<b>Chair</b>	Hiroshi UETSUKA	Japan Atomic Energy Agency
<b>Co-chair</b>	Masuro OGAWA	Japan Atomic Energy Agency
<b>Members</b>	Yoshiaki OKA	Waseda University
	Yasumasa FUJII	The University of Tokyo
	Kazuaki MATSUI	The Institute of Applied Energy
	Akira INOUE	Hitachi-GE Nuclear Energy, Ltd.
	Hiroyuki OTA	Toshiba Corporation
	Futoshi OKAMOTO	Fuji Electric Co., Ltd.
	Yuji KIDO	Marubeni Utility Services, Ltd.
	Shuichi KUBO	IBIDEN Co.,Ltd.
	Takashi KONISHI	Toyo Tanso Co.,Ltd.
	Akira KONDO	Tokai Carbon Co.,Ltd.
	Noboru FURIHATA	Nuclear Fuel Industries, Ltd.
	Yoshiharu MATSUOKA	Iwatani Corporation
	Nobuaki MIURA	Shimizu Corporation
	Yukitaka MITARAI	Nippon Steel & Sumikin Chemical Co., Ltd.
	Isao MINATSUKI	Mitsubishi Heavy Industries, Ltd.
	Seiichiro YAMAZAKI	Kawasaki Heavy Industries, Ltd.
	Kazuhiko YAMAMOTO	The Japan Atomic Power Company
Ryutaro HINO	Japan Atomic Energy Agency	
Kazuhiko KUNITOMI	Japan Atomic Energy Agency	
<b>Assistant Co-chair</b>	Yoshiyuki INAGAKI	Japan Atomic Energy Agency
	Nariaki SAKABA	Japan Atomic Energy Agency

## HTR2012 Technical Program Committee

<b>Chair</b>	Yasumasa FUJII	The University of Tokyo
<b>Co-chair</b>	Kazuhiko KUNITOMI	Japan Atomic Energy Agency
	Yukitaka KATO	Tokyo Institute of Technology
	Tetsuaki TAKEDA	University of Yamanashi
	Akira INOUE	Hitachi-GE Nuclear Energy, Ltd.
	Tomomi OTANI	Mitsubishi Heavy Industries, Ltd.
	Kazutaka OHASHI	Fuji Electric Co., Ltd.
	Jun OHASHI	IBIDEN Co.,Ltd.
	Ryoma KATO	Toshiba Corporation
<b>Members</b>	Yuji KIDO	Marubeni Utility Services, Ltd.
	Akira KONDO	Tokai Carbon Co.,Ltd.
	Masanao SAITO	Shimizu Corporation
	Noboru FURIHATA	Nuclear Fuel Industries, Ltd.
	Isao MAEKAWA	Kawasaki Heavy Industries, Ltd.
	Yoshiharu MATSUOKA	Iwatani Corporation
	Fumito MORIKAWA	Nippon Techno-carbon Co., Ltd.
	Masatoshi YAMAJI	Toyo Tanso Co.,Ltd.
	Kazuhiko YAMAMOTO	The Japan Atomic Power Company
<b>Assistant Co-chair</b>	Shigeaki NAKAGAWA	Japan Atomic Energy Agency

## HTR2012 International Organizing Committee

<b>Chair</b>	Hiroshi UETSUKA	Japan Atomic Energy Agency
<b>Co-chair</b>	Michael A. FUTTERER	European Commission, Joint Research Centre
	Yuliang SUN	Institute of Nuclear and New Energy Technology
	Josef KRALOVEC	Nuclear Research Institute Rez plc
	Takis MANOLATOS	European Commission
<b>Members</b>	Franck CARRE	Commissariat a l'Energie Atomique
	Antonio HURTADO	Technische Universitat Dresden
	Ludwik PIENKOWSKI	AGH University of Science and Technology
	Masuro OGAWA	Japan Atomic Energy Agency
	Ryutaro HINO	Japan Atomic Energy Agency
	Yasumasa FUJII	The University of Tokyo

Tetsuaki TAKEDA	University of Yamanashi
Afaque SHAMS	Nuclear Research and Consultancy Group
Jan-Leen KLOOSTERMAN	Delft University of Technology
N. G. KODOCHIGOV	Afrikantov Experimental Machine Building Design Bureau
Frederik REITSMA	PBMR
Jonghwa CHANG	Korea Atomic Energy Research Institute
Tim ABRAM	The University of Manchester
Layla SANDELL	Westinghouse Electric Company LLC
Finis SOUTHWORTH	AREVA
Dominique HITTNER	AREVA
Trevor COOK	United States Department of Energy
Yassin HASSAN	Texas A&M University
Bismark TYOBEKA	International Atomic Energy Agency

**SCHEDULE AT A GLANCE**

SCHEDULE AT A GLANCE							
	Monday October 29, 2012			Tuesday October 30, 2012			
	9:30-12:20	13:20-16:15	16:30-17:55	9:10-11:00	11:10-12:00	13:20-16:05	
MIRAICAN Hall	Opening Ceremony Keynote Speech Plenary Session 1	Trk1-National Research Programs and Industrial Projects (Track Outline by Track Chair) (6 Papers)	Trk7-Engineering, Experiments, Design and Economics (Track Outline by Track Chair) (3 Papers)	Plenary Session 2	Trk7-Engineering, Experiments, Design and Economics (2 Papers)	Trk7-Engineering, Experiments, Design and Economics (4 Papers, Break, 2 Papers)	
		13:20-18:20			11:10-12:00	13:20-17:45	
Conference Room 1		Trk3-Fuel and Waste (Track Outline by Track Chair) (4 Papers, Break, 6 Papers)			Trk3-Fuel and Waste (2 Papers)	Trk3-Fuel and Waste (5 Papers, Break, 5 Papers)	
		13:20-18:20			11:10-12:00	13:20-15:50	16:05- 17:55
Conference Room 2		Trk5-Nuclear Physics Analysis (Track Outline by Track Chair) (5 Papers, Break, 6 Papers)			Trk5-Nuclear Physics Analysis (2 Papers)	Trk5-Nuclear Physics Analysis (6 Papers)	Trk4-Materials and Components (Track Outline by Track Chair) (4 Papers)
		13:20-17:55			11:10-12:00	13:20-15:25	15:40-17:05
Innovation Hall		Trk6-Thermal-hydraulics and Coupled Code Analyses (Track Outline by Track Chair) (5 Papers, Break, 5 Papers)			Trk6-Thermal-hydraulics and Coupled Code Analyses (2 Papers)	Trk6-Thermal-hydraulics and Coupled Code Analyses (5 Papers)	Trk2-Process Heat Applications (Track Outline by Track Chair) (3 Papers)
	Wednesday October 31, 2012			Thursday November 1, 2012			
	9:10-12:00	13:20-15:35	16:30-18:00	9:00-10:40	11:15-11:45	14:00-16:45	
MIRAICAN Hall	Plenary Session 3	Trk8-Safety and Licensing (Track Outline by Track Chair) (5 Papers)	Panel Session - Regulation -	Trk8-Safety and Licensing (4 Papers)	Closing Ceremony		Public Forum (in Japanese)
		13:20-16:15		9:00-11:05			
Conference Room 1		Trk3-Fuel and Waste (7 Papers)		Trk3-Fuel and Waste (5 Papers)			
		13:20-15:25		9:00-11:05			
Conference Room 2		Trk4-Materials and Components (5 Papers)		Trk4-Materials and Components (5 Papers)			
		13:20-15:25		9:00-11:05			
Innovation Hall		Trk2-Process Heat Applications (5 Papers)		Trk2-Process Heat Applications (5 Papers)			

## Address by Local Organizing Committee

Dear HTR2012 Participants,

HTR, the International Topical Meeting on High Temperature Reactor Technology, has been held every two years since the first meeting in Petten, the Netherlands in 2002. It is the only international meeting series dedicated to the High Temperature Gas-cooled Reactor (HTGR). This meeting is the 6th one in the meeting series and the first one held in Japan.



HTGR holds promise for a high level of safety and a variety of effective non-electricity nuclear heat applications, for example, process steam supply, hydrogen production, desalination of seawater and so on. Thus, recently, HTGR is recognized worldwide as a reactor of safe and multipurpose nuclear energy.

However, the severe accident at Fukushima Daiichi nuclear power station brought on by the Great East Japan Earthquake on March 11, 2011 has seriously damaged the public confidence in nuclear power generation in Japan and negatively affected the use of nuclear energy in the rest of the world. Although the relevant organizations and persons in Japan accepted this situation with sincerity, and they are making efforts to restore the public's trust on use of nuclear energy, the pros and cons of nuclear energy use are being fundamentally questioned.

It is against this backdrop that holding the HTR2012 in Japan is of particular significance. This meeting includes about 120 presentations on HTGR development plans in various countries and in eight research fields, such as nuclear heat application, reactor physics, thermal hydraulics, nuclear fuel and waste, material and components. I am sure that the outcome of this meeting will contribute a great deal to the development of HTGR technologies in the world. At the same time, I strongly expect that the outcome will assist nationwide discussion to be made in our country on the use of nuclear energy from each and every point of view.

Finally on behalf of the Local Organizing Committee, I would like to give sincere acknowledgement for everyone concerned in Japan and overseas who has made much effort to hold this meeting.

A handwritten signature in black ink, consisting of stylized Japanese characters, located below the text of the speech.

Hiroshi UETSUKA

Chair of HTR2012 Local Organizing Committee  
Executive Director, Japan Atomic Energy Agency

## Address by Organizer

Dear HTR2012 Participants,

On behalf of the organizing body, JAEA, let me take the opportunity to give a few words, opening the conference.

First of all, JAEA is greatly honored to host this international conference to get together the world leading figures on High Temperature Gas-cooled Reactor. I would like to express sincere appreciations for all the participants, in particular those who have spent a lot of time to come.



The immense tsunami following the extraordinarily massive earthquake taking place in the north-east part of Japan's main island on March 11th, 2011 becomes an unprecedented event we will never forget. Serious difficulty in the disaster-stricken area still remains, more than one and a half years after the earthquake, and to our deepest regret, the huge inundation led to the severe accident in the Fukushima Daiichi nuclear power station, which should never happen.

The government has been fully committed with the recovery from the accident: environmental restoration with decontamination of off-site vast areas, safe management and dismantlement of the Fukushima nuclear facilities, and so on.

As a national body, JAEA has been requested to assist the government's commitments since the accident: environmental radiation monitoring, environmental radioactivity measurements and decontamination, and research and development of technologies required for dismantlement, and so on.

Needless to say, the Fukushima Daiichi accident reminds us of the vital importance of nuclear safety, and JAEA has more responsibility than ever before, to lead advanced safety research and development for future. I consider the inherent safety of a future reactor to be a key item of study in the medium to long term, in addition to studies on enhancing safety performance and improvement of engineered safety measures for severe accident in current generation reactors.

As you are aware, High Temperature Gas-cooled Reactor, HTGR, has excellent features on inherent safety. In case of severe accident, HTGR can be shut down inherently and cooled down passively using natural heat radiation while retaining fission products within coated fuel particles even without intervention of active protection system or plant operators.

Such inherent safety performance has been actually demonstrated as an OECD/NEA program. To be specific, a reactor experiment for station blackout involving loss of coolant flow without scram was successfully implemented at JAEA's engineering test reactor HTTR. I believe HTGR is one of the most promising technical solutions to assuring inherent safety of nuclear power production system.

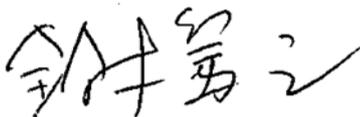
Sometimes, the fact that human beings have got possession of nuclear technology is perceived as the phrase “open Pandora’s box,” which means performance of an action that may appear innocuous though turning out to have severe and far-reaching consequences.

As is well-known, the Greek myth says that impelled by her curiosity, Pandora opened the box, and all evil contained therein escaped and spread over the earth. From this, people may simply think that human beings are not allowed to open the Pandora box. In other words, human beings should not use technologies that potentially bring about such severe and far-reaching consequences.

Those who consider technologies in such a pessimistic way, however, are missing the kernel of the myth, which was hidden at the bottom of the box, because, following the previous description, the mythical story mentions that Pandora hurried to close the container, but the whole contents had got away, except for one thing that lay at the bottom, which was the Sprit of Hope. My personal understanding is that, thanks to the existence of this sprit, Pandora was not punished by Zeus.

What we should do in the aftermath of the Fukushima Daiichi accident is to figure out this Sprit of Hope, and my hope is that the inherent safety nature of HTGR, for instance, is closely related to this sprit. What I want to address with greatest emphasis at this particular occasion is that we JAEA will do all we can with this Sprit of Hope.

Finally, I do hope the conference would be truly productive and constructive for all the participants.

A handwritten signature in black ink, consisting of stylized Japanese characters and a checkmark-like flourish at the end.

Atsuyuki SUZUKI  
Organizer of HTR2012  
President, Japan Atomic Energy Agency

## Address by International Organizing Committee

Dear HTR 2012 Participants,

For the sixth time, this bi-annual conference wants to give you the opportunity to exchange fresh research results with your colleagues from many countries, to update your networks face-to-face and to debate about what the future could look like for HTR technology, for nuclear energy in general and, consequently, also for you, personally.



I bow in front of the local organizers who have prepared this meeting under very difficult circumstances. In the name of the International Organizing Committee, I sincerely thank them for maintaining their engagement to host this conference in Japan despite the tremendous changes affecting nuclear energy here.

We are meeting this time in a very special country and in a very special context. Japan has endured many natural catastrophes in its history, and is taking now severe measures to overcome a nuclear accident. The people's confidence in nuclear technology is shaken and not easily re-gained. Time alone will not heal their wounds.

This period of reflection and transition in Japan and several other places in the world is also an invitation to you for action. It is both an opportunity and a responsibility for you as the top experts in HTR technology to make clear where you stand and to make it known to decision makers and to the public. With a much-reduced public tolerance for nuclear risks in mind, could HTR technology possibly be part of the answer of what a much safer future of nuclear energy could look like? What is your position? Can you make this happen?



Michael A. FÜTTERER

Co-chair of HTR International Organizing Committee

Project Manager, European Commission, Joint Research Centre

## Sessions

### **KEYNOTE SPEECH:** Some Thought on the Nuclear Energy After March 11, 2011 **Shunsuke KONDO** Chairman, Japan Atomic Energy Commission

Presentation materials:

<http://www.aec.go.jp/jicst/NC/kaigai/A%20Thought%20on%20the%20Nuclear%20Energy%20After%20March%202011.pdf>

### **PLENARY SESSION 1:** Expectation to HTGR

**Chair: Kazuaki MATSUI, Executive Director, The Institute of Applied Energy**  
*Nuclear Safety and Utilization*

**Koji OKAMOTO** Professor, The University of Tokyo

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*Nuclear Energy Policy in Kazakhstan*

**Shaiakhmet SHIGANAKOV** Department Head, Atomic Energy Agency of the Republic of Kazakhstan

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*The Atomic Energy Contribution to the Sustainable Energy Mix for Saudi Arabia*

**Muhammad Ahmed GARWAN** Chairman, Nuclear Team at King Abdullah City for Atomic and Renewable Energy (K.A.CARE)

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*Next Generation Nuclear Plant (NGNP) Project in USA*

**John MAHONEY** Secretary-Treasurer, NGNP Industry Alliance Ltd.

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### **PLENARY SESSION 2:** Present Status of HTGR Project

**Chair: Yasumasa FUJII, Professor, The University of Tokyo**  
*HTGR Projects in the World –What can we contribute? –*

*Japan:*

**Kazuhiko KUNITOMI** Supreme Researcher, Nuclear Hydrogen & Heat Application Research Center, Japan Atomic Energy Agency

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*USA:*

**David PETTI** Director, Very High Temperature Technology Development Office, Idaho National Laboratory

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*China:*

**Zuoyi ZHANG** Director, Institute of Nuclear and New Energy Technology, Tsinghua University

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*Republic of Korea:*

**Yong Wan KIM** Director, Nuclear Hydrogen Reactor Technology Development Division, Korea Atomic Energy Research Institute

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### PLENARY SESSION 3: Towards Commercialization

**Chair: Kazuhiko YAMAMOTO, Senior Staff, Research & Development Department,  
The Japan Atomic Power Company**

*Expectations and Approaches of Various Users and Vendors*

*Multi-purpose User:*

**Faisal Bin Turki AL-FAISAL**

HRH, President, Global Strategic Studies  
Institute, Kingdom of Saudi Arabia

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*Hydrogen User (Iron and Steel Making):*

**Yoon-Ho CHOI**

Manager, Nuclear Business Group, POSCO,  
Republic of Korea

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*Hydrogen User (Automobile):*

**Akihiro IYAMA**

Expert Leader, EV System Laboratory, Nissan  
Research Center, Nissan Motor Co., Ltd., Japan

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*Nuclear Reactor Vendors:*

**Kenichi KUBOTA**

Senior Fellow, Nuclear Energy Systems &  
Services Division, Toshiba Corporation Power  
Systems Co., Japan

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**Makoto TOYAMA**

Deputy Head of Nuclear Systems, Mitsubishi  
Heavy Industries, Ltd., Japan

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*Chemical Plant Vendor:*

**Yoshimi OKADA**

Principal Researcher, R&D Center, CHIYODA  
Corporation, Japan

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### PANEL SESSION: Safety Standards for Commercial HTGRs

**Chair: Matt RICHARDS, Manager, Ultra Safe Nuclear**

*Japan:*

**Kazuhiko KUNITOMI**

Supreme Researcher, Nuclear Hydrogen & Heat  
Application Research Center, Japan Atomic Energy  
Agency

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*USA:*

**Arkal SHENOY**

Former Director, Fission Programs, General Atomics

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*China:*

**Fu LI**

Deputy Chief Engineer, Institute of Nuclear and New  
Energy Technology, Tsinghua University

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*Republic of Korea:*

**Won Jae LEE**

PM, VHTR (NuH2) System Concept, Korea Atomic  
Energy Research Institute

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## **TECHNICAL TRACKS**

### **Trk1: National Research Programs and Industrial Projects**

**<Track leader: Kazuhiko KUNITOMI, JAEA>**

Status of national R&D programs and industrial programs including specific program and project development, plant and equipment development and construction, operating experience, and test facilities and results.

### **Trk2: Process Heat Applications**

**<Track leader: Yukitaka KATO, Tokyo Institute of Technology>**

Various HTR heat applications such as hydrogen production, petrochemical and chemical processes, seawater desalination etc., including design, engineering, and test of process equipment and systems, economic assessment of HTR process applications and issues as well as analytical methodology.

### **Trk3: Fuel and Waste**

**<Track leader: Kazuhiro SAWA, JAEA>**

Design, manufacture, quality control, irradiation testing, post-irradiation examinations, safety testing and qualification steps, on various types of fuel, and waste management.

### **Trk4: Materials and Components**

**<Track leader: Yoshiyuki INAGAKI, JAEA>**

Metallic and non-metallic materials, corrosion at high temperature, effect of irradiation, and issues associated with the design of important components (mainly IHX, circulators, hot gas ducts, steam generator, etc.).

### **Trk5: Nuclear Physics Analysis**

**<Track leader: Nozomu FUJIMOTO, JAEA>**

Neutronics benchmarking and analyses, new developments in the field of calculation methods (reactor physics, transient analysis, fuel burn-up, control rod modeling, shielding, etc.), computer codes, and fuel/core designs (pebble fuel design, prismatic fuel design, control rod design, core layout, coolants, etc.).

### **Trk6: Thermal-hydraulics and Coupled Code Analyses**

**<Track leader: Tetsuaki TAKEDA, University of Yamanashi>**

Thermal-hydraulic benchmarking and analyses, structural integrity and thermal-hydraulics coupled analyses, new developments in the field of calculation methods, and computer codes.

### **Trk7: Engineering, Experiments, Design and Economics**

**<Track leader: Xing Long YAN, JAEA>**

Engineering approaches and solutions for HTRs, physical testing and characterization of components and systems, new HTR design concepts and updates to existing HTR design concepts, economic assessments and analysis methodology, etc.

### **Trk8: Safety and Licensing**

**<Track leader: Kazutaka OHASHI, Fuji Electric Co., Ltd.>**

Safety design and analyses, advanced safety concepts and framework proposals, licensing strategies, and licensing application and development status, etc.

## EXHIBITION

The conference comprises a number of exhibition stands in the Conference room 3. The exhibits are open during conference hours.

### Exhibition Booths

Fuji Electric Co., Ltd.  
Japan Atomic Energy Agency  
Mitsubishi Heavy Industries, Ltd.  
Toshiba Corporation  
Toyo Tanso Co., Ltd.

### Catalog Booths

Engineering Advancement Association of Japan  
Hitachi-GE Nuclear Energy, Ltd.  
Nippon Techno-Carbon Co., Ltd.  
Sanwakoki Co., Ltd.  
Tokai Carbon Co., Ltd.

## WELCOME RECEPTION

The welcome reception takes place in Restaurant at Miraikan on Sunday, October 28 from 18:00 - 20:00. Participants must carry their badges.

## BANQUET

The conference banquet takes place in the Hotel Nikko Tokyo on Monday, October 29 from 19:00 – 20:30.

## TECHNICAL TOUR

- **Date:** Friday, November 2, 2012
- **Time:** 13:00 - 16:30
- **Registration deadline:** September 13, 2012
- **Participation fee:** Free
- **Visit facilities:**
  - 1) The High Temperature Engineering Test Reactor (HTTR)
  - 2) Experimental facility of thermochemical hydrogen production IS (Iodine-Sulfur) process

The HTTR of 30MW thermal power is operated at the Oarai Research and Development Center of Japan Atomic Energy Agency, which is the only high-temperature gas-cooled reactor in Japan. Also, the thermochemical hydrogen production IS process is being developed. For more information, please visit the following web sites.

<http://htr.jaea.go.jp/eng/index.html>

<http://www.jaea.go.jp/04/o-arai/nhc/index.html>

### Declaration of HTR2012

- Tests at the AVR, HTR-10 and recently on the HTTR have demonstrated that HTGR continues to stand out as an exceptionally safe and reliable nuclear energy technology. The HTTR will be employed for even more extensive safety testing soon, which will be useful for strengthening worldwide public confidence and acceptance.
- HTGR proven up to 950°C coolant outlet promises to be highly efficient and adaptable to both electrical and industrial applications including hydrogen production. Its practical uses can lead to reduction in CO<sub>2</sub> emission from industry.
- There is confirmed demand for nuclear process heat applications ranging from steam to hydrogen with very high market potential.
- HTGR can help cope with problems related to population growth, industrial development and the resulting CO<sub>2</sub> emissions and finite fossil fuel resources.
- HTGR is close to commercial deployment, and should be recognized for its value by industry, policy makers, users and investors.
- Excellent research and development progress has been made since the last meeting held in Prague in 2010. Completing research and development as well as licensing efforts through private and public cooperation is needed to realize HTGR deployment in the near future.

# Miraikan

## The National Museum of Emerging Science and Innovation (Miraikan)

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URL: <http://www.miraikan.jst.go.jp/en/>



## Access Map



# Venue Floor Map

