Experience of HTTR licensing for Japan's New Nuclear Regulation
Dr. Etsuo Ishitsuka, JAEA, Japan

Berta Oates
Welcome everyone to our Next GEN-IV international forum webinar presentation. Today's presentation 'Experience of HTTR Licensing for Japan's New Nuclear Regulation' will be presented by Dr. Etsuo Ishitsuka. But first let's do some housekeeping, we'd like to do start things off.

Doing today's introduction is Dr. Patricia Paviet. Dr. Paviet is the group leader of the Radiological Materials Group at Pacific Northwest National Laboratory. She is also the current chair of the Gen-IV International Forum Education and Training Working Group. Patricia.

Patricia Paviet
Thank you so much, Berta. Good morning everyone. It's a pleasure to be here today and to welcome Dr. Etsuo Ishitsuka, who is the general manager of the HTTR Reactor Engineering Section at the Department of the High Temperature Engineering Test Reactor project in JAEA. He earned his doctorate of engineering from the University of Tokyo in 1999. He started his research career at the Japan Atomic Energy Research Institute in 1986 as a research engineer for the Japan Materials Testing Reactor project. He worked in a wide field of neutron irradiation technology development such as production of medical radioisotopes, fusion blanket materials, plasma facing components and plasma diagnostic components. He was promoted to senior research engineer in 1994 and managed the experiments of a fusion blanket functional test in JMTR and the ITER project as a deputy general manager.

After managing an international cooperation and training of foreign young researchers, he joined HTTR project in 2015 as a general manager. His current interest is in neutron irradiation technology of HTTR and its new applications. So without any delay, I give you the floor, Dr. Ishitsuka. Thank you so much again for volunteering, and we are very happy to have you today.

Etsuo Ishitsuka
Thank you, Patricia-san, and welcome at this webinar, and welcome to my presentation.

I will be talking about – before my presentation I will shortly introduce about HTGR. HTGR is well-known like the small module reactor. Most important thing is very safety, and can supply stable power. Economic efficiency is heat utilization rate is more than 80%, electric generation efficiency using gas turbine is more than 50%, and also high burnup.

If we compare to the conventional LWR, it is more four times larger. That means spent fuel is also decreasing about four times. Such a property will be contributing to the reducing carbon dioxide emission in the future.

Lastly, the right side, the most important thing is the HTGR can produce hydrogen and electricity, both, and can be used as a heat, as a chemical plant or something. Most important thing, the combination of the renewable energy like the solar system or something will be very good. This means if some cannot produce electricity from solar power system, HTGR can produce the electricity during night time or something. Also if solar system can produce enough electricity, HTGR can produce hydrogen and it can keep the energy [ph].

This feature is very unique and ideal. That means that please imagine the relationship of sun and potato. The light cannot use the nuclear energy directly. Potato can translate to the fusion energy, that means nuclear energy, can change to hydrogen energy and can accumulate and spread it in a potato. And that means [Unclear] is very good as a chemical energy. This means maybe in the future, I hope that translation of chemical energy, we can make some food like potato. Maybe such possibility I can see in the usage of hydrogen production system.

Let’s go to the next slide.

This is my presentation content. I’ll be talking about the outline of HTTR, maybe the most important thing that we must know about HTTR before my presentation. Next one is Japanese nuclear regulation, I will briefly introduce. Number 3 is the main part of my talking and adaptability to the new regulatory requirements.

And related to HTTR, if you can see this difference, maybe you can know more about HTTR. First one is the technology, you can easily download from website, and maybe free. Next one maybe you need some money. Maybe you can get such books from JSME.

Before my talking, I will just shortly introduce myself. My name is Ishitsuka Etsuo. Japanese name, Etsuo is given name. And then Japanese character, one character has each own meaning. Etsuo means pleasure, and ‘o’ means man. That means my name is pleasure man. I hope you can enjoy my presentation. It is my pleasure. And I hope you enjoy my presentation.

Right side, this is my talking of summary. For the license in 1990s, this is before the construction of HTTR, we could use similar safety logic of NPP because we don't have any experience of operation of HTTR. And then can be cleared by using similar logic. But nowadays, maybe all people know that all of Japanese nuclear regulation is increasing more higher level of hurdle because of last big disasters. But we already have operational experience, especially like safety demonstration test. We can use such experience and we can clear such higher hurdles. This is my content.

Next page.

Outline of HTTR.

HTTR is located in northern part of Tokyo, maybe around 150 kilometers to the north, and maybe another here is Fukushima maybe 200 kilometers south from Fukushima. Our research institute is a very beautiful location, near the coast of Pacific Sea. We have three major reactors. One is JMTR. This is a water cooled research reactor for material testing. This is an artificial lake, Natsumi lake. It is for cooling water to JMTR. Another one is the fast sodium-cooled reactor, Joyo here, and HTTR here. Joyo and HTTR is cooling, final heat sink is air and no need of water.

This is an old picture. Nowadays, I will let you know later – it is a surrounded fire-break zone. This is a request from government. Nowadays cut the surrounded trees and make something that looks like a road, we call fire protection road, fire break road or something. Nowadays, around near here is trees are cut, and this is a small cliff in here, and a very beautiful scenery now. If you have a chance to visit here, I recommend to see here.

Natsumi Lake, Natsumi is a good pronunciation, and I decided to name my younger daughter the same name. My younger daughter name is Natsumi. We are not talking about this one.

Anyway, going to the next one. This is a major specification of HTTR. HTTR's thermal power is 30 megawatt, average density is 2.5. This is a very low density if you compare to the LWR nuclear power plant and other research reactors. But this is one of the good features for safety. This is outlet temperature: maximum is 950 degrees centigrade, cool by AU and pressure is 4 megapascal. Moderator is graphite. Core is so big, if you compare to the research reactors. Height is 3 meters and diameter is 2.3 meters. Fuel used for low-enriched UO2. There are many kinds of enrichment through this percentage used for this because one to avoid hot spot. Our core is changing one time, I mean no replacement, no changing the position of the fuel. By using this enrichment, dispersion, and totally fuel burnup, and then we select the many kinds of enrichment fuel.

Fuel element is Prismatic block. For the pressure vessel, to use the chrome molybdenum steel. This is high temperature material for the steel. Containment vessels we have but usually thin if you compare the nuclear powerplant.

Go to the next one.

HTTR, first criticality is 1998. We got permission before two years. This is the first permission, I explained already. Our project started very long time ago, more than 15 years ago. After first criticality, we did several tests. We say safety demonstration set. In 2002, this control rod drawing test. And 2004, we got the highest temperature, maximum 950 degrees centigrade. This is record of the world in that time. In 2010, we operated the 50 days continuous operation. This is to prove enough reliability to operation. After that, we started the loss of forced cooling test; I'll explain later. This is also a kind of safety demonstration test. After finishing this safety-demonstration test, and after one month, Great East Japan earthquake came, and after that our reactor stopped. During this time, we tried to get approval. Finally, we got permission on 3rd June of last year.

This is the overview of the HTTR project. Now we are waiting for restart. We already got the permission. Our target of facility is this one. We want to try to connect the helium gas production and gas turbine power generation system to connect to our reactor and want to demonstrate generation of helium gas from the electric power by gas turbine. This is an elementary study and development is already carried out. This turbine part is almost finished, and nowadays hydrogen production or development is ongoing.

This is just a view of HTTR developed by only Japanese technology. For example, the design or construction was done by the major big company of atomic energy area: Mitsubishi, Toshiba, Hitachi, Fuji, or something. They have lot of technical data already accumulated to build the next commercial reactor. For the fuel, this is also ceramic coated fuel [Unclear] generally speaking. This high quality fuel is also produced in Japanese company. This is high temperature resistant material. This is also developed by Mitsubishi material. Hastelloy X is usually used. The content is a little bit changed and newly developed Hastelloy XR is used, XR meaning reactor grade. Another one is graphite. Toyo Tanso can produce high quality and reactor grade graphite. This has a very good high strength and high thermal conductivity and high irradiation resistance. Anyway all these technologies are developed the domestic technology, by Japanese company.

This is view of reactor building. Core is here, surrounded by reactor pressure vessel. Reactor pressure vessel is covered by containment vessel. This is water-cooled heat exchanger here. And also, we have intermediate heat exchanger. This means water-cooled heat exchanger means primary coolant of helium is cooled by pressurized water. The intermediate heat exchanger, meaning primary helium coolant is cooled by secondary helium. Finally, we want to take off the secondary high temperature helium to generate the hydrogen and the turbine system. This is heated helium by core. The heat moves to the pressurized water, and then that heated water comes to the top of the building and then cooled by the air cooler. Maybe you can imagine a car radiator, it is a similar system. Now, secondary helium is also cooled by secondary pressurized water cooler, because now it is not connected to such a hydrogen production system or this turbine system, and nowadays cooled by just water. This water is also cooled by this radiator system.

Go to next one.

This is a core component of HTTR. This core is 150 fuel assembly is located here. One layer is 30 and there are total 5 layers, so total 150. This is the double tube. Cooled helium comes to the outside of tube like this. And helium goes up to down and cooled by cooler. The heated helium comes to the inside of double tube. I'll explain later, for the design based accident, most severe case is this double pipe breaks, this is the most severe case. Please remember this one, I'll explain later, related to the beyond design based accident.

This fuel is including the fuel compact, and the fuel compact includes another 20,000 fuel particle in the inside tube. This fuel pink [ph] contains 14 fuel compact in here. Ceramic coated fuel is very good for higher temperature resistance. Until 1600, fission products do not release. In case of graphite, it can also stand for higher temperature, around 2500 degrees centigrade. This tube part gives good safety future to the HTTR.

Go to the next one.

This is reactor shutdown system. White one is fuel block, the 30 fuel blocks in here. This one is control guide block, total 16 blocks in a core. Each block has two holes for the control blocks. Control of neutral absorber is B4C cylinders absorbed by boron [ph] and each control block has two absorber systems. That means total 32 neutron absorbers are inserted as controller.

Also, we have another reserved shutdown system. This is in case of trouble of control rod, B4C pellets is loaded to the path [ph] site. In case of trouble of control, the plan is go up by using a motor, and this pellet goes down into the reactor. This white part is such a space, in case of emergency. This is also important, and please remember the reserve shutdown system. We have two shutdown systems in plan reserve.

This core is surrounded by a kind of belt and fixed to the position. Even in a big earthquake did not break this belt, and that means it supports strongly the core component inside of the reactor vessel.

Go to next one.

This is the cooling system. Primary cooling system is the yellow part here. Primary cooling system is cooled by water heat exchanger and also intermediate heat exchanger. Intermediate heat exchanger 10 megawatt can be removed. Only 10 megawatt is used for hydrogen production system or gas turbine system, and can operate in parallel with heat exchanger.

Another one we have in case of abnormal condition, and after reactor shutdown to remove the decay heat. We have auxiliary cooling system here. This is 3.5 megawatt. This means it can cool slowly, because if cooling speed is high, maybe we worry about the crack inside the core material, and then cooled slowly. The capacity is decided by this one. This anyway is abnormal condition and after reactor shutdown.

Another one, we have another abnormal condition for the cooling system, we say the vessel cooling system. This is like a panel outside. This is the reactor vessel and cooled by this panel. This panel is cooled by water by cooling tube. This role is cooling. But in case of trouble of both systems, can remove the heat by only this one is possible. For example, the natural convention in this [Unclear] of concrete and reactor vessel, and then radiation such as natural convection and heat removed to this panel. This one, also we have another abnormal cooling system.

This is another safety feature. I explained already but the Japanese fuel product is very high grade. This is the data of 50 days continuous operation at 950 degrees centigrade. This is the result of kind of fission product. If we compare to the other reactors such as AVR, and FSV, the radiation level is very small, more than maybe three order lower than the other. This means, in case of higher case, it will occur from initial defect of the fuel, but our fuel quality is very good and keeping the low, that is the meaning of this graph.

Go to next one.

This is another safety issue for inherent reactor safety design. I already said about fuel particle cannot reach the fission product even in an accident. In case of accident in design base, this is maximum around 1450 degrees centigrade. But this is the maximum of the accident. But this fuel, if the temperature is up to the 1600 degrees centigrade, it will be no problem with no release of the fission product. Maybe, more than 2000 also is maybe no trouble. Anyway, it is good to keep fission product inside.

Another one, helium is an inert gases and no chemical reaction, no hydrogen production in case of accident. Maybe, everyone knows about that.

Also, graphite core is also important. It's negative reactivity coefficient is very good, and high heat capacity and large thermal conductivity heat of graphite and is a good feature. This means if I have some trouble, heat is removed outside by this good thermal property of graphite. This is one of the examples of simulation in loss of coolant. It can keep more than 1600 degrees centigrade.

Please remember this, negative reactivity coefficient is very good. This issue is very important, and please remember this one. I'll explain later.

Anyway, HTTR has inherent reactor safety from design, but in case of first construction, that means more than 20 years ago, we did not use such good feature, and just follow all the nuclear power plant regulation. Then this is old time case of our license.

I'll be talking finally about the safety demonstration test. This is the view graph. Before the Big Earthquake one month ago, we finished this test. In this case, the 9-megawatt operation, this is 30% of the power. During operation, we stopped the helium gas. This means no cooling by helium gas. This is a vacuum cooling system, this is out cooling system. This is not available in this test. But we stopped the scram by control rod. This is the result. The flow rate is here and stopped by saturators and then flow rate is stopped and goes to zero. In this case, temperature of the fuel is a little bit increased but it comes from the Doppler effect of the fuel and also the moderator's effect. Reactor power is automatically down to zero.

This safety demonstration test is programmed as OECD/NEA project and then we did this one. This means it has lot of cooling, heat is removed to the outside and reactor is automatically stopped by physical property of core and stop ton this safety. This is the meaning of this one.

In the future, after research, we plan 100% power, that's a similar test, and other one, the 30% power, but vacuum cooling system is also stopping is the plan. After restarting, we tried this next safety demonstration test.

I will shortly explain about the Japanese nuclear regulation.

Maybe everyone know about the Fukushima Daiichi Nuclear plant accident. In this case, by tsunami and first time the loss of power due to earthquake and tsunami and could not be cooled. By loss of cooling, the core damage generated hydrogen and this leaked hydrogen make an explosion and then released the fission product. This is an initial impact and go to the crisis to the severe accident that developed to go to the severe accident.

Before this time, this is the Japanese regulation on the left side. The old regulatory rule is regulatory requirements did not cover severe accidents. This means management of severe accident was defined as the owner, the responsibility owner in this case. No legal framework of continuous safety improvement and lack of risk awareness of natural disaster. Such issue is one of the reasons for such an accident.

Anyway, after the new regulatory standard, all of parties are reinforced and some are introduced newly: for example the volcano, tornado, or forest fire, or internal flooding. Of course, seismic evaluation is also reinforced. Another one added for the severe accident like this, also add for measures against terrorism, aircraft attack or something. Some kind of severe accidents must be introduced in new regulation.

That is in case of nuclear powerplant. This is for the research reactor. Old regulatory standard is almost similar by previous nuclear power plant. This is now new regulatory standard. Reinforced, this green part is almost same. But in case of severe accident, this is prevent from large amount of radioactive release, is only added into the new research reactor. We say this is beyond design based accident, BDBA, as it is called. This is a countermeasure of severe accident. This means even in very low possibility, we must prepare the final weapon for keeping safety. This is a question from government, and we must answer this one, what is the final weapon against such a crisis. This is the meaning. But we wanted early restart and we needed to make new safety theory by using the inherent safety design that are coming from result of safety demonstration test or something. We tried to do like this.

This is the main part of my talk.

This is just the viewgraph of the schedule. This is the permission. This is a very complicated name but this is for the permission. If stopping the reactor must keep safety, this is such an activity line. This one is, the upper part is just design. This one is more detailed design for this meaning. This activity is now carrying on till now. After finishing some construction, we plan to restart around end of July of this year. This is before restart, we need some inspection from the government.

This is just a confirmation of what is the difference from nuclear power plant from HTTR. This is a very low power and low density, and emergency cooling system is not necessary, and decay heat can be removed by natural heat transfer or natural convection and so on [ph].

Next one is also a similar viewgraph. The core is not melting even in the accident, also including beyond design-based analysis also. Reactor shutdown, we have two devices, main control load and reserved shutdown system, but also additionally we have inherent test design. This is coming from reactor physics, the physical property of core, and can be stopped automatically. This is the meaning. Heat removed from core in case of nuclear power plant is forced cooling but passive cooling is okay in our reactor.

Fuel integrity, even in accident there is no trouble in our case. Containment vessel is also, it can contain in the inside of fuel and load of containment vessel is lot of important, but that is the meaning. This final column is a difference because if air is introduced into the core, maybe oxidation occurs. We don't like to introduce air and water inside of core. But by our experiment, for example, in higher pressure part, air or water cannot be introduced into the core in case of higher pressure. Such introduced air in case of our experiment about five days later after cooling the core, and then air comes inside the core component. But in this case, core is already in cooled condition. That means no trouble for oxidation. I did not explain about the detail, but this is that meaning.

This is almost similar one. In case of controlled reactivity, during the design base analysis, we can use control system. But more severe case, we can stop for the physical properties of core. Heat removal also, during the design based analysis only vessel cooling system is enough, but more difficult case is just natural convection is okay, there is no problem. For the containment and keeping the radio fission product, always contain fuel particle. Maybe can almost keep the fuel particle and we have another barrier, for example, the fuel element, pressure vessel, containment vessel and reactor building, that means no problem. That means cannot go to more severe accident in our case. It is very different from nuclear power plant.

This is safety importance classification. This is the most important part of my presentation. In case of Japanese regulation, we have two kinds of safety importance: one is PS1 or MS1. This is prevention system, mitigation system, this is the category for the facility. Other category is the seismic importance, with S class, B class, and C class. This classification is ruled by the two guides. We are thinking of low density and we have infrared safety feature. We classified again. And then the unique classification was approved by the government. This means that. Maybe the PS and MS are usually used in other countries I think. Maybe I will explain in the case of seismic in the next slide.

This is the classification of seismic design. C class is general industrial facility. B class is 1.5 times strength more than the industrial facility. This means, if I broke the S-class, surrounding people radiation dose is forecast to the 0.05 millisievert. And then S-class is three time strength than general industrial facility. And if we have some important [Unclear], 5 millisievert occur for the dose of surrounding people.

For the seismic evaluation, we say seismic standard waves, I will explain later. Anyway, by using this, if broken or not must be checked for all S-class facility. Sd is seismic design wave. This is half of one. How to decide this, maybe also have a guide in the Japanese regulation. We are making this wave by using this guide and checking each facility. Important facility is the S-class.

This is the result of the review. I am very sorry, for the physical protection, I mean against the countermeasure for the [Unclear] I cannot talk about that. I cannot show some safety issue for the related physical protection. I must say only by talk. I cannot show the picture, very sorry. Anyway, I will explain about related seismic. Old case is maximum acceleration is 350 Gal, and now the new one has become to around three times higher, to 973 Gal. This is wind. After the Big Earthquake, we must check the fault of the ground, and also including the fault of undersea also. The more fault near our site is identified. That is one of the reasons. And another one is this is coming from the rule. And near the fault assumed to be moving simultaneously. This is the guide. This means maybe you know about Big Earthquake and Fukushima. This is big fault have together underlying to the nearby, and that fault is moving simultaneously. Seismic wave is very long time. Anyway, we have such experience and rule is near fault must be thought to simultaneously move. That means seismic wave becomes very high. That is the reason that acceleration is very high.

Next one is downgrade, I explain about the classification. We try to reduce such important classification. If you go to the more downgrade, it is very easy to clear the hurdle. That is the meaning. This is core heat removal S-class to B-class. Maybe you remember the original cooling system, this is in case of abnormal condition. Also vacuum vessel cooling system also. That cooling system is previously the S-class. But please remember the safety demonstration test. All of cooling system is down but heat goes outside naturally, and such forced cooling is not necessary. That means such kind of facility importance is not necessary such a high level. Then we can explain to the government and can succeed to downgrade S-class to B-class.

Next is internal structure. This means previous regulation of our design, internal core component, I mean graphite block or something, it must survive during the S-class seismic wave. Because that time the cooling gap must be key for the reactor safety. That means forced cooling is necessary in the quote our proposal. But please remember the safety demonstration test. If the stopping forced cooling, there is no problem as the heat is removed to the outside and cooled by natural convection. This meaning if graphite block have crack by earthquake, it is not a problem. That is the meaning. If the shape does not change, it is no trouble. Do remember that inner core part is fixed by the outside belt. This outside belt is S-class. This is not changed. But inside the graphite part can reduce to the S-class to B-class. We allow some crack by earthquake is okay. No problem for the heat transfer. Then successfully we come down to the classification from S to B. If not successful, that is very severe in case of seismic motion.

Next is tsunami evaluation. This is simulated by tsunami level. The most higher case is 17.8 meter from sea level, but our location is 36.5 meters, no trouble. Not required anything.

Next one, this is including natural disaster such as tornedo, volcano, and forest fires also. In case of tornado, 100-meter per second speed must be taking account. This is coming from result data near our area, but such high speed wind may not occur. Other one is volcano. This is some kind of ash. If you have some volcano, it will be maximum 50 centimeter. We dig the ground and check by old experience here. The maximum thickness is 50 centimeter. This thickness also including water is more heavier. If we have such high speed wind and some flying object comes and attacks the reactor building, there is no trouble. That is the evaluation.

In case of ash, if ash falls on top of the building and in case of such rainy including, that reactor building has no trouble. This is the evaluation. And result is no problem. But this is forest fire. I explained about the viewgraph of our institute already. We have the fireproof belt; fire protection road is required from the government. Now they have already constructed in our facility. The view is good sightseeing for me.

Next one is fire, this is mainly the internal fire. Regulatory requirement is cable protection. We have many important cable lines for the electricity or measurement. Usually the double or triple safety, I mean parallel to introduced one. But in case of internal fire, at least one line must survive. Only one line must be lapping to survive during the fire, during one hour. That image is some glass fibers made lapping material is covered by some special cable play or something. That is the image of this cable protection.

Next one is BDBA. Do you remember the design base analysis? This is broken and double tube in the lower part of the HTTR core. This is DBA's worst case and must be overlapped to the other issues for one of failure of scram, or health removal, and failure of containment vessel. This possibility is very, very low, but I explained already the government question is what is the final weapon or something even in such an unexpected severe accident. We must answer this one.

Anyway, our core will not melt in case of all the BDBAs. But it is only necessary for monitoring during such a severe accident. Of course, no electric power. And we need some portable power generator for monitoring is necessary.

Without significant additional reinforcement, we got the approval by using inherent safety feature of HTTR.

Sorry, this took time.

This is conclusion. Upper part is already explained. In the future, we will try to start, restart the safety demonstration test. This is OECD/NEA project. In the more future, we try to attach the heat utilization system. This means the hydrogen production system and gas turbine electricity generation system. At the present time I cannot share the details, maybe little bit secret, but in the near future, we can hear the good news from government or something. We are expecting that. Please watch our project in the near future. The other one is international cooperation by using HTTR. We are expecting this also.

Anyway, through this big earthquake, Japanese recognized that helping each other is very important. Maybe some foreigners say Japan is very kind, but for Japanese, helping each other is the only way for survival because Japan has many disasters. For collaboration, being friendly and kind is better for the collaboration. I think that this is why other people think so kindly for Japanese. Because we cannot escape from Japan. It is a very small island.

Also I want to say for the global warming and COVID-19, the Coronavirus, they are teaching us collaboration is the most important for surviving. This is my understanding. The only way is helping each other. And then collaboration in our project is also very important for surviving I think and we hope for such cooperation in the future. Anyway, we cannot escape from the earth. Cooperation is the only way for survival.

That's all for my presentation. Thank you so much.

Berta Oates
Thank you very much, Dr. Ishitsuka. If you have questions, go ahead and type them into the questions pane. While questions are coming in, we have some information that we are happy to share with you on 'Pitch your Gen IV Research' competition. Patricia, do you want to talk a little bit about it?

Patricia Paviet
Yes, thank you Berta. Again, good morning everyone. I wanted you to be aware of this 'Pitch your Gen IV Research' competition event. The GIF education and training working group has launched 1st of February a pitch competition which is virtual, and we have asked the junior researchers around the world to send us an abstract. We got 51 people who competed, and 21 of them have been selected and they have pitched their research through a video. These videos are available on two platforms, the YouTube platform and the BiliBili platform. I am asking you if you could watch these videos, they are very short and vote for your favorites, and favorites with one S, which means that you can vote several times. The winner of this

vote, this is really the public vote, will be able to present his or her work through a GIF Webinar in 2022. So again, thank you so much for participating. I think it means a lot to the junior researcher work on these Gen IV system to be included. These are our future. These are the next generation and probably leaders in this field. So thank you in advance.

The vote is open until April the 30th, so at the end of the month. Okay, Berta, if you want to show the next slide.

I talked about that last month, but I would like to bring your attention to a special GIF Webinar to celebrate the 20th anniversary celebration of the GEN IV International Forum. I am very pleased to be the moderator. We have an international panel with six current and former chairs of the GEN IV International Forum. They will talk about the progress and future prospects towards developing and deploying GEN IV reactors as advanced nuclear energy systems. So, I encourage you to watch this webinar. It will be certainly interesting. Also we have two panelists, Ms. Diane Cameron and Dr. Fiona Raymond, who will give the introduction and concluding remarks. Thank you again. Give you back the floor, Berta, thank you.

Berta Oates
Thank you Patricia. So just a quick look at the upcoming webinars. We have planned gain the special presentation on April 28th, and then returning to our normal monthly GIF presentations in May, Advanced Manufacturing for GEN IV Reactors; in June, In Service Inspection and Repair Developments for SFRs and Extension to Other GEN IV Systems. And in July, Evaluating Changing Paradigms across the Nuclear Industry. So thank you for your attention during that.

Also I want to draw your attention. On your slide deck there are several slides that have been provided as appendices that provide some additional technical information from today’s presentation. Dr. Ishitsuka was kind enough to put together and share those details with you.

Okay Ishi-San, I have elevated you to organizer, so you should be able to see the questions. There are several questions in the pane now, starting at the earliest question, there was a question of what is the composition of the fuel kernel UO2 or UCO.

Etsuo Ishitsuka
Yeah, it’s a U2O.

Berta Oates
Thank you. Please explain more on how more negative temperature reactivity was.

I am sorry.

Etsuo Ishitsuka
UO2, sorry.

Berta Oates
Please explain more on how the negative temperature reactivity was achieved in the HTTR. Can you make a comparison of HTTR core with RPMK type reactor core without regard to reactivity coefficient?

Etsuo Ishitsuka
Sorry? Sorry, I cannot see the question, and maybe for the questions please see the appendix, maybe you can understand more detail I think.

Berta Oates
Are there any hydrogen risks during accident in HTTR, and how is it managed?

Etsuo Ishitsuka
Because we are just using helium gas, and pressurized water is more lower pressure than helium gas. That means cannot introduce the water into core. That means no problem for the hydrogen production. Is it okay?

Berta Oates
Does HTTR have any protective measures against volcanic ash? Is there any risk of volcanic ash will reduce the heat removal capacity of the reactors such as intake or blockage? I think you talked about that on one of your slides, but perhaps you could embellish a little bit on that.

Etsuo Ishitsuka
Maybe there are some part asking for the ash. We cannot control the ash. Ash is coming by wind, and if accumulated on top of the building, we remove that ash by hand and cannot control it.

Berta Oates
Thank you. Is the legal environment in Japan ready for one, commercial HTGR reactor, not a research or test facility? And two, non-electrical applications of HTGR, for example coupling with the industrial sites? And if not, which are the key points to be implemented in legal acts etcetera?

Etsuo Ishitsuka
In case of commercially HTGR reactor, of course nothing for such a regulatory. Maybe, we must be talking, but our experience will affect such thinking and will be more better way than conventional nuclear power plants. That means government approval is our inherent safety feature.

Berta Oates

Thank you. Do you have a PSA or a PRA model of the HTTR that has been approved by MRA?

Etsuo Ishitsuka
We don't have such activity.

Berta Oates
Some utilities are planning or proposing demonstration projects of HTGR in Canada, US, and UK. They have different designs from HTTR, so they are not vHTGR. Some are micro modular reactors and some use pebble-bed fuel type. How do you think they can make use of the benefit from JAEA's experience for their licensing efforts?

Etsuo Ishitsuka
Maybe our experience will contribute, but actually in IAEA, I heard such a safety issue is already start the discussion in all over the world, and they want to make some safety regulation level or something, I heard. Anyway, our experience will be affected in a good way.

Berta Oates
Thank you. What are the real scientific challenges that slow the progress of this magnificent technology in spite of global hunger for clean energy? It's probably pretty high level for the discussion here today.

Etsuo Ishitsuka
Yeah, HTGR maybe really contribute to such a global warming or something and will be expected – I already explained it is more sympathy with renewable energy, and maybe contribute in the future. Maybe is it okay for my answer? I am sure.

Berta Oates
What happens to the spent fuel? Is it stored in its original state or is it reprocessed?

Etsuo Ishitsuka
We did not decide the reprocessing, but we have all time have some research. But that fuel particle can be broken mechanically. After that, the conventional treatment is possible. Maybe not so much trouble, we are thinking about it like that.

Berta Oates
Have previous earthquakes affected the HTTR operation in any way? Thanks for the interesting talk.

Etsuo Ishitsuka
Pardon, sorry, again.

Berta Oates
Have earthquakes affected the HTTR operation in any way?

Etsuo Ishitsuka
In case of earthquake, our plant is stopped. But trouble from earthquake we cannot find because I did not see that day in our facility for reducing the thermal expansion, our components hang from the ceiling [ph]. That means more flexibility can move to reduce some expansion. And such system is very good for the earthquake and maybe no trouble. We cannot find any trouble due to such earthquake.

Berta Oates
Thank you. What are the latest innovations in decay heat removal? Do HTTR offer any differences in this regard to PWR? I wondered if you came across heat pipe technology that could be considered.

Etsuo Ishitsuka
Heat pipe? May I ask again?

Berta Oates
What are the latest innovations in decay heat removal? Do HTTR offer any differences in this regard to PWR? I wondered if you came across heat pipe technology that could be considered.

Etsuo Ishitsuka
Sorry, I don't know about the heat pipe technology, but maybe if that technology is better, maybe we can introduce. Sorry, I am not a specialist about this one. Very sorry.

Berta Oates
Could control rods omitted when disasters are impossible because of the inherent safety control – let's see, it's hard for me to – could control rods omitted when disasters are impossible because of the inherent safety and control of intensity be fulfilled be the spread of helium and number of fuel elements?

Etsuo Ishitsuka
Sorry, it is difficult to…

Berta Oates
Yeah, this one is hard for me to read. I'll try and send it to you.

Etsuo Ishitsuka
I cannot hear about the question. Can you read again?

Berta Oates

Yes. I sent it to you in the chat also for you to read with me. It reads, could control rods omitted when disasters are impossible because the inherent safety and control of intensity be fulfilled be the spread of helium and number of fuel elements?

Patricia Paviet
Berta and Ishi, because the question is not very clear, I am asking maybe [Unclear] from Germany to send an email directly to Ishi. The email is written on the second slide, and maybe you can have a conversation through email.

Etsuo Ishitsuka
Yeah, it's more better it think.

Patricia Paviet
Yeah, that's easier.

Berta Oates
Thank you. That's a great suggestion. Do you have a ballpark figure for the burnup in megawatts per day?

Etsuo Ishitsuka
In the design of our HTTR fuel, in 660 days for 30 megawatts. This is our design. Nowadays, our burnup is around 300 days for the 30 megawatts. That means about half of burnup of design now. Is this enough for you, maybe?

Berta Oates
Thank you, yes. There is a followup question on the PRA model. If you do not have a PRA model, how did you identify the events and accident sequences to be considered in the safety review?

Etsuo Ishitsuka
Yeah, we don't have such activity.

Berta Oates
What is the exclusion zone radius considered for HTTR sites?

Etsuo Ishitsuka
Pardon? What exclusion zone? Maybe, in case of emergency it is 5 kilometers. In case of some accident 5 kilometers people must evacuate. This is the Japanese law. Is it okay?

Berta Oates
Thank you. Do you have young engineers that are interested in this technology or are there skill shortages expected in the future?

Etsuo Ishitsuka
I could not understand this meaning, and maybe…

Berta Oates
Maybe I could rephrase it. In Japan, you reach out to the next generation. Are you encouraging the young engineers into the nuclear industry also?

Etsuo Ishitsuka
Yes, of course, I think so.

Berta Oates
Yes, I think so.

Etsuo Ishitsuka
Okay, I can find the questions now. Okay, next one.

Berta Oates
How many more years will the HTTR operate under new licensing from NRA?

Etsuo Ishitsuka
That means in the future?

Berta Oates
Yes.

Etsuo Ishitsuka
Maybe after the safety demonstration test, maybe we are stopped again because we tried to make a connection to the hydrogen production system or gas turbine electricity production system, and then maybe few years operate and we will stop for the next step.

Berta Oates
Thank you. How much amount of carbon14 produced in the reactor core? Will not be a significant problem for waste disposal?

Etsuo Ishitsuka
Yeah. Carbon-14 is actually the produce but it's a very low data [ph] and then maybe I think not so trouble.

Berta Oates
Thank you again for all of your time and sharing your expertise with us. The time scheduled for today is ended. There is a couple of comments that I will forward to you so that you can continue back and forth by email with people one the question that was unclear to me and I apologize for that. But thank you everyone for your attention and for participating in a lively discussion. Thank you, Ishi-san, for sharing your expertise. Patricia, thank

you for your organizational skills and promoting this to the next generation. It's invaluable to do that work.

Patricia Paviet
Thank you, Berta. Thank you again Ishi, very good webinar. And if you can join us next week on the 28th of April, I think you will love it. It will be very different. So, wishing you a good day, and you all stay safe.

Berta Oates
Bye bye.

Etsuo Ishitsuka
Thank you very much.

Patricia Paviet
Bye.

END
