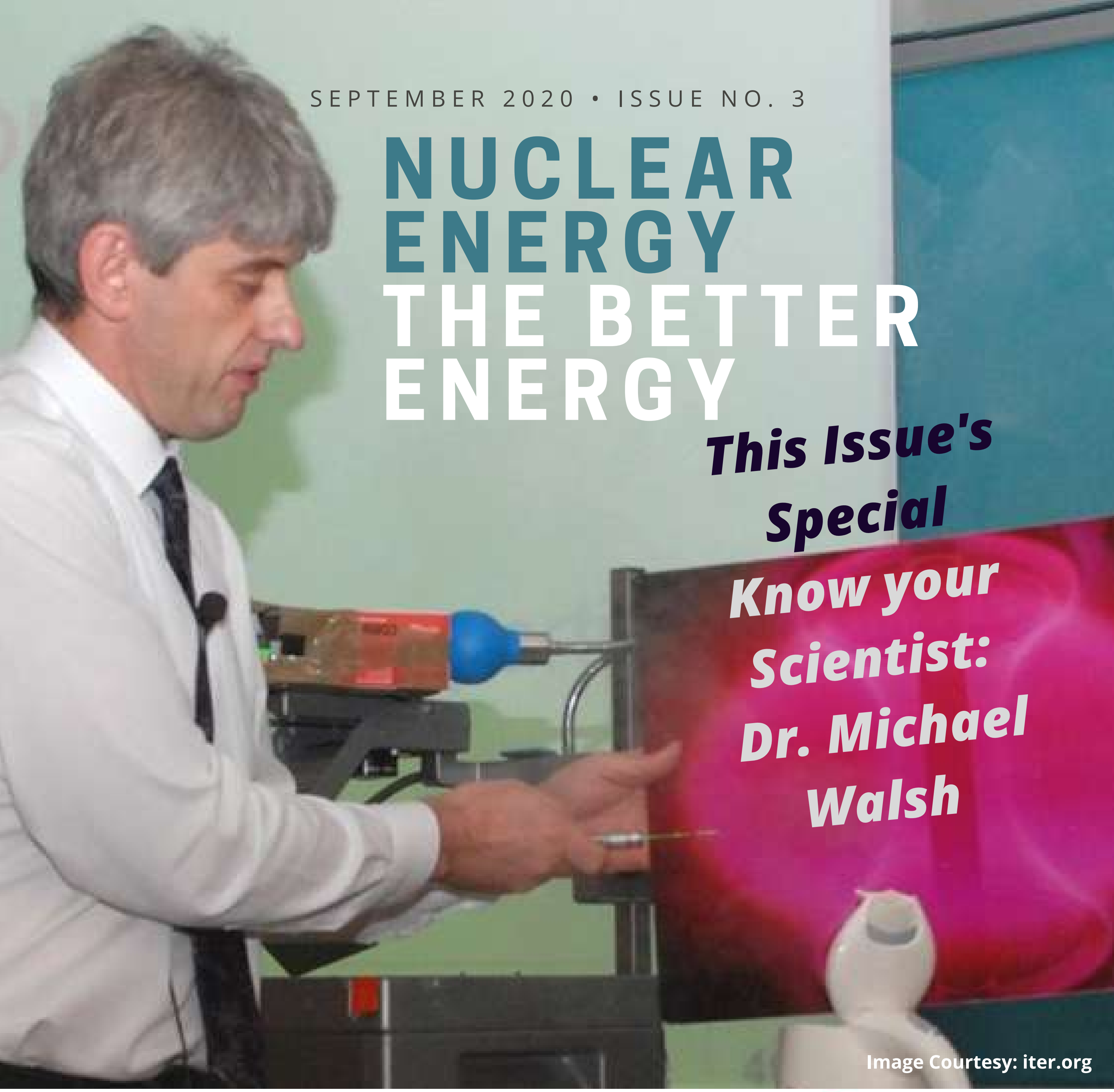
SEPTEMBER 2020 • ISSUE NO. 3

NUCLEAR ENERGY THE BETTER ENERGY

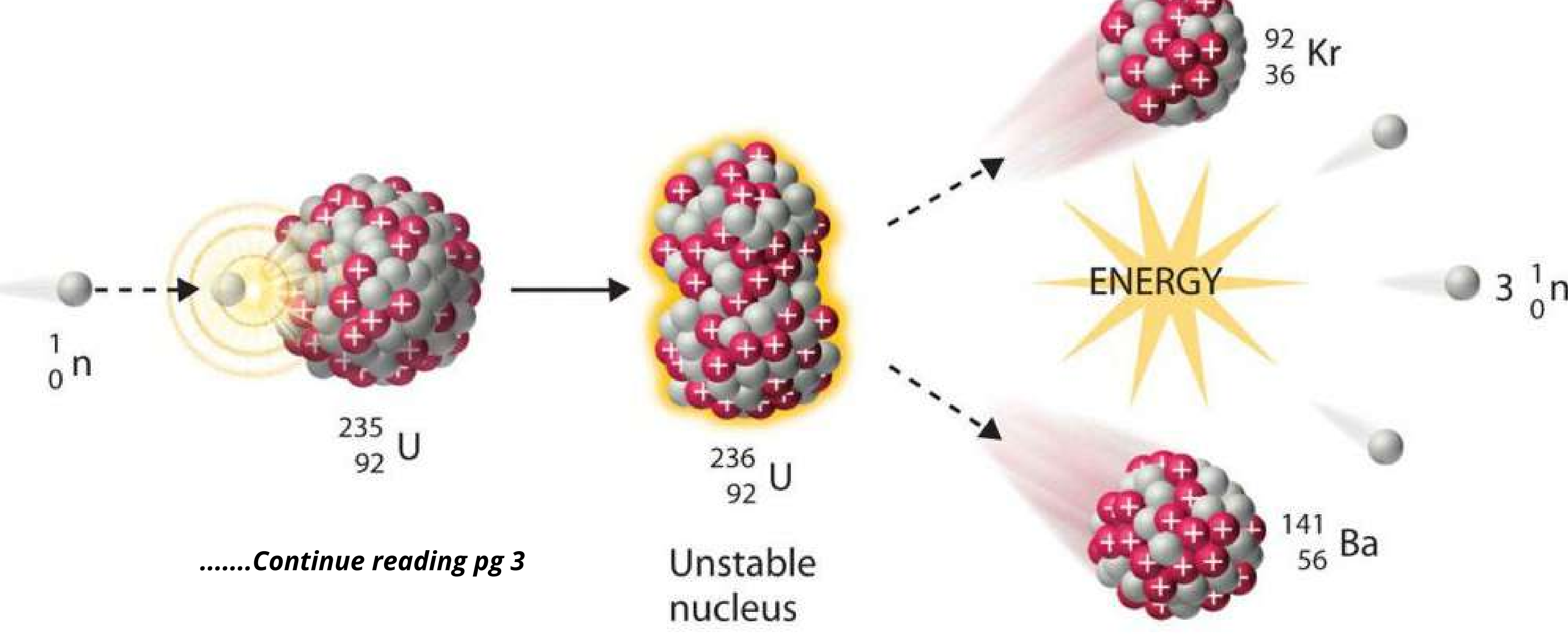


This Issue's Special

Know your Scientist: Dr. Michael Walsh

Image Courtesy: iter.org

What is Nuclear Fission



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LETTER FROM THE FOUNDER

Nirupama Sensharma

It seems like only yesterday that my team was finishing up the draft of the second issue of our magazine and here we are already with our third issue. In the present work-from-home culture, time seems to fly and we do our best to help you stay informed and updated on everything Nuclear!

In this issue, we will introduce you to the intricacies of a nuclear fission reactor. But wait, there is a twist! It is not just the man-made nuclear reactors that we have brought to you. My team members Nilormi and Ashabari have collaborated to present to you the concept of 'natural nuclear reactors', something that existed on our planet Earth 2 billion years ago!

In our last issue, we had dived into fusion reactors. This time, we have taken another step forward and my team member, Vaishnvi has worked hard to arrange an interview with Dr. Michael Walsh, the Head of Diagnostics at the International Thermonuclear Experimental Reactor (ITER). This interview will help you clarify any doubts that you might have had regarding the success of fusion reactors.

Last but not the least, my team takes this magazine as an opportunity to introduce to all our readers a newly designed Nuclear Energy – The Better Energy (nUeBe) logo. I want to thank my members Nilormi, Vaishnvi and Vivek for the numerous iterations they worked on before finalizing The One.

That's me signing off with the hope that you enjoy this issue as much as you enjoyed the last two.
Happy Reading!

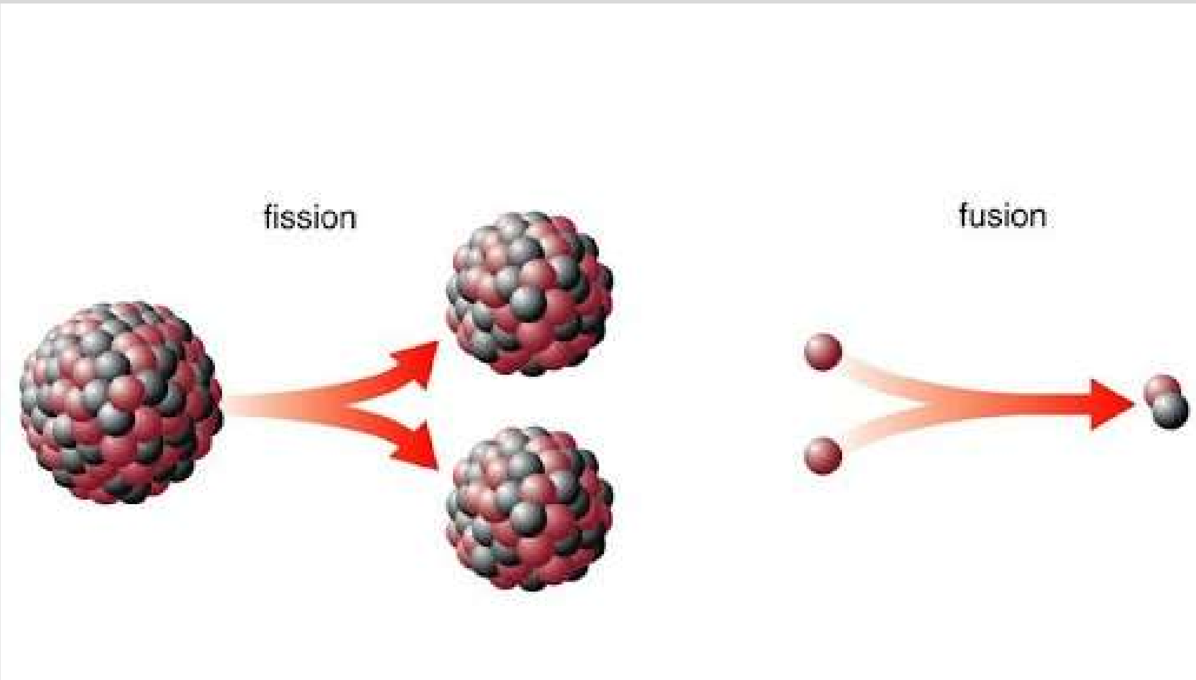
NUCLEAR FISSION

-Ashabari Majumdar

-No wonder we keep hearing atoms are the building blocks of all matter. Different permutation and combination of atoms build essentially every matter around us. Along with creating matter, atoms can help release a large amount of energy with certain reactions termed as fission and fusion.

Hold on ..! What is even meant by Fusion or Fission?

-Glad you asked! Well fusion is when a combination of specific atoms fuse together to release energy (see our July issue for details). We will focus here on the star of this issue- fission! In simple words, it is the exact opposite phenomenon of fusion. Fission is when the core of a heavy atom (or what we formally call a nucleus) is broken by an incoming neutron into two or more lighter atoms of comparable masses and releases a significant amount of energy at the same time. The heavy nucleus used for this energy generating reaction is usually uranium or plutonium. These are about 200 times heavier than hydrogen which is the lightest atom known to human. Now this can happen all naturally (although very rare!) or in man made lab set-up in a controlled manner.



But why is this important ?

-The energy released in this process can be in the form of invisible gamma rays or it can be thermal energy or heat. The heat released is then used for generating electricity in nuclear power plants. The mechanism of converting the heat energy to electrical energy follows the similar mechanism as in fossil fuel power plants. Let's have a closer look at this. Shall we?

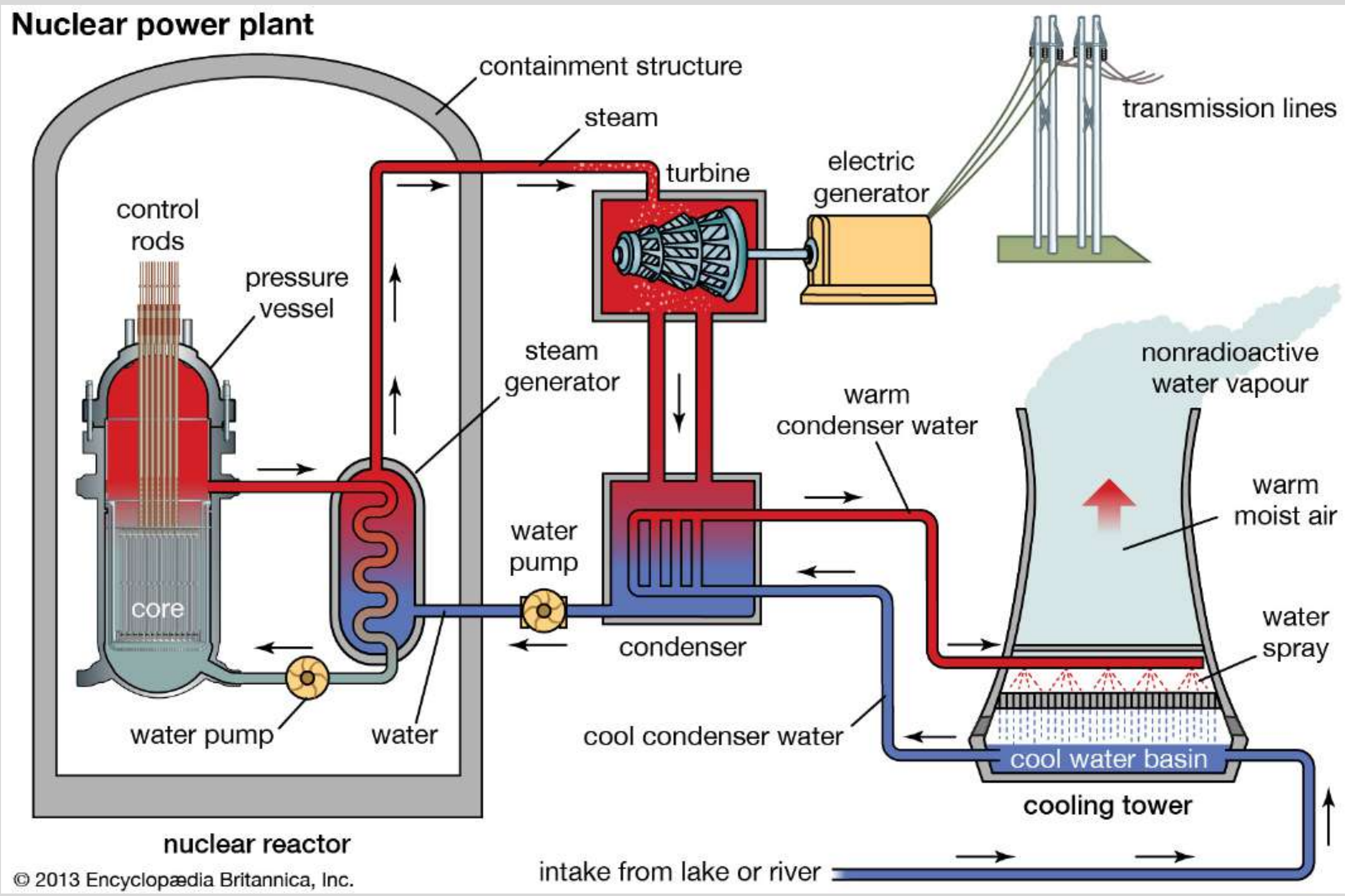
The fission reaction creates thermal energy and the rate of the reaction is controlled using control rods. The heat generated is used to generate steam which drives turbine to convert the heat energy into mechanical energy. That in turn goes through generator to produce electrical energy. The core of the reactor is protected with shields which absorbs the radiation and prevents it from being released to the surroundings.

How much is the efficiency ..?

-The energy provided by 0.1-ounce pellet for fission releases energy equivalent to energy released by 2000 pounds of coal, 120 gallons of oil or 17000 cubic feet of natural gas!

-Oh Wow?! Sounds too good to be true! Is there really no downside to it?

-Well, the answer to your question is both yes and no! It is a great and efficient way of generating electricity without escalating our carbon footprint (remember global warming?!!) Currently 20% of US and 10% of the world's total electricity is generated by nuclear power plants safely. The hazard lies in maintaining the radioactive wastes generated as a by product during fission reactions. Only Finland has ensured a deep geological repository for stable long-term radioactive waste storage. Currently scientists are working on closed nuclear fuel cycle i.e., reprocessing the fuel used in nuclear reactors, but this is an ongoing process.



Oklo - Natural by nature

- Nilormi Das

The second largest continent in the world has always been evolving, even the first hominids evolved in Africa. It is the land of origin. Since childhood I have had a strong interest in this continent, even before coming across “Chander Pahar'' (Mountain of the Moon) by the Indian author Bibhutibhushan Bandopadhyay, who is known for his travelogues. The wilderness as well as the adventurous prospect of the continent has been vividly portrayed in his novel. The desire got more stronger after reading excerpts on life of Jane Goodall, an English primatologist and anthropologist, who has done intensive groundbreaking research on the chimps of Gombe, Tanzania giving me a taste of the wilds. Africa has a discrete and varied demographics, flora and fauna including deserts such as Sahara, Kalahari, the savannahian national reserve, Masai Mara, an extension of the Serengeti National Park, Tanzania, where The Great Migration takes place. Even penguins can be found in the southern part of Africa. The wonders of this early human continent never ceases to surprise me.

Can you imagine this early land had initiated the process to curb energy crisis and that too a billion years ago! It is rightly said that Africa is way ahead of time. In the year 1972, what suspiciously surprised French physicist Francis Perrin was the discrepancy in the amount of U-235 in the UF6 samples from the Oklo Uranium mine, Gabon, a country located in Central Africa. The natural abundance of U-235 is normally 0.72% whereas the samples from Oklo had 0.60% with a significant difference of around 0.1% which is very unusual. Anomalies were observed in other fission products as well. Isotopic discrepancies were observed in case of Neodymium (Nd) and Ruthenium (Ru). These discrepancies and anomalies are possible only if a continuous self-sustaining nuclear chain reaction is being carried out. But how? No nuclear reactor existed in and around Oklo. Then was it something Supernatural!?

No, it was nature advancing itself for future to meet the energy crisis. This incident reminded the French physicists about the prediction made in 1956 by Paul Kazuo Kuroda, a Japanese-American Nuclear Scientist regarding the possibility of existence of natural self-sustaining nuclear fission reactions. He calculated and proposed the circumstances under which self-sustained spontaneous nuclear fission can occur. After further investigations and examinations it has been confirmed by physicists that the depletion in U-235 at Oklo is solely due to natural fission reactions as high abundance of fission products have been obtained from this African uranium repository. Thus, this discovery of natural self-sustainable fission reactions led to the naming of The Oklo Phenomenon.

Another thought of wonder was self-regulation of the chain reaction. What was moderating the neutrons about 2 billion years ago? Super power? A wizard? Because according to the fundamental concept, loss of neutron economy would result in ceasing of the chain reaction and if the chain reaction is not moderated, loss of neutron economy will occur. This is where groundwater hopped in and played the role of a natural neutron moderator that helped in resuming self-sustaining fissionable chain reactions.

This has lead the scientists to conclude that nature is self-sufficient and a great tutor in itself. In and around the Oklo site, other natural fission reactors were also discovered. Thus, there’s nothing to worry about natural radioactivity as nature has its own way of emitting it in a controlled manner. It’s all around us coming from the cosmos and we have been dealing with it since time immemorial.

Introducing our logo

"Nuclear Energy -The Better Energy got its name from our founder Nirupama Sensharma in the year 2018. Combining her research and her social responsibilities, this initiative was started as a mission to spread awareness about the benefits of nuclear energy. Along the way, she warmly welcomed all those who wanted to join her initiative. Within 2 years, it has become an international team of 8 members, each fulfilling different responsibilities for our sole dream of preaching nuclear energy as the better energy. It was decided to give our organization a nickname (acronym) as nicknames are said to create affection. After numerous suggestions, we came up with ‘nUeBe' (pron: new bee). The thought behind such an acronym is of course the title of the organization along with our objective. We, the new bees of nUeBe are new in the field of nuclear science. We strive for a cleaner and greener tomorrow. We hope this logo will help us stand out whilst also making our objective clearer.

KNOW YOUR SCIENTIST

DR. MICHAEL WALSH

Head of Diagonistics Division (ITER)

Born in Ireland, Dr. Michael Walsh pursued a degree in Electrical Engineering and Microelectronics from 1982 to 1986 at University College Cork in Ireland. During this time, as well as the usual engineering topics, he developed an interest in optics and lasers; taking the opportunity to work initially with Far-Infrared Laser systems.

After his degree, he followed his interests in lasers and optics to develop a compact high-power tunable carbon dioxide waveguide laser which led to a Masters in Engineering Science. His PhD work was carried was supported by EURATOM and carried out at the Culham Science Centre near Abingdon, Oxfordshire in the UK. This work was on the study of Ion-Transport in the Magnetic Fusion Device, HBTX-1D. Accessing the information needed for the study, involved the development of various diagnostic systems.

After completing the PhD, he continued to work in the Fusion field and especially in the area of diagnostic development. Following this he has worked at START, MAST, COMPASS and JET at the Culham Laboratory in the UK. He is now head of Diagnostics for ITER based in the South of France. All ITER partners are involved in the Diagnostics mission and he works with the development teams across all the different countries. He is a keen hiker and the outdoors in general and living in the south of France provides many opportunities.

Vaishnvi: ***It's been over 50 years since the initial conceptualization of Tokamaks. What are the present day challenges faced by the Fusion Reactor Technology to attain a lead role in the global energy market?***
Dr. Walsh : Fusion reactor technology has made significant progress over the years with many developments and optimisations. In each case, the operational scenarios have become better understood and controlled. In particular, fusion power output demonstrated in both Europe and the USA with Deuterium-Tritium fuel. Deuterium and Tritium are the main fuel inputs needed for the modern Fusion device. Ultimately, to make power efficiently, size matters and remember that we are trying to make a sun on earth. The present day challenge is to build a device at a scale where the output thermal power from the fusion reaction is significantly more than the input heating power. In ITER, one of the design requirements is that the output power will be 10 times the input power. Once this is demonstrated, the technology can be further optimised and commercialised. This means that the ITER is at a critical and very exciting step.

Vaishnvi: ***The main objective of the ITER thermonuclear fusion reactor is "to demonstrate the possibility of producing a steady plasma for a substantial time, that produces more thermal power from the fusion process than is used to heat the plasma itself." Can you tell us about the present problems with obtaining a steady-state fusion?***
Dr. Walsh: One of the goals of ITER is to show that we can also produce fusion power for a long time. To do this, it will be necessary to develop the operational scenarios to run in long-pulse mode. In this scenario, the stabilising current which is initially driven by an internal coil will be coming from what is called a "bootstrap" effect and will be driven by external heating. With this, the plasma will be able to run for around an hour which is effectively steady state operation.

Vaishnvi: ***The ITER project has the participation of seven members: China, the European Union, India, Japan, Korea, Russia and the United States. This unique scientific collaboration to further the advancement of fusion energy is commendable. Apart from this shared vision, what are the major takeaways for these members?***
Dr.Walsh: The big advantage for each member is that it is possible to invest in a share of the project while having access to the full intellectual property. This means that investments that may be beyond the reach of each member individually can be attained with significantly less cost and risk. Furthermore, each member will be able to more effectively deploy the expertise and knowledge in their own countries to take on the next steps in optimisation and commercialisation.

Vaishnvi: ***ITER is equipped with numerous diagnostic instruments to control and evaluate the plasma performance. Could you tell us more about how the diverse divisions are managed and integrated into the tokamak?***

Dr. Walsh: ITER has many diagnostics to be able to understand what the device is doing and to be able to provide feedback on the measurements to control the power optimally. To control the power output, it is necessary to measure many parameters and then feedback in to the different control points. Generally the parameters are measured using different technologies varying from the radio-waves to the gamma-rays. For critical parameters, there is built-in redundancy in the measurements to ensure operational efficiency. For each measurement, specific parameters are determined. For example, some relatively simple loops of wire in different configurations can measure the change in magnetic flux and with some processing one can determine the magnetic field and flux lines. Having several detectors or even grouped detectors and models that describe how the plasma behaves, one can control the geometry of the magnetic field and hence set the plasma shape and position inside the vacuum chamber. Of course, knowing the position of the magnetic field lines is not sufficient to know all about the plasma so other measurements are needed. For example, knowing about the flux of neutrons inside the plasma tell us about the fusion power. Knowing about the temperature of the particles inside the plasma tells us whether we are in the right regime to achieve the fusion power. The control software collects the diagnostic measurements from a central data highway and uses these in different combinations to bring the plasma to the optimum condition for making fusion power. With a good set of reliable measurements, it will be possible to understand and control the plasma. This is why the design of ITER has required a strict set of parameters to be measured and made available to the control system.

Vaishnvi: ***When it comes to Nuclear Fission Reactors, a lot of safety measures have been put to place to prevent the release of radiation in the event of an accident. Despite all these measures in place, there are still apprehensions regarding their safety. Do you think that Fusion energy technology will face similar apprehensions?***
Dr. Walsh: While fusion is a nuclear process, it works in a very different way to fission. One is splitting of atoms and the other is combining. The fusion process is controlled very precisely to be on or off and the “waste product” is non-radioactive Helium. Fusion does of course have neutrons but these neutrons are very controllable. If there is a situation when the reactor needs to be off, then it can be switched to off very quickly. Unlike with nuclear fission, the fusion reaction does not involve a chain reaction, and there is no build-up of a “decay heat” inventory; so there is no possibility of a meltdown accident. Because the process is very controllable and doesn’t accumulate long lived radioactive isotopes, then there is no need to fear any long terms apprehensions.

Vaishnvi: ***How is radiation safety accounted for at ITER?***
Dr. Walsh: The plant is designed to high level Nuclear plant standards with accident scenarios – such as gas leaks, water leaks, fire and other scenarios – as part of the design. Each step in the design and build is subject to rigorous checks for conformity with the design, and it is at the forefront of our methodology. Safety is paramount and always foremost in our design and implementation strategy.

Vaishnvi: ***In your opinion, how will ITER impact the future of clean energy and our society?***
Dr. Walsh: ITER in Latin means “the way” and that is the main ambition. The big contribution of a device like ITER is that it will set out a path for tokamaks to be used to create very high levels of sustained, reliable and readily available power without producing or emitting CO2. This energy can be used to power our hospitals, factories, homes and vehicles. And with a virtually unlimited supply of fuel, hydrogen fusion has the potential to supply concentrated “baseload” power for millions of years. That will be the impact of ITER.

Vaishnvi: ***Are you satisfied with the branding of Fusion as the energy for the future? What is your opinion regarding the ongoing efforts and the current state of public awareness regarding Fusion? Any suggestions to improve both the branding and awareness?***
Dr.Walsh: Fusion energy is still a developing technology. The ITER project has many visitors to the site and is well followed on the social media. However, the steps to create a fully functioning Fusion power source is a common need by the planet’s occupants and more public awareness and support is crucial to its success. In this light, more public awareness is very important. The true potential of this power will be seen when the ITER device demonstrates its objectives but until then more and more diffusion of the message of the objectives, planned outcomes and benefits need to be shared with the public.

Vaishnvi: ***ITER is notably the largest of the fusion reactor projects to date. After years of tireless efforts, the Assembly Phase of the tokamak has recently begun. Based on this present situation, how far are we from receiving electricity generated out of nuclear fusion in our homes?***
Dr.Walsh: ITER is designed to demonstrate that it is possible to get ten times more thermal output power than input heating power. This is planned to be reached beginning in 2035. This will be a very big step as it will show the true potential of fusion power. For commercialization, it is necessary to have one further step where all the aspects for the electricity generation from source to transmission to users are included. This would come after ITER and several members are already designing such devices, commonly known as DEMO.

Vaishnvi: ***Any word of advice or suggestions for the students who wish to enter the world of nuclear research as a profession?***
Dr. Walsh: Fusion is a clean and controllable process with enormous potential. It is the process that has powered the stars for billions of years. The development of an energy source with this kind of capability is necessary but a large technical challenge to overcome. To make this a reality, it needs highly skilled people across multiple disciplines such as engineering, science, manufacturing, management and others.

Meet the Team

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