A/CFTA
Newsletter 1-2018
December 6, 2018

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Alberta/Canada Fusion Technology Alliance

ACFTA.ca

VISION
"Fusion energy is society's fundamental source of primary energy".

Message from the President:

I am pleased to see the inaugural newsletter being issued. There is a need for a venue that provides an overview of global fusion development. We, the Alberta Canada Fusion Technology Alliance, are taking on this challenge.

We welcome all comments and suggestions.

May you have an enjoyable read…

Glenn Stowkowy P. Eng.
President
Alberta Canada Fusion Technology Alliance

Upcoming Activities:

Upcoming newsletters will include
- *10 common questions, with answers about fusion energy*
- *The results of a national survey on energy literacy being sponsored by ACFTA*
- *A series of technical articles on various aspects of fusion technologies*

Information sessions are ongoing. Public sessions will be announced on the website ACFTA.ca or in future newsletters

Speakers are available if your organization would like a presentation on fusion technologies.

SYNOPSIS OF RECENT ACTIVITY

Global funding for fusion research is increasing. *While the largest investments are occurring in Europe and Asia, the United States and Canada are increasing funds for fusion R&D. The United States currently spends over $1 billion in the two major technology approaches (magnetic and inertial confinement), recently doubling its annual contribution for the International Thermo-nuclear Experimental Reactor (ITER) magnetic fusion energy (MFE) project, helping to ensure that this fusion facility, the largest in the world, remains on schedule for completion. In addition, the United States announced funding of $36.4 million for numerous projects dealing with basic aspects of MFE and plasma science. The laser facility at the University of Rochester has been granted $80 million per year to continue its program in inertial fusion (IFE) research. While modest in comparison, Canada recently announced funding of $49.3 million to General Fusion, a private company in BC that is pursuing an alternative fusion confinement technology. Canada is not yet investing in the two major confinement approaches. Consequently, the difference between the two countries is that the US support is broader in that it encompasses various approaches and numerous entities. In contrast Canada is funding just one entity, but it is a start on recognizing the actions identified by the Canadian fusion alliance in its Fusion 2030 Roadmap.*

AN INTRODUCTION TO FUSION

Fusion energy and related technologies have the desired characteristics to address social objectives such as energy equity and sustainable energy development. Successful development requires a sustained long-term commitment, with the subsequent returns far outweighing related investments.

Fusion is the source of all the energy provided by the sun. It involves the fusion or joining of two atoms into one heavier atom. To make it work, a threshold energy is required to "push or join" the two atoms together. Once "joined" or "fused", far more energy is given off than used to "join" the atoms. The concept is well understood. However, society has yet to achieve net energy production let alone at a scale that can be used for practical applications (i.e. the provision of heat, electricity and transportation fuels), though achievement is very close.

Today, approaches are focused on using isotopes of hydrogen (deuterium and tritium), which are fused to make helium. Deuterium is found in water and is in abundant supply world-wide, while tritium is produced in the energy production cycle in an on-demand basis. Current efforts are using magnetic or inertial confinement with auxiliary heating (electric currents, electromagnetic waves, particle beams, lasers) to contain and heat the deuterium and tritium to threshold conditions for fusion (the high temperature state is called plasma).

The innovation process behind fusion is the same as with any technology development – the transitioning of a concept to proven technology requires innovation. For example, having planet orbiting communication devices such as a satellite is a concept. To make satellites practical, a whole host of singular innovations are required, which all undergo continuous improvement. This is no different then the development of the telephone through to cell smart phones, or cancer mitigation technologies. The successful development of a concept to real-world practical applications requires numerous individual and related innovations.

Fusion research started in the late 1940's early 1950's. To those directly involved with fusion research, the amount and level of knowledge gained since then is substantial. To an outsider, it may appear that advancement has been minimal. Hence the polarity of views, with some saying fusion is a far-off dream (nothing has happened) to those that speak of imminent commercial development in a matter of decades.

Current annual global effort is in the order of $4 billion (US$), on the same scale if not larger than the global effort in carbon capture and storage. Ongoing research and innovation exhibits a high degree of collaboration among the nations involved. As with any innovation process, collaboration is the highest at the initial learning stages, but once practical applications and business opportunities can be found for the various singular innovations, open collaboration decreases and is replaced by business ventures that rely on confidentiality. The transition from a fully collaborative environment to a business approach is beginning today.

FUTURE VISION

"Fusion energy is society's fundamental source of primary energy".

Energy is fundamental to the development of any society. It provides basic life needs such as food, drink, shelter and warmth, as well as security and stability. Without energy, today's society would not exist.

There are various forms of primary energy. They can be categorized in various ways such as renewables versus non-renewables, reservoir versus non-reservoir based, and hydrocarbon versus biological versus non-hydrocarbon and non-biological based. To be useful to society, a primary energy must be converted to a commodity energy, either heat, electricity or transportation fuel.

Fusion energy has the best energy equity and energy density characteristics of any primary energy form. In terms of energy equity, the fuel source for fusion, water, is abundant and available globally, hence the need for extensive infrastructure and the potential for geopolitics is minimal. In terms of energy density, in comparison to other primary energy forms, it minimizes the use of input resources that have limitations such as process water, and land; the least impact on bio-diversity; and the smallest consequential outputs of waste products (radioactive and non-radioactive, waste water, air emissions, and green-house gases).

RESEARCH STATUS

Today, the two major approaches to fusion are magnetic and inertial (laser).

Magnetic Fusion Energy

Magnetic confinement fusion aims to contain a hot plasma in a device with immensely strong magnetic fields. Specific approaches include tokamak, stellarator, z pinch and reversed field pinch. The world's largest magnetic fusion project is the ITER Tokamak reactor, which is under construction (France). Once completed it will be the world's largest experimental fusion facility. It is the first-of-a-kind global collaboration. Total cost is $25B US$. Europe (EU member countries) is contributing half the costs. The remaining members, China, India, Japan, the Republic of Korea, Russia and the United States are contributing to the remaining half.

Magnetic confinement struggles with controlling and containing the high temperature plasma and keeping it stable long enough to sustain fusion.

Recent announcements include the following:

March 2018 — The US doubled its annual funding for the ITER project from a scheduled $63 million to $122 million. More than 600 US companies, laboratories and universities are participating in ITER. This funding is helping ITER meet its project timelines.

March 2018 — A collaboration between MIT, Commonwealth Fusion Systems with support from the Italian energy company, ENI, are developing a project that they envision will see fusion power on the electrical grid in 15 years. The project will be using a new class of high-temperature superconductors to produce ultra-powerful magnets to hold in place the plasma needed to facilitate fusion, thus significantly reducing the amount of energy that needs to be in place for the fusion reaction to occur. The project, called Sparc, is designed to produce about 100 MW of heat. In comparison, ITER is sized at 500 MW with a volume of 1000 cubic meters (2 m3/MW). Sparc, with is ultra-strong magnets, will be about 1/65th of the volume of ITER (0.15 m3/MW) leading to significant capital reductions versus ITER.

June 2018 — The ITER Council announced that the project is 50% complete and affirmed project progress to achieve First Plasma in 2025

August 2018 — The US Department of Energy announced funding of $36.4 million for fusion energy science research for 37 research awards at universities, national laboratories and private companies. Projects include support for tokamaks and variants, stellarators and computational work modelling plasma behavior.

September 2018 The US Department of Energy and the Princeton Plasma Physics Laboratory with collaboration with the National Fusion Research Institute (NFRI) in Korea, have developed a new method for reducing instabilities in Tokamak fusion plasmas without triggering any consequential problems. The method addresses plasma instabilities called edge localized modes which are bursts of energy in man-made plasma fields, similar to how the sun releases bursts of energy in the form of solar flares.

Inertial (laser) Fusion Energy

Inertial confinement fusion aims to compress hot ions in a plasma, heating them to conditions where fusion will occur. Specific approaches include laser fusion, beam fusion, fast ignition, and magnetized target fusion. The two largest initial fusion projects are the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory (LLNL) (US) and Laser Megajoule (France).

Inertial confinement requires high efficiency of reactions to exceed the energy required to drive the primary laser or ion beam driver sources.

Recent announcements include the following:

June 2018 The latest results were published from LLNL reporting a doubling of the fusion energy yield in experiments from 27 kJ to 56 kJ over the previous 2 years, meaning they are now within a factor of two of igniting a fusion burn wave through the fuel which would release megajoule level energies.

July 2018 The LLNL NIF set a record firing 2.15 (MJ) of energy to its target chamber thereby meeting its National Security Administration (NNSA) level 2 milestone for 2018. This ensures continued funding.

October 2018 The 2018 Nobel Prize in Physics was awarded to three physicists for ground-breaking inventions in the field of laser physics, including pulse laser physics, which are the essential component in inertial confinement fusion.

Hybrid Approaches

There are numerous other facilities at various universities and private companies using a variety of fusion energy approaches. The following is a list of recent announcements and developments:

AGNI Energy (Olympia, Washington), formed in 2017, is working on a reactor design that combines the stability of magnetic confinement with a beam to target inertial fusion.

Helion Energy (Redmond, Washington) is focusing on small scale units using magneto-inertial fusion.

CTFusion (Seattle, Washington) is developing a fusion reactor using a process called imposed-dynamo current drive.

General Fusion (Vancouver, British Columbia) recently fired-up the world's largest and most powerful plasma injector (10 times more powerful than its predecessor) and has announced (October 2018) $49.3 million in federal government funding through the Strategic Innovation Fund. It is targeting a commercial plant by 2030.

HB 11 Energy (Australia) recently founded in Australia to pursue inertial confinement fusion using the proton - boron-11 reaction which is a neutron-free fusion system but requires even higher plasma temperatures to initiate than tradition deuterium - tritium fusion