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Canadian Nuclear Society
Fusion Science and Technology Division
(CNS-FSTD)

Summary for CNS Officer's Seminar
October 21-22, 2011

Blair P. Bromley, Chair of FSTD

History

- CNS-FSTD was established as an official CNS technical division in August, 2010.
    - *The predecessor of the CNS-FSTD was the CNS Fusion Science and Technology Committee (CNS-FSTC), formerly known as the CNS Fusion Committee, which was chaired by Blair Bromley since August, 2009. Prior to that, in the period of approximately 1990-2008, the Fusion Committee had been chaired by a number of individuals, including Murray Stewart.*
    - *Due in part to the reduction in support by Canadian federal and provincial governments for R&D work in the area of fusion since 2001, and the then Government of Canada's withdrawal from the multi-national ITER project, there had been a widespread and deep decline of active interest in fusion in Canada. As a result, the CNS Fusion Committee had become relatively dormant.*
    - *The CNS-FSTD has been established to help facilitate the re-birth of fusion science and technology R&D in Canada, through encouraging technical communication among scientific researchers, educators, entrepreneurs, enthusiasts, government officials, etc.*

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Recent CNS-FSTD Success:

- The CNS-FSTD was able to organize a fusion science and technology technical session at the CNS 2011 Annual Conference in Niagara Falls, with six technical papers in fusion, attracting participants from across Canada, and from another country. This was the first dedicated fusion technical session at a CNS conference in more than ten years.

Ongoing Action Items and Activities:

- **Recruit new chair for CNS-FSTD.**
    - *Preferably a CNS member who is currently doing some work in fusion, or closely related. It is expected that this individual will be able to dedicate more time and effort in leading and coordinating the activities of various volunteers within the division.*

- Need to identify list of CNS Members who are also members of CNS-FSTD.

- Need volunteers to assist with activities.

- Establish an Organizing Committee for FSTD.

- Develop an updated email list for fusion researchers and enthusiasts.

- Plan for a Canadian Fusion Workshop in future, perhaps as an embedded meeting following a CNS Annual Conference.

- Need an FSTD Representative on CNS Annual Conference Organizing Committee, and Technical Program Committees.

- Organize a fusion technical session at CNS Conference.

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- Recruit fusion papers and plenary session speakers for CNS Conference.
- Organize tours for fusion-related research facilities in Canada.
- Maintain a dialogue with the Plasmas Physics Division of the Canadian Association of Physicists (CAP).
- Having a person serve as a liaison for the CNS with CAP might be helpful; someone who serves on both the CNS Council and the CAP Executive, to help facilitate communication. This may be an appropriate role for a professor in engineering physics or applied physics. Face-to-face interactions may be required.
- Set up a fusion webpage on the CNS website.
- Prepare a CNS position paper on fusion science and technology.
  - Need input from researchers across Canada to develop this.
- Set up a blog or discussion group for fusion in Canada.
  - Maybe a Facebook Page.

Feedback, Questions and Suggestions:

- If you have any feedback, questions, or suggestions, or would like to become a volunteer to assist with FSTD (even doing something small, for a couple of hours per year would help), then please contact Blair Bromley by email and/or by telephone: Blair Bromley, bromleyb@aecl.ca; yelmorb7@nrtco.net, 613-584-8811 ext. 43676, or 613-584-1518

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Letter to Participant at the CNS Officer's Seminar

Dear CNS Member,

Greetings! My name is Blair Bromley, and I am the current Chair of the Canadian Fusion Science and Technology Division.

Downturn in Fusion

Due to various reasons, there has been a downturn in Canadian participation in research and development (R&D) in fusion science and technology within the international community since 2001. As a result, there was also a decline in the CNS Fusion Committee, which had become relatively dormant.

Revitalization of Fusion in CNS

In 2009, there was an initiative to re-vitalize the CNS Fusion Committee, and this has culminated in with the milestone of establishing the CNS Fusion Science and Technology Division, which became an official technical division of the CNS in August, 2010.

Fusion Energy has Large Long-Term Potential

Considering the long-term potential and value of the development of fusion energy, it is vital that there be a sustained effort to preserve and hopefully grow the fusion S&T knowledge base and R&D activities in Canada. Such sustained activities will help contribute to the eventual development of fusion energy as a power source to complement others.

Fusion will Require Commitment

It is realized and fully understood that the goal of developing fusion energy is apt to be very difficult and long-term, as it has been for the last 60 years. Making continual progress towards reaching that goal will depend on long-term public support and private investment. It will also likely require more collaboration between nations on existing and potential future projects.

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Become a Member of FSTD

Therefore, I would like to invite you to become a member of the CNS Fusion Science and Technology Division, a broad network through which researchers, educators, entrepreneurs, and enthusiasts across Canada can continue to communicate and exchange ideas and information in long-term support of developing fusion energy in Canada.

Volunteer to Help FSTD Grow and Develop

As a member of this division, you will get out of it what you put into it, as it is a purely volunteer activity, but we may have the opportunity to make a long-term difference by re-building and growing fusion research in Canada. Shown on the following page is a short list of tentative goals for this committee. Perhaps you might like to help contribute to achieving one or more of those goals as part of a group effort.

Join the CNS-FSTD Organizational Committee

If you would like to be a part of the ***CNS-FSTD Committee,*** please contact me. If you know of a colleague who might be interested, please forward this letter to them.

Thank you for your time and consideration. I look forward to hearing from you soon.

Sincerely,

Dr. Blair P. Bromley,
Chair, Fusion Science and Technology Division, Canadian Nuclear Society

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Goals of CNS Fusion Science and Technology Division

(Last Update: October 18, 2011)

1. To develop a position paper by the CNS for long-term Canadian strategy for Fusion S&T R&D.

2. Encourage Canada-wide participation and sharing of information on research in fusion, plasma physics, and related sciences and technology through participation in technical sessions / conferences at Canadian Nuclear Society annual meetings (yearly or every 2nd year), or at other meetings co-sponsored by the CNS.

3. To promote Canada-wide co-operation and collaboration between universities, various research laboratories, and private companies.

4. To get co-sponsorship with various societies (e.g. Canadian Association of Physics, etc.)

5. To provide resources / information to all stakeholders (e.g. federal and provincial governments, universities, industry, associations, societies) to encourage their long-term, continued and sustained support on Canadian R&D in fusion science and technology.

6. Maintain CNS-FSTD Website on CNS Website.

7. Publish an annual CNS-FSTD Newsletter.

8. Inform CNS-FSTD members of news, stories and information about what is going on in fusion science and technology research and development, both in Canada, and in other nations.

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Supplementary Information and Commentary

A Qualitative Review of Historical Progress in Fusion Science and Technology

Early Promises

Many of you may recall early predictions of "commercial fusion power plants within 10, to 20, to 50 years", and this statement has been repeated for the last 50 years. It would now seem that there is no definite time frame for if and when fusion power plants will become a reality. Clearly, it is quite probable that there are many remaining physics and engineering obstacles to overcome in fusion science and technology before the ultimate goal of fusion-based electric power plants become a reality.

Fusion More Challenging than Initially Realized

Many research groups at various universities and laboratories across the world have been working over the last several decades on developing various fusion concepts, many which since have been abandoned due to limited progress and success. In a numbers of situations, there was a failure to meet early expectations and promises, many which were grossly unrealistic. These failures were followed by the subsequent drying up of funds to carry out further research.

Up and Down Support for Fusion R&D

As many of you may have experienced and observed, funding for fusion R&D has been going through periods of ups and downs throughout the international community. The early excitement, enthusiasm, and promise of fusion energy dating from the early 1950's has since given way to a more subdued and reserved approach. This has occurred due to the scientific and technical difficulties in achieving break-even and net fusion power production, coupled with the reality that there are numerous alternative sources of energy that, in the foreseeable future, will be much easier and more economical to exploit (e.g. fossil fuels, nuclear fission, and various renewable resources).

Alternative Energy Supplies – Perception of No Urgency Yet for Fusion

Thus, it may be considered by many governments that there is no immediate or urgent need to massively invest in developing fusion energy. It may be expected by many countries that reserves of fossil fuels and the growing exploitation of nuclear fission and renewable energy resources (e.g., wind, photo-

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voltaics, solar-thermal, geothermal, biomass, tidal systems, ocean wave, etc.) will be adequate to meet the world's energy needs for the next several centuries.

Long-term Potential for Fusion Too Big to Ignore

Nevertheless, it is realized that the potential energy resources for nuclear fusion are enormous by comparison to all other current sources. Therefore, it would be prudent, in the long-term interests of ensuring energy supplies, to take the necessary steps to develop the science and technology to enable the harnessing of the vast energy resource of fusion fuels available on Earth (eg. deuterium extracted from water, tritium bred from lithium extracted from the earth's crust).

Some Current Mainstream Fusion Projects

Today, there are two mainstream fusion concepts that are under investigation with substantial government support.

Inertial Confinement Fusion (ICF)

One is Inertial Confinement Fusion (ICF), which is largely supported by defense spending due to the commonality of its physics with that of nuclear weapons (http://en.wikipedia.org/wiki/National_Ignition_Facility). Construction of the National Ignition Facility (NIF), sited at Lawrence Livermore National Laboratory (LLNL), which is a large laser-based ICF experiment, was completed in early 2009, and ignition test experiments have been underway since 2010.

Tokamak Magnetic Confinement Fusion

The other fusion device is the well-known "Tokamak" concept for electromagnetic confinement of plasmas, with several variants having being built and tested around the world over the last 40 years. Currently, the world's latest and largest test facility for the Tokamak concept is being built in Cadarache, France as part of an international project, ITER (International Thermonuclear Experimental Reactor, www.iter.org). ITER (~500 MW_{th}, Q~10) is expected to become operational by approximately 2020 and will operate for 20 years. ITER is to be followed by DEMO (~2,000 MW_{th}), which is planned to be the first demonstration magnetic fusion-electric power plant.

On first glance, it might appear that a demonstration fusion electric power plant may become a reality in the next 30 to 40 years based on two mainstream concepts.

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Potential for Alternative Fusion Concepts

The current world emphasis on supporting the Tokamak and ICF fusion concepts does not mean that other fusion device concepts have no potential. Alternative means for confinement of fusion fuels at high enough densities and temperatures to achieve net power production may be possible. Although many early fusion concepts may have lost out on financial support for further R&D or have much smaller-scale budgets (e.g. stellarators, reversed-field pinches, magnetic mirrors, field-reversed configurations (FRC), magnetic cusps, Z-pinches, theta-pinches, dense plasma focus (DPF), Penning Traps, electrostatic confinement, radio-frequency confinement, etc.), the alternative concepts may still have the potential to work, and to have some practical and economical advantages over the mainstream concepts. Further R&D may help may help uncover physics and engineering solutions to enhance performance.

Potential for Hybrid Fusion-Fission Systems

In addition to pure-fusion systems, another possibility for the not-too-distant future is the development of hybrid fusion-fission systems (e.g. http://web.mit.edu/fusion-fission/), where a low-Q fusion reactor (Q~1) would be used to provide 14-MeV neutrons from the D-T fusion reaction to drive a sub-critical fission reactor made of thorium or depleted uranium. Such a system could serve as both a burner and breeder for fission fuels, and may act as a technology bridge to developing practical and economical full-fusion systems. A hybrid fusion-fission system may also be more economical than an accelerator-driven sub-critical reactor system, and it would have the ability to burn conventional fissile isotopes and fertile heavy actinides, such as those found in spent fission reactor fuels.

Competition for Funding

Historically, there has tended to be a very competitive environment for getting funding for fusion research. With limited government budgets allocated fusion R&D, at times there have been fierce competitions between various research groups to win funding, sometimes resulting in indirect attacks to discredit each other's work. Thus, a number of research groups have resorted to "fighting over the pie" with the "winner takes all" approach rather than "increasing the size of the pie".

In a number of cases, demonstrated successes, indication of good scaling outcomes, effective technical marketing and clever salesmanship has convinced some government programs and

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wealthy benefactors to focus their investments on very limited number of R&D projects, leaving other proposals to wither.

Hedging One's Bets – A Multi-Prong Approach

In the long-term, it may be better to "hedge one's bets" and take a multi-prong approach to investing in fusion R&D. By historical example, the Manhattan Project to develop nuclear weapons during World War II had taken a multi-prong approach to find ways to enrich uranium and also develop a plutonium-based nuclear explosive. The urgency and necessity of success during war-time helped open up government coffers to support R&D to investigate and test numerous approaches, many which failed, but ultimately resulting in finding solutions that did work.

Thus, while mainstream activities go on in fusion R&D, there is an opportunity and a prudent necessity to investigate as many avenues of fusion research and concepts as reasonably possible, to improve the long-term chances of developing practical and economical fusion-based electric power.