American Nuclear Society
Fusion Energy Division
December 2007 Newsletter

Letter from the Chairman, Roger E. Stoller, Materials Science and Technology Division, Oak Ridge National Laboratory, Oak Ridge, TN.

Writing this first chairman's letter has been a reminder that I am less experienced in the ways and wiles of ANS and the Fusion Energy Division than many of my predecessors. I'd like to thank the previous Chairman, Jeff Latkowski, and the current secretary, Lee Cadwallader, for their assistance in sorting out some of the details of the position.

In addition, trying to find news items of interest to the Division has reminded me of the diversity of the background and interests of the Division membership. I assume ANS initially established divisions based on the perceived common interests of a given group of members. Interest in fusion seems to define a logical subset, particularly in a society with a substantial focus on nuclear fission. However, it is difficult for me to determine what uniquely characterizes the FED membership besides their general interest in turning small atoms into larger ones. At the coarsest level, we may divide between interest in magnetic and inertial fusion systems, both of which have multiple competing concepts. Supporting each concept, we have plasma physicists, materials scientists, computational scientists, mathematicians, and engineers of every stripe – mechanical, electrical, nuclear, civil, and environmental. In fact, this short list doesn't begin to do justice to the range of disciplines and specialties required to support fusion research and the ultimate goal of fusion energy production. This is a reflection of the complex nature of our objective. I think it is fair to say that the realization of usable electricity generation from fusion energy will require building and operating what may be the most challenging engineering structures and systems in human history.

While enduring the pleasures (?) of boot camp in San Diego in 1970, I recall seeing a select group of my colleagues who were members of what was called the Correctional Custody Platoon. They would pass by a couple times a day carrying buckets full of rocks and pushing a large wooden cart filled with bigger rocks and sledge hammers. Their days were spent in mechanical transformation of the large rocks into small rocks. This process was not unlike nuclear fission although it did not provide a net energy gain to the participants – hence the "correctional" component. Working on the U.S. nuclear fission programs has also sometimes seemed like punishment since the late 1970s, although the tide has been more favorable in recent years. To this point, fusion researchers have not had to labor under the gaze of a disapproving public. Perhaps the closest we have come is a skeptical response to predictions of when fusion will be ready for prime time, the perennial 35 years away. The formal initiation of ITER as an international project (see below) brings fusion's day of reckoning significantly closer. Since turning big rocks into small rocks is considerably easier than the reverse process, success will require the disparate collection of fusion scientists and engineers to work in increasingly clever and cooperative ways in the years ahead.

18th TOFE

The Eighteenth Topical Meeting on the Technology of Fusion Energy is scheduled for 28 September to 2 October 2008. It will be held at the Stanford Court Hotel in San Francisco, CA. For more information, see the report below from Jeff Latkowski, who is the General Chairman for the meeting, and visit the meeting website: http://www.18th-tofe.com.

Fusion Reactor Materials

The 13th International Conference on Fusion Reactor Materials will be held in Nice, France from 9-14 December 2007. More than 500 papers have been scheduled for presentation in oral and poster sessions, with 68 presented by researchers from the United States. For more information, see: http://www-fusion-magnetique.cea.fr/icfrm13.

News from FESAC

Since the FED Chairman is an *ex officio* member of the Fusion Energy Sciences Advisory Committee (FESAC), I was able to attend the FESAC meeting on 23 October. Dr. Raymond Fonck, Associate Director for the DOE Office of Fusion Energy Sciences, provided an update of the current budget status for the Office's programs. In spite of the uncertainty associated with operating under a continuing resolution because the Congress has failed to pass a budget, expectations for the 2008 fiscal year seem fairly clear. Budget marks from the responsible committees in both the House of Representatives and Senate are very similar. The primary difference is related to the funding request for the High Energy Density Laboratory Plasma program, which had zero funding in the Senate mark. This difference may be related to a misunderstanding of the nature of the HEDLP program and is expected to be resolved prior to or during Congressional conference committee activities. Three significant issues discussed during the meeting were reports from:

1. Panel on Strategic Planning presented by Dr. Martin Greenwald from MIT
2. NCSX Science Review Panel presented by Prof. Richard Hazeltine from University of Texas
3. Panel on the Fusion Simulation Program presented by Dr. Bill Tang from PPPL.

Details on these panel reports can be found in their presentations that are available at http://www.science.doe.gov/ofes/fesac.shtml. Further information from FESAC is contained in the article by Stewart Prager, FESAC Chairman, later in this issue.

ITER Status

ITER is now officially a live, international project. The International Atomic Energy Agency (IAEA) confirmed that the ITER Agreement entered into force on 24 October 2007, which was 30 days after the IAEA received confirmation of adoption of the Agreement from all Parties according to their national laws and practice. The first session of the now legally-constituted ITER Council was scheduled for 27 and 28 November 2007.

The ITER organization's design review was to be completed by November 2007. This will result in a reference design to serve as the basis for future work, such as resolving a number of pending design change requests. The ITER Council has requested a comprehensive baseline design and Integrated Project Schedule by mid-2008. Additional information on ITER is contained in this issue in an article by Ned Sauthoff, project manager of the U.S. Contributions to ITER Project.

Slate of Candidates for 2008/2009 FED Executive Committee, Jeff Latkowski, Lawrence Livermore National Laboratory, Livermore, CA, and Lee Cadwallader, Idaho National Laboratory, Idaho Falls, ID.

ANS Headquarters will mail out ballots and the candidate list to all 800 members of the FED early next year. Please remember to vote and return your ballot by postal mail. The outcome of the election will be announced before the next FED Executive Committee meeting in June 2008. The FED nominating committee is always looking for fusion professionals, like those listed here, who are willing to serve the division. If you are interested in becoming active in the division, please contact any executive committee member.

We have an excellent set of both inertial and magnetic fusion researchers running for positions in the FED for this election. Their willingness to contribute their time and talents to the division is appreciated by the FED. The current Vice Chair/Chair Elect, Farrokh Najmabadi from the University of California-San Diego, will become the FED Chair at the end of the Executive Committee meeting in Anaheim, CA, in June 2008. Lee Cadwallader, from the Idaho National Laboratory, will continue in his position as Secretary/Treasurer, completing his term in 2009. The immediate Past Chair, Roger Stoller, from Oak Ridge National Laboratory, will become the nominating committee chair. The list of candidates for other positions is given below in alphabetic order:

Vice Chair:	Lance Snead (ORNL)
Executive Committee (3 members to be elected):	Ryan Abbott (LLNL) Hesham Khater (LLNL) Art Nobile (LANL) Wayne Reiersen (ORNL) Alice Ying (UCLA).

18th ANS Topical Meeting on the Technology of Fusion Energy, Jeff Latkowski and Wayne Meier, Lawrence Livermore National Laboratory, Livermore, CA.

Plans are moving along nicely for the Eighteenth Topical Meeting on the Technology of Fusion Energy (18th TOFE). The conference will be held September 28-October 2, 2008 at the Stanford Court Hotel in San Francisco, California. The hotel is located in the city's Nob Hill district, which is centrally located for easy access to Union Square, Market Street and Chinatown.

The conference will begin with a mixer at the conference hotel on the evening of Sunday, September 28, and the technical program begins on Monday, September 29. On the afternoon of Wednesday, October 1, buses will be provided to transport conference attendees to Lawrence Livermore National Laboratory for a tour of the National Ignition

Facility. The conference banquet will be held at Wente Sparkling Cellars immediately after the NIF tour (separate transportation will be available for those not going on the tour). Technical sessions will resume on Thursday, October 2, and the conference will adjourn late that afternoon.

The Fusion Energy Division (FED) of the American Nuclear Society (ANS) will distribute awards for Outstanding Technical Accomplishment, Outstanding Achievement, and the Best Student Paper. Each award consists of a cash prize and a plaque. To be eligible for the award, students must be the lead author on a technical paper, must be enrolled in an undergraduate or graduate degree program, and must submit the full written paper by the first day of the conference (September 28).

As a professional development opportunity, we are planning a satellite workshop on how researchers can gain access to facilities such as the NIF and Omega. Details on this workshop will be available around the first of the year.

The fully functional conference web site will be available around the first of the year. Currently, the call for papers can be found at the site: www.18th-tofe.com. We look forward to seeing you in San Francisco!

Call for Nominations, ANS-FED Awards, Neil B. Morley, University of California-Los Angeles, Los Angeles, CA.

The Honors and Awards Committee of FED/ANS is seeking nominations for Fusion Energy Division of ANS Awards:

1) **Outstanding Achievement Awards:** This award is for recognition of a continued history of exemplary individual achievement requiring professional excellence and leadership of a high caliber in the fusion science and engineering area.

2) **Technical Accomplishment Award:** This award is for recognition of a specific exemplary individual technical accomplishment requiring professional excellence and leadership of a high caliber in the fusion science and engineering area.

Detailed descriptions of the awards and past recipients can be found at http://fed.ans.org/awards.shtml.

Deadline for nominations is July 1, 2008 for the awards to be presented at the 18th ANS Topical Meeting on the Technology of Fusion Energy, to be held 28 September to 2 October 2008 in San Francisco, CA. Nominations from the 2006 ANS TOFE in Albuquerque will automatically be considered.

Nominations can be made by individuals and submitted anytime to the FED Honors and Awards Committee Chair (N. Morley). Nomination package should include:

a) Nominee's CV
b) A description of exemplary achievements
c) Support letters (and/or co-signature on the nomination form).

Details are available at http://fed.ans.org/awards.shtml.

Please send nominations to:

Neil B. Morley
43-133 Engineering IV
Mechanical and Aerospace Engineering, UCLA
Los Angeles, CA 90095-1597
morley@fusion.ucla.edu

Electronic submission via email is encouraged.

FESAC Activities, Stewart Prager, FESAC Chair, University of Wisconsin-Madison, Madison, WI.

The Fusion Energy Sciences Advisory Committee (FESAC) is constituted to provide advice to the Department of Energy (DOE) Office of Fusion Energy Sciences (OFES). Recently, FESAC has been quite active. At its recent meeting (October 23-24, 2007) it issued three reports, each responding to a charge from Dr. Ray Orbach, the Under Secretary for Science at DOE. The reports concerned strategic planning for magnetic fusion energy, the National Compact Stellarator Experiment (NCSX), and the Fusion Simulation Project. Below, we summarize highlights from each report.

In the charge letter on strategic planning, Dr. Orbach notes that past studies indicated that "U.S. involvement in ITER should constitute the penultimate step to consideration of a fusion Demonstration Power Plant (DEMO) in the United States." The crux of the letter states "To assist in planning for the ITER era, it is critical that FESAC identify the issues arising in a path to DEMO, with ITER as the central part of that effort." The task consists of three parts:

1) Identify and prioritize the broad scientific and technical questions to be answered prior to a DEMO
2) Assess available means (inventory), including all existing and planned facilities around the world, as well as theory and modeling, to address these questions
3) Identify research gaps and how they may be addressed through new facility concepts, theory, and modeling.

The charge assumes a direct path from ITER to DEMO, based on the tokamak (and its variants), and perhaps on the stellarator. Inertial fusion approaches and non-tokamak concepts (other than the stellarator) were not considered in this report.

The panel formed to answer the charge was chaired by Martin Greenwald (MIT) and issued a report entitled "Priorities, Gaps, and Opportunities: Toward a Long-Range Strategic Plan for Magnetic Fusion Energy." The scope of the report extends over several decades, but the panel's main interest is to inform decisions about major next steps in the U.S. program. The panel identified scientific and technical questions likely to remain after the successful completion of current and planned research, including ITER, and formulated major research initiatives that could answer those questions. The panel has produced a remarkably comprehensive and informative study. The report identifies 15 broad scientific questions, prioritizes those questions (all of which must be answered for attainment of fusion energy), analyzes the capabilities of the world program, assesses U.S. strengths and weaknesses, summarizes the resulting gaps in our knowledge on a path to DEMO and, finally, identifies research activities that could fill the gaps. The panel identified nine potential initiatives, ranging from targeted research on key topics in fusion science and engineering to large, integrated plasma experiments exploring aspects of the fusion reactor environment. The initiatives cover fusion engineering, materials sciences, and plasma physics. This report forms the basis from which a detailed strategic plan could be developed. The panel recommends the development and implementation of such a plan as soon as possible.

The charge letter regarding the NCSX experiment at the Princeton Plasma Physics Laboratory (PPPL) notes that the project is projecting substantial cost (~ $40 million) and schedule (~ 2 year delay) overruns. The letter further states that the overruns are large enough to add new burdens on the limited resources in the fusion program, and therefore requests FESAC to conduct a scientific and programmatic review of the NCSX program and its potential effect on the U.S. fusion energy sciences program. The review includes evaluation of the critical scientific issues for the U.S. compact stellarator program, the role of NCSX in the international context, and options for the U.S. stellarator program if the NCSX program were not continued.

The panel, chaired by Richard Hazeltine (University of Texas) stressed that stellarators address two key issues in fusion research: disruption avoidance and steady-state operation. Quasisymmetry is a design concept that ameliorates the large neoclassical transport rates associated with more conventional stellarator designs. NCSX is a quasi-axismmmetric stellarator that is more compact than conventional stellarators (NCSX has an aspect ratio of 4.4). The report notes that by virtue of both quasi-axisymmetry and compactness, NCSX offers a similarity to tokamak science that is unmatched by any other stellarator device. It also discusses the potential advantages and disadvantages of compactness for a reactor. NCSX will be unique in the world program, because of both its quasi-axisymmetry and compactness. The committee finds that the comparison of NCSX with LHD (a large stellarator in Japan) and W7-X (a stellarator under construction in Germany) will be extremely useful in understanding the physics optimization of advanced stellarator configuration. Each of the three experiments has different approaches to stellarator design optimization. The panel notes that NCSX is the only proof-of-principle stellarator in the U.S. program, and therefore the only device capable of examining the key issues in an integrated context. If NCSX were abandoned, the U.S. would have to reduce significantly its ambitions in stellarator research. In the absence of

NCSX, a restructured U.S. stellarator program could maintain scientific leadership in selected research areas, but would have difficulty playing a significant role in the direction of the worldwide stellarator program.

In the charge letter for the Fusion Simulation Project (FSP), Dr. Orbach notes that this initiative will be led by OFES with collaborative support from the Office of Advaced Scientific Computing Research. The primary objective of FSP is to produce a world-leading predictive integrated plasma simulation capability that is important to ITER and to major current and planned magnetic fusion devices. A FSP workshop was convened between May 16 and May 18, 2007 to develop a detailed road map. A workshop report was produced by a panel co-chaired by Arnold Kritz (Lehigh University) and David Keyes (Columbia University). The charge letter requests that FESAC critically review the FSP workshop report, assess its feasibility, and recommend a course of action. FESAC is charged to address the workshop report identification of scientific issues, assessment of critical technical challenges, identification of a plan to establish fidelity of the physics modules, identification of critical areas of computational science for which investment would produce tools needed for the FSP, and assessment of issues of management.

The FESAC panel, chaired by William Tang (PPPL), finds that the FSP project report has properly articulated the need for and the potential benefits of the FSP. With regard as to whether the FSP Workshop Report accomplished the five goals listed above, the FESAC panel states a “conditional yes.” That is, in each area the panel had recommendations for additional specificity. The panel also recommends that the FSP move forward to a Project Definition phase of development.

Fusion Award Recipients, Laila El-Guebaly, University of Wisconsin-Madison, Madison, WI.

Fusion awards have been established to formally recognize outstanding contributions to fusion developments made by members of the fusion community. The following awards (listed in alphabetical order) were available to the newsletter editor at the time of publishing this newsletter. We encourage all members of the fusion community to submit information on future honorees to the editor (elguebaly@engr.wisc.edu) to be included in future issues. The ANS-FED officers and executive committee members congratulate the honored recipients of the 2006/2007 fusion awards on this well-deserved recognition and our kudos to all of them.

ANS Awards

At the 5th International Conference on Inertial Fusion Sciences and Applications IFSA-07 conference (Kobe, Japan, Sept. 10-14, 2007), the prestigious ANS/FED Edward Teller Medal was presented to **Kunioki Mima** (Institute of Laser Engineering at Osaka University, Japan) and **Brian Ronald Thomas** (Atomic Weapons Establishment, United Kingdom).

Prof. Mima was recognized for his seminal role in developing an understanding of the physics basis for inertial confinement fusion implosions. He and his group have been leaders in understanding the ultra-intense laser and plasma interactions related to the fast ignition concept.

Dr. Thomas was recognized for his seminal contributions to the use of high-power lasers for High Energy Density Science. He pioneered using indirect drive for studying hydrodynamic phenomena and material properties. These unique applications are the foundation of the emerging field of High Energy Density Science that is attracting international interest.

APS Awards

John Lindl (Lawrence Livermore National Laboratory) is the 2007 recipient of the American Physical Society's prestigious James Clerk Maxwell Prize for Plasma Physics. **Lindl** is cited for 30 years of continuous plasma physics contributions in high energy density physics and inertial confinement fusion research and scientific management.

Andrea M. Garofalo (Columbia University), **Edward J. Strait** (General Atomics), **Gerald A. Navratil** (Columbia University), and **Michio Okabayashi** (Princeton Plasma Physics Laboratory) are the recipients of the APS 2007 John Dawson Award for Excellence in Plasma Physics research. The award cites their work on experiments that demonstrated the stabilization of the resistive wall mode and sustained operation of a tokamak above the conventional free boundary stability limit.

FPA Awards

David E. Baldwin (GA) has received the Fusion Power Associates 2007 Distinguished Career Award that recognizes individuals who have made distinguished lifelong career contributions to fusion development. In selecting Dr. **Baldwin**, the FPA Board noted his many scientific contributions to fusion research over several decades and his leadership of the fusion programs at the Lawrence Livermore National Laboratory and General Atomics. The Board also noted the key policy roles he has played over many years in guiding the national and international fusion efforts.

Richard J. Hawryluk (PPPL) has received the FPA 2007 Leadership Award that recognizes individuals who have shown outstanding leadership qualities in accelerating the development of fusion. In selecting Dr. **Hawryluk**, the FPA Board noted his scientific leadership previously of the Princeton Large Torus (PLT), Princeton Divertor Experiment (PDX), and Tokamak Fusion Test Reactor (TFTR) projects and, more recently, the National Spherical Torus (NSTX) and National Compact Stellarator (NCSX) projects. In addition, the Board also noted his recent involvement with the ITER Working Groups that are providing much needed input for final design decisions for ITER.

Brian D. Wirth (University of California, Berkeley) received the FPA 2007 Excellence in Fusion Engineering Award that recognizes individuals in the early part of their careers who have shown both technical accomplishment and potential for becoming exceptionally influential leaders in the fusion field. In selecting Professor **Wirth**, the FPA Board noted his many scientific contributions to the international fusion materials research program and, in particular, his outstanding papers on computational simulation of radiation damage events in irradiated fusion materials.

IEEE/NPSS and SOFE Awards

The IEEE/NPSS awards recognize outstanding contributions to research and development in the field of Fusion Technology. They were presented, along with the SOFE Best Student Paper Award, at the 22nd Symposium on Fusion Engineering – SOFE-2007 (Albuquerque, NM, June 18-22, 2007):

Farrokh Najmabadi (University of California, San Diego) was awarded the 2007 IEEE/NPSS Fusion Technology Award for his outstanding and innovative technical leadership in the development of fusion energy, for his contributions to the merging of physics and engineering considerations into the development of attractive fusion reactor concepts, and for his many years of service to the fusion energy sciences community.

Brandon M. Smith, a graduate student at the University of Wisconsin-Madison was awarded the 22nd SOFE Best Student Paper Award for a paper entitled "3-D Neutronics Analysis of the ITER First Wall/Shield Module 13." **Brandon** recently finished his first year of graduate school at the University of Wisconsin in the Engineering Physics Department.

Steven Zinkle (Oak Ridge National Laboratory) was awarded the 2006 IEEE/NPSS Fusion Technology Award for his outstanding contributions to the understanding of radiation effects in materials and his exceptional leadership in the U.S. fusion materials program.

IEEE/PPPS Award

Siqi Luo, a graduate student in electrical and computer engineering - University of Wisconsin-Madison, won the 2007 IEEE PPPS best paper award and $500 prize for the paper "Atmospheric Pressure Laser Initiated and Radio Frequency Sustained Plasmas." IEEE chose the paper from about 75 student-authored publications. **Luo** received the honor at the Albuquerque International Pulsed Power and Plasma Sciences conference in June 07.

MA-FNT Awards

The Miya-Abdou awards were presented at the 8th International Symposium on Fusion Nuclear Technology (Heidelberg, Germany, October 1-5, 2007). The award aims at acknowledging outstanding technical contributions to the field of Fusion Nuclear Technology at a young age, 40 y or younger.

Two 2007 awards were presented to:

- **Dr. Olivier Gastaldi** (CEA, France) in recognition of his outstanding technical contributions to the Tritium and Fuel Cycle Technology and Engineering.
- **Dr. Hiroyasu Tanigawa** (JAEA, Japan) in recognition of his outstanding technical contributions to the Fusion Structural Materials and Blanket Engineering.

News from Fusion Science and Technology (FS&T) Journal, Nermin A. Uckan, FS&T Editor, Oak Ridge National Laboratory, Oak Ridge, TN.

During the past 12 months period (from Oct. 1, 2006 to Sept. 30, 2007), we have received a total of 358 papers. Of the 358 papers, 177 are from North America, 70 are from Asia, 96 are from Europe (including Russia), and 15 are from other countries. During this period we have also received 118 camera-ready papers from the 2006 International Conference on Open Magnetic Systems for Plasma Confinement (OS06), published in FS&T Transactions (Mar07). OS06 papers are not included in paper counts.

In CY2007 (Volumes 51 & 52), FS&T published about 2410 pages with the following breakdown: 875 pages in typeset regular issues; 310 pages in camera-ready regular issue; 790 pages in camera-ready/regular issue Proceedings (TOFE06); and 435 pages in camera-ready Transactions (OS06).

The following special (dedicated) issues have been published in 2007:
- Stellarators (Part 3) – FS&T Jan07 (15 papers)
- NCSX Stellarator – FS&T Feb07 (7 papers)
- Alcator C-Mod Tokamak (MIT) – FS&T Apr07 (14 papers)
- IFE Target Fabrication – FS&T May07 (49 papers, camera-ready)
- EC Wave Physics, Technology and Applications (Part 1) – FS&T Aug07 (23 papers)
- TOFE06 Proceedings (Parts 1 & 2) – FS&T Proc., Oct/Nov 07 (135, camera-ready)
- Open Systems 2006 – FS&T Transactions, Mar07 (118 papers, camera-ready).

The following dedicated issues are planned/under consideration for 2008:
- EC Wave Physics, Technology and Applications (Part 2) – FS&T Jan08 (24 papers)
- MFE Diagnostics (EU, JA, RF, US) – FS&T Feb08 (13 papers, over 500 pages)
- JET Tokamak (EU) – FS&T regular issue (12 papers – to be scheduled)
- ARIES Compact Stellarator Study – FS&T regular issue (12 papers, under review)
- 8th Int. Conf. on Tritium Sci. & Technol. 2007 – FS&T Proc. (2 issues, papers due)
- 8th Carolus Magnus Summer School – FS&T Transactions (papers due late 2007).

The following issues are in the planning stages for 2009 and beyond:
- JT-60SA (JA-EU Broader Approach) – FS&T regular issue (in planning/preparation)

- DEMO Studies (EU, JA) – FS&T regular issue (in planning/preparation)
- IFMIF (EU-JA Broader Approach) – FS&T regular issue (in planning/preparation)
- KSTAR (Korea) – FS&T regular issue (under discussion)
- W7-X (Germany) – FS&T regular issue (under discussion)
- Test Blankets (EU, JA, RF, US) – FS&T regular issue (under discussion/on hold).

FS&T has been offering color printing for special issues for the past several years and recently started offering color online figures for black and white print issues (tested in April 2007 with Alcator C-Mod special issue). All (regular/special) FS&T issues are now color online.

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Please send your comments and suggestions on FS&T content and coverage and potential future topical areas that are timely and of interest to mailto:fst@ans.org.

ONGOING FUSION RESEARCH:

The Role of the Virtual Laboratory for Technology in Fusion Research,

Stanley L. Milora, Oak Ridge National Laboratory, Oak Ridge, TN.

The Virtual Laboratory for Technology (VLT) represents the diverse activities of 24 U.S. organizations involved in fusion technology research and development for the U.S. DOE Office of Fusion Energy Sciences. The VLT is organized into 11 technical program elements that span the spectrum of technologies required to carry out its mission

> "*To contribute to the national science and technology base by:*
> 1) *Developing the enabling technology for existing and next-step experimental devices,*
> 2) *Exploring and understanding key materials and technology feasibility issues for attractive fusion power sources,*
> 3) *Conducting advanced design studies that integrate the wealth of our understanding to guide R&D priorities and by developing design solutions for next-step and future devices.*

The three legs of this mission are critical elements of the DOE mission to develop the knowledge base for practical magnetic fusion energy systems.

ITER Project Support

ITER has recently become the primary focus of the VLT's first mission. As the first fusion device to operate at high levels of sustained fusion power, ITER will provide significant opportunities (and challenges) to advance the development of enabling technologies to the scale required for follow-on devices that will deliver commercial levels of electrical power production. VLT participants led in the planning activities and are actively engaged in design, R&D and qualification of many of the U.S. ITER Project Office (USIPO) hardware packages, including:

- The 13-T, 277-V·s central solenoid magnet assembly and toroidal field conductor that requires development of Nb_3Sn superconducting wire that exceeds the performance of currently available wire.
- The feed system for the 20-MW ion cyclotron heating and current drive antenna which will require the development of actively cooled coaxial transmission lines operating at up to 5 MW each.
- Low loss electron cyclotron transmission lines and mode control units that supply the 24-MW electron cyclotron heating and current drive launchers at up to 1 MW/line.
- A gas gun based DT pellet fueling system that continuously supplies 5-mm diameter cryogenic DT pellets at mass throughput requirements, significantly beyond present-day designs.
- Twenty percent of the actively cooled Be-clad first wall armor panel and shield block module assemblies that must withstand the combined effects of ~0.5 MW/m^2 surface heat loads from the plasma, erosion, and nuclear heating levels of ~10 MW/m^3.
- The exhaust gas processing system that separates hydrogen isotopes from water, methane and inert gases from the exhaust stream of 400- to 3000-s-long tokamak pulses at high throughput and with very high decontamination factors.

Also, many VLT participants have been actively engaged in several cross cutting supporting activities for both the USIPO and the ITER International Organization. These include the development and evaluation of cast stainless steel alloys as a lower cost shield block fabrication option, 3-D CAD based high fidelity neutronics modeling of all in-vessel components, and analysis and mitigation of hazard potentials associated with substantial tritium inventories and various energy sources (chemically reactive dust, high magnetic fields, etc.).

Research Supporting ITER and Utilization of ITER as a Test Bed

Apart from direct contributions to the ITER project, the VLT has been conducting research and developing and deploying on fusion research facilities advanced technologies that are expected to eventually be incorporated in ITER to improve its operation and performance. These include:

- Massive gas injection systems for mitigating the effects of plasma disruptions – this will be tested on DIII-D.
- Pellet pacing systems to reduce peak heat loads on plasma facing components caused by edge localized modes (ELMs) – this will be tested on DIII-D.
- An ITER-like load tolerant high power density (9 MW) ion cyclotron antenna concept that allows the radio frequency transmitters to operate closer to full power output – this has recently been deployed on JET in collaboration with the European Fusion Development Association.

- Research on electron cyclotron heating systems, using gyrotrons that employ depressed collector technology and improved internal mode convertors, promises to deliver 1.5 MW systems at overall efficiencies exceeding ITER's target of 50%.
- Mixed material experiments on the PISCES device have revealed a synergistic effect of Be in deuterium plasmas that substantially reduces chemical sputtering of carbon from graphite targets and hence the source of tritium co-deposition from the ITER divertor.
- Researchers are investigating the potential of tungsten as an alternative to carbon and Be as the materials for plasma facing components of the first wall and ITER divertor.

As part of its mission to demonstrate the scientific and technological feasibility of fusion, ITER will deploy several test blanket modules using various combinations of coolants employing solid and liquid breeders for testing tritium breeding concepts. VLT participants have been engaged in international planning activities for the ITER test blanket module (TBM) program and have taken the lead on developing an advanced PbLi self cooled TBM concept. Using helium cooled reduced activation ferritic steel (RAFS) for the TBM structure and silicon carbide composite flow channel inserts to electrically and thermally insulate the flowing PbLi primary coolant from the steel structure, this concept has the potential to operate at high temperature for the extraction of higher grade heat. This focused activity integrates the efforts of several program elements of the VLT (chamber systems, neutronics, materials science, plasma-facing components, and safety and tritium).

Beyond ITER

ITER is the stepping stone to devices that must employ (or develop) high performance materials and fusion nuclear technologies that are required for electrical power production. The VLT conducts broadly based research in these areas primarily through its Materials Science, Chamber Systems, Safety and Tritium Research and ARIES program elements. The materials program focuses primarily on basic and applied research on reduced activation conventional and advanced ferritic steels and SiC composites, advanced functional materials, and cross cutting theory and modeling of radiation effects on the mechanical properties of materials, with emphasis on the effects of helium. A long standing collaboration with the Japan Atomic Energy Agency is investigating the effects of thermomechanical processing, joining, and low dose neutron irradiation on conventional and advanced nanostructured ferritic steels that possess superior high temperature strength. Another important collaboration with Japan's National Institute of Fusion Sciences is addressing a range of technical issues associated with tritium breeding blankets with emphasis on synergistic effects of neutron irradiation on plasma and pressure driven tritium permeation through first wall/blanket materials (W and W coated RAFS). In association with the Chamber Systems and Tritium Research programs, this collaboration will also investigate the complex MHD flow patterns in prototypical liquid metal breeder geometries and the solubility of tritium in PbLi coolant at extremely low partial pressures.

Finally, the ARIES advanced systems studies program integrates our present understanding of magnetic confinement systems and state-of-the-art technologies to examine the potential of the portfolio of fusion concepts as power sources. Relying extensively on new 3-D design and analysis tools, the ARIES team has recently completed the compact stellarator (CS) study, concluding that a CS power plant with acceptable alpha power losses can be similar in size to an Advanced Tokamak.

Attractive Scenarios for Managing Fusion Active Materials: Recycling and Clearance, Avoiding Disposal, Laila El-Guebaly, University of Wisconsin-Madison, Madison, WI.

After decades of designing magnetic and inertial fusion power plants, it is timely to develop a new framework for managing the large volume of activated (and contaminated) materials that will be generated during plant operation and after decommissioning – a framework that takes into account the lessons learned from numerous international fusion and fission studies and the environmental, political, and present reality in the U.S. and abroad. Since the inception of fusion projects in the early 1970s, the majority of power plant designs have focused on the disposal of active materials in geological repositories as the main option for handling the replaceable and life-of-plant components, adopting the preferred fission waste management approach of the 1960s. Because of the sizable amount of fusion active materials, limited capacity of existing repositories, and the political difficulty of constructing new repositories worldwide, managing the continual stream of radioactive fusion materials cannot be relegated to the back-end as only a disposal issue. Concerns about the environment, radwaste burden for future generations, lack of geological repositories, and high disposal cost direct our attention to more environmentally attractive scenarios, such as:

- Recycling and reuse within the nuclear industry
- Clearance or release to the commercial market, if materials contain traces of radioactivity.

There is a growing international effort in support of this new trend [1]. In recent years, recycling and clearance became more technically feasible with the development of advanced radiation-resistant remote handling (RH) tools that can recycle highly irradiated materials and with the introduction of the clearance category for slightly radioactive materials by national and international nuclear agencies [2]. Such recent advances encouraged many designers to apply recycling and clearance to all fusion components that are subject to extreme radiation levels: very high levels near the plasma and very low levels at the bioshield.

How Much Radioactive Material Does Fusion Generate?

Fusion power cores generate a sizable volume of active materials (AM) relative to fission reactors. To put matters into perspective, we compared ITER, the advanced ARIES tokamak (ARIES-AT), and a compact stellarator (ARIES-CS) to ESBWR (Economic Simplified Boiling Water Reactor) – a Gen-III^{+} advanced fission reactor. Figure 1 displays the notable difference in sizes and a typical classification into high-level waste

(HLW), low-level waste (LLW), and clearable materials that contain traces of radioactivity.

Surrounding the fusion power core is the bioshield, a 2-3 m thick, steel-reinforced concrete building that essentially protects the public and workers against radiation. Being away from the plasma source, the bioshield is subject to low radiation and contains very low radioactivity. However, its volume dominates the waste stream. Since burying such a huge volume of slightly activated materials in geological repositories is impractical, the US Nuclear Regulatory Commission (NRC) and the International Atomic Energy Agency (IAEA) suggested the clearance concept where such components could temporarily be stored for the radioactivity to decay, then released to the commercial market for reuse as shielding blocks for containment buildings of licensed nuclear facilities, concrete rubble base for roads, deep concrete foundations, non-water supply dams for flood control, etc.

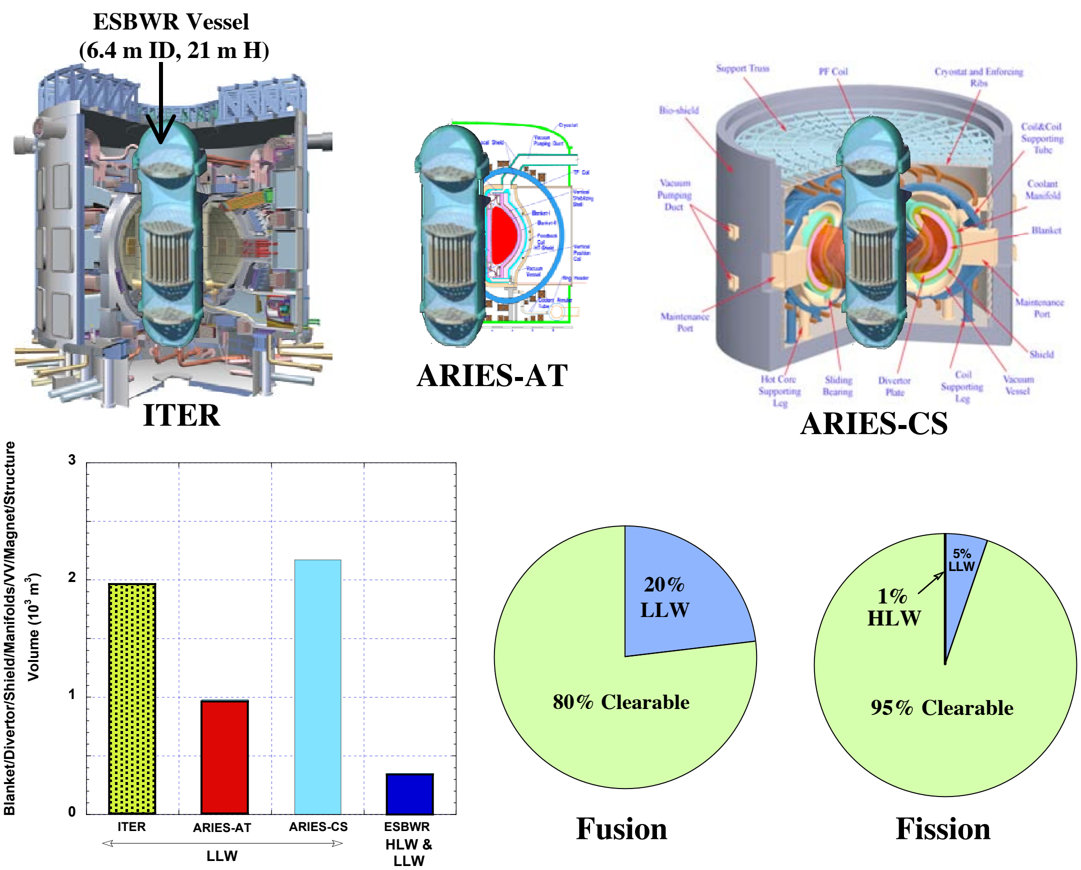

Figure 1. Comparison between selected fusion devices and vessel of advanced fission reactor.

The Disposal Option

To date, and after 50 years in the energy market, the nuclear industry continues to struggle with the management of radioactive waste from fission power plants. The reason is that, while radioactivity and toxic hazard can be estimated for many years, the prediction of geological and climatology conditions is less accurate for longer times into the future. This is probably one of the biggest advantages of fusion power vs. fission: it does not produce large volumes of long-lived radionuclides. Moreover, future availability of LLW disposal capacity [3] and disposal cost are highly uncertain and regulatory standards tend to become more stringent with time. Therefore, recent efforts suggest minimizing the AM sent to repositories by recycling and clearance.

The majority of fusion power plants will generate only low-level waste that requires near-surface, shallow-land burial as all fusion materials are carefully chosen to minimize the long-lived radioactive products. The LLW will decay to dismissal level during the period of active institutional control, typically around 100 years. In the U.S., the disposition of LLW by shallow-land burial is performed on a regular basis at three commercial land disposal facilities: the Barnwell facility in South Carolina, the Clive facility in Utah, and the Richland facility in Washington [3]. Beginning in July 2008, the Barnwell repository may limit the amount of LLW that they currently accept. Many nuclear facilities are currently storing their LLW and HLW onsite because of the limited and expensive offsite disposal options.

Several critical issues for the disposal option can be identified based on the outcome of numerous fusion studies:

- Large volume to be disposed of (7,000 - 8,000 m^3 per plant, including bioshield)
- Immediate or deferred dismantling?
- High disposal cost (for preparation, packaging, transportation, licensing, and disposal)
- Limited capacity of existing LLW repositories
- Need for fusion-specific repositories designed for T-containing activated materials
- Political difficulty of building new repositories
- Tighter environmental controls
- Radwaste burden for future generations.

The Recycling Option

At present, a reasonable recycling experience exists within the fission industry. In the U.S., the Department of Energy (DOE) has operated small-scale “restricted” releases of mildly radioactive materials to the nuclear industry throughout the 1990s. With the renaissance of nuclear energy, it seems highly likely that recycling technology will continue to develop at a fast pace to support the mixed-oxide (MOX) fuel reprocessing system and the Global Nuclear Energy Partnership (GNEP) initiative that seeks expanding the worldwide use of fission nuclear power. Fusion has a much longer timescale than 30 years. Developing its long-term strategy, fusion will certainly benefit from the ongoing fission recycling experience and related governmental regulations.

Recycling processes include storing in continuously monitored facilities, detritiation, segregation of various materials, crushing, melting, and re-fabrication [4]. Most fusion AM contains tritium that could introduce serious complications to the recycling process. Detritiation treatment prior to recycling is necessary for fusion components with high tritium content. Today, advanced RH equipment (that can handle up to 10,000 Sv/h) is available in the nuclear industry, in hot cells and reprocessing plants. The vast majority of fusion components can potentially be recycled using conventional and advanced RH equipment [1].

There is no doubt within the fusion community that recycling has a key role to play to help minimize the volume of radioactive materials assigned for geological disposal. However, some argue recycling could result in substantial technological difficulties, while others claiming the environmental benefits far outweigh any adverse effects. In fact, there was a cost saving in recycling lead shielding bricks at INL versus disposal in U.S. LLW repositories [5]. Moreover, tests with INL shielding containers showed that millwright composition adjustments after slag removal in the foundry produced metal alloys with properties very similar to, or equal to, those of fresh alloys.

Recycling should be pursued despite the lack of detail on how to implement it now. In order to provide a broader perspective of the relevant issues involved in the recycling process, several critical issues should be examined with dedicated R&D programs:

- Development of radiation-resistant RH equipment (> 10,000 Sv/h)
- Large interim storage facility
- Energy demand for recycling process
- Cost of recycled materials
- Treatment and complex remote re-fabrication of radioactive materials
- Radiochemical or isotopic separation processes for some materials, if needed
- Efficiency of detritiation system
- Any materials for disposal? Volume? Radwaste level?
- Properties of recycled materials? Any structural role? Reuse as filler?
- Aspects of radioisotope buildup by subsequent reuse and radiotoxicity buildup
- Recycling plant capacity and support ratio
- Acceptability of nuclear industry to recycled materials
- Recycling infrastructure.

The Clearance Option

Several regulatory agencies suggested the unconditional clearance option where slightly radioactive components (such as the bioshield) after decontamination can be handled as if it is no longer radioactive. This means solid materials containing traces of radioactivity can be reused without restrictions, recycled into a consumer product, or disposed of in a non-nuclear landfill, with no controls. If necessary, it could be stored safely at an onsite (or offsite) interim storage facility for a specific period, beyond the licensed operational life of the plant, then released to the commercial market for reuse.

Recent clearance guidelines have been issued by several national and international organizations [2]. They all recommend an individual dose for cleared solids of 10 μSv/y

(< 1% of the natural background radiation). The in-vessel components (FW, blanket, and shield) are not clearable. With a strict impurity control on Nb and other impurities, the vacuum vessel could qualify for clearance after an interim storage period (< 100 y) along with a few magnet constituents, cryostat, and bioshield, representing ~80% of the total active material volume. Clearing the majority of fusion materials frees ample space in the geological repositories for more radioactive waste.

As clearance is highly desirable for the nuclear industry, the NRC, IAEA, and other organizations should continue developing clearance standards for all radioisotopes of interest to fission and fusion applications. There is no established clearance market in the U.S. Nevertheless, some experience already exists in several European countries: Sweden, Germany, Spain, and Belgium. Currently, the U.S. industries do not support unconditional clearance claiming it could erode public confidence in their products and damage their markets. However, there have been some steps forward in clearance. Several U.S. societies and organizations have published guidance on clearance indicating it can be conducted safely with no risk to public health. And clearance has been performed in the U.S. since the 1990s only on a case-by-case basis during decommissioning projects.

Other clearance-related issues that need further assessment include:

- Discrepancies between US-NRC & IAEA clearance standards [2]
- Impact of missing radioisotopes on CI prediction
- Need for fusion-specific clearance limits
- Large interim storage facility
- Clearance infrastructure
- Availability of clearance market.

Concluding Remarks

Recycling and clearance are the most environmentally attractive solutions, offering a significant advantage in terms of minimizing the volume of fusion radwaste and avoiding the waste burden for future generations. We call upon the worldwide conceptual power plant designers to minimize the volume of active waste by clever design and choice of material, mandating the use of recycling and clearance, if technically and economically feasible, even if we lack the details of how to implement them today in our designs. At present, the experience with recycling and clearance is limited, but will be augmented significantly by advances in spent fuel reprocessing (that deals with highly radioative materials), fission reactor dismantling, and bioshield clearing before fusion is committed to commercialization in the 21st century and beyond.

While recycling/clearance is a tense, contentious political situation, there has been some progress. For instance, limited scale recycling within the nuclear industry has been proven feasible at several U.S. national laboratories and in Europe. A clearance market currently exists in Spain, Germany, Sweden, Belgium, and other European countries. In the U.S., the free release has been performed only on a case-by-case basis during decommissioning projects since the 1990s. While the clearance process has been ongoing for decades, a more uniform and universal process is highly desirable.

To promote fusion as a nuclear source of energy with minimal environmental impact, the fusion development strategy should be set up to accommodate this new active material management trend. A dedicated R&D program could optimize the waste management scheme further and address the critical issues identified for each option. Seeking a bright future for fusion, we provide the following general recommendations for making sound decisions to restructure the framework of handling fusion active materials:

- Fusion designers:
  - Continue developing low-activation materials. Stringent specifications on impurities could be relaxed by developing advanced recycling tools
  - Minimize radwaste volume by clever design
  - Promote environmentally attractive scenarios such as recycling and clearance, and avoid geological burial
  - Identified critical issues should be investigated for all three options
  - Technical and economic aspects must be addressed before selecting the most suitable radwaste management approach for any fusion component.
- Nuclear industry and organizations:
  - Continue developing advanced radiation-resistant remote handling equipment capable of handling 10,000 Sv/h or more
  - Nuclear industry should accept recycled materials from dismantled nuclear facilities
  - National and international organizations (US-NRC, IAEA, etc.) should continue their efforts to show that clearance can be conducted safely with no risk to public health
  - Regulatory agencies should seriously take into account fusion-specific and advanced nuclear materials and issue official guidelines for the unconditional release of clearable materials.

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INTERNATIONAL ACTIVITIES:

ITER Update, Ned Sauthoff, U.S. ITER Project Office, Oak Ridge National Laboratory, Oak Ridge, TN.

The ITER Agreement is now in full force! Following the November 21, 2006 signatures of the Agreement by the ministers of the 7 ITER parties, the agreement then entered into a process of ratification. Following China's completion of ratification in September, a 30-day waiting period was completed and the ITER Agreement came into force and the ITER Organization came into existence on October 24. This milestone marks the beginning of ITER construction, a long-awaited event for the demonstration of the scientific and technological feasibility of fusion power.

Also during the past year, the parties have been actively engaged in the ITER Design Review to update the project baseline. Parties and the ITER team submitted "issue cards" to identify concerns and possible directions for resolution. These cards were then referred to 8 working groups. The Chairmen and Co-Chairmen of the Design Review Working Groups were

- Physics and Requirements (P. Thomas, D. Campbell)
- Safety and Licensing (J.P. Perves, J.P. Girard)
- Buildings and Site Layout (C. Strawbridge, J. Sovka)
- Magnets (M. Huguet, N. Mitchell)
- Vacuum Vessel and Cryostat (S. Wu, K. Ioki)
- Heating and Current Drive (J. Jacquinot, A. Tanga)
- Tritium Plant (D. Murdoch, M. Glugla)
- In-vessel Components (I. Mazul, M. Pick, C. Lowry)

The parties provided members to these working groups, who mobilized the world fusion program to address the issues and to suggest solutions, producing an update of the 2001 design. The process involved a series of expert meetings that developed recommendations, which were entered into the IO Design Change Control (DCR) system for formal consideration. Approximately 80 design change requests were developed. Principal Deputy Director General Norbert Holtkamp formally concluded the design review at a Technical Coordination Meeting in September. The ITER Organization will present the outcomes of the Design Review at the first official ITER Council meeting in late November. The design changes and issues will be addressed by the project team (both the ITER Organization and the seven Domestic Agencies) and will mature the basis for the Procurement Arrangements that will formalize the assignments of detailed technical scope to the parties.

The U.S. community should be proud of its extensive participation in the ITER Design Review. The U.S. community provided its expertise to the analysis of the issues and the development of recommendations. In many areas, the U.S. was among the most involved parties. This engagement is both encouraging and indicative of the level of interest by the U.S. community, which sees ITER as a research opportunity in both burning plasma science and technology.

Highlights of 2nd IAEA TM on First Generation of Fusion Power Plants,

A. Malaquias, International Atomic Energy Agency (IAEA), Vienna, Austria.

The 2nd IAEA Technical Meeting on "First Generation of Fusion Power Plants - Design and Technology" was organized and hosted by the IAEA Headquarters in Vienna on 20 – 22 June 2007. It follows the first meeting held in 2005 in Vienna. This series of meetings has been initiated under recommendation of the International Fusion Research Council for the IAEA and is expected to initiate, develop and mature ideas on fusion strategy that would benefit all players.

The objectives of this meeting are to:

- Provide a forum to discuss concepts, technology and environmental aspects of future fusion power plants, the next step following ITER, and the role of fusion in future energy mix
- Assess a selection of urgent topics aiming at identifying the physics and technological requirements that ITER and a fusion-grade materials developing program will have to address in support of the construction of DEMO(s) or fusion power plant(s) prototype, demonstrating viable or acceptable economics.

The meeting was organized in five sessions addressing five topics:

- (PPCA) Power Plant Concepts and systems Analysis.
- (MCP) Materials analysis/Component design/Plasma requirements
- (NE) Non-Electric applications of fusion
- (SESE) Social, Economic, Safety and Environmental aspects of fusion
- (EP) Energy Policy, strategy and scenario for fusion development

A summary session took place at the end of the meeting. Thirty-three participants representing 12 countries and 3 International Organizations were present at the meeting.

Highlights

Power plant concepts based on various regional approaches having different targets and leading to different technical solutions were presented:

- In Europe, the three-step approach (ITER, IFMIF, DEMO) being sequential, based on budgetary considerations, may not be the fastest track. The fusion track could be accelerated at the cost of increasing the risk and following more conservative aims.
- In Korea, power plant studies are ongoing and results where presented from a code that finds the design parameters which satisfies the plasma physics and engineering constraints or optimizes the design depending on the given figure of merit.
- The development objectives for the Chinese power plant concept are to continue the domestic plasma research effort using experiments such as HL-2A (HL-2M) and EAST, to strengthen the domestic fusion reactor research and to cooperate with international effort in DEMO design activities. A multiple-function fusion reactor has been proposed based on existing fusion technology for exploiting the possibility of earlier application of fusion energy as a volumetric neutron source.

The Chinese reactor aims at different types of utilization such as fission waste disposal, plutonium 239 breeding from uranium 238, hydrogen production, tritium production, component testing for fusion reactors, and electricity power plant demonstration.

- The Indian power plant concept has been developed based on a code that includes physics and engineering constraints and has been validated by applying it to existing tokamak devices. The design was chosen to be conservative for a power plant delivering 3.3 GW (Q=30).
- A concept of a power plant based on the compact stellarator configuration with dimensions comparable to advanced tokamaks was presented as a possible U.S. option. Reduction in the cost of electricity and significant reduction of radwaste volume have been achieved in the present compact design when compared to conventional stellarators.

Detailed results for several concepts were presented for the divertor heat load indicating that with 3 GW fusion power and 200 MW heating power, the radiated power fraction should be above 60%. The studies showed how the liquid or gas coolant choice impacts the radial build. As for the conversion processes several cycles, alternative to the Rankine, were discussed, such as the indirect Brayton and the supercritical Rankine cycles, offering improvements to the overall conversion efficiency. One presentation addressed the concept of an inertial fusion energy power plant. In this new concept, the pre-compressed fuel core (1000 x solid density) is directly heated to 5 keV with a pico-second laser pulse from a heating laser. This fast ignition scheme enables designing a power plant with a 1 MJ-class, compact laser whose output energy is 1/4 of the previous central ignition scheme.

The environmental and safety impact of fusion was addressed in three presentations. As for the radwaste management strategy, recycling and clearance seem to be a more attractive path, avoiding the geological disposal. However, much work remain to be done in homogenizing the clearance standards, defining specific fusion guidelines, availability of the clearance market, and the acceptability of the nuclear industry to recyclable materials. In Korea efforts are ongoing in establishing the contents, schedule plan, and strategies in developing regulatory technologies aiming at establishing a future licensing framework for Korean fusion power plants. Failure mode analysis was developed in detail for the Chinese ITER test blanket module based on a bottom-up approach. All the possible failure modes that could occur in the operating states were evaluated in terms of accident frequencies and relative category classification, failure cause and possible action to prevent the failure, consequences and actions to prevent or mitigate the impact of the resulting consequence.

Detailed work on several blanket concepts have been presented. In the U.S., GA is developing a study for a new plasma facing component based on boron infiltrated in a W-mesh. This BW-mesh concept is at a very early stage of development and will be tested in DIII-D. Concepts for integration of the Helium Cooled Pebble Bed blanket into the power plant using the ‘Multi-Module-Segment’ (MMS) were discussed in detail. One of the main advantages is that this connection does not have to be handled from inside the vessel and compensation for EM loads is intrinsic by design. A study of the energy storage system for re-initiating a pulsed fusion power plant with 4-8 h operation and dwell time of 5-20 min was presented. Metal hydrides could be the best candidates for such a system for several reasons, like very large heat of fusion and the option of combining heat from fusion with heat from chemical reaction, thereby increasing the latent heat based thermal storage capacity.

Co-generation of hydrogen was discussed by three authors. As the hydrogen market is potentially three times larger than that for electricity, this co-generation approach would make fusion much more attractive. Blanket designs to cope with the high temperatures (~1000 ºC) at optimal efficiency for hydrogen and electricity production were presented.
Two presentations discussed the role of fusion in the future and the share of fusion in the energy market. The present projections for impact on climate changes indicate that it is absolutely necessary to keep CO_2 concentration below 550 ppm to avoid an average earth temperature increase of 3 ºC. Giving the present trends, it seems justifiable and urgent to strengthen the fusion program developing technology even if in a non-ideal form but faster, by relaxing the targets for the internal cost of electricity for the first generation of fusion power plants. Correspondingly, reduced targets for the technical performance (e.g. plasma scenarios, materials endurance, blanket efficiency) of DEMO(s) aiming at demonstration of fusion electricity production in twenty years, may lead to widespread deployment of fusion power earlier than in previous fast track scenarios. Present projections for China economic growth, population increase and the demand in energy reaching 1.5 TW in 2050 would require a serious strategy on development of energy. The most promising path in satisfying this demand with reduced environmental impact would be to increase the fissile power contribution (now only 1%) to 6% of the total capacity, duplicate the renewable contribution to achieve 30% of operating power plants, and promote high efficiency coal power plants. However, due to limited access to natural uranium ore and increase of radwaste that this development would imply, an aggressive fusion road map is being considered in China to accelerate fusion development. The targets are to achieve steady state operation on EAST in 10 years, contribute to the design, construction, and assembly of ITER, and initiate construction of the first multi-function fusion power plant by 2020-2030.