Japanese Nuclear Energy Policy and Fusion Energy Research

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Japan Atomic Energy Commission (JAEC)

- It is responsible to plan, deliberate and decide a framework for governmental actions to promote research, development and utilization of nuclear energy for the production of energy and the promotion of science and industry, limiting them only to peaceful purposes and assuring nuclear safety and security.
- JAEC decided in 2005 **the Framework of Nuclear Energy Policy** that specified government activities for these purposes across three different time frames; short term, mid-term and long-term and for fostering the foundation of nuclear energy utilization such as human resource development, public involvement and international cooperation.

Short-term Activities

- **The Objective**
  - Improve existing activities for utilizing nuclear energy technologies and nuclear power generation capacity, in particular, so as to be able to utilize them as safely and efficiently as practicable.
  - At that time 53 nuclear power generating units with total installed capacity of 47 GWe were in operation and 4 units with capacity of 3.7 GWe were under construction.
- **Major activities to be promoted**
  - Ask operators to ensure the existence of responsible safety and quality management systems in their organizations so as to maintain low incident rates and high plant availabilities at the plants.

Activities to Foster the Foundation of Nuclear Energy Policy

- Pursue mutual understanding between nuclear operators and the resident around nuclear facilities with a view to establishing a win-win relation between them for sustaining a community worth living.
- Ensure that nuclear materials are used exclusively for peaceful purposes and in a safe and secure manner and support countries embarking on nuclear power to develop an appropriate infrastructure in their governmental, industrial, technical, and educational institutions that assures that nuclear materials are used in safe, secure and proliferation resistant manner.

Mid-term Activities

- **The objective:**
  - Add new technologies and systems that will improve the sustainability of nuclear energy supply with a view to making nuclear power as one of the major measures for reducing greenhouse gas emissions from the energy sector.
  - One of the most important energy policy goals at that time was to pursue a society with significantly reduced greenhouse gas emissions as the environmental damages caused by the carbon-dioxide gas emitted mainly by burning fossil fuels become obvious and are palpable.
- **Activities to be promoted:**
  - Prepare advanced light water reactors.
  - Prepare systems to recycle nuclear fuel and systems for long-term management of nuclear waste.

Long-term Activities

- **The objective**
  - Explore the possibility of radical new energy technologies that will address effectively the challenges of air pollution, climate change and energy supply insecurity.
- **Activities to be promoted**
  - The research and development of the fourth generation fission reactors with increased sustainability and with applicability beyond electricity generation,
  - The research and development of nuclear fusion energy technologies,
  - Basic and generic research that will enable us to define innovative concepts and measures on which future nuclear energy technologies could rely.

On March 11, 2011 the Great East-Japan earthquake and the resulting tsunami hit people and facilities including nuclear power plants located on the Pacific coast of Japan.

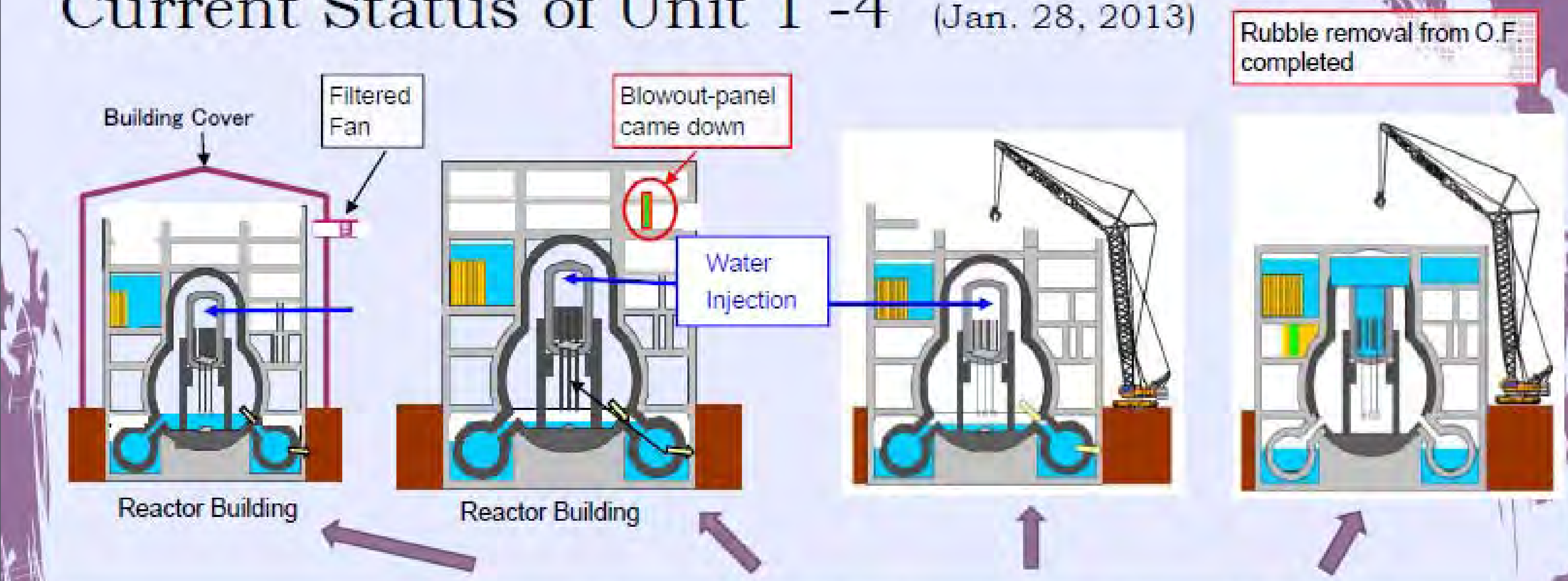
Major Accidents at the TEPCO Fukushima Daiichi Nuclear Power Station

- The station was hit by Magnitude 9.0 earthquake and 15 m tsunami.
- A loss of all off-site power and on-site power left the unit 1-4 without any emergency power.
- The resultant damage to fuel, reactor, and containment caused large-scale releases of radioactive materials to the region surrounding the site over an extended period of time.
- Emergency response activities were executed in high radiation environment, using the roads on which the residue of tsunami and that due to hydrogen explosions in reactor buildings (RBs) housing units 1, 3, and 4 were scattered.

- The fact that this accident has raised concerns about the safety of nuclear power generation around the world is a matter that Japan takes with the utmost seriousness and remorse.

- Japan has received tremendous outpouring of supports and expressions of solidarity from around the world since the event. Taking this occasion, I would like to convey the Japanese people's sincere gratitude to the global community for its support.

Current Status of Unit 1 -4 (Jan. 28, 2013)



	Unit #1	Unit #2	Unit #3	Unit #4
Core Melt	Y	Y	Y	N
Hydrogen Explosion	Y	N	Y	Y
RPV Temp. (℃)	18	31	31	NA
PCV Temp. (℃)	20	32	31	NA
PCV Water level (m)	+2.8	+0.6	Unknown	NA
Dose rate O.F.(mSv/h)	53.6	880	500	1.3
# of SPF	392	615	568	1,533
SFP Temp. (℃)	10	12	9	20

Current Status of the Site

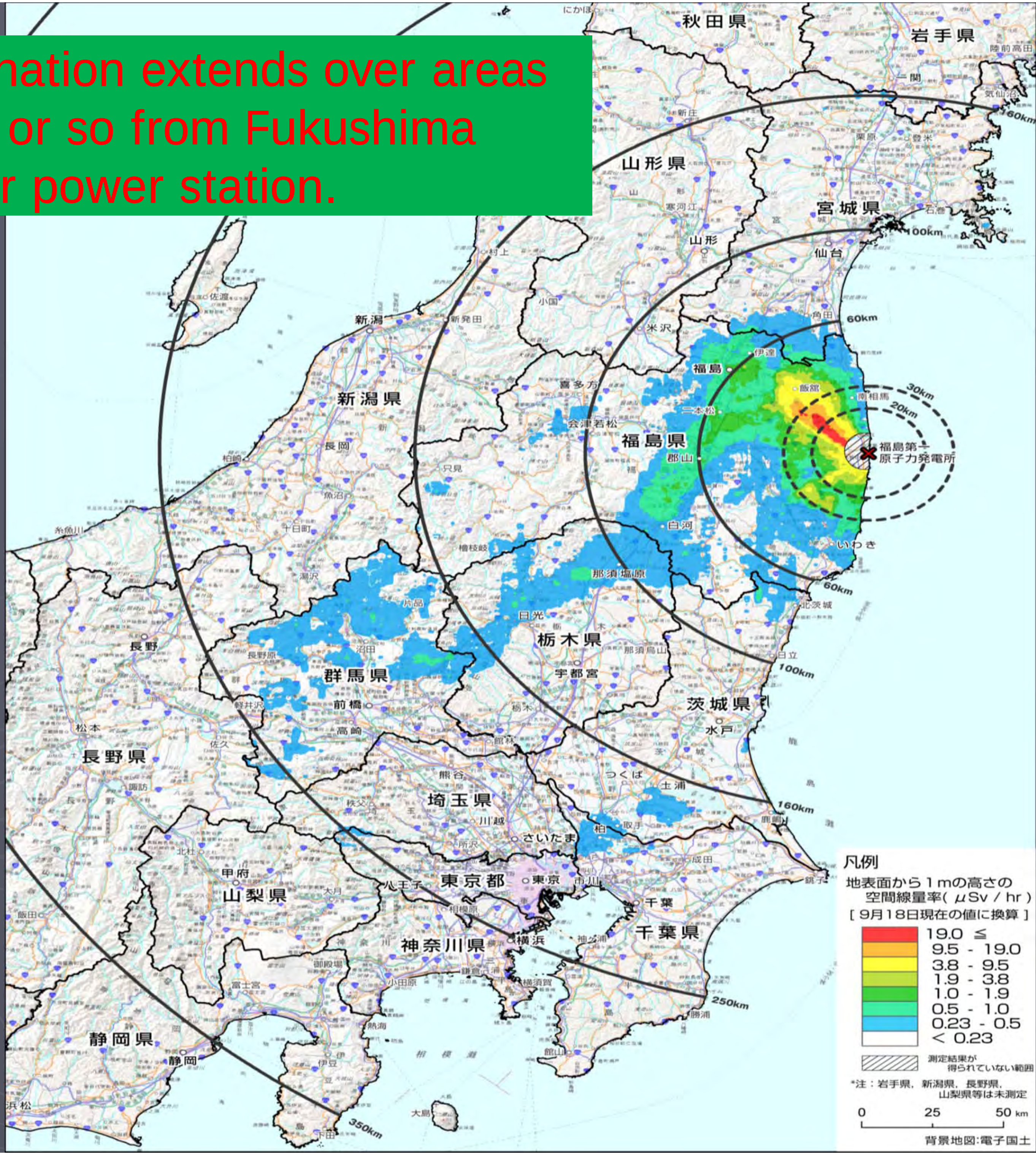
- Major short-term challenges:
  - Improve the reliability of reactor cooling system.
  - Manage contaminated water due to the intrusion of groundwater into RBs, reduction of intrusion, decontamination, storage and deliberate releases to sea.
  - Improve working conditions and assure human resources for cleanup activities.
- Decommissioning: mid-and long-term challenges

  Three phase activities that include necessary R&D projects;
  - Phase 1 to commence fuel removal from spent fuel pools within 2 years: it will be started in November, this year.
  - Phase 2 to commence fuel debris removal from RPVs within 10 years:
  - Phase 3 to complete the decommissioning process within 30 to 40 years.

Major R&D Projects

- Develop various robots and remote manipulation devices for cleanup activities:
- Develop equipment/device to observe the fuel/debris in RPVs and PCVs, and characterize them with a view to preparing for their removal.
- Develop robust models and simulation tools for the analysis of severe accidents, focusing on post accidental heat removal, coolability of relocated reactor core, in-vessel core melt progression, in-vessel molten corium retention, molten-core-concrete-interaction, and corium stabilization in containment:
- Develop technologies for conditioning and storing radioactive waste generated in these activities.

Land contamination extends over areas within 250km or so from Fukushima Daiichi nuclear power station.



Off–Site Consequences

- Some 80,000 people are still requested to be out of home and about the same number of peoples have made choice to leave home. They are suffering from a psychological agony due to the fear of radiation exposure, separation of family, disruption of communities, loss of work, uncertainty in the future etc.
- Though anyone has not been hurt by the radiation so far, the accident has caused thousand or so deaths due to the worsening of diseases owing to dislocation, including emergency evacuation from hospitals, and/or stress in the life in a shelter after dislocation.
- It is sad and painful but true that the sales of the products from Fukushima Prefecture are still continuing to be damaged due to consumer fears and producers choose to be out of work, even though they are not contaminated as the production of agricultural and marine produce is strictly restricted at the place where competent authorities see the danger of contamination.

Off–Site Consequences (Cont'd)

- In the areas where additional exposure is less than 20mSv/y, the Government has been supporting the decontamination of people's living environment with a view to reducing the estimated annual exposure of people by 50 % and that of children by 60 % in 2 years.
- In the areas where additional exposure was higher than 20mSv/y, in which 11 municipalities are located, the Government has started the decontamination work to reduce annual exposure there below 20mSv/y in two years, excluding areas where doses are higher than 50mSv/y.
- The Government is making utmost efforts to start the operation of Interim Storage Facility(s) that will store 15-28 million m^3 waste generated by these decontamination activities.
- Three municipalities have decided, however, that they would not return to hometown in five years, appealing for the uniform remediation of whole area. One of the biggest issues in this respect is the appropriate measure for decontaminating the forests that cover more than 80% of the areas.

Publication of Various Accident Investigation Reports

- The IAEA International Fact-Finding Expert Mission
  - There were insufficient defense-in-depth provisions for tsunami hazards.
- The Independent Investigation Commission of RJIF
  - The crisis was essentially a man-made disaster caused by TEPCO's systematic failures and weaknesses in the government's regulatory regime.
- The Government's Investigation Committee
  - The government and TEPCO failed to prevent the disaster because they were reluctant to invest time, effort and money in protecting against a natural disaster considered unlikely: they were overly confident that events beyond the scope of their assumptions would not occur.
  - A culture of complacency about nuclear safety and poor crisis management led to the nuclear disaster.
- National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission (NAIIC) chaired by Dr. Kurokawa
  - What must be admitted - very painfully - is that this was a disaster 'Made in Japan'. Its fundamental causes are to be found in the ingrained conventions of Japanese culture: our reflexive obedience, our reluctance to question authority, our devotion to 'sticking with the program', our groupism and our insularity.

Where We Are Today

- The release of such judgment made it difficult for the Government to allow nuclear power plant operators to restart their plants after introducing emergency measures to cope with the tsunami attack, directed by the regulator at that time, NISA.
- The Government decided to wait the action to be taken by the Nuclear Regulation Authority (NRA), a newly established independent commission body that solely exercises regulatory authority in the field of nuclear safety and security in Japan. This is the reason why only two units among 50 units or so are in operation at present.
- To compensate the loss of nuclear power generation, electric power companies have increased thermal power generation based on fossil fuels, importing a significant amount of fossil fuels from abroad. The additional payment for this import amounted to 3 trillion yen or so in 2012, which aggravated the trade balance significantly. Furthermore this necessarily caused an increase of 65 million tons of CO_2 emission in 2011 over that in 2010 and in 2012, further increase of 45 million tons over 2011.

Where We Are Today (2)

- The Government is expecting the restart of the operation of idling nuclear power plants as an important power source, when they comply with the new safety regulation rules set by the NRA in July.
- As the majority of the public now regards the nuclear power generation as dangerous to our society, I believe it essential for the electric power companies to sincerely communicate with the public about their preparation for the restart and their resolve to do what they should do at the right time in a right manner and never betray the nation’s right to be safe from nuclear accidents, recognizing their special responsibility to assure nuclear safety.
- The future of nuclear energy policy will be decided, paying due attention to the public perception about nuclear energy that will evolve from such efforts of nuclear energy community.

Fusion Energy R&D

- **Why does Japan promote fusion research?**
  - Because, though fusion research is not easy, its research has the potential to provide a sustainable solution to global energy needs and in particular it can provide a continuous base-load power supply that is sustainable, large-scale and environmentally responsible, using fuels that are universally available.
- **The objectives of the fusion energy R&D are**;
  - To establish the technological basis for tokamak prototype fusion reactors and,
  - To promote scientific understanding and engineering innovation for attractive fusion energy.

To establish the technological basis for tokamak prototype fusion reactors

I. Technologies for producing energy from tokamak fusion plasma

A. Establish technologies for keeping the high pressure and density burning tokamak plasma dominantly heated by self-heating mechanisms:

B. Realize continuous (steady- state) operation of tokamak plasma:

C. Demonstrate power generation using practical blanket modules in a tokamak facility with burning plasmas:

D. Establish system integration technology for tokamak fusion facilities.

II. Technologies essential to the realization of a tokamak DEMO reactor

E. Establish scientific and technological bases for high-beta steady state operation:

F. Develop neutron resistant structural materials with a large operating temperature window:

G. Establish technology bases of fusion power reactors, including heat and particle exhausting divertors, tritium fuel supply system, remote maintenance devices and so on.

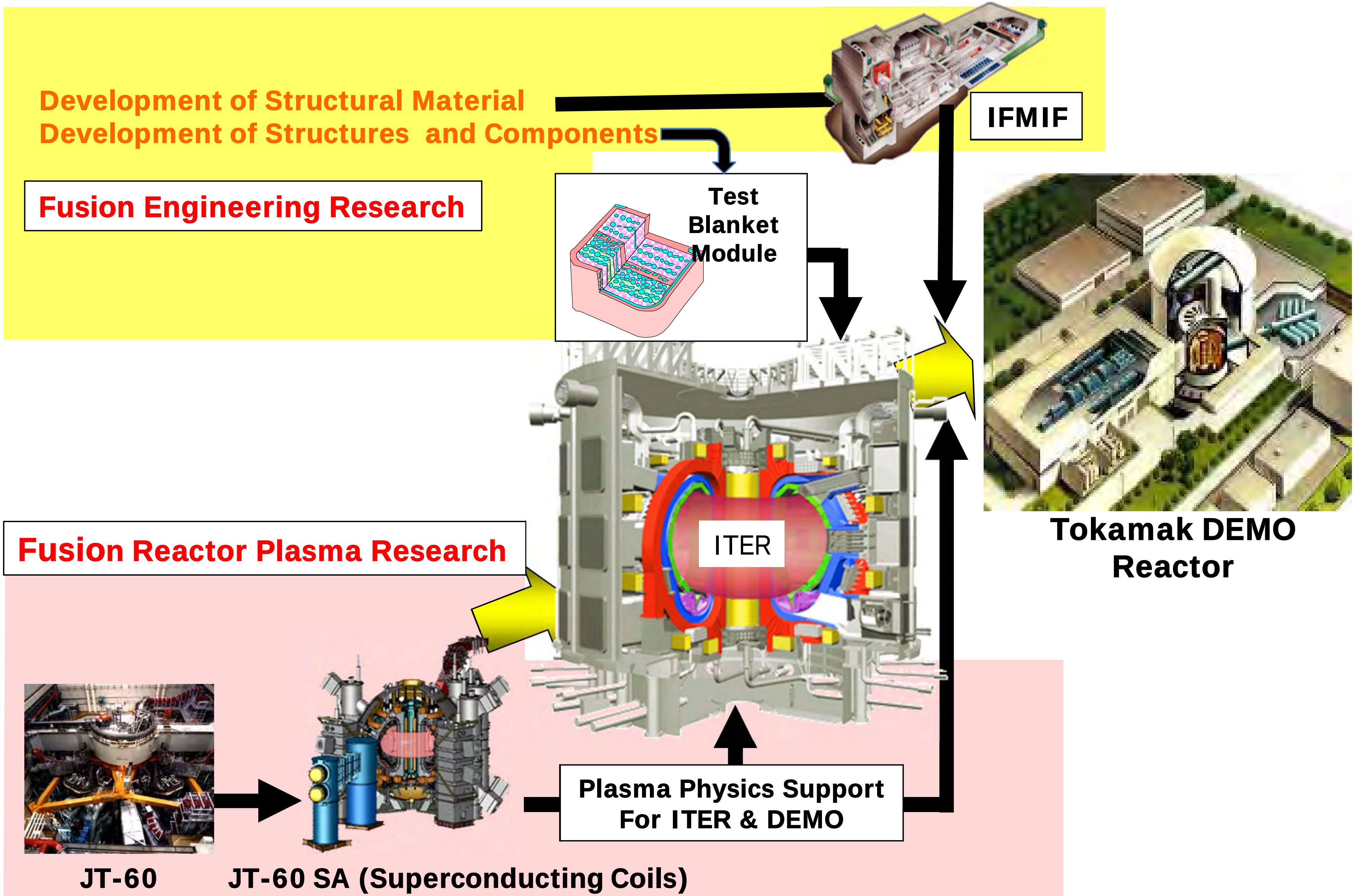
H. Establish fusion power reactor design technology:

I. Fusion plasma physics research based on theory and modeling

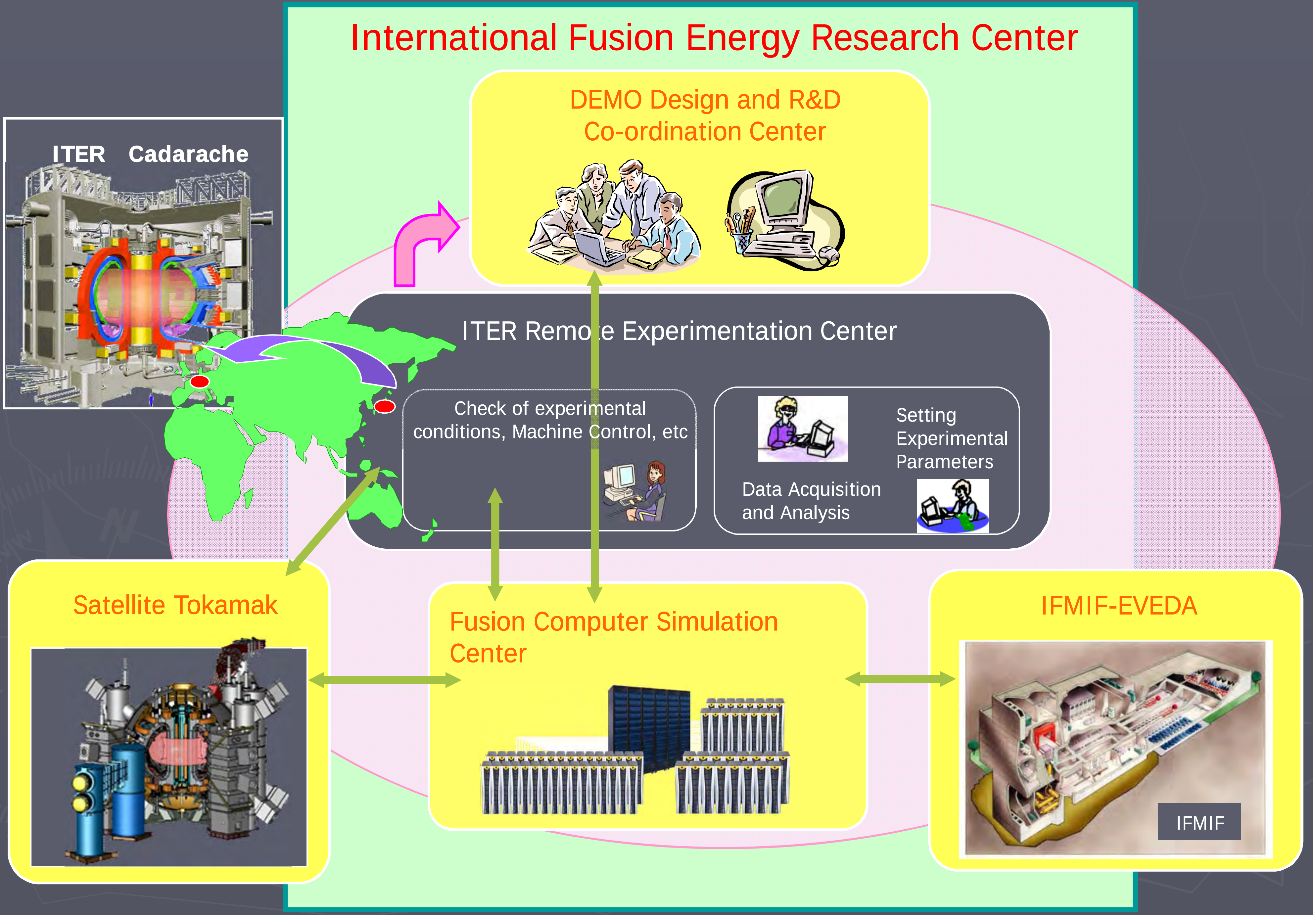
J. Research on social acceptability and environmental safety of fusion power systems.

Roadmap to Tokamak DEMO Reactors

(Oct.2005, AEC)

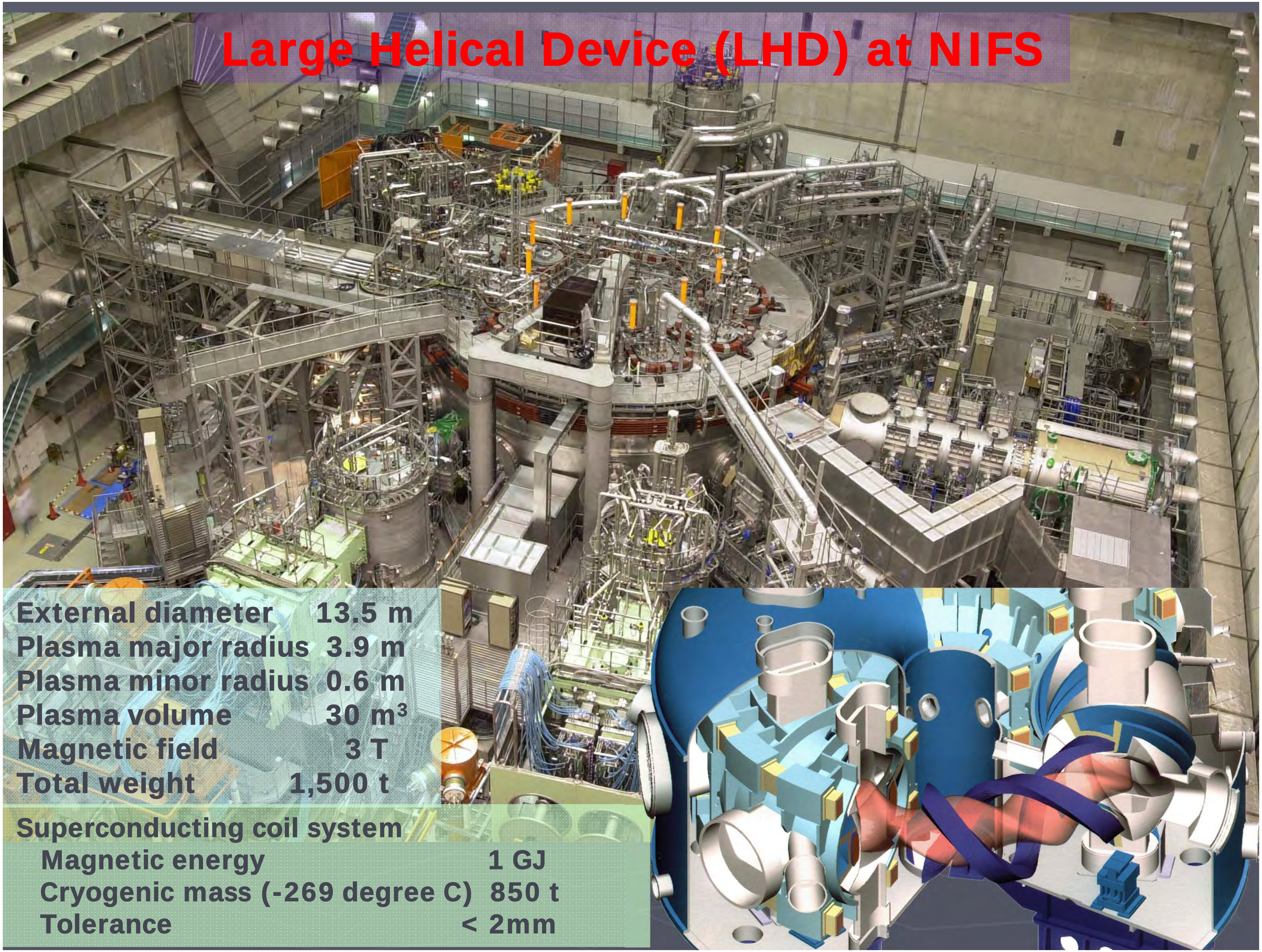


BA Activities toward DEMO



To advance scientific understanding and engineering innovation for attractive fusion energy;

- Promote the studies on
  - The science and engineering of helical fusion plasma at NIFS
  - The inertial confinement fusion using laser at ILE of Osaka University


Large Helical Device (LHD) at NIFS
External diameter 13.5 m
Plasma major radius 3.9 m
Plasma minor radius 0.6 m
Plasma volume 30 m³
Magnetic field 3 T
Total weight 1,500 t
Superconducting coil system
Magnetic energy 1 GJ
Cryogenic mass (-269 degree C) 850 t
Tolerance < 2mm

The Institute of Laser Engineering (ILE) Osaka University

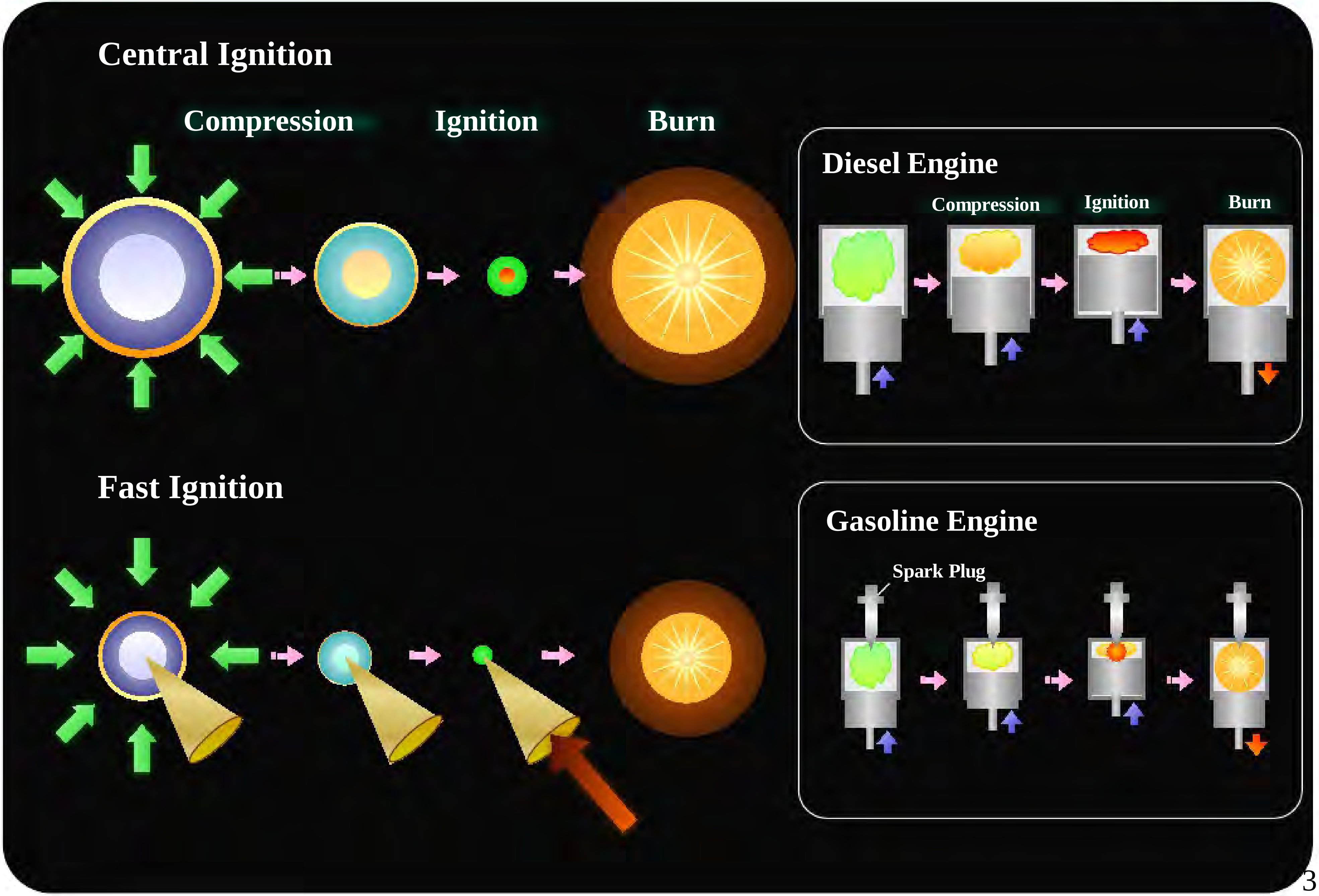
Mission: Establish the high-energy density science, a new science encompassing astrophysics and other fields, which is related to extreme states of ultra high-density, ultra high-temperature, and ultra high-pressure created through the use of high power lasers facilities including GEKKO XII and peta-watt laser.

Laser Fusion Research at the ILE: The ILE is currently promoting the FIREX program that aims at realizing ignition and burning plasma based on fast-ignition laser fusion.

FIREX: Fast Ignition Realization EXperiment

So far, heating to 1 keV was achieved.

Central and Fast Ignition Schemes



Conclusion

- Japanese nuclear energy policy is uncertain at this time , except the policy to promote the tasks to recover the Fukushima from the damage caused by the accident and to restart idling plants that satisfy the NRA’s new regulation rules.
- As for fusion energy research, we are pursuing two objectives and laser fusion research is being promoted with a view to pursing the second objective of promoting scientific understanding and engineering innovation for attractive fusion energy.
- The ILE of Osaka University is challenging a fast ignition approach, of which preliminary result is promising so far.

Thank you for your kind attention!

An Assessment of the Prospects for Inertial Fusion Energy

Committee on the Prospects for Inertial Confinement Fusion Energy Systems

National Research Council (2013)

- The appropriate time for the establishment of a national, coordinated, broad-based inertial fusion energy program within DOE would be when ignition is achieved, though the potential benefits of energy from inertial confinement fusion (abundant fuel, minimal greenhouse gas emissions, and limited high-level radioactive waste requiring long-term disposal) provide a compelling rationale for including inertial fusion energy R&D as part of the long-term R&D portfolio for U.S. energy.
- At this time, fast ignition appears to be a less promising approach for IFE than other ignition concepts, though continued fundamental research into fast ignition theory and experiments, the acceleration of electrons and ions by ultra-short-pulse lasers, and related high-intensity laser science is justified.

Merit of Fusion Energy Research

- The scientific understanding and key innovations that will be developed for pursuing an attractive fusion energy source and the knowledge gained in the process can be applied not only to a number of theoretical and experimental areas including materials science, physics and chemistry in new regimes but also to manufacturing and industrial activities.
- In the case of laser fusion research, experimental and theoretical methods developed for studying inertial-confinement fusion have been used for the investigations into many physical systems under extremes of pressure, temperature and density, and the intense lasers and the device for their generation are contributing to the creation of new technologies and industries.

Conclusion

- Japanese nuclear community should not only make every effort to support the Government and TEPCO to promote the off-site and on-site remedial activities after Fukushima accident, but also evaluate the design and safety aspects of existing plants and those features to protect against and mitigate the effects of severe natural events, in particular, and introduce additional measures to strengthen plant safety and enhance emergency preparedness, sharing its experience and lessons derived from the severe accident with the world.
- It is essential for the electric power companies to sincerely communicate with the public about their resolve to do what they should do at the right time in a right manner and never betray the nation's right to be safe from nuclear accidents as the future of nuclear energy policy will be decided, paying due attention to the public perception about nuclear energy that will evolve from such efforts of nuclear energy community.

Conclusion (2)

- The energy supply is one of the major challenges our global community will have to face in the medium and long-term future, though the pursuance of a sustainable energy supply has been major importance for Japan who is a meagerly endowed island country.
- It is a tremendous task for science and technology to provide the necessary energy sources for the future that allows for a sustainable development. It takes a long time to develop the components of modern energy supply systems from novel ideas. Alessandro Volta discovered the battery in the 18th century: We have been exploring the way to improve the efficiency of solar cell for more than 30 years. The joint efforts among research organizations and industries are most required and beneficial.
- The fusion energy R&D and laser fusion energy R&D should not be an exception, as we see the collaboration and partnership have already started to reinforce the global platform for the realization of fusion reactors as a sustainable and secure energy source.

Communication of Radiation Risk

- Almost all of off-site and on-site activities necessarily involve issues related to the management and communication of risk of radiation exposure among people and parties concerned.
- The Government has established safe levels of radiation exposure below which the situations may be considered relatively harmless.
- However, the Government has decided to present them with a caveat stem from a linear non-threshold model adopted in radiation protection.
- This caveat has caused psychological effects on people living in the environment where radiation level is higher than before the accident, even if it is below that at some areas of Europe or USA.

The Report of NAIIC

- National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission (NAIIC) chaired by Dr. Kurokawa
  - The accident was clearly “manmade.” It was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by said parties. They supported faulty rationales for decisions and actions and effectively betrayed the nation’s right to be safe from nuclear accidents.
  - What must be admitted - very painfully - is that this was a disaster ‘Made in Japan’. Its fundamental causes are to be found in the ingrained conventions of Japanese culture: our reflexive obedience, our reluctance to question authority, our devotion to ‘sticking with the program’, our groupism and our insularity.

FY2014 Budget request for major fusion R&D programs in Japan