The policy of Japan about Fusion R&D and ITER

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Why Fusion?

To achieve the target of CO$_2$ level, 550 ppm, the supply of energy must be shared in this way.

- In order to maintain the CO$_2$ level at 550 ppm

Nuclear Fusion Energy

• Abundant Resources

Deuterium and Tritium are fuels for fusion. Deuterium abundantly exist in the sea water, and Tritium can be produced from Li which also commonly exist in sea water. Energy Resource universally exists. Enormous amount of energy will be produced from small amount of fuel.

• Inherent Safety

No nuclear runaway (no uncontrolled power excursions) compared with Fission, easier safety control.

• Environmental

Very small amount of CO\textsubscript{2} will be created. Low level radio-active wastes will be generated, however, conventional technologies are sufficient for disposal of these wastes.
Policy of Fusion Research & Development

• **Long-Term Program for Research, Development and Utilization of Nuclear Energy**  (November 2000)
Research and development of nuclear fusion should be promoted to expand various energy options and to clarify their feasibility for the future.

• **Science and Technology Basic Plan 2001**  (March 2001)
Energy supply insecurity is expected in future. From a viewpoint of securing energy supply, Japan will realize safe and stable energy demand structure and less reliance on fossil fuel at the same time, while taking measure against global warming for the global environment preservation or increase of efficiency. Examples are: fuel cells, solar power generation, new energy sources such as biomass, energy saving technologies, nuclear fusion technologies, innovative atomic-energy technologies, and technologies for nuclear safety
Organization of Fusion Research & Development

Ministry of Education, Culture, Sports, Science and Technology

National Institute for Fusion Science

National Universities (Osaka Univ., Kyusyu Univ., Tsukuba Univ., etc.)

Japan Atomic Energy Research Institute (Special Public Institution)

National Institute for Materials Science (Independent Administrative Institution)

Ministry of Economy, Trade and Industry

National Institute of Advanced Industrial Science and Technology
Fusion Research Prioritization

Tokamak, Helical, Reactor Engineering, and Laser fields

Helical
LHD (NIFS)

Tokamak
JT-60 (JAERI)

Laser
Gekko-XII (Osaka Univ.)
Plasma Performance and its Duration

[Graph showing plasma performance metrics such as nτT and duration, with data points for various tokamaks including ITER, JET, TFTR, DIII-D, and others, indicating performance levels and duration scales from minute to day.]
“The future System of Fusion Research in Japan”

Report by the Working Group on Fusion Research / Council for Science and Technology/ Science Special Committee on Basic Issues -January 2003

• Policies of future fusion research in Japan:
  – Prioritization of fusion research plan
    • Tokamak, Helical, Inertial Fusion, and Nuclear technology of fusion reactors.
  – Enhancement of research collaboration among universities and research institutions.
  – Planning of human resource development consistent with the prioritization.
Mega Science Project to ASIA

- Japan always promotes mega projects in the long-term view: J-PARC, SPring-8, etc.
- Japan have a strong intention of realizing the fusion project for progress of science and technology in Asia.

EU: CERN
(Conseil Europeen pour la Recherche Nucleaire)

US: ISS
(International Space Station)
International Thermonuclear Experimental Reactor (ITER) Project (Overview)

- Fusion Energy is a promising choice of future energy.
- ITER is clearly positioned as an experimental reactor in our long term planning of Fusion Research and Development.
- Scientific and Engineering feasibility of the fusion will be verified by ITER.
International Thermonuclear Experimental Reactor (ITER) Project (history, plan)

• 1985, November: US-Soviet Union Summit Meeting
• 1988 ~ 1990: Conceptual Design Activities (CDA)
• 2001, November: Start of the ITER Negotiations Meeting (Participating Parties: JA, EU, Russia, Canada)
• 2003, February: US and China joined the negotiations
• 2003, June: Korea joined ITER
• 2004: aiming at the agreement on the implementation of ITER and the construction site.
Schedule
ITER Construction, Operation, Decommissioning

Under responsibility of the ITER Organisation

Under Responsibility of Host Country

0  5  10  15  20  25  30  35
(years)

Construction (10 years)
Operation (20 years)
De-activation (about 5 years)
Dismantling and Decommissioning
Dissolution of Organization

Establishment of Organizati

Start of Construction
First Plasma
Start of De-activation
1. Atomic Energy Commission investigated:
   -Mainly from technological viewpoint,
   -And from priority-setting in nuclear energy utilization.
   Conclusion: It would be of great significance for Japan to host ITER (June 2001) in addition to participating as a key member.

2. Council for Science and Technology Policy investigates:
   -Meaning and priority of ITER in total S & T Policy,
   -Priority and securing resources for ITER in public S & T budget.
   -Other important issues, estimation on cost overrun, such as safety, waste management, etc.
   Conclusion (May 2002)

3. Cabinet agreement was made based upon the CSTP conclusion (31 May 2002)
Cooperation between Korea and Japan

Fusion collaboration meeting for KSTAR and procurement
KSTAR: Human resource development, etc
Procurement: Plan for procurement process, information exchange, etc.

1ST : April 20-22, Daejon, Korea
2nd : May 24-25, Tokyo, Japan
3rd : July 6-7, Busan, Korea
Site Proposed for ITER

Cadarache site
- Inside the CEA site (1,560ha) with many nuclear facilities
- 600ha of free area
- Electrical line with a capacity of 500-700MW
- Existing river and storage pond for cooling water supply
- 40km distance from Aix-en Provence (Population: 0.15M)

Rokkasho site
- Near nuclear site with a fuel reprocessing facility
- Stable electric line, sufficient water supply
- Near harbors
- 50km distance from Aomori-city (Population: 0.3M) & Hachinohe-city (Population: 0.24M)
Location of Rokkasho Site

Aomori Prefecture

Aomori City (Pop. 298,700)

Rokkasho-mura

Candidate Site

Misawa-Shimoda (Pop. 70,000)

Hachinohe City (Pop. 242,000)
## Advantageous Site Characteristics

<table>
<thead>
<tr>
<th>1. Superior soil characteristics</th>
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<tbody>
<tr>
<td>- A stable subsoil widely extends with adequate thickness.</td>
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<td>- The land is almost flat and square, and allows for the flexible layout of buildings and facilities.</td>
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<td>- The land of 70 ha is offered with no charge.</td>
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<tr>
<th>2. Stable power supply and capacity for water supply and drain</th>
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<tbody>
<tr>
<td>- Required high-voltage power will be transmitted through neighboring Kamikita substation.</td>
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<tr>
<td>- The site will provide a high level of flexibility for extensive operations, such as steady-state operation in future, with sufficient capability of cooling water and drain.</td>
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<tr>
<th>3. Efficient transportation</th>
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<td>- Mutsu-Ogawara Port can accommodate for up to 5,000 ton ship and unloading of components up to 1,000 tons.</td>
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<tr>
<td>- Heavy and large components (600 tons) can be easily transported from the existing wharf to the site through the existing route.</td>
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<th>4. Clear disposal plan of radioactive wastes</th>
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<td>- Aomori Prefecture stated plainly that Aomori will be responsible to the low level radioactive waste produced by the operation and decommissioning of ITER.</td>
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<th>5. Favorable public acceptability for nuclear facilities</th>
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<td>- There are existing nuclear fuel cycle facilities in the region and well understanding of the local community regarding nuclear energy.</td>
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<th>6. Social Life</th>
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<td>- There are medical facilities with experience in treating foreigners in neighbouring cities; Misawa, etc.</td>
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<td>- In Rokkasho, a new residential development area, called the “Lakeside Village”, is planing with the intention of creating “International Scientific and Technological Research Culture Village”.</td>
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<tr>
<td>- An international school from a kindergarten to high school course (the 12th grade) will be established in Rokkasho.</td>
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Flexibility and Possibility of Extensive Operation

- High voltage electrical power will be supplied from the main electrical grid via Kamikita Substation near the site.

- Ample supply of cooling water sufficient for steady state long pulse operation of ITER is available.

- Choice of sea water cooling system will be also possible.
Mutsu-Ogawara Port accommodates docking of 5,000 ton (DWT) class ships and unloading of components as heavy as 1,000 tons.

Transportation of the heavy and large components from the port to the site is possible via already existing public roads.

Transportation of extra heavy and large components such as PF coils will be possible by constructing a dedicated road for transportation.
Extra Offers - Transportation Route

- North Wharf
- Mutsu-Ogawara Port
- ITER Site
- Public Route For transportation of Heavy and Large Components
- Dedicated Road To be constructed For Extra Heavy and Large Components
- Hachinohe Port
- To South Wharf Of Mutsu-Ogawara Port
- North Wharf Mutsu-Ogawara Port
Well defined strategy of decommissioning

The radioactive wastes from ITER will be treated and disposed of in accordance with the present practice.

Aomori Prefecture as the local government has agreed to the buried disposal of all of the radioactive materials within the territory of the prefecture.
Solid Industrial Infrastructure

Japanese industries have internationally high level of standards and quality with excellent manufacturing capability.

Considering on-going construction of the Nuclear Fuel Cycle Facilities by the Japan Nuclear Fuel Limited in the vicinity of the site, a sufficiently large pool of technically skilled workforce already exists in the area.
In the vicinity of the site, the following scientific and research resources exist:

- Rokkasho-mura: Institute for Environmental Sciences
- Hachinohe City: Hachinohe Institute of Technology
- Aomori City: Department of Engineering / Aomori University
- Hirosaki City: Faculty of Science and Engineering / Hirosaki University
- Mutsu City: JAERI Mutsu Establishment, Mutsu Institute for Oceanography of Japan Marine Science and Technology Center

Fusion research and development in Japan is at the top level in the world, and there are a total of about 1000 researchers in JAERI, National Institute for Fusion Sciences and national universities which support ITER.

Computational facilities and library systems of these institutions will be remote-accessed from the ITER site.
Access to Aomori Prefecture

- Misawa Airport to ITER Site—35km, 50 minutes
- Aomori Airport to ITER Site—70km, 100 minutes
- Haneda to Aomori: 578km, 70 minutes
- Haneda to Misawa: 572km, 70 minutes
- Bullet Train: Tokyo to Hachinohe, 2 hours 56 minutes
- Hachinohe Station
- Narita Airport to Haneda: Express buses depart at 20 minutes intervals, 70 minutes
- Direct flight to Incheon: 3 times/week
- Direct flight to Gimpo: 4 times/day

Seoul
Extra Host Offers

- Technical Aspects(1) -

- Free provision of the land (40 +30 ha)
  - Solid and firm soil and stable subsoil
  - Flat and flexible geometry
- Provision of the HV line up to the Site
- Excellent Mutsu-Ogawara Port facilities 4 km from the site
- Improvements of existing roads for transport of heavy and large components
- Possible dedicated road for transport of extra large and heavy components
• Local electric energy storage system providing flexibility in plasma operation
  • Rapid control of magnets and heating system will be possible.

• Seismic isolation system to increase the technical margin against the seismic activities.
  • R&D for ITER specific conditions are already completed. Seismic isolation is an commonly established technology in Japan.
Extra Host Offers
- Technical Aspects(3) -

- Flexible choice of the cooling systems; Fresh Water/See Water
  - To secure longer pulse and possible high power operation.
- Licensing Support
  - Basic approach is already established.
  - Technical standards are under review.
Extra Technical Offers

- Entrance Road To the Site
- Local Electricity Energy Storage
- Dedicated Road for transport of Extra Heavy and Large Components, If required
- 275 kV Lines
- Tokamak Building Seismic isolation at Base Mat
- Cooling Water from Takahoko Lake (Sea Water Cooling as an option)
- Entrance Road To the Site
- Potable Water Sewage
- Industrial Water Sewage
- Electrical Power during Construction
- Potable & Industrial Water
- Local Electricity Energy Storage
- Potable Water
- Sewage Industrial Water
- Sewage
Comparison between JA and EU candidate sites

**Rokkasho-mura**

- Large harbor facilities near the site (5 km) enable the speedy and safe transportation of components from abroad.
- Several routes of transportation enable the flexible transportation fitted to the schedule.
- Flat site area makes it easy to construct buildings.

- Although frequency of earthquake is high, their intensity is not large and can be dealt with highly advanced seismic isolation technology.

- All Japanese fusion community, including Japan Atomic Energy Research Institute, supports the construction and operation of ITER.

- Beautiful environment with four seasons. Cost of living is much cheaper than that in Tokyo. The criminal rate is the second lowest in Japan, which itself has good public peace.

- Aomori prefecture promises to establish international school from kindergarten up to high school.

- Cost share of site preparation (government and local community) is clear.

**Cadarache**

- Very long distance from port (100 km) arises risks of damages on components during their transportation.
- Actually there is only one route of transportation, which causes delay of schedule due to the concentration of transport.
- The transportation of large and heavy components requires large-scale reinforcement of the existing roads and bridges within a very short time.

- Frequency of earthquake is low. But the estimation of the active fault near the candidate site is not enough.

- Fusion research institute of CEA locates in the neighborhood, which can support the construction and operation of ITER. (nuclear research and development are accumulated in the area.)

- Located in the southern France area which is famous for the international resort. But the cost of living is high like Paris and the public peace is poor.

- Plan of international school is not clear.

- Cost share of site preparation (EU and host country) is not always clear.
Overview of the Area

Climate
Temperate climate, few dramatic temperature changes and some snowfall in winter

Access to the Area
Easy access to the area from Tokyo and abroad via Aomori’s two airports and the Shinkansen (Bullet Train)

Public Security
Very safe area with low occurrences of crime—Aomori’s crime rate is half that of the national average

Housing
Ample housing in the area, in rural, suburban and urban environments, available to ITER participants

Education
A new international school will be established and existing facilities will also be provided for students
Climate

Average High and Low Temperature

- Rokkasho (high)
- Rokkasho (low)

Average Temperature

- Chicago (Fermilab)
- Grenoble (ESRF)
- Geneva (CERN)

Snowfall in the Area

- Hachinohe
- Misawa
- Muro-no Kubo, Rokkasho
- Obuchi, Rokkasho
Access to the Area by Air

**International Access**

1. **Aomori Airport**: Seoul (3 flights/week)
2. **Sendai Airport**: Seoul (7 flights/week), Beijing (5 flights/week), Guam (4 flights/week), Shanghai (3 flights/week), Changchun (2 flights/week)
3. **Narita Airport** (same day flights): 8 destinations in **Europe**, 11 destinations in **North America**, daily flights to Moscow, Seoul, Shanghai and Beijing

**Domestic Access**

1. **Aomori Airport**: Haneda Airport (6 flights/day, Sapporo, Nagoya, Osaka (2 flights/day), Fukuoka (1 flight/day)
2. **Misawa Airport**: Haneda Airport (3 flights/day), Osaka and Sapporo (1 flight/day)
3. **Sendai Airport**: 11 domestic destinations, including direct flights to **Narita Airport**
Access to the Area via Train

Access to and from Hachinohe via Shinkansen

- Number of Trains: 15 daily
- Time to Sendai: 1 hour 20 minutes
- Time to Tokyo: 2 hours 56 minutes

Access to other Cities via Express Train

- Number of Trains (Hachinohe-Aomori City): 17
- Time (Hachinohe-Aomori City): 55 minutes
- Time (Hachinohe-Misawa): 15 minutes

Extension of the Shinkansen

- Hachinohe-Aomori City branch completion: 2010
- Time (Hachinohe-Aomori City): 30 minutes
International Comparison of Certain Personal Crimes (OECD)

National Comparison of Certain Criminal Offences

- Car Theft
- Robbery
- Personal Theft
- Assaults and Threats

Robbery
Violent Offenses
Total

Aomori
Tohoku
Nationwide
Regional Activities

Local and International Activities

Classic Concert in Rokkasho
Rokkasho Country Club
Rokkasho Concert Hall
Rokkasho Indoor Pool
Hachinohe Historical Museum

Japanese Culture Exchange In Misawa
Hachinohe’s Tanesashi Coast
Cogema personnel participate in the Nebuta Festival
Misawa Ice Arena
Local Activities

Wide Variety of Activities in Rokkasho
1. 8 Community Centers offer a range of courses, including:
   A. Arts: Music, Choir, Ballet, Japanese dance, Piano, Painting
   B. Crafts and Hobbies: Cooking, Ikebana (flower arrangement), Ceramics, Gardening, Bonsai, Sign Language
   C. Health and Social Activities: Emergency care, infant and child care, gender issues, financial advice
   D. Language courses: Korean and English
2. Athletic Park and Gymnasium offer the following activities:
   Aerobics, Baseball, Golf, Walking and hiking, Alpine skiing, Ice skating, Track and field
3. Public Library covering 600m² with a current stock of 30,000 volumes that is being expanded

Social Activities  Rokkasho Library  Oishi Athletic Park
The following quotes, taken from an article written by Raphaëlle Marcadal of AFP (Agence France Presse) on 9 February, provide a firsthand glimpse into what life is like in Rokkasho for foreign researchers living in the area:

“The critics of the Japanese site...say the area is ‘too isolated’. (However), this in an unconvincing argument for a French engineer...who has lived in Rokkasho for 3 ½ years.”

“The nature is quite beautiful and offers and appreciable quality of life: people can ski in winter and enjoy the hot springs, while in summer they can swim or play golf”.

The engineer also emphasized, “the ‘quality of life in the open air’ and the ‘kindness of the local people’.”
Regional Attractions

- Summer Fields in Aomori
- Kanto Festival in Akita
- The Mountains of Yamagata
- The Beaches of Fukushima
- Gokoku Shrine in Miyagi
- Skiing in Iwate
- World Cup Stadium in Sendai
Potential Residential Areas

Ample Housing in the Area
1. 850 new apartments built in the area in 2002
2. Majority of apartments less than 20 years old
3. Over 33,000 houses available for rent in Aomori—with 1,700 in Misawa
4. Furnished and short-term rentals also available in the area
5. Residential development areas expanding year-by-year

Renting Housing in the Area

- Rental housing currently available in all areas
- Apartments currently being built in all areas
- Average prices for 2-bedroom apartments are:
  - 45,000 Yen/month in Rokkasho
  - 52,000 Yen/month in Misawa
  - 60,000 Yen/month in Hachinohe
Housing

New Housing Developments

- Eight residential areas in Misawa currently under development
- Three new residential areas (100 ha) in Rokkasho—2 north of Lake Obuchi and one on the lake’s east coast
- This development, called “Lakeside Village”, will be completed in 2-3 years and include 160 houses and 400 apartments
- Construction of new houses in Japan is extremely efficient—houses can be built in 3 to 6 months
- New houses in Aomori are 4th largest in the country (at 150m²) and the 3rd most reasonable in the country (21.9 million Yen)

Municipal Housing in the Area

- Housing is built and maintained by each municipality
- Over 415 units available in Rokkasho and Misawa—60 units constructed in the Rokkasho area in 2002
- Average rent for a 2-bedroom unit:
  - 25,000 Yen/month in Rokkasho
  - 35,000 Yen/month in Misawa
## Living Costs

### Average Cost of Living for Aomori City

(Yen/month)

<table>
<thead>
<tr>
<th>Living Expenditures</th>
<th>361,656</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Items</td>
<td>60,416</td>
</tr>
<tr>
<td>Dining Out</td>
<td>10,136</td>
</tr>
<tr>
<td>Housing Expenditures</td>
<td>19,953</td>
</tr>
<tr>
<td>Electricity and Water Costs</td>
<td>22,560</td>
</tr>
<tr>
<td>Furniture and Household Supplies</td>
<td>10,682</td>
</tr>
<tr>
<td>Clothes and Apparel</td>
<td>17,301</td>
</tr>
<tr>
<td>Health and Medical Care</td>
<td>9,749</td>
</tr>
<tr>
<td>Health Insurance</td>
<td>40,005</td>
</tr>
<tr>
<td>Transportation and Communications</td>
<td>31,062</td>
</tr>
<tr>
<td>Education</td>
<td>18,275</td>
</tr>
<tr>
<td>Culture and Entertainment</td>
<td>26,600</td>
</tr>
<tr>
<td>Other Expenditures</td>
<td>68,681</td>
</tr>
<tr>
<td>Direct Taxes</td>
<td>26,226</td>
</tr>
</tbody>
</table>

### Averages in Aomori City

- Age of head of household: 44
- No. of household members: 3.4
- Average income: 460,927 Yen/month

### Expenditure Breakdown

- Food Items
- Housing Expenditures
- Apparel
- Medical Care/Insurance
- Transport/Communications
- Education
- Culture/Entertainment
- Direct Taxes
- Other Expenses
Facilities will be provided for students who would like to study a curriculum that is commensurate with their home country.

These facilities could be used to teach entire curriculums or weekly lessons, such as Saturday school.

Currently, French students use school facilities in Misawa—they are provided with a bus service to and from their homes everyday.

Country-specific schools, mostly concentrated in the Tokyo area, are also another possibility for the children of ITER participants.

Events could also be planned in conjunction with existing schools in the area, such as the American school in Misawa.
Recent meeting for agreement of ITER Site

June 19th 2003: 1st Preparatory Meeting for ITER Decision Making (Vienna)
October 9th 2003: 2nd Preparatory Meeting for ITER Decision Making (Vienna)
December 4-5th 2003: Preparatory Meeting for the Ministerial Meeting for ITER (Vienna)
December 20th 2003: Ministerial Meeting for ITER (Washington D.C.)
February 21st 2004: 2nd Preparatory Meeting for Ministerial Meeting for ITER (Vienna)
March 12-13th 2004: Technical Forum (Vienna)
March 23rd 2004: 1st JA-EU Preparatory Meeting (Tokyo)
April 6th 2004: 2nd JA-EU Preparatory Meeting (Brussels)
April 24th 2004: 3rd JA-EU Preparatory Meeting (Tokyo)
June 18th 2004: 3rd Preparatory Meeting for ITER Decision Making (Vienna)
Broader Approach to Fusion Power

(1) A Distributed ITER Project
   The ITER Facility Center: Host
   The ITER Research Center(s): Simulation and research

(2) Satellite Tokamak Facilities
   Existing satellite Tokamak(s): JT-60, JET, KSTAR, etc.
   Physics R&D topics related to the operation scenarios of ITER
   Development of plasma scenarios for advanced operation of ITER

(3) Fusion Power Plant Technology
   Development of DEMO relevant technology
   Fusion material research
   Fusion power plants technology coordination center: IFMIF
Rokkasho is superior in the crucial points such as transportation, site preparation and so on.

From a viewpoint of world wide fusion energy research, it is more effective that Broader Approach should be carried out in Europe, where has much researched and many existing research bases.

From a viewpoint of development of science and technology in Asia, we have a strong intention of realizing the fusion project in Asia symbolically.
Delegations from China, European Union, Japan, the Republic of Korea, the Russian Federation, and the United States met at the IAEA headquarters in Vienna on 18th June 2004 to advance the ITER negotiations.

The two potential Host Parties, European Union and Japan, presented their positions, taking account of recent bilateral discussions on a broader approach to realising fusion energy. The parties noted that the contents of these offers were essentially symmetrical and showed a readiness of each of the potential Host Parties to contribute significantly to the realisation of elements of the Broader Approach other than ITER in addition to their contributions to ITER itself.

All Parties stressed the urgency of reaching a rapid resolution of the siting issue so as to move forward to implementation of ITER in a framework of international collaboration.