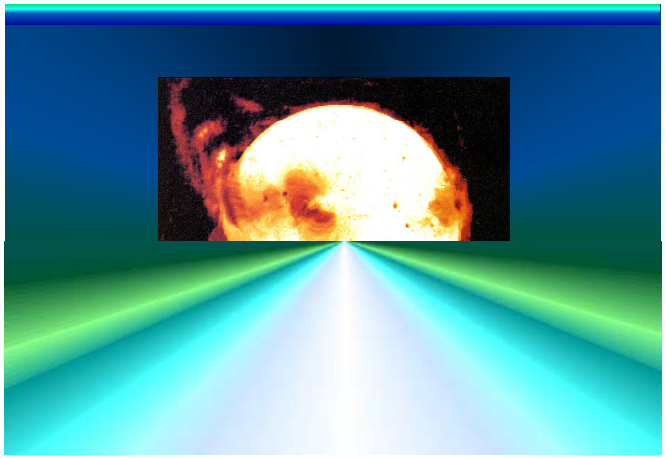


Abstract

Fusion is an energy source of the Sun and the Star. It is a quite challenging scientific project to realise controlled fusion power generation on the Earth. Fusion is safer and environmentally attractive energy source with significantly lower radiological toxic hazard potential than that of fission plant and fairly lower CO2 emission rate than that of fossil power plant.

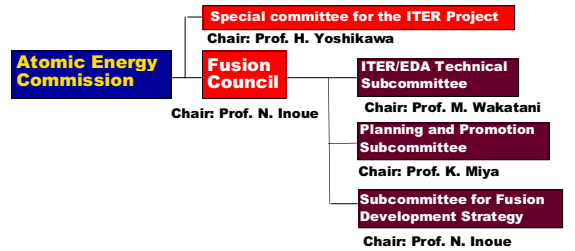
The world fusion research has been focused on confinement of high temperature plasma for 40 years. And now, we have produced high temperature plasmas up to 520 Million Kelvin in fusion experimental device JT-60U at Japan Atomic Energy Research Institute far enough to fuse deuterium and tritium to produce fusion energy. It is a time to proceed to the next step, namely to build ITER as an International Thermonuclear Experimental Reactor to demonstrate feasibility of fusion energy for the 21 century.

In Japan, Fusion Council under Atomic Energy Commission formed the Subcommittee for Fusion Development Strategy (Chair : Prof. N. Inoue) to investigate technical feasibility of fusion energy including advantages and conditions of Fusion Energy as an energy option and to identify its development strategy towards the future electricity production with DEMO.

We report key observations and conclusions in the subcommittee such as advances in fusion research, advantages of Fusion Energy in comparison with fossil, fission and renewable, preliminary assessment of target conditions to come into the energy market, and the development strategy with ITER.

This paper summarize key findings in the Subcommittee for Fusion Development Strategy in Japan

Structure of Fusion Program Promotion in Japan
(before May 17,2000)



Scope of this 18th World Energy Congress

Energy Markets: The Challenges of the New Millennium

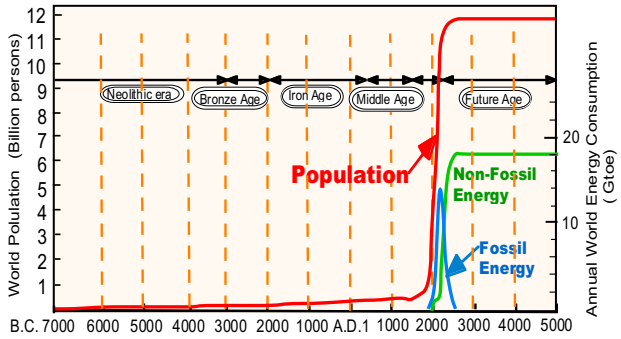
#1 : First WEC in new millennium
#2 : First WEC in Latin America

Population and Energy Trend in Millennium Time Scale shows clear Transition at 2000

[1] Large scale non-exhaustible (at least for a few millennium time scale) new energy sources (~18Gtoe/y) must be developed to sustain large polulation (~12billion persons) in new millennium (See right figure).

[2] This new energy must be environmentally benign. Such sources are Renewables (Energy supplied by Fusion reaction in the Sun) and Fusion on the Earth.

[3] Fusion research is now ready for large scale energy production. It is a time to re-recognize Fusion as one of very important millennium energy options.



Historical Relationship(Fusion & Argentine)

[1] Fusion research has an important historical relationship with Argentine exactly 50 years ago.

[2] Announcement on Fusion by Past President of Argentina, Mr. Peron, in 1951 attracted a strong positive public interest on Fusion Research.

[3] Time, Place and Main Theme of 18th WEC are very suitable for the renewed interest on Fusion Energy Development by leading personalities of the energy world.

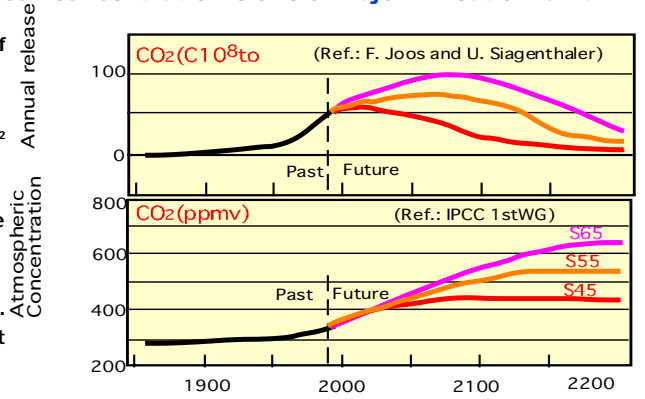
Global Warming with increasing CO2 Concentration is one of Major Threat of Humankind

[1] Large combustion of fossil fuel produced significant increase of CO_2 concentration in the air.

[2] CO_2 emission rate must be suppressed to stabilize CO_2 concentration in the air.

[3] Development of new energy sources with low CO_2 emission rate is urgent matter for the humankind.

[4] Fusion research is now ready for large scale energy production. It is a time to re-recognize Fusion as one of very important millennium energy options.



Fusion is a Promissing Candidate of New Millennium which has Many Advantages over Fossil and Fission Energy sources.

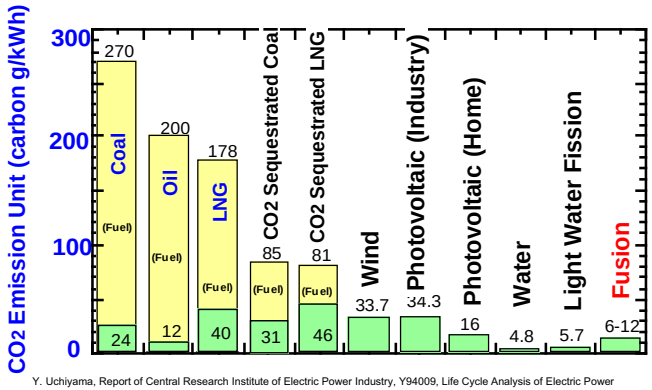
1. Low CO_2 emission rate
2. Low Radiological Hazard Potential
3. No explosion
4. Virtually inexhaustible resources

Fusion produces little CO_2 to Atmosphere

[1] Fossil energy sources have high C02 emission rates (after Prof. Uchiyama, Tsukuba Univ.).

[2] C02 emission rate evaluated by Dr. Tokimatsu (IAEA TCM 1998) was found to be small (6–12 Carbon g/kWh) similar to that of Fission power plant.

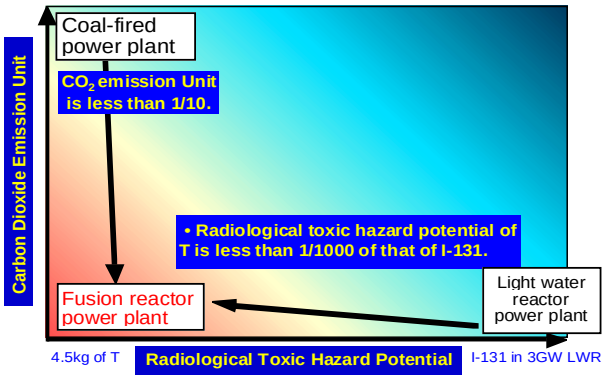
[3] Fusion is found to be promissing with respect to the Global Warming Problem.



Y. Uchiyama, Report of Central Research Institute of Electric Power Industry, Y94009, Life Cycle Analysis of Electric Power Generation System (1995).

K. Tokimatsu et al., 6th IAEA TCM on Fusion Power Plant Design and Technology (1998).

Fusion reduces risks for Global Warming and Radiological Hazard , simultanelously

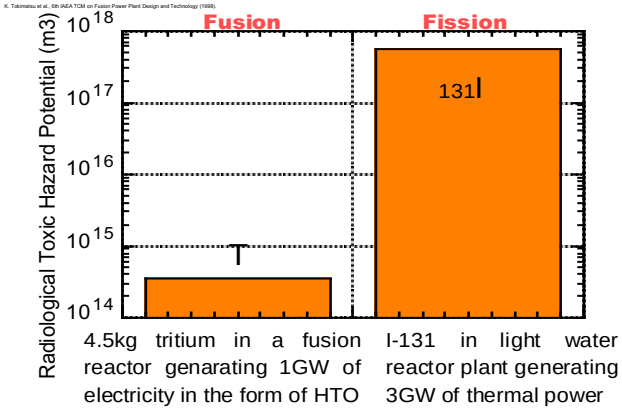


Fusion has low radiological hazard potential

[1] Hazard potential of radioactive material is measured by a ratio of radioactivity (Bq) to concentration limit in the air (Bq/cm^3).

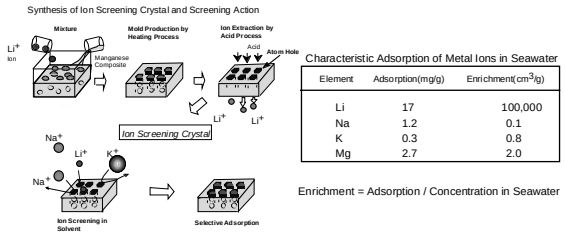
[2] Concentraion limit of ^{131}I ($10Bq/cm^3$) produced in fission reactor is 1/500 times lower than that of tritium since ^{131}I tends to concentrate in specific organ (thyroid gland) and stayed longer.

[3] Fusion has 1/1500 times lower hazard potential compared with fission.



Resource for Fusion is abundant and is not maldistributed

The resource for world electricity production ($1.25x10^7$ GWh/year)
Lithium (without recycling) : 1,500,000years
Beryllium (with recycling) : 70,000 years
Niobium (without recycling) : 70,000years



Characteristic Adsorption of Metal Ions in Seawater

Element	Adsorption(mg/g)	Enrichment(cm^3/g)
Li	17	100,000
Na	1.2	0.1
K	0.3	0.8
Mg	2.7	2.0

Enrichment = Adsorption / Concentration in Seawater

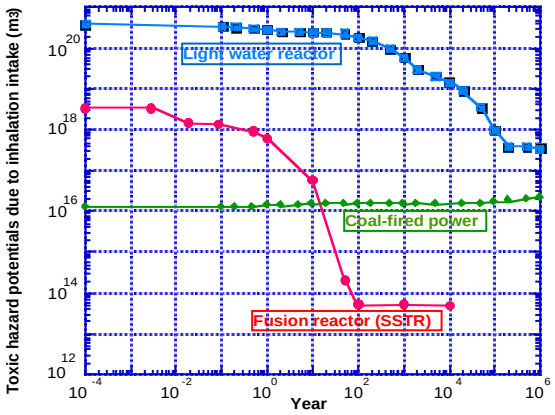
Y Miyai, K. Ooi et al., Lithium Extraction from Seawater by Manganese Oxide Adsorbent, Report of Shikoku National Industrial Research Institute, Agency of Industrial Science and Technology No.28(1996).

diological Hazard of Fusion waste is much Lower th that of Fission

[1] Hazard potential of radioactive waste is measured by a ratio of totalradioactivity (Bq) to concentration limit in the air (Bq/cm^3).

[2] Hazard potential of Fusion waste is much lower than that of fission since high level waste is not produced.

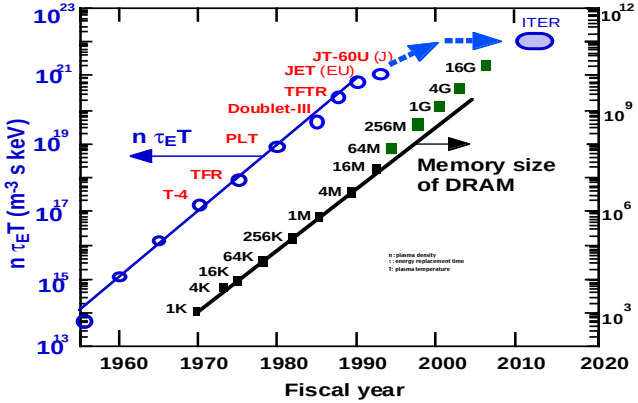
[3] Hazard potential of fusion waste becomes even lower than that of coal ashes (containing ^{238}U, ^{232}Th etc).

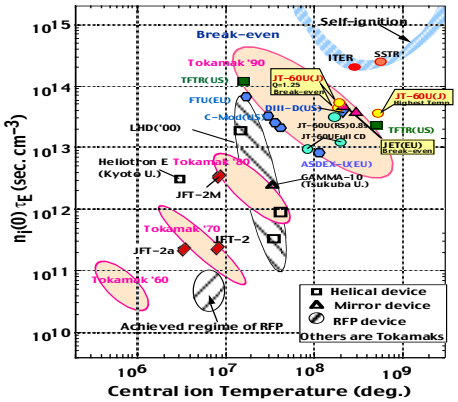


Progress of Fusion Research

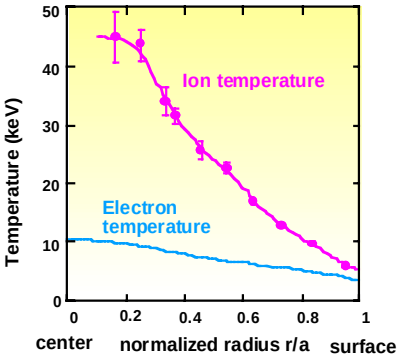
1. Fusion triple product increased by 10^6 within 30 years.
2. Physics of tokamak is understood well.
3. Fusion Technologies are ready .
4. Irradiation test shows quite promising for Fusion Material.

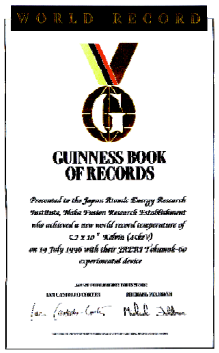
Achieved Fusion Triple Product ($n\tau T$) increased as rapid as DRAM memory size

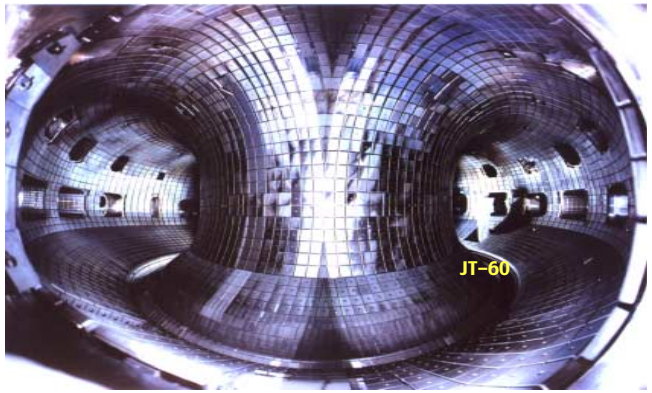


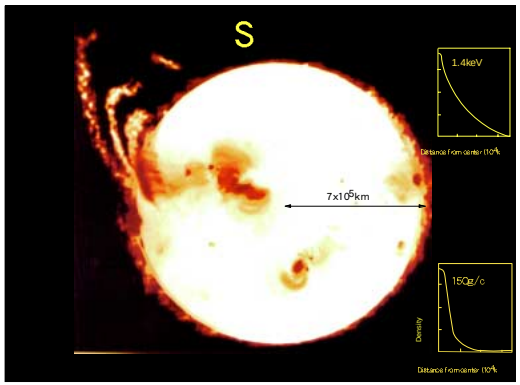


Japanese Fusion Device JT-60 produced world highest temperature 45keV (5.2×10^8 deg) much higher than that of the Sun.





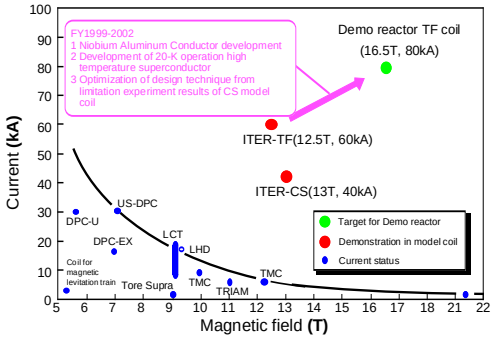


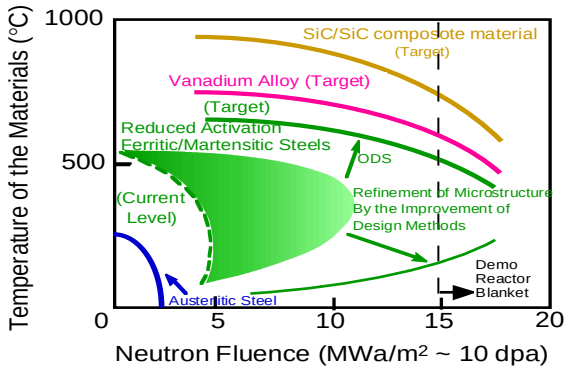


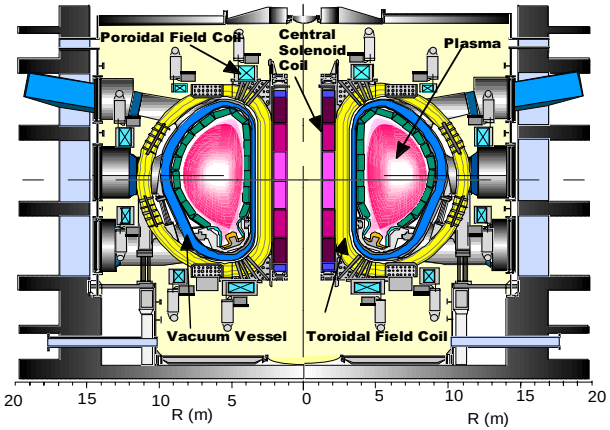
ogies such as Superconducting magnet are ready for the Fusion Energy Pro

Irradiation-resistant Structual Materials for Fusion Blanket are dev

ITER-FEAT Design (R. Aymar, et al.)







Load to Fusion Power Production

1. Demonstration of Scientific and Technological Feasibility by ITER
2. Fusion Power Generation by DEMO
3. Commercialization of Fusion Power

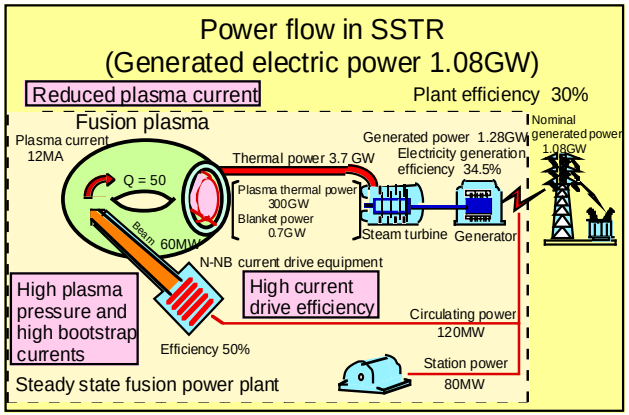
Development Strategy

[1] The principal experimental objective of ITER is the production and control of burning plasmas.

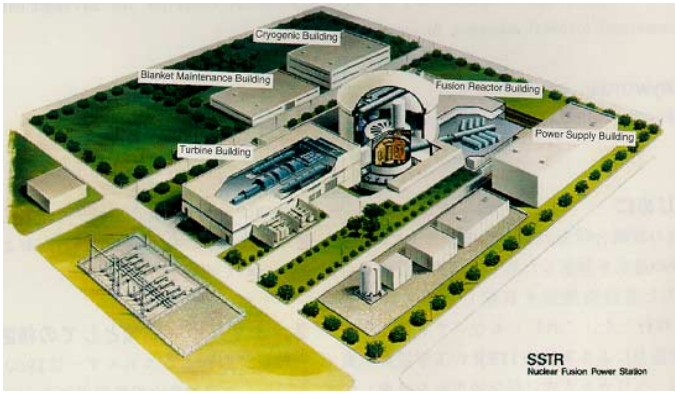
[2] Fusion energy development can be achieved by advancement of existing technologies if the control of burning plasma becomes possible.

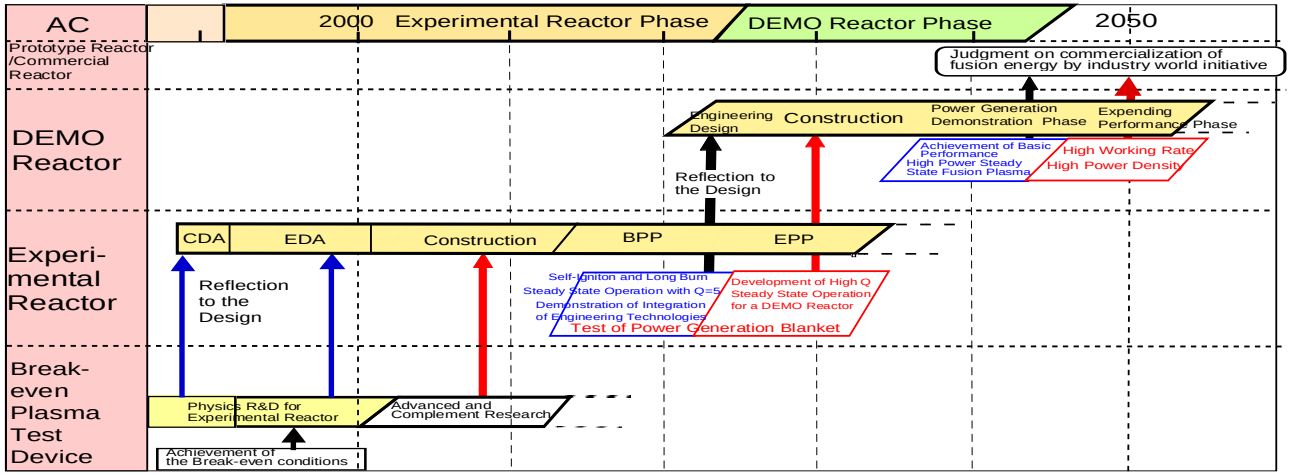
[3] Attractive DEMO reactor can be realized by demonstrating steady-state operation.

Power flow in Fusion Reactor



Example of Japanese DEMO Design





[Studies of Nuclear Fusion Energy Potential Based on a Long-term World Energy and Environment Model]

by K. Tokimatsu et al, Research Institute of Innovative Technology for the Earth (RITE)
IAEA Fusion Energy Conference (2000)

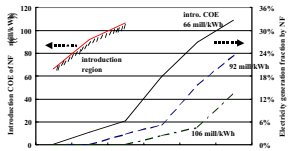
Linealized Dynamic New Earth 21 Model

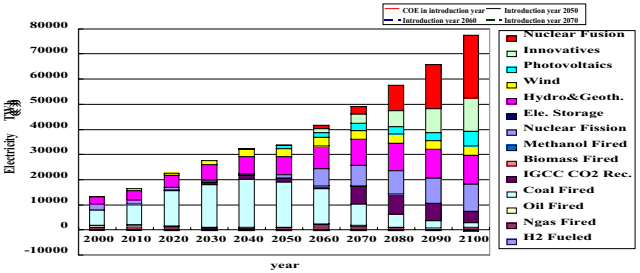
Main Conclusion of their paper:

[1] Present tokamak type nuclear fusion reactors can be introduced between 2060 and 2070, and electricity generation fraction will go around 20% in 2100.

[2] In conclusion, nuclear fusion energy is revealed to be one of the candidates of energy supply technologies and CO2 mitigation technologies.

Condition :CO_2 concentration of 550ppm in 2100





Conclusion

[1] Fusion is characterized by its low CO_2 emission rate and also by its low radiological hazard potential.

[2] Resources for fusion is abundant and is not maldistributed.

[3] Fusion research is an exciting and challenging project of humankind.

[4] ITER is a most important step to demonstrate scientific and technical feasibility of fusion energy.

[5] Fusion community is ready for significant energy production with ITER.

[6] Fusion can be an attractive energy option for new millenium if appropriate R&D has been performed.