Socio-economic Studies in JAERI and Their Impacts on Fusion Plant Design
-Can Fusion Be a Viable Energy Source in Future? -

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Question

Will Fusion have a future market?

- What energy will future society want？
- Can Fusion respond to it？
- Will future people buy Fusion electricity？(Economy issue)
- Will future people accept Fusion energy？

(Social and Environmental Issue)

Can investment for fusion be returned?

→Fusion will need a clear target of social eligibility and market share in the future.

Future Energy Market

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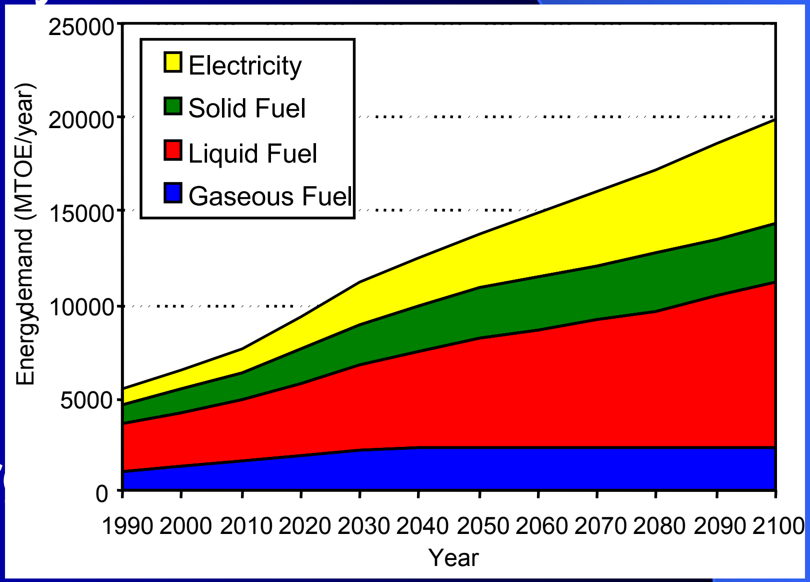
１． Electricity Demand Increases
２． Small, Dispersed, Independent Generators Required
３． Fuel（Liquid, Gas） Demand Remains Larger, Particularly
for Transportation
４． Consumption Increases in Developing Countries,
While Market in Developed Country Matured

→ Developing Countries
cannot accept GW scale stations

→ Developed Countries are
happy with LPRs

→Fusion requires large market



Example of Outlook of Global Energy Consumption by IPCC92a

Outline of Socioeconomic Study of Fusion

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1. Energy Model Studies

   Collaboration with RITE(Dr. K. Tokimatsu) and IEEJ

2. Assessment of Economic Effect of Fusion Research

3. Externality study

   Collaboration with Institute for Policy Sciences

4. Tritium Fuel Cycle

   Collaboration with CRIEPI and RITE

5. Fusion Energy Application

   Research Committee under Prof. Y. Ogawa(U. Tokyo)

6. International Collaboration under IEA

Energy Model Studies -1

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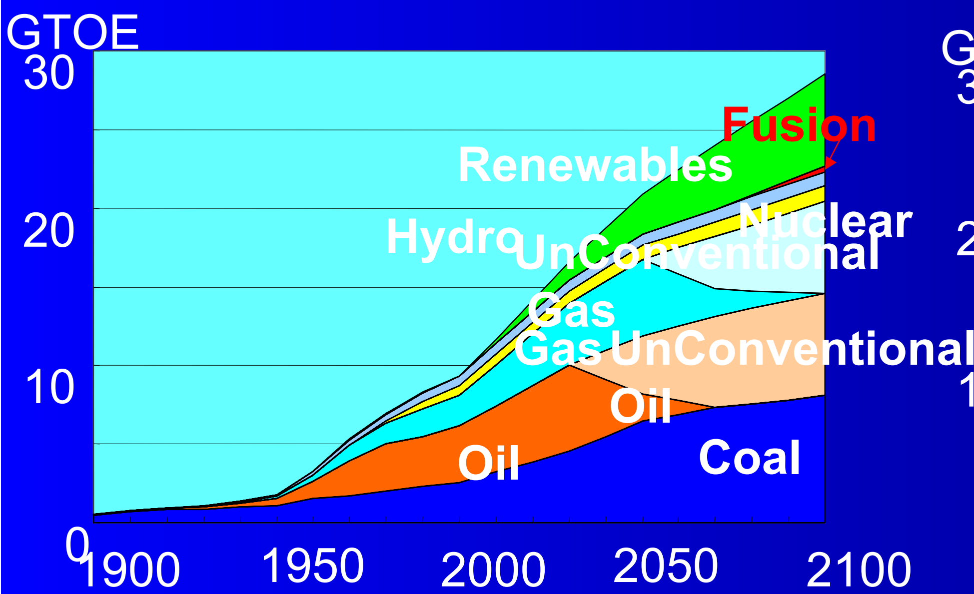
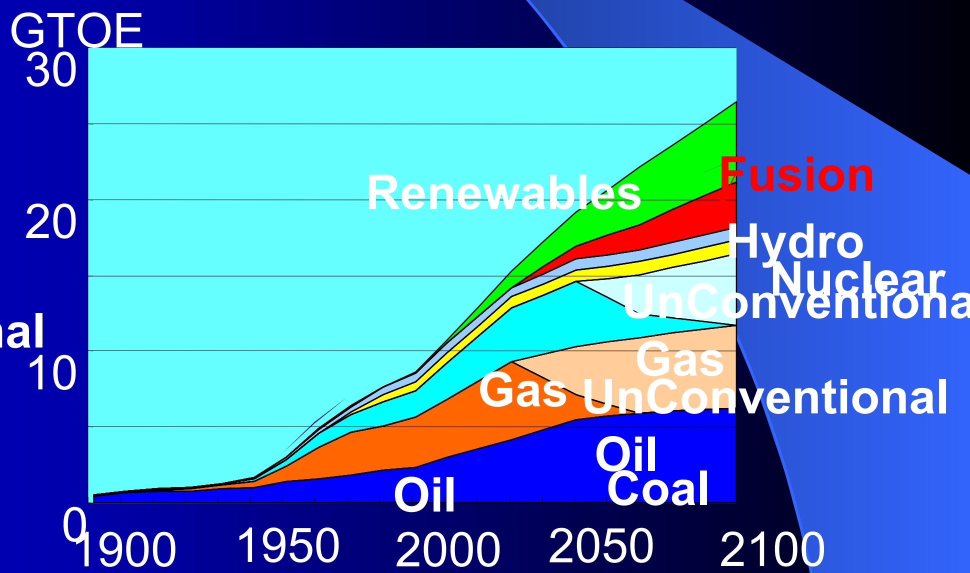
Analysis by Institute of Energy and Economics of Japan

1.business as usual with fusion continues to be expensive



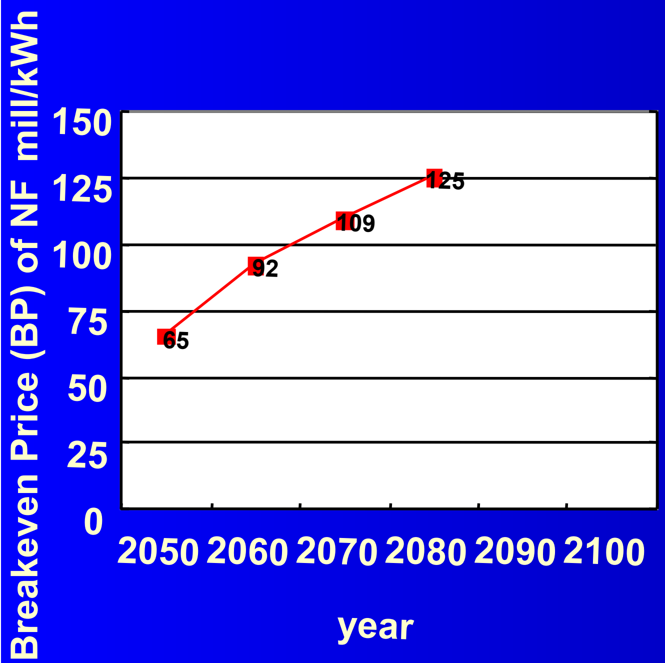
2.Fusion start business in 2050 at competitive COE

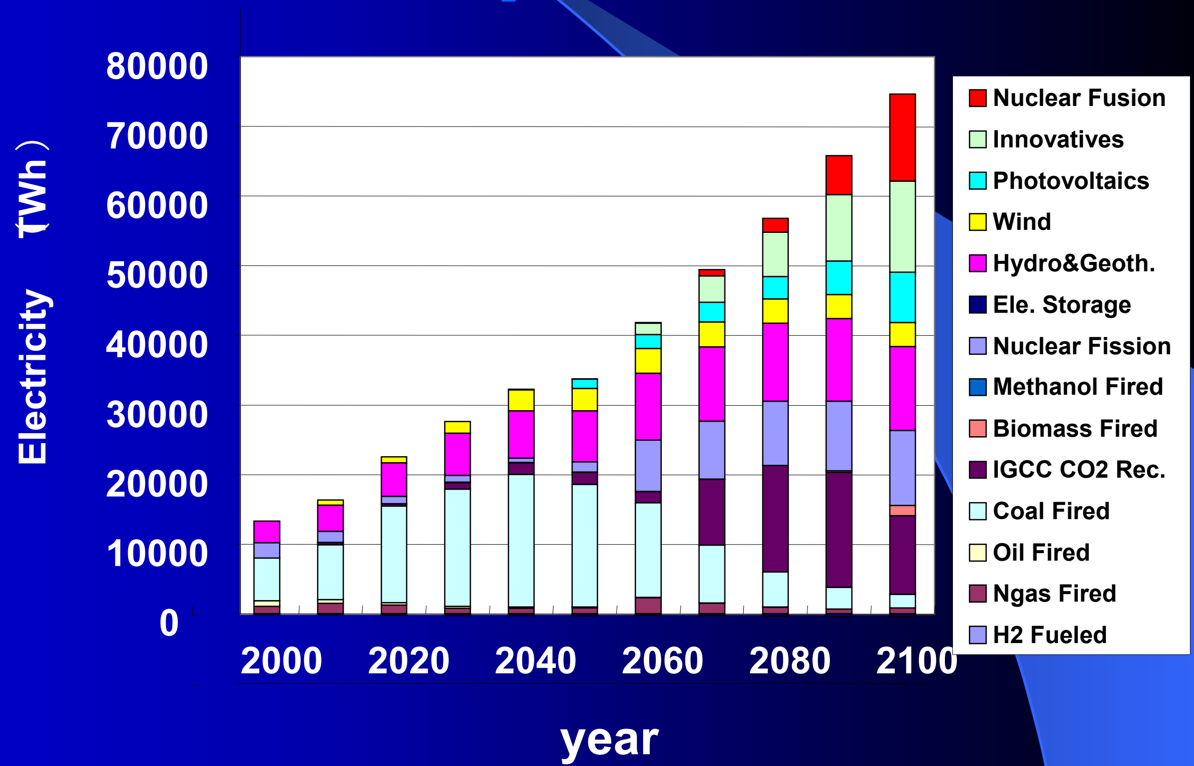


Energy Model Studies -2

Analysis by Research Institute of Innovative Technology for the Earth

DNE21 model: The model can illustrate future energy systems in the 21st century by minimizing world total energy systems costs under CO_2 constraints.





Fusion can be introduced into the market in 2050 when competitive COE (65 kil/kwh) is achieved.

Construction speed, particularly supply of initial tritium limits the growth.

Fusion as an Investment

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1. Total sales of fusion electricity

   (integrated from 0% in 2050 to ca,30% in 2100)

   1.6×10^{15} yen (1.2×10^{13} \$) as global total GDP.

   Japanese share 5%.

2. Electricity Cost Reduction

   COE estimated to be 65 mill in 2050 and 145 in 2010 without fusion

   Integrated global cost saving will be ca. 7×10^{14} yen (5×10^{11} \$).

3. Trading Fusion Devices

   Trading market of fusion devices estimated to be 1.4×10^{14} yen world wide and 6×10^{13} for respective domestic use.

   Most of contribution by industry and utility.

It will dwarf the development cost, IF SUCCESSFUL.

Implication of Initial Tritium Constraint

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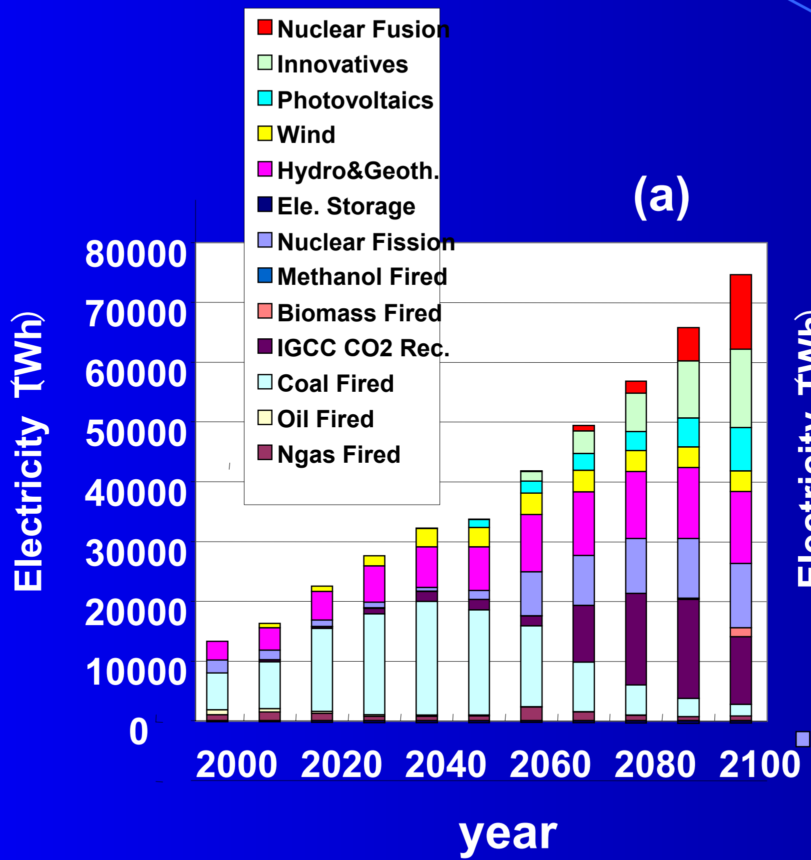

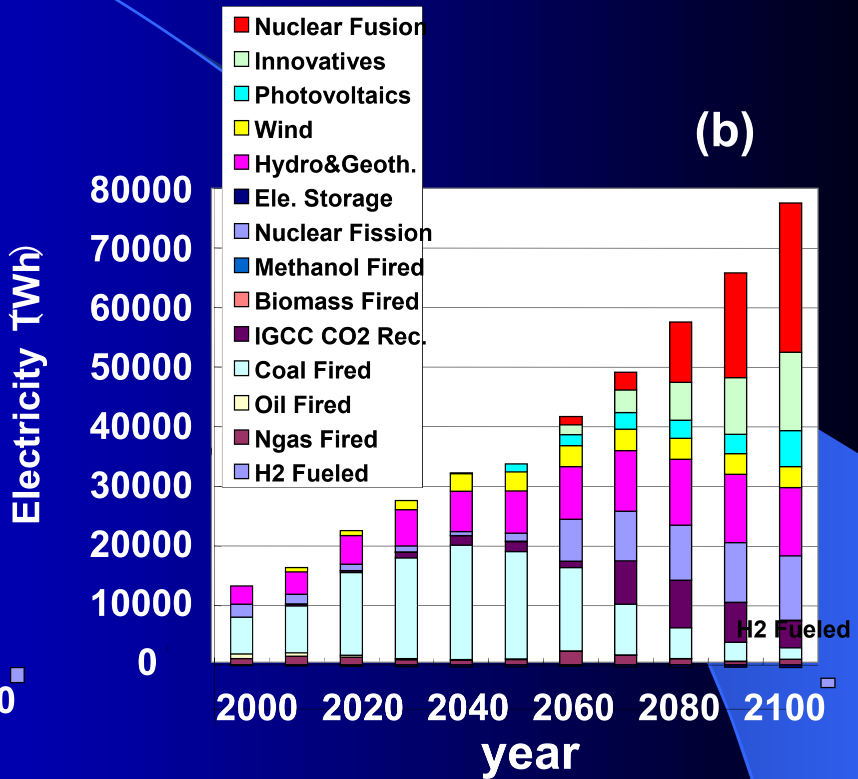

Breakdown of electricity supply . Fusion is assumed to be introduced in 2050 and deployed (a) with initial tritium constraint and (b) without it.

Implication of Initial Tritium Constraint 2

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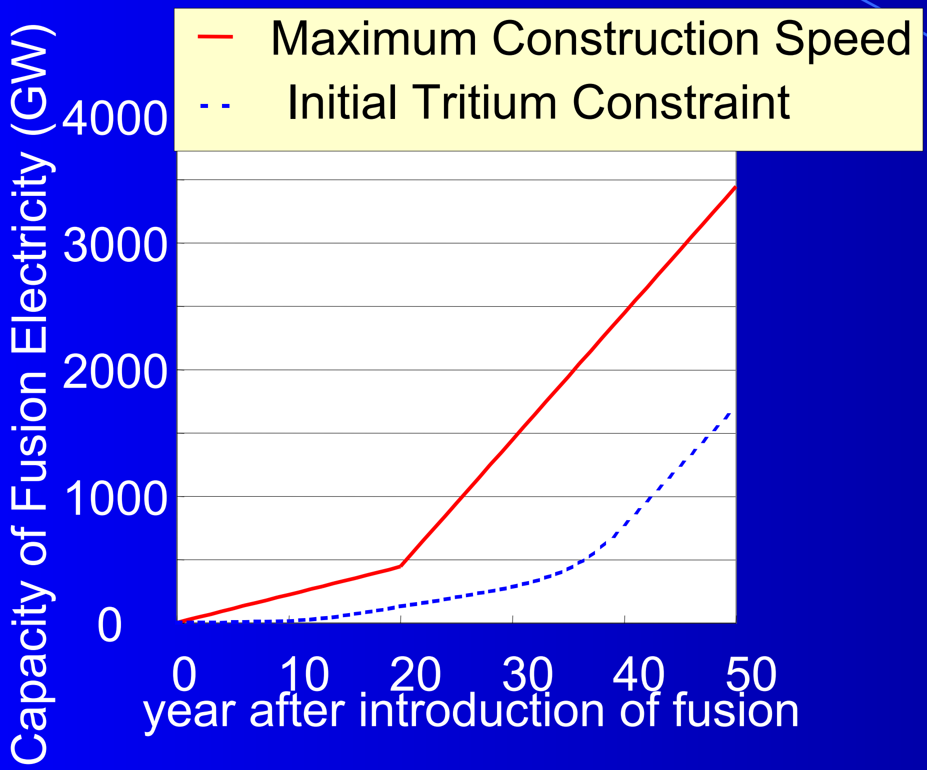

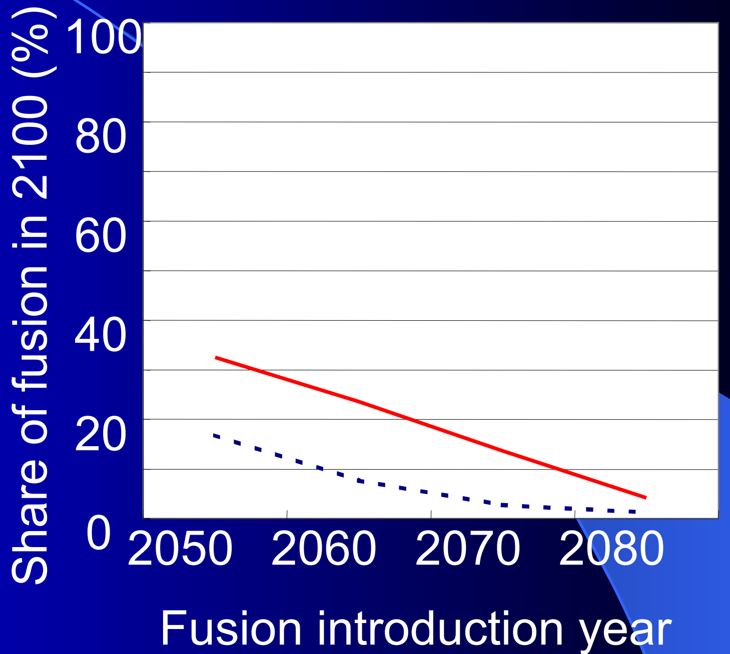

Avoiding initial tritium constraints increases capability of fusion.
Construction speed could be essential for possible fusion share.

Use of Fusion Heat

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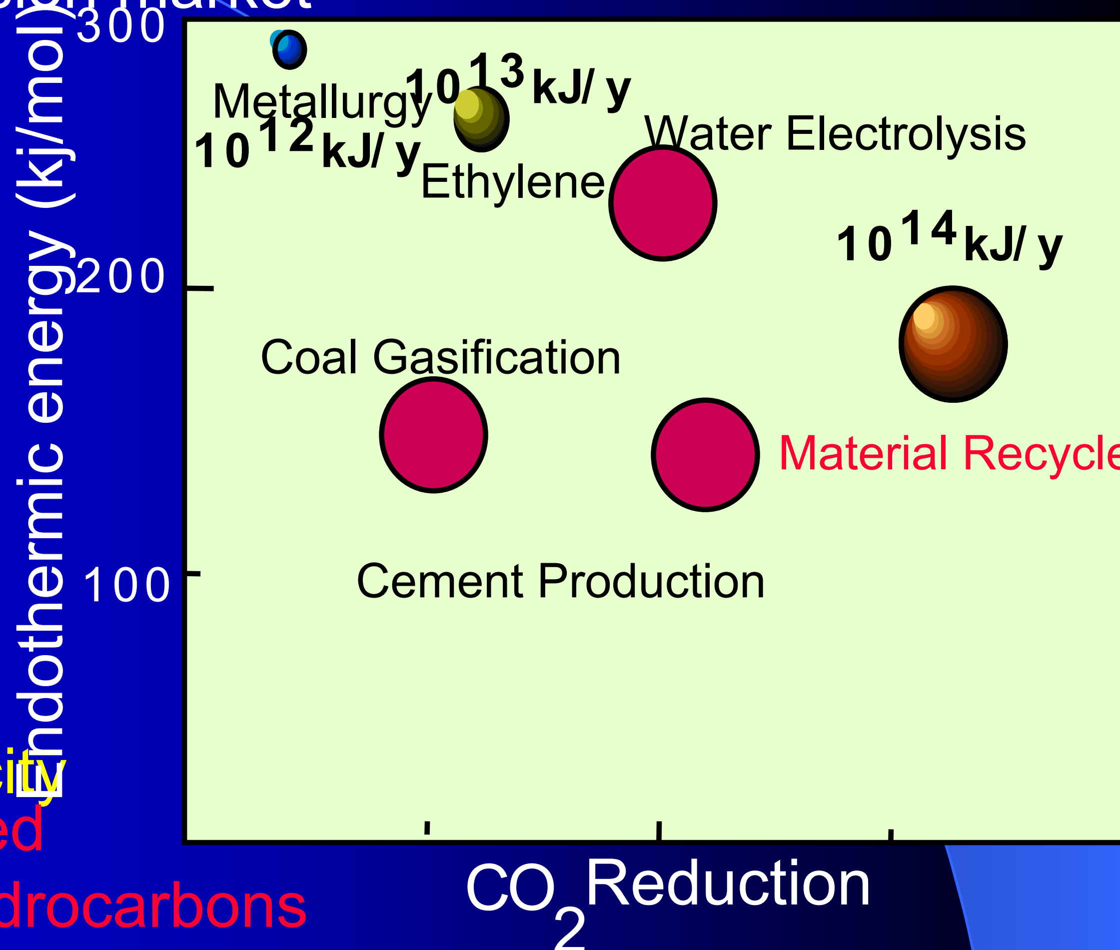
Searching for future fusion market

Criteria

○Endothermic Process
  ・as transformation of fusion energy
○Reduction of CO2
  ・Replacing fossil fuel with fusion
○Market scale
  ・Need large market
  ・Need large unit capacity

→Material Recycle selected
biomass, wastes and hydrocarbons



CnHmOi....+(n-1)H2O → nCO + (2n-2i+m)/2 H2 +...

(900~1200℃)、30kcal/mol

Material and Energy Balance

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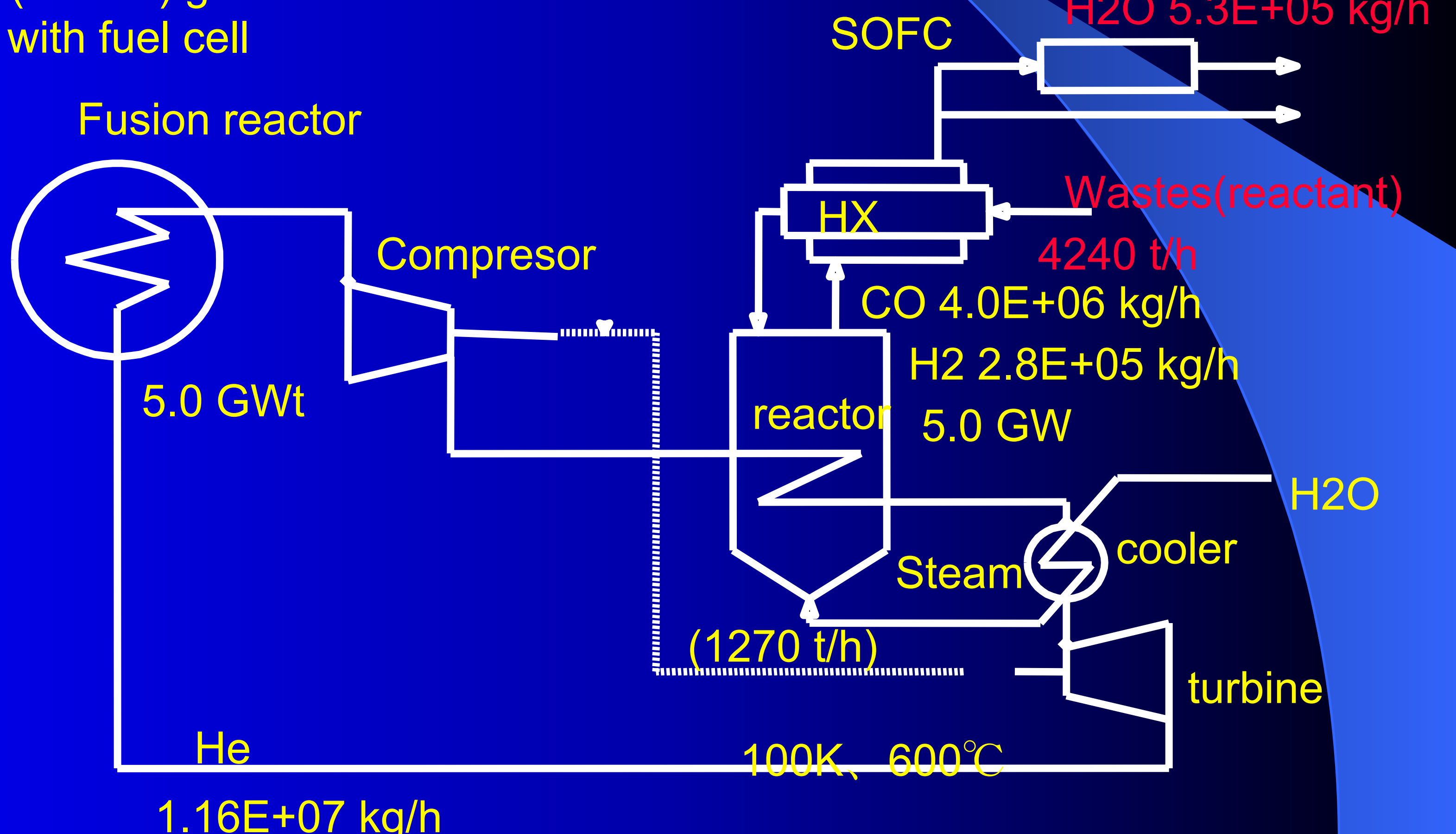
○Processing capacity
- ４２４０t／h waste processed
- 4000t of CO、280t of H2 generated

○Electricity Generation
- 4GWf (５GWt) generates 10.3GWe with fuel cell

Combination with Solid Oxide Fuel Cell has advantages.



Technical Features

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○Reactant (wastes)

- Available in large quantity anywhere (advanced or developing)
- Cheap (Negative value. Processing itself is benefit)
- Makes future fuel and other organic materials.
- When burnt, carbon neutral. With fusion energy, carbon negative.

○Process

- Large endothermic reaction, transforming fusion to chemical energy.
- All the heat is efficiently used for front end.
- Applicable for fuel cell or other form of electricity without grid.
- Nominal efficiency over 100%. Free from Carnot limit.
- With adiabatic (or isothermal) compression, temperature highe than the reactor outlet could be used.

Starting DT Plant Without Initial Tritium

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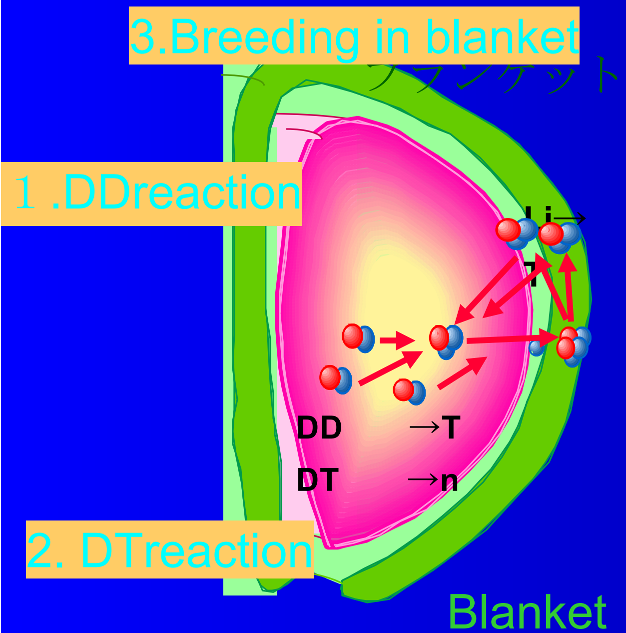
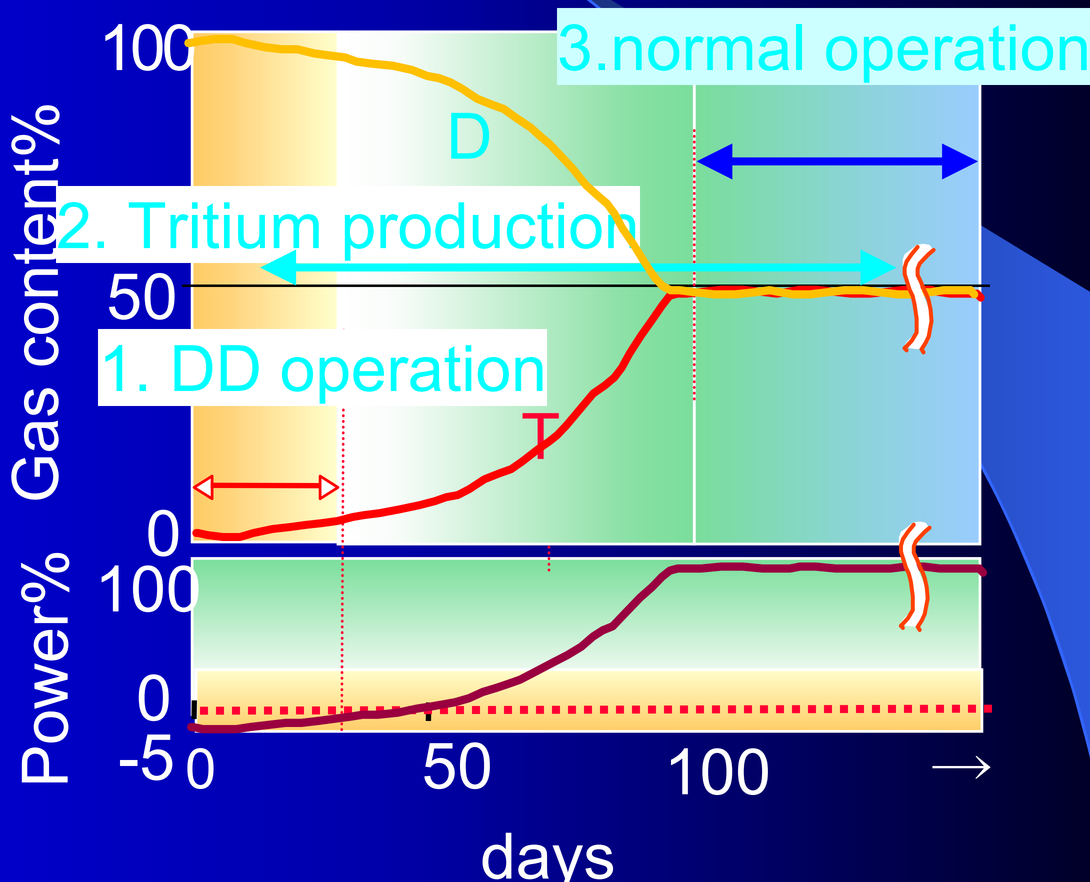
Supply of initial tritium limits the speed of deployment of fusion.





Fusion plant with TBR>1.1 can produce its tritium in ca. 100 days.

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More advantages..

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○Using Fuel Cells on Site

- Electricity stored in the form of fuel
- Fuel cell can be inversely used for water electrolysis

-Accommodate change in raw material supply.

- Can be used for start up battery

○Features of multipurpose plant

- Partial use of heat can fit in smaller electricity market.

- use a part of the blankets

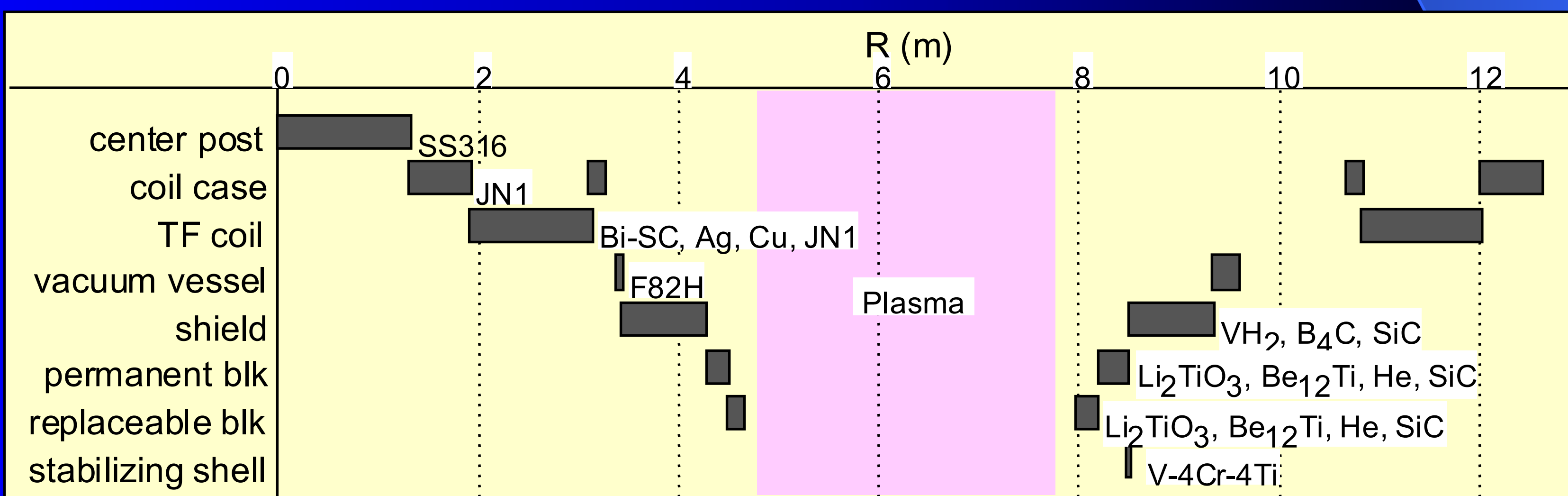
- Hydrogen production may respond to changing load.
- Expands fusion market.

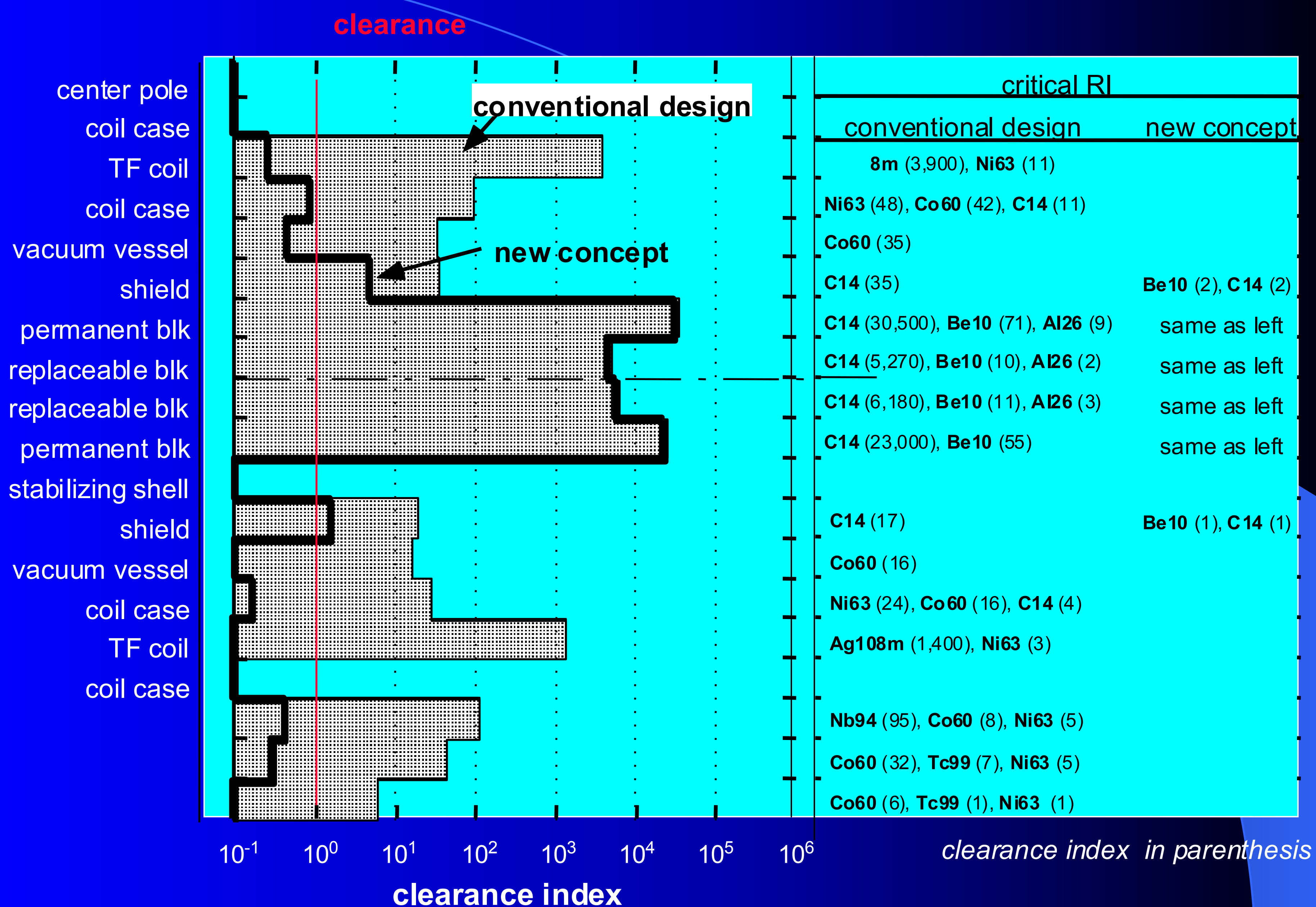
Minimizing Fusion Rad-waste

○Radwaste minimum concept (by K. Tobita)

- Minimize the quantity of radwaste
- Shield design optimized to minimize the waste
- Reinforce shield with advanced material while keeping reactor size.
- Radwaste either cleared or reused.

Radial build of the new concept for A-SSTR2





clearance
center pole
coil case
TF coil
coil case
vacuum vessel
shield
permanent blk
replaceable blk
replaceable blk
permanent blk
stabilizing shell
shield
vacuum vessel
coil case
TF coil
coil case
conventional design
new concept
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
10^6
clearance index
critical RI
conventional design
new concept
Ag108m (3,900), Ni63 (11)
Ni63 (48), Co60 (42), C14 (11)
Co60 (35)
C14 (35)
Be10 (2), C14 (2)
C14 (30,500), Be10 (71), Al26 (9)
same as left
C14 (5,270), Be10 (10), Al26 (2)
same as left
C14 (6,180), Be10 (11), Al26 (3)
same as left
C14 (23,000), Be10 (55)
same as left
C14 (17)
Be10 (1), C14 (1)
Co60 (16)
Ni63 (24), Co60 (16), C14 (4)
Ag108m (1,400), Ni63 (3)
Nb94 (95), Co60 (8), Ni63 (5)
Co60 (32), Tc99 (7), Ni63 (5)
Co60 (6), Tc99 (1), Ni63 (1)
clearance index in parenthesis

Minimizing Fusion Rad-waste2

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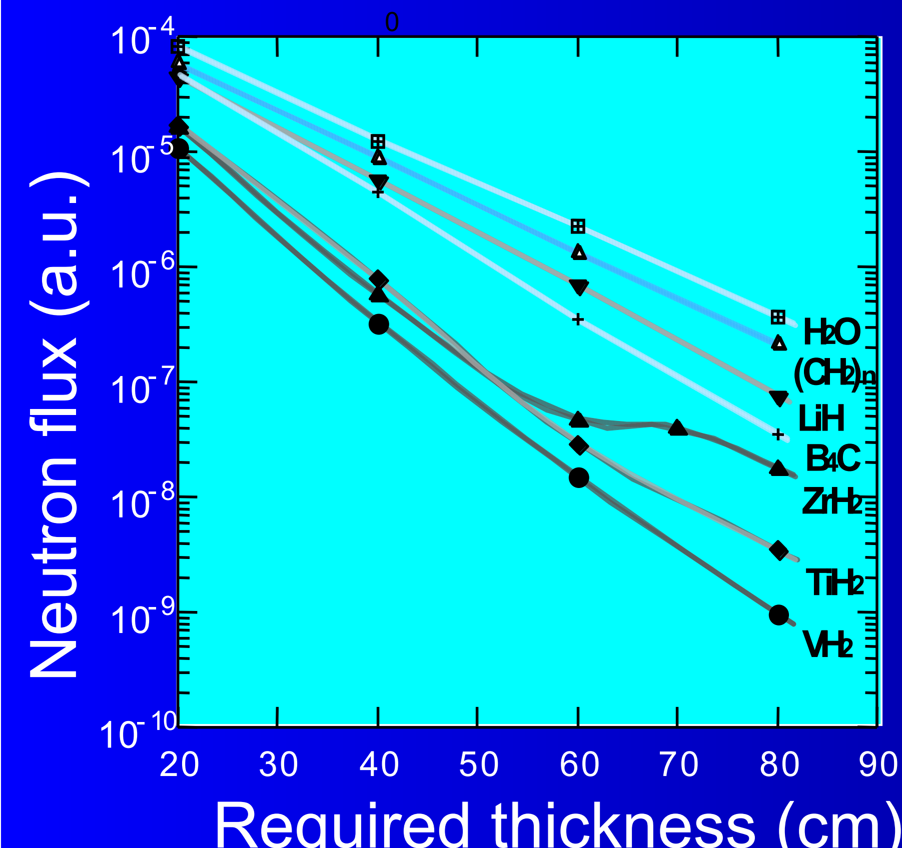
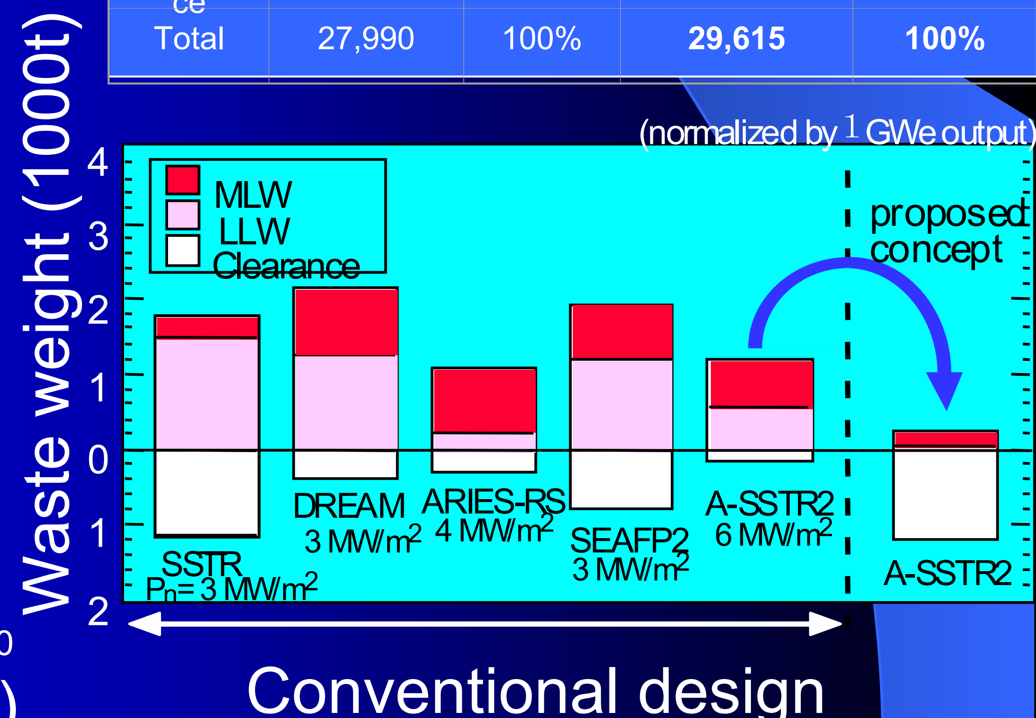
Large amount of radwaste may not be a disadvantage of Fusion.

	Conventional Concept		**New Concept (Radwaste Minimum)**	
	Weight (t)	wt.%	Weight (t)	wt.%
MLW	14,044	49.7%	**4,689**	**15.8%**
LLW	5,651	20.4%	**296**	**1.0%**
Clearance	8,295	29.9%	**24,630**	**83.2%**
Total	27,990	100%	**29,615**	**100%**





Next step of fusion development

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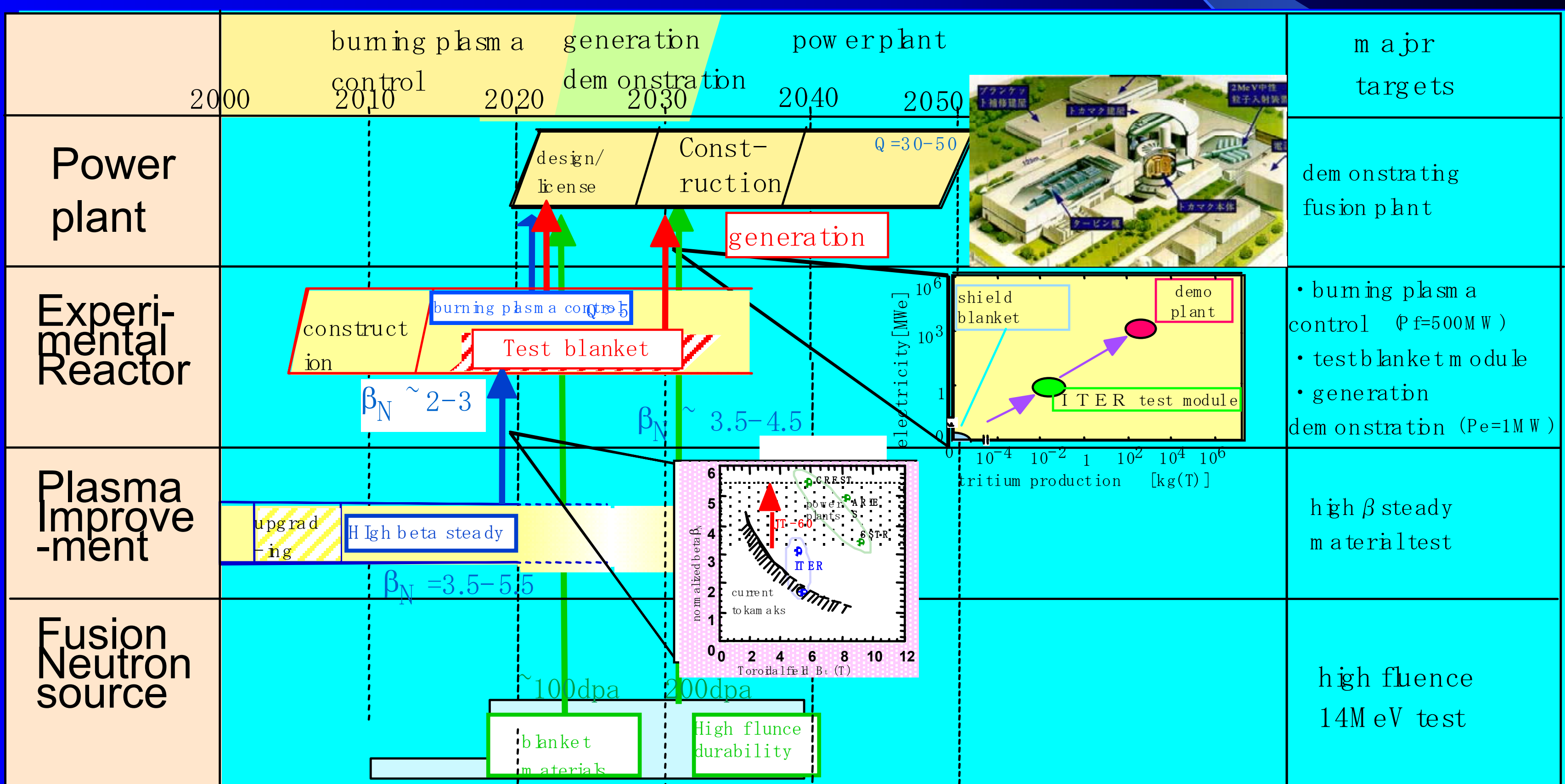
- Objective : To Realize fusion electricity and provide power to the grid.
- Strategy : To concurrently promote burning plasma research, study of improved plasma, blanket development and irradiation test of materials, during ITER operation
  To integrate the achievements into a construction of power plants.

"DEMO" is expected to the last step toward commercial plant.



If we would make it faster?

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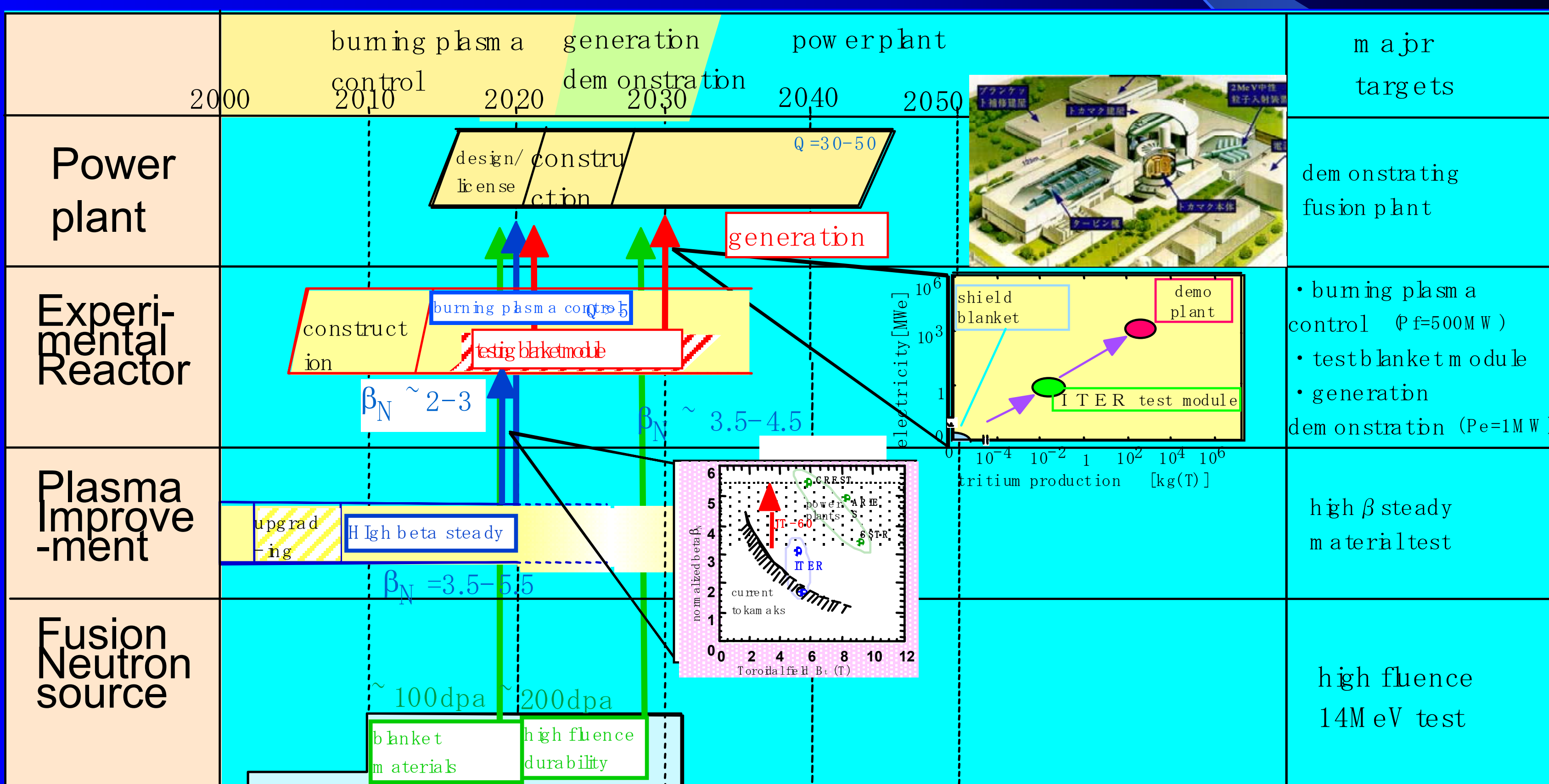
From socioeconomic reason, it is desirable to make the DEMO faster.
Change will appear in the ITER test program and IFMIF

1. Demonstrate generation of 1MW electricity with ITER test blanket modules as early as possible .
2. Promote advanced plasma research for modification of fusion plasma (βN=3.5-5.5 in steady state) .
3. Acceleration of irradiation tests of reduced activation ferritic steel and advanced materials with IFMIF to confirm durability in the rance of 100-200dpa



Some other topics

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1 .Plant operation issues
- Disruption control is no longer a safety problem, but investigated as operational issues (reliability/unscheduled outage)
- Start up, burn control, plant scale, construction period , etc. are being studied in comparison with other sources.

2.Plant safety
- Safety study is continued with improved understanding of ITER license process.
- Tritium safety, behavior in environment and biological effect is studied.

3.Externality
- Conventional “externality” study with Extern-E methodology has started on environmental and public health issues.
-“Social Externality” study in the context of security, proliferation and public acceptance issues started.

Conclusion

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-Socioeconomic study of fusion started in Japan in various fields.

- Although in their initial stage, collaboration with non-fusion specialists brought interesting results.

-Reactor design studies need review from socio-economic aspect.

- “Accountability” issue seems common for all fusion researchers.

- Information exchange under IEA framework is expected to work.