FUSION POWER

A STRATEGIC CHOICE FOR THE FUTURE ENERGY PROVISION

Why is so much time lost for decision making?

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Overall Energy Situation

Problematic situation; “squaring the circle?”

In the long run, major *perturbations* expected:
- considerable increase of world energy demand
- finiteness oil and gas; geopolitically ‘unstable’ regions → higher prices…
- enhanced greenhouse effect (coal only with CO$_2$ sequest)
- energy efficiency & renewable sufficient?
- drive towards decentralized power; base load work horses
- revival of nuclear fission?
- hydrogen economy not really ‘solution’; energy *carrier*
Need for Energy Research

Major challenge on long term scale:

- Energy is vital for society
- Sustainable energy provision not evident
  - Security of supply
  - Clean
  - Affordable
- Major uncertainties for context & technological solutions

→ Need much more energy R&D and urgently to deliver in time
Need for Fusion Research

Because of uncertainties and challenges

- Cannot afford to fail
- There is no silver bullet
- Need portfolio of energy-technology research

→ Irresponsible to stop or delay development of potentially successful source: nuclear fusion
Views on Fusion Research

- Scientific progress fusion research remarkable
- ITER process ‘bumpy’ but good technical design
- Reactor orientation biggest promise for success
- Alternative-concepts & materials R&D needed
- Independent experts and industry supportive
- Utilities not interested because liberalization
- Fusion stands good chance for commercial electricity generation
Realistic Time Frame for Fusion

- Middle of next century reasonable time table for commercial fusion
  - ITER construction 8 - 10 y
  - first ITER experimental campaign 10 y
  - design DEMO 6 - 10 y
  - DEMO construction 8 - 10 y
  - test & measuring phase DEMO 10 y
  - construction PROTO / FOAK reactor 10 y

Fast track combines DEMO and ‘old’ PROTO; but still need for a FOAK!
ITER History

- 1985 summit Geneva USA & USSR
- 1988-1990 ITER CDA; two divertors, R < 6m
- 1992-2001 ITER EDA:
  - Stage 1: Rebut; bottom divertor, R > 8m
  - Stage 2: Aymar-1 till 1998; ≈ Rebut design, Cost 6 G €
  - Stage 3: Aymar-2 till 2001; ITER FEAT, Cost 3 G €
- 2001-2002 ITER CTA; support negotiations
- 2003-… ITER TA; idem

US leaves ITER in 1998-1999
2001-… ongoing ‘Negotiations’ on ITER site
## ITER-EDA Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>$P_{\text{fus (nom)}}$</td>
<td>$1500 \text{ MW}_{\text{th}}$</td>
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<tr>
<td>$P_{\text{design}}$</td>
<td>$2500 \text{ MW}_{\text{th}}$</td>
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<tr>
<td>Burning duration</td>
<td>$1000 \text{ s}$</td>
</tr>
<tr>
<td>$R_{\text{maj}}$</td>
<td>$8 \text{ m}$</td>
</tr>
<tr>
<td>$I$</td>
<td>$20 \text{ MA}$</td>
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<tr>
<td>Cost construction</td>
<td>$\sim 6000 \text{ MEuro}$</td>
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ITER FEAT Parameters

- Long pulse duration ~ 300-500s with $Q > \sim 10$
- Demonstrate current drive with $Q \sim 5$
- Aim for ignition
- $P_{\text{fus}} = 500 \text{ MW i.s.o. } 1500 \text{ MW}$
- $R \approx 6 \text{m } \text{i.s.o. } 8 \text{ m}$
- $I \sim 13 \text{ MA } \text{i.s.o. } 20 \text{ MA}$
- Modular and evolutive construction
ITER-site negotiations

- < 2003, only three partners: EU, JP, RF
- Originally 4 sites: CAN, FR, ES, JP
- CAN drops out; EU selects Cadarache
- 2003: US returns, CH and S Kor join negotiations
- End of 2003: deadlock
  - EU, CH and RF favor Cadarache
  - JP, US and SK prefer Rokasho-mura
- Early 2004 ‘technical’ evaluation 9 topics
- Middle 2004 EU proposal ‘Broader Approach’
  
  Winning site pays 50% ITER + 50% IFMIF
Reflections and Observations on Negotiations

- < 2003, three partners expressed ‘willingness’ to build machine: 50%, 35%, 15%
- < 2003, EU never thought JP wanted to host ITER; JP negotiations ‘misinterpreted’
- Does international politics play a role (US↔FR)?
- Did Europe make the ‘wrong’ choice?
- Does US science politics (lin accel) play a role?
- US approach ‘strange’: only 10% in ITER and dropping of FIRE?
Way out of these negotiations?

- Ph. Busquin announces ‘breakthrough’
  cfr ‘Broader Approach’
- JP has not changed position…
- **Way out?**
  - ‘dissolve’ present ITER club;
  - one candidate host to propose to build alone;
  - invites other partners (also worldwide) to join new club
- **But no need for two ITERs!**
- **Non-ITER site to host IFMIF + complementary fusion experiment**
Conclusions

- Major energy-related challenges & uncertainties: energy is a strategic issue!
- Much more energy R&D needed
- Fusion development so far very successful → fusion to be part of energy R&D portfolio
- Current funding of fusion R&D too low!
- Pharmacist’s scale approach unsuccessful
- Stalemate ITER siting shame for fusion development
- Break gridlock and get ITER built ‘somewhere’!