The Greens | European Free Alliance
in the European Parliament

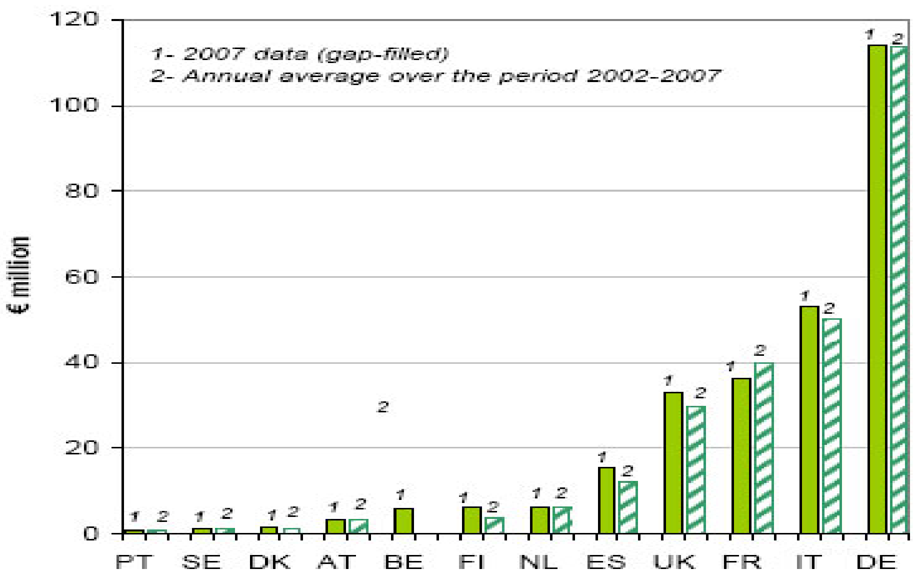
Fusion blows the mind, but it also blows the energy budget: A short backgrounder note on International Thermonuclear Experimental Reactor (ITER)[1]

May 2010

The fascination with fusion is easy to understand as it has been described as 'the fundamental energy source of the universe. It is the process that powers the sun and the stars[2]'. What could be more exciting for scientists than to master the power of the universe? What could be more appealing to politicians than to support their scientists in every effort to make that dream come true?

As a result, during the past six decades, no other energy technology has received as much political and public financial support as nuclear fusion. Figure 1, shows the contribution of Member States to nuclear fusion over the past years, which as can be seen is dominated by Germany, which has made available over €100 million per year over the last five years.

Figure 1: Approximate Annual R&D investment in nuclear fusion by Member States of the EU

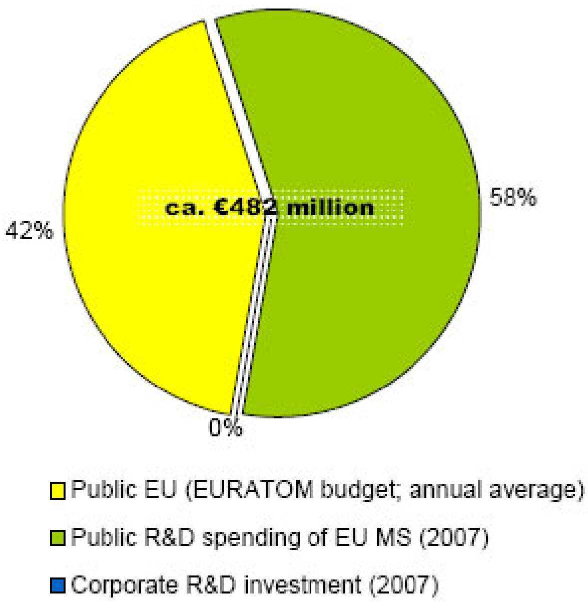


Source: EC 2009[3]

[1] Parts of this note are taken from the article "Fusion blows the mind, but it also blows the energy budget", by Rebecca Harms, co-president of the Greens-EFA group in the European Parliament, and published by Research Europe , 6th August 2009
[2] http://www.hellasfusion.gr/englishver/basic.php
[3] EC 2009: Commission Staff Working Document Accompanying Document To The Communication From The Commission To The European Parliament, The Council, The European Economic And Social

Figure 2, shows the contributions of the European Union and the commercial sector to the fusion budget in Europe. As can be seen, the EU has been providing a little over 40% to the budget, with negligible contribution from the business community. However, these relative allocations are set to change as most of the construction cost of the next demonstration facility will be paid for via the EU budget.

Figure 2: Annual Contribution of the EU, Member States and the Private Sector to the European Fusion Budget



Source: EC 2009[4]

Few areas have attracted as many well-trained scientists, but still the outcome in terms of collective benefit is close to zero. Furthermore, there is no machine in operation based on fusion technology that provides net power and we are still decades away from any potential commercial application. Even the nuclear lobby point to the perpetual nature of the commercialisation timetable for future power "A long-standing joke about fusion points out that, since the 1970s, commercial deployment of fusion power has always been about 40 years away[5]".

Fusion

Nuclear fusion requires the fusing together of atoms to create energy, contrasting the splitting of the atom, that occurs in existing nuclear power plants – a process called nuclear fission. In the core of a fusion reactor a mixture of deuterium and tritium (D –T) fuse together and the neutrons that are subsequently generated are absorbed by a blanket of lithium, which surrounds the core. This then transforms the lithium into tritium and helium while creating heat. This heat is then used to generate electricity, as in a conventional power station. The main technical difficulty is to develop a device that can heat the D-T fuel to a high enough temperature and confine it long enough for more

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Committee And The Committee Of The Regions On Investing In The Development Of Low Carbon Technologies (SET-Plan) R&D Investment In The Priority Technologies Of The European Strategic Energy Technology Plan, October 2009, SEC(2009) 1296
http://ec.europa.eu/energy/technology/set_plan/doc/2009_comm_investing_development_low_carbon_technologies_r_and_d.pdf

[4] ibid

[5] WNA 2010: Nuclear Fusion Power, World Nuclear Association, April 2010, http://www.world-nuclear.org/info/inf66.html

energy is released through the fusion reactions than is used to get the reaction going. At present, two main experimental approaches are being studied:

- The first method uses strong magnetic fields to contain the hot plasma and is where most of the international collaboration is engaged, for example in the ITER. These designs are often categorised as tokamak reactors. A variant of this is the stellarators, which are being developed in a number of countries, including by the Max Planck Institute in Germany, where the Wendelstein 7-X, is under construction and the TJII which is in operation in Madrid;
- The second involves compressing a small pellet containing fusion fuel to extremely high densities using strong lasers or particle beams. The world's most powerful laser fusion facility, is the $4 billion National Ignition Facility (NIF) at Lawrence Livermore National Laboratory (LLNL) was completed in March 2009. European projects are also underway with the construction by the French Atomic Energy Commission of the Laser Mégajoule (LMJ) – near Bordeaux. This type of facility, has also a number of military research functions, including the simulation of sequences of nuclear explosions.

Fusion is considered a "particularly attractive energy solution," says the Commission, as it uses fuels that are abundant in nature or are derived from abundant materials. The Commission says that one gram of fusion fuel would generate an amount of clean energy equivalent to the combustion of eight tons of coal. Furthermore the supporters of fusion claim that the wonder machine would not have any of the traditional problems of nuclear fission: risk of accidents; radioactive waste; and nuclear weapons proliferation.

However, the truth is that if nuclear fusion power ever became commercially feasible it would be dangerous, create new proliferation risks, and come in at an absurd cost. Many technical features of a fusion reactor remain unknown and would require materials able to withstand and confine temperatures of around 100 million degrees centigrade.

Proliferation Risks

One thing is clear: a fusion system would need unprecedented amounts of tritium. Estimates of the annual needs are between 10 kg and more than 50 kg, for comparison, a sophisticated nuclear warhead contains a few grams of it—but the release of even a fraction of that amount could lead to a disaster.

Nuclear Waste

The radioactive inventory of a fusion reactor is expected to be comparable to that of a fission reactor of the same size as some of the component materials become radioactive due to the bombardment with high-energy neutrons. Compared to a fission reactor, the fusion inventory is generally less toxic and shorter-lived because it consists of tritium and activation products and contains no fission products and actinides. However, there are also activation products with half-lives in the order of millions of years.

Environmental Risks

There are also other potential environmental risks, in particular those relating to the containment and release of tritium. As an isotope of hydrogen, tritium is easily incorporated into water, making the water itself weakly radioactive, therefore it can be inhaled, absorbed through the skin or ingested. Inhaled tritium spreads throughout the soft tissues and tritiated water mixes quickly with all the water in the body. Furthermore, with a half-life of about 12.3 years, tritium remains a threat to health for about 125 years. Finally it is very difficult to contain since it can penetrate concrete, rubber and some grades of steel[6].

ITER - Financial white elephant

After decades of negotiations the *ITER* Agreement was signed in November 2006 by Ministers from the seven Members (China, EU, India, Japan, Russia, South Korea and United States), which approved the project's location in Cadarache, France. The choice of the Cadarache site for the ITER is contentious, as in 2003 a commercial plutonium fuel-fabrication plant on the site was shut down because of its vulnerability to earthquakes. Protection against seismic risk further complicates the ITER design and increases costs.

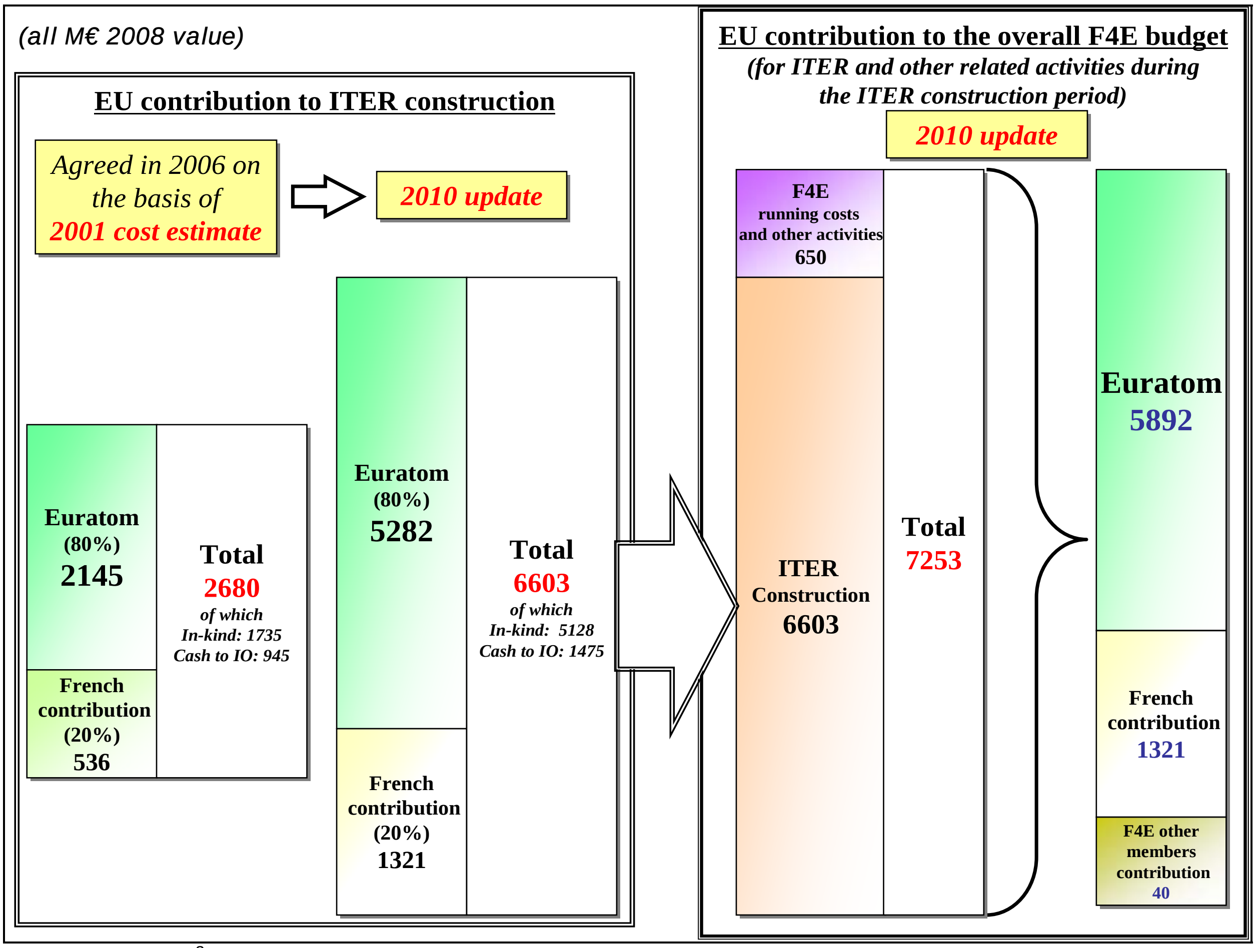
The 2001 cost estimates for the total ITER construction was € 5.9 billion (€ 5.896 billion in 2008 value). The construction time was reported to be around 10 years. However, by early 2010, this has nearly tripled and is estimated to reach about € 16 billion (2008 value).

Of the seven partners the EU (plus Switzerland) has the largest financial share, providing 45% of the total construction budget, out of which France has committed to pay 20%. Therefore[7]:

- The original EURATOM contribution was expected to be €2.7 billion (€2.680 billion in 2008 value).
- This contribution (as shown in the graph below) was updated according to the revised schedule (2007-2020) and presented to the ITER Governing Board in March 2010, and had reached €7.253 million (in 2008 value).

[6] WNA 2010: Nuclear Fusion Power, World Nuclear Association, April 2010, http://www.world-nuclear.org/info/inf66.html
[7] European Commission 2010: Communication From The Commission To The European Parliament And The Council ITER status and possible way forward, SEC(2010) 4th May 2010, COM(2010) 226 final

Figure 3: EU Contribution to ITER



Source: EC 2010[8]

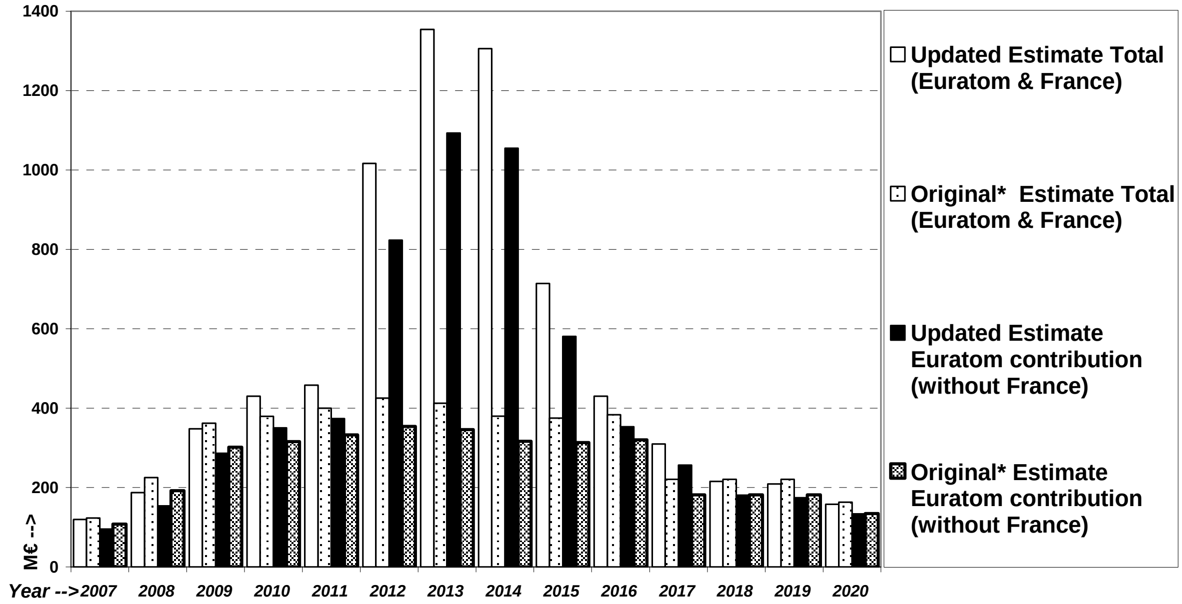
The anticipated expenditure from EU's research budget (7th Framework Programme – FP7) was €346 million for 2012 and €344 million for 2013 in current value. Therefore EURATOM is facing an estimated financial gap of about €1.4 billion (in current value) for the years 2012-2013 (€550 million in 2012 and €850 million in 2013).

Lock-in effect:

Should Europe support the start of the major construction activities in 2012 then this will start a process that will be difficult to stop. As shown by the Commission, in this case, the resources needed for the construction will peak during the years 2012 to 2015 at about €4 billion, which basically means EUR 1 billion per year (see figure 4).

[8] EC 2010: Commission Staff Working Document "Status of the ITER project"- Accompanying Document to the Communication from the Commission to the European Parliament and the Council on "ITER status and possible way forward", May 2010, SEC(2010) 571

Figure 4: EU Budget Schedule for the ITER



*The original estimate in this graph includes the Euratom contribution to ITER construction based on 2001 assessment and the resources projected for the running cost of F4E and other activities as included in the 2007 Council decision establishing F4E

Source : EC 2010[9]

In 2008, before the new constructions costs were estimated, an independent analysis of EU research funding into fusion undertaken for the European Parliament concluded that "organisational and management arrangements appear insufficient to tackle the extreme riskiness of the project". Furthermore, the assessment found that the "excessive focus on ITER" might "jeopardise the attainment of important EU goals" such as the development of a sustainable energy mix[10].

These budgets do not include financing for the operation or decommissioning of the facilities. At the time of the agreement of financing the project the annual costs of operating ITER were estimated to be, on average, on the order of $188 M (54% of the 1998 ITER design operating costs). This was to be shared among the participating Parties, and totalling $3760 M over 20 years. These estimated costs include personnel costs (~32%), energy and tritium fuel costs (~20%), and capital improvements, spare parts and materials, and waste management operations (48%). However, given the rise in construction costs, it is expected that these estimates are likely to rise.

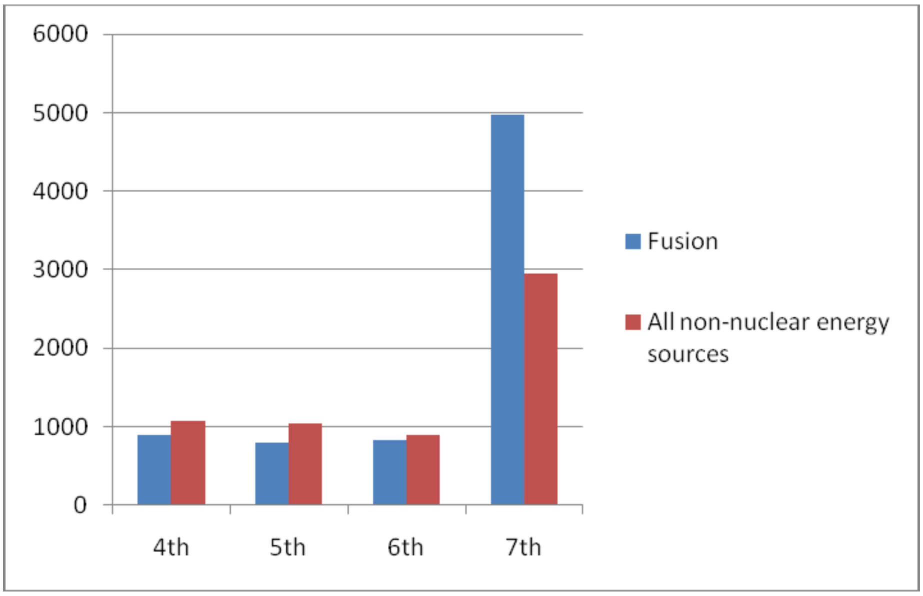
The graphic below highlights the anticipated increase in fusion budget and how it compares to the rest of the EU's energy research and development. As can be seen the current research programme, the fusion budget is close to double that of all non-nuclear energy sources.[11]

[9] EC 2010 ibid

[10] European Parliament 2008, Evaluation Of EU Funding Of Research In The Fields Of Nuclear Fusion And Aeronautics/Aerospace, European Parliament, Policy Department of Budgetary Affairs, July 2008. http://www.pedz.uni-mannheim.de/daten/edz-ma/ep/08/EST22651.pdf

[11] The budget for the 7th Framework programme for non-nuclear energy sources runs for 7 years, while the original Euratom budget, which includes the fusion research, was only for 5 years. However, this figure has included the anticipated budget request for the additional two years.

Figure 5: EU Framework Programme Non-nuclear energy and Fusion Budgets (billion €)



Source: Various EU documents

ITER: A financial dilemma or an opportunity to save money?

Under normal budgetary conditions funding such an amount at short notice would be complicated, but given the current financial and budgetary constraints raises even more significant and potentially insurmountable problems. There are a number of options on the table, including:

1) Increase contributions from Member States and in particular France. As the host country France has already committed 20% to the EU's total construction finance. Ensuring that France's contribution to the budget shortfall is at least 20% would be in line with previous thinking. Furthermore, in the current financial circumstances, it is unconceivable that Member States will accept to increase their share. However, even France is arguing to limit its own contribution to its 20% share based on the original 2001 construction costs estimates. This would increase the gap to at least an additional €800 million.

2) Increasing the EURATOM framework budget from other EU sources, such as the EC framework programme. While this is possible, and probably the most likely option, the financial gap is so large that this possible solution could - at most - meet only part of the shortfall. Furthermore, it raises significant political issues (which budget should the funding come from, Galileo, other fusion projects or renewables energy?) and economic problems, given the need for budgetary restraints in general.

3) Proposals to seek a loan from the European Investment Bank have been put forward. However, the lack of certainty over the revenue streams and the inherent financial risks in the project make this solution unlikely. The Commission does not support this option.

4) Delaying the construction schedule to enable the higher costs to be dispersed over a longer period and potentially into a period of less global financial uncertainty. This would demand political courage from the Commission and Euratom when the project's financial future will be discussed with the other international ITER-partners at the next ITER Council in mid-June in China.

5) Suspending the construction of ITER to enable a reassessment of the appropriateness of the technology in light of the rapid development of other energy options, such as concentrated solar power, offshore wind and hot rock geothermal energy, all of which offer similarly huge energy resources. This is likely the less costly solution since the bulk of the construction phase has not started yet.

Conclusions and recommendations

While fighting both climate change and the economic crisis we simply cannot afford to continue to pour billions of euro into a programme that will not deliver any energy for at least three to five decades and that will never be clean.

It is time to face the hard truths of the ITER programme and therefore the EU must publicly acknowledge that there is not enough public money to start its construction in 2012. The EU must re-allocate the resources towards the fastest and cheapest solutions, energy savings and renewables, before it is too late. Pull the plug on fusion, now!

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1st JUNE UPDATE: CHAOS IN THE EUROPEAN COUNCIL[12]

"The crunch is so serious that some European states have gone as far as to ask the commission to investigate the possibility of withdrawing from ITER": Nature 28th May 2010[13]

The May 25/26th Competitiveness Council discussed the ITER project and failed to agree a mechanism to address the budget shortfall. Instead they proposed "a task-force to analyze possible options in order to find a sustainable solution". They further stated that "the result of the discussions of this task-force will feed into the work of the Council preparatory bodies, with a view to carrying out further deliberation in the Competitiveness Council prior to the ITER Council meeting". This later point is surprising give this was the last Competitiveness Council before the ITER Council in mid-June. This probably means that an extraordinary Competitiveness Council will have to be organised in the coming two-three weeks.

[12] http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/intm/114631.pdf :

[13] Financial meltdown imperils reactor - Faced with a huge budget shortfall, Europe rethinks future of ITER fusion project. Nature - 28/05/2010 - Will the ITER reactor ever have its day in the sun?