



Brussels, 14.6.2017
SWD(2017) 232 final

COMMISSION STAFF WORKING DOCUMENT

The ITER Project Status

Accompanying the document

Communication from the Commission to the European Parliament and to the Council

EU contribution to a reformed ITER project

{COM(2017) 319 final}

I. INTRODUCTION

ITER is a global project to build and operate an experimental reactor with the aim of demonstrating the scientific and technological feasibility of fusion as a sustainable and economic energy source. ITER contributes therefore to the strategic agenda of the European Union for clean and secure energy and supports the first objective of the Commission's political agenda: 'boosting, jobs, growth and investment in future high potential technologies'.

The importance of this project cannot be underestimated. It has the potential to change globally the way energy is produced and currently it is also one of the largest international research projects under construction in the world. This pioneering initiative is developed under the terms of an International Agreement¹ between the European Atomic Energy Community (Euratom) and 6 other Members - China, India, Japan, Korea, Russia, and the United States - signed in Paris in November 2006 and entered into force in October 2007.

ITER is an important step in the development of fusion as an energy source – although over 200 fusion projects currently exist in the world in a number of countries and some have already achieved important scientific results, no single country has the capacity to develop a project of the size of ITER, the scale of which is necessary for the breakthrough expected to demonstrate the feasibility of fusion as an energy source.

The ITER project will be followed by a demonstration reactor (provisionally called DEMO) which will build on the experimental achievements of ITER and demonstrate the economic feasibility of commercial exploitation of fusion power.

- **A positive benefit of the ITER investment for the EU**

In its present construction phase, ITER is already having a positive economic impact in the region where the site is located and, more generally, on the European industry, SMEs and the research community involved in the development and construction of thousands of first-of-a-kind technological components.

In fact, between January 2008 (the start of ITER activities) and December 2015, contracts for approximately EUR 3.6 billion have been awarded in Europe through about 750 procurement contracts and about 150 grants supporting Europe's ITER activities. These contracts and grants have benefited companies including SMEs from at least 20 different Member States. All this translates into new knowledge and cutting-edge technology, market-oriented research and innovation and high skilled jobs and knowledge all over Europe.

As the project evolves, more procurements and grants will follow, not only in relation to Euratom in-kind contributions but increasingly also for the assembly and tooling work needed by the project's central executive (the ITER Organization). These procurements will include new specialisations and activities, like diagnostics, remote handling and heating systems which require high technology solutions, opening opportunities for businesses from industrial

¹ The agreement established the ITER Organization with full international legal personality, responsible for the joint implementation of the ITER project.

sectors and geographical regions that have not so far been prominently represented amongst the beneficiaries.

- **Euratom has a unique role (and responsibilities) in the ITER agreement, and has set up the Domestic Agency "Fusion for Energy" to fulfil its obligations**

Pursuant to Article 1.2 of the ITER Agreement, Euratom is the Host Party of the ITER project, which entails specific responsibilities, in particular, pursuant to Article 26.1 of the ITER Agreement, the Host Party cannot withdraw from the project. Moreover, in accordance with the ITER Agreement, during the construction phase Euratom contributes a value of 5/11 (around 45%) of which 80% is funded by Euratom, and 20% by France as the Host State of the project), while the rest is equally divided among the other 6 ITER Members (1/11 or around ~9% each). During the subsequent operation and deactivation phases, Euratom will contribute 34% (of which 80% will be funded by Euratom and 20% by France as Host State of the project) of the total costs, while the other Members will increase their contributions from 9.09% to 10%, with the exception of United States and Japan, who will contribute 13%.

The contribution of each ITER Member is provided both in cash and mostly in kind: in cash through contributions to the budget of the ITER Organization needed for its functioning and in kind through the delivery of components of the ITER machine. Article 8.4 of the ITER Agreement foresees that each Member shall provide its contribution to the ITER Organization through an appropriate legal entity, a so called Domestic Agency. For Europe the Domestic Agency is the Joint Undertaking "Fusion for Energy" (F4E) established by Council Decision 2007/198/Euratom of 27 March 2007². Fusion for Energy has its seat in Barcelona (Spain). The Members of Fusion for Energy are the EU Member States, Euratom and Switzerland³.

The Euratom contribution to the ITER project is defined in this document and in the Communication as the joint contribution of the EU budget, France as Host State and the Members of Fusion for Energy. This contribution is paid to the budget of Fusion for Energy. The share of the Euratom contribution to ITER (thus, through Fusion for Energy's budget) is funded 80% by the EU budget and ~20% by France. The overall budget of Fusion for Energy also benefits from an additional ~2% paid by its Members.

The European Commission represents Euratom at the ITER Council and its subsidiary bodies as well as at the Fusion for Energy Governing Board.

- **The project has already been re-baselined once, in 2010**

The ITER agreement was signed in 2006 on the basis of a baseline⁴ established and agreed by the Members in 2001 in order to be able to converge on a "Final Design Report" and a division of the in-kind procurements.

² OJ L 90, 30.03.2007, p.58.

³ Article 1.3.c of the Fusion for Energy statutes allows third countries having a cooperation agreement with Euratom in the field of fusion that have associated their research programme to the Euratom programmes to become Members of the Joint Undertaking if they so wish.

⁴ A "baseline" refers to the inter-related elements of scope (specifications of the machine to build), schedule (timetable for construction) and cost.

The 2001 baseline estimated the total ITER construction costs at about EUR 5.9 billion (5896 million in 2008 values). The Euratom contribution thus amounted to about EUR 2.7 billion (around 45%, EUR 2680 million in 2008 values), composed of about EUR 1.7 billion for the components/systems to be provided "in kind", and about EUR 1 billion to be provided "in cash" to the ITER Organization. Each Party committed to provide the agreed contributions in kind independently of the final cost of procuring and delivering components. These estimates for the Euratom contribution to ITER did not include the contribution to Fusion for Energy's expenditures for other activities⁵ or its running costs.

Soon after the start of the project in 2007 it became evident that the 2001 baseline was not accurate. In 2010, a new ITER baseline, focused on the construction phase, was adopted by the ITER Council based on estimated costs that were much higher than those agreed upon in 2001. As part of the discussions on the agreement of the 2010 revised baseline, the Council of the EU established a EUR 6.6 billion cap up to 2020 (2008 values), for the construction phase of ITER, the completion of which was then estimated to be by 2020. This cap was on all the activities of Fusion for Energy. The annual financing obligations for Euratom stemming from the 2010 baseline are provided in table 1 of the annex.

- **Current challenges: cost and schedule overruns create a need to put the project back on track**

Although the 2010 baseline was based on a more realistic time plan and estimate of costs, the project has again been facing delays and cost overruns since at least 2012. The delays can partly be put down to the highly complex and technical nature of such a unique project where many components are first of a kind and management concerns. However, there is also recognition that the schedule and cost estimates adopted in 2010 were based on an immature design and initial assumptions that have not been sufficiently robust, and that the management in the ITER Organization was cumbersome, which led to slow-decision making.

The combination of these factors has led to constant design changes resulting in significant delays and additional costs to the project. The additional costs accrued both on the side of Fusion for Energy (as design changes increased the cost of in-kind contributions) and on the side of the ITER Organization (as longer design times result in more personnel costs and design changes, which impact other activities, including e.g. future assembly works).

These effects were further exacerbated by insufficient coordination and collaboration between the Domestic Agencies and the ITER Organization. This meant that the ITER Organization did not feel directly the impact of these design changes (for which the ITER Organization was largely responsible) which were mainly impacting the Domestic Agencies who therefore bore the brunt of the resulting cost increases from their domestic budgets.

This was particularly critical for the delivery of the Tokamak Buildings Complex, which falls within Europe's in-kind obligations and which suffered from continuous changes to its

⁵ "Other activities" refer to the implementation of the Broader Approach agreement with Japan and activities in preparation for the construction of a demonstration fusion reactor and related facilities (including the International Fusion Materials Irradiation Facility (IFMIF), and the ITER Test Blanket Programme).

specifications, from knock-on effects of design changes to components to be housed within it, and from increased safety requirements following the Fukushima incident. As a consequence, over the last years Fusion for Energy accumulated substantial cost overruns in its in-kind contributions. These costs have been quantified and estimated in December 2015 to be over EUR 2 billion⁶.

The 2013 Management Assessment of the ITER Organization⁷, although underlining the complexity of the project, emphasised that important shortcomings in the management and governance of the ITER Organization still remained, in particular the poor leadership of the ITER Organization top management, and recommended, inter alia, the early replacement of the ITER Organization Director-General, the simplification of the decision-making procedures and the development of a stronger project culture and nuclear safety awareness.

II. TURNAROUND OF THE ITER ORGANIZATION

As a response to the recommendations of the 2013 Management Assessment, the ITER Organization developed action plans to address the managerial/organisational matters and governance issues identified. In addition, the ITER Council decided to accelerate the process to replace the ITER Organization Director-General, in line with the recommendations of the 2013 Management Assessment of the ITER Organization. A new Director-General was selected and nominated by the ITER Council of November 2014 with official appointment as from 5 March 2015 by an Extraordinary ITER Council. The 2013 Management Assessment was thus a turning point which pointed to the inadequate management and started the turnaround process which led to the 2015 changes.

The European Commission has worked closely with other ITER Members and with the new ITER Organization management to put in place a comprehensive strategy to put the ITER project back on track. The main focus of this strategy was to ensure management improvements of the ITER Organization and increase the effectiveness of governance, in order to put the project back on track and thus provide a reliable schedule for the construction and operation of ITER.

The action plan of the new Director-General included major changes to the ITER Organization both in the project management and globally. The action plan has been built around the strong integration of the ITER Organization and Domestic Agencies at all levels, and with centralisation of executive authority through on the ITER Organization Director-General as the Chief Executive Officer of the entire project, with full authority over all technical aspects.

In order to enable effective decision-making, the action plan foresaw the introduction of a number of new instruments, e.g. an Executive Project Board (in charge of supervising

⁶ Fusion for Energy Report to the Council of the EU 2015.

⁷ The ITER Agreement, Art. 18 foresees that "Every two years, the Council shall appoint a Management Assessor who shall assess the management of the activities of the ITER Organization. The scope of the assessment shall be decided by the Council [...]. The purpose of the assessment shall be to determine whether the management of the ITER Organization has been sound, in particular with respect to management effectiveness and efficiency in terms of scale of staff".

technical aspects of the project) and the Integrated Project Teams, formed by the ITER Organization and the Domestic Agencies, and in charge of key components and actions.

Furthermore, a Reserve Fund was created to cover the additional costs of the Domestic Agencies caused by changes initiated by the ITER Organization to the design of components. The provisions for its use were adopted by the ITER Council in 2015 and its implementation is under the direct responsibility of the Director-General of the ITER Organization. It is funded from the cash contribution of the ITER Members according to their share in the construction phase (45% for Euratom). Euratom has insured that its contribution to the Reserve Fund is within the capped budget for ITER up to 2020. From 2021 onwards the ITER Organization has estimated a total contribution to the Reserve Fund which for Euratom is taken into account in the estimates for the in-cash contribution reported in tables 1 and 2 of the annex. In the same tables a best estimate of the potential revenue from the Reserve Fund to Euratom from currently known design changes is explicitly given. The Fund introduces an incentive for the ITER Organization to minimize changes as much as possible, and therefore acts as a risk mitigation measure.

The action plan also suggested some reforms to the ITER Organization, in order to optimise human resources. The year 2015 was marked by several organisational changes in the appointments of the ITER Organization senior management, including a very rigorous selection process of the two Deputy Directors-General, as well as the replacement of other key division leaders and restructuring of the functions of the ITER Organization departments. An important change is that one of the two Deputy Directors-General is also the Chief Operating Officer, supporting the Director-General in all matters related to design, construction, installation, testing, commissioning and operation, thus providing much needed technical leadership. The reduction of the top management functions from 7 Deputy Directors-General (one per Party) to just two was an important step to de-politicise the organisation. The resulting new senior management structure reflects better the needs of a construction project.

In about one year and a half of his leadership, the Director-General of the ITER Organization has completed about 60% of his action plan, and the rest is making good progress. The progress in the management turnaround received positive feedback from the Management Assessment 2015, which acknowledged noticeable efforts of the ITER Organization to make the ITER project advance. It recognised, in particular, the effectiveness of the Director-General's leadership and of his action plan, with improvement of the decision making processes, cooperation between the ITER Organization and Domestic Agencies, human resource management, and overall performance of the ITER Organization management, thus leading to a positive momentum change in the construction activities and the achievement of (nearly) all construction milestones.

The positive appreciation of the progress made both by the ITER Organization management and the project itself was expressed also in other recent independent reviews (see section IV for details).

III. TURNAROUND IN FUSION FOR ENERGY

Ensuring that Euratom participation in the ITER project is cost-efficient for European taxpayers and effective in terms of benefits for Euratom requires changes not only in the ITER Organization but also in Fusion for Energy, where improvements in sound management practice and effective cost control need to continue. The Commission works on ensuring further improvements in close collaboration with Fusion for Energy's management.

Fusion for Energy's role in the ITER project is crucial, in line with the dominant (45%) share of Euratom in the project. The major large contracts for the Tokamak Buildings Complex, the vacuum vessel and the superconductive magnet (toroidal and poloidal) coils have been signed and construction and manufacturing are in progress. With the progress of the work, Fusion for Energy has been experiencing difficulties, largely due to the numerous changes requested by the ITER Organization to the specifications of the components to be delivered, as pointed out in the previous sections.

Weaknesses in Fusion for Energy's organization and management were first identified in 2009 in an internal management assessment of Fusion for Energy initiated by the Governing Board, which underlined in particular the lack of a project culture and industrial expertise. A series of changes in the structure of its governance followed in the period 2010-2015. The Governing Board took first measures to better prepare the meetings of the Governing Board, but also to follow up specific critical issues between meetings. The Governing Board also endorsed the involvement of the Commission Internal Audit Service (IAS) in Fusion for Energy as from 2012, complying with a recommendation of the Court of Auditors and thus establishing the IAS as the internal auditor of Fusion for Energy. In parallel, the Commission repeatedly urged Fusion for Energy to implement cost-containment measures.

Based on the lessons learned, the Commission has also re-structured the working relations aiming at establishing efficient and transparent coordination and exchange of information between Fusion for Energy and the services of the Commission.

The effectiveness of these changes was undermined by the frequency of changes of the Fusion for Energy Director (in total, 5 persons occupied the function of Fusion for Energy Director for periods of various lengths over the 9 years of Fusion for Energy's history from 2007 to 2015) as well as the instability in project management in the ITER Organization.

The main opportunity to redress the situation came in spring 2015 with the action plan presented by the acting Director of Fusion for Energy, focused on actions in support of the action plan of the new Director-General of the ITER Organization. The plan involved the following major points:

- Full implementation of audit recommendations;
- Improvement of the contract management tools, with in particular reinforcement of the on-site supervision of work at contractors;
- Gradual merging of configuration management processes and tools with those of the ITER Organization;

- Implementation of a system to manage cost estimates and fund/contingency with delivery at the end of 2015 of a new estimation of the cost at completion for the ITER components to be delivered by Euratom during the construction phase.

It led to important changes in Fusion for Energy, such as the creation of a Project Management Department to reinforce planning and control processes, redeployment of staff to high priority areas and moving of staff to Cadarache to improve work relations and efficiency with the ITER Organization. Efforts were also made to restructure Fusion for Energy's management and strengthen project control and cost containment measures.

These steps laid the ground for the arrival in January 2016 of a new Fusion for Energy Director whose selection in late 2015 focused for the first time on industrial and project management experience. This is expected to bring a new impulse in the way Fusion for Energy manages and delivers the Euratom contribution to ITER.

Notwithstanding the above, the European Court of Auditors (ECA) has always issued an 'unqualified' opinion on Fusion for Energy's annual accounts since 2007 (when Fusion for Energy was set up). While this assurance on the legality/regularity of Fusion for Energy's operations and on absence of material errors in Fusion for Energy's accounting and financial transactions is very important, it is not sufficient to guarantee a clean bill of health as regards Fusion for Energy's governance and management record. Indeed, the European Parliament in April 2016 postponed its decision on granting the Fusion for Energy Director discharge in respect of the implementation of the Joint Undertaking's budget for the financial year 2014. The urgent need for a credible revision of the ITER schedule and for curtailing the risk of continuous cost increase was the major issue underlined by ECA ('emphasis of matter') and was reflected in the basis for the European Parliament's decision. The discharge was eventually granted in October 2016⁸ on the basis of the overall progress of both Fusion for Energy and the ITER Organization, and the revision of the baseline. This confirms that the project needs a new baseline, a need felt not only in Euratom but also in the ITER Organization and shared by other ITER Members. The Management Assessment 2015 report, as its predecessor Management Assessment 2013, also urges that the ITER Organization and Domestic Agencies should be fully committed in developing a realistic ITER project schedule.

IV. TOWARDS A REVISED ITER PROJECT BASELINE

- **The Updated Long-Term Schedule - proposed in November 2015 and rejected by the ITER Council because it did not address all issues and did not take into account the constraints of the Members**

In November 2015, the ITER Organization submitted to the ITER Council a proposal for an Updated Long Term Schedule, covering schedule, resource estimates and a preliminary staffing plan. The proposal did not take into account existing constraints from the Members, and did not include sufficient risk mitigation actions to provide confidence in the proposed

⁸ Official Journal of the European Union, L 333/66 (8.12.2016).

schedule. It also required significant additional cash contribution from the ITER Members (and especially from Euratom, given the share of construction costs) and requested to double the number of ITER staff, but without clear and convincing justifications for this request.

Additionally, in this proposal there was no evidence that the resources were concentrated to finalise the construction phase of the machine, and at the same time it envisaged a delay by five years for First Plasma (from 2020 to 2025), the critical milestone when the main construction phase can be considered as completed. For Euratom in particular, endorsement of such a proposal would have required an additional financial contribution of about EUR 0.5 billion above the total Euratom contribution until 2020 compared with the 2010 Baseline.

The ITER Council rejected the proposal and requested that further iterations between the ITER Organization and the Domestic Agencies take place to ensure reliability, stability and cost sustainability of the schedule over the long term, and to avoid the risk that the forecasted date of the First Plasma is immediately impacted, because of additional delays in the delivery of critical path components. The ITER Council additionally requested that a high level independent assessment be carried out of the ITER Organization proposal on the Updated Long Term Schedule. The ITER Council agreed therefore to form the ITER Council Working Group on Independent Review of the Updated Long-Term Schedule and Human Resources (in brief ITER Council Review Group) to assess the rejected Updated Long Term Schedule (with the associated costs/resources) as well as a revised schedule and cost/resource estimates that takes into account the financial constraints of the Members.

In parallel, to allow the project to move forward and at the same time monitor the project and gain confidence that the project was under control, the ITER Council also approved a working schedule for ITER for 2016 and 2017, together with a set of critical milestones for the same period for monitoring purposes. This two-year schedule requires a modest increase in staffing that partially satisfied the requests from the ITER Organization, and is funded without additional in-cash contribution from the ITER Members with respect to the agreed 2010 baseline.

- **From the Updated Long-Term Schedule to the staged approach**

On 27 April 2016, the ITER Council endorsed at an extraordinary meeting the assessment of the ITER Council Review Group. The final report was fully in line with the concerns consistently raised by the Euratom Delegation: it acknowledged the good work carried out with the development of the first schedule proposal of November 2015 but confirmed the two major weaknesses already identified by the ITER Council. The ITER Council Review Group recognised that the sequence and duration of activities of Updated Long Term Schedule were fully and logically mapped and that resource estimates were generally complete and credible, with no significant overestimates or underestimates. However, it pointed out that both schedule and cost estimates had no contingency, which represented an important element of risk to achieve the First Plasma date in December 2025 and therefore made it impossible to have confidence in the Updated Long Term Schedule.

The ITER Council Review Group also judged the exercise of revision of the Updated Long Term Schedule based on additional iterations between the ITER Organization and the

Domestic Agencies to be beneficial and providing important added value. The ITER Council Review Group report⁹ concluded that the revision exercise should continue and further iterations should be taken by the ITER Organization and the Domestic Agencies in completing the revision of the schedule and associated resources (the so-called Iteration Modelling). It recommended a staged approach to the project, focusing on successful achievement of First Plasma as a first step, and with each following stage focused on clearly identified key project deliveries. The staged approach would thus be an important tool to complete construction while managing and reducing the risks.

In this context, the ITER Council Review Group furthermore recommended to enhance the ITER Organization risk mitigation management by prioritising risks (in terms of occurrence and impact), quantifying the cost contingency needed and expanding the scope for use of the Reserve Fund.

With regards to the organisation and management of Human Resources within the ITER Organization, the ITER Council Review Group conducted a benchmarking exercise with other organisations and analysed cost books and staffing for a sample of key activities. The results show that the size of the organization is reasonable and requests for staff are, for the most part, warranted. The ITER Council Review Group encouraged the use of Domestic Agencies' expertise as one way to optimise the use of staff resources.

- **The staged approach focuses available resources on First Plasma in December 2025 (earliest technically achievable date) and ensures that the Euratom contribution remains within EUR 6.6 billion by 2020**

Following the Iteration Modelling exercise in full cooperation with all Domestic Agencies, the ITER Organization submitted to the 18th meeting of the ITER Council of June 2016 its proposal for a revised schedule to First Plasma and an overall strategy from First Plasma to the Deuterium-Tritium phase, which took into account the recommendations of the ITER Council Review Group report and the constraints of the Members. The ITER Council of June 2016 proposal is built on the staged approach, with the first stage focusing on delivering First Plasma in December 2025 (the earliest technically achievable date i.e. assuming all risks can be mitigated). The United States Department of State stressed in its report for Congress¹⁰ that further risk of schedule slippages could still materialize. A subsequent detailed review of the project to First Plasma carried out by the United States Department of Energy in January 2017 further confirmed that the project schedule should have a contingency of 24 months. Rather than including an explicit time contingency, in the revised schedule project risks are actively reduced by tackling progressively technical challenges, and providing flexibility for accommodating placed contracts. Construction activities to First Plasma are to be followed by additional Final Installations activities (also covered by the construction budget) in the operation phase from January 2026 until the start of Deuterium-Tritium Operation in 2035. From the beginning of the schedule revision exercise, the Commission stressed to Fusion for

⁹ Report of the ITER Council Working Group on the Independent Review of the Updated Long-Term Schedule and Human Resources, 15 April 2016.

¹⁰ U.S. Department of Energy, "U.S. Participation in the ITER Project" (May 2016).

Energy that the capped budget of EUR 6.6 billion (2008 values) up to 2020 had to be adhered to, and furthermore that additional savings were needed for the period after 2020 to contain the overall extra costs to completion. Fusion for Energy's internal restructuring of activities and resources (the so-called "Straight Road to First Plasma") was made to ensure this and it provided its input to the ITER Organization accordingly.

The ITER Council of June 2016 proposal based on the staged approach and taking into account Fusion for Energy's Straight Road to First Plasma strategy enables Euratom to stay within the EUR 6.6 billion cap up to 2020 (in 2008 value) thanks to the reduction of in-kind contributions during the period up to 2020. It also results in lower in-kind contributions for the period 2021-2025 compared with the Updated Long Term Schedule proposal, as non-First Plasma components (also included in the construction budget) are largely shifted to after 2025.

- **Staged approach From First Plasma to Deuterium-Tritium operation and cost containment**

The detailed schedule for the period from First Plasma in December 2025 to the Deuterium-Tritium phase estimated in 2035 was presented to the ITER Council in November 2016. This proposal included:

- a complete schedule and cost including staffing estimate in the form of updated Overall Project Schedule (OPS), Overall Project Cost (OPC) and Project Plan and Resource Estimate (PPRE) for the period up to 2025;
- an indicative schedule and cost baseline for the period from 2026 to 2035.

The updated schedule from First Plasma until the Deuterium-Tritium phase now envisages additional Final Installations activities (also covered by the construction budget) in the operation phase from January 2026 until the start of Deuterium-Tritium Operation in 2035 by alternating installation stages, for all remaining components necessary for fusion power operation, with limited operation campaigns in between. This approach focuses available resources in a structured way, ensures that the known constraints of the Members are taken into account and minimises the delay to the start of the Deuterium-Tritium operation. At the same time, it allows for meaningful experimental campaigns between assembly phases, thus allowing the fusion community to gain confidence in operating the machine and building up to full performance before going into the nuclear (DT) phase with fusion power operation. The total number of staff remains capped to a maximum of 1050.¹¹

- **Endorsement *ad referendum* of the schedule**

The ITER Councils of June and November 2016 approved the new schedule and associated estimated costs (costs approved *ad referendum*) as the basis to prepare a new ITER Baseline that should be approved by the ITER Members at an ITER Council meeting, most likely in 2017 at ministerial level.

¹¹ Record of Decisions of the 19th ITER Council (16-17 November 2016).

- **Potential impact of the staged approach for the European scientific community**

ITER remains the most important facility in the European fusion roadmap. ITER is on the critical path of this roadmap, and any delay in ITER operation will impact on the achievement of the roadmap's long-term objective, that of delivering fusion electricity to the grid within a realistic yet ambitious time horizon. However not all research in the roadmap requires ITER to be operational and the delay in the start of ITER operation enables crucial long-lead time research (such as development of new materials for DEMO and eventual fusion power plants) to progress to a much more advanced stage by the time ITER achieves its operational objectives.

Delays in ITER can be partially mitigated also through a more concerted approach to the exploitation of other key tokamaks around the world, thereby better preparing for ITER operation and enabling the ITER experimental programme to be accelerated as much as possible. Within Europe, such an approach is already integrated into the EUROfusion¹² joint programme, with the exploitation of the European medium-sized tokamaks, including larger facilities like JET (in the UK) fully coordinated and focused on support for ITER. This can be extended to the global scale by better coordinating the exploitation and scientific programmes of the large tokamaks operated by the other ITER Members, such as K-STAR (Korea), EAST (China), and DIII-D (United States.). This is particularly the case for the JT-60SA Tokamak (Japan), being constructed on budget and on time by Euratom, the Voluntary Contributors to the Broader Approach¹³ and Japan as part of the ITER Broader Approach project. This could bring greater confidence in how to operate ITER both technically and with optimum plasma performance.

The on-going mid-term review of the EUROfusion activities 2014-18, and associated revision of the fusion roadmap (due to be available by spring 2017), must of course take into account the revised ITER schedule. This should further enable crucial long-lead time research for the fusion research community needed to underpin the commercial viability of future fusion reactors, such as the development of new materials through the construction of suitable facilities for instance for materials irradiation using a neutron source, e.g. the DEMO Oriented Neutron Source DONES. In this respect, three EU Members States (Croatia, Poland and Spain) are currently interested to host this facility.

- **Active risk mitigation through careful monitoring of high level milestones**

At ITER Council of June 2016 the Commission also stressed the need to monitor closely the project's progress in the next two years against the set of milestones selected by both the ITER Organization and the Domestic Agencies as approved by the ITER Council. The ITER Council Review Group agreed with this approach, and in its report also recommended to identify further critical milestones for the years after 2017 in order to provide early warning to critical path deliverables or assembly risks. The ITER Organization therefore included as part

¹²The European Consortium for the Development of Fusion Energy (EUROfusion, <https://www.euro-fusion.org/>) is a consortium of 30 national fusion research organisations and laboratories from 26 EU Member States (excluding Luxembourg and Malta), plus Switzerland and Ukraine (from 1/1/17), that participate in collective fusion research activities under a European Joint Programme co-financed under the Euratom Research Programme (2014-2018).

¹³ Belgium, France, Germany, Italy, and Spain.

of their reinforced risk mitigation process the careful monitoring of additional high level milestones, which would be reviewed and complemented at the end of each year by additional working level milestones for the next two years' period.

- **The status of the project allows a better planning for longer term**

- **Maturity of the design**

The ITER Organization and Domestic Agencies have made significant progress in the development of the project. Work done by the Domestic Agencies under the Procurement Arrangements (91% of which have now been signed by the ITER Organization with all Domestic Agencies in terms of nominal shares of value credits¹⁴) is progressing well and momentum is building. The ITER Organization, together with the Domestic Agencies, has analysed the global status of First Plasma components¹⁵ in areas such as design, procurement, manufacturing, shipment, on-site installation, and testing and commissioning. This analysis is based on key elements of the scheduled activities which represent the major ITER systems, but exclude Assembly and Installation. The percentage completion up to First Plasma has been estimated by the ITER Organization to be 89% complete through final design, and 24% manufacturing. The percentage of manufacturing includes partial credit for components partially completed. The percentage completion for non-First Plasma components was also estimated by the ITER Organization to be 71% complete through final design, 11% manufacturing¹⁶.

To further reduce the risk of schedule delays and cost overruns, the ITER Council also requested at ITER Council of June 2016 that the interfaces of the First Plasma components linked to the schedule be frozen as quickly as possible.

- **Improved governance**

Through his action plan, the Director-General of the ITER Organization reformed the management of the project in several areas (see section II). At the 18th ITER Council of June 2016 improvement was reported in several areas, in particular:

1. Tight coordination of the activities of the ITER Organization and Domestic Agencies staff, now jointly in charge of specific equipment or tasks through the creation of Integrated Project Teams (to date three Project Teams have been established: Cryogenics, Vacuum Vessel, and Buildings, Site Infrastructure & Power Supplies Distribution).
2. Human Resources are being continuously optimised for improved efficiency and cost effectiveness, including the recent replacement of the Head of the Human Resources Department.

¹⁴ This nominal share is formally accounted through the ITER Unit of Account (IUA), defined so that 1 IUA = USD 1 thousand (January 1989 value), or EUR 1,690.12 (2016 value).

¹⁵ First Plasma systems include: Buildings, Steady State Electrical Networks, Cable Trays, Vacuum Vessel, Gas Injection System, Magnets, Cryostat, Thermal Shield, Cooling Water, Vacuum System, Cryoplant and Distribution, Coil Power Supplies and distribution, CODAC, Central Interlock System, Central Safety System, ECRH, Diagnostics and Port Plugs, In-Vessel Viewing System, Access Control and Security Systems.

¹⁶ MAC-21_04.4.1, Report on Activity Plans (21st MAC meeting, 24-26 May 2016).

3. Implementation of coordinated tools for establishing a nuclear project culture, in particular a plan to enhance knowledge on nuclear safety in the ITER Project focusing on root causes.

In the present context of efforts to put the project back on track, it is necessary to pay further attention to the governance of the project. Efficiency in the decision-making of the ITER Council can be increased for instance by structuring the agenda of the meetings so that they focus on strategic questions. Thorough preparation of the ITER Council discussions should be ensured in advance through the Council Preparatory Working Group (CPWG) in addition to the Management Advisory Committee (MAC) and the Science and Technical Advisory Committee (STAC). Approval of general non-strategic and/or operational issues could be delegated to the MAC and to the STAC where relevant. At the initiative of the Euratom and United States Delegations, the ITER Council has therefore decided at the ITER Council of June 2016 to establish a study group to look into the implementation of the governance of the project through the various standing committees mentioned above as well as the Financial Audit Board and the Management Assessment, and formulate recommendations for improvement where necessary. At the 19th ITER Council (ITER Council of November 2016) the Study Group presented some solutions for the rationalisation in the work of ITER Council subsidiary bodies but that further improvements in the efficiency of the ITER Council will be necessary. On this basis, the ITER Members endorsed most of the recommendations of the Study Group and requested the group to carry out a further analysis to merge subsidiary bodies and improve preparations of ITER Council meetings to achieve further streamlining and efficiency in decision-making. The ITER Council in November 2016 agreed to reduce the number of sub-committees and to eliminate overlaps. In 2017 the ITER Council will further analyse simplification opportunities with the objective to focus governance on delivery and strategic issues.

- **Professional risk management is introduced in the management of the project**

In the past there have been attempts to reconcile the different approaches to risk management of the ITER Members. In particular, there is (in general) a division in how different countries approach risk management. From the scheduling point of view, it is customary in Europe and the United States to make a success-oriented schedule and then estimate separately possible delays and any foreseeable additional work directly from the individual tasks. The associated risks are then estimated and folded into the schedule to make it more realistic and establish a confidence level for the achievement of e.g. First Plasma at a given date. At the same time, a risk register is established and possible mitigation actions are identified. On the contrary, Asian countries have an almost complete success-oriented approach, without taking into account risks and delays. This difference in approach implies that the assumptions of the Domestic Agencies in their submissions to the schedule may differ and this causes problems when integrating them into an overall project schedule.

The approach taken to develop the schedule is to create a technically achievable schedule based on the submissions from all the Domestic Agencies and then add the risk at the central level, taking into account the risk assessment provided by the Domestic Agencies, especially for those risks that have an important impact at the overall schedule are taken into account.

In parallel, the ITER Organization is implementing a reform of the risk management capability through the preparation of a Management Plan and the creation of an overall internal risk management system, including Project Risk & Opportunity Management Committee for joint assessment of risks and mitigation actions by the ITER Organization and Domestic Agencies.

- **Critical path issues are being addressed: freezing the design of the buildings, transfer of vacuum vessel sectors, and realistic estimates for the Assembly**

As a result of the above mentioned reforms, there is now more attention to the critical path at project level and the management is focusing on critical in-kind deliverables and on the assembly process itself. This is particularly important for the Euratom in-kind contribution, which is 45% of the total and has several important components on the critical path to First Plasma. Two significant examples of this situation are the buildings and the vacuum vessel, now managed by Integrated Project Teams that ensure tight coordination of the activities.

In particular, while the buildings have suffered (and continue to suffer to some degree) in the past from constant design changes, the situation is now that the specifications are gradually being frozen with floor by floor and building by building due dates being established, after which new changes can be made only after specific approval of the ITER Organization Director-General¹⁷.

The vacuum vessel is provided by both Euratom and Korea. The original division of in-kind contribution foresees that Fusion for Energy is responsible for delivering 7 out of 9 sectors, and the Korean Domestic agency the remaining 2 sectors. Due to serious and prolonged technical and organizational problems of some companies of the consortium producing the European sectors, at The ITER Council of June 2016 and with the consent of Euratom the responsibility to procure two of the seven European sectors was transferred from Euratom to the ITER Organization that will delegate to the Korean Domestic Agency the management of the manufacturing and delivery of the two transferred sectors in addition to those originally attributed to Korea. This transfer will allow a better balance of the work between the two Members and create float in the European schedule.

Regarding the Assembly, the situation is different: assuming the components are available on site at the time they are needed, the duration of the assembly and commissioning schedule (~ 7 years) is determined by the duration of the different tasks and by the use of parallel execution (in particular in the Tokamak area) as far as possible. The assembly will be managed by a "Construction Manager as Agent" (CMA), under a contract signed in July 2016 after approval by the ITER Council. While the assembly work has been looked at in detail by the ITER Organization, the contract foresees that the CMA reviews Contract and Management Requirements before the tenders for assembly works are launched at the end of 2017. The consequent delay of these contracts (by about one year) has been mitigated by signing end of 2016 two separate contracts for the Site Services Building and the Sector Sub-

¹⁷ Record of Decisions, 18th meeting of the ITER Council (June 2016).

Assembly Tooling. As a consequence, the overall assembly should not be delayed, while the part covered by the CMA contract will have a much more solid base.

- **Monitoring of milestones allows the ITER Council to closely supervise the ITER Organization's progress**

The overall monitoring of the ITER Organization has improved. The ITER Council milestones, requested by the ITER Council at its November 2015 meeting to monitor progress and adherence to the schedule for the years 2016-2017, are an effective tool to control the progress of construction and act as an early warning system on the basis of which it is possible to act swiftly to solve any emerging problems in the construction schedule. At its June 2016 meeting, therefore, the ITER Council decided to expand this list to cover the schedule up to First Plasma. In parallel, the ITER Organization established a much more extensive list of so-called Internal Project Milestones, with set threshold dates and an automatic warning when a forecast date goes beyond its threshold. The delay that can occur before the warning is given depends on the criticality of the milestone: for more critical milestones this difference between the threshold date and the reference date is much shorter than for less critical ones.

V. THE FINANCIAL IMPLICATIONS OF THE NEW BASELINE

- **The Euratom contribution post 2020 will finance the completion of all critical path components to First Plasma, and prepare the ground for subsequent assembly phases beyond First Plasma leading to the fusion performance phase (Deuterium-Tritium)**

The resources needed by Euratom to enable the successful completion of the facility and the start of the performance operation phase have been estimated in this section on the basis of the cash request presented by the ITER Organization to the ITER Council of November 2016 and Fusion for Energy's estimates presented at its Governing Board of December 2016¹⁸. All quoted values are in 2008 unless explicitly stated otherwise, while the enclosed tables report the estimates in both 2008 and current values.

The total amount of cash for the ITER Organization from all the ITER Members for the construction phase to First Plasma is now foreseen at about EUR 5.6 billion, for the period 2014-2025 (until First Plasma). Out of that, EUR 3 billion of cash contribution from the ITER Members concern specifically the period 2021-2025, which covers the construction phase to First Plasma¹⁹.

As mentioned above, the staged approach proposal presented at the ITER Council of June 2016 restructured the schedule to take into account the financial constraints of the ITER Members, notably of Euratom. This has been obtained by limiting the in-cash contribution to the ITER Organization, as well as postponing the procurement and installation of all components not essential for First Plasma. Consequently, Fusion for Energy is on target to respecting the EUR 6.6 billion cap up to 2020.

¹⁸ Implications of the ITER updated Schedule and Resources Estimates on Fusion for Energy, F4E(16)-GB36-12.1.

¹⁹ Proposal for the Updated Project Plan and Resource Estimates (PPRE), ITER_D_U29DBA v1.1

The resources needed after 2020 by Euratom following the revision of the schedule are reported in detail in Table 1 (in 2008 value, and corresponding Table 2 in current values) in annex. The total (2014-2035) estimated Euratom contribution to the cash requirements (including operation and decommissioning/deactivation) of the ITER Organization is EUR 3.7 billion, of which EUR 1 billion is covered by the current Multi-annual Financial Framework. For the period 2021-2025 (up to First Plasma), the ITER Organization will require EUR 1.1 billion. The remaining EUR 1.6 billion of Euratom contribution will cover the period up to the start of the performance operation (2026-2035), and will cover both the Final Installation activities (paid from the construction budget at 45% of the total contribution) and operations, including upgrades, spares, decommissioning and deactivation costs (paid from the operations budget at 34% share of the total contribution). The total construction budget from 2021 until the end of construction activities includes the estimated contribution to the Reserve Fund of the ITER Organization.

Correspondingly as shown in Table 1, Fusion for Energy estimates that an additional EUR 2.2 billion will be needed during the period 2021-2025 to cover the cost of the Euratom in-kind contributions necessary to complete the critical path components needed to achieve First Plasma, as well as the cost of the initial stages of design and construction for the components under Euratom responsibility required for the Final Installation activities.

Regarding the *total additional Euratom resources needed to complete construction* (i.e. required by both the ITER Organization and Fusion for Energy, see summary Tables 3 and 4), while they are still within the current capped budget to the end of 2020, during the period 2021-2025 additional EUR 3.8 billion are required to First Plasma. Since construction continues to some extent after First Plasma with the Final Installation Activities, additional resources required from the construction budget during the period 2026-2035 are of the order of EUR 1.5 billion (EUR 0.6 billion in cash and EUR 0.9 billion for the in-kind contribution).

There are a number of conclusions that can be drawn from these figures. Firstly, the measures taken to restructure the schedule through the *staged approach* forecast that Fusion for Energy is on target to respecting the EUR 6.6 billion (up to 2020). This has been obtained by limiting the in-cash contribution to the ITER Organization, as well as postponing the procurement and installation of all components not essential for First Plasma.

The total additional Euratom resources needed to cover fusion for Energy's budget for both the ITER Organization and Fusion for Energy's needs from 2021 until 2035 are currently estimated to be ~EUR 7 billion.

A complete overview of the estimated share of the Euratom resources needed for the ITER project is given in particular in Table 4, where the contributions from the EU budget, France and Fusion for Energy Members are shown in detail. This table also shows the estimate of the EC average administration costs of the project, Fusion for Energy's administrative costs and the costs of ITER-related activities carried out by Fusion for Energy.

VI. PRECONDITIONS FOR EURATOM'S CONTRIBUTION

Radical changes have been introduced in the last two years to reform the ITER project and put it back on track. Continued monitoring and additional tools will be needed both at the ITER Organization level and at European level with Fusion for Energy to ensure that the Euratom contribution to ITER is used in the framework of sound management practice and on the basis of evident project progress. The revision of the schedule and a restructured project management working to maintain improved project performance are major conditions that have been met. However, the following additional initiatives should be considered as the basis to ensure the future Euratom contribution to the project.

- **Regular project reviews of the ITER project**

Following the example of the independent review on the schedule proposed by the European Delegation at the ITER Council of November 2015 and carried out by the ITER Council Review Group, the ITER Council should introduce regular reviews focused on critical areas, such as project management, risk management, technical progress, safety, cost and schedule monitoring.

On this basis, Euratom has worked with other delegations at the ITER Council of June 2016 and ensured the introduction of regular reviews in the ITER Council plans. It was agreed that such focused additional reviews of ITER management performance and progress on selected issues should be conducted by the Management Advisory Committee, with involvement of additional independent experts to strengthen the value and impact of such reviews. In November, the ITER Council concretised this agreement and decided to carry out regular six-monthly in depth risk reviews focused on critical areas of the project, starting with the review of risk management in early 2017. Such reviews represent another effective way of identifying possible shortcomings and risk factors and addressing them before they bear negatively upon the project

- **Improved risk management**

The ITER Organization must have in place a robust risk management system to ensure that relevant risk reduction and mitigation measures keep the First Plasma date of December 2025. For this reason, Euratom considers that it is important for the ITER Organization to implement the recommendations on risk management of the ITER Council Review Group.

Initiatives already adopted by the ITER Organization, such as a centralised approach for risk management instead of individually by the Domestic Agencies, need to be further developed. A central Risk Register, capturing all the risks (including in terms of potential additional cost) of the ITER Organization and the Domestic Agencies would allow more transparency and clarity on the possible impact of risks should they materialise and better control of the project's schedule and cost.

At the same time, further work has to be undertaken in Fusion for Energy to improve the management of risk as regards specifically the European participation in the project.

- **Improved governance of the ITER Organization**

The governance of the ITER project is set up in the ITER Agreement. A formal revision of the provisions of the agreement is complicated and would probably bring not much benefit for

the project and would further compromise the First Plasma date by introducing unnecessary uncertainties in the project at a critical stage of the construction phase. Within the current framework, there is some margin of maneuver to further streamline the decision-making process to make it more efficient.

The ITER Council needs to focus on the most strategic decisions, leaving its subsidiary bodies to deal with routine and administrative items, preparing the decisions of the Council and at the same time be empowered to adopt decisions in a more independent way on the day-to-day work of the ITER Organization. To this end the review should look at how policies are established (e.g. principles, rules and guidelines to reach the long-term goals) and how supervision tools can ensure that activities are on schedule to meet the objectives and performance targets.

The ITER Council, therefore, also decided at in June 2016 to establish a study group to review the governance of the ITER Organization by the ITER Council assisted At the ITER Council of November 2016 the study group presented some solutions for the rationalisation in the work of ITER Council subsidiary bodies but that further improvements in the efficiency of the ITER Council will be necessary. On this basis, the ITER Members endorsed most of the recommendations of the study group and requested the group to carry out a further analysis to merge subsidiary bodies and improve preparations of ITER Council meetings to achieve further streamlining and efficiency in decision-making. The ITER Council in November 2016 agreed to reduce the number of sub-committees and to eliminate overlaps. In 2017 the ITER Council will further analyse simplification opportunities with the objective to focus governance on delivery and strategic issues.

- **Enhanced oversight of Fusion for Energy**

The Commission's oversight of Fusion for Energy relies on three different categories of supervision tools: Governance Bodies (Governing Board and Committees), regular structured monitoring (using reporting as well as regular audit actions), and ad-hoc supervisory tools (mainly for tackling emergency situations).

The Governing Board (of which Euratom is a member together with the EU Member States and Switzerland) and its subsidiary bodies (in some of which Euratom is also represented) are responsible for the overall supervision of Fusion for Energy. Compared to the other members of the Governing Board, Euratom has a different role as the largest contributor of the budget, the responsibilities to report to the European Council and to the European Parliament and the supervision of Fusion for Energy as a European Joint Undertaking, which means F4E has to follow the financial and staff regulations of the European Commission or regulations specifically set up.

This specific budgetary and institutional role of the European Commission on behalf of Euratom implies a particular responsibility of the Commission with respect to the supervision of Fusion for Energy, in spite of the formal limitation in terms of Euratom voting rights at the

Governing Board. The current *Administrative Agreement between the Commission and Fusion for Energy* specifies²⁰ that:

- An annual activity report reporting the implementation of the work programme of the previous year shall be sent to the Commission by the 15 of June of the following year.
- The specialised financial irregularities panel set up by the Commission according to the Financial Regulation shall exercise the same powers in respect of Fusion for Energy as it does in respect of Commission departments.
- OLAF shall enjoy the same powers in respect of Fusion for Energy as it enjoys in respect of the Commission departments (Fusion for Energy statutes and Governing Board decisions).

For this reason, this agreement has been reviewed and updated to take into account these specific needs which will allow the European Commission to fulfill completely its budgetary and inter-institutional role as well as any additional enhancements. This should thus ensure that the Commission receives early specific and detailed information concerning the administrative and financial planning of the Joint Undertaking, as well as e.g. regular reporting on the difficulties Fusion for Energy faces and potential mitigating actions, information on the budget implementation with information on deviations from the planning.

- **Emphasis on cost containment**

The Commission has repeatedly urged the ITER Organization and Fusion for Energy to implement cost-containment measures and seek further savings. While progress has been made, further work remains to be done, in particular to improve the internal control framework, integrated project management and reporting system in both organisations. Fusion for Energy has prepared a comprehensive strategy to deal with cost claims, which will contribute to the mitigation of the risk of further cost increases, mainly from buildings, and will as such form one of the instruments of cost containment. A complete cost containment effort will also have to include a further improved and effective assessment of current and future contracts, reflecting the experience gained so far with key contracts, such as for buildings or the vacuum vessel, as well as the optimization of requirements and manufacturing processes.

²⁰ *Administrative Agreement between the Commission and Fusion for Energy* (2008), Art. 19-21

Table 4: Overview of the estimated Euratom contribution (from the EU budget, France as Host State and Fusion for Energy Members) both in 2008 and current values (EUR billion). F4E Members include the EU Member States and Switzerland. The differences in the amounts for the period 2007-2013 and 2014-2020 in Tables 3 and 4 can be clarified as follows. The F4E total revenues in commitments appropriations during the period 2007-2013 could not be used in full because of the delays of the project. In view of the specificity of the ITER project, the F4E Financial Regulation foresees in Article 14.1 that ‘Appropriations which have not been used at the end of the financial year for which they were entered shall be cancelled. Given the needs of the Joint Undertaking, the cancelled appropriations may be entered in the estimate of revenue and expenditure of the following financial years’. While Table 4 refers to the revenue as occurred for the periods 2007-2013, Table 3 (and table 2 in the Communication) refers to the occurred expenditures in commitment appropriations for the period 2007-2013, which resulted to be lower than the received revenue. This difference has remained available to compensate the higher expenditures in the subsequent period 2014-2023 through the possibility to re-introduce unused appropriation of the previous year.

Euratom budget 2008 value	Up to the end of the current MFF period		To First Plasma	From First Plasma to DT		Total after 2020
	2007-2013	2014-2020	2021-2025	2026-2027	2028-2035	
EU budget	2.73 ²³	2.58	3.16	1.00	1.72	5.88
France	0.45	0.73	0.7	0.19	0.3	1.19
F4E Members	0.02	0.03	0.02	0.01	0.04	0.07
Totals	3.2	3.34	3.88	1.2	2.06	7.14

Euratom budget current value	Up to the end of the current MFF period		To First Plasma	From First Plasma to DT		Total²³Error! Bookmark not defined. after 2020
	2007-2013	2014-2020	2021-2025	2026-2027	2028-2035	
EU budget	3.36 ²⁴	2.96	4.56	1.51	2.58	8.6
France	0.52	0.84	0.95	0.3	0.5	1.7
F4E Members	0.02	0.03	0.03	0.01	0.06	0.1
Totals²³	3.9	3.8	5.5	1.8	3.1	10.4

²³ Amounts rounded off to one decimal

²⁴ The EU budget for 2007-2013 is higher than that derived from currently known executed figures because the actual commitment per year profile is slightly different for years until 2020 due to the “anticipated” commitment of the cash contribution. For completeness, it also contains EUR 44 million (2008 value) of preparation costs spent before 2007