ORIGINAL

Supporting Analysis for an Impact Assessment on the Future Funding of EU Participation in ITER Project and Broader Approach (BA) Activities under the next MFF

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Supporting Analysis for an Impact Assessment on the Future Funding of EU Participation in ITER Project and Broader Approach (BA) Activities under the next MFF

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Abstract

English

This report supports the Commission impact assessment on the future European contribution to ITER. A variety of potential delivery mechanisms, legal setups and budget scenarios of the European contribution to ITER (including the current approach) are assessed according to their effect on a number of indicators. The knowledge base for the analysis consists of a wide-ranging literature review, in-depth interviews with stakeholders, and econometric modelling via the E3ME model. The key output of this report are two tables that summarise the impact that changes to the baseline approach are likely to have on the operational, economic, and political reality of European involvement in ITER.

Français

Ce rapport soutient l'analyse d'impact de la Commission sur la future contribution européenne à ITER. Une variété de mécanismes de mise en œuvre potentiels, d'organisations juridiques et de scénarios budgétaires de la contribution Européenne à ITER (y compris l'approche actuelle) sont évalués en fonction de leur effet sur un certain nombre d'indicateurs. La base de connaissances pour l'analyse consiste en un examen approfondi de la littérature, des entretiens approfondis avec les parties prenantes et une modélisation économétrique sophistiquée via E3ME. Les principaux résultats de ce rapport sont deux tableaux qui résument l'impact que les changements apportés à l'approche de référence sont susceptibles d'avoir sur la réalité opérationnelle, économique et politique de la participation Européenne à ITER.

ABBREVIATION LIST

30R	30% Reduction (scenario examined abbreviation)
ASICS	Application Specific Integrated Circuits
ATM	Air Traffic Management
BA	Broader Approach
BOT	Build-Operate-Transfer
CA	Commitment Appropriations
CE	European Conformity
CeBr	Cerium Bromide
CEF	Connecting Europe Facility
CERN	European Organisation for Nuclear Research
CoA	Court of Auditors
DA	Domestic Agencies
DBO	Design-Build-Operate
DEMO	DEMOnstration nuclear fusion power station
DG	Directorate-General
DG BUDG	European Commission Directorate-General for Budget
DG ENER	European Commission Directorate-General for Energy
DG RTD	European Commission Directorate-General for Research and Innovation
DG TREN	European Commission Directorate-General for Transport and Energy
DM	Delivery Mechanism
EA	Executive Agency
E3ME	Energy-Environment-Economy Global Macro-Economic Model
EC	European Commission
EFDA	European Fusion Development Agreement
ERA	European Research Area
ERIC	European Research Infrastructure Consortium
ESA	European Space Agency
ETP4HPC	European Technology Platform for High-Performance Computing
EU	European Union
EUR	Euros
EURATOM	European Atomic Energy Community
EUX	European Union Exit (scenario examined abbreviation)
F4E	Fusion for Energy (www.fusionforenergy.europa.eu)
FNB	Full New Baseline (scenario examined abbreviation)
FP	Framework Programme
FP6	6^{th} Framework Programme
FP7	7^{th} Framework Programme
GJU	Galileo Joint Undertaking
GNSS	Global Navigation Satellite Systems
GRT	An F4E coding for Grant funding
GSA	European GNSS Agency
GVA	Gross Value Added
HPC JU	High-Performance Computing Joint Undertaking
IP	Intellectual Property

IPR	Intellectual Property Rights
ITER	International Thermonuclear Experimental Reactor (www.iter.org)
ITER IO	The ITER Organisation
IUA	ITER Unit of Account
IVVS	In-Vessel Viewing System
JET	Joint European Torus
JRC	The Joint Research Centre (of the European Union)
JU	Joint Undertaking
KIT	Karlsruhe Institute for Technology
KPI	Key Performance Indicator
LF	Legal Form
MFF	Multiannual Financial Framework
NACE	The statistical classification of economic activities in the European Union
NoC	New Baseline, No Contingency (scenario examined abbreviation)
OPE	An F4E coding for Operational expenditures
PA	Payment Appropriations
PET	Positron Emission Tomography
PBR	Post-Brexit Reference (scenario examined abbreviation)
PF	Poloidal Field
PPP	Public-Private Partnership
QA	Quality Assurance
R&D	Research and Development
SESAR JU	Singe European Sky ATM Research Joint Undertaking
SME	Small and Medium Enterprises
SWOT	Strengths Weaknesses Opportunities Threats
TF	Toroidal Field
TFEU	Treaty on the Functioning of the European Union
VfM	Value for Money
WBS	Work Breakdown Structure

CONTENTS

Executive Summary

Context

Nuclear fusion is the combination of light atoms to form heavier atoms with a small amount of the mass involved being converted into energy. Since the 1950s scientists and engineers from all over the world have been carrying out research to assess the most promising approach to utilise this energy release to generate electricity. The merits of fusion include the abundance of the basic fuels (deuterium and lithium), the absence of greenhouse gas emissions, a very low impact on the environment with no long-lasting radioactive waste and the inherent safety of fusion reactors. These merits support the hope that by the end of this century, as fossil fuels phase out of the energy mix, fusion could become a suitable complement to energy from renewable sources.

Europe is at the forefront of fusion research, having already constructed and operated the world's leading fusion device; the Joint European Torus (JET). The next stage of moving fusion towards commercial exploitation is to design and build the ITER facility at Cadarache in the south of France. There are seven parties participating in the ITER project; the European Union including Switzerland, Japan, China, Korea, the Russian Federation, India, and the USA. The ITER Organization (IO)is responsible for the construction, operation, exploitation and decommissioning of the ITER device. Europe has taken the lead in this project with a 45% stake of the construction costs of which 80% is funded from the EU budget and 20% by France as the ITER host country. About 75 % of the investment in ITER is spent on the creation of new knowledge and cutting-edge materials and technology. This offers European industries a valuable opportunity to innovate and to develop 'spin off' products for exploitation outside fusion.

In 2010, Euratom and the European Commission approved the current ITER Baseline, which predicted that construction would be complete enough to achieve 'First Plasma' in 2020. At 'First Plasma' the essential components of the machine can be tested and the operational phase can start. The Council of the EU capped the budget for the construction phase at EUR 6.6 billion (2008 values) up to 2020. These resources also cover the administrative costs of the Euratom Joint Undertaking 'Fusion for Energy (F4E)'. F4E is the European 'Domestic Agency' responsible for delivering the Euratom contribution to ITER. The construction of ITER has met with delays and cost overruns, mainly due to design changes and manufacturing challenges owing to the 'first of a kind' nature of the project but also to weaknesses in its management and governance. These delays made the completion of the construction within the expected schedule impossible. The weaknesses were recognised, and actions have been taken to address them.

The 2013 independent management assessment of the ITER Organization recommended changes in the project management and the development of a more realistic schedule and resource plan. In March 2015 decisions were adopted by the ITER Council to restructure the management and on an Action Plan under the leadership of a new Director-General. Following a positive review by independent experts, in June 2016 the ITER Council endorsed an updated schedule and associated cost estimates for the completion of the ITER construction to First Plasma estimated in December 2025. The new baseline also includes operational actions to 2035.

Objectives / priorities

The main objective for the ITER programme during the next Multiannual Financial Framework (MFF) is to progress to the goal of First Plasma. This goal should be achieved as close to budget and as close to schedule as possible. The earliest possible date for this is 2025. As with all EU spending ITER needs to respond to a number of other challenges for the next MFF period, these include:

- Pressure to constrain the total EU budget, partly because of the reduction in total funds that is likely because of Brexit;
- Need to demonstrate flexibility;
- Need to pursue simplification;
- Need to maximise coherence and synergy.

The fact that the timeline for ITER extends to 2030 and beyond (towards DEMO) means that it will require funding well beyond the next MFF.

If the level of funding provided is lower than the baseline it will impact the delivery of the components and the construction, which (as these are critical path costs) will directly translate into overall project delays. A reduction in funding can also lead to additional future costs as it implies that spending must be reprofiled, meaning that activities in some areas have to stop, and restarting them implies an additional opportunity cost.

The basis of EU participation in ITER is the single internationally agreed project (the ITER agreement) with domestic commitments[1]. This is different from the vast majority of EU programmes. The ITER agreement lasts for 35 years, which stretches over several MFF periods. This length of commitment is also different to other EU programmes which are usually established for a single MFF (even if they are repeatedly renewed). If the EU does not assign funds that allow the EU's participation in the project in accordance with its commitments, the EU will be in breach of its international obligations because of their signature of the ITER Agreement. The ITER Agreement states that Euratom, as 'Host Party' cannot withdraw from the project.

Delivery mechanisms and legal forms

There are a number of options (including the existing arrangement) for the delivery mechanism and legal form that the European contribution to ITER can take. The delivery mechanisms describe the way in which the funding is provided - i.e. by which entity and via which specific channel. The legal forms describe the specific procedural setup and governance of the budget – i.e. the nature of the intermediary entity set up to operate the funding. The two concepts are not mutually exclusive, and their combination creates policy options.

The three delivery mechanisms considered are:

- ‘MFF programme’ - funding via the European Commission to an ITER specific programme;
- ‘MFF wider programme’ – funding via the European Commission via a programme which includes other research support (i.e. the successor to H2020);

[1] Establishing the European Joint Undertaking for ITER and the Development of Fusion Energy 2007/198/Euratom: 'A European Joint Undertaking for ITER and the Development of Fusion Energy is hereby established for a period of 35 years starting on 19 April 2007'. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007D0198&from=FRN

- 'Pooled contributions' European contribution to ITER provided solely by individual member states.

The legal forms considered are as follows:

- *Public-private partnership (PPP)* - a contractual agreement between a public authority and a private entity;
- *Joint Undertakings (JUs)* - a research entity combining the EU (through the EC) and industry-led associations. The current set up of F4E is a JU, although it cannot have private stakeholders;
- *EU Agencies* - distinct bodies from the European Institutions: they are their own legal entity and are responsible for performing specific tasks under EU law. The types of EU Agencies are: Decentralised Agencies; Euratom Agencies and bodies; and Executive Agencies (EAs);
- *Intergovernmental organisation (IGO)* - created by a group of sovereign states (or other IGOs) in response to a decision between the parties for a specified joint effort;
- *Private company* - In this approach the partners to the treaty act as shareholders;
- *European Research Infrastructure Consortium (ERIC)* - a specific legal form to ease the establishment and operation of research infrastructures with a European interest.

Analysis of Scenarios

The conclusions on the scenarios can be summarised under three main variables: financial, budget and delivery methods and the duration of the MFF.

Financial scenarios

The financial scenarios have a larger impact on the indicators of success than the budget and delivery methods. The scenario which offers the most positives in comparison to the baseline is the full new baseline (FNB), with each of the other financial scenarios, where the amount of money reduces, being less attractive. A summary of the changes under each indicator (to measure the EU contribution to ITER) is as follows:

- *Jobs*: If less is invested, less employment (direct, indirect, and induced) will be created. In the FNB scenario, approximately 19,000 more jobs are created compared to the Baseline during the period of 2020 – 2030, while in the NoC scenario approximately 14,500 more jobs are created over the same period. A reduction in jobs created is observed in the other three scenarios; 4,000, 6,000 and 19,000 less jobs than the Baseline for the PBR, 30R and EUX scenarios respectively over the same period. When employing pooled MS contributions, the results do not exhibit major changes (disregarding the legal implications of changing the delivery mechanism, which could initially slow down employment growth of a specific scenario);
- *Growth*: As with jobs, lower investment leads to lower GVA. The total added value in the FNB scenario for the period 2020 – 2030, is almost EUR 5bn, while for the NoC scenario, for the same period, this is just more than EUR 3.6bn. In the other three scenarios a reduction was observed; approximately EUR 1bn, EUR 1.5bn and EUR 5bn for the PBR, 30R and EUX scenarios respectively. The results are not significantly changed when the delivery mechanism is changed to pooled MS contributions. The observed effect might also be delayed here, due to the legal adjustments that would be required;
- *Synergies / Spill-overs*: As with jobs and growth, if less is invested there will be less benefits in terms of spin off employment creation. In the FNB scenario, the impact of spill-overs on employment is almost 3,000 more jobs compared to business as usual during the period 2020 –

2030, while in the NoC scenario almost 2,000 additional jobs are created over the same period. A reduction in jobs created is observed in the other three scenarios; 750, 1,100 and 3,100 less jobs than the Baseline for the PBR, 30R and EUX scenarios respectively for the same period. The impact of spill-overs on the total added value in the FNB scenario for the period 2020 – 2030, is almost EUR 700M, while for the NoC scenario, for the same period, this is roughly EUR 450M. In the other three scenarios a reduction is observed; approximately EUR 150M, EUR 230M and EUR 720M for the PBR, 30R and EUX scenarios respectively;

- *Effectiveness of delivery of the EU contribution*: Investment that is lower than the best estimate of what is required to keep ITER on track implies a reduction in the likelihood of ITER being delivered on time and to the required specification;
- *EU added-value*: Less investment means less jobs, GVA and spill-overs;
- *Value for money*: Less investment increases the chance of delays, and the chance that certain areas of work will need to be stopped and restarted in the future with a consequent increase in costs;
- *Risk mitigation*: As with value for money, a reduction in investment increases the risk of ITER not being delivered on time and to budget and specification;
- *Simplification*: Reducing the investment does not obviously or directly affect simplification, but the increases in risk associated with a reduction in investment are generally considered negative for simplification;
- *Flexibility*: Reductions in investment are considered as having a negative impact on flexibility because they reduce the availability of budget to respond to potential requirements to move funds around (and/or make use of contingencies) to keep ITER on schedule and specification.

Budget and Delivery Models

The alternative combinations of delivery models and legal forms do not offer many clear benefits in comparison to the baseline (MFF programme + ‘special’ Joint Undertaking). The potential benefits that they do offer are largely outweighed by the dis-benefits of the disruption they cause (mostly of a legal nature) and consequent increases in risk. Moving down through the options, the following key points can be made about each alternative:

- *Moving to a standard Joint Undertaking* (where private companies are allowed to participate) – this might increase the value for money and flexibility, by directly involving more commercially orientated partners. However, it could also increase risks and move against simplification by increasing the number of partners and implying a need to renegotiate the F4E structure and objectives;
- *Moving to a Decentralised Agency* (that is allowed to run procurement procedures) – the effects are expected to be similar for both a direct programme or wider programme delivery mechanism. This legal form has the budget for the entire project decided on at its inception and only has one interlocutor (EC) for budget-related issues. This delivers opportunities both for simplification as well as risk mitigation. However, it also runs the risk of flexibility issues if the initial budget estimate turns out to be insufficient;
- *Member State Contributions and Joint Undertaking* – leads to the same potential benefits in terms of value for money and flexibility from including private companies and could also bring some benefits by moving away from annual to multiannual budgeting. However, it would also increase risks and move against simplification by implying a need to renegotiation the F4E structure and objectives and by potentially increasing the direct influence of MS governments in the detailed operation and progress of ITER;

- *Member State Contributions and Intergovernmental Organisation* - leads to some of the same negatives as the MS contribution and joint undertaking option (i.e. increased risks). It could potentially help with simplification, if a model that was simpler than the current arrangements could be found, though this is by no means certain. It seems likely that the result would be simpler in some areas (e.g. procurement rules) but more complex in others (e.g. the need for all the participating MSs to see what they regard as a fair return on their investments, in terms of contracts being awarded to their companies). This option also carries significant risk of delay and loss of reputation for the EU, as European fusion efforts would not continue to be under its direct influence.

Duration of MFF

Different MFF-lengths could, in certain circumstances, have a significant effect on some of the indicators if paired with certain scenarios. However, this is only the case for combinations that rely on the MFF as their delivery mechanism. One potential problem that can arise from financing the European contribution to ITER under the FNB or NoC scenarios, is the political difficulties it can create if paired with a 5-year MFF (the end of which would coincide with scheduled First Plasma). If further delays, whatever the source, make it impossible for F4E and the IO to reach First Plasma in 2025, this would put the programme in a weak position to ask for further funding from the subsequent MFF (post-2025). Having been granted the FNB, and therefore a favourable funding position for F4E before, Parliament and the Council might not be willing to provide additional finance beyond-baseline into ITER post-2025. In this scenario, the indicators on effectiveness, EU added-value, value-for-money, and risk mitigation could be much worse for MFF combinations than stipulated in table 5-3.

For the PBR and 30R cases the employment and growth impacts are generally steady over time, reflecting the fact that investment levels are constant (in current prices) over the period. For these scenarios the duration of the MFF has no real consequences on effectiveness, no matter what legal form or MFF programme they are paired with.

Monitoring and evaluating performance

The performance of EU participation in ITER can be split between progress on ITER (in terms of construction and operation on time and to specification and budget) and generation of added value (jobs, GVA and spin offs). The indicator that F4E appear to favour, and that appears to be the most informative in terms of progress towards First Plasma is the ITER credits measure. This shows the expenditure incurred weighted by its relative importance (in terms of ITER progress). The measurements of added value carried out for this report and the parallel VfM study use modelling of F4E data on contracts and contractors. These models could be rerun on an annual basis or some simple multipliers could be used to estimate jobs, GVA and spin offs based on these model runs (though the assumptions would gradually become outdated as the economy and ITER evolve).

Résumé

Contexte

La fusion nucléaire est le processus qui consiste à combiner des atomes légers pour former des atomes plus lourds, une petite quantité de la masse étant convertie en énergie. Depuis les années 1950, des scientifiques et des ingénieurs du monde entier mènent des recherches visant à évaluer l'approche la plus prometteuse pour utiliser cette libération d'énergie aux fins de produire de l'électricité. Les avantages de la fusion sont l'abondance des combustibles de base (deutérium et lithium), l'absence d'émissions de gaz à effet de serre, un impact environnemental très faible grâce à l'absence de déchets radioactifs de longue durée de vie ainsi que la sécurité inhérente aux réacteurs à fusion. Ces avantages alimentent l'espoir que d'ici la fin du siècle, parallèlement à la diminution progressive de la part des combustibles fossiles dans le bouquet énergétique, la fusion puisse devenir un complément adéquat aux énergies renouvelables.

L'Europe est à la pointe de la recherche sur la fusion, puisqu'elle a déjà construit et exploité le premier dispositif de fusion au monde, le Joint European Torus (JET). La prochaine étape vers l'exploitation commerciale de la fusion est la conception et la construction de l'installation ITER à Cadarache, dans le sud de la France. Sept parties sont associées au projet ITER: l'Union européenne, y compris la Suisse, le Japon, la Chine, la Corée, la Fédération de Russie, l'Inde et les États-Unis. L'organisation ITER (OI) est responsable de la construction, de la mise en service, de l'exploitation et de la désactivation des installations ITER. L'Europe a pris la tête de ce projet avec une participation de 45 % des coûts de construction, dont 80 % sont financés par le budget de l'UE et 20 % par la France en tant que pays d'accueil d'ITER. Environ 75 % de l'investissement dans ITER est consacré à la création de nouvelles connaissances et de matériaux et technologies de pointe. Ce projet offre aux industries européennes une occasion précieuse d'innover et de développer des produits dérivés pour une exploitation en dehors de la fusion.

En 2010, Euratom et la Commission européenne ont approuvé la base de référence d'ITER, qui prévoyait que la construction serait suffisamment avancée pour atteindre le «premier plasma» en 2020. C'est au stade du «premier plasma» que les composants essentiels de l'installation peuvent être testés et que la phase opérationnelle peut commencer. Le Conseil de l'UE a plafonné le budget de la phase de construction à 6,6 milliards d'euros (valeur 2008) jusqu'en 2020. Ces ressources couvrent également les coûts administratifs de l'entreprise commune Euratom «Fusion for Energy» (F4E). F4E est l'«agence nationale» européenne chargée de fournir la contribution d'Euratom à ITER. Dans le cadre de la construction d'ITER, les retards et les dépassements budgétaires se sont accumulés, principalement en raison de modifications de la conception et des défis de fabrication inhérents au caractère de «premier du genre» du projet, mais aussi du fait de faiblesses dans sa gestion et sa gouvernance. Ces retards excluent l'achèvement de la construction selon le calendrier prévu. Les faiblesses ont été identifiées et des mesures ont été prises pour y remédier.

L'évaluation indépendante de la gestion de l'organisation ITER réalisée en 2013 recommandait des changements dans la gestion du projet ainsi que la définition d'un calendrier et d'un plan de ressources plus réalistes. En mars 2015, le conseil ITER a adopté des décisions visant à restructurer la gestion et concernant un plan d'action placé sous la responsabilité d'un nouveau directeur général. À la suite d'une analyse positive réalisée par des experts indépendants, le conseil ITER a approuvé en juin 2016 une mise à jour du calendrier et des estimations des coûts associés pour l'achèvement de la

construction d'ITER jusqu'au stade du premier plasma, qui devrait se situer en décembre 2025. La nouvelle base de référence comprend également des mesures opérationnelles jusqu'en 2035.

Objectifs/priorités

Le principal objectif du programme ITER pendant le prochain cadre financier pluriannuel (CFP) est de progresser vers l'objectif de la première plasma. Cet objectif devrait être atteint en respectant au plus près le budget et le calendrier fixé. La date la plus proche possible est 2025. Comme pour toutes les dépenses de l'Union européenne, ITER doit relever un certain nombre d'autres défis pour la prochaine période couverte par le CFP, notamment:

- Pression pour limiter le budget total de l'UE, en partie à cause de la réduction du financement total qui résultera probablement du Brexit;
- Nécessité de faire preuve de flexibilité;
- Nécessité de poursuivre la simplification;
- Nécessité de maximiser la cohérence et la synergie.

Le fait que le calendrier d'ITER s'étend jusqu'en 2030 et au-delà (vers DEMO) signifie que le projet nécessitera un financement bien au-delà du prochain CFP.

Si le niveau de financement fourni est inférieur à la base de référence, cette diminution aura un impact sur la livraison des composants et la construction (qui sont des coûts liés au chemin critique), ce qui se traduira immédiatement par des retards sur l'ensemble du projet. Une réduction du financement peut également entraîner des coûts futurs supplémentaires, dès lors qu'elle implique un report de certaines dépenses, ce qui implique une interruption des activités dans certains domaines, dont leur redémarrage impliquera un coût d'opportunité supplémentaire.

La base de la participation de l'UE à ITER est le projet unique qui a fait l'objet d'un accord au niveau international (l'accord ITER), avec des engagements nationaux[2]. Cette participation diffère de la grande majorité des programmes de l'UE. L'accord ITER a une durée de 35 ans et qui s'étendra sur plusieurs CFP. Cette durée d'engagement est également différente de celle d'autres programmes de l'UE qui sont généralement établis pour un seul CFP (même s'ils sont renouvelés à plusieurs reprises). Si les fonds nécessaires ne sont pas dégagés pour assurer la participation de l'Union au projet conformément à ses engagements, l'UE sera en défaut de ne pas respecter pas ses obligations internationales résultant de la signature de l'accord ITER. L'accord ITER prévoit qu'Euratom, en tant que «partie hôte», ne peut se retirer du projet.

Mécanismes de mise en œuvre et formes juridiques

Un certain nombre d'options (y compris le dispositif existant) sont envisageables pour le mécanisme de mise en œuvre et la forme juridique de la contribution européenne à ITER. Les mécanismes de mise en œuvre décrivent la manière dont le financement est assuré, c'est-à-dire par quelle entité et par quel canal spécifique. La forme juridique décrit la structure procédurale spécifique et la gouvernance du budget, c'est-à-dire la nature de l'entité intermédiaire créée pour gérer le financement. Les deux concepts ne s'excluent pas mutuellement et leur combinaison crée des options politiques.

[2] Décision du Conseil instituant une entreprise commune pour ITER et le développement de l'énergie de fusion (2007/198/Euratom): «Une entreprise commune européenne pour ITER et le développement de l'énergie de fusion (Fusion for Energy) est constituée pour une période de trente-cinq ans débutant le 19 avril 2007». Consultable sur la page: http://eur-lex.europa.eu/legal-content/FR/TXT/PDF/?uri=CELEX:32007D0198&from=FRN

Les trois mécanismes de mise en œuvre envisagés sont les suivants:

- «Programme CFP» - financement d'un programme spécifique ITER par l'intermédiaire de la Commission européenne;
- «Programme CFP élargi» - financement par l'intermédiaire de la Commission européenne par le biais d'un programme incluant d'autres aides à la recherche (c'est-à-dire le successeur du programme H2020);
- «Contributions individuelles mises en commun» - la contribution européenne à ITER est fournie uniquement par les États membres individuels.

Les formes juridiques considérées sont les suivantes:

- *Partenariat public-privé (PPP)* - un accord contractuel entre une autorité publique et une entité privée;
- *Entreprises communes (EC)* - une entité de recherche combinant l'UE (par l'intermédiaire de la CE) et des associations dirigées par l'industrie. La structure actuelle de F4E est celle d'une entreprise commune, bien qu'elle ne puisse pas avoir d'actionnaires privés;
- *Agences de l'UE* - organismes distincts des institutions européennes: il s'agit d'entités juridiques distinctes responsables de l'exécution de tâches spécifiques en vertu du droit de l'Union. Les types d'agences de l'UE sont: les agences décentralisées; les agences et organes Euratom et les agences exécutives (AE);
- *Organisation intergouvernementale (OIG)* - créée par un groupe d'États souverains (ou d'autres OIG) à la suite d'une décision prise par les parties en vue d'un effort conjoint spécifique;
- *Société privée* - Dans cette approche, les parties au traité agissent en tant qu'actionnaires;
- *Consortium pour une infrastructure européenne de recherche (ERIC)* - forme juridique spécifique visant à faciliter l'établissement et l'exploitation d'infrastructures de recherche d'intérêt européen.

Analyse des scénarios

Les conclusions relatives aux scénarios peuvent être résumées par rapport à trois variables principales (la méthode financière, la méthode budgétaire et la méthode de mise en œuvre) et par rapport à la durée du CFP.

Scénarios financiers

Les scénarios financiers ont un impact plus important sur les indicateurs de succès que les méthodes budgétaires et de mise en œuvre. Le scénario qui offre le plus de points positifs par rapport à la base de référence est la toute nouvelle base de référence (*Full New Baseline* - FNB), étant donné que tous les autres scénarios financiers prévoient une diminution du financement[3], ce qui les rend moins attractifs. Un résumé des modifications apportées à chaque indicateur (pour mesurer la contribution de l'UE à ITER) est présenté ci-après:

- *Emplois:* Toute baisse du niveau des montants investis entraînera une baisse du nombre d'emplois créés (directs, indirects et induits). Dans le scénario FNB, environ 19.000 emplois supplémentaires sont créés par rapport au scénario de référence au cours de la période 2020-2030, tandis que dans le scénario NoC, environ 14.500 emplois supplémentaires sont créés sur

[3] *Les scénarios financiers sont décrits dans le rapport principal. Ils sont dénommés comme suit: Statu quo (Business as Usual - BAU), Toute Nouvelle Base de référence (Full New Baseline - FNB), Nouvelle base de Référence (New Baseline), Aucun imprévu (No Contingency - NoC), Référence post-Brexit (Post-Brexit Reference - PBR), Réduction de 30% (30% Reduction - 30R) et Sortie UE (EU Exit - EUX).*

la même période. Une réduction des emplois créés est observée dans les trois autres scénarios: respectivement 4.000, 6.000 et 19.000 emplois de moins que le scénario de référence pour les scénarios RBP, 30R et EUX sur la même période. L'application du système de la mise en commun des contributions individuelles des États membres n'entraîne pas de changements majeurs (sans tenir compte des implications juridiques de la modification du mécanisme de mise en œuvre, ce qui pourrait dans un premier stade ralentir la croissance de l'emploi d'un scénario spécifique);

- *Croissance:* Comme pour l'emploi, une baisse de l'investissement entraîne une baisse de la valeur ajoutée brute. La valeur ajoutée totale dans le scénario FNB pour la période 2020-2030 s'élève à près de 5 milliards d'euros, alors que, pour le scénario NoC, elle dépasse à peine les 3,6 milliards d'euros sur la même période. Dans les trois autres scénarios, une réduction est observée: environ 1 milliard d'euros, 1,5 milliard d'euros et 5 milliards d'euros respectivement pour les scénarios PBR, 30R et EUX. Les résultats ne sont pas modifiés de manière significative lorsque le mécanisme de mise en œuvre est remplacé par les contributions individuelles des États membres mises en commun. L'effet observé pourrait également être retardé ici, en raison des adaptations juridiques nécessaires;
- *Synergies/Retombées:* Comme dans le cas des emplois et de la croissance, si l'on investit moins, il y aura moins d'avantages en termes de création d'emplois indirects. Dans le scénario de la FNB, l'impact des retombées sur l'emploi est de près de 3.000 emplois supplémentaires par rapport au maintien du statu quo au cours de la période 2020-2030, tandis que le scénario NoC entraînerait la création de près de 2.000 emplois supplémentaires au cours de la même période. Une réduction des emplois créés est observée dans les trois autres scénarios: 750, 1.100 et 3.100 emplois de moins que le scénario de référence respectivement pour les scénarios RBP, 30R et EUX sur la même période. L'impact des retombées sur la valeur ajoutée totale dans le scénario FNB pour la période 2020-2030 s'élève à près de 700 millions d'euros, alors que pour le scénario NoC, il est d'environ 450 millions d'euros sur la même période. Dans les trois autres scénarios, on observe une réduction d'environ 150 millions d'euros, 230 millions d'euros et 720 millions d'euros respectivement pour les scénarios PBR, 30R et EUX;
- *Efficacité de la mise en œuvre de la contribution de l'UE:* Un investissement inférieur à la meilleure estimation de ce qui est nécessaire pour maintenir ITER sur la bonne voie entraîne une baisse de la probabilité qu'ITER soit livré à temps et selon les spécifications requises;
- *Valeur ajoutée pour l'UE:* Toute réduction des investissements entraînera une réduction du nombre d'emplois créés ainsi qu'une baisse de la valeur ajoutée brute et des retombées;
- *Optimisation des ressources:* Un investissement moindre augmente le risque de retards et la probabilité de devoir mettre à l'arrêt certaines parties des travaux dont le redémarrage ultérieur entraînera une forte augmentation des coûts;
- *Atténuation du risque*: Comme pour l'optimisation des ressources, une réduction des investissements augmente le risque qu'ITER ne soit pas livré à temps et que l'installation ne soit pas conforme au budget et aux spécifications ;
- *Simplification*: Une réduction des investissements n'a pas d'incidence évidente ou directe sur la simplification, mais l'augmentation du risque associée à une réduction des investissements est généralement considérée comme un élément négatif pour la simplification;
- *Flexibilité*: L'on considère que les réductions des investissements ont un impact négatif sur la flexibilité parce qu'elles réduisent la disponibilité du budget pour répondre aux besoins potentiels de déplacer les fonds (et/ou utiliser les provisions pour imprévus) afin de maintenir ITER dans les délais et de respecter les spécifications.

Modèles de budget et de mise en œuvre

Les autres combinaisons de modèles de mise en œuvre et de formes juridiques n'offrent pas beaucoup d'avantages nets par rapport à la base de référence (programme CFP + entreprise commune «spéciale»). Les avantages potentiels qu'ils offrent sont largement compensés par les désavantages de la perturbation qu'ils causent (le plus souvent de nature juridique) et par l'augmentation du risque qui en découle. En passant en revue les diverses options, les points clés suivants peuvent être dégagés à propos de chaque alternative:

- *Le passage à une entreprise commune standard* (dans laquelle les entreprises privées peuvent avoir des participations) - ce changement pourrait accroître l'optimisation des ressources et la flexibilité, par l'implication directe de partenaires à orientation plus commerciale. Mais il pourrait également accroître les risques et aller à l'encontre de la simplification en augmentant le nombre de partenaires, ce qui impliquerait la nécessité de renégocier la structure et les objectifs de F4E;
- *Le passage à une agence décentralisée* (qui est autorisée à gérer les procédures de passation de marchés) - les effets attendus seraient similaires tant pour un programme direct que pour un mécanisme plus large de mise en œuvre du programme. Pour cette forme juridique, l'entité dispose d'un budget fixé lors de sa création pour l'ensemble du projet et elle n'a qu'un seul et unique interlocuteur (CE) pour les questions budgétaires. Cette formule offre des possibilités de simplification et d'atténuation des risques. Mais elle risque aussi d'être la source de problèmes de flexibilité si l'estimation budgétaire initiale s'avère insuffisante;
- *Contributions des États membres et entreprise commune* - cette formule offre les mêmes avantages potentiels en termes d'optimisation des ressources et de flexibilité liés à la participation d'entreprises privées et pourrait également apporter certains avantages induits par le passage d'une budgétisation annuelle à une budgétisation pluriannuelle. Toutefois, cette formule augmenterait également les risques et irait à l'encontre de la simplification, car il faudrait alors renégocier la structure et les objectifs de F4E au risque d'augmenter l'influence directe des gouvernements des États membres sur le fonctionnement détaillé et les progrès d'ITER;
- *Contributions des États membres et organisation intergouvernementale* - cette formule entraîne les mêmes aspects négatifs que l'option de la contribution des États membres et de l'entreprise commune (c'est-à-dire des risques accrus). Elle pourrait contribuer à la simplification, si l'on pouvait trouver un modèle plus simple que le dispositif actuel, même si ce n'est absolument pas une certitude. Le résultat final serait probablement plus simple dans certains domaines (par exemple, les règles de passation des marchés publics), mais plus complexe dans d'autres (par exemple, la nécessité pour tous les États membres participants de voir ce qu'ils considèrent comme un juste retour sur investissement, en termes de contrats attribués à leurs entreprises). Cette option comporte également un risque important de retard et de perte de réputation pour l'UE, car les efforts européens en matière de fusion ne seraient plus sous son influence directe.

Durée du CFP

Un changement de durée du CFP pourrait, dans certaines circonstances, avoir un effet important sur certains indicateurs en conjonction avec certains scénarios. Mais tel n'est le cas que pour les combinaisons qui s'appuient sur le CFP comme mécanisme de mise en œuvre. Un problème potentiel qui peut découler du financement de la contribution européenne à ITER dans le cadre des scénarios FNB ou NoC est lié aux difficultés politiques en cas de liaison à un CFP de cinq ans (dont la fin coïnciderait avec le premier plasma prévu). Si de nouveaux retards, quelle qu'en soit la cause, empêchent F4E et l'OI d'atteindre le premier plasma en 2025, le programme se trouverait dans une position de faiblesse pour solliciter un financement supplémentaire au CFP suivant (après 2025). Ayant obtenu la FNB, et donc une position de financement favorable pour F4E auparavant, le Parlement et le Conseil pourraient ne pas être disposés à fournir un financement supplémentaire au-delà de la base de référence pour ITER après 2025. Dans ce scénario, les indicateurs relatifs à l'efficacité, à la valeur ajoutée pour l'UE, à l'optimisation des ressources et à l'atténuation des risques pourraient être beaucoup plus mauvais pour les combinaisons du CFP que ce qui est indiqué dans le tableau 5-3.

Dans les scénarios RFP et 30R, les incidences sur l'emploi et la croissance sont généralement stables dans le temps, ce qui reflète le fait que les niveaux d'investissement sont constants (en prix courants) au cours de la période. Pour ces scénarios, la durée du CFP n'a pas de conséquences réelles sur l'efficacité, quels que soient la forme juridique ou le programme du CFP auquel ils sont associés.

Suivi et évaluation des performances

Les résultats de la participation de l'UE à ITER peuvent être scindés entre les progrès liés à ITER (en termes de construction et d'exploitation dans les délais et conformément aux spécifications et au budget) et la création d’une valeur ajoutée (emplois, VAB et retombées). L'indicateur que F4E semble favoriser et qui semble être le plus informatif en termes de progrès vers la première plasma est la mesure des crédits ITER. Cet indicateur montre les dépenses encourues pondérées en fonction de leur importance relative (en termes de progrès d'ITER). Les mesures de la valeur ajoutée effectuées aux fins du présent rapport et de l'étude parallèle de la VfM utilisent la modélisation des données de F4E sur les contrats et les contractants. L'on pourrait réappliquer ces modèles sur une base annuelle ou utiliser certains multiplicateurs simples pour estimer les emplois, la VAB et les retombées découlant de ces modèles (bien que les hypothèses deviendraient progressivement obsolètes au fur et à mesure que l'économie et ITER évoluent).

1 Introduction: Political and Legal context

Key points

- Nuclear fusion is the combination of light atoms to form heavier atoms with a small amount of the mass involved being converted into energy;
- The merits of fusion include the abundance of the basic fuels (deuterium and lithium), the absence of greenhouse gas emissions, a very low impact on the environment with no long-lasting radioactive waste and the inherent safety of fusion reactors;
- These merits suggest that fusion has an important role in the future energy mix;
- Europe is at the forefront of fusion research and the next stage of moving fusion towards commercial exploitation is to design and build ITER that can generate part of its own fuel and produce power on a more continuous basis;
- ITER is an international project, with Europe taking a 45% share of the costs;
- In 2010, Euratom and the EC approved the current ITER Baseline, with construction largely complete and 'First Plasma' by 2020 at a cost of EUR 6.6 billion (2008 values) up to 2020;
- The construction of ITER has met with delays and cost overruns, mainly due to design changes and manufacturing challenges owing to the 'first of a kind' nature of the project but also because of weaknesses in its management and governance;
- A series of assessments and changes to the management from 2013 to 2016 have led to an adjusted baseline and budget working towards first plasma in 2025 and operational actions out to 2035.

1.1 Scope and context: Nuclear Fusion and ITER

At extreme pressures and temperatures, the fusion of light atoms to form heavier atoms leads to a small amount of mass being converted into energy, as per Einstein's well-known $E = mc^2$ equation. This is the process that powers our sun and other stars. Several approaches have been explored to make fusion happen on earth. One of these involves heating a gas to very high temperatures (100-150 million degrees centigrade) so that it becomes a plasma which can conduct electricity. Magnetic fields can then be used to contain this plasma long enough for fusion to occur. In fusion experiments, the magnetic confinement of the hot plasma is achieved using a doughnut-shaped vessel with magnetic coils. Since the 1950s scientists and engineers from all over the world have been carrying out research to assess the most promising approach and the tokamak configuration has emerged as a leading contender.

The merits of fusion include the abundance of the basic fuels (deuterium and lithium), the absence of greenhouse gas emissions, a very low impact on the environment with no long-lasting radioactive waste and the inherent safety of fusion reactors, where no meltdown or runaway reactions are possible. These merits support the hope that fusion can play an important role in Europe's future energy landscape. By the end of this century, as fossil fuels phase out of the energy mix, fusion could become a suitable complement to energy from renewable sources. This is particularly important following the 2015 Paris Agreement and the EU commitment to lead the way in decarbonising the economy and tackling global climate change in a cost-effective manner.

Europe is at the forefront of fusion research, largely due to the integration of national fusion programmes into a single co-ordinated Euratom fusion research programme, including the construction and operation of the Joint European Torus (JET), the world's leading fusion device. While JET and other tokamak experiments succeeded in producing significant amounts of fusion power for short periods, none of these experiments were capable of demonstrating fusion on a scale that would be needed for a reactor and a number of technologies are needed to allow it to generate part of its own fuel and produce power on a more continuous basis. ITER, "the way" in Latin, is the next major project in tokamak fusion research and is about twice as large as any existing fusion experiment. Its objective is "to demonstrate the scientific and technological feasibility of fusion energy. It is being constructed at Cadarache in the south of France. There are seven parties participating in the project (the European Union including Switzerland, Japan, China, Korea, the Russian Federation, India, and the USA. ITER aims to produce a significant amount of fusion power (500MW) for about seven minutes, or 300MW for 50 minutes. For the first time it will be possible for scientists to study a "burning" plasma – this is when the plasma is mostly heated by fusion reactions rather than by externally applied heating. It will also demonstrate many of the key technologies needed for future fusion reactors. The ITER Organization (IO)is responsible for the construction, operation, exploitation and decommissioning of the ITER device.

Europe has taken the lead in this project with a 45% stake of the construction costs of which 80% is funded from the EU budget and 20% by France as the ITER host country (the other ITER Members share is around 9% each). This cost distribution will change in the operation phase, with Europe providing 34%. ITER's construction involves over 10 million components being built in factories around the world. About 75 % of its investment is spent on the creation of new knowledge and cutting-edge materials and technology. This offers European high-tech industries and SMEs a valuable opportunity to innovate and to develop 'spin off' products for exploitation outside fusion (such as the broader energy sector, aviation and hi-tech instruments like the NMR - nuclear magnetic resonance - scanners).

ITER is one of the most challenging projects mankind has ever undertaken. It is pushing the limits of science and technology in many fields, from high-field superconducting magnets to large-volume vacuum systems, cryoplants, precision-machined heat resistant materials and nuclear technology, to advanced control systems and computational models of plasma turbulence. It is often called 'the most complex device' on earth. These challenges force companies to invention, product development and precision engineering of the highest order. ITER therefore is thought to promote innovation and increased competitiveness for the industries that participate in it.

Continued investments will be required to advance the technology and to bring it towards fully-fledged implementation: the ITER project should lead to DEMO in 2055, which should prove the feasibility of large scale electricity production. With the above in mind, ITER is arguably best currently seen as a Big Science project, comparable to CERN or ESA, which generates positive effects on its own account, with the prospect of generating carbon neutral energy more than 30 years from now.

1.2 The history of ITER and the lessons learnt

In July 2010, the Council of the EU mandated the European Commission to approve, on behalf of Euratom, the current ITER Baseline, which was based on the assumption that the construction of ITER would be completed with so called First Plasma in 2020. The Baseline refers to the inter-related elements of scope (specifications of the machine to build), schedule (timetable for construction) and projected costs. First Plasma represents the stage in the construction of the fusion machine that will allow testing the essential components of the machine; under the terms of the ITER Agreement, it is the point where the construction phase is formally completed, and the operation phase starts

The Council of the EU capped the budget for the construction phase at EUR 6.6 billion (2008 values) up to 2020. These resources also cover the administrative costs of the Euratom Joint Undertaking 'Fusion for Energy (F4E)'. Fusion for Energy is the European 'Domestic Agency' responsible for delivering the Euratom contribution to ITER. It was established as a Joint Undertaking by the Council Decision 2007/198/Euratom of 27 March 2007. Its Members are the Member States of Euratom, Euratom and Switzerland. It was set up set up to procure Euratom's components to ITER and implement other activities related to ITER (mainly the activities with Japan under the Broader Approach Agreement and the Test Blanket Module programme) and DEMO (the project after ITER that will demonstrate the first commercial production of fusion electricity, being at the end point of the European fusion roadmap[4] and building on the results from the operation of the ITER).

Since the adoption of the 2010 baseline delays and cost overruns accumulated, mainly due to design changes and manufacturing challenges owing to the 'first of a kind' nature of the project but also to weaknesses in its management and governance. These delays made the completion of the construction within the expected schedule impossible. The weaknesses were recognised, and actions were taken to address them.

Soon after the adoption of the 2010 baseline the ITER Members came to realise that, in addition to the immaturity of the design and the manufacturing challenges, management deficiencies and a lack of cooperation between the Domestic Agencies and the ITER Organization were hindering the implementation of the project. Both the 2010 schedule and cost estimate were thus perceived to be unreliable.

The 2013 independent management assessment of the ITER Organization recommended changes in the project management and the development of a more realistic schedule and resource plan. In March 2015 decisions were adopted by the ITER Council to restructure the management and on an Action Plan under the leadership of a new Director-General. This Plan envisaged a complete re-organisation of the ITER Organization, close cooperation with the Domestic Agencies, freezing designs to allow the construction of buildings and other components and the establishment of a Reserve Fund. This Fund was created to cover the additional cost to the Domestic Agencies caused by changes initiated by the ITER Organization to the design of components. The Fund introduces an incentive for the ITER Organization to minimise changes as much as possible, and therefore acts as a risk mitigation measure.

The Action Plan is also focussed on cost control and the establishment of a new reliable schedule and associated cost estimates that should lead to a new baseline. In about one year and a half the ITER Organization had already completed about 60% of this action plan and is making good progress in the remainder. A complementary Action Plan was adopted by the Governing Board of Fusion for Energy in 2015 that led to the creation of a Project Management Department to reinforce planning and control

[4] *Fusion Electricity: A roadmap to the realisation of fusion energy*. At the beginning of 2012 the European Commission requested EFDA (now known as EuroFusion - a consortium of national fusion research institutes located in the European Union and Switzerland) to prepare a technical roadmap to fusion electricity by 2050. Available at: https://www.euro-fusion.org/wpcms/wp-content/uploads/2013/01/JG12.356-web.pdf

processes, the redeployment of staff to high priority areas and the strengthening of project control and cost containment measures. To date 80% of the actions have been implemented and good progress is being made in the implementation of the remainder.

Following a positive review by independent experts, in June 2016 the ITER Council endorsed an updated schedule and associated cost estimates for the completion of the ITER construction to First Plasma estimated in December 2025. This is the earliest technically achievable date for the ITER construction. This schedule does not include contingencies and therefore assumes that all major risks can be mitigated. This exclusion of a contingency provision for unscheduled developments and risk-events is unusual in projects of comparable complexity.

The detailed schedule from First Plasma in December 2025 to full performance operation, using deuterium-tritium fuel (the so-called Deuterium-Tritium phase) estimated in 2035, was endorsed by the ITER Council in November 2016. Associated costs were also endorsed (subject to approval by the European council, MFF conclusions and Euratom members) as the basis for the new ITER Baseline. This updated schedule and associated cost estimate enable Euratom to stay within the current budget cap set by the Council of the EU in 2010, i.e. EUR 6.6 billion to 2020 (in 2008 values), thus ensuring that all necessary contracts can continue to drive progress in the construction and that additional delays and cost overruns can be minimised. The resources needed post 2020 are summarised in the July 2017 SWD[5] on the EU Contribution to a Reformed ITER Project.

[5] EU contribution to a reformed ITER project. Available at:
https://ec.europa.eu/energy/sites/ener/files/documents/eu_contribution_to_a_reformed_iter_project_en.pdf

2 Objectives

Key points
• The main objective for ITER during the next MFF is to progress to the goal of First Plasma as close to budget and schedule as possible. The earliest possible date for this is 2025; • ITER also faces a number of challenges common to all EU funding: constraints on the total EU budget and the need to demonstrate flexibility, simplification and to maximise coherence and synergy.

2.1 Challenges for the programme during the next MFF

The main objective for the ITER programme during the next MFF is to progress to the goal of First Plasma. This goal should be achieved as close to budget and as close to schedule as possible. The earliest possible date for this is 2025 and the target budget is as outlined in SWD on the EU Contribution to a Reformed ITER Project[5].

As with all EU spending ITER needs to respond to a number of other challenges for the next MFF period, these include:

- Pressure to constrain the total EU budget, partly because of the reduction in total funds that is likely because of Brexit;
- Need to demonstrate flexibility;
- Need to pursue simplification;
- Need to maximise coherence and synergy.

The fact that the timeline for ITER extends to 2030 and beyond (towards DEMO) means that it will require funding for at least three more MFFs (2027-2034) (2034-41) (2041-48).

2.2 Objectives of the programme during the next MFF

The normal method for structuring the objectives of a programme is an objective tree/intervention logic. There is no pre-existing diagram of this nature for ITER, so Figure 2-1 was created.

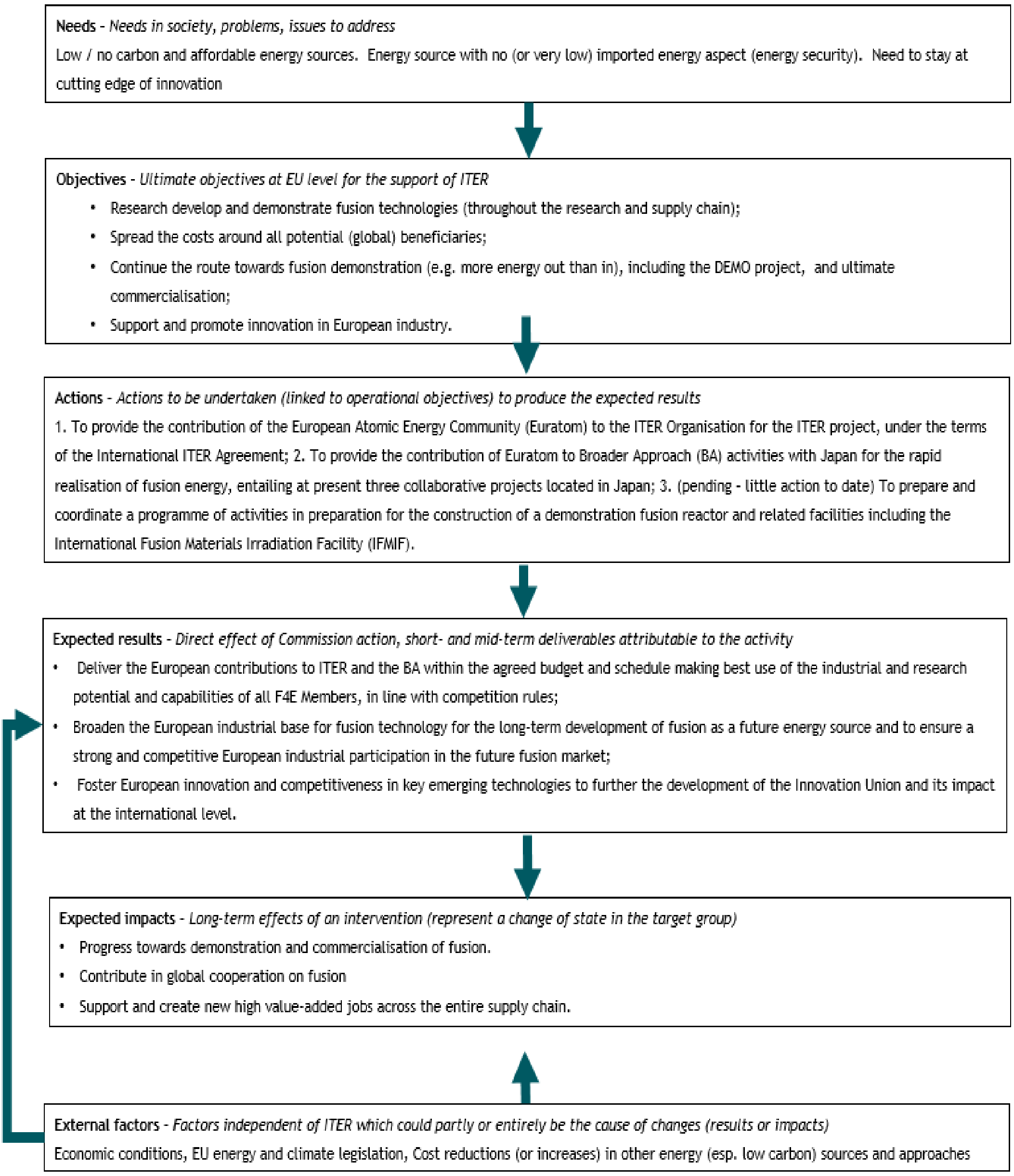
The diagram starts with the broad **needs** in society in terms of problems that need to be addressed. For ITER this is the need to provide energy sources that have low or no emissions, are secure, affordable and safe. Another problem of relevance to ITER is the need to ensure that the EU remains a leader in terms of scientific excellence and innovation.

These needs translate into a set of **broad objectives** for ITER. These include the research, development and demonstration of fusion technologies, towards the goal of getting more energy out than is put in and ultimately commercialisation. The large costs involved need to be spread around all potential (global) beneficiaries. The support and promotion of innovation in European industry is also important.

The next step is practical **actions**, that describe how the broad objectives are to be translated into results. For ITER this centres on ensuring that the Euratom contribution to ITER and the Broader Approach occurs.

These actions lead to results. Deliver the European contributions to ITER and the BA within the agreed budget and schedule making best use of the industrial and research potential and capabilities of all F4E Members,; Broaden the European industrial base for fusion technology for the long-term development of fusion as a future energy source and to ensure a strong and competitive European industrial participation in the future fusion market; Foster European innovation and competitiveness in key emerging technologies to further the development of the Innovation Union and its impact at the international level. The results lead to longer term impacts – which should link to the highest-level needs/problems. For ITER these are Progress towards demonstration and commercialisation of fusion. Contribute to global cooperation on fusion. Support and create new high value-added jobs across the entire supply chain. The results and the impacts can be influenced by external factors, In the case of ITER these include economic conditions, EU energy and climate legislation and cost reductions (or increases) in other energy (especially low carbon) sources and approaches

Figure 2-1: Intervention Logic for ITER



3 Programme structure and priorities

Key findings
• Funding less than the baseline is likely to cause delays and an increase in future costs. The increase is because spending has to be reprofiled, meaning that activities in some areas have to stop, and restarting them implies an additional opportunity cost; • The legal basis for EU participation in ITER is different from the vast majority of EU programmes. The basis is an international legal agreement which states that Euratom, as 'Host Party' cannot withdraw from the project; • The legal agreement has commitments beyond the next MFF; • The ITER project appear to offer EU added value with the costs being proportional to the benefits.

3.1 Prioritised actions to achieve the objectives

The main practical goal for the ITER project during the period of the next MFF is to achieve First Plasma by December 2025 (or as soon as possible thereafter). In order to achieve this goal there needs to be sustained progress in the design, fabrication and assembly of the numerous components and in the construction of the site. This construction and assembly needs to be financed by all the ITER parties, so it is imperative that their commitment, including the leadership of the EU is maintained.

In addition to financing the components and construction that is on the critical path to First Plasma there is also a need for funding post 2020 to support the development of the construction and installation that will be required as ITER moves beyond First Plasma to the fusion performance phase. The **resources** needed to enable the successful completion of the facility and the start of the operation/experimental phase are detailed in the Commission Communication on "the EU Contribution to a Reformed ITER Project[6]" adopted by the Commission in June 2017.

The complexity of the ITER machine (for example, the magnets just outside the tokamak need to be supercooled to extremely low temperatures, but they are in close proximity to plasma which is at extremely high temperatures), plus the fact that it is a first of a kind technology that needs to be intensely measured in order to learn lessons vital to scaling it up, mean that there are unavoidable risks of components taking longer and costing more to build than expected. F4E have taken a pro-active approach to risk management and this approach has evolved and improved over time. This implies that the project needs to have an adequate contingency to allow progress to be maintained if adverse developments occur. The lack of an appropriate contingency in previous cost predictions for ITER is an aspect that has been recognised and criticised. The level of contingency proposed in the current ITER baseline cost prediction is 15%. The Commission communication referenced above makes the point that this is typical for large scale complex projects, where contingency levels vary between 10 and 20%. In order to avoid this contingency becoming effectively part of the expected expenditure it will be important that other reductions in spending are considered before it is utilised. This could be achieved

[6] EU contribution to a reformed ITER project. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/eu_contribution_to_a_reformed_iter_project_en.pdf

by including the contingency with a review clause, that allows its withdrawal if certain performance levels or targets are not achieved.

3.2 Critical mass (of spending) to effectively achieve the objectives

Given that the objective of ITER is to progress fusion research closer to the point where it can be commercialised, while at the same time supporting the development of EU industry and innovative capacity, the critical mass of funding is whatever the cost of progressing this is. This cost is effectively the new baseline cost for the construction of ITER, as this is the best estimate of what is needed, and the way in which the costs and expenditure are managed have been refined to the point where they are deemed to be close to optimised. The critical path to First Plasma, and beyond, consists of funds under the following four headings:

(i) the estimated cost of in-kind contributions due from Euratom, to be delivered to IO by F4E;
(ii) Euratom cash contributions to fund IO activities, which in the next MFF period will notably entail the assembly, commissioning and start of operations (First Plasma); and
(iii) supporting/complementary activities mandated by F4E Statutes (notably those related to cooperation with Japan under the Broader Approach and the preparation of TBM, DONES, DEMO);
(iv) overhead: administrative costs of F4E and of requisite COM resources.

The costs under each of these headings can be broken down further with subcomponents differentiated by timing, role for the overall project and degree of interdependence.

The new ITER baseline, and the European contribution to the IO have been validated by the F4E Governing board, and external independent expertise informed by ongoing reviews. As stated above, this baseline is therefore a highly credible prediction of the costs that need to be incurred. If the level of funding is lower than this baseline it will impact the delivery of the components and the construction, which (as these are critical path costs) will directly translate into overall project delays. A reduction in funding can also lead to additional future costs as it implies that spending has to be reprofiled, meaning that activities in some areas have to stop, and restarting them implies an additional opportunity cost.

If the amount of funding provided to the "other F4E activities" reduced this would have negative consequences on the long-term future of ITER, for example the collaboration with Japan and the other international partners would be affected. This would have negative repercussions on the long-term viability and the need to progress from ITER to DEMO in a way which is most efficiency and timely.

The critical mass of funding described above will help provide stability to the project and the companies and research centres involved in it. It will allow current contracts to be completed and necessary new ones to be launched in the coming years. It will also allow the continuation of cooperation with ITER Members and their Domestic Agencies under the terms of the ITER Agreement

3.3 Necessity of EU action / legal basis

The scale and complexity of the work involved in moving towards the realisation of a future fusion power plant requires sustained financial, scientific and managerial commitment that is beyond what any single country is able to provide. This is the main reason why European level action is appropriate and also explains why countries outside Europe are also participating in these joint fusion activities.

The legal basis for EU participation in ITER is different from the vast majority of EU programmes. The basis of EU participation in ITER is the single internationally agreed project (the ITER agreement) with domestic commitments[7] . The ITER agreement lasts for 35 years, which stretches over a number of MFF periods. The length of the commitment is fundamentally different to other EU programmes which are usually established for a single MFF (even if they are repeatedly renewed). Another difference is that the EU has the remit to discontinue other programmes without breaking the terms of an international agreement. With ITER, if the EU does not assign funds that allow the EU's participation in the project in accordance with its commitments, the EU will be in breach of its international obligations as a result of their signature of the ITER Agreement.

The ITER Agreement states that Euratom, as 'Host Party' cannot withdraw from the project: article 26 of the Agreement allows an ITER Member other than Euratom to withdraw after 10 years from the entry into force of the Agreement (i.e. from October 2017). However, the Member is obliged to continue providing its contribution for the construction phase but cannot participate in the experimental phase

In order to implement the approved funding, the Council Decision establishing F4E would need to be modified. The current level of funding would need to be increased from the level in the current MFF to what is required in the next MFF. In addition to adjusting the level of funding the following modifications could also be made:

(i) inclusion of the Commission’s administrative expenditure for ITER and the other related activities;
(ii) provision for a mid-term evaluation for the next MFF period; and potentially;
(iii) modifications to the governance structure of F4E, including possible recalculation of the UK voting rights, in the light of Brexit.

In addition to these minimum interventions, a more radical revision of F4E Statutes could be taken up to improve the functioning of the Governing Board (e.g. by creating some executive committee or giving new roles/powers to the Bureau that at the moment has no decision-making powers). This decision will need to be based on the conclusions of this Impact Assessment.

3.4 EU added value and Proportionality

EU added value

As described above in the case for EU intervention the scale, complexity and long-term nature of the ITER project imply that it is not feasible for private industry to finance it, not is it appropriate for a single Member State to support it. The potentially global benefits of the technology also imply that

[7] Art. 1 of the Council Decision establishing the European Joint Undertaking for ITER and the Development of Fusion Energy 2007/198/Euratom: 'A European Joint Undertaking for ITER and the Development of Fusion Energy is hereby established for a period of 35 years starting on 19 April 2007'. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007D0198&from=FRN

global cooperation in developing them is appropriate. The fact that Europe is committed via Euratom signature to the international ITER agreement also implies that action at EU level is more appropriate than single Member State action. The scale, diversity and excellence of activity that is enabled through pooling resources is vital to achieving the critical mass required to construct this complex and first of a kind project.

ITER aims to bring the prospect of meeting a large share of our electricity needs through fusion significantly closer. Europe has taken the lead in this project with a 45% stake of the construction costs of which 80% is funded from the EU budget and 20% by France as the ITER host country (the other ITER Members share is around 9% each). This cost distribution will change in the operation phase, with Europe providing 34%. ITER's construction involves over 10 million components being built in factories around the world. About 75 % of its investment is spent on the creation of new knowledge and cutting-edge materials and technology. This offers European high-tech industries and SMEs a valuable opportunity to innovate and to develop 'spin off' products for exploitation outside fusion (such as the broader energy sector, aviation and hi-tech instruments like the NMR - nuclear magnetic resonance - scanners).

The costs for ITER must be seen in the context of a significant transformation in Europe set out in the Energy Union strategy[8] that is estimated to require about EUR 200 billion annually in the next decade. Fusion's future as a viable energy source depends on the successful construction and operation of ITER. Already in the present construction phase ITER is having a positive impact on European industries and SMEs involved in the manufacture of thousands of first-of-a-kind technological components required for this complex endeavour. An example of this is the successful fabrication by a European consortium of companies of the superconductors and the winding packs for the ITER Toroidal Field Coils, which is a major technological advance as winding packs of this size have never been manufactured before.

The Value for Money study (2018) focusses on the economic benefits that have been generated by the EU's participation in ITER to date. The study does not attempt to value the potential future benefits of a clean and plentiful source of energy but instead considers ITER more as a 'big science' project where the ongoing benefits of employment and the development of new and improved technologies and expertise are the focus. The report summarises the main economic effects emerging from the implementation of F4E contracts as follows:

- Spending on ITER by F4E is having significant positive economic impacts compared to no spending, with 34 000 job years created to date, including 7 400 in 2017 alone; and almost €4.8 billion in GVA to date, with more than €1.1 billion in GVA estimated in 2017;
- For the majority of contracted parties, implementing F4E contracts is seen as part of their core business. However, for a substantial minority of the contracted parties, an F4E contract is regarded as a stepping stone towards realising longer term spin-offs and benefits;
- Firms judge that working on ITER bolsters their reputation as a leading high-tech company and many also have a positive appraisal of the indirect benefits outside of fusion and big science;
- More than a third of firms have developed new cutting-edge technologies as a result of their work on ITER. Whilst only a handful of these have led to specific spin-offs this is a longer-term process, and one could expect that these benefits will become more visible in future;

[8] A framework strategy for a resilient energy union with a forward-looking climate change policy. Available at: https://setis.ec.europa.eu/system/files/integrated_set-plan/communication_energy_union_en.pdf

- Around a quarter of firms reported that the work on ITER has helped them to access new business opportunities both inside and outside fusion. Consortium working is utilised by almost 40% of firms and many of these firms reporting synergies and new opportunities;
- Finally, 85% of surveyed firms noted that working on ITER had required them to develop new knowledge and skills, with 25% substantially developing their knowledge and skills.

ITER, the European Space Agency (ESA) and CERN (the European Organization for Nuclear Research, particle accelerators and detectors[9]) are the three largest Big Science projects in the EU and are among the leading ongoing Big Science projects globally. The experience with ESA and CERN is that they can deliver a return on investment in the medium-long term. For ITER, the positive economic indicators at this relatively early stage bode well for similar positive net returns in future, including the benefits from spin offs developed from ITER technology and techniques.
The types of technologies being developed for ITER have links to those also being developed for CERN and ESA, this provides opportunities for synergies between these projects. Opportunities for synergies with ESA have already been identified through joint discussions between ESA and F4E. The synergies are also applicable for firms that work on Big Science as the network and process enables easier connection to business opportunities in ITER or other Big Science projects.

Proportionality

The Better Regulation Toolbox (tool 5)[10], describes proportionality as follows: “The content and form of Union action must not go beyond what is necessary to meet the objectives of the Treaties. Respect for the principle of proportionality is about ensuring that the policy approach and its intensity match the identified problem/objective.” The toolbox contains a number of questions that test proportionality. The questions that are applicable for ITER, and the responses for ITER are as follows:

- ***Does the initiative go beyond what is necessary to achieve the problem/objective satisfactorily?***
No, because the purpose of ITER is to design, construct and operate the facility and use the lessons learnt to enable the construction of a larger scale prototype.

- ***Is the initiative limited to those aspects that Member States cannot achieve satisfactorily on their own, and where the Union can do better? (boundary test)***
The large scale and complex nature of ITER are appropriate to researching and developing a way of harnessing fusion as an energy source. The long term and high risk (though high reward) nature of the project mean that a joint effort between Member States (and many other countries outside Europe) is more effective than actions by a single Member State, or uncoordinated actions by multiple Member States.

- ***Is the form of Union action (choice of instrument) as simple as possible, and coherent with satisfactory achievement of the objective and effective enforcement?***
The overall form of Union action, with contributions from each Member State to a single action, is as simple as possible and is coherent with achieving a project of the large scale and complexity of

[9] https://home.cern/about
[10] Better Regulation Toolbox 5. Available at: https://ec.europa.eu/info/files/better-regulation-toolbox-5_en

ITER. The details of the instrument design, i.e. the way the funding is structured and managed are reviewed in the detailed options considered later on in this analysis.

– ***Does the initiative create unjustified financial or administrative cost for the Union, national governments, regional or local authorities, economic operators or citizens? Are these costs*** *commensurate with the objective to be achieved?*
The ultimate objective of fusion, a clean, secure and safe energy source, is of very high value, and when compared to the overall costs of energy provision the costs of supporting ITER are commensurate, even though there are risks that the objective will not ultimately be achieved.

– ***Does the Union action leave as much scope for national decision as possible while achieving satisfactorily the objectives set?***
The nature of the ITER project, constructing a single location facility, limits the scope for national decision making. However, F4E's board gives a voice to each Member State in the process.

- ***While respecting Union law, are special circumstances applying in individual Member States taken into account?***
This question typically refers to policy areas where the required Member State response needs to be adjusted to reflect their starting point. For example, Member States with a higher reliance on landfill to dispose of waste have been given longer to move to alternative forms of waste treatment and disposal. This test is therefore not that strong for this application, though there is one aspect of potential relevance, as follows: The level of some Member State's contribution (France) reflects the benefits they receive. However, the principle of 'just retours' does not apply to the contribution from other Member States. The contracts are awarded on the basis of the best qualified company. As would be expected according to European purchasing requirements and the need to ensure that the highly complex components are appropriately manufactured. Therefore, the distribution of contracts between Member States is not equal as it reflects the presence of appropriate expertise in each Member State.

4 Delivery Mechanisms and legal forms

Key findings

- Three delivery mechanisms (DM) and six legal forms (LF) to govern the European contribution to ITER were identified and presented:
  - Two of the legal forms (private company, ERIC) were deemed unlikely to be applicable.
- A preliminary qualitative analysis of the pros and cons of the remaining DMs and LFs in the context of ITER was conducted based on interviews and an intensive literature review. This led to the following general observations:

  Delivery mechanisms:
  - Keeping ITER as its own programme under the MFF solidifies its position as a political priority. Even though it might not allow for much flexibility, this delivery mechanism creates budgetary stability as ITER does not have to compete with other projects for funding;
  - Placing ITER in a wider programme enables more synergies with other related nuclear research projects but increases the risk of budgetary friction between those projects and ITER as well;
  - Funding ITER outside the MFF and via pooled MS contributions could spark higher overall investment but would also require significant legal action to replace or amend existing agreements.

  Legal forms:
  - F4E is set up as a Joint Undertaking whose members are Euratom (represented by the Commission), the MSs of Euratom, and third countries which have concluded a cooperation agreement with Euratom in the field of controlled nuclear fusion. Thus, there is no provision for private stakeholders in the current statutes;
  - A PPP or JU, via inclusion of the private sector, can potentially increase the overall availability of funding. However, an attractive business case that could warrant the private sector's involvement has not yet crystallized from ITER;
  - Operationalisation through an EU agency setup would ensure higher stability for the project as the funding is signed-off in its entirety from the beginning and would not be a matter of reoccurring negotiations. This, nonetheless, likely leads to miscalculations of costs up until completion of ITER;
  - An intergovernmental organisation (IGO) can provide more dynamism to the budget and decision-making process but also requires significant legal changes that are likely to provoke delays for ITER.

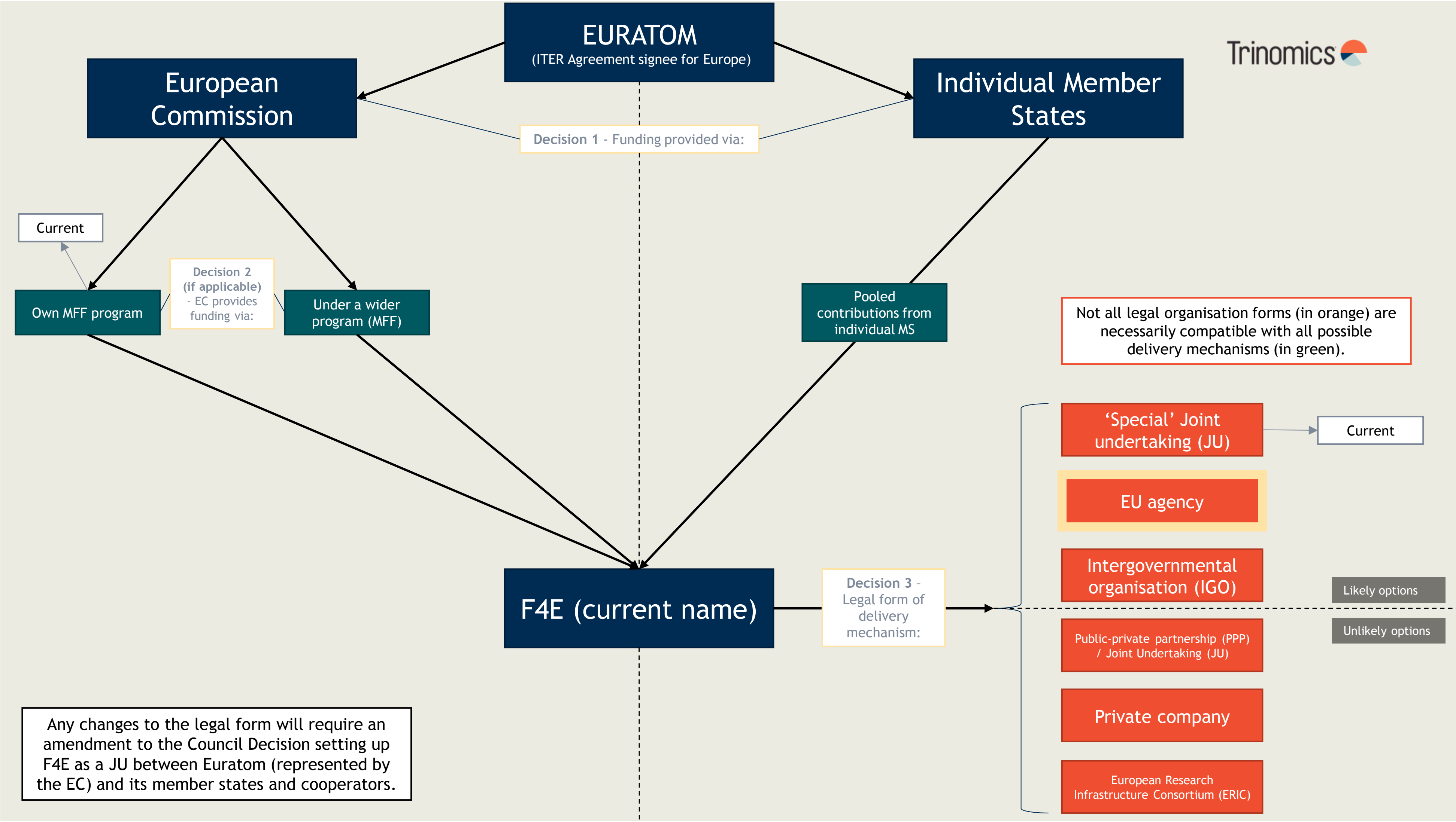
4.1 Introduction

This chapter identifies and discusses the various delivery mechanisms and legal forms that the European contribution to ITER can take, as a basis for the quantitative and qualitative assessments carried out in the next chapter. They are examined with inputs originating from a thorough screening of the literature, as well as from interviews conducted by the consultant team. After identification and discussion, a thorough analysis of the pros and cons of each delivery mechanism and legal form is performed.

The delivery mechanisms describe the way in which the funding is provided - i.e. by which entity and via which specific channel. The legal forms describe the specific procedural setup and governance of the budget – i.e. they characterise the nature of the intermediary entity set up to operate the funding. The two concepts are hence not mutually exclusive and create policy options in the way they are combined. These pairing options and their different impacts are discussed in more detail in the next chapter. In this chapter, they are handled individually (delivery mechanisms in 4.2. and legal forms in 4.3.) to allow an assessment of their specific nature and their ITER-related pros and cons in isolation.

In order to better understand the range of choices applicable to the European contribution to ITER, Figure 4-1 visualises the different delivery mechanisms and the legal forms and their relationships.

Figure 4-1: Relationship diagram of delivery mechanisms and legal forms



In Figure 4-1, the blue boxes represent the entities that are responsible either for the funding itself or the management. The European Commission (representing Euratom) or individual member states to Euratom represent the former, whereas F4E represents the latter.

Funding can be provided via three distinct delivery mechanisms, which are highlighted in green. The 'MFF programme' and 'MFF wider programme' options are only possible if funding originates from the Commission. 'Pooled contributions' would be used as the delivery mechanism if the European contribution to ITER were to be provided solely by individual member states.

Possible legal forms of the managing entity are highlighted in orange. These describe the nature of governance and procedures of the managing entity (i.e. F4E). It should be noted, however, that not all of the legal forms can be matched with all of the delivery mechanisms[11]. Legal forms that are highly unlikely to be relevant for ITER are mentioned, but not further assessed in later chapters. These aspects are explained in more detail in the following sections.

Setting up (or changing) the way that the European contribution to ITER is provided requires three crucial steps - these are marked as decision boxes. The decision boxes 'guide' the reader through the logical flow of the diagram and provide 'impact points' for the assessment in the next Chapter.

The following sections present the delivery mechanisms (green boxes) and legal forms (orange boxes) before assessing their individual pros and cons.

4.2 Presentation of delivery mechanism options

4.2.1 *Business as usual - dedicated programme in the MFF*

The funds allocated by the European institutions, comprising the annual EU budget, are based on the Multiannual Financial Framework (MFF) interinstitutional agreement between the European Commission, Parliament and Council[12]. The agreement also sets the limits of the maximum amount of commitment appropriations of the EU budget. The broad policy areas where funds are allocated are grouped under various headings. The interinstitutional agreement fixes the annual 'ceiling' for the payments and commitment appropriations for these headings[13]. The legislative procedure to be followed when adopting the Multiannual Financial Framework and yearly budgets is elaborated in a broad array of legislative acts. The main steps to be followed are stipulated in Articles 310 to 316 under Title II of the Treaty on The Functioning of The European Union (TFEU), which detail the financial provision of the Union[14].

According to Art. 312 under Chapter 2 of the TFEU, which stipulates the general time-frame, the Multiannual Financial Framework is set for a specific number of no less than five years[15]. Paragraph 2 establishes the interinstitutional relations when it comes to adopting the MFF, stating that:

[11] This is why, for example, 'EU Agency' is highlighted with yellow borders. It is a form of direct management by the EC and can hence not be coupled with a 'pooled funding' delivery mechanism.
[12] http://ec.europa.eu/budget/biblio/documents/fin_fwk0713/fin_fwk0713_en.cfm
[13] *Ibid.*
[14] Consolidated Version Of The Treaty On The Functioning Of The European Union. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT&from=EN
[15] *Ibid.*, Art 312

> *The Council, acting in accordance with a special legislative procedure, shall adopt a regulation laying down the multiannual financial framework. The Council shall act unanimously after obtaining the consent of the European Parliament, which shall be given by a majority of its component members.*
>
> *The European Council may, unanimously, adopt a decision authorising the Council to act by a qualified majority when adopting the regulation referred to in the first subparagraph*[16].

The MFF itself, caps the amounts of the 'ceilings' which represent the maximum amount of funds that can be spent by the EU on an annual basis for different political fields, combined in the dedicated 'headings'[17]. These headings allow the European institutions to discharge funds in the pursuit of carrying out and implementing common policies for the agreed period[18].

The European institutions must also follow an annual budget cycle. It begins with the European Commission's proposal of a draft budget, which must comply with the 'ceiling' agreed under the Multiannual Financial Framework. The annual budget foresees both the Commitment Appropriations (CA) as well as the Payment Appropriations (PA). Commitment Appropriations set the limit of legal obligations carried out in a budget year for activities leading to committed payments in the current or future budget years. Payment Appropriations set the amount of funds available to be spent during the budget year, arising from commitments in the budget for the current or preceding years.

This distinction between PA and CA is particularly important to understand given the nature of financing the ITER project because it refers precisely to multiannual programmes and projects. The difference occurs because the funds are committed at the stage when the programme or project are agreed upon, but they are paid out throughout the years of the actual implementation.

The last two MFFs, under which funds from the EU budget have been allocated to the ITER project, were both set for a period of seven years, from 2007 to 2013 and from 2014 to 2020 respectively. However, it is important to note that ITER does not fit the traditional classification used by the European Commission regarding programme financing. According to the established rules, the Secretariat-General adopts separate budget lines for all of the activities that receive funding under the MFF. This is the reason why they are considered as separate programmes. The ITER project is agreed internationally via an intergovernmental agreement (ITER Agreement) between the member countries so the overall budget is provided by all ITER Member Parties. ITER also spans over 35 years which means that the European contribution will inevitably span several EU MFFs. Until this point the ITER project has received financing from two MFFs. However, the internal mechanisms for budget allocation in these two MFFs were different.

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[16] *Ibid.*, Art 312, Para 2

[17] Svetlana Kineva (2015), The Multiannual Financial Framework and European Union Budget in Theory and Practice, *Economic Alternatives*, Issue 3. Available at: http://www.unwe.bg/uploads/Alternatives/2_3_2015.pdf

[18] *Ibid.*

In the current 2014-2020 MFF, funds are allocated to a dedicated ITER programme under heading 1a: The Smart and Inclusive Growth/Competitiveness for growth and jobs[19]. The total available EU funds for the 2014-2020 MFF amount to EUR 1.08 trillion. For the 2014-2020 financial envelope, the commitments foreseen by the European Budget for the ITER project amount to EUR 2.986 billion in current prices. This represents 0.27% of the total MFF funds[20]. In the 2016 budget, the commitments for ITER reached EUR 330.1 million or 0.21% of the total 2016 EU budget[21]. The actual payments allocated were EUR 474.6 million[22]. The difference in amounts is explained by the procurement schedule inherent to the ITER project where some components might have to be commissioned and delivered in advance in order to be tested, fitted and assembled prior to their actual installation on the construction site. In 2017, the spending remained stable with commitments of EUR 322.71 million, or 0.20% of the total EU budget for 2017. Actual payments in 2017 were EUR 426.3 million[23].

With regard to the overall cost evolution of the ITER project, there have been some significant overruns during the years. In 2006, when the ITER Agreement was signed, it was estimated that the overall construction phase would cost, to all the parties involved, EUR 5.9 billion, in 2008 prices. However, in June 2008, after the design was revised, the estimated cost rose to approximately EUR 19 billion for the total construction of all ITER related facilities. These funds would have had to be further divided between the ITER Member Parties. As a result of this revision, the delivery of first plasma was envisioned for 2019. After the 2016 assessment, approved by the ITER Council, the baseline was once again revised, in order to take into account the differences between the contributions of all ITER member parties. Given that all of the parties had the responsibility to procure the in-kind hardware in their own territory using their own currencies, a direct conversion of the value estimate for the ITER construction phase into a single currency was considered as feasible[24]. This latest revision also adjusted the baseline and brought the estimated overall EU contribution for the entire life-span of the ITER project to over EUR 18 billion and pushed the first plasma stage to 2025[25]. The table below shows how this revised baseline is split and foreseen in the ITER funding from the EU (thus only the Euratom contribution part, in current prices).

[19] Multiannual financial framework 2014-2020 and EU budget 2014 figures, Available at: https://publications.europa.eu/en/publication-detail/-/publication/d2cf202e-f36a-45b2-84e7-1ac6ad996e90
[20] European Parliament, Briefing How the EU budget is spent September 2017, ITER. Available at: http://www.europarl.europa.eu/RegData/etudes/BRIE/2017/608715/EPRS_BRI(2017)608715_EN.pdf
[21] *Ibid.*
[22] *Ibid.*
[23] *Ibid.*
[24] *Ibid.*
[25] *Ibid.*

Table 4-1: Scheduled Euratom contributions to ITER (IO), 2007-2020+ by cost, € billion (2016 baseline**)[26]

	Up to the end of the current MFF period		To First Plasma	From First Plasma to Performance Operation		
	2007-2013	2014-2020	2021-2025	2026-2027	2028-2035	Total after 2020
F4E total cash to IO	3.5	1.1	1.5	0.7	1.6	3.8
Construction budget		*1.1*	*1.4*	*0.4*	*0.4*	*2.2*
Operations budget		*0.0*	*0.1*	*0.3*	*1.2*	*1.6*
F4E in kind contribution		2.5	3.1	0.8	0.7	4.6
F4E administration		0.4	0.3	0.1	0.6	1.0
F4E other activities		0.1	0.5	0.2	0.01	0.8
EC project administration		0.07	0.05	0.02	0.08	0.15
TOTAL	3.5*	4.2*	5.5	1.8	3.1	10.4

**Project delays meant it was not possible to use F4E commitment appropriations for the period 2007-2013 in full, so appropriations initially committed for 2007-2013 were cancelled and re-appropriated to the following financial period.*
***The figures in this table refer to the total European contribution to ITER managed by F4E [i.e. EU budget, French contribution (as host country) and the Euratom participating states' contribution].*

The figures show that most of the financing coming from the EU for ITER will be delivered in the MFFs between 2007 and 2035, due to the intensive initial construction phase of the project.

Financing the European contribution to the ITER project through a dedicated programme in the MFF allows for greater visibility of the allocated funds and highlights the overruns, when they occur. Financing ITER separately from the other research programmes also decreases the likelihood of ITER absorbing financial resources initially allocated to other projects. Reducing the option of financing one bigger and more capital consuming research project at the expense of several others also improves internal management and reduces inter-project friction issues that may occur.

Continuing with the business as usual scenario of separate programme dedicated budget line under the MFF for the next stage of financing of the ITER project also allows for better predictability for the available funds. This guarantees to the institutions involved in the discharge of these funds, that the resources initially pledged will indeed be delivered. It also means that it is less likely that these resources will be transferred to other programmes falling under the same 'heading' in the broader programme.

4.2.2 In a wider program within the MFF

Both nuclear fission and fusion programmes have a rich history in the context of the European policymaking process. Before being a separate programme in the Multiannual Financial Framework, the ITER project was associated to the EURATOM's involvement in the Sixth European Community Framework Programme for Research, Technology Development and Demonstration (FP6) spanning form 2002 until 2006. In the 7th Framework Programme (FP7) that followed, ITER was part of the FP7 Euratom Programme[27], which had its own financial programming. Given that in the current MFF, ITER is

[26] EU contribution to a reformed ITER project. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/eu_contribution_to_a_reformed_iter_project_en.pdf
[27] It is important to note that prior to the ITER project there were other fusion projects which ran under financing schemes provided by the Framework Programme and managed by EURATOM. The successful results achieved by the Joint European Tours (JET) fusion project have contributed to the leading role Europe played in establishing fusion technology. It was one of the main advantages for choosing Europe and the Cadarache site, in the south of France, as the location where ITER would be built.

split from the Horizon 2020 Programme as a dedicated programme of the MFF, it would be possible to consider for the next financial programming period a wider programme (i.e. FP9) encompassing the European budget for ITER (under EURATOM Framework Programme allocations).

According to the input collected from recent interviews with Fusion for Energy officials, the financing structure was switched to a dedicated programme due to the fact that ITER has reached a more mature project phase. This meant that the actual facility construction activities had to be carried out, followed by manufacturing, assembly and installation of the components. The potential delays, emanating from the complicated international supply chain meant that it would be easier to manage EU funding if it were allocated in a dedicated ITER programme. Another reason for a separate programme was the concern that due to its scale and overruns, resulting in the need for additional financing, it may end up absorbing funds from various other Horizon 2020 funded activities. Given the stage of the project this could have put several Horizon 2020 research projects behind schedule. All of these reasons meant that it was felt to be more efficient and transparent to manage the EU's ITER financial contributions through a dedicated MFF programme, rather than in a wider programme like FP7 or Horizon 2020.

The FP7 (2007-2013) was hence the last Framework Programme to incorporate funding for ITER under its EURATOM programme budget. Table 4-2 provides an overview for the thematic split of the EURATOM budget for the period 2007-2011[28] and 2012-2013, stating explicitly how much was allocated to ITER during that time span and under which topic. The last two years of EURATOM budget under the FP7 period (2012-2013) were covered by a two-year extension of the EURATOM Framework Programme. EUR 2.56 billion was allocated for this[29]. The total EURATOM budget for the FP7 period was thus EUR 5.257 billion.

Table 4-2: EURATOM FP contributions as part of the 7^{th} FP for RTD and Demonstration Activities (EUR million)[30][31]

Activities	Goals	Values 2007-2011		Values 2012-2013
EURATOM Framework Programme (EUR million)		**2 751**		**2 560**
1. Fusion Energy Research (of which):	Developing technology for safe, sustainable, environmentally responsible and economically viable energy source.	1 947		2 209
1.1 ITER	Construction of the fusion energy source ITER.		1047	- (no official distinction); *implemented amount: 2022*[32]
1.2. Other			900	- (no official distinction); *implemented amount: 187*[33]

[28] Other than the MFF, the EUREATOM budget is fixed for only 5 years.
[29] Council decision concerning the Framework Programme of the European Atomic Energy Community for nuclear research and training activities (2012-2013). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011PC0072&from=EN
[30] https://ec.europa.eu/research/fp7/index_en.cfm?pg=euratom
[31] Council decision concerning the Framework Programme of the European Atomic Energy Community for nuclear research and training activities (2012-2013). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011PC0072&from=EN
[32] Statement of estimates of the European Commission for the financial year 2013, SEC(2012)270 – May 2012 page 107, and Statement of estimates of the European Commission for the financial year 2014, SEC(2013)370 – June 2013 page 107.
[33] Simple estimation based on the implemented amount identified for 1.1 and the total amount available for Activity 1 in the timeframe 2012-2013 (=2209-2022).

Activities	Goals	Values 2007-2011	Values 2012-2013
EURATOM Framework Programme (EUR million)		**2 751**	**2 560**
2. Nuclear Fission and Radiation Protection	Enhancing safety performance, resource efficiency, and cost-effectiveness of nuclear fission and other uses of radiation in industry and medicine.	287	118
3. Nuclear Activities of the Joint Research Centre (JRC)[34]	Activities in the fields of nuclear waste management and environmental impact, nuclear safety, and nuclear security.	517	233
Grand Total FP7		**50 000**	**100%**

The grand total of the funds available for the 2007-2013 period under FP7 were around EUR 50 billion. The EUR 5.257 billion allocated to the EURATOM Framework Program represented around 10.51% of the total funds. Given the proportions of the EURATOM budget in 2007-2011 going to the construction of ITER, it can be estimated that the two-year extension of the EURATOM Framework programme brought another EUR 1.19 billion to the fusion reactor[35].

In hindsight, according to a broad consensus amongst the interviewees, the disadvantages of having the ITER project in a wider programme outweigh the benefits. Due to its large scale and the unforeseen challenges of designing and building a first of its kind facility, the ITER project has suffered significant cost overruns. As a result, interviewed officials from DG RTD expressed their concerns, that it ended up competing with other nuclear projects and absorbing funds from other programmes. According to them, this in turn increased the risks of smaller programmes becoming neglected and their resources being taken over by larger projects, as ITER. Officials from DG RTD also seem to think that this highlights the friction between the competing programmes and puts ITER under public pressure for delivering the outcomes under the initially agreed financial terms and conditions.

Going back to such a scenario would mean facing similar problems under the next Multiannual Financial Framework.

4.2.3 *Pooled contributions of individual MS*

Individual countries pooling finances to achieve a common goal is a popular approach to deliver funding for the realisation of Big Science projects. Under this approach countries are free to decide about their participation and the size of the contribution that they are willing to make. After establishment of a willingness to fund an endeavour together, funding rules are established by the stakeholder countries[36]. Contributions of countries can be established as either mandatory or (restricted) voluntary. Both options have different impacts on the way the project is subsequently legally set up and governed[37].

[34] The recent evaluation report of Euratom further suggests a better coordination of the indirect Euratom research activities (e.g. EUROfusion funding) with the direct Euratom research activities (performed by the JRC). Source: https://ec.europa.eu/research/evaluations/pdf/archive/other_reports_studies_and_documents/com_2017_697_report_on_interim_evaluation_of_euratom_research_and_training_programme_2014-2018.pdf
[35] Out of the EUR 2.56 billion provided for 2012-2013.
[36] Graham, E.R. (2016). The institutional design of funding rules at international organizations: Explaining the transformation in financing the United Nations. *European Journal of International Relations*. Available at: http://journals.sagepub.com/doi/abs/10.1177/1354066116648755
[37] Graham, E.R. (2015). Money and multilateralism: how funding rules constitute IO governance. *International Theory*. Available at: https://www.cambridge.org/core/journals/international-theory/article/money-and-multilateralism-how-funding-rules-constitute-io-governance/EE4B1F15213AF7EE7DCE1BA2A03EDA82

This is the foundation of the delivery mechanism. The exact management of the budget, however, depends on the legal form of the intergovernmental endeavour (see section 5.2. for more detail).

Such joint international financing gained significant importance in the wake of World War II and during the Cold War. Especially in (nuclear) science, the tensions of the post-war global political environment led to consolidated funding of (military) R&D projects by member states of the different blocs (NATO and the Warsaw Pact). Europe's first Big Science projects, such as CERN, were funded by pooled individual contributions from stakeholder countries[38]. Today, eight out of the nine most important European Big Science projects in size and relevance were founded by, and continue to receive their funding from, a grouping of interested European parties[39].

There are two reasons for the continued use of the 'pooled funding' delivery mechanism in Europe. The first one is that a common legal EU framework on Big Science is still lacking. To get large research infrastructure projects off the ground, interested countries therefore need to coordinate funding between themselves. The second one is that each new Big Science project presents unique construction and scientific challenges which favours an *ad hoc* approach to its membership and funding, adapted to the specific circumstances.[40] Not all countries in the EU might be fundamentally, politically, or financially motivated to participate in a certain Big Science project. At the same time, geographic and procedural requirements might differ greatly between projects, making it more sensible for some countries to engage than others. This *ad hoc* approach has led to numerous distinct forms of legal and process environments which are (to an extent[41]) discussed in more detail in section 5.2.

To date, the European contribution to ITER has only ever been delivered under the umbrella of the European Commission (via the MFF, as described above)[42]. As such, all member states of the EU are technically financing the project. Changing the delivery mechanism for the European contribution to ITER to 'pooled funding' of individual European countries would carry significant legal implications that are touched upon in later sections.

4.3 Legal forms of delivery mechanisms

4.3.1 Public-private partnership (PPP)

A public-private partnership (PPP) is a contractual agreement between a public authority and a private entity. This agreement ensures that the skills and assets of both public and private stakeholders are

[38] Hallonsten, O. (2014). The Politics of European Collaboration in Big Science. **Chapter taken from:** Mayer, M. et al. (2014). The Global Politics of Science and Technology – Vol. 2. *Springer-Verlag Berlin Heidelberg*. Available at: https://www.izwt.uni-wuppertal.de/fileadmin/izwt/Kolloquium/WS_14-15/2014-11-05_HALLONSTEN__Dr._Olof_ANHANG_zum_VORTRAG_Hallonsten_Springer_book_chapter.pdf

[39] Technically, ITER is also funded by a 'pooled funding' delivery mechanism. Its European contribution, however, is currently provided in European unison via a direct MFF budget line from the EC.

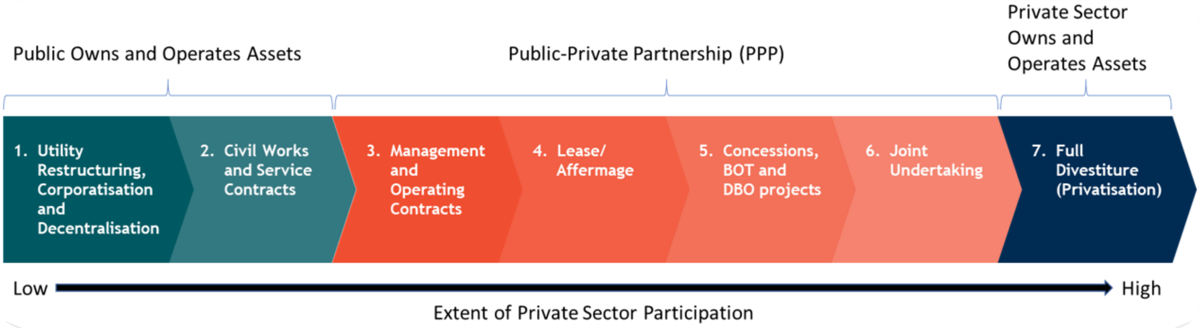
[40] Hallonsten, O. (2014). The Politics of European Collaboration in Big Science. **Chapter taken from:** Mayer, M. et al. (2014). The Global Politics of Science and Technology – Vol. 2. *Springer-Verlag Berlin Heidelberg*. Available at: https://www.izwt.uni-wuppertal.de/fileadmin/izwt/Kolloquium/WS_14-15/2014-11-05_HALLONSTEN__Dr._Olof_ANHANG_zum_VORTRAG_Hallonsten_Springer_book_chapter.pdf

[41] Almost all of the *ad hoc* setups are unique to their respective projects. Only the umbrella legal forms (e.g. IGO, private company) are therefore discussed in section 5.2. (with more specific examples from selected Big Science projects).

[42] There was, however, a proposal for a Council Decision drafted in 2011 that would have seen the European contribution to ITER outside of the MFF after 2013. Hereby, a 'Supplementary Research Programme' under the Euratom treaty (funded by individual MS contributions) was coined as a possible delivery mechanism. This proposal was never adopted. Document available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011PC0931

combined effectively to deliver a utility/service for general public use[43]. PPPs are actually a mechanism for public authorities to procure and implement public infrastructure and services by utilising private sector's resources and expertise and are usually created to deliver a project or a service traditionally provided by the public sector[44]. A PPP is an appropriate financing scheme to reduce significant up-front funding requirements, and they range from fully-public responsibility to fully-private responsibility, depending on the project. Figure 4-2 shows the different options for PPP agreements. Each option is explained in Annex A.

Figure 4-2: The Spectrum of PPP agreements[45]



In any of these schemes, Value for Money (VfM) is only achieved by exploiting the private sector's competencies and allocating responsibilities and risks between the public and private collaborators[46]. Usually, public authorities budget a project based on lower cost and earlier delivery time, rather than the more rationale outcome. This is caused by the fact that public authorities have no incentives to manage risks effectively. Every time a risk is allocated to a private stakeholder that is capable of managing that risk, the VfM is improved. On the other hand, if the private contractor cannot handle that particular risk, the VfM is reduced.

Due to a conflict of interest between the public sector's intention to only pay for the services it consumes, and the private contractor's commitment to pay back their debts to their lenders, there are two payment method applicable in PPP schemes:

- Availability payment: The contractor receives payment depending on the availability of a service, rather than the frequency of use;
- Volume payment: The users of a service pay depending on the frequency of using the facility or service provided, e.g. highway tolls.

Currently, F4E is set up as a Joint Undertaking. In order to be converted to a PPP, it would need to provide potential economic benefits to the candidate private stakeholders, which is not applicable to ITER, for the near future. Furthermore, it would require a long-term commitment from the private stakeholders, as ITER is not projected to initiate the deuterium-tritium operation before 2035.

[43] https://www.ncppp.org/ppp-basics/7-keys/
[44] https://ppp.worldbank.org/public-private-partnership/about-public-private-partnerships
[45] https://ppp.worldbank.org/public-private-partnership/agreements
[46] Bertrán X. and Vidal A. (2005), The Implementation of a Public-Private Partnership for Galileo, ION GNSS 18th International Technical Meeting of the Satellite Division. Available at: https://pdfs.semanticscholar.org/0e5f/62adb497e65e776e273c878cf7e2f0682c73.pdf

The case would be different for DEMO, as the gap between construction and commercial exploitation would be significantly shorter, maybe in the range of 10-15 years. Another issue that should be taken into consideration and clarified clearly before setting up F4E as a PPP, is the IPR for technologies and equipment developed for ITER. The current IPR provision is not attractive for private entities to enter the current ITER agreement or ITER ecosystem[47]. With the current situation it is highly probable that companies will be willing to participate in ITER only if risks are mostly covered by the public.

In 2001, during the site selection procedure for ITER, a location in Canada was proposed by a consortium formed by Canadian companies and banks. The delay in taking that decision (South France was selected in 2005), eroded the resilience of the Canadian consortium. It was clear at that time that only an organisation treated by a government could bring forward this situation because it was not yet an industrial project[47]. Currently, ITER is considered more as a long-term R&D project and companies focus much more on short-term prospects. On the other hand, a PPP legal form would simplify the administration procedures during the construction phase, by benefiting from simpler administrative processes than the current call-for-tenders procedure[48].

Box 4-1: Case of a EU PPP: Galileo PPP[49]

Galileo PPP

Galileo was the first PPP scheme ever undertaken at EU level. The reason behind the decision to use PPP was the willingness to optimise the procurement efficiency, minimise the public sector's exposure to risks and reduce the life cycle costs by utilising the private sector's management skills. Nevertheless, the institutional set-up was too complex, consisting of two parts, the "Sponsoring and Decision Making", consisting of EU institutions and the MSs, and the "Project Management" part consisting of the European Space Agency (ESA), DG TREN and Galileo JU (GJU). Never before had such a satellite navigation programme been run as a PPP. The closest case to Galileo PPP was the British military-communications satellite programme Skynet, which included only four satellites and both the technical and business complexity were much lower. Initially, it was expected that the winning consortium would be selected before the end of 2004 and that a concession contract would be in place by the end of 2005. However, after several delays and after the two bidders had merged into one consortium, the two parties could not reach an agreement on allocating the market risks and liabilities and the Galileo PPP was eventually cancelled in early 2007. Compared to other PPP projects, Galileo has higher technical and business complexity, which is also the case for ITER. For example, Galileo's deployment phase relies on launching services, which include a significant risk of launch failure, because of which space equipment can no longer be retrieved. This results in a substantial waste of time and money and increases the insurance cost. Similarly, in ITER, there are several technological barriers that need to be overcome to reach the goal of First Plasma, which implies a substantial degree of uncertainty both in terms of delivery duration and cost. This is an important risk factor that should be discussed thoroughly and come to an allocation agreement before setting an ITER PPP. According to the European CoA, the Galileo PPP was inadequately prepared and conceived which resulted in negotiating an unrealistic PPP.

[47] Information extracted during phone interview with F4E staff
[48] Information extracted during phone interview with F4E staff
[49] The Management of the Galileo Programme's Development and Validation Phase. Available at: https://www.eca.europa.eu/Lists/ECADocuments/SR09_07/SR09_07_EN.PDF

Joint undertaking

Joint Undertakings (JUs) are a research entity between the EU (through the EC) and industry-led associations[50]. In some cases, MSs also participate as founding members. According to Article 187 of the Treaty of the Functionality of the European Union (TFEU), the EU is entitled to set up Joint Undertakings to efficiently execute research, technological development and demonstration programmes[51]. Technically, JUs are a form of a PPP as shown in Figure 4-2.

A JU is an autonomous EU legal entity with its own personnel, agenda, budget and governance and can assign tasks under research programmes, e.g. H2020. JUs also have the option of combining EU budget with other sources, e.g. national and private, for implementing R&I and demonstration programmes.

JUs are also able to define their own procurement and financial rules and organise their own procurement procedures following rules defined by their governing board. These rules, however, have to be based on the European Union's financial regulation model.

The option of Joint Undertaking has been utilised by the EC in several complex and large budget projects, e.g. Galileo, SESAR, HPC and others.
Table 4-3 shows the founding members for each JU. Out of the 10 JUs reviewed, only F4E has no provision for private stakeholder's participation[52].

Table 4-3: Founding members of JUs

JU Name	Founding Members
F4E[53]	Euratom (EC), MSs of Euratom, third countries
BBI[54]	EC, Bio-based Industries Consortium AISBL (BIC)
Clean Sky 2[55]	EC, 16 leaders, 66 associates
ECSEL[56]	EC, 25 MSs, AENEAS, ARTEMISIA, EPoSS
FCH[57]	EC, Hydrogen Europe, Hydrogen Europe Research
Galileo[58]	EC, ESA, EIB, any undertaking, after the Commission has, under Article 4 of Council Regulation (EC) No 876/2002 of 21 May 2002 setting up the Galileo Joint Undertaking (1), informed the Council of the outcome of the tendering procedure, and after approval in accordance with the procedure set out in Article 5 of that Regulation.
HPC[59]	EC, 13 MSs, ETP4HPC, BDVA

[50] http://eur-lex.europa.eu/summary/glossary/joint_undertaking.html
[51] Consolidated version of the Treaty on the functioning of the European Union. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT&from=EN
[52] Establishing the European Joint Undertaking for ITER and the Development of Fusion Energy and conferring advantages upon it. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007D0198&from=FRN
[53] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007D0198&from=FRN
[54] Establishing the Bio-based Industries Joint Undertaking. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0560&from=EN
[55] Establishing the Clean Sky 2 Joint Undertaking. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0558&from=EN
[56] Proposal for Council regulation on the ECSEL Joint Undertaking. Available at: http://eur-lex.europa.eu/resource.html?uri=cellar:e457e697-eaf1-11e2-a22e-01aa75ed71a1.0002.01/DOC_1&format=PDF
[57] Establishing the Fuel Cells and Hydrogen 2 Joint Undertaking. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0559&from=EN
[58] Setting up the Galileo Joint Undertaking. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32002R0876&from=EN

JU Name	Founding Members
IMI[60]	EC, European Federation of Pharmaceutical Industries and Associations (EFPIA)
SESAR[61]	EC, Eurocontrol, EIB, any other public or private undertaking or body including those from third countries that have concluded at least one agreement with the European Community in the field of air transport.
Shift2Rail[62]	EC, 8 companies

Box 4-2: Case of a JU: SESAR JU[63] [64] [65]

SESAR JU

A significant increase in the frequency of delayed flights in the late 1990s raised the need to reform European Air Traffic Management (ATM). This resulted in the creation of the Single European Sky ATM Research (SESAR) JU in 2005 from the European Union and Eurocontrol. The SESAR JU was created to guarantee the modernisation of the European ATM system by coordinating all relevant research conducted across the EU. SESAR now has 19 members which include airport operators, air navigation service providers, ground and aerospace manufacturing industry, aircraft and airborne equipment manufacturers. In the case of SESAR JU (SJU), it was observed that the policy of concentrating R&D in the SJU, reduced the opportunities for R&D in academia, which was considered unsustainable in the long term, as it would limit the availability of qualified staff for future developments. This is crucial for a project with the life span of ITER. On the other hand, SJU was very effective in organising the various tasks during the Development phase. It should be noted that SESAR Deployment is done under Connecting Europe Facility (CEF) funding programme, namely outside of SESAR JU budget.

4.3.2 *EU Agencies*

EU budget can be managed by the EC in three different ways, 1) in collaboration with national authorities, 2) directly by the EC or 3) indirectly by other authorities, either inside or outside the EU. Direct management by the EC refers to the budget of projects carried out by EC departments, EU delegations or EU Executive Agencies[66].

EU Agencies are distinct bodies from the European Institutions: they have their own legal entity and are responsible for performing specific tasks under EU law. There are different types of EU Agencies[67]:

- Decentralised Agencies: They are set up by the EU to perform technical and scientific tasks, providing EU Institutions with specialised knowledge and assisting them in decision-making and implementing policies. Decentralised Agencies operate in quite diverse conditions, since they

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[59] ANNEX to the proposal for a Council regulation on establishing the European High-Performance Computing Joint Undertaking. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:c48188c9-f6bb-11e7-b8f5-01aa75ed71a1.0001.02/DOC_2&format=PDF
[60] Establishing the Innovative Medicines Initiative 2 Joint Undertaking. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0557&from=EN
[61] Establishment of a Joint Undertaking to develop the new generation European air traffic management system (SESAR). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007R0219&from=EN
[62] Establishing the Shift2Rail Joint Undertaking. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0642&from=EN
[63] http://www.sesarju.eu/discover-sesar/history
[64] http://www.sesarju.eu/discover-sesar/partnering-smarter-aviation
[65] Final Evaluation of the SESAR Joint Undertaking (2014-2016) operating under the SESAR 1 Programme (FP7). Available at: https://ec.europa.eu/transport/sites/transport/files/final_evaluation_of_sesar1_final_report.pdf
[66] https://ec.europa.eu/info/funding-tenders/how-eu-funding-works/management-eu-funding_en
[67] https://europa.eu/european-union/about-eu/agencies_en#type_of_agencies

are set up on a case-by-case basis to respond to emerging individual policy needs[68]. Decentralised Agencies are scattered across the EU and are set up for an indefinite period of time;

- Agencies under Common Security and Defence Policy: these three Agencies are responsible for technical, scientific and management tasks related to EU's Common Security and Defence Policy[69];
- Euratom Agencies and bodies: These Agencies were created to support Euratom's member states in coordinating national nuclear research programmes for peaceful purposes, providing knowledge, infrastructure and funding for nuclear energy and ensuring sufficient, and secure supply of nuclear energy[70];
- Executive Agencies (EAs): The Commission delegates powers to the Executive Agencies for the implementation, on its behalf and under its responsibility, of all or part of Union programmes. These agencies have a limited lifetime and are responsible for coordinating and supervising specific tasks related to EU programmes. Executive agencies are typically located where the EC and its departments are located, namely Brussels and Luxembourg[71]. This means that a possible conversion of F4E to an EA, would require a transfer of the Agency either to Brussels or Luxembourg, which would result in additional expenses and a substantial delay. Furthermore, EAs can only implement grants, which makes that option unsuitable for ITER, as F4E needs to implement procurements as well. If F4E was converted to a Decentralised Agency, all MSs would have equal voting rights, which might cause unrest among members with a higher contribution.

Since the option of Executive Agencies is not a viable solution for ITER, for the rest of the analysis EU Agency will refer to the option of Decentralised Agencies.

Box 4-3: Description of a decentralised agency[72,73]

European Global Navigation Satellite Systems (GNSS) Agency

European GNSS Agency (GSA) was established on the 12th of July 2004 as a decentralised agency based in Prague, CZ. GSA is, among other tasks, responsible for the deployment and operating phases of the Galileo project. The Agency has an autonomous budget, ensuring its full autonomy and independence. Although the Galileo JU and PPP phases were problematic resulting in significant cost overruns and delays, the period 2014 – 2016 of the GSA was characterized as successful in achieving important objectives of the Galileo and EGNOS projects. For the same period, the Agency was awarded the ISO-9001 certification, indicating a quality management system.

[68] https://europa.eu/european-union/about-eu/agencies/overhaul_en
[69] https://europa.eu/european-union/about-eu/agencies_en#type_of_agencies
[70] *Idem*.
[71] Laying down the statute for executive agencies to be entrusted with certain tasks in the management of Community programmes. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32003R0058&from=EN
[72] Council regulation on the establishment of structures for the management of the European satellite radio-navigation programmes. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:246:0001:0009:EN:PDF
[73] Report from the Commission to the European Parliament and the Council on the implementation of the Galileo and EGNOS programmes and on the performance of the European GNSS Agency. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017DC0616&from=EN

4.3.3 *Intergovernmental organisation (IGO)*

An intergovernmental organisation (IGO) is created by a grouping of sovereign states (or other IGOs) in response to a decision between the parties for a specified joint effort. An IGO is usually[74] set up on the basis of a treaty signed and ratified by lawful representatives of all the member states (at least two) that seek to be part of it. The treaty renders the IGO a legal entity according to international public law, which enables the organisation to enter into agreements with other (institutional) entities[75]. Characteristically, an IGO also has congregations of the signing parties at regular intervals (normally every 4 years) to discuss performance and future ambitions of the respective IGO.

Upon signature of the treaty, a non-symbolic headquarter or secretariat is set up for the IGO. The treaty furthermore provides the governance structure of the organisation and lays down its procedural rules.

While facilitation of international cooperation lies at the heart of the organisation, the specific goal of each can take varying forms such as high-level political (e.g. United Nations), scientific (e.g. CERN), or economic (e.g. World Trade Organisation) collaboration. In science, IGOs are normally formed when the financial and political stakes of a project are comparatively large[76]. In Europe, the model has been used for the creation of CERN and ESA, two of the continent's flagship Big Science projects.

Given the complex managerial and financial challenge of, especially, Big Science projects, IGOs that are setup for Big Science purposes tend to vary significantly in how they are governed[77]. Varying degrees in bureaucratic organisation and autonomy from the signing parties can be observed[78]. Box 4-4 provides a description of how IGOs can be governed in the Big Science context, utilising the example of CERN.

[74] Informal intergovernmental organisations (not based on a treaty) do also exist (G8, G20, BRICS). However, they do not form a legal entity and can hence not engage into agreements.
[75] http://hls.harvard.edu/dept/opia/what-is-public-interest-law/public-service-practice-settings/public-international-law/intergovernmental-organizations-igos/
[76] U.S. Congress, Office of Technology Assessment, International Partnerships in Large Science Projects, OTA-BP-ETI-150 (Washington, DC: U.S. Government Printing Office, July 1995. Available at: http://ota.fas.org/reports/9527.pdf
[77] Hallonsten, O. (2014). The Politics of European Collaboration in Big Science. **Chapter taken from:** Mayer, M. et al. (2014). The Global Politics of Science and Technology – Vol. 2. *Springer-Verlag Berlin Heidelberg*. Available at: https://link.springer.com/chapter/10.1007/978-3-642-55010-2_3
[78] Volgy, T.J. et al. (2008). Identifying Formal Intergovernmental Organizations. *Journal of Peace Research*. Available at: http://journals.sagepub.com/doi/pdf/10.1177/0022343308096159

Box 4-4: Case of a Big Science IGO: CERN[79]

CERN

The CERN convention established the Council as the highest decision-making entity of the organisation. It is made up of two representatives (a government representative and a national scientist) of each member state to the convention. The Council is responsible for oversight of all administrative proceedings but also functions as the final authority on scientific programming and financial planning, such as budget adoption and expenditure review.

The Council meets four times a year under the chairmanship of the President, with the Director-General acting as Secretary. The Director-General manages the daily business of CERN and is assisted by a directorate.

The Council and DG are supported in their activities by two subsidiary bodies:

- the *Scientific Policy Committee* makes recommendations to the Council on CERN's scientific programme;
- the *Finance Committee* is composed of representatives from national administrations and supports the Council in issues concerning MS contributions and the budget.

CERN is further split into 10 different departments ranging from *Experimental Physics* to *Human Resources*.

ITER, as a global project, is established according to an international agreement which created the ITER Organisation as the IGO managing the endeavour. The contribution of the 29 European signatories[80] to the ITER agreement, however, is currently provided via a Joint Undertaking (F4E) created by a European IGO (Euratom[81] - which has all the 29 signatories as members). The European contribution could, in practice, be provided directly by Euratom, granted that the origin of funds is shifted from the EU MFF (current setup) to a 'pooled funding' delivery mechanism[82].

Instigating this change to the current delivery mechanism and legal setup would bring significant legal implications, such as:

- An amendment to the ITER agreement which will require all parties to Euratom to sign the treaty individually (and all the other non-European signatories to agree to this measure);
- Negotiations on, and establishment of, the new split of contributions among Euratom member states;
- If Euratom was not used as the intermediary IGO acting as domestic agency (DA) delivering the funding to the IO, then:
  - Negotiations of MS partnership for novel IGO and new split of contributions;
  - Set up of novel IGO in terms of governance and procedures.

[79] Convention for the Establishment of a European Organization for Nuclear Research (as amended on 17 January 1971). https://council.web.cern.ch/en/content/convention-establishment-european-organization-nuclear-research
[80] Via Euratom which includes: EU-28 + Switzerland.
[81] Represented in the F4E agreement by the European Commission.
[82] Since legally it would not make much sense to provide the funding from the MFF into a (hypothetical) IGO, which is then redirected to another IGO (ITER Organisation).

Either way, the contributions from outside Europe will have to continue to match, in size, the commitments made by Europe in the original agreement. Otherwise, penalties will apply for Euratom[83].

4.3.4 Private company

A popular legal setup for user-oriented Big Science projects is a private company (if the delivery mechanism is 'pooled funding'). In this approach the partners to the treaty act as shareholders in e.g. a *société civile* in the case of France or a *Gesellschaft mit beschränkter Haftung (GmbH)* in Germany.

These private company setups are used in neutron sources that are intensively used by industry and academia like the ILL (France) and the ESS (Sweden) or x-ray facilities like the ESRF (France) and the XFEL (Germany).

However, given that ITER is not meant to be user-oriented Big Science infrastructure, it does not make much sense to consider this legal setup as a valid option.

4.3.5 European Research Infrastructure Consortium (ERIC)

A European Research Infrastructure Consortium (ERIC) is a specific legal form to ease the establishment and operation of research infrastructures with European interest. The primary mission of ERICs is to establish and operate new or existing research facilities on a non-economic basis. An ERIC can only carry out limited economic activities related to its tasks as long as they are closely related to its primary mission[84]. However, it should keep track of revenues and expenditures of its economic activities. An ERIC should not be considered as a Community body, and as such, the community is not necessarily a member of the ERIC and it does not make any financial contribution to it. In order for establishing a research infrastructure as an ERIC, it must meet the following criteria[85]:

- It is essential for accomplishing European research programmes and projects;
- It provides added value to the European Research Area (ERA);
- Access is granted to the whole European research community consisting of researchers both from MSs and associated countries;
- It contributes to the spread of knowledge and mobility of researchers across the ERA and increases the use the intellectual potential across Europe;
- It contributes to the dissemination and optimisation of the results of Community research.

The application for the formation of ERIC should be submitted to the EC by the organisations/institutes intending to form the ERIC, including a technical and scientific description of the research infrastructure to be established and operated by the ERIC. The application will be evaluated by independent experts assigned by the EC. Although members of an ERIC can be MSs, associated countries, third countries and intergovernmental organisations, it is mandatory to have at least three MSs as members. ERIC's budget should include all revenue and expenses and should be in balance. An ERIC is responsible for submitting an annual activity report, comprising of the scientific, operational and financial aspects of its activity.

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[83] Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project. Available at: https://www.iter.org/doc/www/content/com/Lists/WebText_2014/Attachments/245/ITERAgreement.pdf

[84] https://ec.europa.eu/research/infrastructures/index.cfm?pg=eric

[85] Council regulation on the Community legal framework for a European Research Infrastructure Consortium (ERIC). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009R0723&from=EN

Since the EC cannot financially support an ERIC, the option of ERIC was not considered further as the scope of an ERIC is not applicable to the ITER case and the setup is very similar to an IGO.

4.3.6 F4E JU - Current status

F4E was set up as the European Joint Undertaking responsible for managing the EU contribution to the ITER project in March 2007. F4E was established as a JU due to its fundamental importance in exploiting fusion as a limitless, safe and sustainable energy, as suggested by Chapter 5 of the consolidated Euratom Treaty[86]. Although there is no geographical restriction for JUs, to date all JUs have been based either in Brussels or Luxembourg. F4E is the first JU to be established outside the EC headquarter cities, similar to a Decentralised Agency[87].

Based on the current statutes of F4E, it cannot have private stakeholders, as F4E only has the following members[88]:

- Euratom (represented by the EC);
- MSs of Euratom;
- Third countries which have come to an agreement with Euratom in the field of controlled nuclear fusion.

F4E also supports fusion R&D initiatives through the Broader Approach Agreement between Euratom and Japan. The purpose of this agreement is the preparation for the construction of demonstration fusion reactors (DEMO)[89]. F4E has the possibility of managing procurement contracts related to the ITER IO.

F4E is the only JU that cannot have private stakeholders and the only one located away from Brussels and Luxembourg. This resembles the GSA which is responsible for the Galileo project. Since F4E cannot have private stakeholders, an amendment in the statutes of F4E would be required in order to permit private stakeholder participation or a transformation to a PPP, similar to the Galileo PPP.

[86] The Euratom Treaty, consolidated version. Available at: http://www.consilium.europa.eu/media/29775/qc0115106enn.pdf
[87] https://europa.eu/european-union/about-eu/agencies_en#type_of_agencies
[88] Council Decision on establishing the European Joint Undertaking for ITER and the Development of Fusion Energy and conferring advantages upon it. Available at: http://www.fusionforenergy.europa.eu/downloads/aboutf4e/l_09020070330en00580072.pdf
[89] https://europa.eu/european-union/about-eu/agencies/fusion-for-energy_en

4.4 Analysis of the pros and cons of each delivery mechanism and legal option

This section, with the help of Table 4-4, provides a first assessment of the ITER-specific advantages and disadvantages of the respective delivery mechanisms and legal forms discussed in sections 4.2 and 4.3. The table also provides some crucial first building blocks for the analysis in chapter 5 of the effect the numerous options have on relevant indicators.

Table 4-4: Analysis of pros and cons for different delivery mechanisms

Delivery Mechanism / Legal Form	Advantages	Disadvantages
	Delivery Mechanisms	
Business as Usual (separate MFF programme)	• Makes ITER a political priority – increases awareness; • Provides strict budgetary control that can keep management of funding in line – important given the problems the ITER project faced in the past; • Provides stability to F4E knowing that financing comes in a separate programme; • Easier for F4E to manage cost overruns; • Easier for internal Commission budget monitoring and management; • Provides direct accountability; • Does not allow for a direct competition for funds between ITER and other purely scientific research programmes; • Allows F4E to manage its own spending plans more easily.	• Having MFF programme, reduces flexibility and does not allow for a larger amount of contingency planning of funds for a big, complex, and uncertain project like ITER; • Reduces potential research synergies between nuclear fusion projects like ITER and Euratom, as well as other scientific programmes; • Could cause delays due to the inherent internal political battles in the European Council and Parliament.
Wider Program (within or outside of MFF)	• Budgetary supervision still strict enough to keep ITER developments in check (within-MFF); • Allows for stronger synergies between ITER and other research projects and programmes in the field of nuclear research; • Strengthens the status of ITER as a scientific and research project and not as an energy generating technology.	• Reduces the operational flexibility of funding for ITER; • Puts ITER in direct competition with other wider programme part(s); • Allows for a possibility where, due to cost overruns, ITER ends up absorbing funds foreseen for other scientific programmes; • Increases the risk that other parts of a wider programme could have their budgets reduced due to the needs of ITER; • Allows for frictions to occur between ITER and other parts of the wider programme, all fighting for the same limited resources; • Increases visibility of cost overruns since every call for additional funds is reducing the funds available for smaller programs and can invoke doubts in MEPs and Member States about the need and cost of the entire ITER project.
Pooled contributions of individual MS	• Allows individual European countries to choose whether they want to	• Implementation could require a possibly lengthy and costly process to

Delivery Mechanism / Legal Form	Advantages	Disadvantages
	support fusion and, if so, to what extent - not 'forced' into participation; • If national interest is strong for a specific partner (or a group of partners) - could spark more European investment than under an MFF programme; • Highly flexible and allows for the development of an *ad hoc* legal and financial setup tailored to the specific needs of European ITER contributions; • Very mature system (i.e. pre-treaty communication) that is known and respected internationally.	amend and re-negotiate the ITER agreement and the Council Decision setting up F4E; • If only richer European countries decide to fund, in-kind contributions setup of the IO could lead to concentration of industry involvement in those richer countries and work against European cohesion efforts; • Budget amount is continuously at the mercy of political or financial quarrels between the member states (e.g. stemming from discussion about effort/benefit ration, fair return, relevance of fusion etc.); • The lack of a common legal EU framework on Big Science can lead to an inefficient innovation system if the project is not managed by the EU itself (e.g. replication of- and competition between fusion projects).
Legal Forms		
PPP/JU	• Introduction of private sector's technology, innovation and managerial expertise; • Incentivises the private sector to deliver projects on time and within budget; • Possibility of combining EU budget with other sources of public and private funding; • Budgetary certainty by allocating present and future costs utility/service over time; • Development of leadership and managerial skills by public utility/service stuff collaborating with private sector stakeholders; • Enhancing limited public-sector capability to deliver infrastructure facilities by its own; • Achieving long-term VfM when appropriately allocating risks to private sector stakeholders who have the know-how to handle that risks throughout the life of the project; • Recognised as international body (exclusion from VAT and excise duties.	• No potential financial benefits for private investors in the near future; • Lifetime of the project too long for private investors to be willing to bear the related risks and contingencies; • There is a limit to the risk the private stakeholders are willing to bear, increased risks will be reflected on their price for the service provided and higher control over operation will be requested. Furthermore, if a risk is allocated to a private contractor that cannot handle that particular risk, the VfM is reduced; • Issues with the protection of IPR may arise; • Creating a proper legal and regulatory framework make require more than a year of preparation, which would result in significant delays compared to continuing with the current form; • Concentrating R&D in a JU may result in reducing the opportunities for R&D in academia, which is considered unsustainable in the long term, as it would limit the availability of qualified staff for future developments. This is crucial for a project with the life span of ITER; • In many cases the public authority is still considered accountable for the quality of the service provided although it is a private responsibility; • Due to long-term life and complexity of this project, it is impossible to

Delivery Mechanism / Legal Form	Advantages	Disadvantages
		identify all possible contingencies during the design phase, and a renegotiation between the stakeholders might be required during the process of the project. There are also cases of projects getting cancelled due to unpredicted changes or issues occurring during the project.
EU Agency	• Lifetime independent of MFF duration; • EA budget available is defined in advance. Afterwards, the EA must make an annual budget report. That would increase flexibility compared to current status; • One interlocutor in budget negotiations (EC). Less vulnerable to political stability due to not discussing budget issues with the Council and the EP.	• Increased contingencies by having to predict in advance the budget for the whole project. In that way there is a high probability of miscalculation and high cost overruns that would require renegotiation during the execution of the project.
Intergovernmental Organisation (IGO)[90]	• Less centralised governance of budget – easier to deal with uncertain nature of ITER procurement; • Has the same legal status as the EU (IGO set up by MS) but is dedicated directly to the purpose – eliminates one step in the funding flow and allows for efficiency gains; • Lack of a common legal EU framework for Big Science increases efficiency and fosters dynamism of the IGO (less bureaucracy, no institutional inertia). It can be free in the way it sets up its governance. This is crucial for a delay-prone project like ITER; • Can be given more autonomy than an entity managed by the EC – this can lead to less procedural and financial bottlenecks in the European contribution to ITER.	• Requires 'pooled funding' delivery mechanism – would hence lead to a radical change in the way the European contribution to ITER is provided *and* governed.
Private company	Not applicable to ITER, as this legal setup rather suits user-oriented Big Science.	

[90] Only matches with a 'pooled contributions' delivery mechanism and hence also incorporates all pros and cons from it.

5 Assessment of the Impacts of the Scenarios, Delivery Mechanisms and Legal Forms

Key findings

• Thorough quantitative and qualitative assessment of all the scenarios, delivery mechanisms and legal forms has been carried out. For some indicators, economic modelling was used to assess the quantitative effects of the scenarios.
• Attention was given to assessing the impact of options on jobs, growth, spill-overs, effectiveness, EU added-value, value-for-money, risk mitigation, simplification and flexibility.
• The results reveal, amongst other things, that:
  o The delivery mechanisms of the MFF program have a small impact on jobs created.
  o In terms of growth, the economic modelling suggests that both the FNB and NoC scenarios have a much more positive impact on industry output and overall GVA than the other scenarios.
  o In terms of value-for-money, ITER costs are mainly driven by the budget that is requested to deliver the objectives, as well as necessary administrative costs. A pooled MS contributions delivery mechanism holds the biggest risk for delays, which could increase total costs and reduce the benefits of the entire ITER project.
  o A dedicated program in the MFF provides higher stability of the available budget than a wider program.
• Qualitative assessment of delivery mechanism pairings with the legal forms lead to the following changes in indicators:
  o A change to the legal setup will most likely worsen effectiveness, EU added-value, and value-for-money indicators, as this change would disrupt ITER's sensitive schedule even further.
  o Opting for a standard JU or an IGO (in case of a pooled MS contributions delivery mechanism) could, in fact, improve those same indicators in the medium- to long-term. However, it is unlikely that the tight ITER schedule and political circumstance will provide the necessary leeway to wait for those effects to crystallize.
  o Advantages and disadvantages of these pairings are summarized in a SWOT analysis at the end of section 5.3.
• Section 5.4. provides a comprehensive overview (Table 5-3 and subsequent text) of the consolidated effect that combinations of scenarios and delivery mechanism/legal form pairings have on the specific indicators.

5.1 Introduction

The following sections present an assessment of the impacts of different budgetary, delivery, and governance scenarios for the European contribution to ITER. This is done by qualitative and quantitative assessment and consideration of the impacts of the scenarios on a number of ITER-relevant indicators. The scenarios include the delivery mechanisms and legal forms discussed in chapter 4. The sub sections of this chapter and the scenarios and analysis they include are as follows:

- **5.2**: Contains a quantitative and qualitative analysis of a set of financial scenario and potential delivery mechanism combinations, plus some standalone qualitative analysis of the delivery mechanisms;
- **5.3**: Contains a qualitative analysis of the legal forms in combination with the delivery mechanisms;
- **5.4**: Brings 5.2 and 5.3 together to rank the combinations of financial scenarios, delivery mechanisms and legal forms according to their impact on the indicators.

The different scenarios and indicators, as well as the fundamentals of the methodology, are briefly presented below.

5.1.1 Quantitative scenarios

The consequences of various levels of F4E contributions to the ITER project after 2020 were analysed. Part of the analysis includes quantitative modelling of five scenarios, each based on an alternative funding level, and each compared to the Business as Usual (BAU) case. This quantitative modelling is used to assess the impact of each scenario on jobs, growth and possible spill-overs of the ITER investment programme. Table 5-1 below provides details of the funding levels in each scenario, under five, seven and ten-year MFF durations.

Table 5-1: Quantitative scenario details

Scenario name	Details	Values (in current prices)
Business as Usual (BAU)	Assumes the same level of funding as the budget within the current MFF	€0.42bn annually 2020-2025 + potentially €0.42 annually 2026-2027 €0.42 annually 2028-2030
Full New Baseline (FNB)	Based on the new ITER baseline including a 15% contingency fund	€1.046bn annually 2020-2025 + potentially €0.874bn annually 2026-2027 €0.368bn annually 2028-2030
New Baseline, No Contingency (NoC)	Based on the new ITER baseline but with no contingency fund	€0.91bn annually 2020-2025 + potentially €0.76bn annually 2026-2027 €0.32bn annually 2028-2030
Post-Brexit Reference (PBR)	Same proportion of ITER funding within the MFF as at present, while assuming the UK's departure leads to a 15% reduction in the EU budget	€0.36bn annually 2020-2025 + potentially €0.36 annually 2026-2027 €0.36 annually 2028-2030
30% Reduction (30R)	Assumes a 30% reduction in funding compared to the budget in the current MFF. This includes a 15% reduction following Brexit and the UK's subsequent departure plus an additional 15% reduction in the budget.	€0.30bn annually 2020-2025 + potentially €0.30bn annually 2026-2027 €0.30bn annually 2028-2030
EU Exit (EUX)	Assumes that the EU withdraws from the ITER project and no further contributions are made	No further investment

The modelling further assesses two different delivery mechanisms in combination with the financial scenarios: a direct MFF program and pooled MS contributions[91]. Annex B provides a detailed explanation of the key features of each scenario and the modelling methodology used.

[91] Modelling the 'Under a wider MFF program' delivery mechanism in combination with the scenarios was not possible with E3ME.

5.1.2 Indicators

The following indicators are important measures of the impact of the scenarios presented in sections 5.2 and 5.3. A broad range of possible effects is covered, which are relevant for ITER on an economic, social and political scale. The impacts are listed and briefly described below:

- Jobs – refers to the amount of employment that the option creates and in which sectors;
- Growth – refers to the sectoral output, GVA, and SMEs created by each option;
- Synergies/spill-overs – refer to positive collateral impact in sectors due to EU spending on ITER. This is assessed in the form of spin-offs, synergies outside fusion, new cutting-edge technology, as well as the instance of partnerships and networking for industry in and outside of Europe;
- Effectiveness – closely linked to ability to deliver - refers to how well the option delivers the objectives of EU participation, namely, the continuation of ITER towards First Plasma and beyond, in line with (or a close as possible to) the projected budget and timings, the provision and disbursement of funding, the value added to EU industry (spin off products, jobs and turnover, innovative capacity) and EU leadership;
- EU added value – the strict definition of this relates to the benefits of EU level action as opposed to MS level action. However, if the case for this is accepted, (centring on the scale and nature of ITER being too large and too long term for MSs to consider acting alone, and the benefits of fusion as an energy source potentially benefitting all EU MSs (and other countries)), then the nature of this changes somewhat. In this context the EU added value is closely linked to effectiveness in that it centres on the value added to EU industry (spin off products, jobs, turnover, innovative capacity);
- Value for money – this is basically a comparison of the costs with the benefits. The costs include both the main expenditure to support the design, manufacture of components and construction, and the administrative costs associated with arranging and managing this expenditure. The benefits include the jobs and turnover associated with the expenditure and also the benefits associated with developing and supporting innovative capacity and the pollical benefits of EU leadership;
- Risk mitigation – refers to the technical, organisational, political, and scientific risks associated with the options;
- Simplification – refers to differences in administrative cost and complementarities of options;
- Flexibility - refers to the level of ability to adjust funding annually, as the project is making progress, e.g. in order to respond to new problems occurring during the lifetime of a single MFF programme. Increased flexibility means higher capability to handle contingencies during the construction of ITER. Flexibility as an indicator is more vulnerable to changes in the delivery mechanism or the legal form, rather than the level of funding;
- Other impacts – Withdrawal of parties – refers to the impacts if one or more parties withdraw from the ITER agreement;
- Other impacts - Duration of the MFF – refers on one hand to both the practicality of the option and the influence it has on the ultimate delivery / progress and on the other hand to the number of years of the MFF.

5.1.3 Methodology

The methodology for the assessment of impacts in the following sub-sections is twofold. For most of the indicators, a qualitative approach is employed based on literature and stakeholder interviews. For several indicators, the scenarios are also modelled quantitatively (and in combination with delivery mechanisms) via the E3ME model.

- **5.2.** provides an assessment at different levels of the impact of delivery mechanisms and scenarios on the selected indicators:
  - The first three indicators (jobs, growth, synergies) are assessed both quantitatively via E3ME[92] and in combination (delivery mechanism + scenario);
  - This is different for the next three indicators (effectiveness, EU added-value, value-for-money) where the impacts on indicators of delivery mechanisms and scenarios are assessed qualitatively and in isolation;
  - Last but not least, the final three indicators (risk mitigation, simplification, flexibility) only concern the delivery mechanisms and are only assessed qualitatively and in isolation for the delivery mechanisms (scenarios are not assessed for these);
  - This section will also assess the likely impacts of one of the members to the ITER agreement leaving the project. (Focus is on the USA and/or India withdrawing);
  - The impact of the MFF duration is also considered.

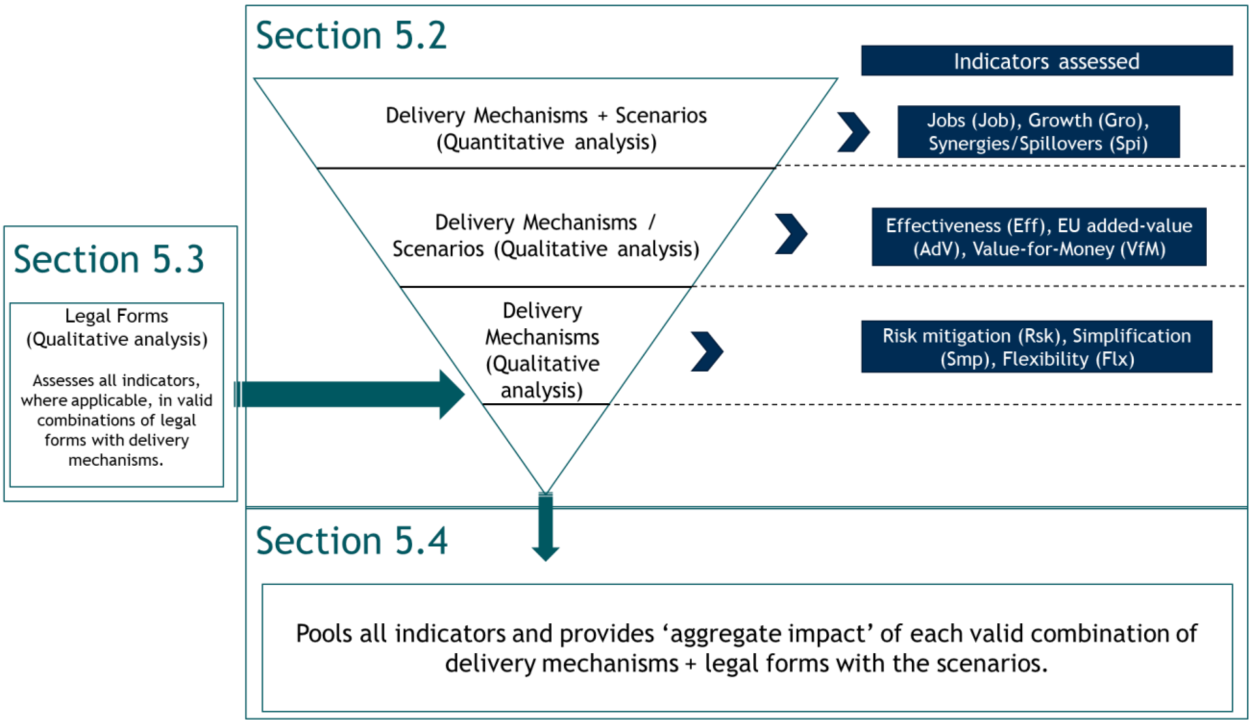
- **5.3.** Provides analysis of **additional isolated impacts** (with no scenarios involved) for combinations of delivery mechanisms and legal forms. It is therefore an **intermediate step** that is necessary to set the scene for the following section (i.e. how do the isolated effects of delivery mechanisms on indicators change under specific legal forms?).
  - The final outcome of this section is a SWOT analysing the four most likely combinations of delivery mechanisms and legal forms.

- **5.4. Combines the indicators together** for each combination of delivery mechanism + legal form pairs and the scenarios, and hence assesses and compares the **aggregate impact** of each of these combinations. A further added value of this section will be to take the impacts on indicators we have assessed in previous sections in isolation and see how they would pan out in combination.
  - The centerpiece of this section is an impact overview table sourcing information from 5.2. and the SWOT in 5.3.

Figure 5-1 below provides a visual aid to explain how the assessment is structured.

[92] The key outputs from the E3ME modelling assessment include the impact upon jobs, growth, and the impact of possible spill-overs of the ITER investment programme. Results are presented as charts for EU28 totals for the period 2020-2030 (reflecting the various options for the length of the post-2020 MFF). For more detailed, disaggregated results by sector please refer to Annex B. In each quantitative subsection below solely, the gross impacts of the scenarios were considered. Analysis of the net impacts, assessing a situation where the funds for ITER were to be invested into an alternative program instead, is not presented. This was excluded because there is no obvious alternative that would deliver the same mix of benefits as the ITER investment (i.e. the progress in fusion research, the benefits of encouraging innovation in companies, and political leadership).

Figure 5-1: Diagram to visualise the assessment logic guiding the methodology



5.2 Assessment of impacts: Scenarios and Delivery mechanisms

In the following sub-sections, each indicator mentioned in Chapter 5.1. is quantitatively or qualitatively assessed according to the impact of the implementation of different (combinations of) delivery mechanisms and budgeting scenarios for the European contribution to ITER.

5.2.1 *Jobs*

Under an MFF program

Figure 5-2 shows the gross impact on employment for the EU28, of each scenario under an MFF programme delivery mechanism (both direct programme and wider programme). The gross employment impact of each funding scenario depends on whether that particular scenario leads to a greater level of available funding post-2020 compared to the BAU case, or whether the available funding is less, i.e. a greater level of funding leads to a greater level of overall employment. The overall gross impacts on employment are very small, so the results are presented as absolute differences from the baseline.

In the FNB and NoC scenarios under both the five-year and seven-year duration possibilities, the level of funding available for ITER-related investments is higher than under the BAU case. This leads to an overall increase in employment of between 1,200 and 3,000 jobs per year over the period 2020-2027, depending on the level of funding. The majority of this increase in employment occurs in the business services sector (which includes sectors such as legal and accounting services, architects etc.), broad industry sector (which includes sectors such as mechanical and electrical engineering), construction and non-business services sectors, because the majority of ITER-related investments relate to these sectors either directly or through supply chains.

Although overall employment increases the most in the business services sector, the construction and industry sectors are the biggest *direct* beneficiaries in terms of employment. The increase in employment in the business services sector is a combination of both direct, indirect and induced impacts. The sectors within business services play an important part in ITER-related activities (and so therefore there are direct increases in employment as a result of ITER investment), but these sectors also feature in the supply chains to other sectors that benefit from ITER investment, such as manufacturing, so there is also an indirect impact on employment. Finally, an increase in employment within the economy in general will lead to greater incomes and household expenditure, in turn creating more jobs in business services sectors (an induced effect).

Towards the end of the period, if the MFF is considered to be of 10-year duration, the change in employment becomes much smaller and then negative in the FNB and NoC scenarios compared to BAU. This is because the level of funding is lower than would be the case under the BAU option. However, this reduction is small - between 200 and 500 jobs each year across the EU28, with the majority of these jobs being lost directly in those sectors that usually benefit most from ITER-related investment, namely industry, construction and business services and non-business services.

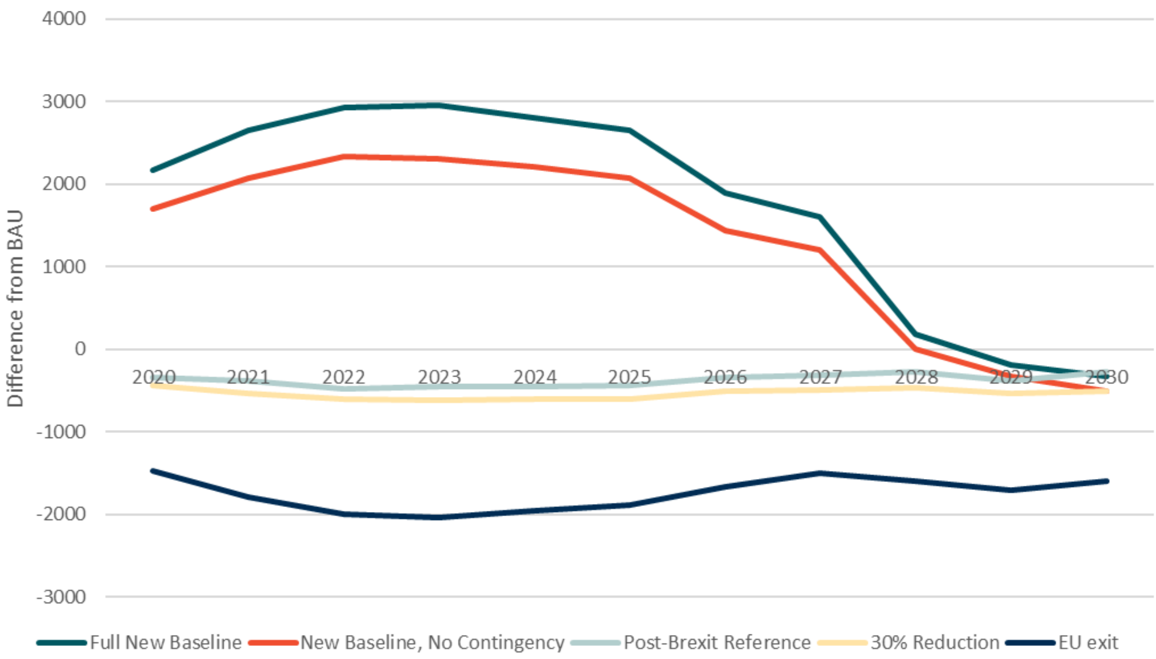
In the PBR and 30R scenarios the overall EU budget is reduced by 15% and 30% respectively. While the proportion of ITER funding remains the same within the budget, the overall level of funding available for ITER-related investments over the period 2020-2030 is lower than in the BAU case. In the examined scenarios, only the available funding for ITER have been reduced (rather than the whole EU budget) so that impacts on jobs and growth that are specific to reduced funding for ITER-related activities could be singled out. Employment declines because of the reduction in available funds for ITER investment, with this impact remaining steady over the period since the difference in the level of funding compared to BAU remains constant. In the PBR scenario the annual reduction in employment is between 300 and 500 jobs over the period 2020-2030, while in the 30R scenario this is slightly higher, with around an additional 100 jobs being lost each year compared to the PBR case.

In the PBR and 30R scenarios the sectors that usually benefit from ITER-related investments are the most affected by the reductions in available funds – construction, business services, non-business services and industry. In these scenarios a large proportion of jobs lost are in the business services and industry sectors. The business services sector typically pays higher wages than other sectors. This leads to a greater knock-on effect on employment due to the induced effects of lower household income and reduced consumption. The industry sector supplies a large proportion of intermediate goods to other sectors within industry itself and construction, meaning reductions in output in those sectors have negative knock-on effects in industry. For this reason, the negative indirect and induced impacts are greater in these scenarios than the negative direct impacts of lower investment. What is also interesting in these post-Brexit scenarios are the changes in employment between EU MS. While all MSs see a reduction in employment of some magnitude because of Brexit and of the subsequent reduction in ITER financing from the lower EU budget, the impacts are usually small (i.e. a reduction of between 0 and 200 jobs years over the period 2020-2030 in both scenarios). In Germany, Spain and France the impacts are larger (although still small), since these countries are the main beneficiaries of ITER investment and therefore a reduction in the financing available from the EU budget will have a greater impact. In the PBR scenario there is a reduction of around 200 to 1,000 job years in these countries between 2020 and 2030. In the 30R scenario this is higher, around 325 to 2,000 job years may be lost. Unsurprisingly, in the UK the impacts are greater (although still small), with 500-1,000 fewer jobs years created in both scenarios over the period 2020-2030.

In the EUX scenario, the EU completely withdraws from the ITER project and no further contributions are made. It was assumed that the levels of investment that are lost under this scenario match the funding levels in the BAU case. This leads to around 1,500 to 2,000 fewer jobs per annum throughout the period 2020-2030. This reduction in the number of jobs remains steady over the period due to the assumption that the same level of investment is lost each year (i.e. €0.42bn as per the BAU case). Once again, the sectors that produce the goods and services required by ITER-related projects are those that lose the most jobs under this scenario – business services, non-business services, industry and construction. The direct impacts of the EU withdrawal from the ITER programme are smaller than the indirect impacts. A large proportion of job losses are in the business services sector, which typically pays higher wages than other sectors, leading to negative induced impacts on employment. There are also relatively large reductions in employment in construction and industry, leading to further indirect knock-on effects on employment through associated supply chains, since these sectors use lots of intermediate inputs.

To summarise, the employment results suggest that the ITER project has a small, but positive effect on employment across the EU28 in terms of the gross impact and added benefit. The greater the level of funding compared to the BAU case, the greater the employment outcome, and similarly, reductions in funding have a negative knock-on impact on jobs.

Figure 5-2: EU28 impact on employment



Sources: E3ME, Cambridge Econometrics.

Pooled MS contributions

The scenarios assessed using the E3ME model in this section implicitly assume a 'business as usual' delivery mechanism, i.e. the financing of EU participation in ITER is delivered through a dedicated programme in the MFF and that this financing is executed through an EU agency such as F4E. In this section the assessment considers the impacts of an alternative delivery mechanism in which the financing of EU participation in ITER is through a dedicated intergovernmental arrangement between EU MS, who pool their contributions into one fund. The intergovernmental agreement case is modelled as a shift in the relevant contributions at a national level, to reflect that contributions to ITER would come from specific MS according to their share of the EU budget, rather than evenly across all States (as is the case when the funding is secured through the MFF).

Due to the way this alternative delivery mechanism is modelled, the gross impacts of each scenario would be no different from the gross impacts of the business as usual delivery mechanism. This is because the only differences are differences in national government debts, which are exogenous to the other economic linkages within E3ME. There is therefore no macroeconomic impact of additional government debt. For this reason, in this section we consider only the net impacts of the ITER project, that is, what is the added benefit of investment in the ITER project rather than a more general investment programme[93]. Conversely to the gross impacts of this delivery mechanism, the net impacts are calculated differently and show quite different results to the business as usual delivery mechanism. In the intergovernmental agreement case, the amount of investment in each MS is calculated by taking the total ITER investment for the EU and sharing this out by each MS's share of contributions to the EU budget (whereas when we assume a business as usual delivery, this is determined by the shares of projected total investment each EU MS is expected to receive, as developed in the ITER VfM study[94]).

In this subsection we consider the net impacts of this alternative delivery mechanism for each of the five scenarios and make comparisons with the results of the business as usual delivery mechanism. In general, the results suggest that across all funding scenarios the impacts on growth are quite similar for both delivery mechanisms. However, the business as usual delivery mechanism leads to more positive outcomes for employment.

The differences in the employment results between delivery mechanisms are mainly driven by the way investment is shared between Member States. In the intergovernmental agreement case, some countries such as France, Spain and Italy receive a large proportion of ITER funding relative to their contribution to this part of the EU budget. The sectoral allocation of investment in these countries then has a greater impact on total EU employment results, compared to the business as usual delivery case. In France in particular, ITER investment is very focused in construction and specialised manufacturing sectors, and less so in the labour-intensive service sectors. There is also evidence of lagged effects in the employment results in France, with employment catching up with growth impacts towards the end of the period. In summary, although output and GVA results are very similar across the different delivery mechanisms, the relative labour-intensities of the sectors that receive the most investment in certain MS, and specific labour market characteristics (such as lagged effects) have a greater overall impact in the intergovernmental agreement case.

Across all scenarios, when we consider an intergovernmental agreement approach, the net employment impacts are small and, in many cases, ambiguous. Overall, the business as usual delivery mechanism produces more favourable employment impacts, suggesting this method of delivery is a better financing option in terms of job creation.

[93] For a more detailed description of the modelling methodology, please refer to Annex B.
[94] *Ref. Ares (2017) 1939420ENER/D4/2017-458*

5.2.2 Growth

Under an MFF program

In order to assess the growth impacts of ITER related investment, gross value added (GVA) by sector, industrial output by sector and the number of additional SMEs in each sector that could be attributed to the ITER investment programme were considered.

GVA is similar in concept to GDP but may be applied at a sectoral level. GVA comprises labour, profits and production taxes; it does not include intermediate purchases of inputs to production. Figure 5-3 below shows the gross impact on GVA for the EU28 as a whole under each scenario. As with the gross employment impacts, the overall impact on GVA is small, so results are presented as absolute differences from the BAU case.

Figure 5-4 below presents the gross sectoral and overall impacts on industry output under each of the various scenarios under an MFF program delivery mechanism (both direct and wider program). These results provide another indication of changes in economic activity that result from ITER-related investments. The difference between output and GVA is that output is a gross measure that includes intermediate material inputs, whereas GVA consists only of labour costs and profits. It was therefore expected to see larger absolute changes in output, particularly in the industry sector where intermediate purchases make up a larger share of costs. The pattern in the output results broadly follow the patterns seen above for employment and GVA, i.e. for each scenario, in the years that include a lower level of funding compared to the BAU case, output is lower and vice versa.

Finally, the impact of each scenario on the number of SMEs in the sectors in which ITER investment takes place, over the period 2020-2030 was considered. This allows us to draw some conclusions about the development and growth of the sectors that directly benefit from the investment, and what the future implications may be. Although the number of SMEs is not a standard E3ME model output, projections were created based on the number of SMEs in each sector in 2015[95] and applied the growth rates in value-added in each scenario to these numbers over the period 2020-2030. Each scenario is then compared to the BAU scenario results so that the additional number of SMEs that may be attributed to the ITER investment programme could be determined. Figure 5-5 below presents the gross impact for each of the funding scenarios. The difference in the number of SMEs is in line with the difference in the funding levels in each scenario compared to the BAU case, i.e. the higher the difference in the level of funding, the greater the difference in the number of SMEs will be. Naturally, the number of business start-ups is likely to be higher towards the beginning of an investment programme or ‘Big Science’ project, as new enterprises are formed to carry out new avenues of research and development and meet additional demand in each sector. Across all scenarios the largest differences in the number of SMEs can be seen in the construction, industry and business services sectors, as new enterprises are created to meet the additional output demands ITER investment places on these sectors. The number of additional SMEs (or the reduction in the number of additional SMEs) in the construction sector usually accounts for approximately half the total number of SMEs created/lost.

The model results show similar patterns in the level of GVA and output as those seen in the employment results. In the FNB and NoC scenarios the available funds for ITER-related investments are higher than the BAU case under a five and seven-year MFF durations. This leads to higher GVA and

[95] Data provided by Eurostat.

output over the period 2020-2027, particularly in the industry, construction and business services sectors, which see the greatest direct impact of ITER investment. However, if a ten-year MFF duration is considered, then between 2028 and 2030 the level of funding is lower in these scenarios compared to the BAU case, and so lower levels of GVA and output occur in these years. The difference in output in the construction industry is highest at the start of the 2020-2030 period since this is when the construction of the ITER site is expected to be in its most intense phase. With the ITER project expected to reach the First Plasma milestone in 2025, less of the investment focus will be on construction and more investment will be targeted towards industry and business services. While these sectors are also main contributors to the increase in output throughout the period, the increase in output in these sectors is more pronounced in the middle of the 2020-2030 period.

In the FNB scenario as many as 1,435 additional SMEs may exist in 2020 as a result of higher investment levels compared to the BAU case. In the NoC scenario this figure is 1,123. The number of SMEs gradually decline each year in these scenarios due to the natural reduction in new start-ups that would be seen in any investment programme, and in line with reducing levels of funding under the varying durations of the MFF.

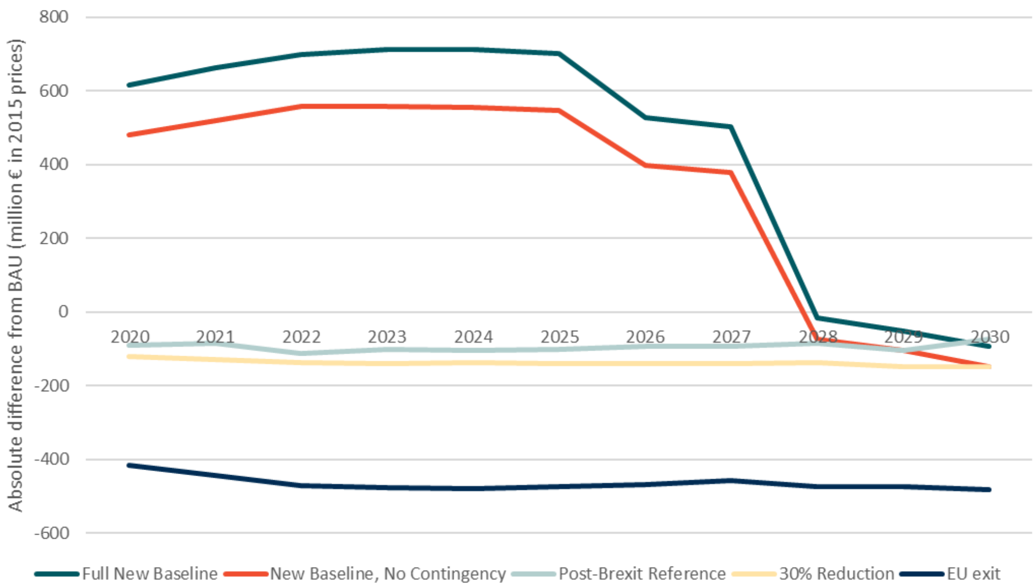
In the PBR and 30R scenarios the level of funding provided through the MFF for ITER investments is lower than that in the BAU in all years for five, seven and ten-year MFF durations. This leads to lower GVA and output across all sectors in the period 2020-2030. The negative impact on GVA and output remains fairly steady over the time period as the same, reduced level of funding is available for all years. In the PBR scenario this negative impact equates to around €75m to €110m of GVA and €170m and €265m of output lost per year while in the 30R scenario this figure is between €120m and €150m for GVA and €300m and €360m for output. Once again, the reduction in construction output is greater in the first half of the period, after which reductions in industry and business services become more prominent. Unsurprisingly the UK experiences some of the largest reductions in GVA and output in these scenarios, since it is assumed that the UK government no longer invests in ITER and does not spend this money elsewhere on other investments. However, France, Germany, Italy and Spain also see some relatively large reductions in GVA and output since these are the countries in which the largest proportions of ITER funding apply and the biggest shifts in sectoral output therefore occur. In the UK, annual GVA is reduced by between €30m and €55m and output is reduced by between €65m and €115m in the PBR scenario, while for France, Germany and Spain this figure is around €8m-€30m annually for GVA and €16m-€81m annually for output. In the 30R scenario the EU budget is cut further. While the impact on the UK is similar as in the PBR scenario, there are greater impacts on remaining EU MS – in France, Germany and Spain the reduction in GVA is around €13m-€57m per annum in this scenario, while output is reduced by €28m-€156m per annum.

In the PBR and 30R scenarios the results show small decreases of around 110-195 additional SMEs each year in the PBR scenario and 210-280 in the 30R scenario. However, in context these figures are extremely small and represent a percentage difference of less than or equal to -0.01% compared to the BAU each year.

In the EUX scenario the impact of the EU completely withdrawing from the ITER project and making no further contributions from its budget was considered. The overall impacts on GVA and output of this scenario are negative, with the effects remaining steady over the 2020-2030 period (around €416m-€485m in lost GVA and €1.1bn-€1.2bn in reduced output per annum). Reductions in GVA in the industry and business services sectors contribute most to the overall decline in this growth indicator, reflecting the high contribution to GVA these broad sectors could have made if they had received future ITER-related investment. When considering output, around 50% of the reduction is felt in the industry sector, followed by relatively large falls in output in the construction and business services sectors. The reduction in the number of SMEs is more pronounced in this scenario with between 630 and 970 fewer SMEs are created compared to the BAU case in each given year over the period 2020-2030.

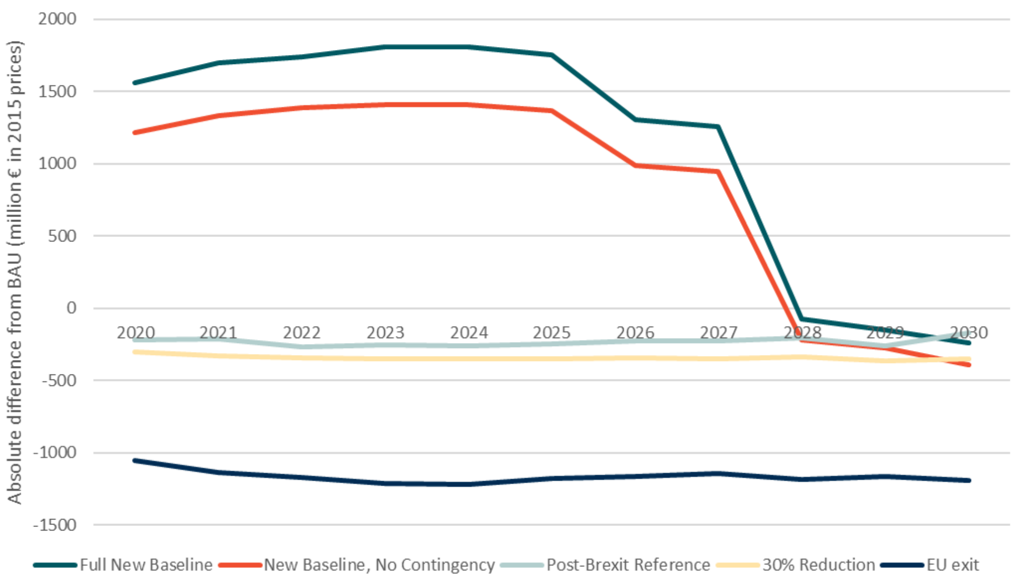
To summarise, as with the employment results, the ITER project has a small, but positive effect on growth across the EU28.

Figure 5-3: EU28 gross impact on GVA



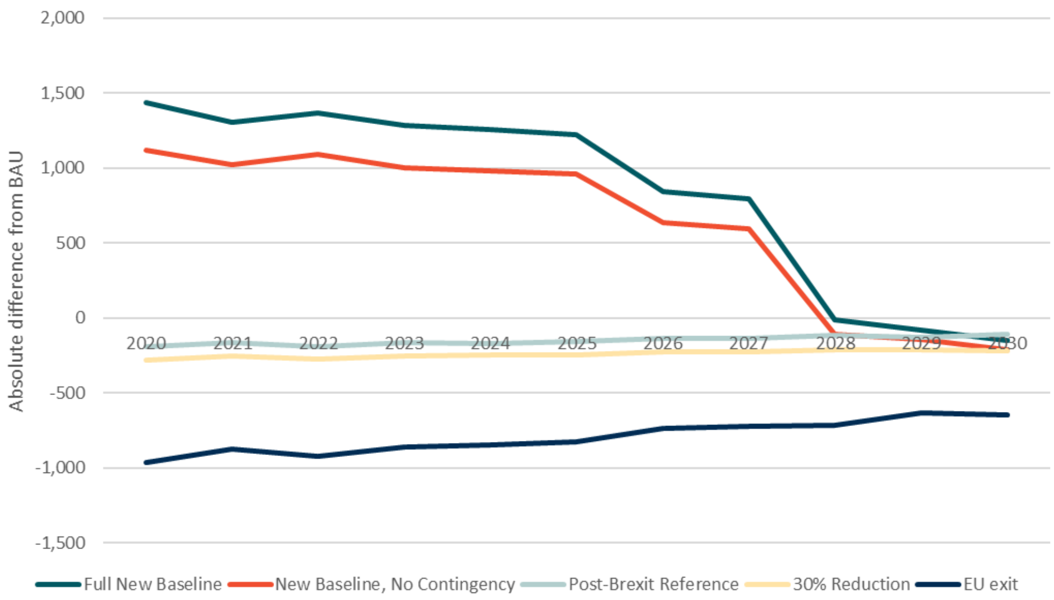
Sources: E3ME, Cambridge Econometrics.

Figure 5-4: EU28 gross impact on industry output



Sources: E3ME, Cambridge Econometrics.

Figure 5-5: EU28 gross impact on number of SMEs, absolute difference from BAU



Sources: E3ME, Cambridge Econometrics.

Pooled MS contributions

In order to assess the net growth impacts of ITER related investment, we consider gross value added (GVA) by sector. The results are very similar to the results presented under the business as usual delivery mechanism, in terms of direction and magnitude, meaning we can therefore assume the delivery mechanism used has little influence on the overall growth impacts of each funding scenario.

5.2.3 Synergies / Spill-overs

Under an MFF program

The VfM study carried out by Trinomics et al. included a comprehensive survey of European firms granted contracts by F4E for ITER-related activities[96]. Only a low number of respondents confirmed that an F4E contract had enabled them set up a company to further develop and commercialise a technology related to an F4E contract. However, the survey results did confirm that 35% of respondents had developed new cutting-edge technologies because of the ITER investment received[97]. In some cases, these technological spill-overs were fusion-related (17%), while others were non-fusion (12%). Some of the technological spin-off examples given include specific welding procedures and bonding techniques, seismic engineering that could be applied to other sectors and state-of-the-art capabilities in structural dynamics.

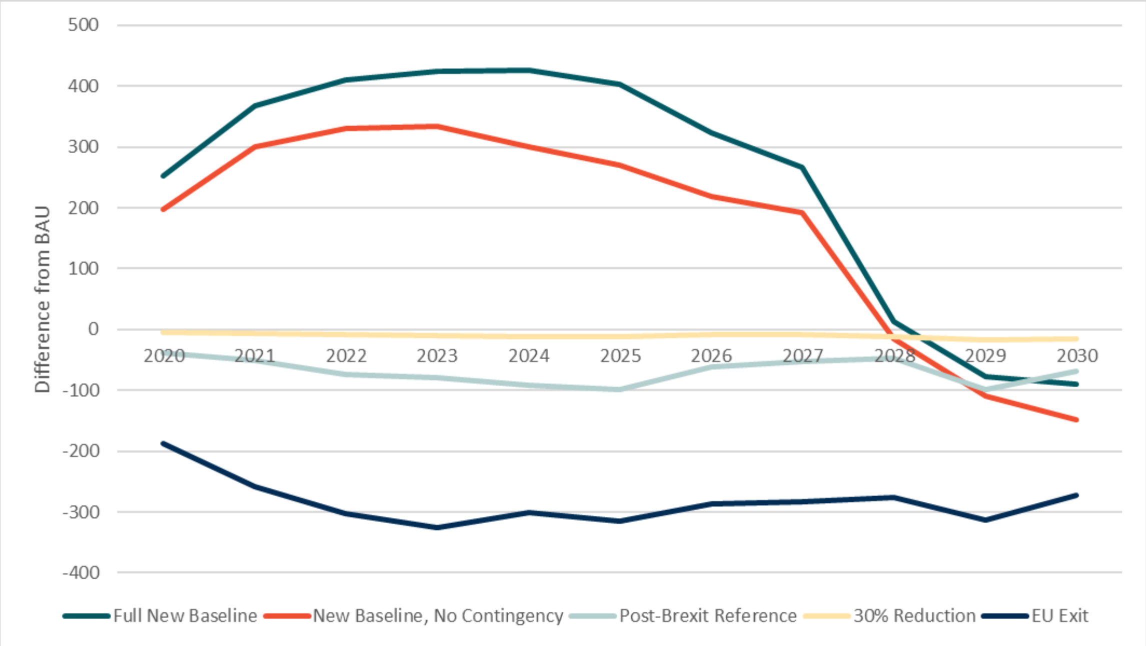
The survey did not provide a quantitative indication of the scale of these ITER investment spill-overs, but for the purposes of our modelling, figures from the survey were used to form some general assumptions that allow for the assessment of the economic impacts[98]. Figures 5-6 and 5-7 show the gross *additional impact* technological spill-overs could have on jobs and GVA in each scenario.

[96] *Ref. Ares (2017) 1939420ENER/D4/2017-458*
[97] Synergies were also built between ITER and other Big Science projects, e.g. CERN or ESA or companies which obtained technical knowledge by working on those projects building synergies with ITER and vice-versa.
[98] Please refer to Annex B: E3ME modelling methodology for more details on how the impacts of spill-overs were calculated.

In the FNB and NoC scenarios the funding levels of a five or seven-year MFF duration lead to higher GVA overall compared to the BAU case, particularly in the industry, construction and business services and non-business services sectors. Part of this increase in GVA over the period 2020-2027 can be attributed to technological spill-overs, which stimulate further investment. The gross impact of this investment includes the creation of around 200-425 jobs per year in these scenarios, as shown in Figure 5-65-6. Economic activity is increased, on top of the initial impact of the ITER funding, leading to a further annual increase in GVA of around €50m - €100m (see Figure 5-7).

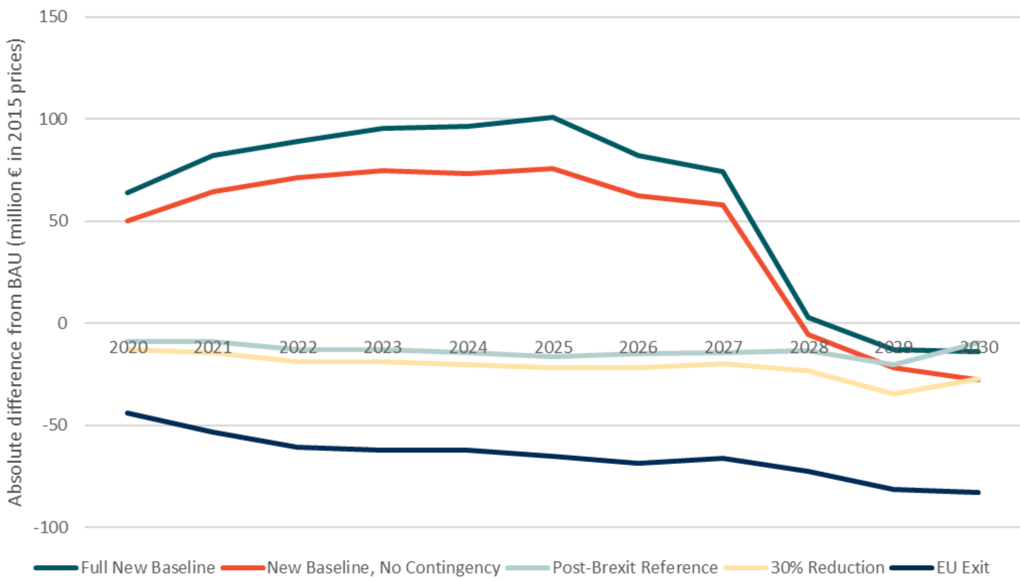
Under a ten-year MFF duration in these scenarios, between 2028 and 2030 the level of funding is lower than in the BAU case. This leads to negative impacts on jobs and GVA compared to the BAU. In these years part of the GVA lost could have been used to further develop technological spin-offs, boosting investment. The negative results shown in Figure 5-6 and Figure 5-7 for these scenarios reflect the potential job and growth increases that are lost out on under a ten-year MFF duration, i.e. potentially, a further 15-150 jobs could have been created annually.

Figure 5-6: EU28 gross impact of spill-overs on employment



Sources: E3ME, Cambridge Econometrics.

Figure 5-7: EU28 gross impact of spill-overs on GVA



Sources: E3ME, Cambridge Econometrics.

In the PBR, 30R and EUX scenarios the level of funding available each year is lower than in the BAU case, leading to lower levels of GVA. Part of this foregone GVA includes that which could have been created through spill-overs and been used to fund further investment. The potential knock-on gross impacts this further investment could have stimulated, are shown in Figure 5-6 and Figure 5-7 as negative results for these scenarios. For the EUX scenario, in which the EU withdraws from the ITER project, around 200-325 additional jobs could have been created annually due to spill-overs from the initial ITER investment These potential spill-overs could also have generated around €40m-€80m additional GVA per annum in this case.

To summarise, the positive impact of the ITER programme may in fact be greater than the results initially captured by the E3ME modelling task, presented in the sections above. The additional analysis carried out suggests that spin-offs from the investment programme could bring further employment and growth benefits.

Pooled MS contributions

As explained in Section 5.2.1, the gross impacts of each scenario would be no different if we assumed an intergovernmental agreement delivery mechanism. The additional gross impacts of potential spill-overs of the ITER project would therefore also be the same as the results presented above. However, the net impacts, which tell us what impact the ITER project spill-overs would have compared to the impacts of spill-overs of an alternative investment programme, are different between the alternative delivery mechanisms.
The results described below are very similar (albeit slightly smaller in magnitude) to the net impacts of spill-overs when we assume a business as usual delivery approach.

In the FNB and NoC scenarios the funding levels of a five or seven-year MFF duration lead to higher GVA overall compared to the BAU case and we can assume part of this increase in GVA over the period 2020-2027 can be attributed to technological spill-overs, which stimulate further investment. The net impact of this spill-over investment includes the creation of around 0-70 additional jobs per year in these scenarios and a further annual increase in GVA of around €0m - €30m. Under a ten-year MFF duration in these scenarios, between 2028 and 2030 the level of funding is lower than in the BAU case. This leads to negative impacts on jobs and GVA compared to the BAU. In these years part of the GVA lost could have been used to further develop technological spin-offs, boosting investment. Potential job and growth increases are lost out on under a ten-year MFF duration in these scenarios, but these potential losses are very small.

In the PBR, 30R and EUX scenarios the level of funding available each year is lower than in the BAU case, leading to lower levels of GVA. Part of this foregone GVA includes that which could have been created through spill-overs and been used to fund further investment, and which could have created further jobs and growth. For the EUX scenario, in which the EU withdraws from the ITER project, up to around 110 additional jobs could have been created annually due to spill-overs from the initial ITER investment. These potential spill-overs could also have generated up to around €38m additional GVA per annum in this case.

5.2.4 Impact on effectiveness of the delivery of the EU contribution

Effectiveness relates to the extent to which the EU contribution enables the achievement of the objectives for which it is intended. The primary objective is to support the progress of ITER in line with progress towards first plasma in 2025 and the milestones beyond this. This progress should be in line with the costs and timings implied in the baseline. The secondary objectives can be summarised as added value. These include the employment, GVA, SMEs and innovative capacity that the spending on ITER induces. The impacts of the various scenarios related to funding that are described in the previous sections therefore strongly link to effectiveness, particularly under the added value objectives.

Under a specific MFF Programme vs. in a wider MFF program vs. with MS contributions

The three options on delivery mechanisms (ITER under its own specific programme in the MFF, ITER as part of a wider programme in the MFF or ITER receiving its funds directly from the Member States) appear to have limited impact on the ability of the EU to route whatever total level of funding is agreed towards ITER, on the assumption that no attempts are made to reduce the total level of funding. The options do have some impact on the flexibility and stability with which this funding is delivered, in terms of the following issues:

- How far in advance F4E has to estimate how much of the total funding they want to spend each year;
- How easy it is for F4E to adjust their estimate of annual spending if they need to spend more in a particular year and move funds between spending years (and not lose unspent funding)[99];
- How easy it is for F4E to increase the total amount of funding they require (in the event of a cost increase above and beyond any contingencies);
- The risks of the EU (or the MSs) wishing to reduce the total amount, or the pre-requested annual amount, of funds allocated to F4E.

[99] The financial regulation of F4E state: “Appropriations which have not been used at the end of the financial year for which they were entered shall be cancelled. The cancelled appropriations may be entered in the estimate of revenue and expenditure of the following financial years, in accordance with Article 34. However, they may be carried over, but only to the following financial year”. Available at: http://fusionforenergy.europa.eu/downloads/procurements/F4E_Financial_Regulation.pdf

These factors are important to effectiveness because increases in any of them lead to increases in the chance of delays (and hence cost increases), which implies a reduction in effectiveness, because the likelihood of the objective of ITER being delivered on time and to budget goes down.

As discussed under risk mitigation, there is little to choose between the options of ITER being under its own specific programme in the MFF and it being part of a wider programme in the MFF. Both options have pros and cons but the ultimate choice appears to be a political decision. The option of ITER receiving its funding directly from the Member States would have a different set of impacts on the stability and flexibility of the funding. However, such a major shift in the way in which F4E receives it funding would in itself introduce a significant risk of delay, because it would require political and financial discussions that would be time consuming and complex. This risk of delay leads to a negative assessment in terms of effectiveness for the option of Member State contributions.

Financial scenarios

The following table summarises the outputs from the modelling of the financial scenarios

Table 5-2: Summary of the economic modelling

Scenario	Funding	Jobs	Output	GVA	SMEs
Baseline	€0.42bn annually 2020-2025 €0.42 annually 2026-2027 €0.42 annually 2028-2030	*Employment (000s)*	*Euros m (2015)*	*Euros m (2015)*	*Number created*
		Total 2020 - 2030, vs. the Baseline (gross)			
Full New Baseline (FNB)	€1.046bn annually 2020-2025 €0.874bn annually 2026-2027 €0.368bn annually 2028-2030	19.4	12,482	4,978	9,283
New Baseline, No Contingency (NoC)	€0.91bn annually 2020-2025 €0.76bn annually 2026-2027 €0.32bn annually 2028-2030	14.5	9,182	3,668	6,963
Post-Brexit Reference (PBR)	€0.36bn annually 2020-2025 €0.36 annually 2026-2027 €0.36 annually 2028-2030	- 4.1	- 2,540	- 1,038	-1,663
30% Reduction (30R)	€0.30bn annually 2020-2025 €0.30bn annually 2026-2027 €0.30bn annually 2028-2030	- 5.9	- 3,755	- 1,513	- 2,632
EU Exit (EUX)	No further investment	- 9.2	- 12,800	- 5,112	- 8,746

Source: E3ME

The following conclusions can be drawn from this summary with regard to effectiveness:
In terms of delivering funding to F4E and ITER, the full new baseline (FNB) scenario is the largest amount (as it includes the contingency). It is based on the best estimate of F4E and ITER on the funds required to maximise the likelihood of ITER delivering First Plasma by 2025. This total, and the adjusted management approach behind it, has also been verified by external experts[100] and proposed to the Commission and Parliament for acceptance[101]. This is therefore the best estimate of the most effective budget with regard to achieving the primary objective of ITER.

[100] External experts positively verified the adjusted approach in 2016 (see: https://www.iter.org/doc/www/content/com/Lists/list_items/Attachments/673/2016_04_IC-Ex.pdf), Experts for the US DoE have also positively reviewed the adjusted baseline and improved management approach in 2016(see: https://science.energy.gov/~/media/fes/pdf/DOE_US_Participation_in_the_ITER_Project_May_2016_Final.pdf)
[101] EU Contribution to a Reformed ITER Project. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/eu_contribution_to_a_reformed_iter_project_en.pdf

With regard to the other (added value) objectives (employment, output, GVA, SMEs (where SMEs refers to the number of companies created. i.e. spin offs)) the FNB scenario is also the most effective because it shows the largest growth versus the baseline in all of these measures. The new baseline no contingency (NoC) scenario is the next most effective, with a better than baseline performance in all of these measures, as would be expected given that the level of funding is higher than under the baseline. The other three scenarios all show a worse performance in all of the measures of the added value objectives, as would be expected given that they all involve a reduced level of investment.

An interesting finding in terms of effectiveness, is that the FNB and NoC scenarios both lead to highly positive figures (including 9,280 SMEs created for the FNB). This is in marked contrast to the results from an Exit scenario, where output is destroyed (-5.1 billion euros) even without taking the legal cost of an exit into account.

5.2.5 *Impact on EU added-value*

EU added value has a significant overlap with effectiveness as it relates to the ability of the approach adopted to deliver against the added value objectives. These include the employment, GVA, SMEs and innovative capacity that the spending on ITER induces. The impacts of the various scenarios related to funding that are described in the previous sections therefore strongly link to added value objectives.

Under a MFF budget line vs. in a wider MFF program vs. with MS contributions

As under effectiveness, the three options on delivery mechanisms (ITER as a dedicated programme in the MFF, ITER as part of a wider programme in the MFF or ITER receiving its funds directly from the Member States) appear to have limited impact on the ability of the EU to route the total amount of funding to F4E and ITER, but they do have some impact on the flexibility and stability with which this funding is delivered. The pros and cons of the options of ITER having its own programme in the MFF or being part of a wider programme appear to result in a relatively equal overall rating, so the choice between these two appears to be political and administrative (related to the annual negotiations within the wider programme). The option of the Member State contributions appears to add significant risk of delay, because of the complexity of the required change, so this option would score negatively in terms of EU added value.

Financial scenarios

With regard to the financial scenarios, the conclusion reached under effectiveness, based on the summary of the modelling, also applies to EU added value. Concerning the added value objectives (employment, output, GVA, SMEs (where SMEs refers to the number of companies created. i.e. spin offs)), the FNB scenario is the highest ranked because it shows the largest growth versus the baseline in all of these measures. The new baseline no contingency (NoC) scenario is the next best, with a better than baseline performance in all of these measures, as would be expected given that the level of funding is higher than under the baseline. The other three scenarios all show a worse performance in all of the measures of the added value objectives, as would be expected given that they all involve a reduced level of investment.

EU added-value can also be determined by considering the additional GDP created for every €1 spent on the ITER project. Conversely, in cases where funding levels are lower than in the business as usual scenario, we can consider the loss in GDP for every €1 less of investment. The results explained below clearly show the macroeconomic benefits the ITER project can provide to the EU28.

The E3ME model results suggest that in the FNB and NoC scenarios (when investment is higher than the business as usual case between 2020 and 2027), every €1 of investment generates around €2.55 of additional GDP in 2020, rising to €3.45 by 2027. The added-value increases over time due to the positive impacts of the investment accumulating over time. When funding levels are lower than the business as usual scenario (between 2027 and 2030 in the FNB and NoC scenarios, and throughout the 2020-2030 period in the PBR, 30R and EUX scenarios), for every €1 not invested in the ITER project, GDP is around €2.60 lower than BAU in 2020, and up to €4.00 lower by 2030.

5.2.6 *Impact on value for money*

Value for money is effectively a measure of the benefits vs. the costs. This relates to the effectiveness as an increase in effectiveness implies an increase in the benefits. The costs are mainly driven by the budget that is requested to deliver ITER, but there is also a variable within the costs related to the administrative costs of delivering the various options.

Under a dedicated programme in the MFF vs. in a wider MFF program vs. with MS contributions

With regards to the benefits, as under effectiveness the three options on delivery mechanisms appear to have limited impact on the ability of the EU to route the total amount of funding to F4E and ITER. However, they do have some impact on the flexibility and stability with which this funding is delivered. The pros and cons of the options of ITER having its own dedicated programme in the MFF or being part of a wider programme appear to result in a relatively equal overall rating, so the choice between these two appears to be political. The option of the Member State contributions appears to add significant risk of delay, because of the complexity of the required change, so this option would score negatively in terms of EU effectiveness and therefore benefits.

With regards to the costs, the option of MS contributions appears to be the outlier in terms of increasing the risk of delay, which risks increasing the total costs (and reducing the benefits). This options therefore scores lower than the other two on value for money.

The administrative costs of the two MFF options appear relatively similar, with each having a similar scale of risk, albeit for slightly different reasons. The administrative costs of the MS contribution approach are difficult to assess because it would depend on what the negotiations resulted in. For all the three options, the administrative costs are a small percentage of the total costs.

Financial scenarios

In terms of benefits, as with effectiveness, the FNB scenario is assumed to be the scenario that maximises the benefits in terms of the primary objective of progressing ITER. The FNB scenario delivers the largest amount, and it includes the contingency. It is based on the best estimate of F4E and ITER on the funds required to maximise the likelihood of ITER delivering First Plasma by 2025. This total has also been verified by external experts. This is therefore the best estimate of the most effective budget with regard to achieving the primary objective of ITER. The FNB scenario also maximises the other (added value) benefits.

For the added value objectives, it is possible to calculate the cost per unit, by dividing the total investment by the number of jobs, unit of output, unit of GVA etc. However, this approach would only be useful if the figures could be benchmarked against a comparable investment. The unique nature of ITER means that it is not possible to identify a truly comparable benchmark. Typical EU investments in research and innovation (i.e. via the H2020 programme) are very much less capital intensive than ITER.

The administrative cost component of the various scenarios is not separately accounted, it is therefore not possible to comment on this.

The recent value for money study attempted to compare the costs and benefits of ITER with other 'big science' projects in Europe. The conclusion was that comparison between high-value infrastructure projects in Big Science and ITER remains a complicated task. The main reason is that that there is currently no other 'big science' project with a similar budget under construction[102]. Most of the comparable projects have already been constructed, are operational, and exhibit net-positive benefits to society. Weak evidence from the construction periods of these other projects (e.g. the Large Hadron Collider (LHC) run by CERN) suggests that, they only recuperate their investment in societal benefits once operational. This is when benefits to industry GVA, scientific publications, and the general public can solidify. Given the pathway of the assessed projects at CERN and the European Space Agency (ESA), it seems likely that ITER is set for a development profile that will provide a long-term return on investment (post-2025).

5.2.7 *Impact on risk mitigation*

According to the 2016 Independent Review produced for the ITER Council working Group on the Updated Long-Term Schedule and Human Resources, the ITER Organisation Central Team has historically not devoted extensive efforts to risk management, especially when it comes to project-wide systemic identification, development of specific mitigation plans and estimation of pre and post-mitigation probabilities of occurrence.[103] However, it also suggests that under the new DG's leadership these issues have been much better addressed and at present ITER risk mitigation concerns are receiving senior management attention.[104]

Under a dedicated programme in the MFF

As far as the financing mechanisms are concerned, if the EU's contribution to the ITER project continues in the business as usual scenario and remains under a MFF programme, several potential risks might occur. According to the information collected from interviews conducted with EU officials, in terms of the organisational side, the dedicated programme under the MFF offers less flexibility conditions, compared to a wider-programme financing option because it does not allow for as much contingency planning and fund relocation.[105] As a consequence, on a project as large and complicated as ITER, this adds a level of uncertainty to the overall management.

Another important risk that a dedicated programme might increase is in regard to other scientific programs[106]. The separation between ITER and other EU funded scientific projects (for example those supported under the successor to H2020) might reduce the potential research synergies between nuclear fusion projects and other scientific programmes.

Potential political risks are also present under this option. Interviewees state that, if the overall budget negotiations on granting the funds needed for ITER get entangled in the internal political discussion which occur in the European Council and Parliament, over annual funding priorities, this could place

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[102] Which would further allow to put effects in the context of the current socio-economic environment.
[103] 2016 - ITER Council Working Group on the Independent Review of the Updated Long-Term Schedule and Human Resources (ICRG). Available at: http://www.firefusionpower.org/ITER_ICRG_Report_2016.pdf
[104] *Idem*.
[105] Information extracted from phone interviews with EU officials working on ITER related activities
[106] *Idem*.

the ITER funding at additional risk. Arguing over the effectiveness and the need for fusion projects, such as ITER, in the overall EU climate and energy strategies could lead to further delays and slow down the progress towards reaching the stage of first plasma in 2025.

As part of a wider MFF programme

If the EU funding contributions goes back to the previous approach of having ITER as part of a wider scientific or research programme such as the 9th Framework Programme (FP9) (i.e. the successor to Horizon 2020) this could also pose several risks. A potential solution to this might be a narrower programme option which only encompass ITER and Euratom or ITER and the fusion-related part of Euratom.[107]

According to the interviewees, in the context of the organisational structure this could reduce the operational flexibility of the available funding, since ITER would have to compete with other scientific programmes for resources. This could mean that if certain (unexpected) products or components need to be procured for ITER, but the necessary additional funds have already been utilised in another part of the portfolio of the research programme there might be further delays which could impact the progress of ITER. In addition, the interviewed officials state that this structure could disrupt the operational and management stability, since ITER funding would have to go through a longer bureaucratic procedure.[108] This potential disruption could also come from having to share the funds with other scientific programs. Several interviewees have expressed their concern that in this case, ITER might end up losing some of the initially pledged resources due to unforeseen changes in the funding priorities within other parts of the wider programme.[109]

This option could also expose the ITER project to additional political risks. If ITER becomes part of a wider programme, financed under the MFF, the interviewees indicated that, this might increase the pressure coming from the European Parliament.[110] Looking at the wider priorities of EU finances, the Parliament might consider that any increase in the funds needed for ITER should come at the expense of other programmes.

Some of the officials interviewed also consider that this approach could pose considerable risks to the potential cooperation and synergies between ITER and other scientific projects. Officials from the European Commission as well as Fusion for Energy, have expressed their concern that this line of action could lead to a loss of cooperation between the investment in ITER and the EUROFUSION initiatives in investing in other nuclear related efforts. It also puts ITER in direct competition with other research programmes for acquiring the resources needed in order to deliver proper functioning of the programmes. Due to the larger scale of the budget needed for ITER, this also poses a risk for the operational stability and financial planning of the ITER project. According to the interviewees, in this context, due to cost overruns ITER might end up absorbing the funds foreseen for other programmes.[111]

[107] *Idem.*
[108] *Idem.*
[109] *Idem.*
[110] *Idem.*
[111] *Idem.*

With MS contributions

If financing was to come directly from several Member States, there might also be considerable risks. According to interviewees, on a global scale, having a complete EU exit from the ITER project, where only several Member States take on the responsibility of providing financing will mean that the EU will lose a significant amount of credibility as a research and innovation world leader[112]. This would also significantly decrease the available soft power the EU has when it comes to international fusion related policies.[113] Having only a selected number of Member States would also mean that they would have to carry a much larger financial burden in order for the operational structure to continue to function in the same way and not experience severe financial disruptions.

5.2.8 *Impact on simplification*

The different delivery mechanisms offer avenues for simplification that influence first and foremost the administrative cost of a project. This can be achieved, for example, by exploiting opportunities to reduce the bureaucratic burden.

Under a dedicated MFF programme vs. in a wider MFF programme vs. with MS contributions

Preparing a realistic multi-annual programme of the expected costs which can be sent to the Commission is currently still one of the largest challenges for F4E in terms of preparing for the MFF. The administrative burden of being funded directly under a specific MFF programme can thus be high[114]. This burden relates to the need to adapt the budget allocation to actual needs, and to negotiate changes to the expenditure profile with Commission, if they emerge.

There are financial regulations and implementation agreements. These rules are put in place by DG BUDG in order for F4E to fulfil its mission within the frame of rules set by Commission. If funding comes from the MFF (directly or as part of a wider programme) where the Council and the Parliament hold direct responsibility, the risk of delays (and hence increased administrative cost) can be significant due to the inherent polarisation processes of these institutions. Not having a single interlocutor means that it is sometimes more difficult to discuss budget issues[115].

The advantage of a pooled MS contribution delivery mechanism for simplification, is that the terms and rules of budget spending can be more independent than MFF financing. A large area of simplification that is possible under an MS contributions setup is the possibility of multiannual appropriation. Hereby, the budget for the whole construction period is signed off by the governing committee. Under an MFF this is not possible due to its confinement to (currently) 7 years. Furthermore, 'annuality' applies for the ITER expenditure under direct MFF funding. This means that any amount of money that is unused, within certain limits, has to be returned and then reassigned. This creates a kind of fictitious break of activities on a yearly basis. With multiannual appropriation, these costs are avoided[116].

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112 *Idem.*
113 *Idem.*
114 Information extracted from phone interviews with F4E staff.
115 Information extracted from phone interviews with relevant stakeholders.
116 Information extracted from phone interviews with relevant stakeholders.

5.2.9 Impact on flexibility

Under a specific programme in the MFF

Under the current situation, F4E is required to submit a request for funding for the following MFF 2,3 or even 4 years prior to the start of that MFF. This requires substantial accuracy from F4E on their forecasts of budgetary needs, commitments and payments, up to 7-8 years in advance before the budget will actually be used. Once these numbers are registered on the MFF profile, they are difficult to change. This means that the current dedicated programme in the MFF provides minimal flexibility[117]. The only flexibility currently available is that F4E is allowed to spend the budget of one year in two years, e.g. the budget of 2018 can be used until the 31st of December 2019[118]. This is not the case with 2020 when the current MFF is terminated. If a part of the current budget is not used by the end of the current MFF due to limited progress in the project compared to what was initially intended, it is not specified in the Financial Regulation of the Joint Undertaking, whether the excess amount of money will go on top of the budget provided for the period 2020-2025 or the excess amount will be deducted from the budget that was intended to be provided to F4E[119]. It was reported that the current dedicated programme in the MFF provides higher stability and longer-term visibility on the available budget; because F4E is not exposed to year by year discussions about the budget allocation to ITER[120]. However, the fact that ITER's funding is covered by several MFFs (by the time ITER construction is finished it will have been funded by 4 or 5 MFFs) creates a discontinuity. It is very difficult to create an estimate in advance of what F4E will have accomplished by 2020 which means that the scope may change, and subsequently the required budget should change but it is not possible to adjust the budget accordingly[118]. Currently the Council and the European Parliament are directly responsible for budget implementation which results in an increased risk of delays due to possible political changes in Member States. Budget issue discussion are made more complicated due to the fact there is not a single interlocutor communicating with F4E.

In a wider MFF programme

In the past, ITER was in the same funding programme (FP7) with the European Fusion Development Agreement (EFDA). Due to the size of the project, ITER consumed the vast majority of the available funding, leaving only a small amount for EFDA. This caused financial issues to the rest of the projects, and friction between the other programmes and ITER, which subsequently reduced the available flexibility for delivering the expected outcomes. As mentioned earlier, currently F4E has the possibility of transferring budget across more than one financial year without that impacting the overall financing. If ITER is merged into a wider MFF, this flexibility might be lost[117].

With MS contributions

Switching to a scheme which pools individual countries finances could increase the need for contingencies since ITER would be more exposed to political changes occurring in one or more contributing MSs which would jeopardise ITER's stability. Furthermore, under such a scheme, it appears likely that direct intervention from the participating MSs demanding a certain degree of their funding contribution to be returned back to them would occur. For example, in CERN procurement regulations

117 Information extracted during phone interviews with F4E staff.
118 Financial regulation of the Joint Undertaking. Available at: http://fusionforenergy.europa.eu/downloads/procurements/F4E_Financial_Regulation.pdf
119 Idem.
120 Information extracted during phone interview with F4E staff

it is stated that if a MS is under return, CERN should award a contract to a company from that MS even if the price offer is 10% higher than the best offer, which creates an increased risk of cost overruns[121].

5.2.10 Other impacts - withdrawal of one of the ITER parties

The ITER Organization is made up of seven international partners, all of whom are responsible for a certain percentage of contributions (both cash and in-kind) to the ITER project. Euratom is responsible for the largest share of contributions – 45% - compared to a 9.1% contribution from each of the remaining six partners. As the lead partner and host for the project, the EU stands to gain the most in terms of increased economic activity and employment. It is therefore in the EU's interests to ensure that the ITER project has sufficient funding to achieve its goals and to meet obligations within the ITER Agreement. Furthermore, adequate funding in the immediate period reduces the risk of further delays to the project and subsequent cost increases (with the knock-on risk of losing international partners). Should another member of the ITER Organization withdraw from the project, Euratom would be responsible for absorbing 45% of their contribution, while all other remaining parties would each absorb 9% of the costs.

In this section, two scenarios where a contributor withdraws from the ITER Agreement – namely the US and India – and the macroeconomic impacts of this for the EU are investigated. Under these scenarios the EU would be required to invest more money in to the ITER project in line with its contractual obligations. This additional investment will create additional jobs and output, but the additional contributions will have to be funded. The modelling of the scenarios outlined below assumes that the EU would increase income tax rates in order to raise the necessary additional revenue needed to finance this increased investment.

US

According to US ITER (the domestic agency responsible for the US contribution to the project) as of December 2017, they had awarded $975m to national organisations to develop and manufacture the required in-kind contributions to the project, with plans to award a further $800m in future contracts until the end of the project agreement in 2042, giving a total in-kind contribution of $1775m122. According to the ITER Organisation, in-kind contributions make up nine-tenths of total contributions, the remaining 10% being made as cash contributions to the project[123]. The total contribution from the US would therefore be $1972m. It was assumed that, in the case of the US withdrawing from ITER, the outstanding investment ($800m in-kind plus the additional 10% in cash contributions, totalling $889m) left to make over the period 2018-2042 is spread evenly over time, meaning an additional investment of $37m per year would be required from the remaining six partners. In this scenario, Euratom would have to absorb 45% of this annual $37m (i.e. $17m annually[124]) and it was assumed that it funds this additional investment through increased income taxes. The E3ME model was used to determine the impacts of this additional annual investment within the EU over the period 2020-2030 (i.e. €17m in each year of this period), compared to the BAU case[125].

[121] Information extracted during phone interview with F4E staff
[122] https://www.usiter.org/media/ITERProject.pdf
[123] https://www.iter.org/proj/Countries
[124] €16m in 2005 prices.
[125] For detailed model results see Annex C: Detailed E3ME results

The overall net impacts on jobs and growth in the EU28 are negative. Increased income tax rates will have a negative knock-on effect on employment, reducing household expenditure, although this will be balanced out somewhat by increased employment from the additional investment. Between 2020 and 2030 the net impact is a reduction of between 2 and 100 jobs each year, with a cumulative total of 501 jobs lost over the period in the EU28 as a whole. There is also a reduction in total economic growth in the EU. Output reduces by between €3m and €20m per annum in most years over 2020-30, although at the start of the period there are small increases in output due to the short-term stimulus effects of the investment. The cumulative reduction in output over the whole period is equal to €52m for the EU28 in aggregate. Similar patterns can be seen in GVA, leading to a cumulative loss of €6m.

India

The Institute for Plasma Research (IPR) manages the contribution of ITER-India to the ITER project. At a press conference held in June 2016 during a visit by a senior IO official, the head of IPR stated that ITER-India had delivered 10% of total contributions India is making to the project.[126]. Using this figure (and assuming this includes both in-kind and cash contributions) and assuming that the overall contribution to the ITER project will be the same as the US contribution (as both contribute 9.1% of total project costs) it could be assumed that the total Indian contribution still to come over the period 2016-2042 is $1774m (90% of $1972m), equivalent to an annual figure of $68m. If India chose to withdraw from the project the EU would be responsible for absorbing 45% of this, i.e. $31m per annum[127]. Assuming the EU meets it obligations, the impact of this annual investment within the EU over the 2020-2030-time period was modelled (i.e. the impact of an additional €31m in each year of this period) compared to the BAU case[128].

There is a negative impact on jobs and growth if India withdraws from the ITER Agreement. The overall macroeconomic impact of India withdrawing from the ITER Agreement is smaller than in the US case, despite the higher levels of additional funds Euratom must raise. This is because the positive effects of the higher investment is balanced out by the negative effects of higher income taxes. Between 2020 and 2030 the net impact in the India case is a reduction of between 2 and 30 jobs each year, with a cumulative total of 113 jobs lost over the period across the EU28. Small increases in output are seen in some years between 2020 and 2030, but these are outweighed by bigger falls in other years. The cumulative impact on output across the whole period is a fall of €0.3m.

In both the US and India cases there are further impacts not captured by the modelling results that should be considered. There are negative impacts to be considered in the US and India themselves, in terms of loss of potential jobs and growth, but also negative implications for their own science programmes (e.g. falling behind international counterparts in terms of research), and the financial costs of withdrawing from the project.

Further impacts for Euratom include a sudden reduction in funding causing considerable delays and subsequent cost increases to the project. The risk of losing further international partners (with associated knock-on impacts for Euratom) increases in this case. Furthermore, The ITER Agreement is a good example of close cooperation and interdependence between international partners, working

[126] http://indianexpress.com/article/india/india-news-india/india-on-schedule-with-deliveries-for-iter-fusion-reactor-official-2880396/
[127] €23.5m in 2005 prices
[128] For detailed model results see Annex C: Detailed E3ME results

together on a large-scale science project, sharing knowledge and research and promoting political unity. It is therefore important that the project succeeds in all aspects, to promote similar cooperation in future.

Box 5-1: Brexit and Euratom / ITER

The position of the UK in relation to ITER and Euratom is not yet clear following the UK's decision to leave the EU. The following text summarises the information that is available on this.

In their first statement regarding their intentions of Brexit the UK government stated that it intended to withdraw from Euratom, largely because the UK's continued membership would place it under the jurisdiction of the European Court of Justice (ECJ) and the UK's position was that this was not acceptable[129] "The UK Government have said that Euratom and the EU are "uniquely legally joined" such that "triggering Article 50 therefore also entails giving notice to leave Euratom". The legal basis of this point is debated[130].". The suggestion that the UK was to leave Euratom raised some concerns in the UK, mainly related to the ability to securely source radio isotopes for medical purposes but also related to the potential loss of UK involvement in nuclear fusion research[131] (i.e. ITER but also the EU funded Joint European Torus (JET) research facility in the UK). A UK government response to this concern (in June 2017), stated that 'the government pledges to meet its fair share of funding for the JET project until the end of 2020' and that the 'payment (is) assured if the EU extends the UK's contract to host the Oxfordshire-based facility beyond 2018'[132]. This issue continues to be discussed in the UK, with disagreements within government as to whether or not the UK should remain within Euratom. A January 2018 UK government statement[133] on this issue states that the intention is still to leave Euratom, but that the UK' will continue to seek a close association with Euratom, including the possibility of future co-operation on nuclear non-proliferation and safeguards, and any potential role for Euratom in supporting the establishment of the UK's own domestic safeguards regime". This statement promised updates every three months, the first such update was released on the 27th March 2018[134], and confirms the points made in this section plus that Euratom membership will stay in place for the so-called transition period (from March 2019 to the end of 2020) but offers no further detail on the approach post 2020. Within the stakeholder community consulted for this study the consensus of opinion is that the most likely scenario is that the UK will continue with Euratom (and ITER) membership in an 'associate' manner (as Switzerland currently does) with contributions roughly equivalent to what it currently makes via the EU. However, this result is by no means guaranteed.

5.2.11 Other impacts - length of MFF

The decision whether the upcoming Multiannual Financial Framework will remain as per the current length of seven years or change to a 5-year or 5+5-year (with revision) setup, will have an impact on the overall functioning of ITER. As previously noted the European Union is the largest financial contributor to the ITER project. Due to the current scheduling plans of delivering first plasma by 2025

[129] https://www.gov.uk/government/publications/queens-speech-2017-what-it-means-for-you/queens-speech-2017-what-it-means-for-you
[130] http://researchbriefings.parliament.uk/ResearchBriefing/Summary/CBP-8036
[131] Brexit briefing, Euratom and Brexit. Available at: http://www.europarl.europa.eu/cmsdata/134202/bma-briefing-euratom-and-brexit.pdf
[132] https://www.gov.uk/government/news/government-commits-to-continue-funding-its-share-of-europes-flagship-uk-based-nuclear-fusion-research-facility
[133] https://www.parliament.uk/business/publications/written-questions-answers-statements/written-statement/Commons/2018-03-26/HCWS586/
[134] Quarterly update to Parliament on the government's progress on the UK's exit from the Euratom Treaty. Available at: https://www.gov.uk/government/publications/euratom-exit-quarterly-update-january-to-march-2018

and bearing in mind the constant time-management issues, having the next financing period extend to seven or ten years will provide better flexibility for managing any potential contingencies that might occur in the process. According to the information, collected through interviewing EU officials, working on the ITER project, having the next MFF last for 7 years or a longer period would also ensure that the first plasma stage will indeed be reached during the next MFF.[135] If, however, the duration of the MFF is shortened, the end of a potential five-year setup will coincide with the expected first plasma stage. In the event of technical problems affecting the timescale, the five-year MFF is hence likely to further constrain management flexibility, and thus delaying the delivery of first plasma by 2025.[136]

Based on the interviews conducted with officials from DG RTD, DG ENER and F4E (including the work done on the Value-for-Money study), several conclusions could be drawn. First, given the already present budget overruns and delays, which have resulted in falling behind the initially agreed schedule, it would be beneficial for the ITER project if the next MFF spans for the longer seven-year period. This would remove the necessity for further financial negotiations while the project is still under construction and has not reached the operational stage.[137] Having the ITER project constructed and functioning would further allow for much more visible and practical benefits to be presented to the stakeholders when the new negotiations for the following MMF take place. Such longer time-period will further allow for greater medium-term financial stability.[138] It will also contribute to improved flexibility when it comes to resource management and allocations during the foreseen period.

On the other hand, this longer time-frame also poses several potential problems, including for the operational procedures that have to be followed by Fusion for Energy. With regard to the financial forecasting reports produced by the EU domestic agency, Fusion for Energy finds it challenging to prepare viable financial forecasting programs for periods longer than 5 or 7 years, due to cost uncertainties and other factors which might impact the medium-term price estimates.[139]

Quantitative assessment

Three potential options for the length of the post-2020 MFF were modelled. The duration of the programming period could be set at five years, seven years, or ten years (with a major review after the fifth year). In this section, it was examined how the funding changes over time in the different scenarios as compared to the BAU case for the same programme duration and consider under what length of MFF the benefits from the ITER programme would be maximised.

In the PBR and 30R cases the employment and growth impacts are generally steady over time, with little growth in the impacts year-on-year, reflecting the fact that investment levels are constant (in current prices) over the period. For these scenarios the duration of the MFF has no real consequences on the effectiveness of the financing programme.

However, for the FNB and NoC scenarios, the levels of funding under a five or seven-year MFF are higher than in the BAU scenario, while for the remaining years of a ten-year MFF (i.e. 2028-2030) the funding available is lower. Between 2020 and 2023, the impacts of the funding on jobs and growth

[135] Information collected through a telephone interview with EU official working on ITER related activities
[136] *Idem.*
[137] *Idem.*
[138] *Idem.*
[139] *Idem.*

gather pace each year, as the productivity impacts of the investment capital accumulate and influence economic activity in subsequent years. However, post 2023 this effect slows down, and post-2026 the sectoral shifts in activity and employment lead to jobs and GVA moving back towards the BAU case.

For the FNB and NoC scenarios it appears that the optimal MFF would be five or ten years, i.e. 2020-2025, with funding decisions being revised in 2025 (a ten-year MFF includes an obligatory mid-term review), ensuring the right level of funding is available to maximise the economic benefits from the ITER programme. Since the impacts of the PBR and 30R scenarios seem to be unaffected by the duration of the MFF, a five or ten-year MFF would also be suitable under these scenarios (i.e. there is no economic cost associated with not choosing a 7-year duration).

5.3 Assessment of impacts: Implications of legal forms

Each delivery mechanism, by default, requires a legal form (as discussed in chapter 4) to become operative. This means that the ultimate impact of the different delivery mechanisms on the indicators also depends on the legal setup that enables it. This section provides an additional, qualitative, assessment of possible combinations of these two variables (delivery mechanisms and legal frameworks). It not only identifies the most likely sets of combinations, but also provides a SWOT of each as an output to inform the analysis. It provides crucial insight into how the impact of delivery mechanisms on certain indicators change when being subjected to a variety of legal forms.

We have identified three delivery mechanisms and six legal forms in chapter 4, which makes for 18 possible combinations. Considering both the length and complexity of the report and the relevance of the combinations, we have limited the analysis to the following five potential combinations:

1. Direct MFF programme + ‘Special’ Joint Undertaking (Status Quo)
2. Direct MFF programme + Joint Undertaking
3. Direct/Wider MFF programme + Decentralised Agency
4. Pooled MS contributions + Joint Undertaking
5. Pooled MS contributions + Intergovernmental Organisation

Box 5-2 further elaborates on the process by which we selected these five combinations.

Box 5-2: Selection criteria and process for relevant combinations of delivery mechanisms and legal forms

- The differences between a direct MFF program (MFFd) and a wider MFF program (MFFw) are ultimately rather small. We therefore propose to regroup these options, except for a JU. The reason for this is that it is not rational to combine a JU with a MFFw as the private partner(s) would probably not be interested in investing in a 'construction' where the budget would be negotiated annually with other programmes in a wider set-up. Although the combination 'MFFd with a JU' is possible, we believe that in the case of a programme like ITER, it will not work. Currently, there are JUs under H2020 (HPC, FCH, etc.) but their budget and duration is not comparable to ITER. Only Galileo had similar complexity, research/knowledge barriers to overcome, budget level duration comparable to ITER, and in that case the PPP approach failed. As already explained in chapter 4, a PPP approach functions well if the responsibilities, risks, financial contributions, etc. can be clearly defined and divided among the partners when starting up the cooperation. Contractors currently include some contingencies in the procurement contracts, but these contracts have a duration of a few months or years. On the other hand, if a company/consortium is going to commit to a JU with a duration of several decades (F4E has an "expiration date" of 2042, if not extended) the risks and the contingencies they have to bear are much greater. That will be reflected on their proposal/request to the EC, in order to overcome any hesitation that they might have in participating in the project. This was, and is still, not possible for a project like ITER and also led to problems in the Galileo project. Article 10 of the IO agreement on Intellectual Property ('any scientific results shall be published or otherwise made widely available after a reasonable period of time') is another factor that would discourage private partners from stepping in. It is for the same reason that we do not select the combination 'MSs contributions – JU);
- We believe that combining a MFFd&w with a private company is not a feasible solution, as EU legislation makes it difficult to give direct finance to private companies. The same criteria apply to pooled MS contributions (the idea of working with private companies as operational vehicles for public money is rather complex and as such not selected as a potential good combination). Although there are European Big Science projects with such a set-up (e.g. ESRF, ILL), we believe such an approach is highly unlikely to be implemented or to have any added value over the current setup for the European contribution to ITER;
- It is legally not possible to combine the direct funding by MS to set-up an EU agency. It also does not make sense, in our opinion, to set up an MFFw hand in hand with an EU agency as it does not function under the structure of a wider programme budget;
- It does not make legal sense to go for an MFFd&w with an IGO;
- We do not mention the combination with an ERIC separately as, effectively, an ERIC is a form of IGO with harmonised EU rules.

The following sections shortly assess the differential effect the combinations of delivery mechanisms with legal forms can have on (some of) the indicators mentioned in 5.2. The current setup (Direct MFF programme + 'Special' Joint Undertaking) is not further assessed here as it has been discussed in detail in previous sections already. However, it will be part of the SWOT table at the end of this section. The following sections build on previous analysis from chapters 4 and 5.

5.3.1 *Direct MFF programme + Joint Undertaking*

In the current JU statutes, no provision is made for the possibility of private stakeholders participating in F4E; therefore, a change in the statutes would be required to enable the participation of private companies/consortiums. That change might take a significant amount of time to agree and implement, which would reduce the effectiveness of the delivery of the EU contribution. A similar effect would also be expected to be observed on EU added-value. Assuming the successful engagement of industry in the project after a change in the statutes, an improvement in both effectiveness and added value should be expected. As mentioned in chapter 4.3.1, the value for money in the case of a PPP structure depends on the successful allocation of risk among the public and private stakeholders. Therefore, getting industry on board will have a positive or negative effect on VfM depending on whether private stakeholders can successfully handle their share of risks. Since MSs are directly stakeholders of F4E, the JU is exposed to political instability that might occur in some MSs.

5.3.2 *Direct/Wider MFF Programme + Decentralised Agency*

Converting the current status into an EU Agency would require a complete new legal setup compared to an amendment in the current setup. That means even longer delays compared to the JU option, which would further undermine the effectiveness of the EU contribution. In this case, EU would have the sole ownership of the project, and therefore the MSs would no longer be stakeholders. That would result in less vulnerability due to political changes in MSs. The option of the EU Agency would increase flexibility since the Agency would be able to adjust the budget based on the progress of the project and would have more freedom to utilise unused appropriations compared to the current status. On the other hand, defining the budget for the whole project in advance brings a higher risk of an incorrect estimate, due to unforeseen difficulties that may arise during the construction phase. In the current voting system adopted for the governing board, stakeholders with higher contributions have more votes.

5.3.3 *Pooled MS contributions + Joint Undertaking*

As mentioned in 5.3.1, an amendment is required in order to enable the participation of private stakeholders, which would cause a delay until it is implemented. In addition to that, further legal changes are required, in order to change the delivery mechanism from MFF, either direct or wide, to pooled MS contributions. The expected delay would be longer compared to the delay caused in the case of changes only in the legal status to a JU with private stakeholders or a Decentralised Agency.

5.3.4 *Pooled MS contributions + Intergovernmental Organisation*

An intergovernmental organisation (IGO) governance setup is the most common in pooled MS contribution approaches. As in 5.3.3, the mere fact of changing the delivery mechanism for European ITER contributions from an MFF would lead to serious delays, as international agreements would have to be renegotiated and drafted. On top of this, negotiations on the exact legal implications of the treaty establishing the IGO would further aggravate delays and seriously hamper effectiveness, added-value, and value-for-money of the European contribution to ITER. As the IGO is dedicated to its purpose: it would eliminate one step in the funding flow and would allow for efficiency gains that could benefit these same indicators.

Furthermore, an IGO can take on different levels of autonomy which, if very independent, can hedge the budget against erratic political action or conflict from the member states. The IGO can also lay down its own rules designed to fit the project at hand. It is not bound to the framework of EU legal constructs (e.g. JU, EU Agency) that require a certain approach. This provides the IGO with an advantage in terms of its operational and financial flexibility.

However, under the tight and contingency-scarce path to First Plasma in 2050, there is little political manoeuvring space to allow for the significant delays that a change of delivery mechanisms and establishment of an IGO would bring about.

5.3.5 SWOT Analysis

The SWOT provides a summary of ITER-specific strengths, weaknesses, opportunities, and threats that are applicable to the five different combinations of delivery mechanisms and legal forms. The SWOT is based on the results of the analysis in Chapters 4 and 5 and helps to create an additional foundation for our final assessment of options in 5.4.

The SWOT can further inform the generation of lessons learned in Chapter 7 by highlighting the advantages and disadvantages of the status quo and the other options in terms of what they offer to ITER.

		Favourable	Unfavourable
Internal		**Strengths**	**Weaknesses**
	MFFd + JU	• Strict budgetary control • Increased stability • Long-term visibility on the available budget • Easier to spot and manage overruns	• Low flexibility • High administrative burden • Annual financial appropriation
	MFFd&w + Decentralised Agency	• Strict budgetary control • Increased stability • Long-term visibility on the available budget • Easier to spot and manage cost overruns • Lifetime independent of MFF duration	• High administrative burden • Increased contingencies • EU carrying larger financial burden (cover MSs share)
	MFFd + 'Special' JU (Status quo)	• Strict budgetary control • Increased stability • Long-term visibility on the available budget • Easier to spot and manage cost overruns	• Low flexibility • High administrative burden • High bureaucracy and institutional inertia
	MS contributions + JU	• High flexibility • Ad hoc legal and financial setup • Multiannual appropriation • Increased autonomy	• Participating members carrying larger financial burden • EU is losing access to a novel technology
	MS contributions + IGO	• High flexibility • Ad hoc legal and financial setup • Multiannual appropriation • Increased autonomy • Less centralised governance of budget • Less bureaucracy and institutional inertia	• Participating members carrying larger financial burden • EU is losing access to a novel technology
External		**Opportunities**	**Threats**
	MFFd + JU	• Political prioritisation of ITER • Improved EC budget monitoring • Possibility of research synergies • Possibility of industry participation • Possibility of combining EU budget with other sources • No possibility for direct funding competition with other scientific programmes	• Vulnerable to delays caused by Council or EP decision and approval processes • Increased political pressure • Reduced opportunities for fusion R&D in academia • Current arrangement on IPR is unattractive private stakeholdersfo
	MFFd&w + Decentralised Agency	• Political prioritisation of ITER • Improved EC budget monitoring • One interlocutor in budget negotiations (EC)	• Reduced possibility for research synergies
	MFFd + 'Special' JU (Status quo)	• Political prioritisation of ITER • Improved EC budget monitoring • No possibility for direct funding competition with other scientific programmes	• Vulnerable to delays caused by Council or EP decision and approval processes • Increased political pressure
	MS contributions + JU	• Possibility of industry participation • Possibility of combining EU budget with other sources • Possibility of enhancing European private investment	• Risk of delay due to political and financial discussions • Reduced stability due to changes in MSs • Jeopardise EU cohesion process • Reduced opportunities for fusion F&D in academia • Inefficient coordination between fusion projects
	MS contributions + IGO	• Possibility of enhancing European private investment • Efficiency gains in the long run	• Significant risk of delay due to political and financial discussions (dependant on level of autonomy) • Reduced stability due to changes in MSs (dependent on rigor of treaty) • Jeopardise EU cohesion process • Inefficient coordination between fusion projects

Strengths

The strengths of each option represent its advantages in terms of optimising the European contribution to ITER. A central theme for the MFF delivery mechanisms is the fact that the budget is subject to strict controls which makes it easier to spot and manage overruns. For the pooled MS contributions delivery mechanism pairings, the main strength comes in the form of high flexibility and multiannual appropriations, hence securing the budget for the project's lifetime.

In both cases, the addition of different legal forms does not lead to major contrasts in how the strengths of each delivery mechanism manifest themselves. Apart from the universal advantages mentioned above, a decentralised agency paired with an MFF programme could, for example, make the project lifetime independent of the MFF duration. An IGO coupled with pooled MS contributions could lead to increased bureaucracy efficiencies.

Weaknesses

Each option also exhibits weaknesses, that can be seen as disadvantages regarding the European contribution to ITER. For an MFF delivery mechanism this mainly concerns the lack of flexibility that the funding channel offers. Pooled MS contribution delivery mechanisms run the risk of reputational damage for the EU and potential loss of access to crucial future energy technology.

Whereas the legal form does not majorly alter the weaknesses for a pooled MS contribution delivery mechanism, the MFF options show stronger weaknesses in specific areas depending on their legal setup. A JU (both in its literal and status quo sense) thereby suffers from the annual nature of financial appropriation. A decentralised agency would require an increased number of contingencies, as cost (and hence budget) of the whole project would need to be estimated at the beginning.

Opportunities

Opportunities are external in nature and hence depend much more on synergies created by options with outside factors. An MFF delivery mechanism creates multiple opportunities due to the fact that it makes ITER a political priority inside the EU scientific research environment. Pooled MS contributions (with either legal setup) generally provide the opportunity for an increased amount of funding.

A decentralised agency coupled with the MFF can lead to various opportunities in efficiency and effectiveness, as there is only one interlocutor in budget negotiations (the European Commission). A usual JU setup can foster research synergies and increase funding by incorporating private sector partners. These opportunities are not necessarily present under the current 'special' JU setup.

Threats

The threats associated with the different options are due to external factors. A major theme across options is the general threat (or increased risk) of delays which manifests itself in different forms. For a JU legal setup (both traditional and status quo) prolonged negotiation to reach a budgeting decision for ITER between the EP, Council and EC could cause the schedule to be negatively affected. For pooled MS contributions, whatever the legal setup, the threat of delay is caused by the necessity to change or renegotiate international agreements that regulate how and by whom ITER as a whole is finance and realised.

5.4 Comparison of options

In order to complete our consideration of the future options for EU participation in the ITER project it is necessary to consider the combinations of the financial scenarios with the budget and delivery model options. This analysis is essentially a combination and summary of the standalone analysis of these scenarios and options that has already been completed. The table below summarises our qualitative ranking of the various combinations in comparison to the baselines.

Table 5-3: Qualitative ranking of combined financial scenarios and budget and delivery models

Budget + Delivery models	**Financial Scenarios**					
	Baseline	*Full New Baseline (FNB)*	*New Baseline, No Contingency (NoC)*	*Post-Brexit Reference (PBR)*	*30% Reduction (30R)*	*EU Exit (EUX)*
MFFd + 'special' JU (Baseline)	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx
MFFd + JU	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx
MFFd&w + Decentralised agency	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx
MS contribution + JU	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx
MS contribution+ IGO	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx	Job Gro Spi Eff AdV VfM Rsk Smp Flx

Colour Key

Much more positive	More positive	Neutral	Less positive	Much less positive

Indicators legend

Job: Jobs	**Gro:** Growth	**Spi:** Synergies / Spill-overs
Eff: Effectiveness of delivery of the EU contribution	**AdV:** EU added-value	**VfM:** Value for money
Rsk: Risk mitigation	**Smp:** Simplification	**Flx:** Flexibility

We can draw the following conclusions from the table:

Financial scenarios

- As can be seen by the fact that the indicators turn pink and red to the right of the table the financial scenarios have a larger impact on the indicators of success than the delivery mechanisms and the legal form of F4E;
- As described in the analysis of the financial scenarios the scenario which offers the most positives in comparison to the baseline is the full new baseline (FNB), with each of the other financial scenarios, where the amount of money reduces, being less attractive;
- A summary of the changes under each indicator is as follows:
  - *Jobs (MFF delivery mechanism)*: If less is invested, less employment (direct, indirect, and induced) will be created. In the FNB scenario, approximately 19,000 more jobs are created compared to the Baseline during the period of 2020 – 2030, while in the NoC scenario approximately 14,500 more jobs are created over the same period. A reduction in jobs created is observed in the other three scenarios; 4,000, 6,000 and 19,000 less jobs than the Baseline for the PBR, 30R and EUX scenarios respectively over the same period. When employing pooled MS contributions, the results do not exhibit major changes (disregarding the legal implications of changing the delivery mechanism, which could initially slow down employment growth of a specific scenario);
  - *Growth*: As with jobs, lower investment leads to lower GVA. The total added value in the FNB scenario for the period 2020 – 2030, is almost EUR 5bn, while for the NoC scenario, for the same period, this is just more than EUR 3.6bn. In the other three scenarios a reduction was observed; approximately EUR 1bn, EUR 1.5bn and EUR 5bn for the PBR, 30R and EUX scenarios respectively. The results are not significantly changed when the delivery mechanism is changed to pooled MS contributions. The observed effect might also be delayed here, due to the legal adjustments that would be required;
  - *Synergies / Spill-overs*: As with jobs and growth, if less is invested there will be less benefits in terms of spin off employment creation. In the FNB scenario, the impact of spill-overs on employment is almost 3,000 more jobs compared to business as usual during the period 2020 – 2030, while in the NoC scenario almost 2,000 additional jobs are created over the same period. A reduction in jobs created is observed in the other three scenarios; 750, 1,100 and 3,100 less jobs than the Baseline for the PBR, 30R and EUX scenarios respectively for the same period. The impact of spill-overs on the total added value in the FNB scenario for the period 2020 – 2030, is almost EUR 700M, while for the NoC scenario, for the same period, this is roughly EUR 450M. In the other three scenarios a reduction is observed; approximately EUR 150M, EUR 230M and EUR 720M for the PBR, 30R and EUX scenarios respectively;
  - *Effectiveness of delivery of the EU contribution*: Investment that is lower than the best estimate of what is required to keep ITER on track implies a reduction in the likelihood of ITER being delivered on time and to the required specification;
  - *EU added-value*: Less investment means less jobs, GVA and spill-overs;
  - *Value for money*: Less investment increases the chance of delays, and the chance that certain areas of work will need to be stopped and restarted in the future with a consequent increase in costs;
  - *Risk mitigation*: As with value for money, a reduction in investment increases the risk of ITER not being delivered on time and to budget and specification;

- *Simplification*: Reducing the investment does not obviously or directly affect simplification, but the increases in risk associated with a reduction in investment are generally considered negative for simplification;
- *Flexibility*: Reductions in investment are considered as having a negative impact on flexibility because they reduce the availability of budget to respond to potential requirements to move funds around (and/or make use of contingencies) to keep ITER on schedule and specification.

Budget and Delivery Models

- The alternative combinations of delivery models and legal forms do not offer many clear benefits in comparison to the baseline (MFF programme + 'special' Joint Undertaking). The potential benefits that they do offer are largely outweighed by the dis-benefits of the disruption they cause (mostly of a legal nature) and consequent increases in risk;
- Moving down through the options, the following key points can be made about each alternative:
  - *Moving to a standard Joint Undertaking* (where private companies are allowed to participate) – this might increase the value for money and flexibility, by directly involving more commercially orientated partners. However, it could also increase risks and move against simplification by increasing the number of partners and implying a need to renegotiate the F4E structure and objectives;
  - *Moving to a Decentralised Agency* (that is allowed to run procurement procedures) – the effects are expected to be similar for both a direct programme or wider programme delivery mechanism. This legal form has the budget for the entire project decided on at its inception and only has one interlocutor (EC) for budget-related issues. This delivers opportunities both for simplification as well as risk mitigation. However, it also runs the risk of flexibility issues if the initial budget estimate turns out to be insufficient;
  - *Member State Contributions and Joint Undertaking* – leads to the same potential benefits in terms of value for money and flexibility from including private companies and could also bring some benefits by moving away from annual to multiannual budgeting. However, it would also increase risks and move against simplification by implying a need to renegotiation the F4E structure and objectives and by potentially increasing the direct influence of MS governments in the detailed operation and progress of ITER;
  - *Member State Contributions and Intergovernmental Organisation* - leads to some of the same negatives as the MS contribution and joint undertaking option (i.e. increased risks). It could potentially help with simplification, if a model that was simpler than the current arrangements could be found, though this is by no means certain. It seems likely that the end result would be simpler in some areas (e.g. procurement rules) but more complex in others (e.g. the need for all the participating MSs to see what they regard as a fair return on their investments, in terms of contracts being awarded to their companies). This option also carries significant risk of delay and loss of reputation for the EU, as European fusion efforts would not continue to be under its direct influence.

Duration of MFF

A factor that is not taken into account in table 5-3 is the effect of the length of the next MFF on the indicators. Different MFF-lengths could, in certain circumstances, have a significant effect on some of the indicators if paired with certain scenarios. However, this is only the case for combinations that rely on the MFF as their delivery mechanism.

One potential problem that can arise from financing the European contribution to ITER under the FNB or NoC scenarios, is the political difficulties it can create if paired with a 5-year MFF (the end of which would coincide with scheduled First Plasma). In the event that further delays, whatever the source, make it impossible for F4E and the IO to reach First Plasma in 2025, this would put the programme in a weak position to ask for further funding from the subsequent MFF (post-2025). Having been granted the FNB, and therefore a favourable funding position for F4E before, Parliament and the Council might not be willing to provide additional finance beyond-baseline into ITER post-2025. In this scenario, the indicators on effectiveness, EU added-value, value-for-money, and risk mitigation could be much worse for MFF combinations than stipulated in table 5-3.

For the PBR and 30R cases the employment and growth impacts are generally steady over time, reflecting the fact that investment levels are constant (in current prices) over the period. For these scenarios the duration of the MFF has no real consequences on effectiveness, no matter what legal form or MFF programme they are paired with.

Apart from these combinations, the general effects of MFF-length on indicators apply as described in section 5.2.11.

6 How will performance be monitored and evaluated

Key findings
• Performance can be split between progress on ITER and generation of added value; • The indicator that F4E appear to favour, and that appears to be the most informative in terms of progress towards First Plasma is the ITER credits measure. This shows the expenditure incurred weighted by its relative importance (in terms of ITER progress); • The measurements of added value carried out for this report and the parallel VfM study use modelling of F4E data on contracts and contractors. These models could be rerun on an annual basis or some simple multipliers could be used to estimate jobs, GVA and spin offs based on these model runs (though the assumptions would gradually become outdated as the economy and ITER evolve).

6.1 What needs to be monitored?

As discussed in previous sections the most important objectives for EU participation in ITER can be split into the following two, high level, groups:

- **ITER Progress** – this relates to the progress of ITER towards first plasma and onwards toward DEMO;
- **Added Value** – this relates to the benefits that ITER participation provides to the EU and includes employment, economic benefit (company turnover and profits), innovation capacity and EU leadership

This chapter discusses the various indicators that could be used to measure and evaluate progress in these two areas. The current 'mid-term' evaluation[140] of ITER contains a detailed review of the progress made by ITER and the ways in which this measured, including a review of the performance framework. The report concludes that the framework of performance and progress indicators effectively report on progress and deviations from plans, and have been developed and improved over time, including the addition of support by IT based tools helping with saving data, analysing data and creating reports.

The report states that the framework covers progress and performance at different organisational levels, but as the project progresses (through the project improvements that were required during construction into operation) the most suitable indicators are likely to change.

6.2 Potential ITER progress Indicators

Our review of the F4E annual reports indicates that there are a very good selection of indicators already developed and reported that cover this issue. The following sections review those that appear most promising.

[140] The European Contribution to ITER: Achievements and Challenges. March 2018. Ramboll.

6.2.1 *Key performance Indicators*

The 2013-2016 F4E annual reports have five key performance indicators (KPIs) reported in them. These indicators are a measure of how many procurements were planned for each year, and how many were achieved. The variables reported are:

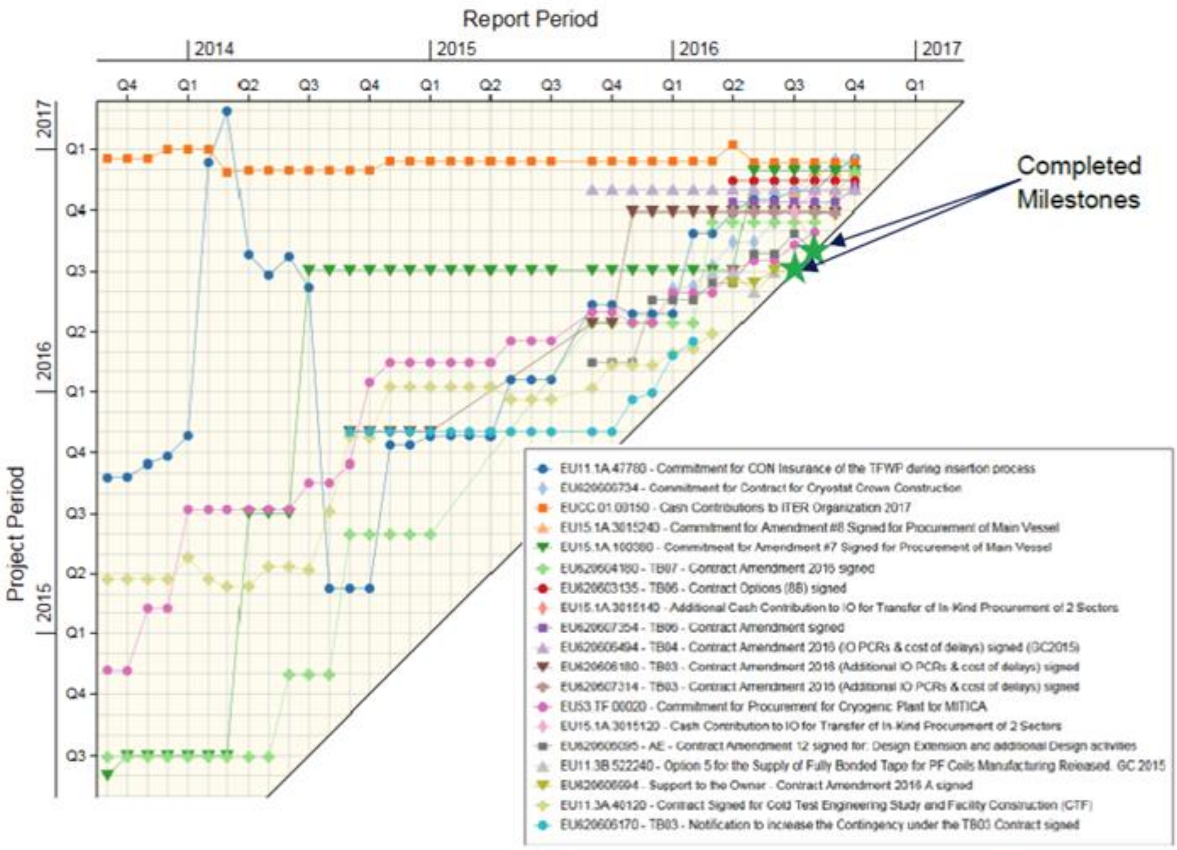
- Procurement Arrangements (PAs);
- Calls for tender;
- Contract signatures;
- Project plan milestones;
- Incoming inter-project links (IPLs). IPLs are milestones for the receipt by F4E of components, designs or other approvals from the IO or other Domestic Agencies (DAs).

The fact that F4E describe these as KPIs suggest that they are very well suited as measures of annual progress. However, the most recently published annual report (2016) has stopped reporting them in the same way as the previous reports, they report a single figure for all five rather than reporting them individually.

The report text implies that the F4E view of these indicators is not entirely positive and they are looking to report an alternative measure. The report says
"While milestone counting provides simple statistics, during 2016, the Milestone Trend Analysis method was introduced at F4E to objectively visualise the evolution of milestones in time and identify trends that indicate possible future slippages as early as possible. An example is shown in Fig. 6-1 for milestones associated with large financial commitments. This method enables F4E to better monitor the evolution of critical milestones, thus allowing F4E to tackle potential issues at an early stage and implement recovery/mitigation actions"

The figure referred to in the F4E text is reproduced below:

Figure 6-1: Milestone Trend Analysis Figure from the F4 E 2016 Annual Report



Source: F4E Annual Report (2016)

This figure contains a lot of information and is not suitable as a way for a non-expert to see progress.

6.2.2 ITER Credits

The F4E annual reports also report progress against projected spend, but not in pure cash, but in 'ITER credits'. These ITER credits reflect the fact that some milestones, and hence the expenditure associated with these milestones, are more important than others. F4E describes this as an Earned Value Management approach. The ITER credits approach is used extensively in the annual reports, but in most places, it refers to specific components and is in too much detail to provide an overall view on progress. However, the 2016 annual report includes the following Figure 6-2 which shows the ITER credit level achieved vs what was planned in the baseline. The first figure shows this for 2016 while the second figure shows this since 2010, with the baseline projected forward to 2034.

Figure 6-2: ITER Credits profile for 2016 and from 2010 to 2016 with the Baseline to 2034

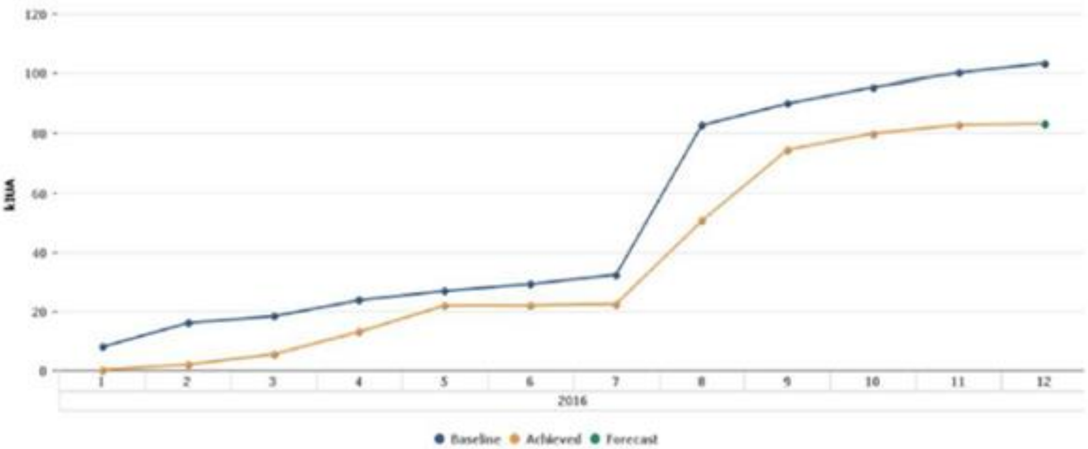


Figure 10: Comparison of the in-year Achieved and Planned Value of ITER Credit during 2016

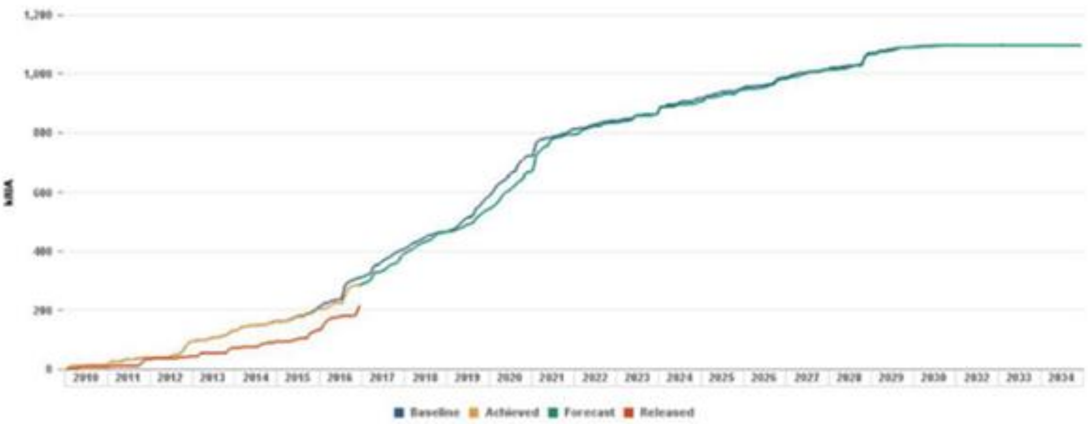


Figure 11: Comparison of the planned/achieved/released ITER Credit over the project lifetime

Source: F4E Annual Report 2016

6.2.3 Quality Assurance

The F4E annual reports also contain annexes that include Quality Assurance (QA) type indicators that appear to show how many of the contracts let each year have some form of problem. This appears to be an interesting potential way of picking up error rates in the work that its contracted. The insight it gives appears to relate more to the difficulties of designing and manufacturing the (often) unique and first of a kind, components that ITER requires. While this is interesting it is not really a measure of progress because these difficulties are related to the nature of the task and do not change according to progress towards the goal.

6.2.4 Component Design

The Commission SWD of June 2017 on the future of ITER states that:

"The final design for components needed for First Plasma has reached 89% while that for non-First Plasma components stands at 71%, according to information provided by the ITER Organization [1] "

6.3 Added Value Indicators

The economic modelling work that have been carried out for this impact assessment and for the value for money study has taken the data that is available on the number, size (value), sector and location of the contracts let by F4E and used these to model the wider economic benefits (jobs and GVA) that these contracts induce. This modelling could be used to produce simple multipliers that take the total contract value (let by F4E) and produce estimates of the resultant employment and GVA. The accuracy of these multipliers will decrease over time as the base data in the model that created them becomes outdated. The only way to keep these multipliers up to date would be to rerun the model with new base data.

The survey of F4E contractors that was conducted for the value for money study could be used as a source of information to estimate the number of spin outs and the protection and enhancement of innovative capacity that the spending on ITER induces. This requires the assumption that the survey is representative, the replies are honest and that the ratio between the total contract value let each year by F4E and these indicators remains constant. The ideal would be for these indicators to be tested each year via an annual survey of the contractors. F4E are in regular contact with their contractors, so it is possible that a selection of the questions used in the contractor survey could be resurveyed each year.

The concept of EU leadership in fusion research is very hard to objectively measure. Based on the fact that the current objectives assume that the current contribution to ITER demonstrates this, it could be argued that as long as the current arrangements are maintained this EU leadership remains.

7 Lessons learned and overall conclusions

7.1 Lessons learned

Through the course of our work on this project we have noticed a number of issues related to the options available for setting up and operating large scale, publicly supported science and research projects. Although these are somewhat beyond the scope of a normal impact assessment we feel there is value in summarising these lessons.

Starting point and history play important roles - It is hard to radically change direction when there are existing procedures, assumptions and people in place. Very few research projects are likely to start with a clean slate.

As does the projected end goal (and the prospect of a commercial return) - this has a major influence on the ease of involving private companies, and if a project has a clear and near-term prospect of commercial returns then the questions needs to be asked as to why the public are involved anyway.

The private sector can add considerable value, but not in every circumstance – If activities can be compartmentalised the private sector will often work out the way in which they can be delivered at the lowest cost. However, this implies the need to ensure that the quality and other factors (timelines, compliance, interoperability, etc.) are to the required standard. There are examples where private sector involvement clearly works, but there are also examples where it has not. Fighting to exclude or include it solely on political grounds is a mistake, and its involvement should be sought on a case by case basis.

One size does not fit all - Each project will have its own combination of history, technical challenges, political challenges and timescales. This implies that the management (legal form) and financial (delivery mechanism) approach needs to be tailored to these circumstances from the beginning.

ITER has evolved and improved and will continue to need to do so – The ITER project appears to have addressed (or to be addressing) many of its early problems. The problems it faces will change as its construction completes and its operation begins.

Management of public activities is a balance between transparency and independence – ITER has been a very heavily evaluated and audited project. The current approach appears to be valid and appropriate, but it is not possible to say if an alternative approach would have worked better. Given the large amounts of public funding involved in a single approach the level of scrutiny is appropriate, but this itself creates overhears and burdens.

Financing structures matters – For such a long-term project like ITER the length of the financial programme and the mechanisms through which it receives funds is crucial for its operational capacities and the ability to deliver the expected outcomes on time.

Risk is always present – Due to the level of complexity arising from the “first of its kind” nature of the ITER, as well as the global supply chain of materials and components, there are considerable risks which can affect the deliverables of the entire project. A political, financial or simple construction issue occurring at one of the ITER parties, can have an important consequence on the overall schedule.

7.2 Conclusions

The conclusions on the scenarios can be summarised under three main variables: financial, budget and delivery methods and the duration of the MFF.

Looking first at the **financial scenarios** they have a larger impact on the indicators of success than the budget and delivery methods and the duration of the MFF. The scenario which offers the most positives in all of the indicators in comparison to the baseline is the full new baseline (FNB), with each of the other financial scenarios, where the amount of money reduces, being less attractive. In comparison to the baseline between 2020 and 2030, the FNB results in 19,000 additional jobs, 5 billion Euro extra GVA, and an extra 3,000 jobs and an extra 700 million Euro GVA in spill overs. The scenario with the least investment (the EU Exit) results in a loss of 19,000 jobs, 5 billion Euro less GVA, and a loss of 3,100 jobs and 720 million Euro GVA in spill overs in comparison to the baseline.

Investment levels that are lower than the best estimate of what is required to keep ITER on track (i.e. the FNB) implies a reduction in the likelihood of ITER being delivered on time and to the required specification. Lower investment levels therefore reduce the value for money because they increase the chance of delays, and the chance that certain areas of work will need to be stopped and restarted in the future with a consequent increase in costs. Reducing the investment does not obviously or directly affect simplification, but the increases in risk associated with a reduction in investment are generally considered negative for simplification. Reductions in investment are also considered to have a negative impact on flexibility because they reduce the availability of budget to respond to potential requirements to move funds around (and/or make use of contingencies) to keep ITER on schedule and specification.

With regards to the **budget and delivery methods, t**he alternative combinations of delivery models and legal forms do not offer many clear benefits in comparison to the baseline (MFF programme + 'special' Joint Undertaking). The potential benefits that they do offer are largely outweighed by the dis-benefits of the disruption they cause (mostly related to delays because of the legal changes required) and consequent increases in risk.

With regard to pooled MS contributions, the results do not exhibit major changes in jobs or growth vs. the current contributions via the EC (disregarding the legal implications of changing the delivery mechanism, which could initially slow down employment growth of a specific scenario).

Moving to a standard Joint Undertaking (where private companies are allowed to participate) might increase the value for money and flexibility, by directly involving more commercially orientated partners. However, it could also increase risks and move against simplification by increasing the number of partners and implying a need to renegotiate the F4E structure and objectives.

Moving to a Decentralised Agency that is allowed to run procurement procedures, has the budget for the entire project decided at inception and only has one interlocutor (EC) for budget-related issues, delivers opportunities for simplification as well as risk mitigation. However, it also runs the risk of flexibility issues if the initial budget estimate turns out to be insufficient.

Member State Contributions and a Joint Undertaking leads to the same potential benefits in terms of value for money and flexibility from including private companies and could also bring some benefits by moving away from annual to multiannual budgeting. However, it would also increase risks and move against simplification by implying a need to renegotiate the F4E structure and objectives and by potentially increasing the direct influence of MS governments in the detailed operation and progress of ITER.

Member State Contributions and Intergovernmental Organisation leads to some of the same negatives as the MS contribution and joint undertaking option (i.e. increased risks). However, it could potentially help with simplification, if a model that was simpler than the current arrangements could be found, though this is by no means certain and it seems likely that the end result would be simpler in some areas (e.g. procurement rules) but more complex in others (e.g. the need for all the participating MSs to see what they regard as a fair return on their investments, in terms of contracts being awarded to their companies). This option also carries significant risk of delay and loss of reputation for the EU, as European fusion efforts would not continue to be under its direct influence.

The management changes in the IO and F4E in 2015 and 2016, and the detailed plan in place to 2025 mean that there is little appetite for further changes to the set up. It can therefore be concluded that, in order to guarantee the smooth continued operation of F4E to First Plasma in 2025 and hence the efficient use of European tax payer's money can almost only be guaranteed under a continued financial commitment according to the ITER agreement and an upholding of the delivery mechanism and legal status quo.

On the **duration of the MFF** for the FNB and NoC scenarios, the levels of funding under a five or seven-year MFF are higher than in the BAU scenario, while for the remaining years of a ten-year MFF (i.e. 2028-2030) the funding available is lower. Between 2020 and 2023, the impacts of the funding on jobs and growth gather pace each year, as the productivity impacts of the investment capital accumulate and influence economic activity in subsequent years. However, post 2023 this effect slows down, and post-2026 the sectoral shifts in activity and employment lead to jobs and GVA moving back towards the BAU case. In the PBR and 30R cases the employment and growth impacts are generally steady over time, with little growth in the impacts year-on-year, reflecting the fact that investment levels are constant (in current prices) over the period. For these scenarios the duration of the MFF has no real consequences on the effectiveness of the financing programme.

If the MFF was only 5 years long, it would put the negotiation period and change-over point to the next MFF immediately before 2025, which is the year when it will become apparent if the goal of first plasma has been reached on time. If First Plasma is delayed for any reason, and this is apparent at that time, it could make these negotiations more difficult for the EC and F4E.

Annex A: Legal forms

Based on Figure 4-2, there are several PPP scheme options from utility restructuring to full divestiture, depending on the level of private involvement:

- Utility restructuring, corporatisation and decentralisation is a first step for a public service or utility to gain greater autonomy or get private involvement. In that case, a separate legal entity is created with dedicated staff, board of directors and budget. It is essential to be combined with reforms ensuring the possibility of revenue coming from sales, retainment of excess revenue and responsibility in case of losses[141];
- Civil works and service contracts refer to when public services outsource a service or a procurement of civil works or equipment to a private company, e.g. providing costumer care or helpdesk support[142];
- Management contracts range from simple technical assistance to full operation and maintenance agreements, they refer to a specific task and usually last from 2 to 5 years. This type of PPP agreements is commonly used in the water sector and to a lesser extent in the energy sector, because these sectors are often considered politically too sensitive to allow higher private involvement[143];
- Lease contracts refer to agreements where the private sector is fully responsible for operating the service/utility but is not required to finance the investment. In these types of contract, a higher commercial risk is passed on to the private operator compared to the management contracts, they usually last longer, namely 8 to 15 years and they include an evaluation process every 4 or 5 years[144]. In the case of a lease the private operator retains revenue collected from the users of the utility/service and has made a specific lease fee payment agreement with the contracting authority. On the other hand, in an affermage[145], the private operator and the contracting authority share the revenue from the users of the utility/service, with the contracting authority bearing the investment risk[146];
- Concessions, Build-Operate-Transfer (BOT) and Design-Build-Operate (DBO) projects usually involve a substantial amount of design and construction effort and a long period of operation:
    - Concessions are long-term agreements (25 to 30 years, or long enough to amortise the initial investment) where the concessionaire is responsible for the operation and a significant fraction of the investment. The public authority keeps the ownership during the concession period and after the termination of it, all the assets are returned to the public authority. The concession includes the whole infrastructure, e.g. a complete highway, airport or bridge, and the concessionaire receives payment directly from the users of the utility/service, e.g. toll fees. Concessions are mostly focused on the output, namely the final outcome, e.g. a finished highway, and there is limited focus on the input, namely the concessionaire has a certain degree of freedom on how to achieve the desired output;

[141] https://ppp.worldbank.org/public-private-partnership/agreements/utility-restructuring-corporatization-decentralization
[142] https://ppp.worldbank.org/public-private-partnership/agreements/civil-works-and-service-contracts
[143] https://ppp.worldbank.org/public-private-partnership/agreements/management-and-operating-contracts#definition
[144] https://ppp.worldbank.org/public-private-partnership/agreements/leases-and-affermage-contracts#definition
[145] Affermage contracts are generally public-private sector arrangements under which the private operator is responsible for operating and maintaining the utility but not for financing the investment.
[146] https://ppp.worldbank.org/public-private-partnership/agreements/leases-and-affermage-contracts#definition

- In BOT projects the public authority grants the private investor the right to construct and operate a facility for a certain period, and usually refer to new projects rather than existing ones. The private investor is responsible for financing and operating the facility during the project period and after the termination of it the ownership of the facility is transferred to the public authority who first granted the right. In many cases, the project company is a special purpose vehicle, and the shareholders include companies with construction, operation and/or managerial expertise;
- In a DBO project, the public authority finances the construction of the new facility, while the private stakeholder is responsible for designing, constructing and operating the facility in a way to meet certain requirements. Administration for DBOs is simpler than concession and BOT schemes, as there are no financing requirements from the private stakeholders and the agreement only includes a construction and operation contract[147].

- A Joint Venture can be formed for an existing utility/service by selling shares to private investors, or in new projects by shared ownership between public and private stakeholders. The level of public ownership varies depending on whether the public authority is willing to keep the management of the utility/service or not. Nevertheless, public authorities can have a certain degree of control even with a minority share, by having the possibility to veto specific decision-making procedures. If a limited scope company is formed, it is common to transfer most of the key functions to the private shareholders through sub-contracts. It is also possible to have a joint undertaking in the form of either a partnership created for a special purpose, or a contractual consortium arrangement, in which the stakeholders work together on a specific project. In the first case, no separate legal entity is required and each of the stakeholders has full responsibility for the project, while in the other case, each stakeholder is rewarded based on the service/equipment provided[148];
- In full divestiture (privatisation) the whole ownership is transferred from a public authority to a private investor by selling shares in the utility/service. In case the private investors is not willing to accept all the existing liabilities of the utility/service, a special purpose company is formed where the assets of the utility/service are transferred, for which the private investor keeps track of records, before the complete acquisition. In contrast to private commercial companies, in divested facilities/services the public authority maintains some form of control, ensuring that the intended service is provided to the public[149].

[147] https://ppp.worldbank.org/public-private-partnership/agreements/concessions-bots-dbos#overview
[148] https://ppp.worldbank.org/public-private-partnership/agreements/joint-ventures-empresas-mixtas
[149] http://ppp.worldbank.org/public-private-partnership/agreements/full-divestiture-privatization

Box A-1: Case of a EU cPPP: ETP4HPC PPP[150]

European Technology Platform for High-Performance Computing (ETP4HPC)

The option of PPP was also initially selected for the High-Performance Computing (HPC) contract, when the contractual public-private partnership (cPPP) European Technology Platform ETP4HPC was created in 2013. However, the performance of ETP4HPC was ineffective which resulted in the formation of the HPC JU in March 2017. In spite the creation of the ETP4HPC, the problems which were initially identified and led to the creation of it, were still unresolved:

- The procurement of equipment was done by MSs in an uncoordinated way;
- Maintained fragmentation of European and national efforts;
- Innovative procurements were not used in HPC;
- Issues with the protection of Intellectual Property Rights (IPR);
- Not possible to coordinate efficiently or pool the available budget due to fragmentation across different funding programme;
- Lack of communication between industry and academia in exploiting high-performance computing systems.

Box A-2: Requirements to establish a successful PPP[151]

Requirements to establish a successful PPP

- Proper preparation: the public authority must define the project requirements clearly, assess the capabilities of the private sector, estimate potential benefits, identify the optimum risk allocation and VfM;
- In order to achieve a feasible solution a clear legal and regulatory framework is necessary;
- Sufficient time must be allocated for defining a robust PPP approach and previous cases estimate that this takes more than a year;
- A dedicated team with managerial and technical skills related to the project must be formed;
- Frequent evaluations to ensure that it continues to offer VfM;
- To attract the private sector's interest:
    - the private investors must be convinced over the potential financial benefits;
    - the lifetime of the project should not be too long to bear increased contingencies and risks.

[150] IMPACT ASSESSMENT Accompanying the document Proposal for a Council Regulation on establishing the European High Performance Computing Joint Undertaking. Available at: https://ec.europa.eu/digital-single-market/en/news/proposal-council-regulation-establishing-eurohpc-joint-undertaking-impact-assessment

[151] The Management Of The Galileo Programme's Development And Validation Phase. Available at: https://www.eca.europa.eu/Lists/ECADocuments/SR09_07/SR09_07_EN.PDF

Box A-3: Description of a Joint Undertaking

Joint Undertaking (JU)

- Autonomous EU legal entity with its own personnel, agenda and budget;
- Independent governance structure;
- Possibility of carrying out procurement procedures –though mainly use of grants for H2020 JUs [Exception is Euro HPC JU];
- Possibility of combining EU budget with other sources of public or private funding.

Box A-4: Case of a EU JU: Galileo JU[152,153]

Galileo JU

Galileo JU (GJU) was set up at the start of European involvement in satellite navigation, when it was decided to investigate the option of launching such a space programme. At that time, the EC had neither the required experience of running such a complicated programme nor the necessary technological background and know how. Therefore, it was a beneficial decision to join forces between the ESA (technical expertise), EC (potential programme manager) and the MSs (political masters). The main problems during the JU phase of the Galileo project were:

- The lack of programme management competences and leadership in the EC;
- The conflict of different managerial and organisational cultures among the stakeholders (industry, ESA and EC);
- The conflicting agenda of staff belonging to different organisations.

Box A-5: Case of a EU JU: HPC JU[154]

High-Performance Computing JU (HPC JU)

EC involvement in HPC started in the form of a cPPP (ETP4HPC), but due to poor performance it was converted into the HPC JU in March 2017. The option of JU was selected because it would enable the inclusion of scientific advisory board members with scientific and industrial background combined with related technology companies. Furthermore, it would ensure better coordination of the national HPC initiatives, enabling a joint procurement process to avoid duplication of research topics and waste of resources which would ultimately result in accelerating the research on scientific topics where HPC is essential for driving the research forward. In addition to that, JU has the possibility to set clear targets for the expansion of European-based HPC facilities which would give incentives to European HPC suppliers to collaborate closely with research institutes, which was identified as one of the key issues leading to the creation of the JU.

[152] The management of the Galileo programme's development and validation phase. Available at: https://www.eca.europa.eu/Lists/ECADocuments/SR09_07/SR09_07_EN.PDF
[153] Information extracted during phone interview with ITER stakeholder
[154] IMPACT ASSESSMENT Accompanying the document Proposal for a Council Regulation on establishing the European High Performance Computing Joint Undertaking. Available at: https://ec.europa.eu/digital-single-market/en/news/proposal-council-regulation-establishing-eurohpc-joint-undertaking-impact-assessment

ANNEX B: E3ME modelling methodology

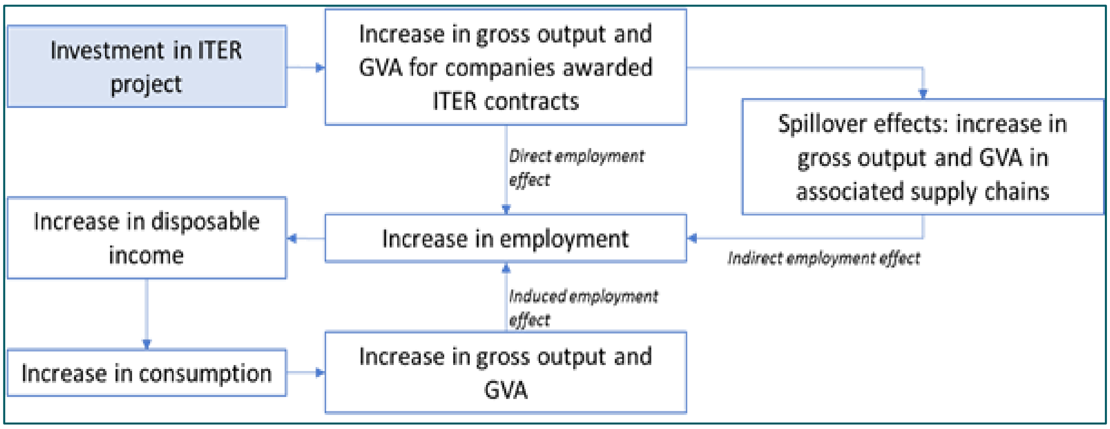
Impacts on jobs and growth

Currently, the EU's contribution to ITER (operationalized by Fusion for Energy (F4E)) is funded through its own programme within the Multi-Annual Financial Framework (MFF). Contributions are in the form of cash contributions to the budget of the ITER Organisation and in-kind contributions through delivery of components of the ITER machine. The econometric modelling assessment in this report explored the impacts of various future levels of funding to be included in the post-2020 MFF.

The E3ME model was used to assess the macroeconomic and sectoral impacts of the future funding levels, including the impacts on jobs, growth, industry output and the number of SMEs attributed to the Eurofusion investment programme. E3ME is a computer-based model of the world's economic and energy systems and the environment, covering 59 global regions, including 33 European countries and the six ITER Members outside of Euratom, namely US, Russia, Japan, China, South Korea and India. The model also covers 69 European industry sectors, based on standard international classifications, closely corresponding to the NACE 2-digit sectors. This high level of sectoral disaggregation allows for the assessment of the effects of specifically targeted investments under the ITER project since investments can be mapped to those sectors that are most likely to receive funding. As a macro-econometric model, E3ME uses an extensive historical database, covering the period 1970-2015 and projects forward annually to 2050. For a general description of the E3ME model please refer to www.e3me.com.

E3ME is built around an input-output structure with a detailed representation of industry interdependencies. This structure allows for the estimation of indirect and spill-over effects for a given level of investment, as well as the induced impact on employment. The key economic flows reflected in the E3ME model are shown in Figure B-1 below.

Figure B-1: Key economic flows modelled in E3ME



The post-2020 MFF funding values are presented as scenarios that explore a range of options for the level of funding that may be available for ITER post 2020, from a 'full new baseline' scenario, in which Euratom receives funding fully in line with the new ITER Baseline, plus a 15% contingency fund, through to complete withdrawal of Euratom from the ITER Agreement. Each of the scenarios are compared to the 'Business as Usual' (BAU) scenario, in which funding is assumed to be at the same level as under the current MFF. Each of the scenarios considers the possibility that the post-2020 MFF may be of a five-year duration, a seven-year duration or a ten-year duration with an obligatory mid-term revision.

The future funding values for the post-2020 MFF were inputted to the E3ME model as a change in investment within specific countries and sectors. This change may be positive or negative, depending on whether investment in a particular year is greater or smaller than in the BAU case. The countries and sectors in which to attribute the investment were decided upon based on research conducted in an earlier study carried out by Trinomics and Cambridge Econometrics *'Study on the impact of the ITER activities in the EU'*[155], which mapped historical ITER contracts and grants within the EU28 to the relevant E3ME sector and made forecasts of investment up to 2030 based on these historical patterns. The shares of investment made in these projections were applied to the future funding levels in the scenarios detailed in Table B-2.

Table B-2 below summarises the scenarios that represent the various funding levels post 2020, the inputs to the E3ME model and the assumptions made.

Table B-2: Scenario Details

Scenario name	Details	Values (in current prices)	E3ME input	Assumptions
Business as Usual (BAU)	Assumes the same level of funding as the budget within the current MFF	€0.42bn annually 2020-2025 + potentially €0.42 annually 2026-2027 €0.42 annually 2028-2030	N/A	Standard E3ME baseline is assumed to include this level of funding within its projections of the EU budget.
Full New Baseline (FNB)	Based on the new ITER baseline including a 15% contingency fund	€1.046bn annually 2020-2025 + potentially €0.874bn annually 2026-2027 €0.368bn annually 2028-2030	Change in investment based on the level of funding, compared to BAU.	Investment is shared out between countries and sectors according to shares derived from the earlier study[1].
New Baseline, No Contingency (NoC)	Based on the new ITER baseline but with no contingency fund	€0.91bn annually 2020-2025 + potentially €0.76bn annually 2026-2027 €0.32bn annually 2028-2030	As above.	As above.
Post-Brexit Reference (PBR)	Same proportion of ITER funding within the MFF as at present, while assuming the UK's departure leads to a 15% reduction in the EU budget	€0.36bn annually 2020-2025 + potentially €0.36 annually 2026-2027 €0.36 annually 2028-2030	Same methodology as the scenarios above, but the UK is excluded from receiving any funding.	We have assumed the UK no longer invests in ITER related activities and does not spend this money elsewhere. The government deficit is reduced, and the balance is therefore improved, rather than investment being spent elsewhere. In this scenario we have not reduced the overall EU budget,

[155] *Ref. Ares (2017) 1939420ENER/D4/2017-458*

Scenario name	Details	Values (in current prices)	E3ME input	Assumptions
				only the funding values related to the ITER programme[2]. When applying the funding values to countries and sectors, it is shared out amongst the rest of the EU (minus the UK).
30% Reduction (30R)	Assumes a 30% reduction in funding compared to the budget in the current MFF. This includes a 15% reduction following Brexit and the UK's subsequent departure plus an additional 15% reduction in the budget.	€0.30bn annually 2020-2025 + potentially €0.30bn annually 2026-2027 €0.30bn annually 2028-2030	As above.	As above.
EU Exit (EUX)	Assumes that the EU withdraws from the ITER project and no further contributions are made	€0 annually 2028-2030	Removal of investment.	We assume the EU (including all current 28 MS) withdraws from ITER and does not spend this part of the budget elsewhere. The future funding levels in the BAU case have been used as the potential reduction in available investment in this scenario.

Note(s):
1. Ref. Ares (2017) 1939420ENER/D4/2017-458
2. Reducing the overall EU budget would be a much bigger and more complicated modelling task. The results of such modelling would also be meaningless in terms of the specific impact of ITER funding options, as the impact of the overall budget reduction would override the small impacts of changes to ITER funding levels. A comparison to results of other funding options would therefore not be possible.

The methodology detailed above, and the scenario design provided in Table B-2 capture the *gross* impact of the investment, i.e. what the impact of the investment is compared to no investment at all. For the purposes of an impact assessment, it is essential to also consider the *net* effect of the investment, i.e. taking into consideration alternative uses for the money earmarked for the Eurofusion programme within the scenarios. For this reason, each of the above scenarios have also been modelled with an additional assumption that the total investment (as per the values set out for the post-2020 MFF) is instead spent in an alternative way, across all 69 economic sectors, in each MS within E3ME (with the UK being excluded from investment in the Brexit scenarios), leading to changes in output across all these sectors. This spending is shared between the sectors based on their respective share of output.

Impact of spill-overs

To assess the impact of potential spill-overs in each scenario, we start by considering the additional GVA that is generated (or lost) in each case. The VfM study carried out by Trinomics et al[156] included a

[156] *Ref. Ares (2017) 1939420ENER/D4/2017-458*

comprehensive survey of firms granted contracts by F4E for ITER-related activities. Based on the 35% of survey respondents who confirmed they had developed new cutting-edge technologies, we assume that 35% of the additional GVA generated by sectors *directly* affected by ITER investment can be attributed to spin offs. We make a further assumption that half of this percentage, i.e. 17.5%, of the additional GVA generated by sectors *indirectly* affected by ITER investment can be attributed to spin offs.

Firms will use part of this increase in GVA to make additional investment. If the scenario leads to a reduction in GVA we assume this is lost GVA that *could have* been used to make further investment. We assume this potential investment may be 50% higher than usual GVA/ investment ratios since investment in new spin-off companies or techniques is likely to be higher than standard investments. The increase/decrease in GVA, plus the likely investments this would have generated is then used as an input to the E3ME model. This allows for an assessment of the impact of spill-overs on jobs and further GVA.

ANNEX C: Literature Review

Date	Title	Author	Administrative Burden	Added Value	Benefits	Broader Approach	Challenges	Delivery Mechanisms	Effectiveness	EU Ability to Deliver	Evaluation of Pros and Cons	Flexibility	Growth	Jobs	Legal Forms	Risk	Simplification	Spill-overs	Synergies
1994	International Partnerships in Large Science Projects	Sedor, J.					X	X	X		X				X	X			
1995	International Partnerships in Large Science Projects	U.S. Congress, Office of Technology Assessment, International Partnerships in Large Science Projects						X											
1999	Transnational cooperation and policy networks in European science policy-making	Grande, E. & Peschke, A.						X	X		X				X				
2002	COUNCIL REGULATION (EC) No 58/2003 of 19 December 2002 laying down the statute for executive agencies to be entrusted with certain tasks in the management of Community programmes	Council of the European Union						X							X				
2003	Towards the Sixth Framework Programme	European Commission						X		X					X				
2004	COUNCIL REGULATION (EC) No 1321/2004 of 12 July 2004 on the establishment of structures for the management of the European satellite radio-navigation programmes	Council of the European Union						X							X				
2004	European Scientific Cooperation and Research Infrastructures: Past Tendencies and Future Prospects	Papon, P.									X				X				
2005	The implementation of a Public-Private Partnership for Galileo	Bertrán, X.	X	X	X			X		X				X	X				
2006	Mid-term Evaluation of the Galileo project for the period 2002-2004	COWI	X				X	X	X	X				X					
2007	Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project	International Atomic Energy Agency	X					X							X				

Date	Title	Author	Administrative Burden	Added Value	Benefits	Broader Approach	Challenges	Delivery Mechanisms	Effectiveness	EU Ability to Deliver	Evaluation of Pros and Cons	Flexibility	Growth	Jobs	Legal Forms	Risk	Simplification	Spill-overs	Synergies
2007	COUNCIL DECISION of 27 March 2007 establishing the European Joint Undertaking for ITER and the Development of Fusion Energy and conferring advantages upon it	Council of the European Union	X					X											
2007	COUNCIL REGULATION (EC) No 219/2007 of 27 February 2007 on the establishment of a Joint Undertaking to develop the new generation European air traffic management system (SESAR)	Council of the European Union						X							X				
2007	Intellectual Property in ITER	CEA/DSM	X			X	X			X									
2008	Ex-post evaluation of the European Fusion Energy Research Programme of the 6th research framework programme (EURATOM)	European Commission		X				X							X				X
2008	Identifying Formal Intergovernmental Organizations	Volgy, T.J. et al.						X							X				
2008	Intergovernmental Organization Memberships: Examining Political Community and the Attributes of International Organizations	Boehmer, C. & Nordstrom, T.						X							X				
2008	Le projet ITER, laboratoire de la recherche publique internationale	Institut d'Études Politiques, Université Lyon 2		X	X														
2009	COUNCIL REGULATION (EC) No 723/2009 of 25 June 2009 on the Community legal framework for a European Research Infrastructure Consortium (ERIC)	Council of the European Union						X							X				
2009	Evaluation of The Sixth Framework Programmes for Research and Technological Development 2002-2006	European Commission, Report of the Expert Group						X							X				
2009	The management of the Galileo programme's development and validation phase	ECA	X							X				X		X			
2010	Mid-term Evaluation of the SESAR Joint Undertaking (TREN/A2/143-2007)	COWI	X	X			X			X	X				X				
2011	Scheduling and its role in the management of ITER	Peter Swenson ITER Head of Project Office	X	X			X									X			

Date	Title	Author	Administrative Burden	Added Value	Benefits	Broader Approach	Challenges	Delivery Mechanisms	Effectiveness	EU Ability to Deliver	Evaluation of Pros and Cons	Flexibility	Growth	Jobs	Legal Forms	Risk	Simplification	Spill-overs	Synergies
2012	Fusion Electricity A roadmap to the realisation of fusion energy	EFDA		X	X					X								X	X
2013	Council Regulation on The ECSEL Joint Undertaking	European Commission						X							X				
2013	Organization without delegation: Informal intergovernmental organizations (IIGOs) and the spectrum of intergovernmental arrangements	Vabulas, F. & Snidal, D.						X			X				X		X		
2014	Annual Report	F4E	X	X	X		X		X		X			X		X			
2014	Annual Report	ITER IO	X					X											X
2014	COUNCIL REGULATION (EU) No 558/2014 of 6 May 2014 establishing the Clean Sky 2 Joint Undertaking	Council of the European Union						X							X				
2014	COUNCIL REGULATION (EU) No 560/2014 of 6 May 2014 establishing the Bio-based Industries Joint Undertaking	Council of the European Union						X							X				
2014	COUNCIL REGULATION (EU) No 559/2014 of 6 May 2014 establishing the Fuel Cells and Hydrogen 2 Joint Undertaking	Council of the European Union						X							X				
2014	COUNCIL REGULATION (EU) No 557/2014 of 6 May 2014 establishing the Innovative Medicines Initiative 2 Joint Undertaking (Text with EEA relevance)	Council of the European Union						X							X				
2014	COUNCIL REGULATION (EU) No 642/2014 of 16 June 2014 establishing the Shift2Rail Joint Undertaking	Council of the European Union						X							X				
2014	Innovation from Big Science: Enhancing Big Science Impact Agenda	Autio, E.									X								
2014	Multiannual financial framework 2014-2020 and EU budget 2014	European Commission		X											X				X
2014	Second mid-term evaluation of the SESAR Joint Undertaking	COWI	X	X			X			X	X				X				
2014	The Politics of European Collaboration in Big Science	Hallonsten, O.	X					X			X				X	X			

Date	Title	Author	Administrative Burden	Added Value	Benefits	Broader Approach	Challenges	Delivery Mechanisms	Effectiveness	EU Ability to Deliver	Evaluation of Pros and Cons	Flexibility	Growth	Jobs	Legal Forms	Risk	Simplification	Spill-overs	Synergies
2015	Annual Report	ITER IO								X	X							X	X
2015	A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy	European Commission		X	X														X
2015	Final Annual Accounts 2014	F4E					X			X	X					X			
2015	Financial Report for 2014	ITER IO					X			X	X					X			
2015	Money and Multilateralism: How funding rules constitute IO governance	Graham, E.R.						X		X	X	X			X	X	X		
2015	Report on the annual accounts of the European Joint Undertaking for ITER and the Development of Fusion Energy for the financial year 2014	ECA	X				X			X		X				X	X		
2015	The Multiannual Financial Framework and European Union Budget in Theory and Practice	Economic Alternatives, Issue 3, 2015								X									
2016	Annual Report	F4E	X	X	X		X		X		X			X		X			
2016	Annual Report	ITER IO								X	X							X	X
2016	Consolidated Annual Activity Report (CAAR) of the European Joint Undertaking for ITER Development of Fusion Energy (Fusion for Energy – F4E)	F4E						X											
2016	EURATOM Treaty, Consolidated Version	EU						X							X				
2016	Final Annual Accounts 2015	F4E					X			X	X					X			
2016	Financial Report for 2015	ITER					X			X	X					X			
2016	Independent Review of the Updated Long-Term Schedule and Human Resources (ICRG)	ITER Council Working Group	X						X							X			

Date	Title	Author	Administrative Burden	Added Value	Benefits	Broader Approach	Challenges	Delivery Mechanisms	Effectiveness	EU Ability to Deliver	Evaluation of Pros and Cons	Flexibility	Growth	Jobs	Legal Forms	Risk	Simplification	Spill-overs	Synergies
2016	ITER Organization 2016 Annual Report	ITER Organisation	X	X	X		X		X		X			X		X			
2016	ITER Council Working Group on the Independent Review of the Updated Long-Term Schedule and Human Resources (ICRG) Report	ITER Organisation							X					X					X
2016	Mid-term review/revision of the multiannual financial framework 2014-2020: An EU budget focused on results	EC						X		X									
2016	Progress in ITER Construction, Manufacturing and R&D, AEA Fusion Energy Conference, Kyoto	ITER Organisation								X						X			
2016	Report on the annual accounts of the European Joint Undertaking for ITER and the Development of Fusion Energy for the financial year 2015	ECA	X				X			X		X				X	X		
2016	U.S. Participation in the ITER Project	U.S. Department of Energy					X	X											
2017	Annual Report	ITER IO								X	X							X	X
2017	Briefing How the EU budget is spent	EP	X		X		X	X		X	X								
2017	Communication From The Commission To The European Parliament And The Council Eu Contribution To A Reformed ITER Project {SWD(2017) 232 Final}	European Commission	X	X			X	X							X				
2017	COUNCIL DECISION of 27 March 2007 establishing the European Joint Undertaking for ITER and the Development of Fusion Energy and conferring advantages upon it	Council of the European Union		X		X				X					X				
2017	Decision of The Governing Board Adopting the Annual and Multi-Annual Programme (2017-2021) of The European Joint Undertaking for ITER And the Development of Fusion Energy	F4E	X			X				X						X			
2017	Decision of The Governing Board Adopting the First Amended 2017 Work Programme of Fusion for Energy	F4E					X					X				X			

Date	Title	Author	Administrative Burden	Added Value	Benefits	Broader Approach	Challenges	Delivery Mechanisms	Effectiveness	EU Ability to Deliver	Evaluation of Pros and Cons	Flexibility	Growth	Jobs	Legal Forms	Risk	Simplification	Spill-overs	Synergies
2017	EU Contribution to a Reformed ITER Project	EC		X	X		X			X								X	X
2017	European Parliament, Briefing How the EU budget is spent September 2017, ITER.	EPRS	X		X	X	X	X	X			X		X	X	X			X
2017	Final Annual Accounts 2016	F4E					X			X	X					X			
2017	Final Evaluation of the SESAR Joint Undertaking (2014-2016) operating under the SESAR 1 Programme (FP7)	European Commission						X							X				
2017	Financial Report for 2016	ITER IO					X			X	X					X			
2017	Final Evaluation of the SESAR Joint Undertaking (2014-2016) operating under the SESAR 1 Programme (FP7)	COWI	X	X			X			X	X				X				
2017	Interim Report of The Committee on a Strategic Plan for U.S. Burning Plasma Research	Committee on a Strategic Plan for U.S. Burning Plasma Research Board on Physics and Astronomy Division on Engineering and Physical Sciences																	
2017	Reflection paper on the Future of EU Finances	EC	X					X		X									
2017	Report from The Commission To The European Parliament And The Council on the implementation of the Galileo and EGNOS programmes and on the performance of the European GNSS Agency	European Commission						X							X				
2017	Report on the annual accounts of the European Joint Undertaking for ITER and the Development of Fusion Energy for the financial year 2016	ECA	X				X			X		X				X	X		
2017	Social Report	ITER IO		X	X								X	X					
2017	The institutional design of funding rules at international organizations: Explaining the transformation in financing the United	Graham, E.R.						X		X	X	X			X	X			

Date	Title	Author	Administrative Burden	Added Value	Benefits	Broader Approach	Challenges	Delivery Mechanisms	Effectiveness	EU Ability to Deliver	Evaluation of Pros and Cons	Flexibility	Growth	Jobs	Legal Forms	Risk	Simplification	Spill-overs	Synergies
	Nations																		
2018	Annex to the Proposal for a Council Regulation on establishing the European High Performance Computing Joint Undertaking	European Commission																	
NA	Spanish industry capacities and activities in fusion energy	Spanish Ministry of Economy and competitiveness		X						X					X			X	X
NA	Financial Regulation of The Joint Undertaking	F4E																	

ANNEX D: Bibliography

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