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Exploitation and improvement of the external costs assessment of fusion power

Y. Lechón [a,*], H. Cabal [a], R.M. Sáez [a], D. Ward [b], B. Hallberg [c], K. Aquilonius [c], R. Korhonen [d], T. Hamacher [e], T. Schneider [f], S. Lepicard [f]

[a] *Euratom/CIEMAT Fusion Association, Avenida Complutense 22, 28040 Madrid, Spain*
[b] *Euratom/UKAEA Fusion Association, UK*
[c] *Studsvik Eco & Safety AB, Association Euratom-NFR, Sweden*
[d] *VTT Association Euratom-Tekes, Finland*
[e] *Euratom/IPP Fusion Association, Germany*
[f] *CEPN, Association Euratom-CEA, France*

Abstract

This study was performed in the framework of the Socio-Economic Research on Fusion (SERF 1999–2000), which is jointly conducted by Euratom and the fusion associations. An assessment of monetarized external impacts of the fusion fuel-cycle was previously performed applying the ExternE methodology (SERF-1), where, based on the SEAFP study, two different power plant designs were assessed, with the main difference being the structural materials and cooling system used. Although external costs values obtained were low, an improvement was achieved in the trade-off between design criteria and consequences on externalities. Structural and shielding materials in the previously studied plant models turned out to have a N-14 content that originated a significant amount of C-14 emissions. The present study includes alternative shielding materials with lower nitrogen content. With updated and improved technical and methodological inputs, a recalculation of externalities in the whole fusion fuel cycle was performed. © 2001 UKAEA. Published by Elsevier Science Ltd. All rights reserved.

Keywords: Fusion power; External cost; SERF-1

1. Introduction

Population growth and economic development result in a constant growing need of electricity. In the last years, industrialised and developing countries have been continuously looking for safer, cleaner and more efficient ways of obtaining energy. In this search, not only the scarcity of resources is born in mind by policy makers but also the environmental risks associated to the dominant use of fossil fuels. That leads to an increase in the investigations and supports received by the renewable sources. Fusion power is also an energy option to be taken into account when planning a global sustainable development since, even though it cannot be considered as

* Corresponding author. Tel.: +34-913-46-6321, fax: +34-913-46-6433.
E-mail address: yolanda.lechon@ciemat.es (Y. Lechón).

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renewable, it has the same advantages for inexhaustibility, safety, cleanliness and efficiency.

2. Externalities assessment

A well-proved method for evaluating the consequences of an energy option on the environment and society is the evaluation of the externalities, that can be positive (benefits) or negative (costs). External costs are those imposed on society that are not accounted for by the producers or consumers of energy, in other words, damages not reflected in the market price. To evaluate the externalities of a future fusion power plant, the Externe methodology (EC-DG XII, [1]) was chosen. That is a bottom-up methodology, developed within the EC Programme Joule II, which considers the effects of an additional fuel cycle located in a specific place. Quantification of impacts is achieved through the damage function or impact pathway approach that follows the sequence of events linking a burden, to an impact and subsequent valuation. This is considered one of the more updated and extensively applied methodologies.

In the previous phase of this project, an assessment of the external costs of two conceptual models of a fusion power plant was performed, based on the work developed in the SEAFP project [2], as well as a comparison with other competing energy options. The whole fuel cycle was analysed from the extraction of materials to the disposal or recycling of fusion waste. The results obtained (CIEMAT, [3]) confirmed the role of fusion as a sustainable energy source in the long term. Some elements were identified as the predominant cause of external costs, the most important being the C-14 emissions from normal operation and waste disposal.

Additional work has been carried out in the framework of the SEAFP (Safety and Environmental Assessment of Fusion Power) and SEAL projects [4] within SEAFP-2 of the Fusion Programme, on the aspects identified in the SEAFP project as needing further study and deeper understanding. Advances carried out in all of these aspects could have an impact on external costs produced, especially the use of low activation stainless steels which results in a decrease in C-14 inventories in the fusion waste. Externalities have been recalculated based on these last results.

The site selected for the implementation of the fusion power plant has been Lauffen (Germany), the same location selected in the SERF-1 project, from where some additional and more updated data have been incorporated. The reference technology is a hypothetical fusion power plant of 1000 MW that would be installed around 2050. For the reactor core three different models have been considered, differing in the used cooling medium and blanket concept [5]. The basic plant models are shown in Table 1.

2.1. Updating of technical inputs

The changes to the plant concepts, the more realistic materials and the switch to a stainless steel shield (which has the effect of reducing the C-14 generation but increasing other nuclides, such as Nb-94) are the main changes over the assumptions underlying earlier SERF-1 work.

Also the development of low activation materials has successfully addressed this issue, but the choice between different materials remains. There are developments in recycling opportunities that can considerably reduce waste volumes and vary with materials. The most important external cost identified in the earlier SERF-1 study was the

Table 1
Summary of the main properties of the three plant models

Plant model	FW/blanket structure	Tritium-generating material	Neutron multiplier	FW/blanket coolant
1	Vanadium alloy	Li_2O ceramic pebble bed	none	Helium
2	Low activation martensitic steel	Liquid $Li_{17}Pb_{83}$	$Li_{17}Pb_{83}$	Water
3	Low activation martensitic steel	Li_4SiO_4 ceramic pebble bed	Beryllium	Helium

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