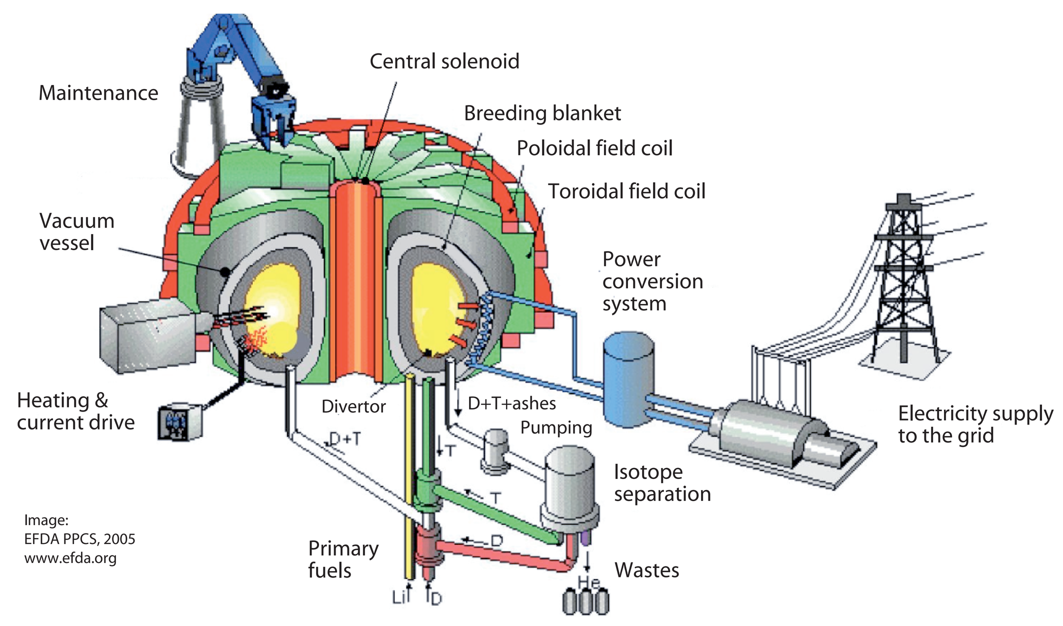
LASEN Laboratory of Energy Systems
CEMI Chair of Economics and Management of Innovation

Estimating spillover benefits of Fusion energy research, development, demonstration and deployment program

Magnetic Confinement Thermonuclear Fusion Technology

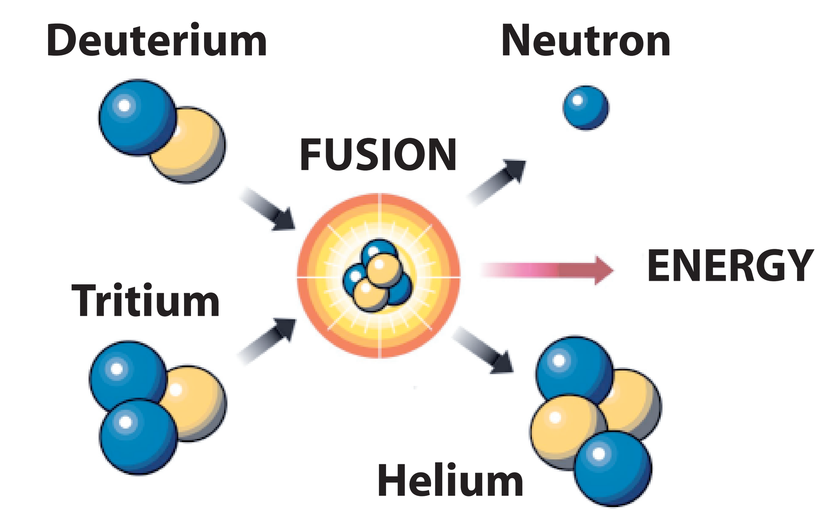


Key Advantages

- Abundant and world-wide equally distributed fuel resources
- Inherently safe (no runaway chain reaction)
- No local air pollution, no emissions of greenhouse gas
- No high-level long-lived radioactive wastes

Drawbacks

- Very long research & development cycle
- Complex reactor technology



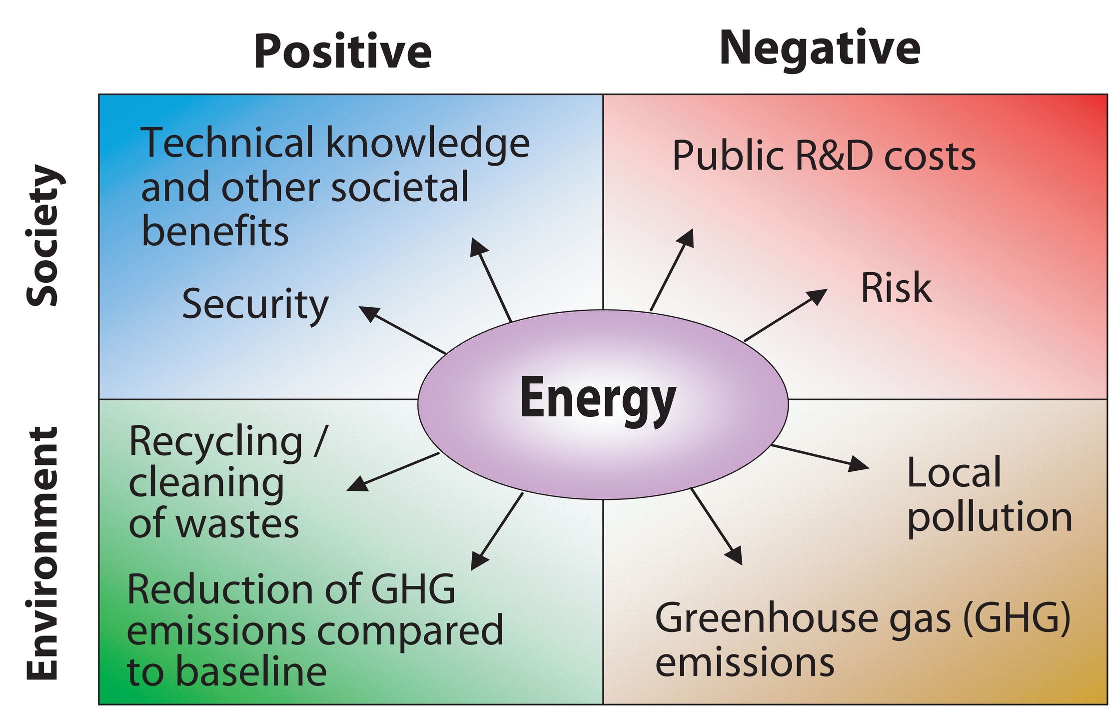
1g of D + T --> 30000 kWh of electricity

Context

- The global quest for energy security creates the need for accelerated development of new safe, clean and resource unconstrained energy technologies, such as thermonuclear Fusion.
- Considering that the expected benefits of Fusion technology are confronted with a high degree of uncertainty, the decision-makers are facing the problem how to optimise the public funding of Fusion RDDD program.
- Recent R&D evaluation practice and scientific literature suggest to consider all social costs and benefits, including negative and positive externality effects, while allocating public funds among multiple R&D programs.
- However, the practical tools allowing to perform socio-economic assessment of global long-term energy R&D programs, such as Fusion, including their positive externalities (spillover benefits), are still missing or incomplete.

Externality Concept

Externalities, also known as spillovers or third-party effects, are unpriced by-products of the production or consumption of goods and services of all kinds



Objectives

1. To identify the main types and specific examples of positive externality effects (spillovers) of Fusion RDDD.
2. To develop an integrated methodological framework that would allow for taking into account spillover benefits in the socio-economic evaluation of Fusion RDDD program.
3. To carry out a case study of Wendelstein 7-X Fusion stellarator experimental facility.
4. To elaborate a set of plausible Fusion demonstration and deployment scenarios and to perform on this basis prospective evaluation of Fusion RDDD program.

Methodology

Module 1
Fusion R&D Spillovers Modelling
Ex post / near term ex ante microeconomic assessment of the socio-economic benefits of Fusion R&D projects

Module 2
Global Long Term Energy Scenarios Building
Prospective techno-economic analysis of future energy markets and projection of potential market share of Fusion technology

Module 3
Fusion R&D, Demonstration and Deployment Scenarios Simulation
Ex ante socio-economic assessment of Fusion RDDD program basing on the global / regional electricity supply scenarios and taking in account the spillover benefits of Fusion RD&D activities and construction of commercial Fusion power plants

Module 4
Strategic Evaluation and Policy Recommendations
Sensitivity analyses and strategy optimisation

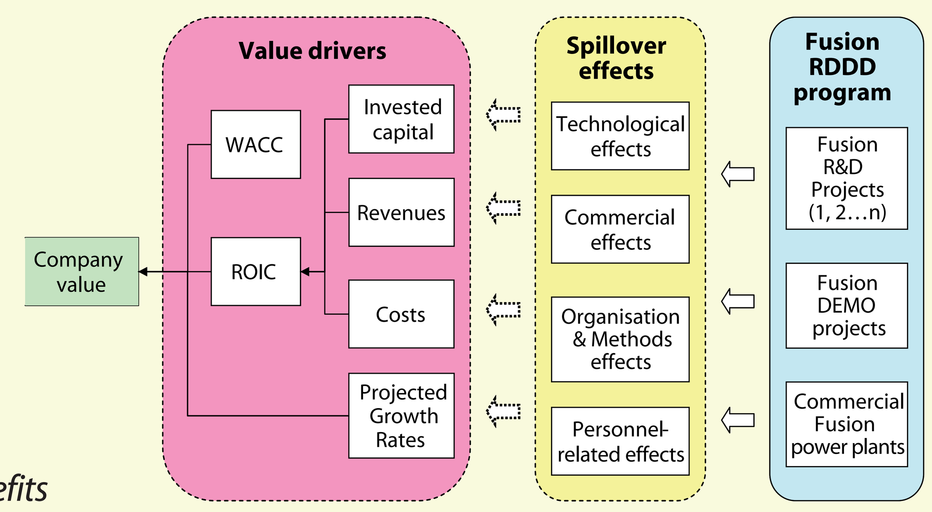
Classification of Fusion RDDD Spillovers

Form \ Level	Intra-sectoral	Cross-industry	Macroeconomic
Embodied	**Improved performance / lower cost of clustered components specific to different energy technologies** (due to learning-by-doing); **Non-electric applications** (heat & hydrogen production; nuclear fuel transmutation; spent fuel treatment)	**Technology spin-offs** (non-energy applications of technologies and products developed in the process of Fusion R&D); **Network spillovers** (learning and scale economies due to increased demand for subjacent products and services; induced innovation in related sectors)	**Market spillovers** (due to supply of competitively priced energy services and non-energy products / services); **Induced economic activity at regional scale** (due to economic multiplier effects); **Improvement of national payment balance** (due to technology export and reduction of fossil fuel imports); **Energy security enhancement**
Disembodied knowledge spillovers	**Accumulation of knowledge stock** (publications, patents); **Formation of human capital** (PhDs, experienced researchers, research networks); **Strengthening of companies' technological and marketing capabilities**; **Creation of "real option" value** (due to flexibility in managerial decisions); **Success / failure signals to industry**		

Module 1

Conceptual Fusion R&D spillovers model

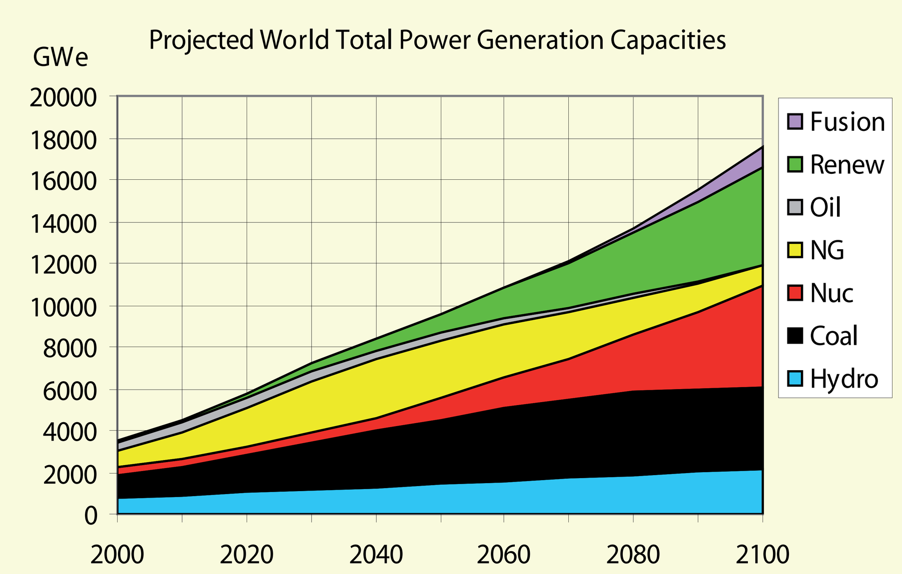
- *Spillover benefits are estimated at the level of individual companies participating in Fusion R&D projects*
- *It is assumed that Fusion R&D spillovers may have a positive impact on the key driving factors of the company value, namely return on the invested capital and growth rate, and their underlying drivers*
- *Calculation of the company value is based on the "Economic Value Added", also known as "Economic Profit" approach*
- *The increase in the company's value subject to different Fusion demonstration, deployment and indicative (no Fusion) scenarios is taken as proxy of the pecuniary value of Fusion R&D spillover benefits*



Module 2

Global long-term energy scenarios building with PLANELEC-Pro model

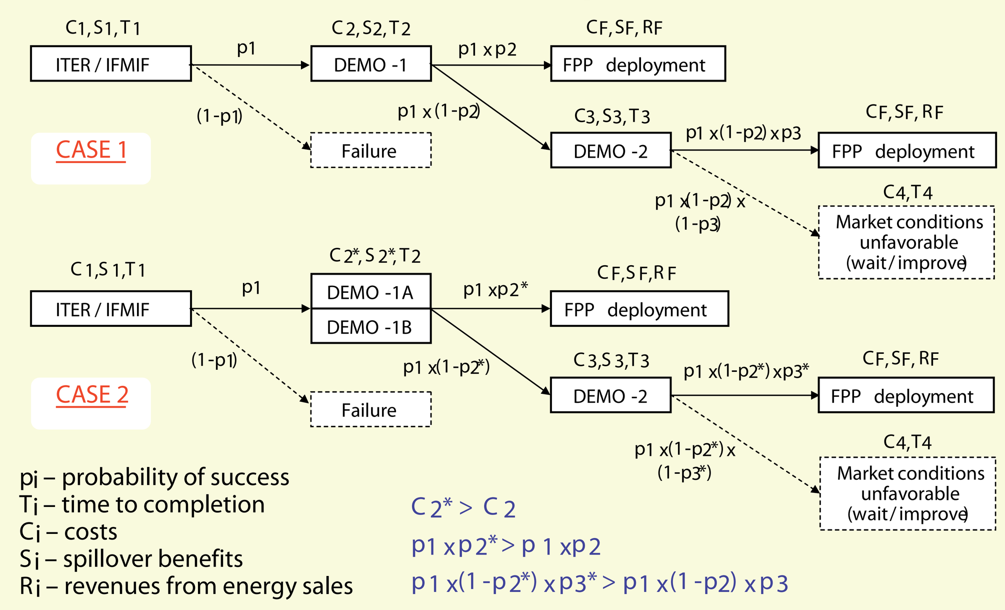
- *Long-term electricity supply scenarios have been developed for 11 world regions using least cost probabilistic simulation dynamic programming model PLANELEC-Pro*
- *The model allows to determine the optimal expansion plans of the power generation systems that adequately meet the projected electricity demand at minimum cost given the quality-of-service and CO2 emissions constraints*
- *The outputs of the model are optimal expansion plans concerning the number, the time and the type of power plants to be installed, total discounted cost of the expansion plan, levelized system electricity cost, CO2 emissions of each year, etc.*
- *For each of the world regions a "reference" case of system expansion without Fusion and its different variants providing for introduction of Fusion power are simulated*



Module 3

Fusion RDDD Real Options model

- *Stochastic Real Options model is being developed in order to perform overall socio-economic assessment of Fusion RDDD program*
- *Numerical estimates of Fusion RD&D spillover rates as well as the costs & revenues of future Fusion power plants (FPPs) are taken as inputs from Modules 1 & 2; assumptions on the deployment spillover rates as well as the cost, duration and probabilities of success of Fusion "R&D" and "Demo" stages are taken as exogenous inputs*
- *The model takes into account both types of uncertainty (aleatory and epistemic) and allows to estimate "strategic" value of Fusion RDDD program arising due to flexibility in the managerial decisions (options to wait / improve if market conditions are unfavourable)*



Publications

- Gnansounou E., Bednyagin D. (2007) Multi-Regional Long-Term Electricity Supply Scenarios with Fusion, *Fusion Science and Technology*, Vol. 52:3, pp. 388-393
- Gnansounou E., Bednyagin D. (2007) Estimating Spillover Benefits and Social Rate of Return of Fusion RDDD Program: Conceptual Model and Implications for Practical Study, *Report on task TW5-TRE-FESS/D*, EFDA - SERF

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Preliminary Results and Conclusions

- Integrated evaluation framework developed in the present study represents an important step forward in the practice of the socio-economic evaluation of global long term RDDD programs in energy sector due to inclusion in the analysis of the previously ignored value of the positive externality effects.
- The results of the simulation of multi-regional electricity supply scenarios demonstrate that Fusion power may become an important energy supply option by the end of XXI century (with market share up to 20% in most developed world regions) provided that sufficient public funding is granted during the demonstration and initial deployment stages.

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