EXTERNAL COSTS OF FUSION POWER PLANTS COMPARED TO OTHER ADVANCED GENERATION TECHNOLOGIES

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Socioeconomic Research on Fusion SERF *3*

EUROPEAN COMMISSION FUSION PROGRAMME

Image of the first plasma from the stellerator TJ-II in CIEMAT (16/12/97)

FUSION: clean, safe and inexhaustible.

Fusion is one of the few energy options that could make a large contribution to world energy production from the middle of the 21st century onwards.

It would have certain intrinsic advantages:

- the basic fuels (D, Li) are non-radioactive, plentifully available and fairly evenly distributed throughout the Earth's crust. Tritium the only radioactive fuel is produced from Lithium within the reactor using the neutrons produced in the fusion reaction.
- a runaway fusion reaction is intrinsically impossible since there are not chain reactions.
- there are few radioactive waste problems since no actinides are produced

OBJECTIVES OF THIS WORK

- What are the environmental external costs of fusion power?

- How does fusion compare with competing energy generation technologies?

EXTERNALITIES

Externalities are defined as **costs/benefits** imposed on society by the generation of energy that are not accounted for by the producers or consumers of energy, and therefore **not included** in the **market price**.

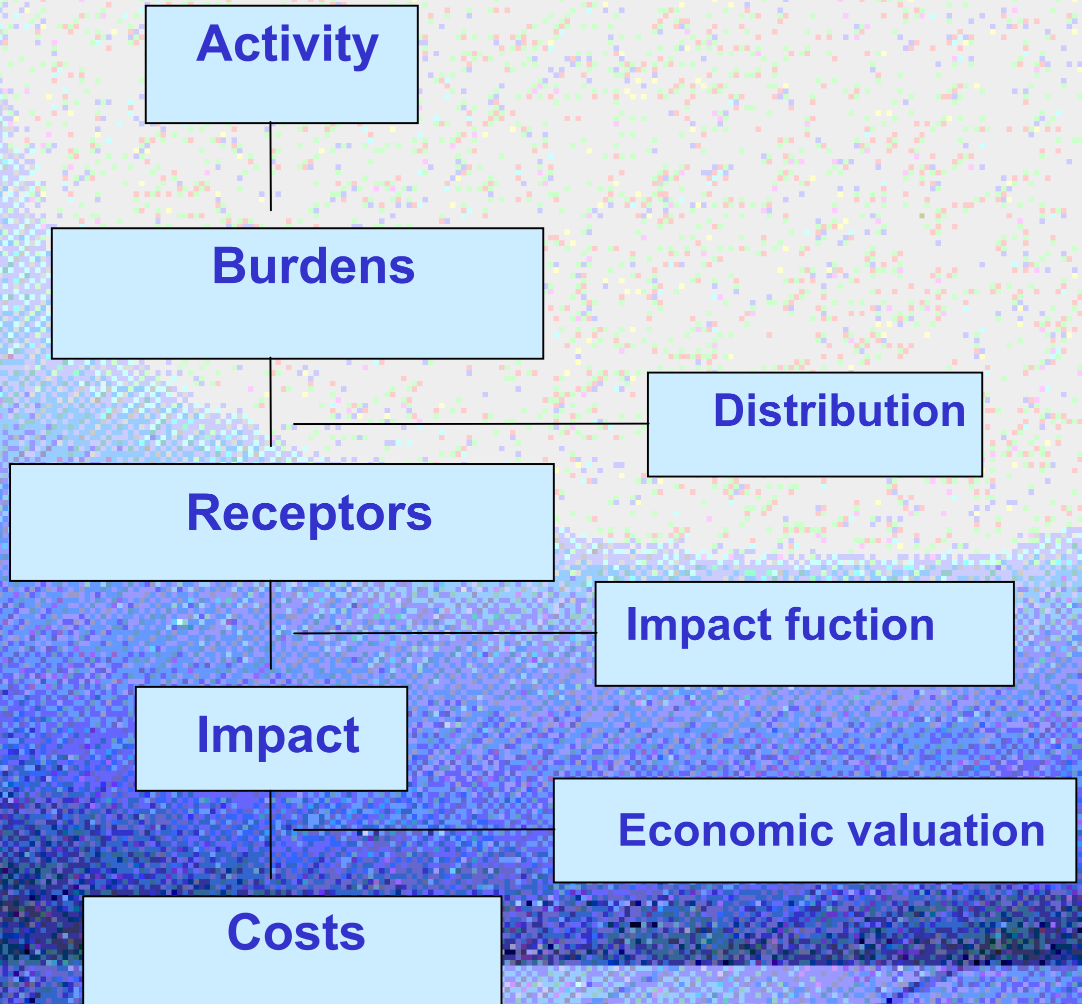
The existence of these externalities produces a distortion in the market, which fails to efficiently allocate resources to the different energy options.

Quantification of externalities and their internalization into prices, through market based mechanisms, is a condition of attaining a sustainable energy production system.

THE EXTERNE METHODOLOGY

- Bottom-up methodology
- Site specific and marginal approach
- Impact pathway approach for the quantification of impacts

The impact pathway approach



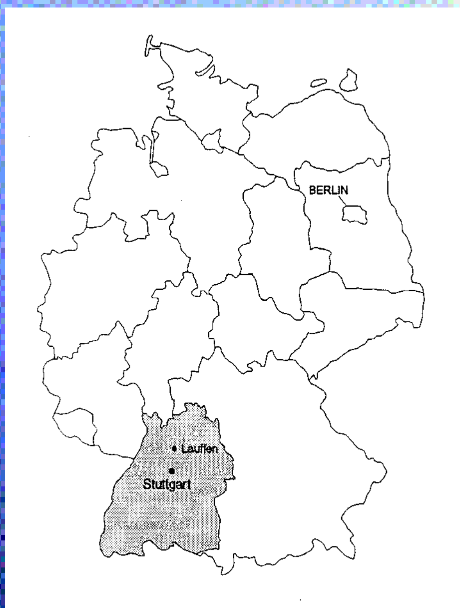
Stages of the methodology

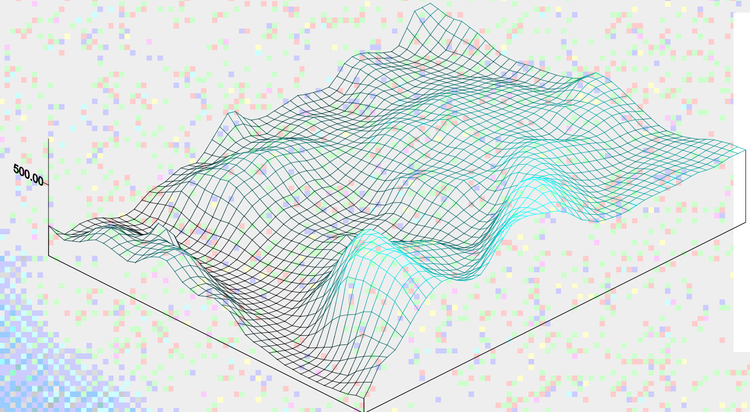
- Site and technology characterisation
- Identification of consequences and impacts
- Prioritisation of impacts
- Quantification of impacts
- Economic valuation
- Assessment of uncertainty

Assumptions

- Discount rate: 0%
- Selection of time horizon for long term impacts: 10000 years
- Cost factors used for climate change impacts:
  Damage factor proposed by ExternE: 2.4 Euro/t CO_2.
  Abatement cost: 19 Euro/t CO_2

The site


BERLIN
Lauffen
Stuttgart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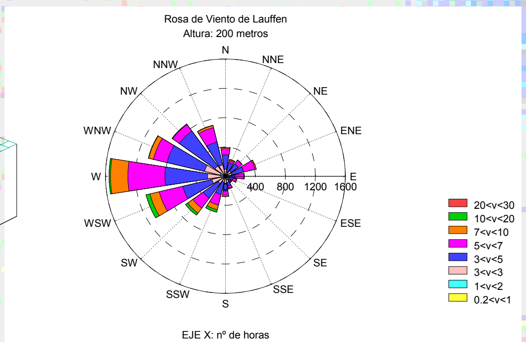
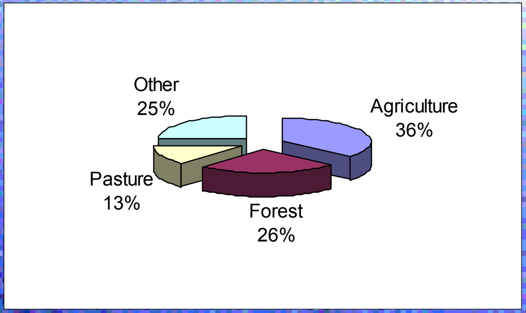
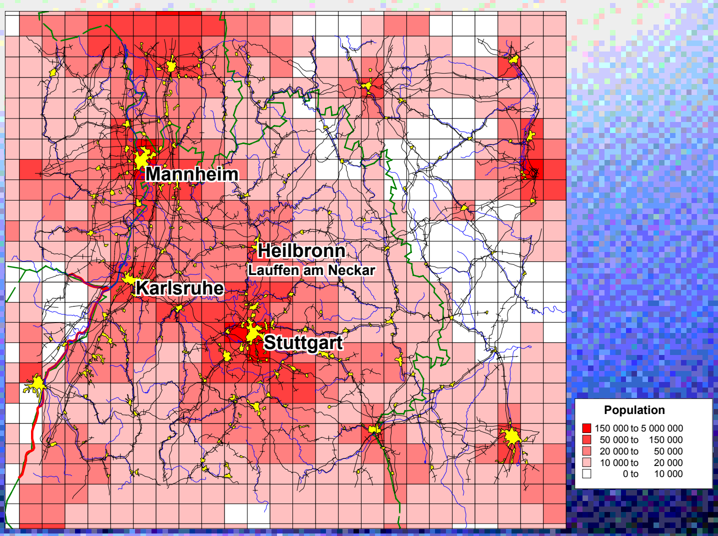

Rosa de Viento de Lauffen
Altura: 200 metros
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
400
800
1200
1600
20<v<30
10<v<20
7<v<10
5<v<7
3<v<5
3<v<3
1<v<2
0.2<v<1
EJE X: nº de horas


Other
25%
Agriculture
36%
Pasture
13%
Forest
26%


Mannheim
Heilbronn
Lauffen am Neckar
Karlsruhe
Stuttgart
Population
150 000 to 5 000 000
50 000 to 150 000
20 000 to 50 000
10 000 to 20 000
0 to 10 000

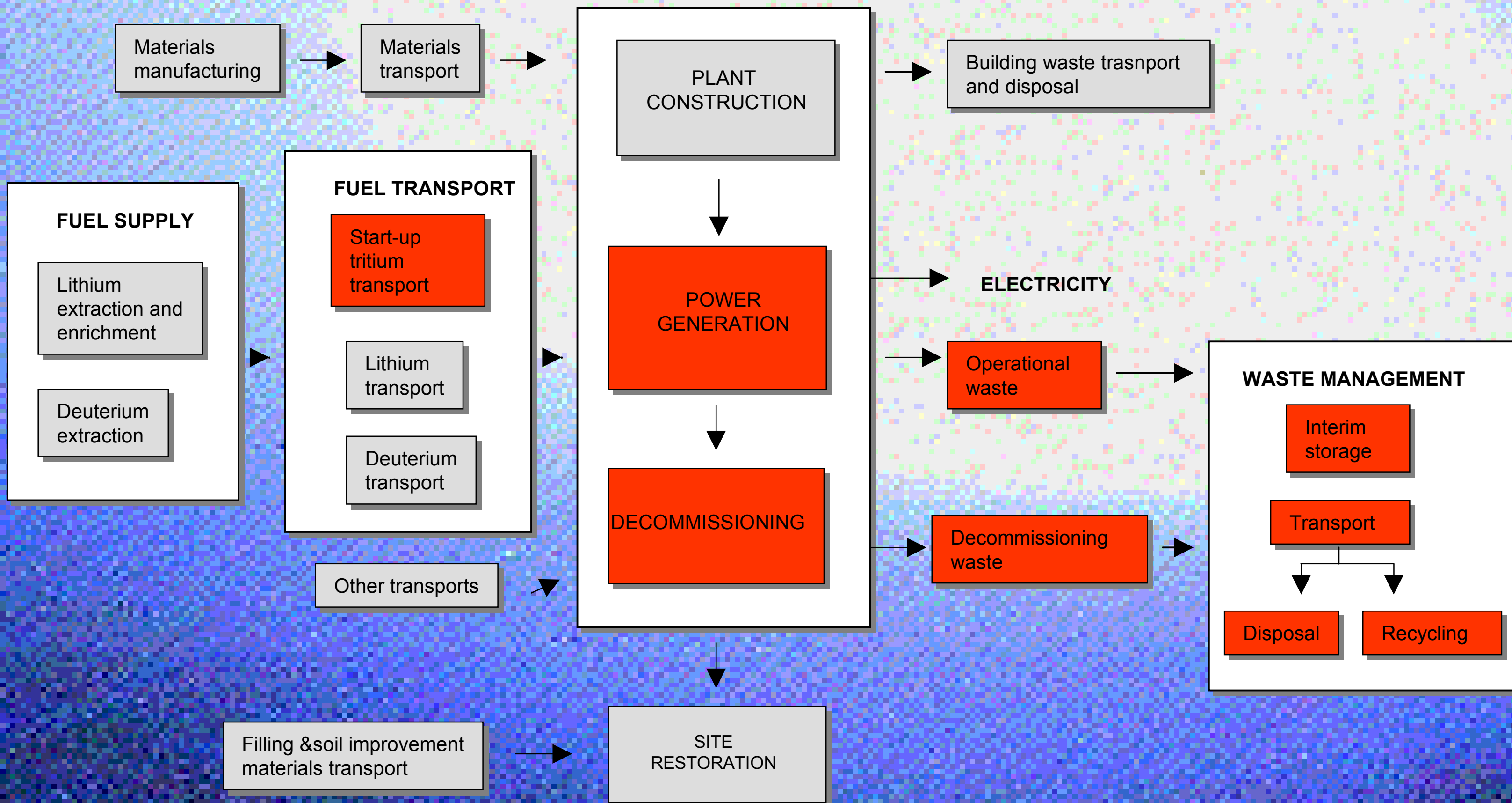
The technology

The reference technology is a hypothetical fusion power plant that would be installed around 2050. For the reactor core six different models have been considered, differing in the used cooling medium and blanket concept.

Plant Model	FW/blanket structure	Tritium-generating material	Neutron multiplier	FW/blanket coolant	Electrical power MW
1	vanadium alloy	Li_2O ceramic pebble bed	None	Helium	1000
2	low activation martensitic steel	Liquid $Li_{17}Pb_{83}$	$Li_{17}Pb_{83}$	Water	1000
3	low activation martensitic steel	Li_4SiO_4 ceramic pebble bed	Beryllium	Helium	1300
4	SiC/SiC	Liquid $Li_{17}Pb_{83}$	$Li_{17}Pb_{83}$	liquid $Li_{17}Pb_{83}$	1500
5	LA martensitic steel with SiC/SiC insulators	Liquid $Li_{17}Pb_{83}$	$Li_{17}Pb_{83}$	Helium and liquid $Li_{17}Pb_{83}$	1500
6	SiC/SiC	Li_4SiO_4 ceramic pebble bed	Beryllium	Helium	1500

Reactor core data: SEAFP project. Buildings and help systems: ITER design. Conventional part of the power plant: based on fission power plants

The fuel cycle



Burdens and impacts. Upstream stages

Manufacturing of Materials

- Procurement, processing, working up of the materials of the power plant.
  - ✓Energy
  - ✓Emissions CO_2, N_2O, CH_4, SO_2, NO_x

Construction of the power plant

- Transport of materials: atmospheric emissions and road accidents
- Building activities: Occupational accidents

Burdens and impacts. Plant operation.

Normal operation

- Atmospheric releases → Inhalation, External exposure, Ingestion
- Aquatic releases → Ingestion
- Occupational exposure
- Non radiological occupational accidents

Accidents

- Loss of coolant, radioactivity mobilization and release of tritium

Burdens and impacts. Decommissioning and site restoration.

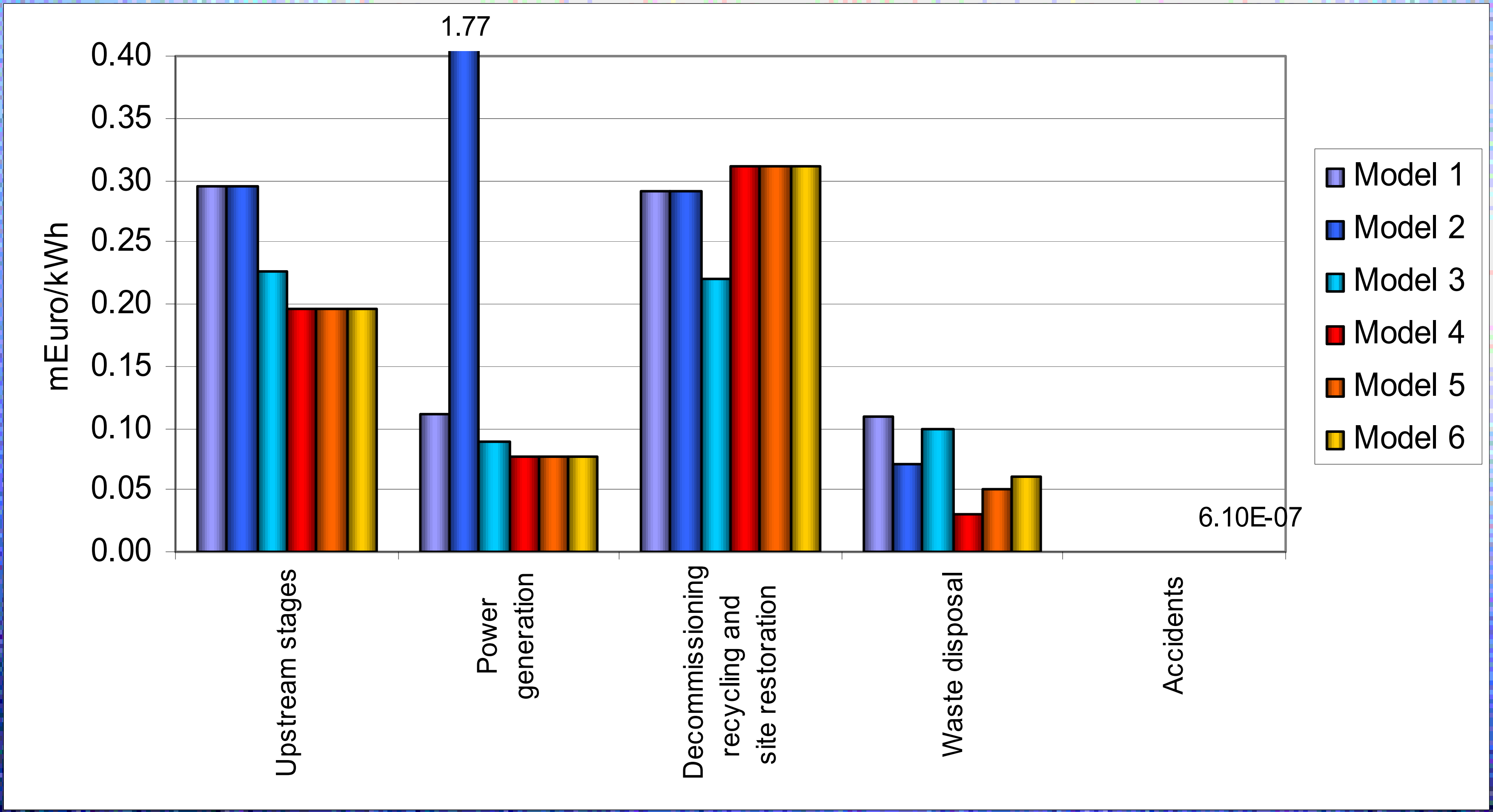
Decommissioning

- Demolition of the buildings
- Decontamination
- Transport of waste
- Recycling plant
- Disposal of waste

Site restoration

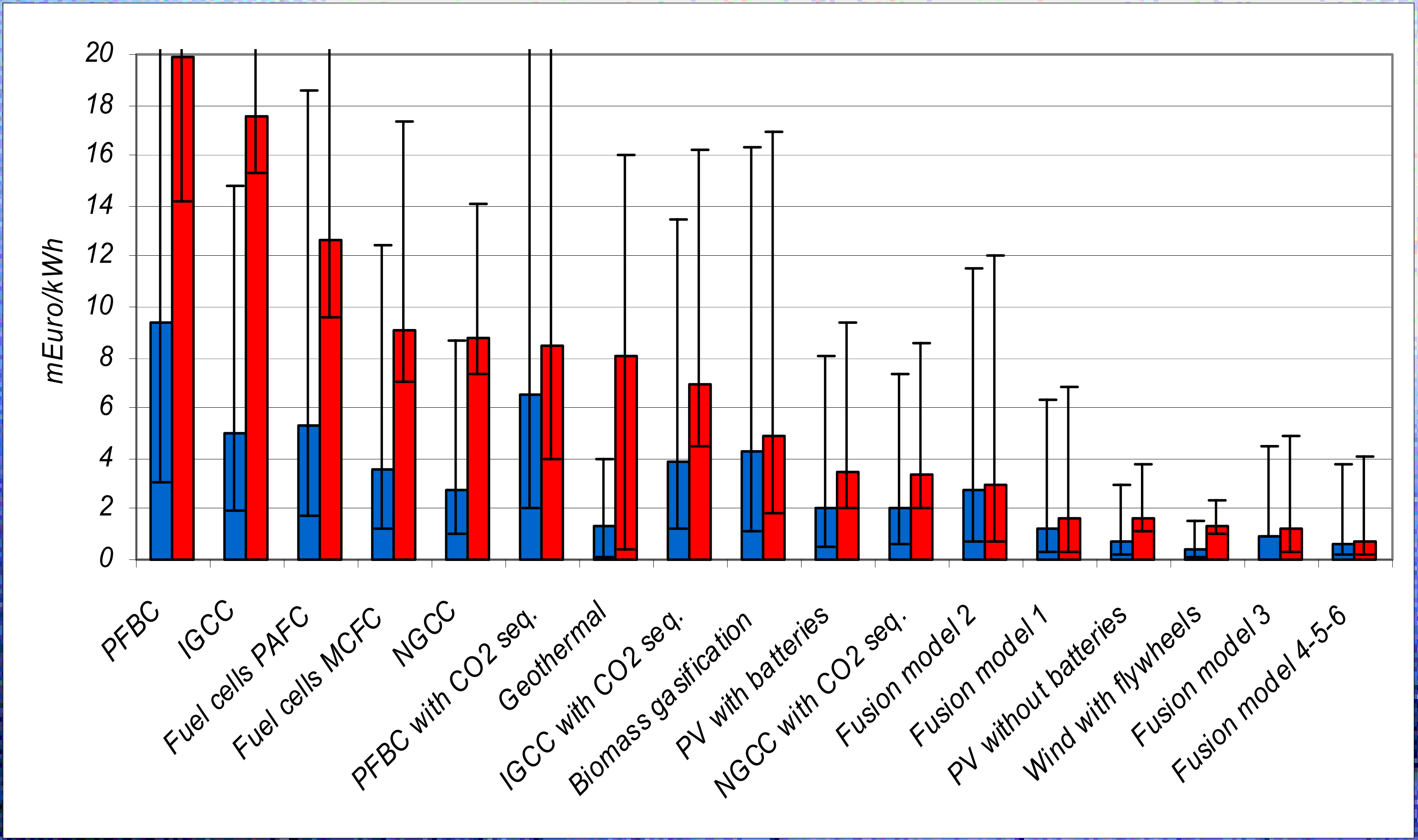
- Transport of building materials
- Filling
- Planting

RESULTS



Model 1: 0.81 mEuro/kWh
Model 2: 2.42 mEuro/kWh
Model 3: 0.63 mEuro/kWh
Model 4: 0.61 mEuro/kWh
Model 5: 0.64 mEuro/kWh
Model 6: 0.64 mEuro/kWh

Comparison with other advanced technologies



CONCLUSIONS

The various models of fusion power plants analysed have external costs that are in the lowest range of the external costs of advanced generation technologies, indicating the outstanding environmental performance of fusion power. This fact, together with other inherent characteristics of fusion energy such us its inexhaustibility, qualify it as a sustainable energy option in the future.

Image of the first plasma from the stellerator TJ-II in CIEMAT (16/12/97)