



Fusion Industry Innovation Forum

Beyond ITER

Fusion Industry Innovation Forum

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Technology transfer

Developing skills

Roadmap to fusion power

Content

- Future prospects of Energy context
- Electricity from fusion – *when and how*
- Research and industry – *building a stronger relationship*
- Intellectual Property – *a requirement for competitiveness*
- Technology Transfer – *benefiting from research*
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- Conclusions

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Energy context

- 1) **The world uses a lot of energy** (average 2.4 kW per person, 5.1 kW in UK) **but very unevenly** (use per person in USA = 2.1x UK = 48x Bangladesh). **1.6 billion people** (over 25% of the world's population) **lack electricity**
- 2) **World population will increase a lot by 2050 chiefly in Asia and Africa**
→ growth necessary to lift billions of people out of poverty and allow **development**
- 3) **80% of energy is generated to day by burning fossil fuels**
→ concern for **geopolitical** concerns
→ concern for the **environment**

**Need for more efficient use of energy
and for major new/expanded sources of cleaner energy**

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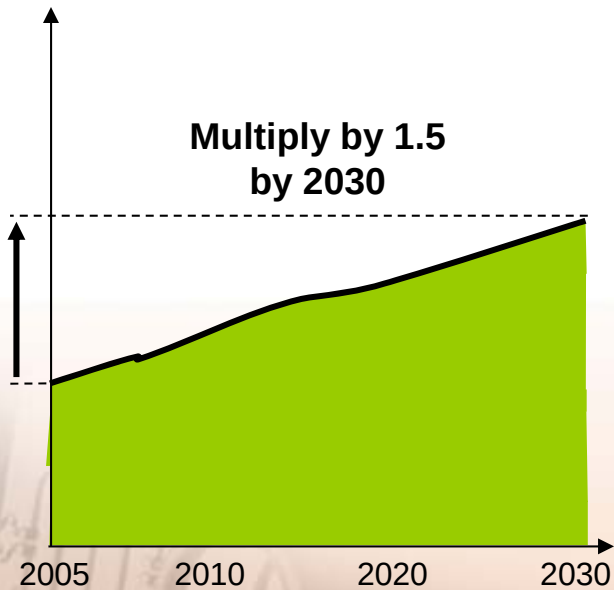
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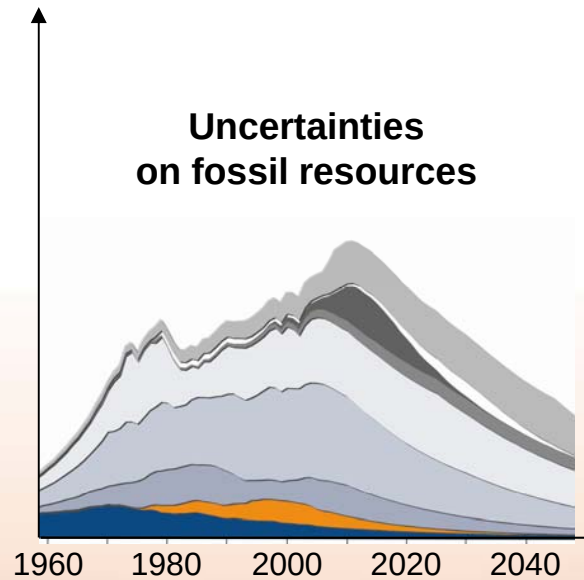
Energy, development , environment :

three simultaneous major challenges for a global world

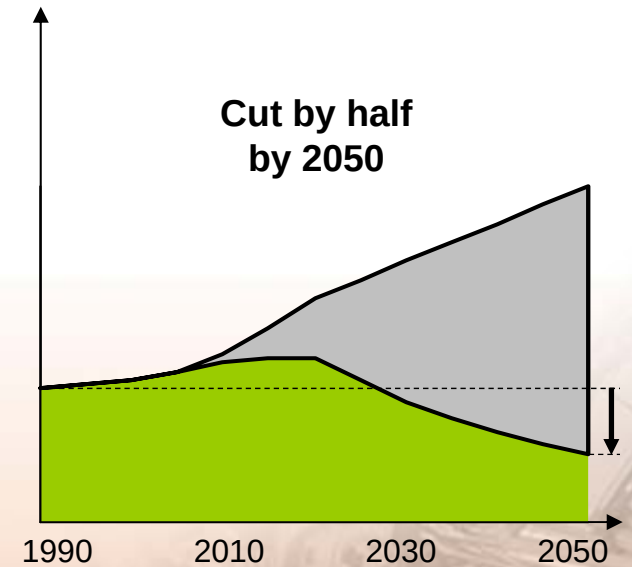
Energy demand



Oil & Gas availability



GHG emissions

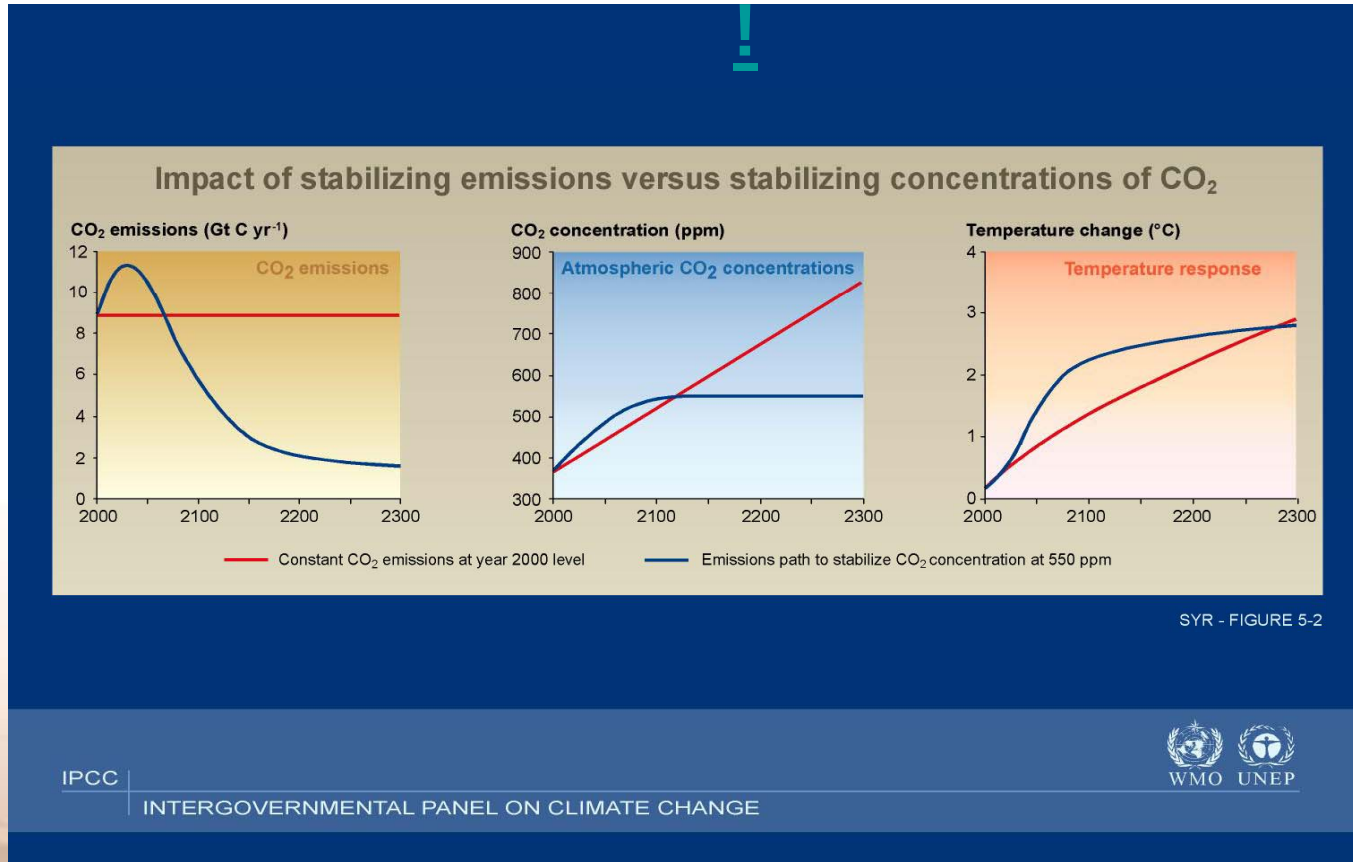


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Consequences for hundreds of years mean “act now”

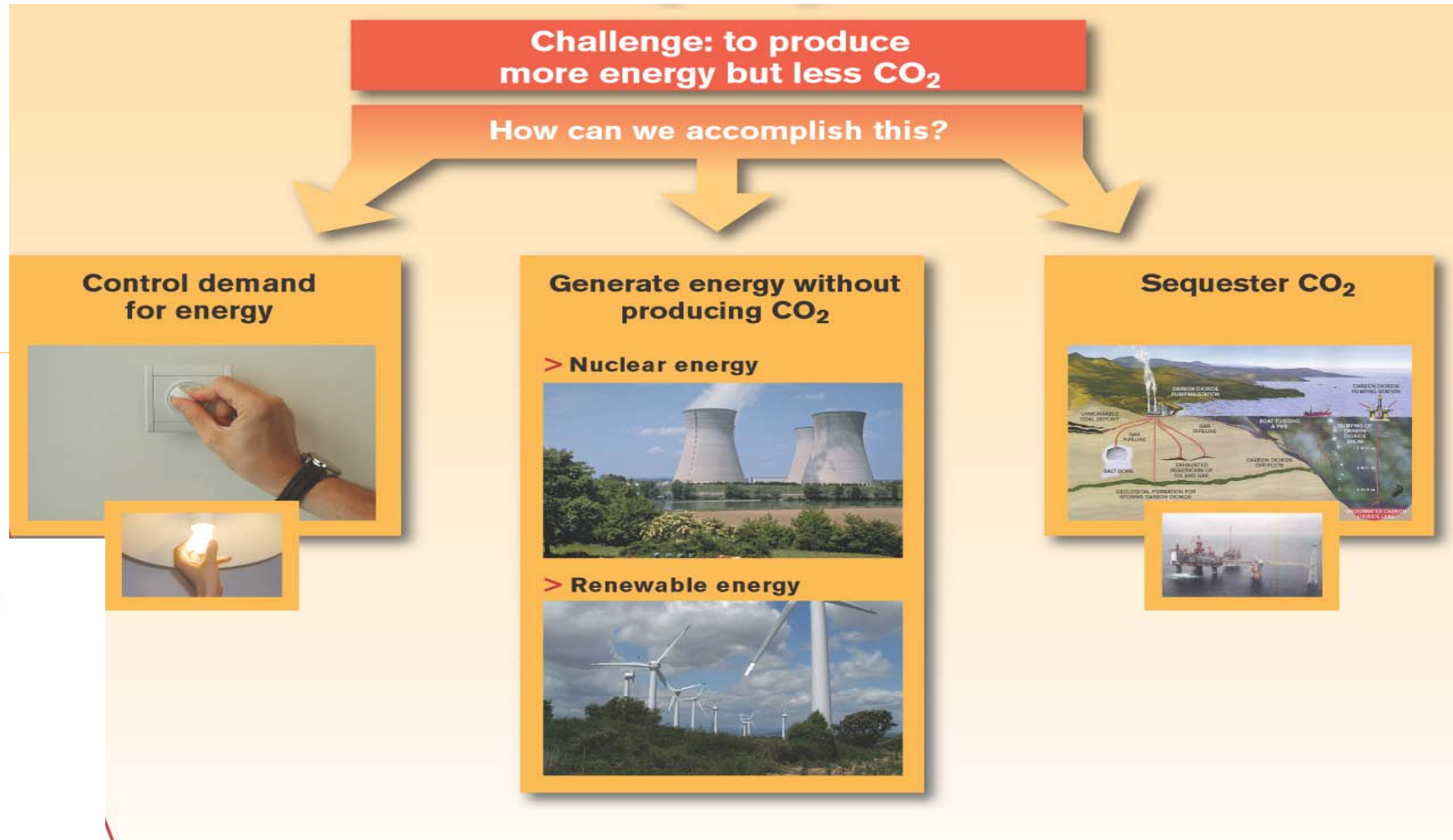


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No miraculous solution !



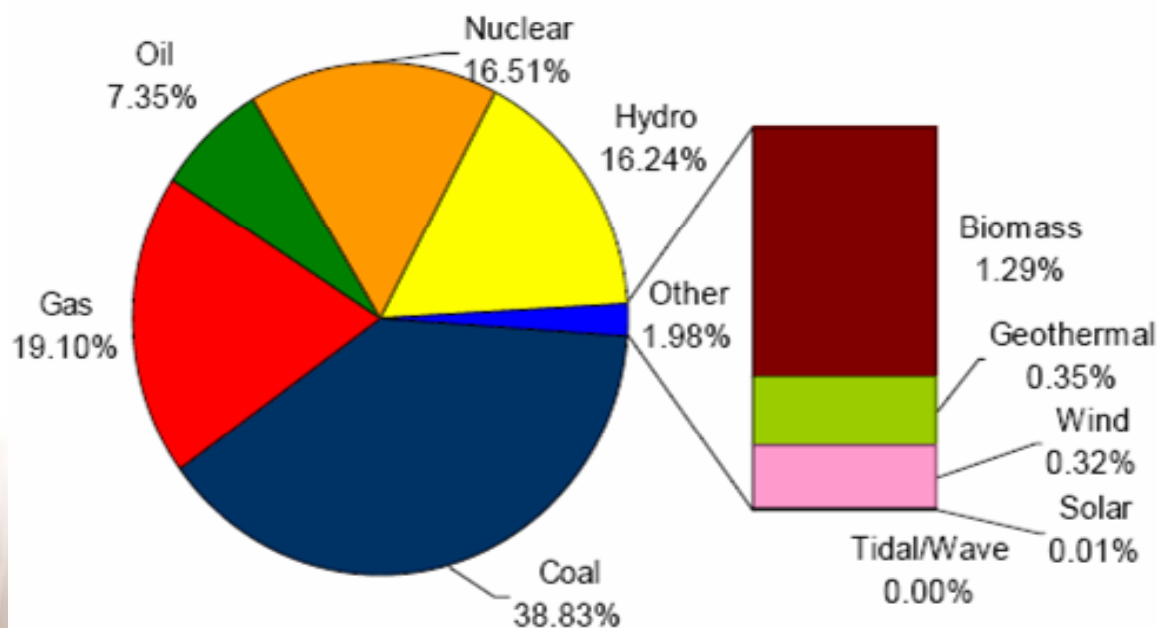
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Even if technologies can be the same for all solutions has to be adapted to local context

Global Share of Electricity Generation (2002)



Mixture of fuels used for electricity is very different in different countries

Coal : ~ 35% in UK, ~76% in China

Hydro : > 40% in Sweden

...

Source: IEA WEO. 2008 IEA Key Statistics give 2.3% of 'Other' (2006 data)

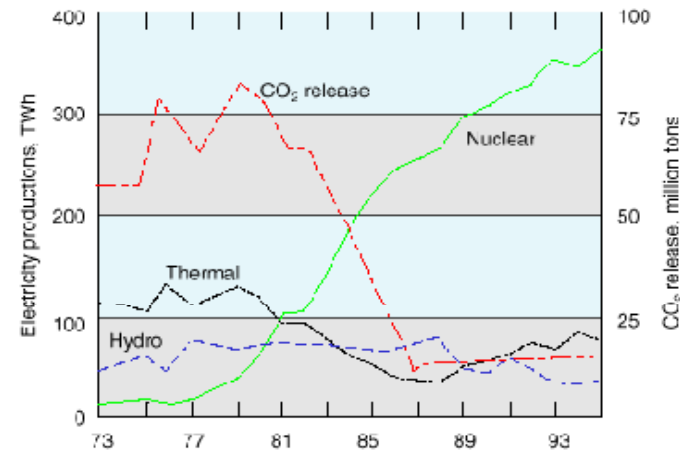
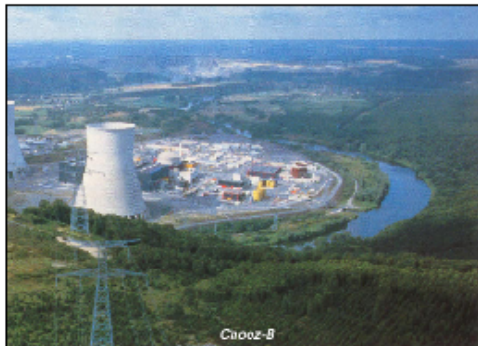
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Only massive changes bring substantial results

CO₂ Emissions Fell 2/3 as a Result of French Nuclear Program



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So what ?

- There is therefore an urgent need to reduce energy use and seek cleaner ways of producing energy on a large scale
- We take an ambitious goal for 2050 : limit CO₂ to twice pre-industrial level. To do this, while meeting expected growth in power consumption, would need 50% more CO₂-free power than today's total production
- We are not completely sure that the technologies to generate this amount of CO₂-free power do exist to day

Fusion, among the solutions

1) **Burning fossil fuels*** (currently 80%) implies to develop & deploy CO₂ capture and storage if and where feasible

- *remaining fossil fuels will be used*

2) **Solar / Wind** imply to seek breakthroughs in production and storage technologies and to invest in grids and their management

3) **Nuclear fission** will be developed ... only with enhanced safety

4) **Fusion** - with so few options, we must continue to invest in fusion as fast as possible, even if success (technology and economy) is not 100% certain ; **but could fusion be “time to market” ?**

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Many road maps are being discussed

China

CN is considering the construction of the next major device around 2020, even though the exact specifications are not yet finalised. They are prepared to take some risk.

The CN strategy is “learning by doing”. All options are indeed open.

United States

Various proposals from the US including:

- CTF (component test facility)**
- FNSF (fusion nuclear science facility)**
- Pilot Plant (replaces CTF and FNSF)... but 3 possible configurations: advanced tokamak, spherical tokamak, or compact stellarator**

No strategic roadmap defined – significant science programme.

Europe

The EU currently speaks of DEMO with the demonstration of electricity to the grid in the 2040's. But what DEMO is and what is the route to get there is still unclear.

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What could this EU DEMO look like and with what performance?

- 1) foremost it should generate electricity, lots of it ~ say several hundred megawatts.
- 2) but maybe more importantly than above, it should demonstrate the complete closed fuel cycle. This has never been seen in the world and is critical for a fusion power plant.
- 3) any Utility would want high availability (>60% for a demonstrator). This means that simplicity and efficient maintenance is required. The design should therefore be driven by remote maintenance consideration.
- Should DEMO be pulsed or steady state? The grid can accept sudden transients of 1GWe ~ long pulses (4-7hrs) would be acceptable.
- Any design activity should include a strong systems integration and management, incorporating all systems and processes. Safety and security should take a global approach.
- Any design must be simple, robust and industrial ; it must fit with economy!
- Finally, regulators and utilities should be integrated into the design process. For fusion to be a success, all stakeholders must be satisfied.

All of the above require that industry and research work closer together

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What still has to be done?

- ITER to DEMO is a significant extrapolation, not only in physics but also technology
- Steady state heating systems need to be developed providing reliability and efficiency
- Remote handling equipment and methods need to be developed and demonstrated to prove the availability
- The component parts and systems for the fuel cycle must be demonstrated
- The internals (diverter, first wall) must be qualified requiring significant advanced in materials and fabrication technologies
- Magnetic structures must be further developed giving simplicity and performance
- A plasma scenario must be demonstrated – DEMO is not a science machine
- All of the above must be brought together in a fully integrated system that takes full consideration of security and safety ...with a realistic cost approach
- Evidently, full experience must be taken from the ITER project

In short, a significant programme is required to realise an industrial DEMO design with the close involvement of all stakeholders

When?

A recurring question in fusion!

- To achieve the vision of the Commission (electricity by 2040) several conditions must come together:
 - Strong political agreement
 - Strong collaboration between industry and the research programme
 - Regular consultation with the regulators and utilities
 - An agreed regulatory framework, and
 - *Success in all ITER objectives – delays in ITER will delay DEMO*

Is DEMO the end of the story?

- Certainly not. But DEMO will be the first opportunity for industry, utilities and regulators to fully understand the socio and economic realities of fusion power
- Without a crystal ball it is practically impossible to know the energy mix and cost of electricity in the middle of this century; anycase at that time fusion will be in a competition
- Only with a timely operation of DEMO and its positive appraisal, fusion power could start to become a commercial reality post 2050

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The fusion programme is entering a transition period from science to application.

To do this, it is important that industry take a more active role in defining and developing fusion technologies. To assist in this:

the Fusion Industry Innovation Forum

has been formed with three main objectives:

- to promote and assist the fusion research community in the realisation of a DEMO design including industrial constraints**
- to promote and assist in technology transfer and spin off generation**
- to promote and assist in the development of skills in industry to position European industry at the forefront of fusion technology and therefore anticipate any future fusion commercial opportunities**

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- EFDA has initiated a programme on Power Plant Physics and Technology (PPP&T)
- The next two year will deliver a pre-conceptual design for a Demonstration fusion power plant
- To guide the EFDA activities, a PPP&T Advisory Board has been formed with an industrial representative
- Over these two years the Forum will work closely with EFDA to define DEMO and a technology roadmap for the its realisation
- In the period 2014 to 2020 (the new Commission Horizon 2020 programme), and with adequate funding, industry will work close with research to implement this roadmap with the target of delivering a comprehensive conceptual design report by 2020
- The forum has already made a preliminary contribution to the Commission proposals for Horizon 2020

Even though work has just started, industry is getting closer to research and is already contributing.

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Intellectual property rights are key to ensuring the competitiveness of the EU research and industry

To provide this competitiveness, industry requires the following:

- 1) Any pre-existing IPR must remain the property of Industry**
- 2) Any pre-existing IPR that is developed, supplemented, enhanced, modified etc should remain vested in Industry. Such IPR can be licensed but not on an exclusive basis and should not be passed on to clients.**
- 3) Where new IPR developed under the Contract is vested in the client (as is most often the case with consultancy work) we should, where possible, seek a license to use IPR produced.**

With industry and research working towards commercialization of fusion energy, the proper management of IPR assets will become even more important

- Industry will bring to the programme its own background information either in the form of knowhow or registered patents**
- The generated knowledge combining the background from industry and the research community must be adequately protected and registered as far as a commercial product is on the way**
- It is pointless spending millions on R&D only to find out several years later that you have lost all the information and someone else could claim its ownership and exploit it commercially**
- The management and protection of intellectual property rights must have in mind that fusion will move from theory to practice, from concepts to products**
- Also, to support the second objective of the Forum, it is important to know what IP exists for effective technology transfer and spin off**

Industry has a vast potential of valorisation of the results

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A technology transfer roadmap should comprise both near and long term activities:

a phase focusing on the identification of spinoff opportunities and the corresponding technology transfer to SMEs and other interested entities

and

a phase fostering the transfer of technology and systems engineering knowhow to potential power plant builders

In the near term the forum recommend setting up a Technology Transfer Programme Office (TTPO) which should:

- 1. Establish the details (processes and tools) of an EU-driven Technology Transfer Programme such that the national initiatives are incorporated in a most efficient (win-win) way**
- 2. Contact potential technology brokerage companies and establish a Europe wide Technology Brokerage Network (TBN)**
- 3. Implement a Europe-wide accessible web-based Technology Marketplace**
- 4. Seek entrepreneurs with innovative ideas for using fusion energy technology, applications and services in domains other than fusion energy**
- 5. Implement a Business acceleration Incubation Centre providing technological, financial and legal advice to start-up companies**
- 6. Promote a seed money funding scheme**

Other large science programme successfully generate visible spin offs and technology transfer. The fusion programme should build on such experiences.

The funding framework should take benefit from all the funding resources and bodies that the Fusion Program has access to in order to create a suitable amount of resources that will ensure a stable running and outstanding performance of the Technology Transfer Program.

This should include funding from the Horizon 2020 program, interested venture capitalist, corporate venture funds, and the returns of the Technology Transfer program itself.

Longer term perspectives

With the successful mission of ITER and an advanced stage in the detailed design of a DEMO, specific technologies and operational processes should be transferred from research to power plant industry, both primes and subcontractors.

This implies capturing:

- The complete spectrum of knowledge generated from ITER and other demonstrators that is required by industry to build fusion power plants in a format suitable for its transfer into industrial processes**
- More specifically a knowledge management process coordinated and managed by the TTPO using project management orientated tools to guarantee the maximum knowledge return and storage from ITER and other projects.**

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Review of present situation

- **Education and training actions has been, up to now, mainly focused on basic education**
- **Very few training are proposed to professional engineers in fusion-related industrial activities**
- **The actions are not, in most cases, job driven and the contents mainly deal with fundamental topics**
- **Plant design, construction, operation, safety issues ... are only considered in some exceptional cases**

**There is thus a need to address short falls
in fusion industrial competences**

From a quick survey of industry (39 companies)

- No specific competences reported in the area of civil design, nuclear licensing, and nuclear grade qualification and control
- Experiences reported mainly in engineering support, quality assurance and project management, diagnostics, electrical power supplies and material development
- Job positions of system engineers, process engineers and procurement engineers did not yet exist for this specific field
- In contrast, the following job positions are considered important for the future industry: system engineers, I&C engineers, electrical, mechanical, quality management engineers, interface and configuration management, project and procurement engineers, project and engineering managers
- Nearly all agreed that a professional training passport, recognized EU wide, would be advantageous

Current initiatives insufficiently satisfy the emerging training requirements. Fusion needs adaptation of conventional disciplines (technical process and systems but also management, procurement, quality assurance ...).

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The Forum has made some initial recommendations:

- **Implement a pilot scheme for training industrial professional engineers including**
 - **dedicated fusion courses provided by the fusion community,**
 - **practical on-the-job training with internships and,**
 - **creating recognisable centres of excellence for academic and vocational training in the different needs of the future fusion industry.**
- **Establish a pilot European Master of Nuclear Engineering / Fusion under the umbrella of ENEN**
- **Embed training actions in the power plant conceptual design activities**
- **Involve experienced personnel from professional training institutions, dedicated to the design, development, coordination and implementation of training actions for all stakeholders in fusion research.**
- **Include basic industry related job positions in the FUSENET mission**
- **Contribute to a European Skills Passport**

Conclusions

- Fusion power must be explored as part of our energy solutions post 2050
- With the correct level of support, Industry can join a research programme to realise a DEMO design including industrial goals
- Industrial competitiveness must be supported by effective IPR management
- The fusion programme should maximise the added value from research and implement, for nearer term, a sound technology transfer programme
- Industry must set up programmes to address the specific skill needed to take, in time, leadership in any future fusion markets

The FIIF is now here to help in all of the above

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**Thank you
for your attention**

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