Energy for a Changing World

Nuclear Reactor Systems of the Future

A step forward in guarding against proliferation?

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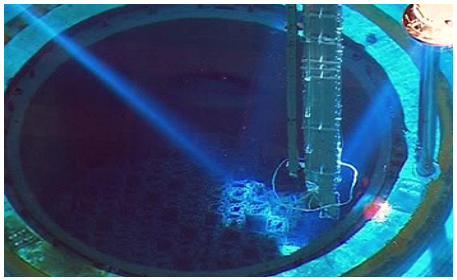
Yes: Generation IV *is* a safer option!

Key drivers in favour of developing new nuclear:

- Greater competitiveness and sustainability
- Improved health & safety, environmental standards
- More efficient nuclear waste management
- Enhanced security and non-proliferation safeguards

What's influencing the debate right now?

- Climate change
- Security of energy supply
- Decline in contribution of nuclear energy to the energy mix worldwide
- Public anxieties about Iran, North Korea etc.



Focus of this presentation

- Insights into Gen. IV Systems: security and choice
- Analysis: are political challenges being allowed to outweigh technical ones?
- Atomic detectives: scientific and technical challenges and the role of the Joint Research Centre - an insider's view

A critical distinction to be made

Nuclear energy is a dual use technology …
But don't forget … civilian ≠ military use

Civilian applications ≠ Military applications

- Low enriched uranium (specific materials/design ≠ criticality) in enrichment and fabrication plants
- Power reactors, sealed reactor core optimized for electrical production, reactor grade plutonium
- R&D programmes aligned to national civil nuclear power programmes

- High enriched uranium > 90%
- Weapon grade Plutonium Pu-239 > 90%
- Short term reactor irradiation (1-3 months)
- Reprocessing for Pu production and conversion to metal or alloys
- Weaponisation programme (explosives, dual use items, codes, delivery systems,…)

Conclusions to be drawn

- No commercial nuclear fuel cycle has ever been used for the production of plutonium and high enriched uranium for nuclear weapons

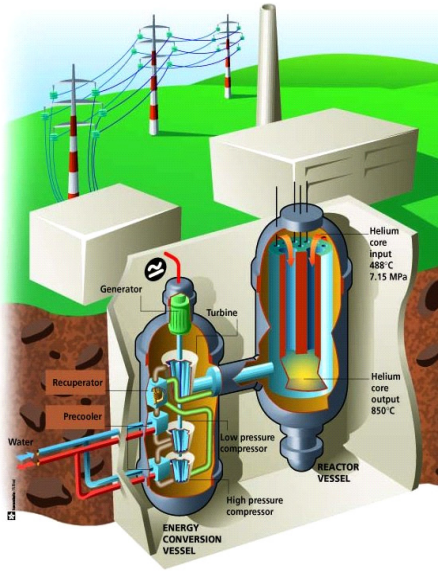
- Countries with nuclear weapons capabilities use separate, dedicated facilities to produce the special nuclear materials needed for weapons applications

- The shutdown of say, existing or future EU, American or Japanese civil nuclear reactors would have zero impact on the ability of another country to obtain nuclear weapons

- Nuclear know-how cannot realistically be confined, effective political and technical instruments have to be implemented within the scope of the Non-Proliferation Treaty

Gen. IV reactors in the pipeline

- **Fast reactors (FRs):** with different coolants (sodium, lead or helium): production of sustainable nuclear energy
- **Very high temperature reactors (VHTR):** combined production of electricity and high temperature, processing heat for industry and hydrogen generation
- **Molten salt reactors (MSR):** integrated molten fuel cycle reprocessing
- **Super critical water reactors (SCWR):** high performance but challenging advanced water-cooled reactor
- **Small Modular Fast Reactors (SMFR):** Long core lifetime (about 30 yrs)



Gen. IV systems are designed to be inherently more Proliferation Resistant (Gen. IV working group)

Challenges (threats)

- Concealed diversion of declared materials
- Concealed misuse of declared facilities
- Overt misuse of facilities or diversion of declared materials
- Clandestine dedicated facilities

Outcome of the System response

- Proliferation Technical Difficulty (e.g. technical sophistication)
- Proliferation Cost (e.g. economic and staffing investment required)
- Proliferation Time (e.g. total time planned by the host State for the project)
- Fissile Material Type (e.g. characteristics not appropriate for nuclear explosives)
- Detection Probability (e.g. ease of detecting a proliferation "scenario")
- Detection Resource Efficiency (e.g. application of international safeguards)

Gen. IV: No direct weapons usable materials, radiation barriers, increased physical protection

1. **Gen. IV fuel cannot be used for weapons:** contains highly radioactive minor actinides (Americium, Curium and Neptunium) and reactor plutonium with high amounts of Pu-240 and Pu-238 = “dirty” fuel

2. Reprocessing is an essential feature for sustainability, but **co-processing of plutonium with minor actinides does not involve the separation of plutonium**

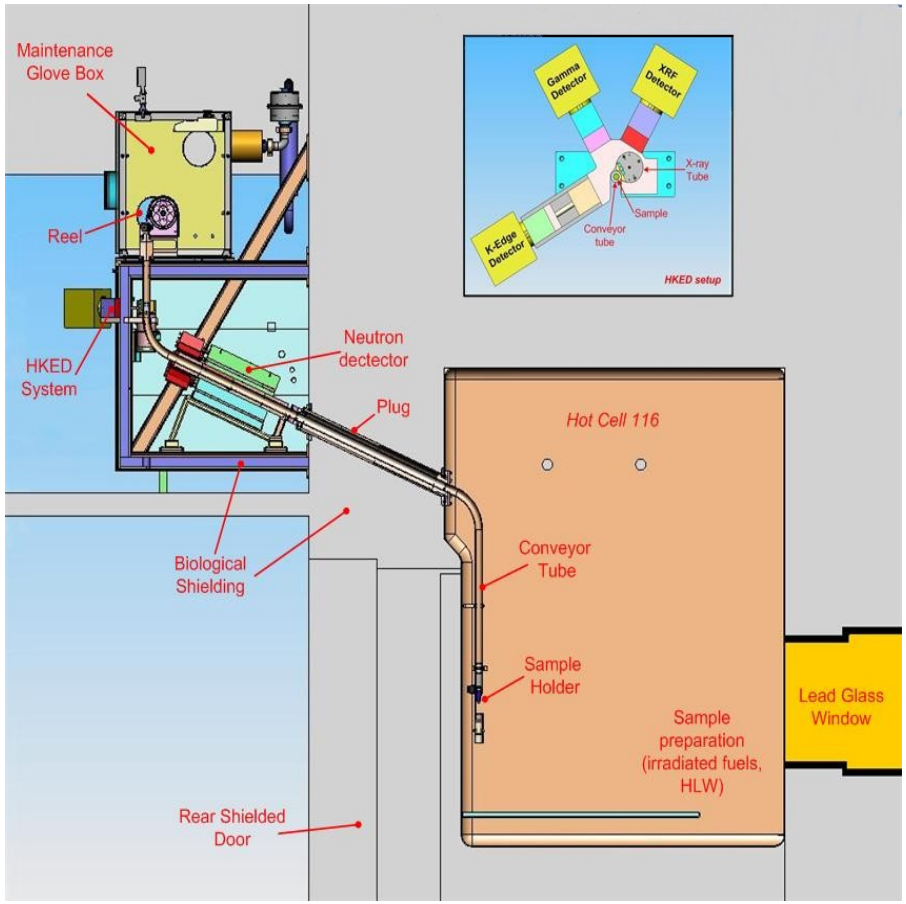
3. **Sufficient safeguard technologies are needed** to cope with misuse scenarios (breeding of plutonium in reactor blanket, like in some research reactors)

Can safeguards technology cope with Gen. IV Systems? Yes!

- **Existing safeguards technologies can be adapted** to future Gen. IV reactor systems. They will benefit from experience gained operating existing fast reactors and reprocessing technologies. Nevertheless, new safeguards technologies will need to be developed

- **New and better verification technologies** for fabrication and reprocessing plants are required for the recycling of minor actinides: dry reprocessing will require a substantially higher development effort for nuclear material accountancy than currently used aqueous reprocessing technology

- **Control of use of facilities will become increasingly important**
"dirty fuel is an advantage regarding proliferation resistance but a "pain" for nuclear material accountancy
- **Modeling of material flows** in sensitive facilities and use of **fingerprinting techniques** to cover diversion scenarios
- **Presence of minor actinides provide additional "fingerprinting" techniques** to monitor the flow and inventory of nuclear materials
- **Increased amounts of nuclear materials is also a challenge** for physical protection (to prevent misuse by, for example, terrorists)



JRC-NDA station (KED, XRF-Ge, XRF-Si, NCC, HRGS) for analytical control of pyrochemical separations of Actinides/Lanthanides

Political, institutional and technical challenges ahead

Political Action

- Adherence to Non-Proliferation Treaty with additional protocol to become the norm
- Clear consequences for non adherence or withdrawal
- Nuclear Weapon States to foster disarmament rather than modernisation of their weapons arsenal
- Foster establishment and make maximum use of independent regional systems ("neighbours watching neighbours" - a powerful concept and excellent confidence building measure)
- Nuclear Weapon States to accept safeguards for their own sensitive facilities
- Develop regime to ensure fuel supply and fuel cycle services on non-discriminatory basis: e.g. Global Nuclear Energy Partnership (GNEP)
- Preserve adherence/implementation of Test Ban and Fissile Material Cut Off Treaty

Institutional (Legal Action)

- Increase the International Atomic Energy Agency's role in export/import control (at least better info exchange on, for example, rejected exports)
- Strengthen the IAEA's role in assurance of supply
- Extend the IAEA's responsibility to cover weaponisation programmes
- Whenever the IAEA's Board of Governors and the UN Security Council act in a unified manner: IAEA should have clear authority and receive best results

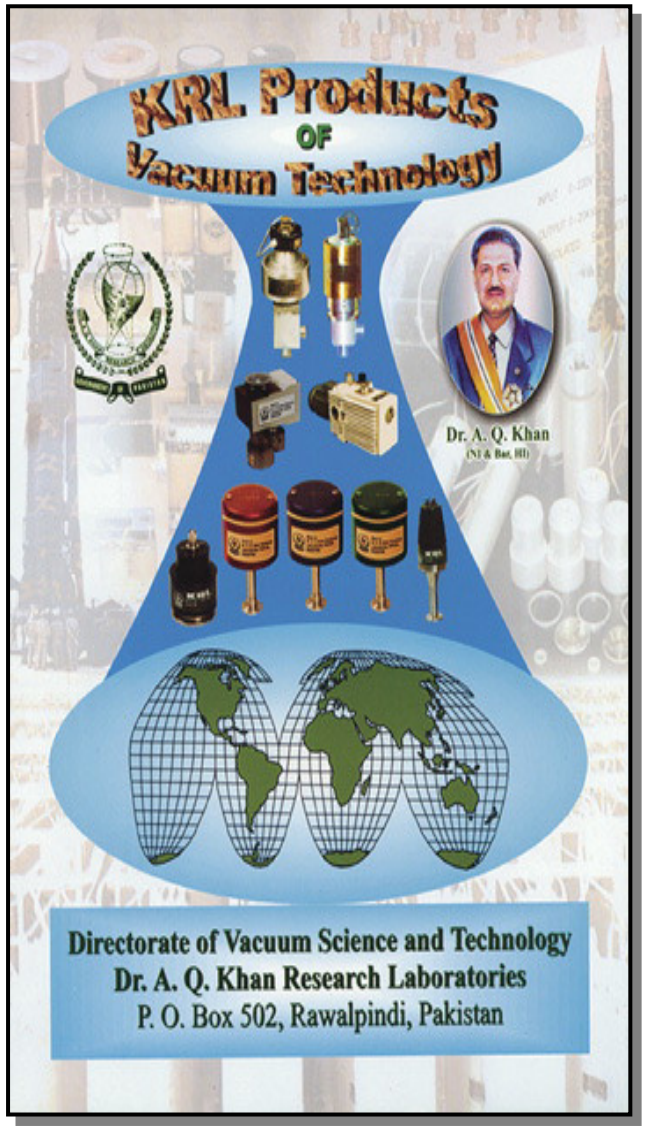
Technical Action / JRC activities

- **Supporting Nuclear safeguard activities in reprocessing plants** and for advanced fuel cycle facilities
- **Detection of clandestine activities** remains a major challenge: toolbox of techniques used by International Atomic Energy Agency needs to be strengthened (wide area monitoring, environmental sampling, satellites, open sources,…)
- **Illicit trafficking / Nuclear Forensics** (prevention, detection, response)

Technical Action / JRC activities

- **Export control** is more complex and challenging
- **Analysis of supply chains for materials, components and facilities** in nuclear country profiles
- **Training** for inspectors to improve their investigative skills with respect to the Additional Protocol

A.Q. Khan's black market



Conclusion

Nuclear Reactor Systems of the Future
Are a step forward in guarding against proliferation

But a lot needs to be done to *inform* citizens that:

- **Gen. IV systems are essential** for the sustainability of nuclear fission energy
- **Gen. IV systems pose a considerable technical challenge** for nuclear safeguards, but proliferation resistance and physical protection are a key feature of their design
- **No direct weapons useable materials will be present** due to the co-processing of plutonium with minor actinides
- **Enhanced Non-Proliferation Treaty instruments are needed** to cope with the expansion of nuclear energy (example: control of weaponisation programmes, location and control of fuel cycle centres)
- **Non-proliferation is becoming more of a political than a technical challenge**

Thank you for your attention

Questions & Answers

(Please state which organisation you represent)

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