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Protected Pu Production (P^3) for Peace and Sustainable Prosperity

- Methodology Development for Pu Categorization-

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Protected Pu Production (P^3) Projects

How to ?

By Transmutation of MA

Denature Pu
(Increase of PR)

How much ?

Attractiveness of Pu

Terminology

IAEA

Proliferation Resistance Fundamentals for Future Nuclear Energy Systems

Department of safeguards, International Technical Meeting, Como, Italy, October 2002.

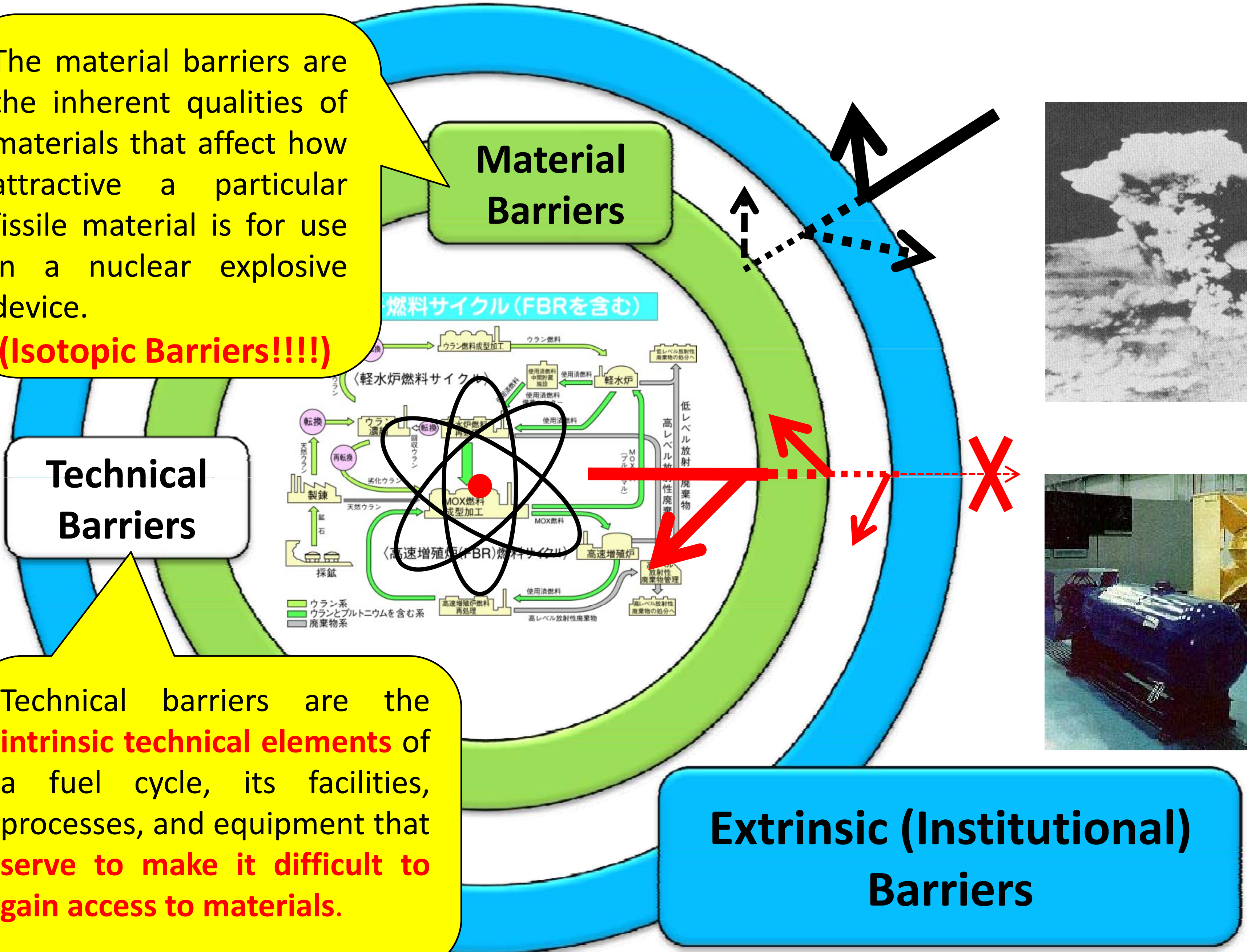
Proliferation resistance is that characteristic of a nuclear energy system that impedes the diversion or undeclared production of nuclear material or misuse of technology by States in order to acquire nuclear weapons or other nuclear explosive devices.

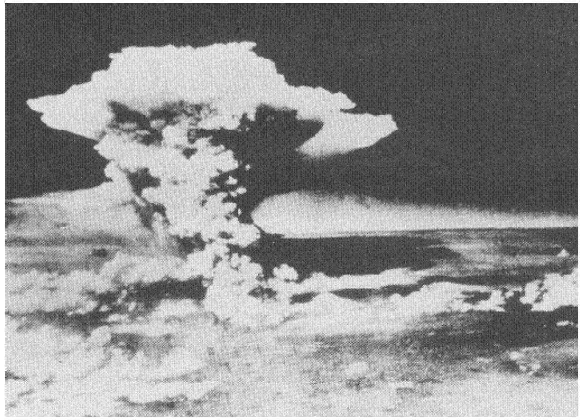
Intrinsic proliferation resistance features are those features that result from **technical design** of nuclear energy systems including those that facilitate the implementation of extrinsic measures.

Extrinsic proliferation resistance measures are those measures that result from States' decisions and undertakings related to nuclear energy systems.

“Defense in Depth” for Proliferation Resistance

The material barriers are the inherent qualities of materials that affect how attractive a particular fissile material is for use in a nuclear explosive device.
(Isotopic Barriers!!!!)





Technical barriers are the **intrinsic technical elements** of a fuel cycle, its facilities, processes, and equipment that **serve to make it difficult to gain access to materials**.

How Resistant
Is
Resistant Enough
in
Proliferation ?

The Concept of Attractiveness of Pu

Yield

$$ATTT = \frac{\textit{Peculiarity of Explosive Energy Release}}{\textit{Technical Difficulty}}$$

Spontaneous Neutron

Decay Heat

Radiation

CURRENT DEFINITION OF ATTRACTIVENESS

$$ATTR = \frac{\text{Explosive Energy}}{\text{Technological Difficulties}}$$

Rossi-α

$$ATTR = \frac{\dfrac{\alpha_\infty}{\alpha_\infty^{239}}}{\dfrac{DH}{DH^{238}} + \dfrac{SN}{SN^{238}} + \dfrac{RD}{RD^{238}}}$$

$$\alpha = \frac{k-1}{l}$$

$$N_f(t) \sim N_0 e^{\alpha t}$$

α_∞: Rossi-alpha of Infinite Mass

DH: Decay Heat [W/kg]

SN: Spontaneous Fission Neutron Emission Rate [n/g･sec]

RD: Radiation Dose Rate [Sv/hr]

Figure of Merit (FOM)*

$$FOM_2 = 1 - \log_{10}\left(\frac{M}{800} + \frac{Mh}{4500} + \frac{MS}{6.8(10)^6} + \frac{M}{50}\left[\frac{D}{500}\right]^{\frac{1}{\log_{10} 2}} \right)$$

M: Bare Critical Mass [kg]

h: Decay Heat [W/kg]

D: Dose Rate at 1m Distance from Materials [rad/hr]

S: Spontaneous Fission Neutron Rate

* Charles G. Bathke, *et. al.*, “The Attractiveness of Materials in Advanced Nuclear Fuel Cycles for Various Proliferation and Theft Scenarios,” Proceedings of Global 2009, Paris, France, September 6-11, 2009.

Comparison with Other Methodologies

ATTR Function (Normalized)

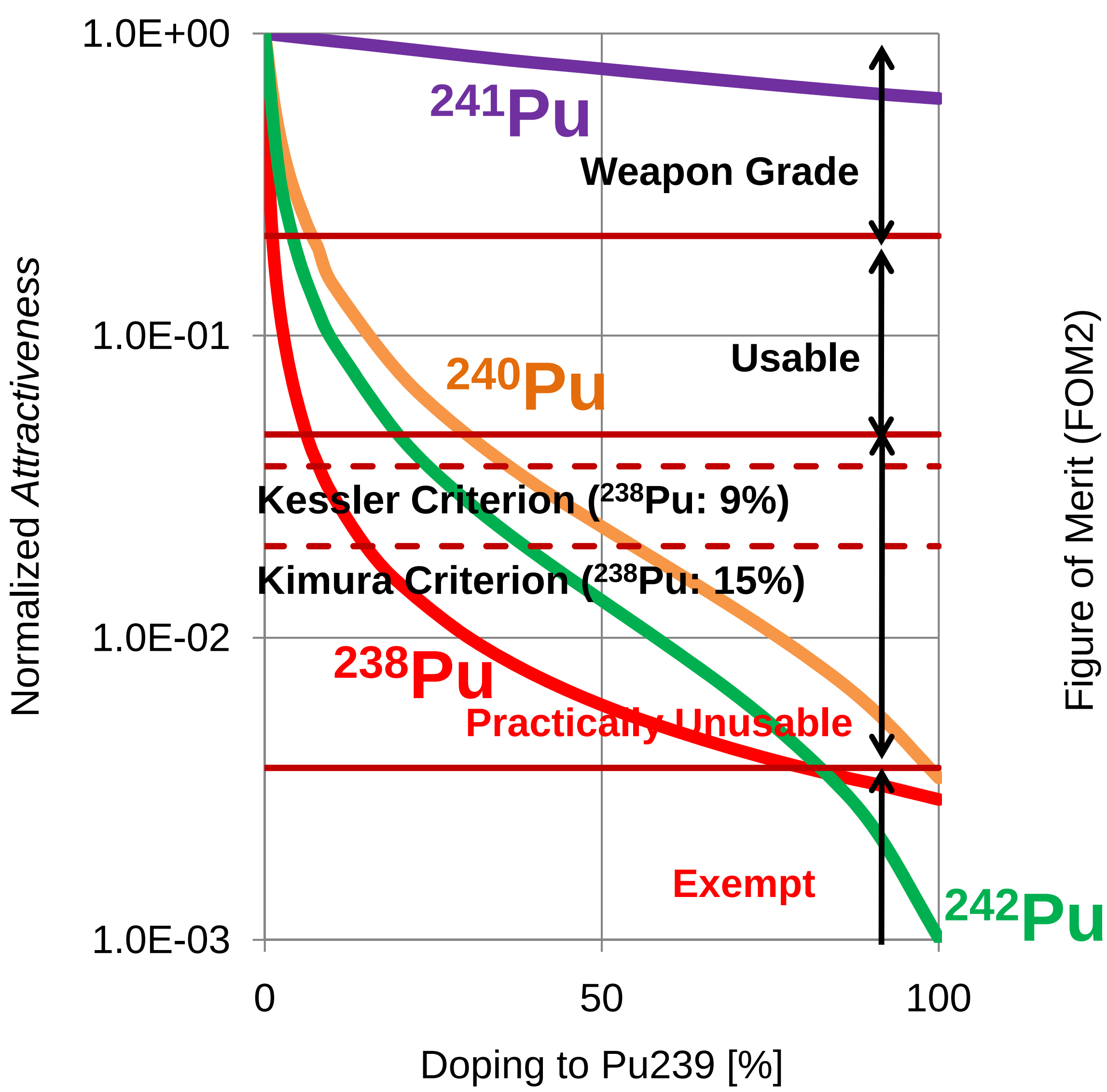
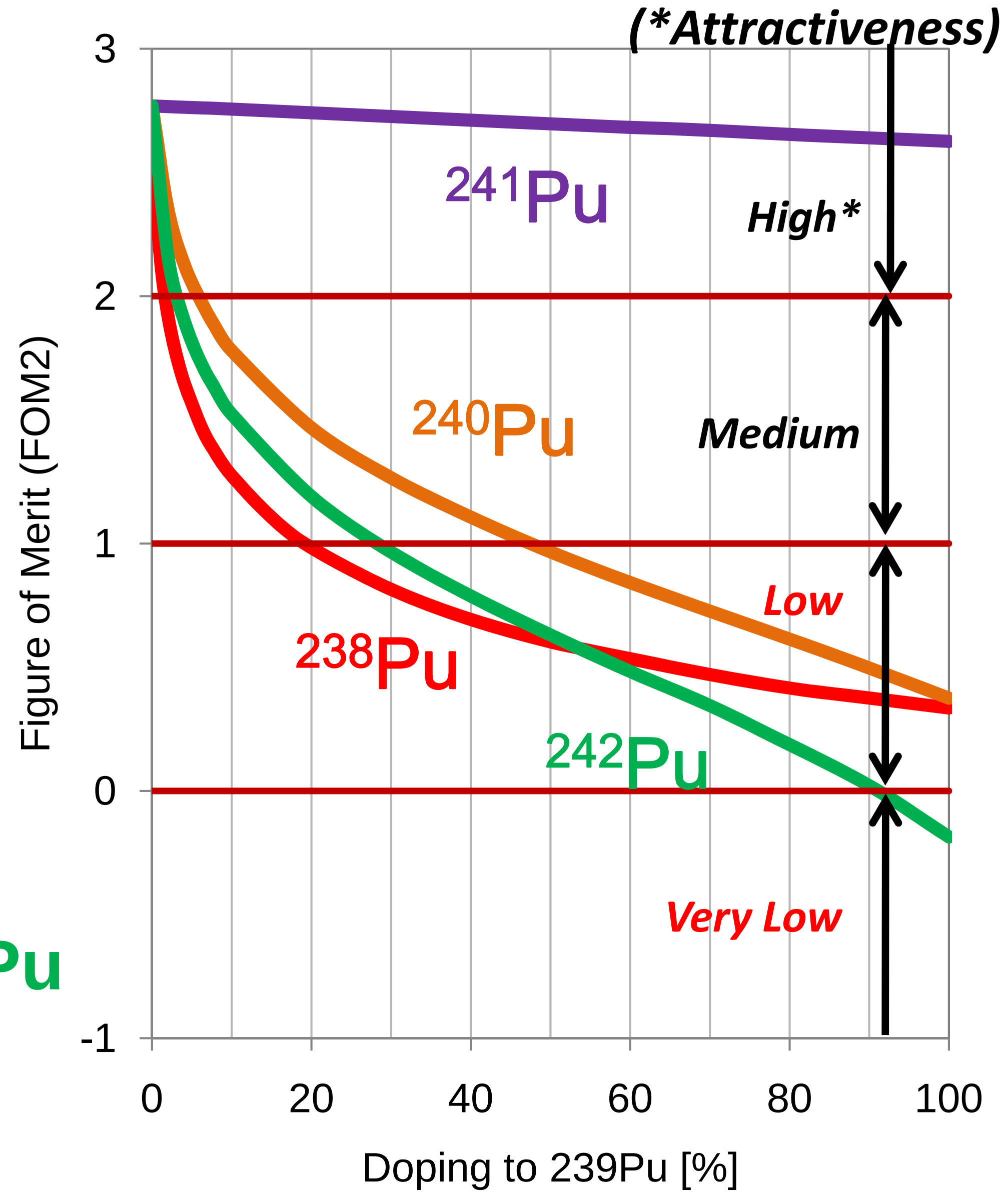
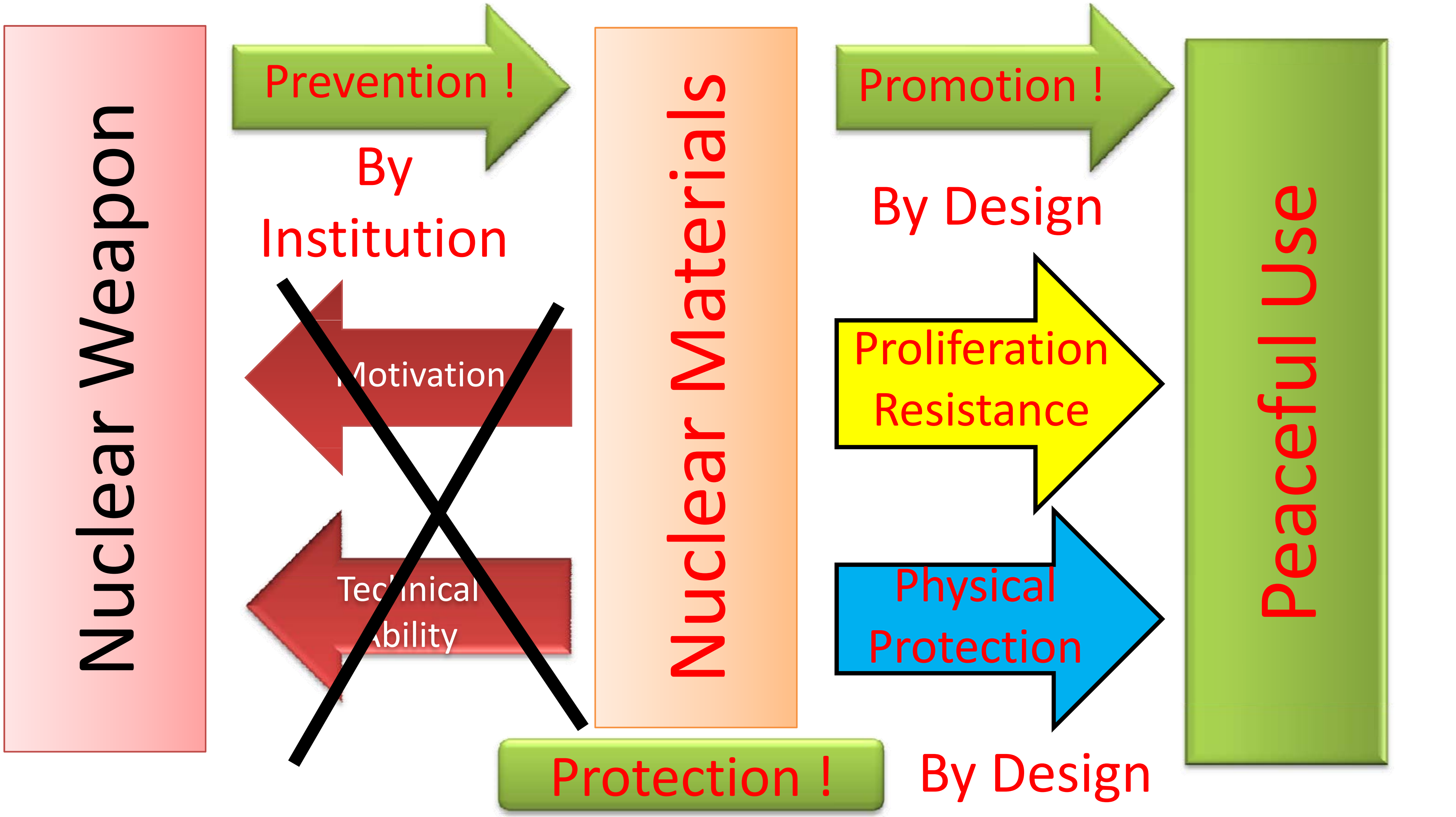


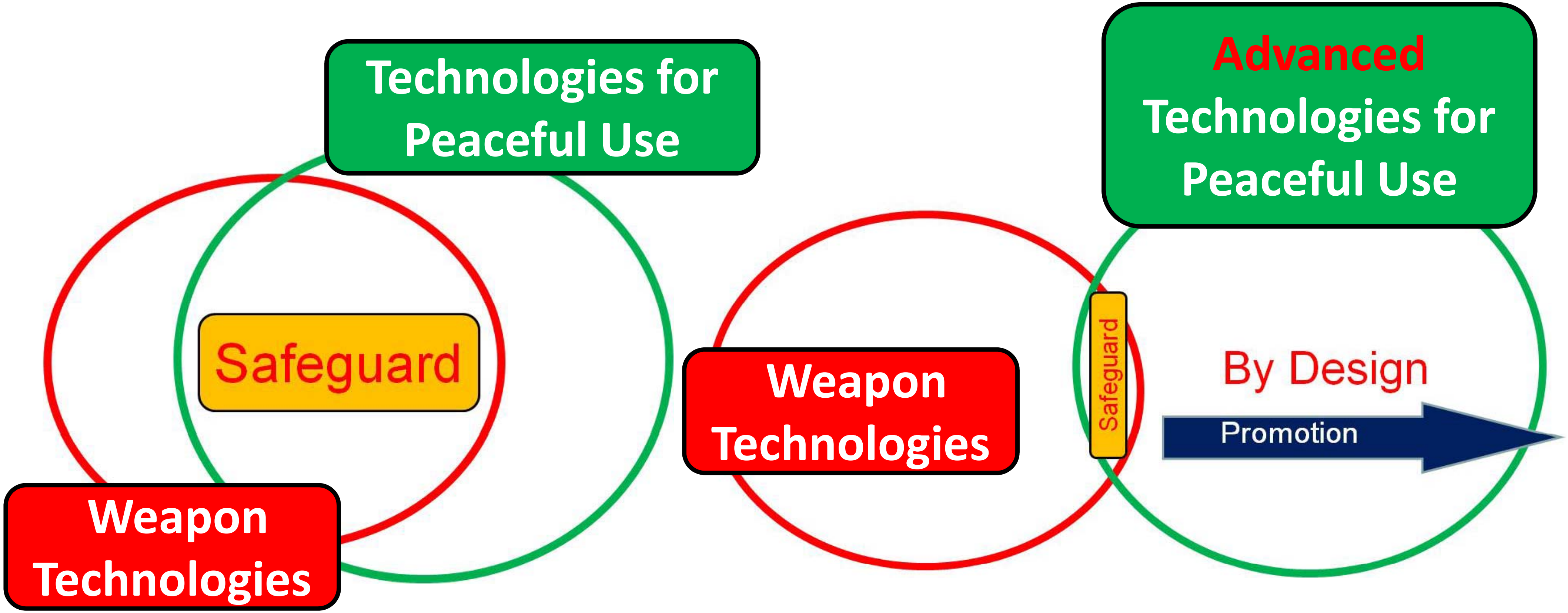
Figure of Merit (FOM_2)



Prevention, Protection and Promotion (P^3) by Institution and Design



Promotion of Inherent Proliferation Resistance by Design for Global Nuclear Renaissance



Conventional Nuclear Energy System

Future Nuclear Energy System