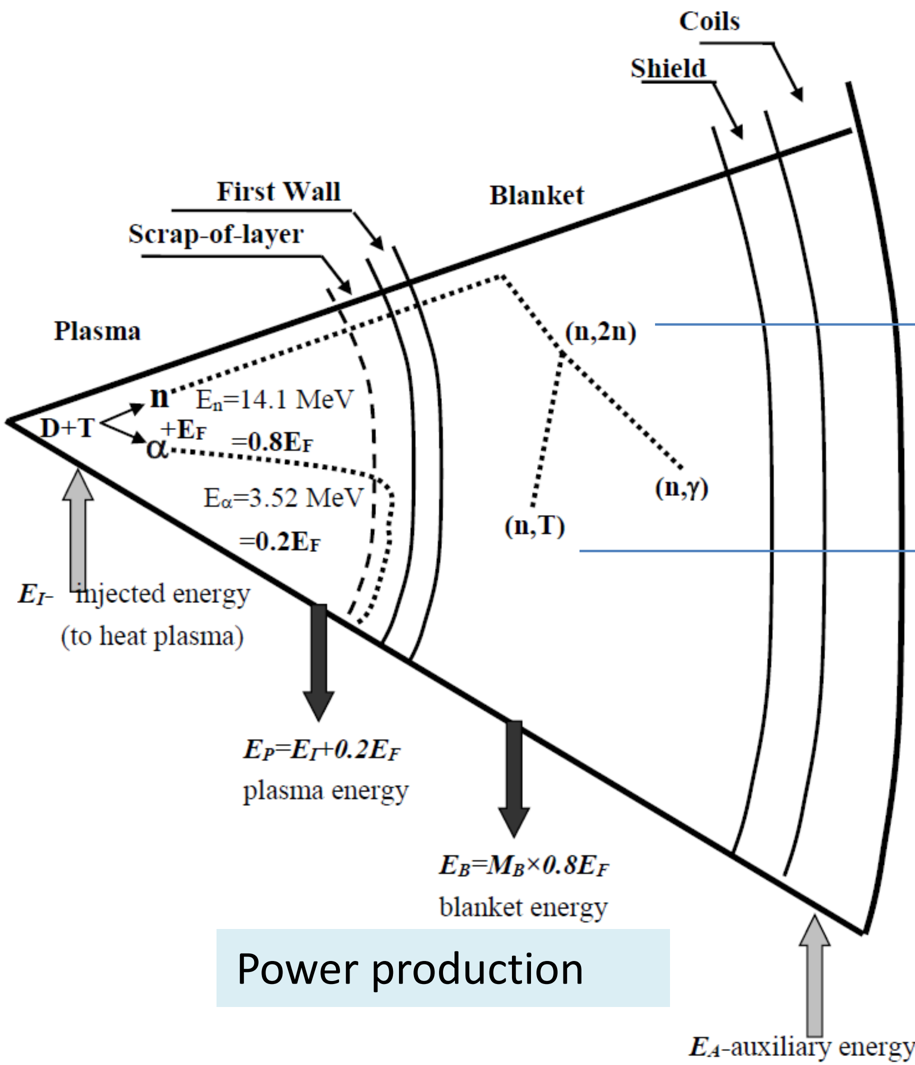
Nuclear fusion as an element of future energy systems

Vladimir Artisyuk

Technical Meeting
on Synergies Between Nuclear Fusion Technology Developments and Advanced Nuclear Fission Technologies
06-10, June 2022

Essentials of Fusion Power Generation



Neutron multiplication

Tritium breeding

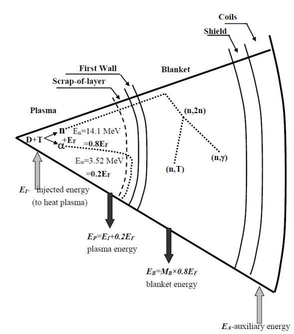
Power production

Characteristics of Power Reactors

	PWR	BWR	HTGR	LMFBR	Fusion[b]
Equivalent core diameter (m)	3.6	4.6	8.4	2.1	30
Core length (m)	3.8	3.8	6.3	0.9	15
Av.core power density (W/cm^3)	96	56	9	240	1.2
Peak-to-av.heat flux at coolant interface	2.8	2.6	12.8	1.43	50

[a] ABDOU, M., Exploring Novel High Power Density Concepts for Attractive Fusion Systems, Fusion Eng.Des. **45** (1999) 145

[b] NWL=3 MW/m^2 ;volume was taken for “in-vessel” component and magnets, so plasma void is excluded



Brief History of Fusion-Fission Hybrids

1954: The idea of hybrids was first considered at the Lawrence Livermore Laboratory at the beginning of fusion programme (Imhoff et al.)

1969: The concept of fusion-fission "symbioses" was presented (Lidsky)

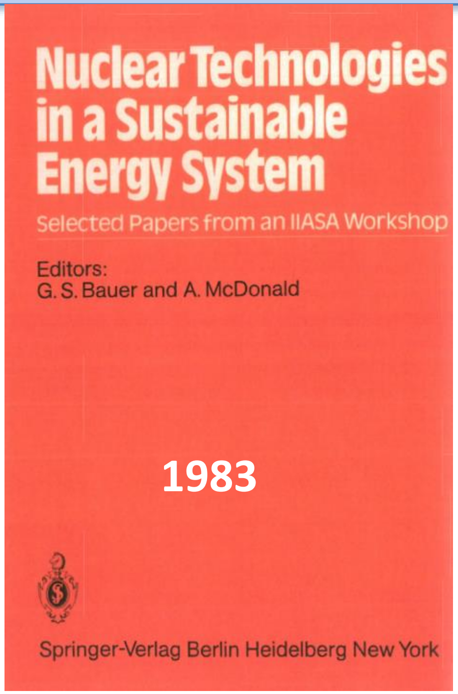
1979: Fission-suppressed class of fissile-breeding blankets (U, Th) (Lee)

1990-s Fusion-Driven transmutation of nuclear wastes (Minor Actinides)

Glance at History: Fuel Breeding

On the Role and Technological Readiness of Fast Breeders and Fusion-Fission Hybrids in the World Nuclear Future

S.I. Abdel-Khalik and G.L. Kulcinski Nuclear Engineering Department, University of Wisconsin, Madison, Wisconsin 53706 (USA)
G. Kessler Nuclear Research Center, D-7500 Karlsruhe (FRG)



"…whether or not it is possible for hybrids to be commercially introduced within the time window (2000-2020) identified earlier as necessary for the world demand to be met within the known resource base."

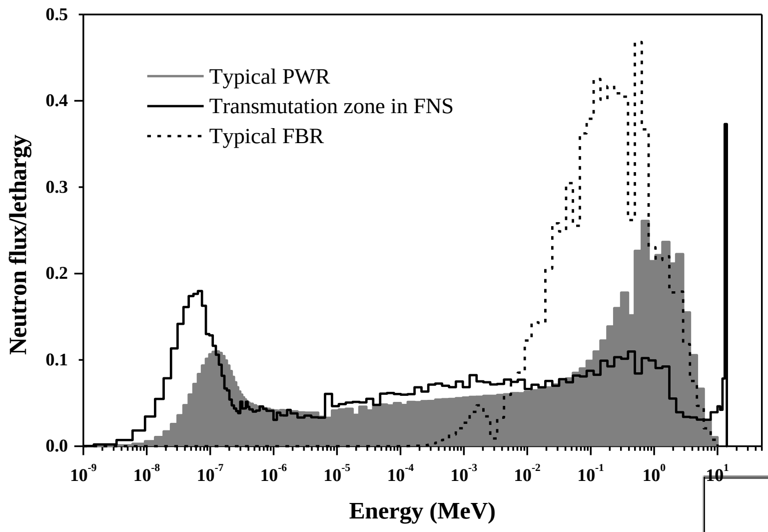
Examination of the current status of fusion physics and technology reveals that there are only three fusion devices which might realistically achieve the necessary performance and be commercially available at such an early datc: namely

- ✓ tokamaks,
- ✓ tandemmirror devices, and
- ✓ light-ion beam-driven inertial-confinement fusion systems

Fuel Breeding:

1 Fast Breeder – supports 2/3 LWR (the same power)
1 Fus-Fis-Hybrid - 25 LWR
(suppressed fission) (U-233)

Glance at History: Waste Transmutation



Cs-135: Half-life 2.3E+6 yrs

Cs vector

	133	134	135	137
Feeding	0.45	-	0.12	0.43
Equilibrium	0.08	0.02	0.27	0.63

Transmutation efficiency

Loading (t)	44.2
Transmutation rate (t/yr)	1.6
PWR-park supported (GW_{el})	21
Fission Utilization Factor (%)	97

Fusion as an Element of Future Energy System

Fusion: neutron reach power

- **to provide effective fuel breeding gain**
- **to work as a “waste cleaning machine”**

in the energy system composed of fission and fusion reactors

Synergy: “the extra energy, power, success etc that is achieved by two or more…elements working together instead of their own”

Oxford Advanced Learner’s Dictionary https://www.oxfordlearnersdictionaries.com/