

B. Radioactive material releases

1) Tritium release

a. Types of T release

- Routine releases from faulty valves, connectors, and pumps in the flow systems of the fusion fuel cycle
- External releases by permeation through pipes and vessel walls
- Non-periodic releases accompanied by maintenances and accidents

b. Pathways to environment during normal reactor operation

- From the air purification system in the containment building
- From tritium treatment facilities
- From contaminated coolants
- Routine ventilation from buildings

c. Permeation leakage

- Core tritium plasma leakage by permeation through FW
- Permeation leakage through coolant pipes from blanket to the primary cooling loop
- Permeation leakage through the pipes of heat exchanger system to the steam generator system

d. Amount (Ci/yr) of T release to environment

from a typical commercial reactor

<u>Source</u>	<u>SS-Li-He reactor</u>	<u>STARFIRE reactor</u>
	gaseous	gaseous + aqueous
Vacuum & Fuel systems	7500	3700
Coolant system	75	2740 + 910
Solid waste treatment system	365	360
Total	7940	6800 + 910

(cf) Comparison between commercial reactors

	<u>SS-Li-He reactor</u>	<u>STARFIRE</u>
<i>structure</i>	SS	SS
<i>breeder</i>	liquid Li	LiAlO ₂
<i>coolant</i>	He	water (H ₂ O)
<i>major/minor radius (m)</i>	7.5/1.5	7.0/1.94
<i>electricity (GWe)</i>	1	1.2
<i>coolant temp. (°C)</i>	200~435	280~320
<i>Tritium burnt (g/d)</i>	380	536
<i>bred (g/d)</i>	400	562
<i>production (kg/y)</i>	7	9
<i>inventory (kg)</i>	4.58	11.61

2) Neutron activated materials

a. Types of major release

- Activated corrosion and erosion materials from the primary cooling loop
- Releases from containment building and radioactive waste treatment
- Cleaner & drain from contaminated area, Decontaminating liquids, etc.

b. Amount of activated materials released from a cooling system (S.S./water) of typical commercial reactor

- Airborne particulate releases (^{58}Co , ^{60}Co , ^{54}Mn , ^{59}Fe) : $2.8 \times 10^{-1} \text{ Ci/y}$
- Aqueous release (^{55}Fe , ^{58}Co , ^{51}Cr , ^{60}Co , ^{54}Mn) : $1.7 \times 10^{-1} \text{ Ci/y}$

c. Activated gaseous releases from the atmosphere of the containment building

<i>Nuclides</i>	<i>Half-life</i>	<i>Release amount (Ci/y)</i>
^{14}C	5730 y	2.0×10^{-3} (air) 1.8×10^{-9} (CO ₂)
^{16}N	7.11 s	2.9×10^{-3}
^{41}Ar	1.83 h	7.4×10^{-3}

3) Radioactive solid waste

a. Solid waste contaminated by tritium

- Blanket module, Replaced auxiliary equipment
- Components (filters, getters, sieves, beds, catalysts) used in tritium, gaseous/aqueous release treatment systems
- Decontaminated waste (papers, gloves, clothes, tools, etc.)

b. Activated solid waste

- Fragments of FW/blanket, structural materials
- Components used in gaseous/aqueous release treatment systems
- Melted or vitrified waste
- Decontaminated waste

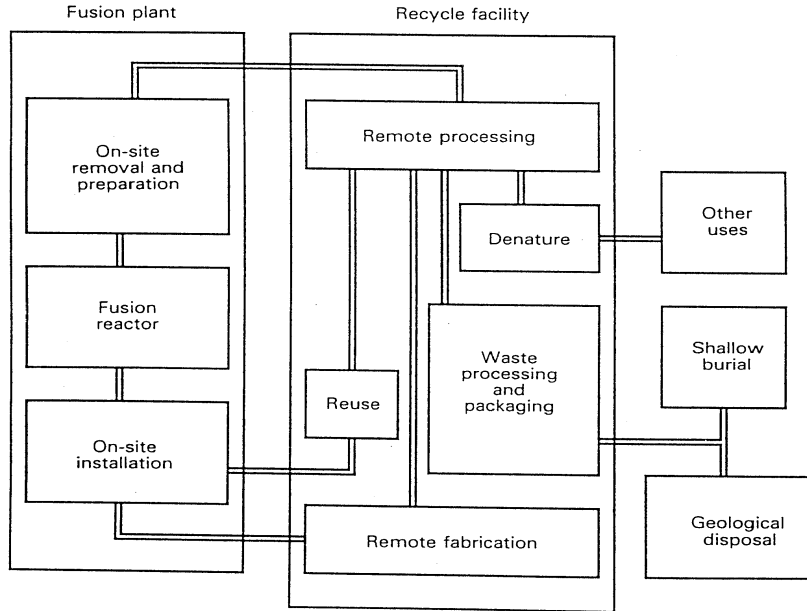
4) Radioactive waste disposal and management

a. Basic strategy

- Recycling and reuse if possible
Breeder & coolant → recycling after purification
FW/structural materials (worker dose < 0.5 rem/yr) → reuse
(e.g.) Al, Al₂O₃ (< 1 year), V, Ti alloy (30 years), S.S. (50 years)
- Final goal of disposal : Shallow burial
US NRC 10CFR61 Class C standard
--> 500 mrem/yr : 500 years after shutdown

- Gaseous/aqueous releases : ALARA
(As-Low-As-Reasonably-Achievable)

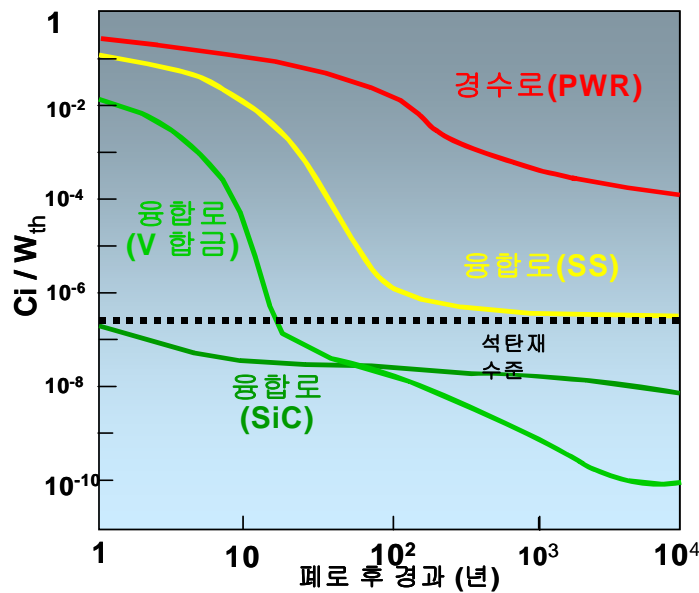
b. Diagram of radioactive waste management and disposal



c. Public acceptance compared with fission power plants

- Comparable amounts of low-level (class A) waste, but much shorter half-lives (< 50 years)
- Practically no high-level waste (use of low activation materials : V alloy, SiC composite)
- Much easier processes of waste treatment and decommissioning

d. Radioactive level after decommissioning

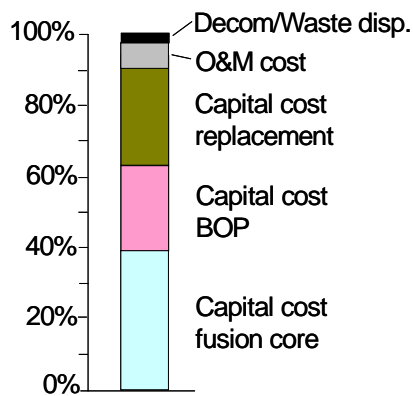


4. Evaluation of environmental impacts

Comparison of environmental impacts among power plants (1 GWe) (Dolan¹⁰ Table 28C1)

<u>Environments</u>	<u>Fossil</u>	<u>LWR</u>	<u>LMFBR</u>	<u>Fusion</u>
<i>Radionuclides (Ci)</i>				
T	0	33,300	1,400	1,400
Kr	0	3,480	2,080	0
Xe	0	48	0	0
Pu	0	0.2	0.16	0
<i>Radioactive Waste (Ft³)</i>				
High-level	0	69	69	0
Others	0	42,000	42,000	20,000
<i>Radiation Dose (person-rem)</i>				
General Public	0	32.5	5.2	3.2
Employees	0	600	440	600
<i>Pu Discharged (tons)</i>				
	0	0.53	2.4	0
<i>Nonradioactive (tons)</i>				
SO ₂	15,700	34	34	34
NO _x	36,000	76	76	76
Chlorine	27	47	23	23
<i>Material Use (tons)</i>				
Coal	4 × 10 ⁶	0	0	0
U ₃ O ₈ /ThO ₂	0	230	30	0
D ₂ O	0	0	0	0.066
<i>Land Use (sq. mile)</i>				
	3	1.3	0.7	0.6

5. Economics



M. Beurskens, FOM (2004)
Originally from UKAEA/EFA Report (1997)

