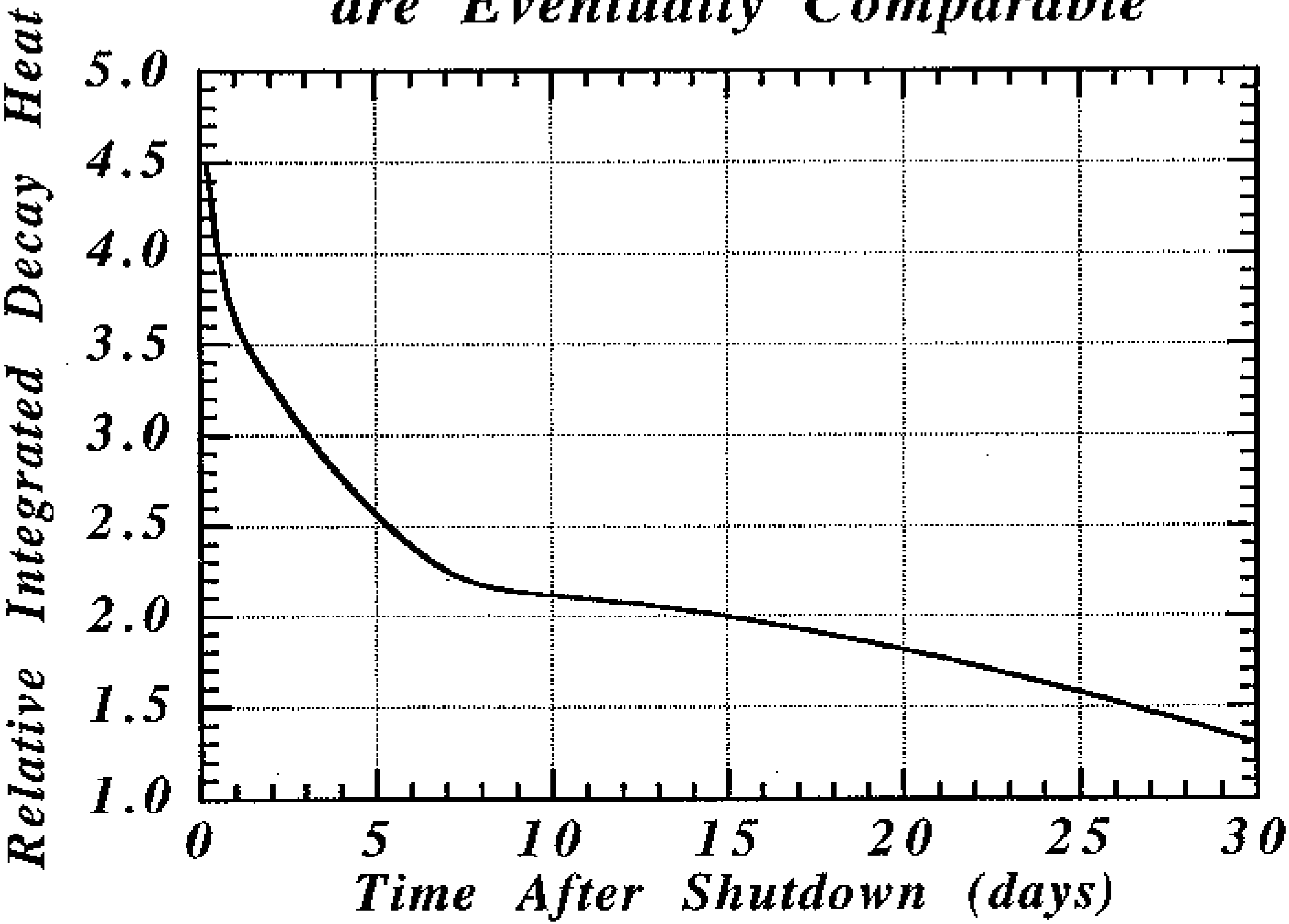
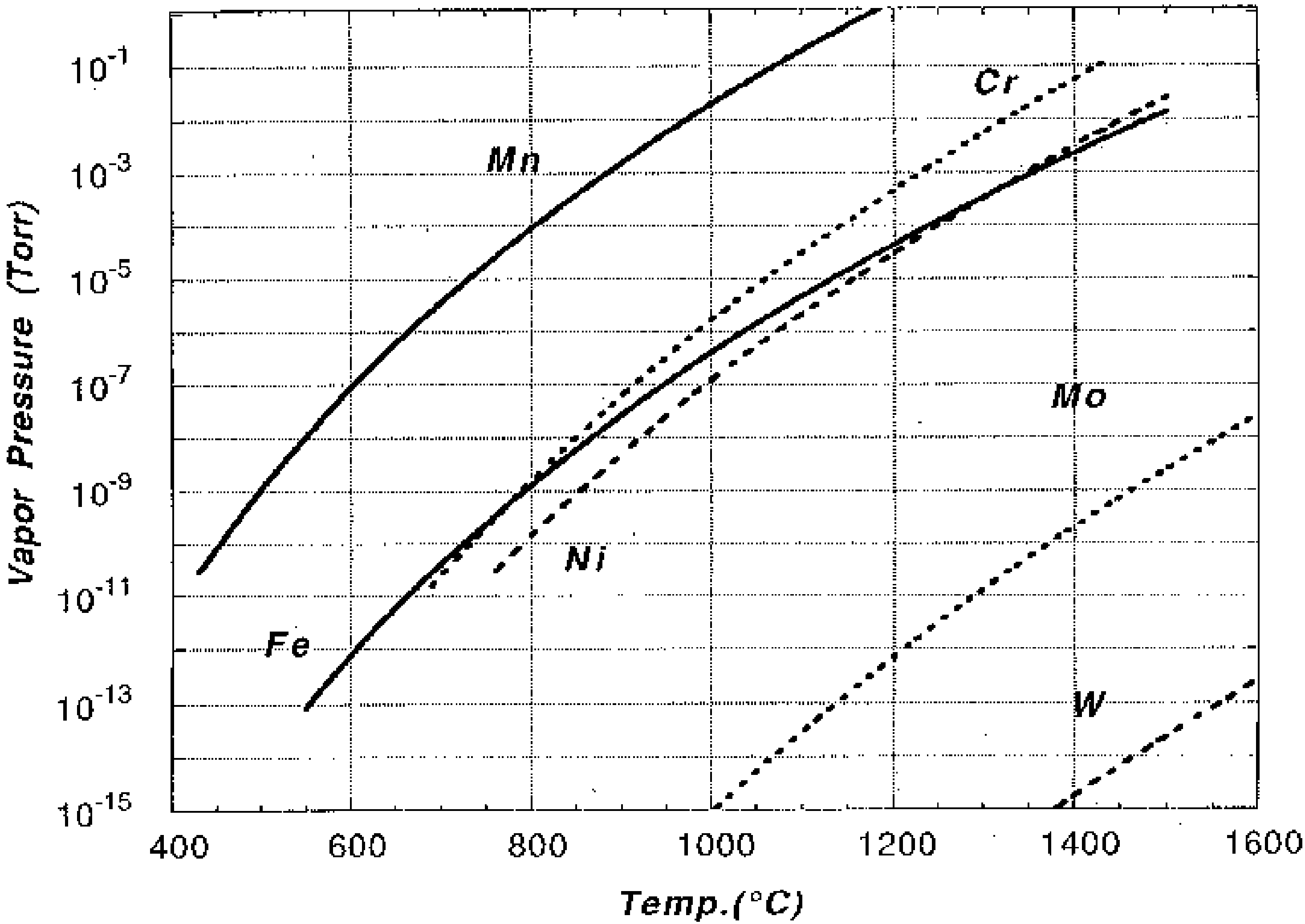
In Spite of High Short Term Afterheat From Mn steels, Total Energy Released by Mn-SS and 316 SS are Eventually Comparable



University of Wisconsin

Manganese is the Most Volatile Radioactive Alloy Element in Stainless Steels



Environmental Aspects of Fusion Power

1.) Curies/unit power = C

2.) Biological Hazard Potential

$$BHP^i = \frac{C^i}{(MPC)_i}$$

where $(MPC)_i$ is the maximum permissible concentration of radioisotope i in :

- **air (inhalation) mainly for accidents**
- **water (ingestion) mainly for leakage in waste storage facilities**

MPC Example - ^{55}Fe

	Occupational		General Public	
	microcurie/ml		microcurie/ml	
Form	Air	Water	Air	Water
soluble	9×10^{-7}	2×10^{-2}	3×10^{-8}	8×10^{-8}
insoluble	1×10^{-6}	7×10^{-2}	3×10^{-8}	2×10^{-3}

$$MPC..\alpha \frac{1}{Eff.Half-Life..t^E_{1/2}}$$

$$\frac{1}{t^E_{1/2}} = \frac{1}{t^B_{1/2}} + \frac{1}{t^P_{1/2}}$$

if $t^P_{1/2} >> t^B_{1/2}$ **then MPC** $\alpha \frac{1}{t^B_{1/2}}$

if $t^B_{1/2} >> t^P_{1/2}$ **then MPC** $\alpha \frac{1}{t^P_{1/2}}$

Density of Radioactivity

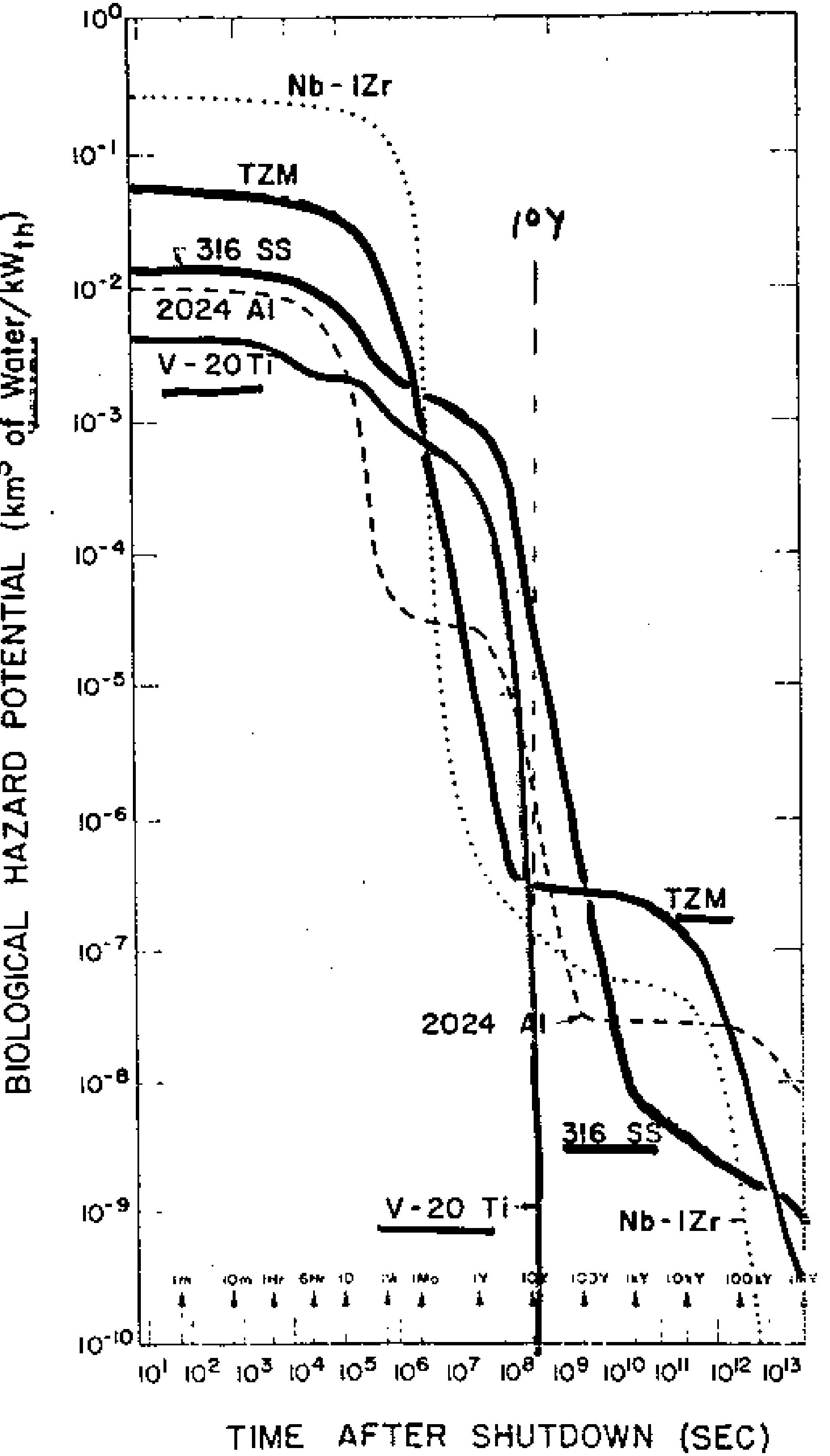
$$\frac{Curies}{cm^3}$$

Alloy	t = 0	t = 1 d	t = 1 y	t = 100 y
Nb1Zr	158	94	0.0006	0.00005
TZM	125	83	0.04	0.007
316 SS	100	68	29	0.005
2024 Al	44	8.7	0.3	0.00001
V-20Ti	27	6.6	0.31	$<10^{-37}$
Nat U				0.000006->

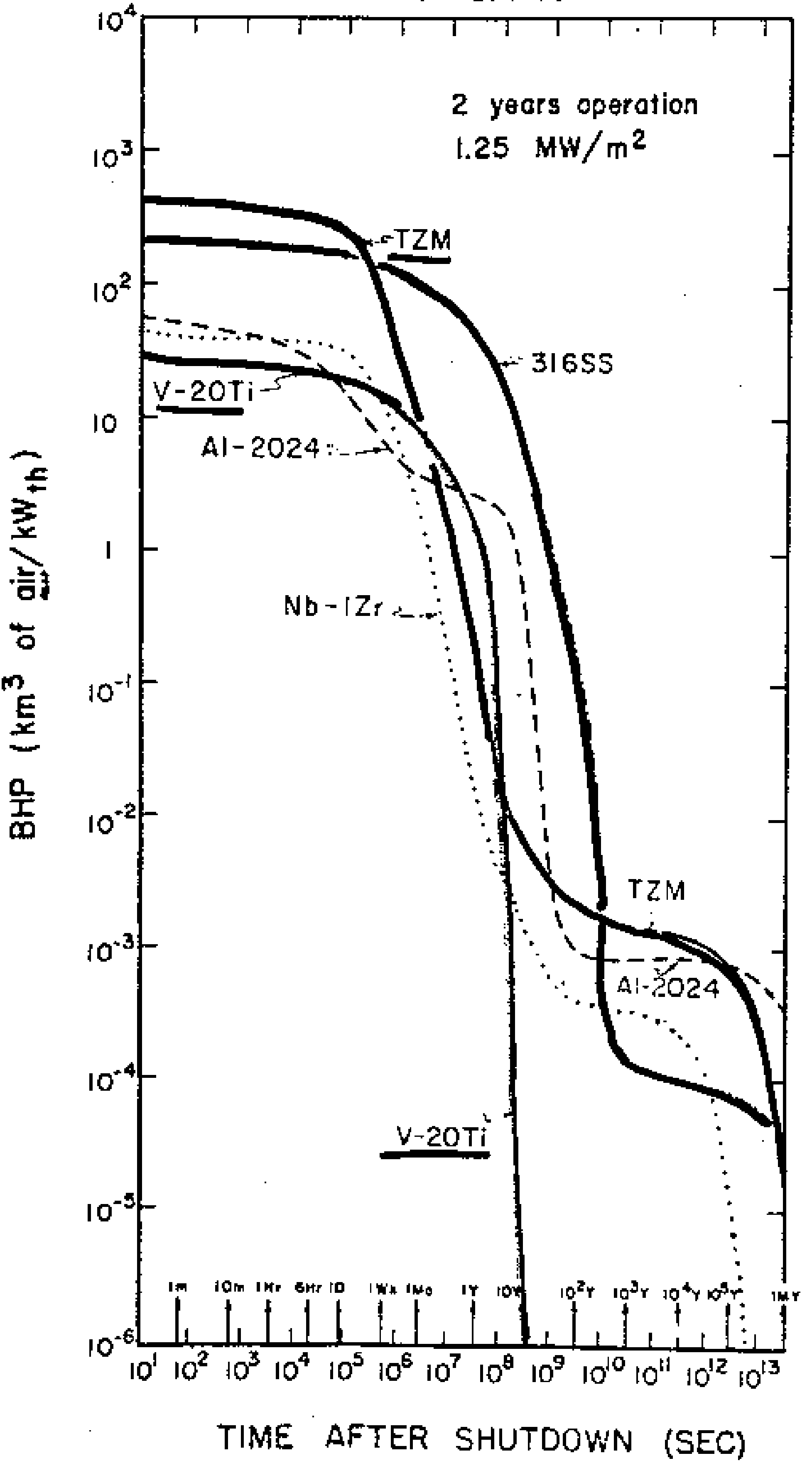
BHP- Level Figure-air,water

Alloy	$\frac{km^3 Air}{cc - metal}$	$\frac{km^3 Water}{cc - metal}$	
	t=0	t=100 Y	t=10,000
TZM	2.9	1.0	0.7
316SS	2.0	5.4	0.03
2024 Al	0.55	0.2	0.2
Nb1Zr	0.36	0.6	0.3
V-20Ti	0.2	insig.	insig
Natural U	0.001	0.2	0..2

CTR Blankets After Shutdown - H_2O Diluent



Biological Hazard Potential (BHP) of CTR Blankets After Shutdown



Another way to approach radioactivity is to calculate the total BHP over the life time of an isotope (a long lived isotope could effect many generations)

Integrated BHP = IBHP

$$\mathbf{IBHP^{(i)} = (BHP)^{i} \cdot \int_{t=0} \exp(-\lambda t)\, dt}$$

$$\textbf{where } \lambda = \frac{0.693}{t_{\frac{1}{2}}^{P_i}}$$

$$\mathbf{IBHP^{(i)} = BHP\ ^{(i)}{}_{t=0}\ \frac{t_{\frac{1}{2}}^{P_i}}{0.693}}$$

Since we are interested in long lived isotopes(much longer than a lifetime)

$$t^{p}_{1/2} >> t^{B}_{1/2}$$

$$\mathbf{IBHP}\ \ \alpha\ \ t^{p}_{1/2} \cdot t^{B}_{1/2}$$

Summary of IBHP for Irradiated Fusion Materials for H_2O Dilutent

Material	$\frac{10,000\ km^3 of\ H_2O - s}{cc\ of\ first\ wall}$
2024 Al	46
TZM	24
316SS	23
Nb-1Zr	17
V-20 Ti	1.6
Natural U	0.2

Comparison of Integrated BHP For Fusion Reactor and LMFBR

	IBHP $\frac{km^3_{H_2O} - s}{kW_{th}}$ $x\ 10^{-5}$
Fission	60
2024 Al	10
316 SS	5
TZM	5
Nb-1Zr	4
V-20Ti	0.4

Figure 5: Cumulative Distribution of Capacity Factors, 1990 and 1998

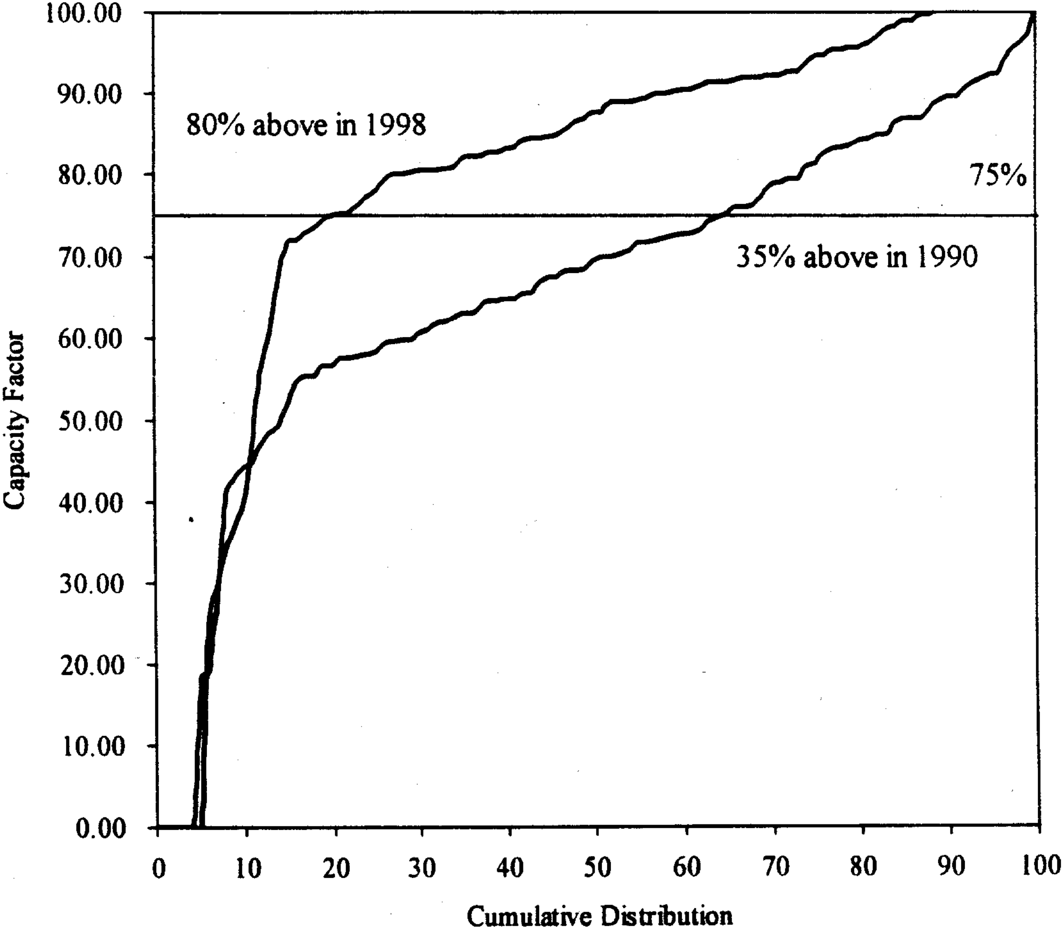
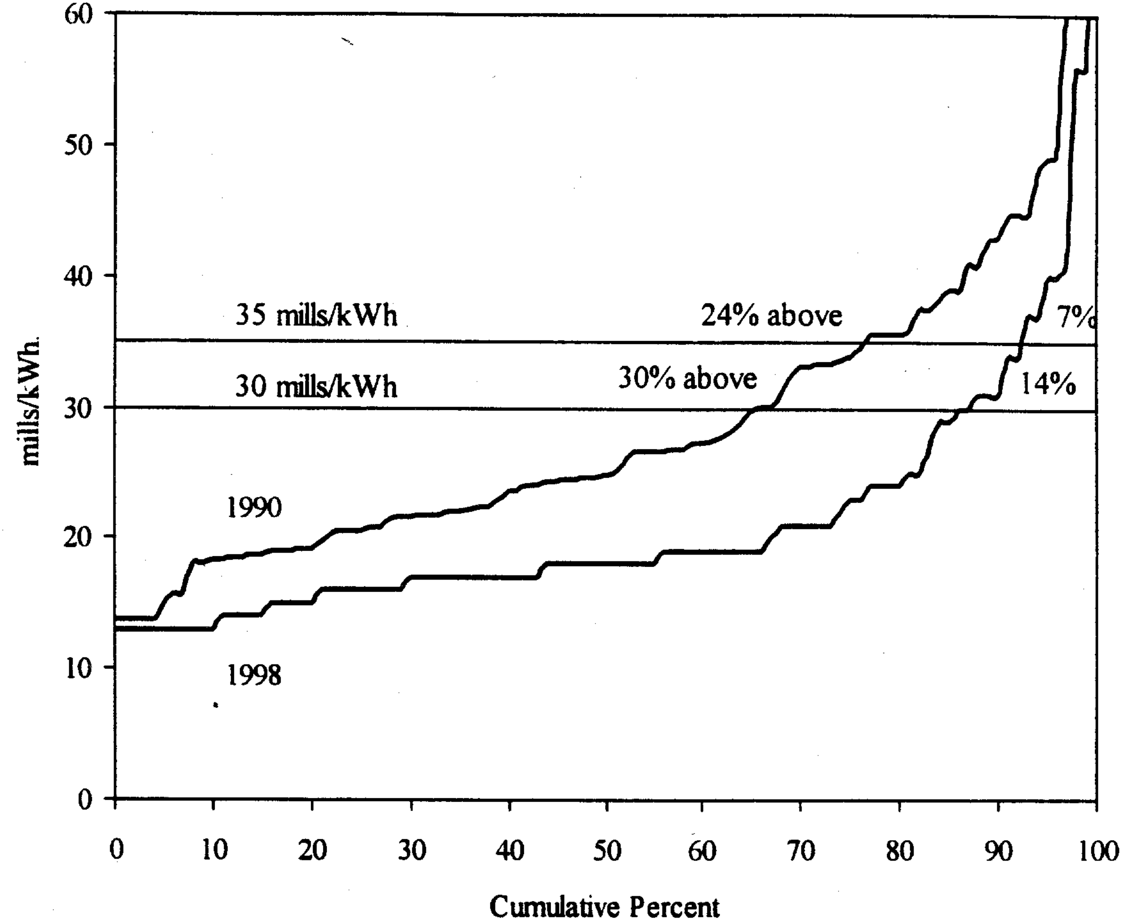
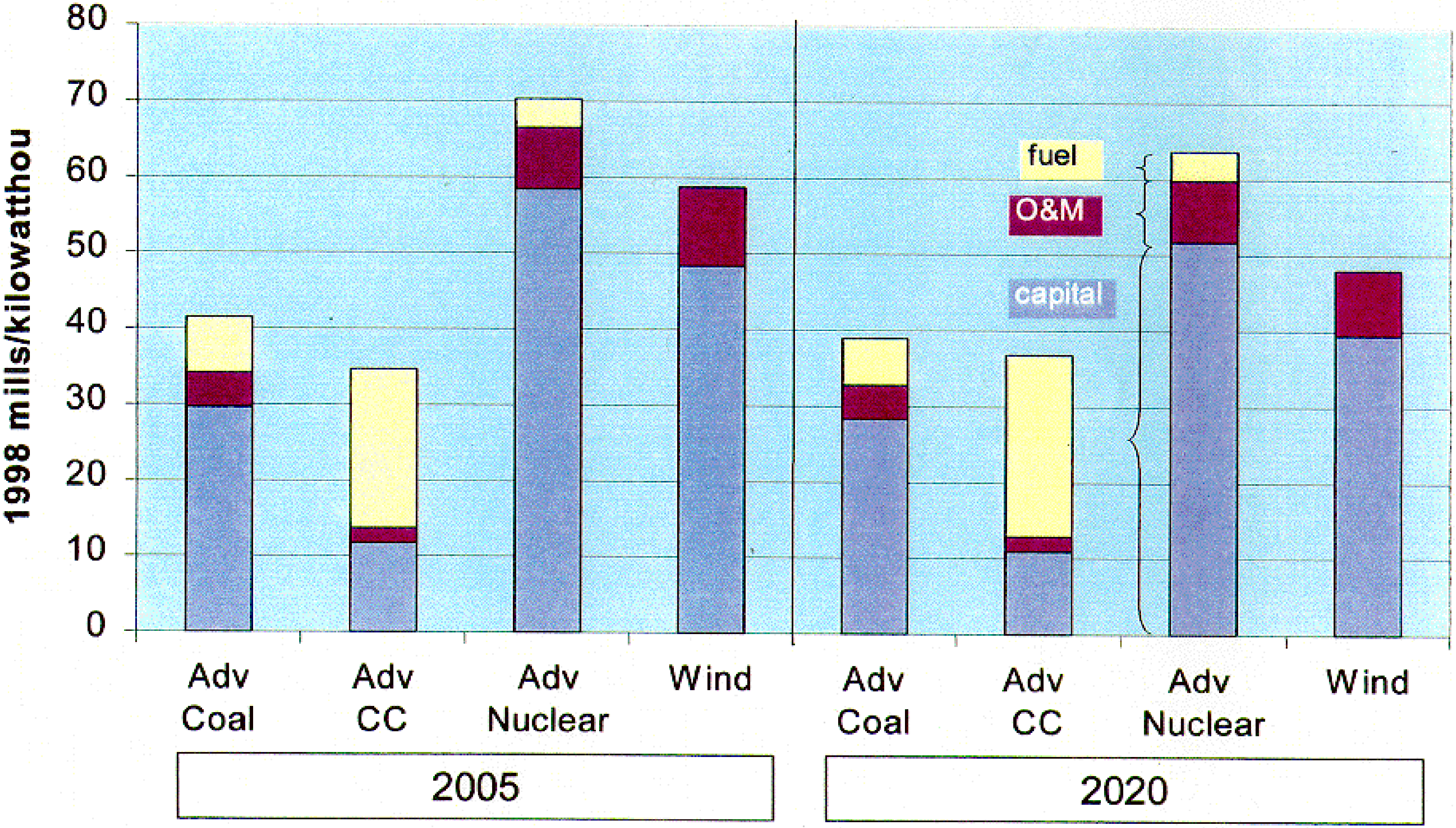


Figure 4: Distribution of Average Variable Expenses, 1990 and 1998 (in 1996$)



Levelized Electricity Generating Costs
AEO2000 Reference Case



Mary Hutzler, EIA

Key Points From NEEP-423

- **Materials for Fission Reactors**
  - **Metallic Fuels**
    Stability
    IFR
  - **Enrichment**
    Approach
    Quantitative Analysis
  - **Zr**
    Reason for Development
    Alloying Effects
  - **Fuel Element Performance**
    Reason for Oxides
    Effect of Stoichiometry
    Temperature Profiles
    Conductivity Integral
  - **Fuel Element Chemistry**
    Effect of Stoichiometry
    Vapor Pressure Effects

Key Points From NEEP-423 (cont.)

- **Swelling Due to Fission Products**
  Coalescence of bubbles
  Migration of vacancies, interstitials, and gas atoms
  Motion of bubbles
  What is bubble resolutioning?
  Nucleation and growth of clusters
  Concept of what is in a bubble
  Motion of bubbles in T and σ gradients

- **Pore Migration and Restructuring**
  Difference between pores, voids and bubbles
  Movement of pores in gradients

- **Fission Gas Release**
  Mechanisms for gas release
  Significance of gas atom release (or non-release)

- **Pressure Vessels**
  PWR's order of problems
  BWR's order of problems
  Mitigating phenomena

- **Fusion Materials**
  Differences From Fission
  Key Requirements
  Radiation Differences
  Radioactivity