Please Come to Boston!

BOSTON • USA • 16-18 October 2012

XXXth International Symposium of the ISSA Construction Section on Occupational Safety and Health in the Construction Industry

CPWR THE CENTER FOR CONSTRUCTION RESEARCH AND TRAINING

issa

www.issaboston2012.org

Nuclear Power Overview

Knut Ringen

Based on

From Three Mile Island to the Future
Improving Worker Safety and Health
In the U.S. Nuclear Power Industry

A White Paper
Prepared for the
Blue Ribbon Commission on America's Nuclear Future
March 14, 2011

Available at www.brc.gov (click on "Commissioned Papers")

Study Team

Name	Title and Affiliation	Principal Role in Study
Dr. Knut Ringen	Principal, Soneturn Consultants	Study Director
Jacky Randall	Principal, Stoneturn Consultants	Regulatory Issues
William McGowan	Independent Researcher	Nuclear Fuel Cycle
H. James Byers	Partner, Millian & Byers	Labor-Management Relations

Objectives

- Review **occupational** safety of nuclear fuel cycle
- From before TMI to present and into future
- Compare to other sources of electricity generation

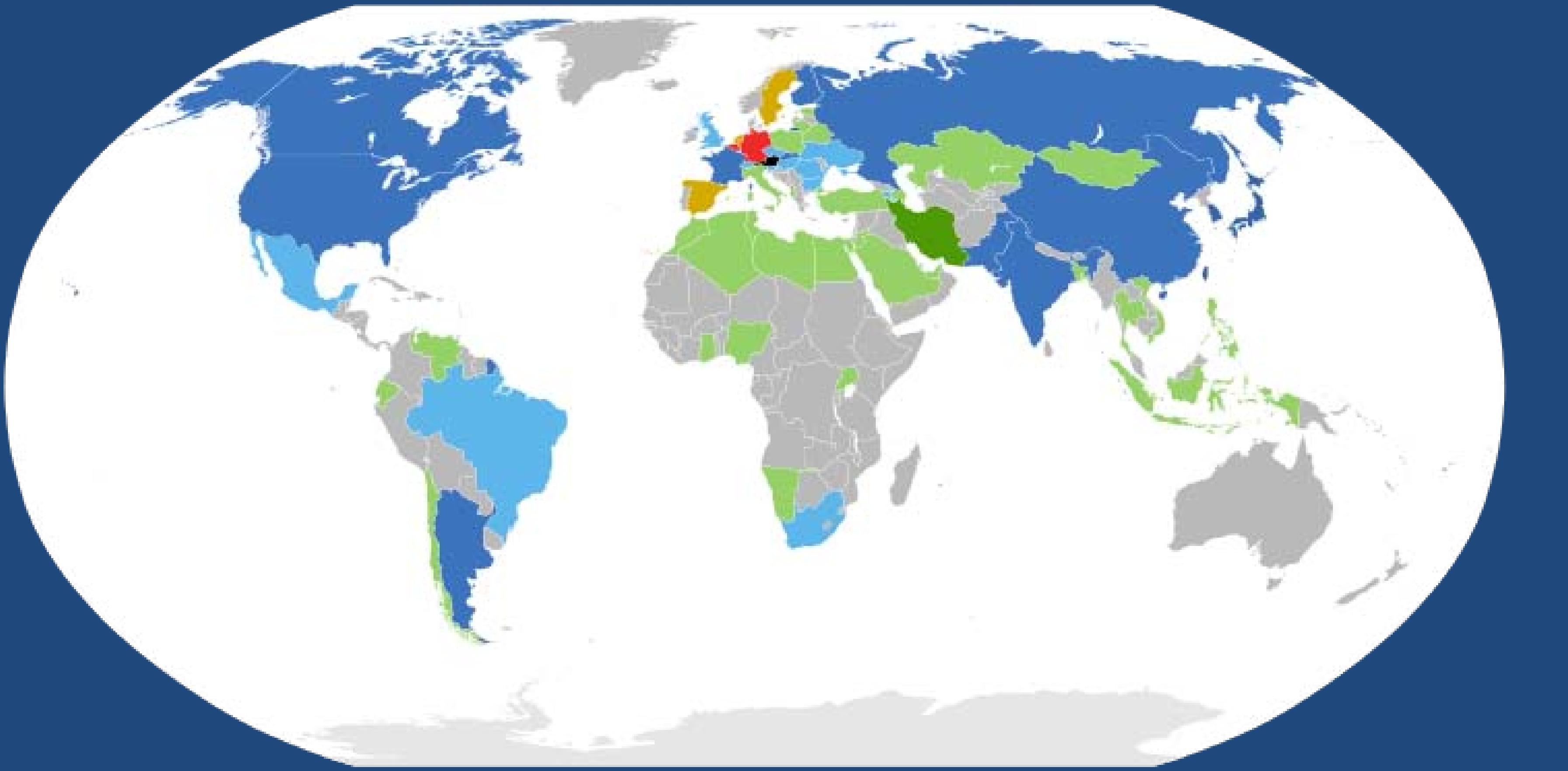
Premise

Nuclear energy should be judged on the basis of its ***relative risk*** **compared to other sources of energy** for:

- Safety for workers and public
- Energy security
- Climate change

Current State of Nuclear Energy Policy

30 Nuclear Countries Worldwide



Countries	State of Policy
UK, France, Russia, China, India, Korea	Gung ho!
Canada, US, Sweden, Finland	Cautiously positive (sort of)
Japan	Hard to say
Germany, Switzerland, Italy	Towards shut-down (maybe)

Current State of Climate Change Policy

Global CO_2 emissions should drop by

- **20% over 2006 by 2020**
- **80% by 2050**

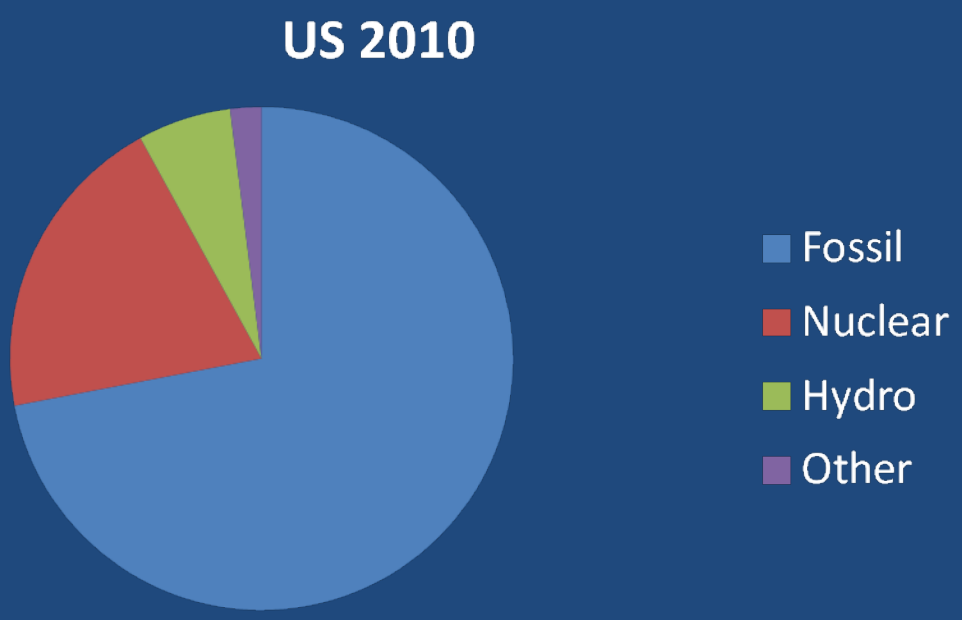
Background:
Electricity in the US

US Energy Consumption

- Total: 4,100 Bill KWH/yr
- Per Capita: 12,400 KWH/yr
- Projected to increase by 25% by 2030

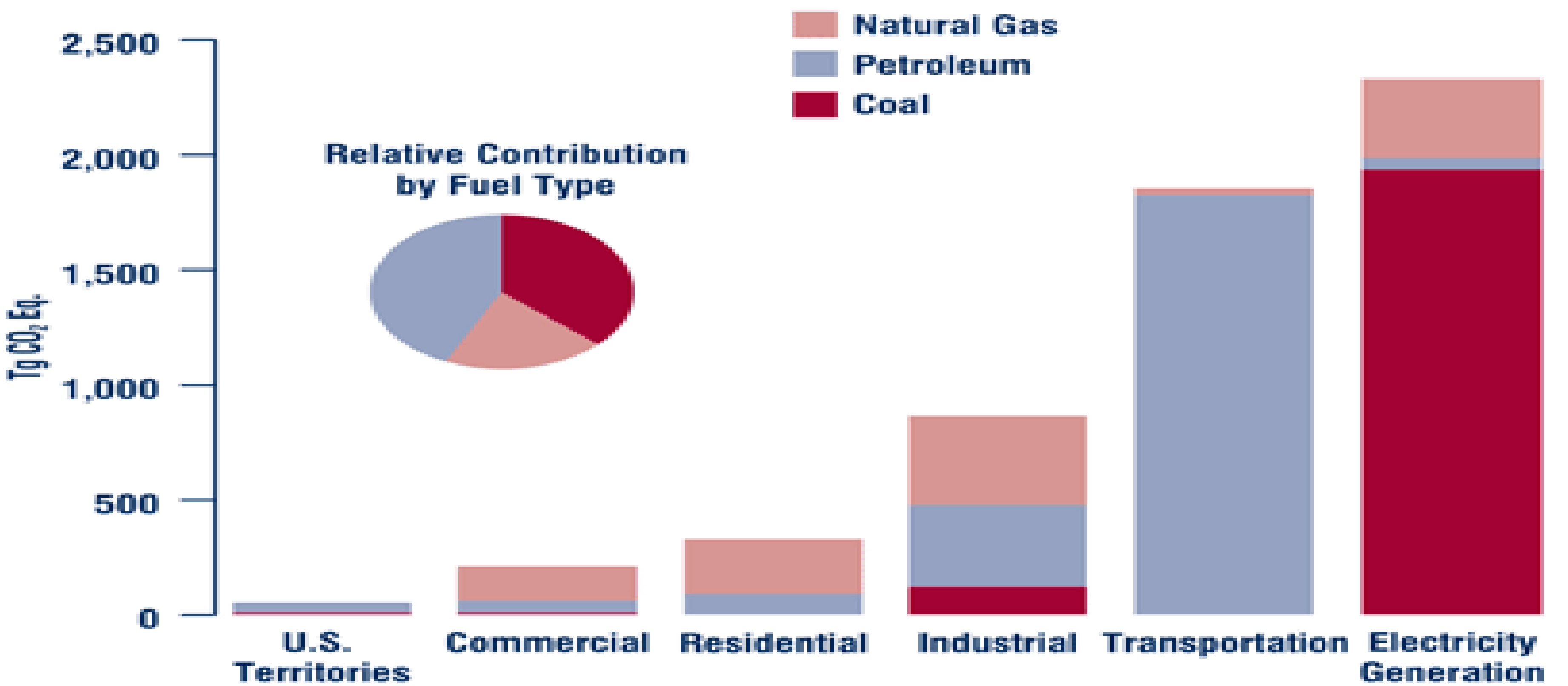
US Sources of Power

- Nuclear, 20%
- Fossil: Coal, natural gas, petroleum, 72%
- Hydro, 6%
- Other: Wind, solar, geothermal, biofuel, 2%



Electricity Generation Largest (41%) Source of Co-2 Emissions

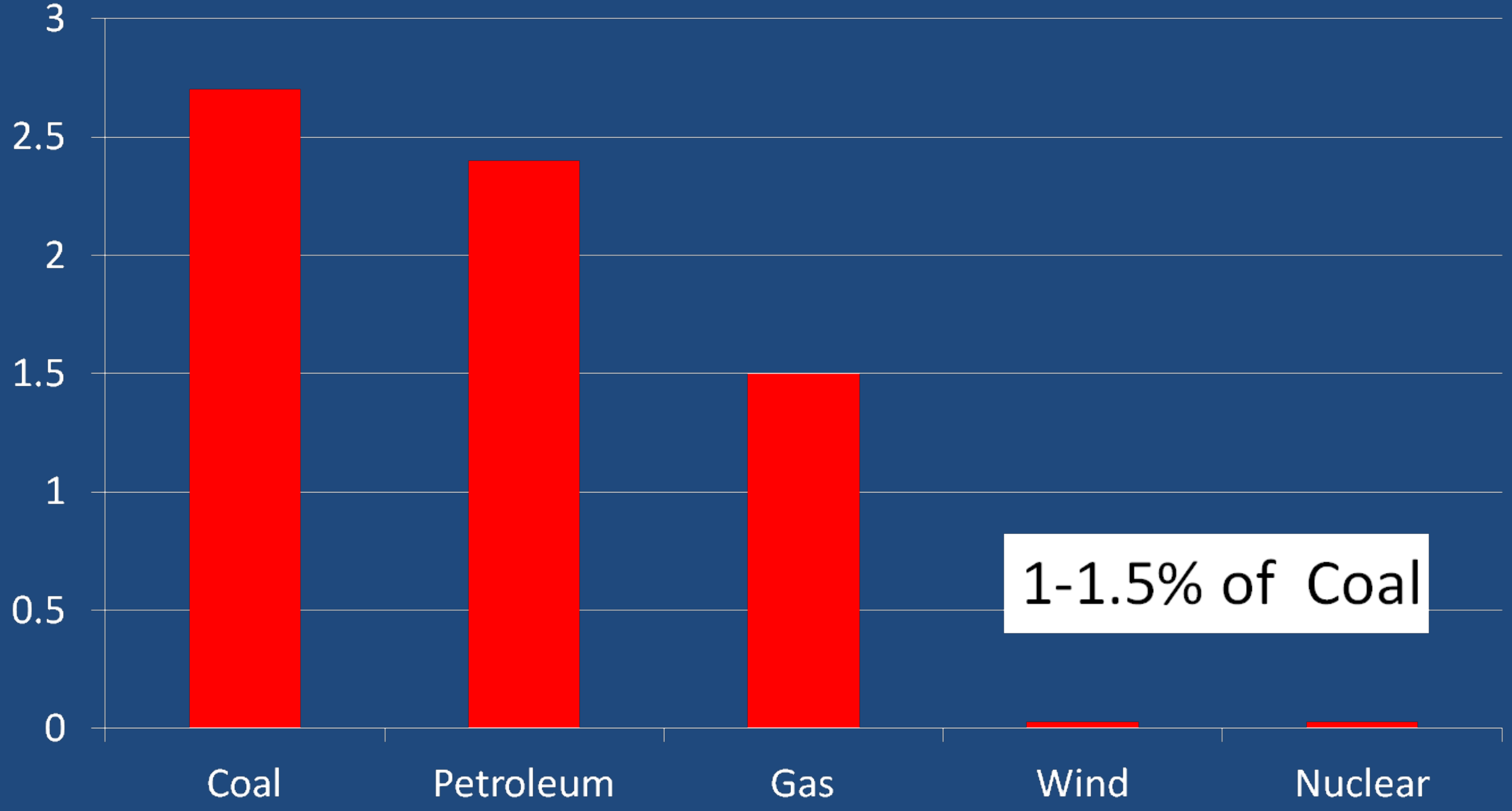
2006 CO_2 Emissions from Fossil Fuel Combustion by Sector and Fuel Type



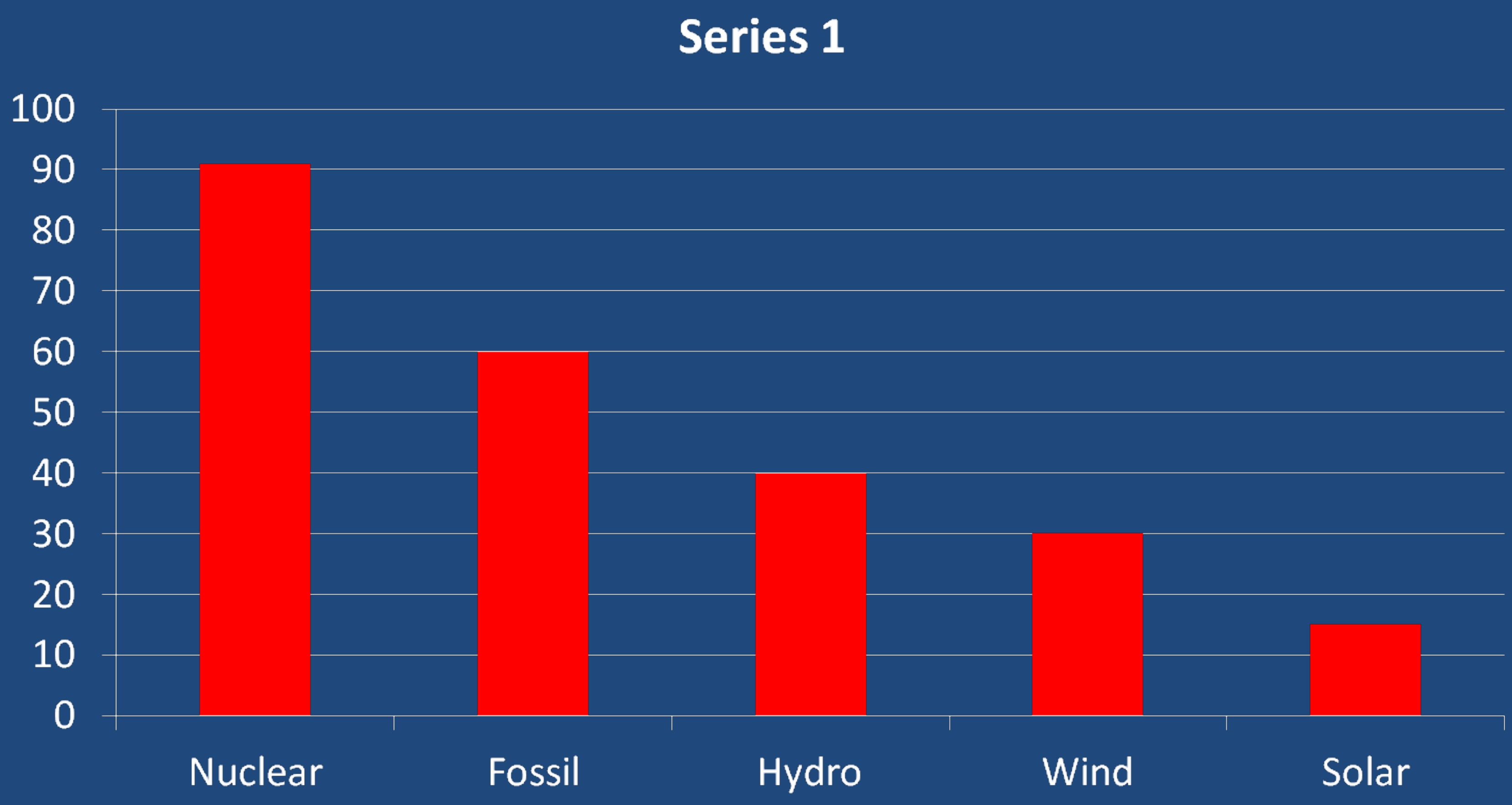
Note: Electricity generation also includes emissions of less than 0.5 Tg CO_2 Eq. from geothermal-based electricity generation.

Life cycle CO-2/Unit of Electricity

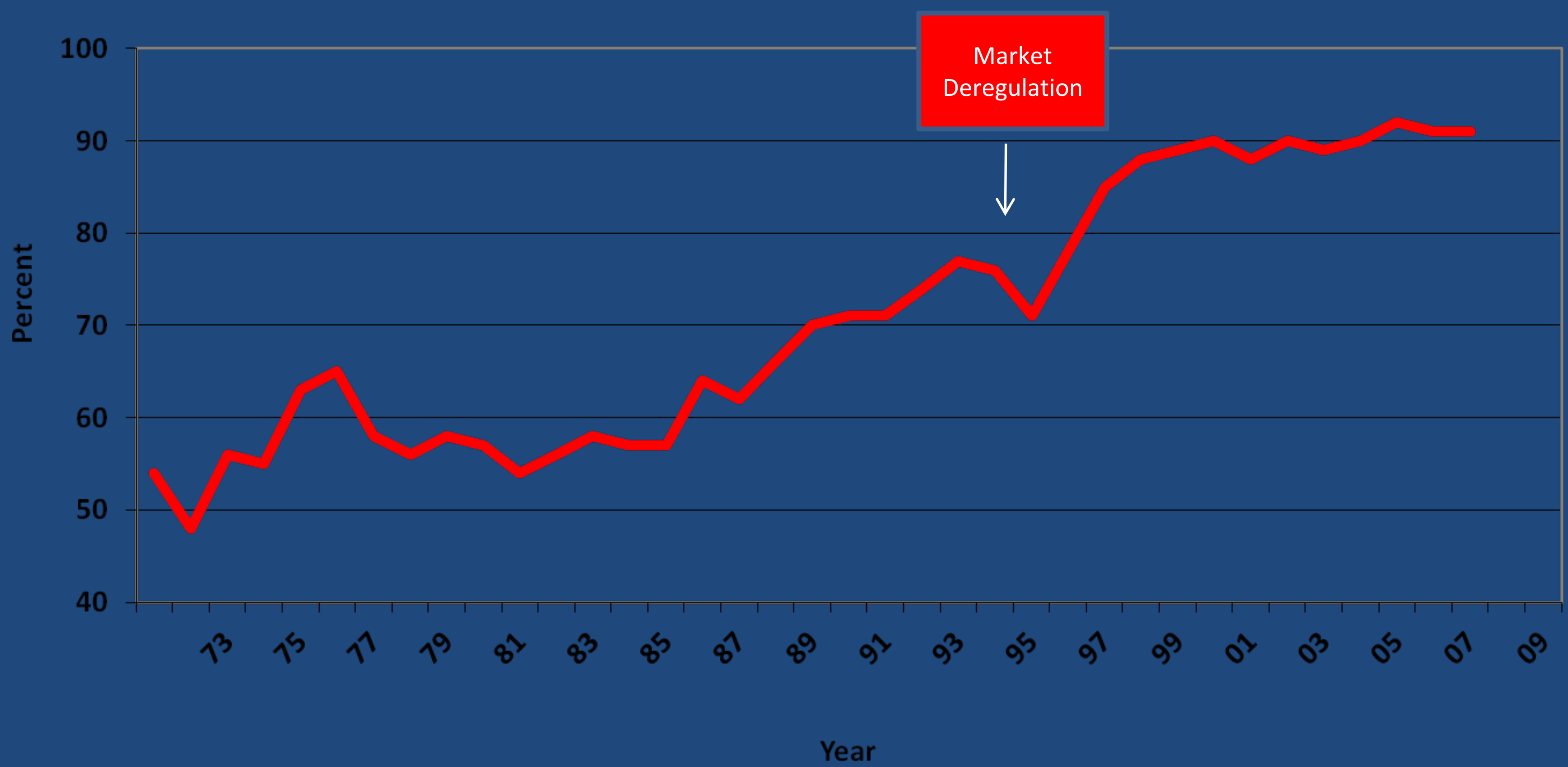
(Pounds/kwh, US)



Capacity Factor – US 2010 (Actual Output/Capacity)



Nuclear Energy Capacity Factor



Average Capacity Per Operating Unit

Sector	Unit Type	No of Units	Capacity (MW)	Cap. Factor (%)	Effective Capacity (MW)
Wind	Turbine	c. 35,000	1	30	0.3
Hydro	Turbine	2,000+	39	45	22
Coal	Boiler	1,436	235	60	141
Nuclear	Reactor	104	1,000	91	910

Roscoe Wind Farm in Texas Largest US Wind Power Facility

- **40,500 hectares (405 km^2/100,000 US acres)**
- **627 turbines (64 hectares (159 acres) per turbine)**
- **Capacity 781.5 MW**
- **Effective Capacity: ca. 200 MW**
- **Effective Capacity = 1/5th of one nuclear reactor**

No of Wind Turbines Required to Replace Existing Sources in USA

- Nuclear reactors: 300,000
  - Land space required: 20 mill hectares/ 50 mill acres
- Fossil plants: 1,200,000
  - Land space required: 80 mill hectares/ 190 mill acres)

Is it more important to replace nuclear reactors due to safety risk or fossil plants due to CO-2 output?

Is it sound policy to replace nuclear plants with fossil plants?

US CO-2 Reduction Goal

BLUEPRINT FOR A SECURE ENERGY FUTURE (March 2011)

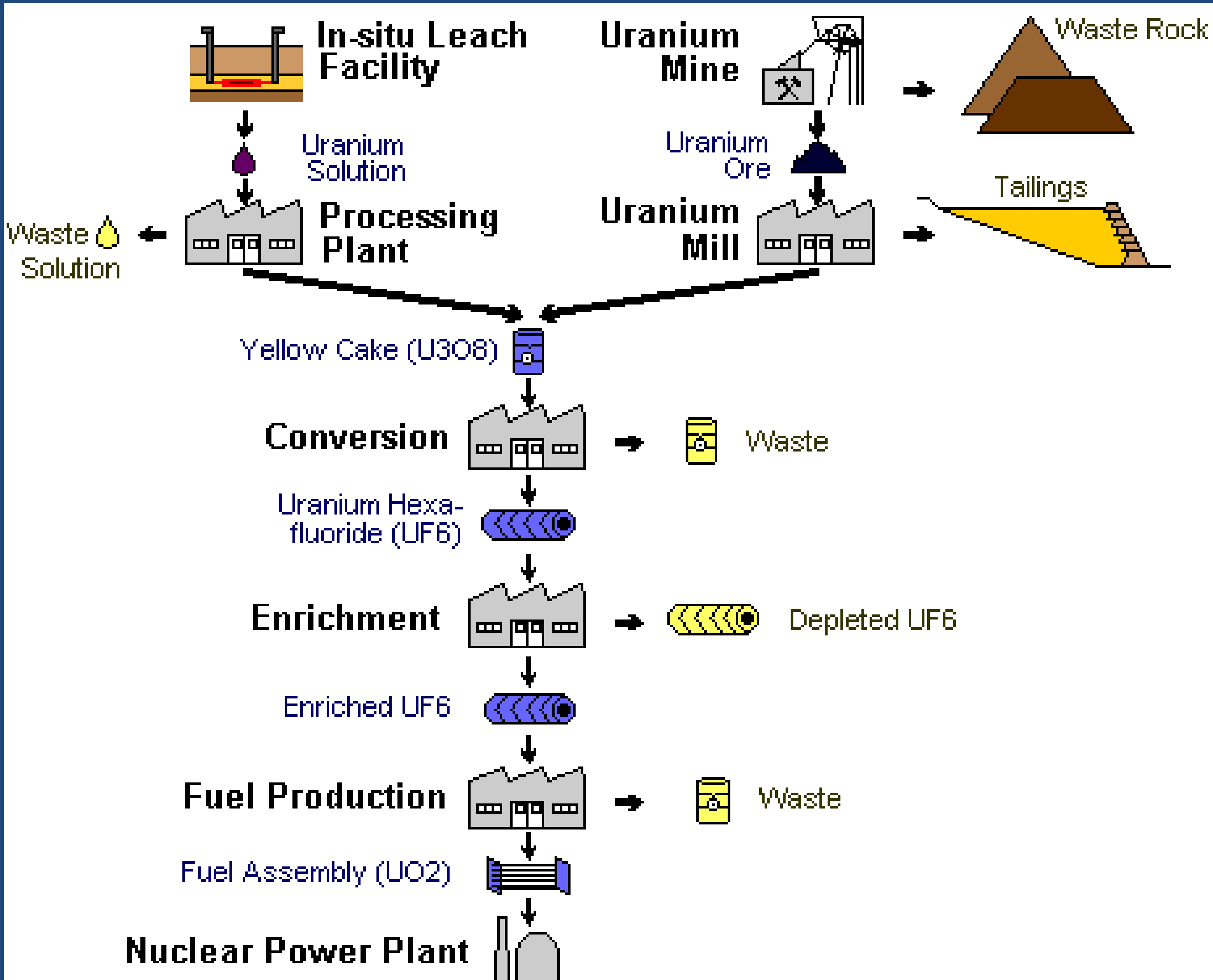
- ***One million plug-in cars by 2015***

If transportation moves from internal combustion to electrical then we have a vastly different scenario

NUCLEAR FUEL CYCLE IN THE US

Nuclear Fuel Cycle

- Front end: mining, milling, conversion, enrichment fuel fabrication
- Power generation
- Back end: spent fuel, storage, reprocessing, permanent waste disposal



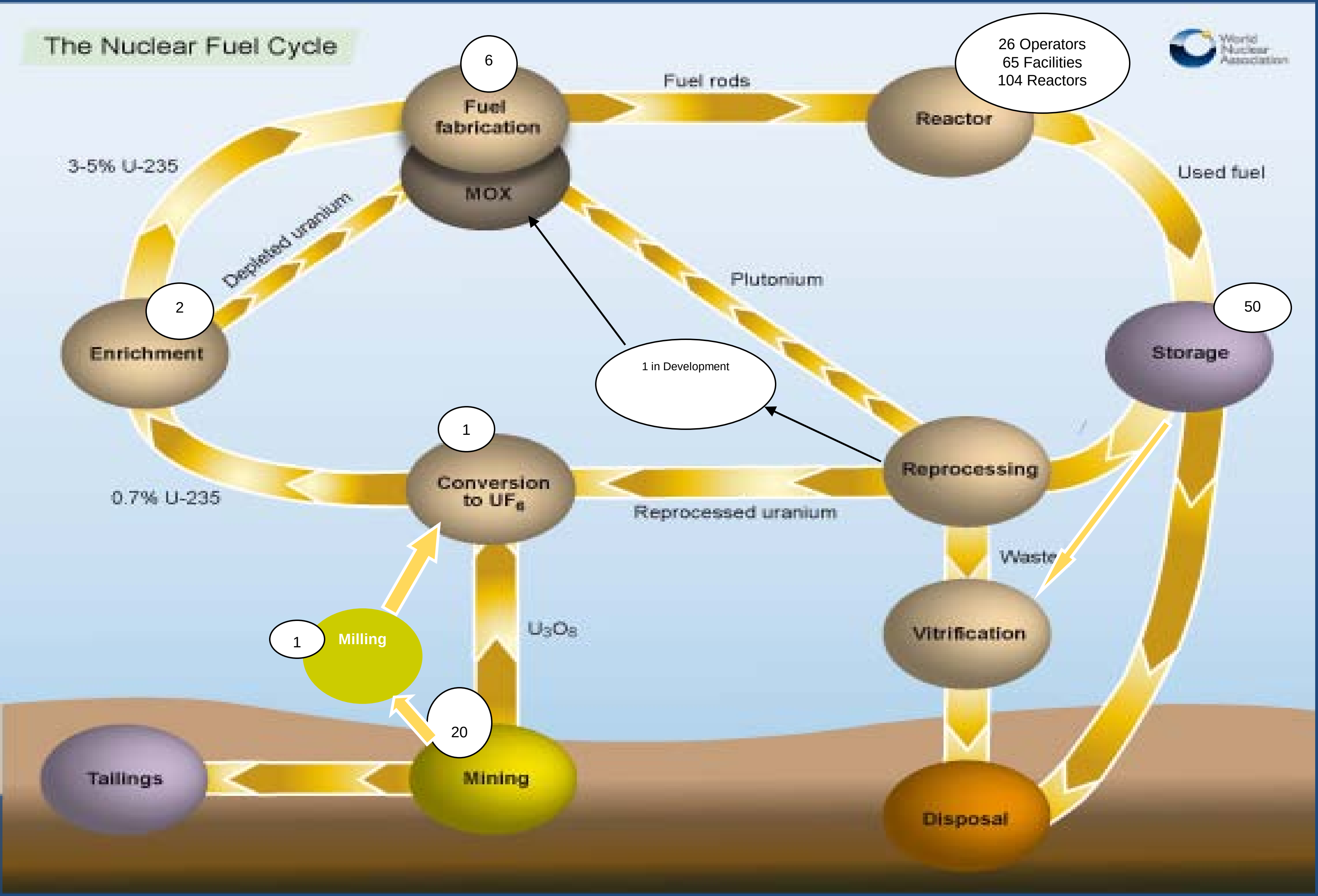
Electricity

Weapons

Medical/industrial Applications

Source: WISE-uranium.org

The Nuclear Fuel Cycle in the U.S.



[1

Table 5.1: Status of Civilian Nuclear Fuel Cycle Facilities and Estimated Employment with Opportunity for Occupational Radiation Exposure in the US, 2010

	Number		Locations
	Facilities	Workers	
Mining (incl. Exploration)	20	1,000	Active and inactive domestic uranium mines are located in: Alaska, Arizona, Colorado, Montana, Nebraska, Nevada, New Mexico, North Dakota, North Dakota, Oregon, South Dakota, Texas, Utah, Virginia, Washington, and Wyoming
Milling	1	200	One operating uranium mill in Utah, three mills in standby status in Colorado, Utah, and Wyoming, and one under development in Colorado.
Conversion	1	700	Illinois (Honeywell UF_6 Plant)
Enrichment	2	3,700	Kentucky; One centrifuge plant in start-up in New Mexico
Fuel Fabrication	6	3,600	Virginia, North Carolina, South Carolina, Tennessee, and Washington.
Reactor Operations	65	119,000	Throughout nation
Interim Spent Fuel Storage	2	100	There are two independent storage facilities, in Illinois and Oregon. In addition 48 ISFS facilities are located in nuclear power plant facilities in 32 states.
Total	97	128,300	

FINDING NO 1:
NUCLEAR INDUSTRY HAS OPERATED WITH A VERY HIGH DEGREE OF OCCUPATIONAL SAFELY

Definitions of Safety

- **Occupational** Safety: recognition and prevention of any hazard in the workplace that can be harmful to human health (incl radiation).
- **Nuclear** Safety: makes sure that facilities that make or use radiation prevent any of the radiation from being released into the environment
- **Radiation** Safety/Protection: monitoring of workers or the environment for radiation and estimating whether the amount of radiation released is hazardous.

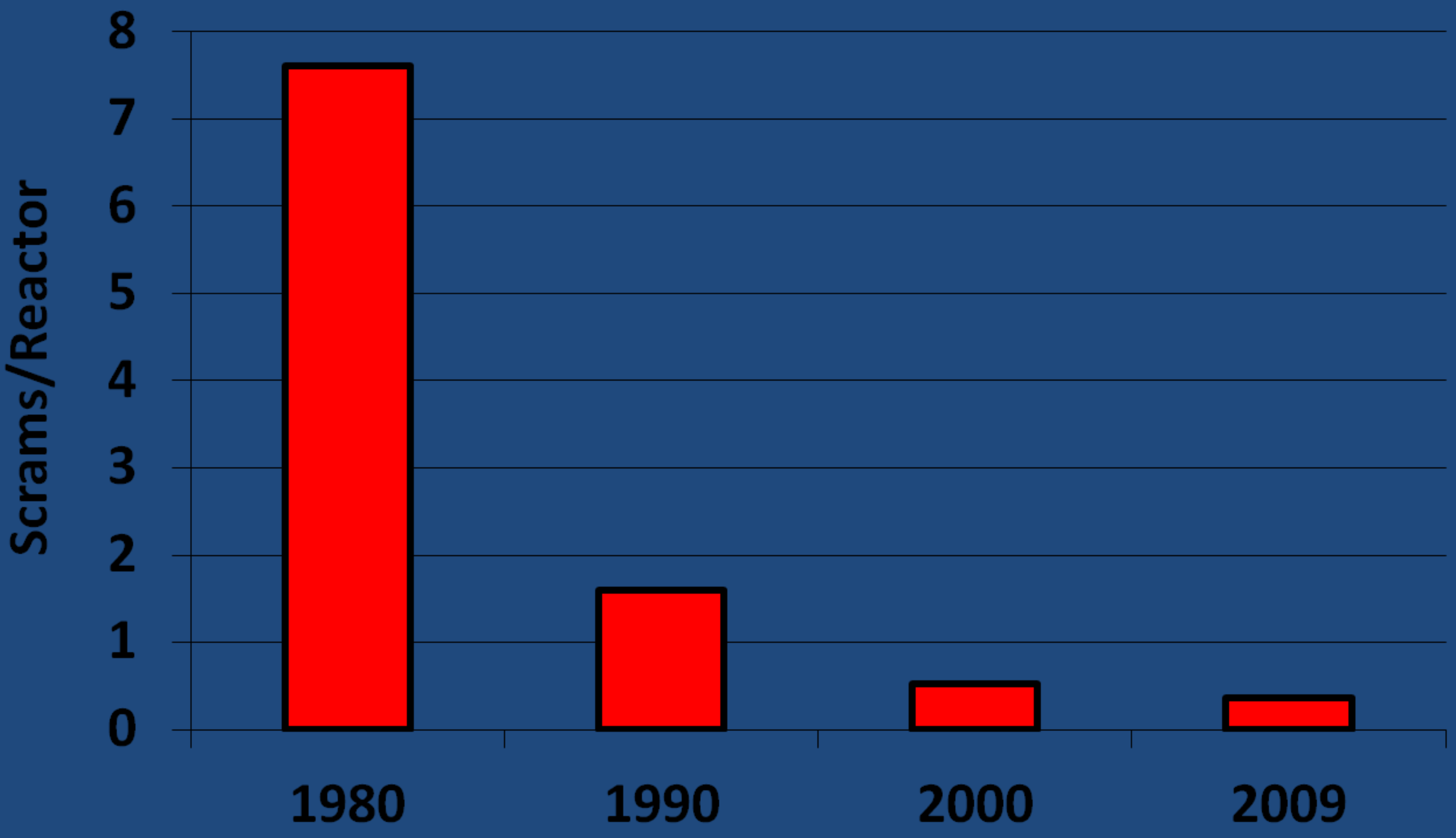
Industry differentiates between nuclear safety and OSH
(OSH usually called “industrial safety”)

Measurements of Safety

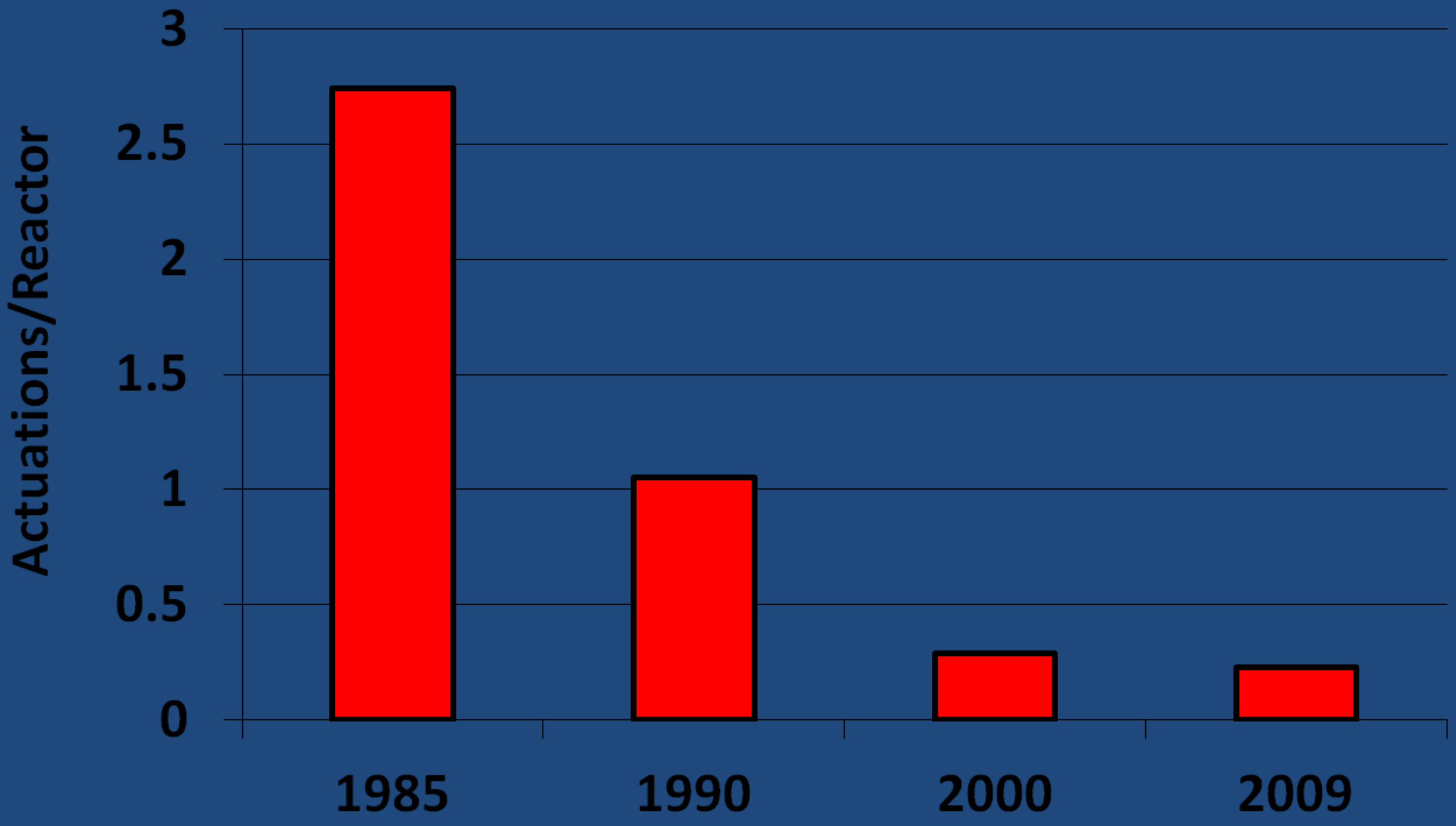
- Nuclear safety
  - Process:
    - Performance Indicators (17)
    - NRC Inspection data
  - Outcomes
    - Worker radiation monitoring data
- OSH
  - Process
    - OSHA inspection data
  - Outcomes
    - Occupational fatality, injury and illness data

NUCLEAR SAFETY

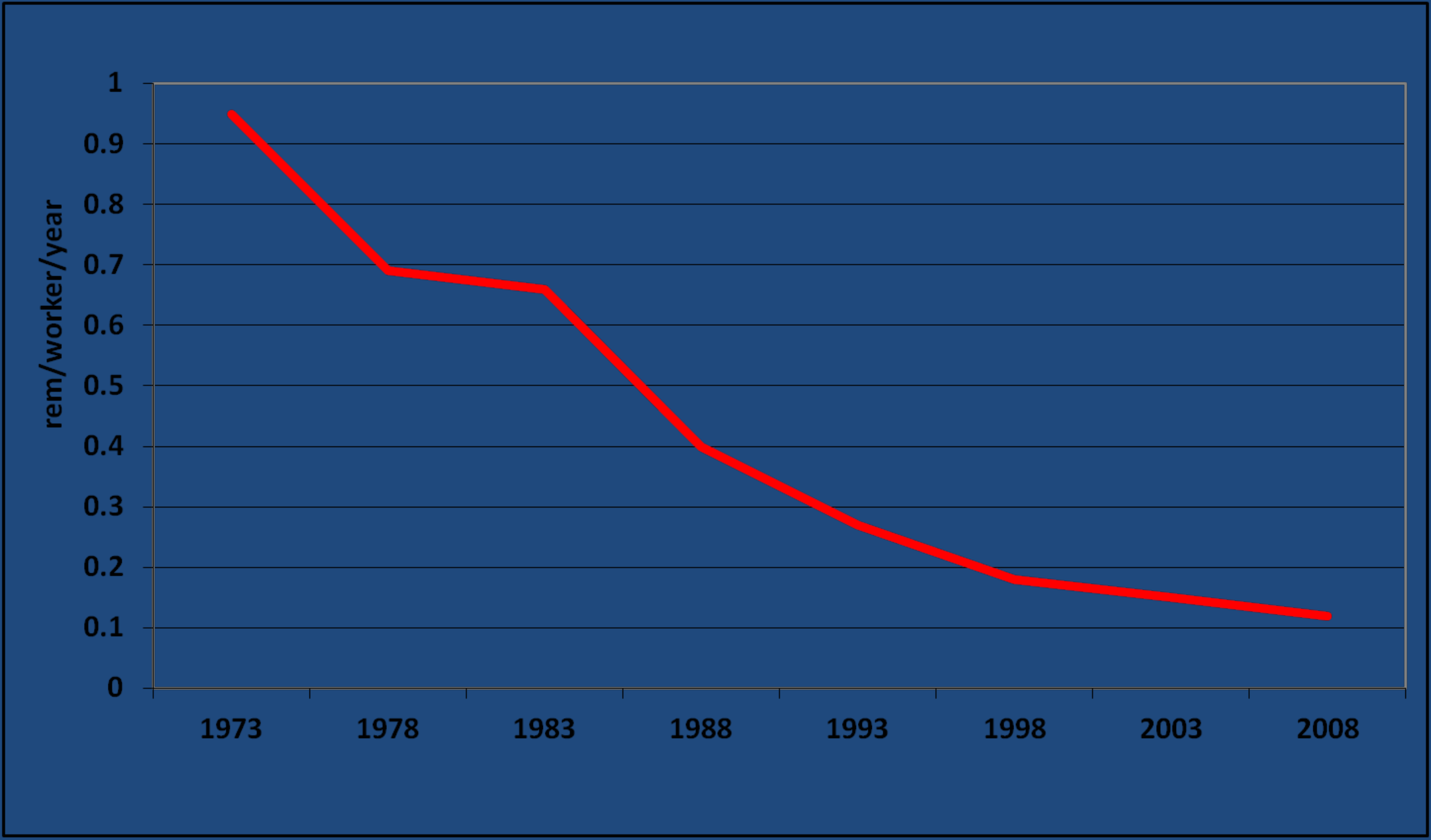
Key Process Indicator
Average Annual Number of Scrams Per Reactor



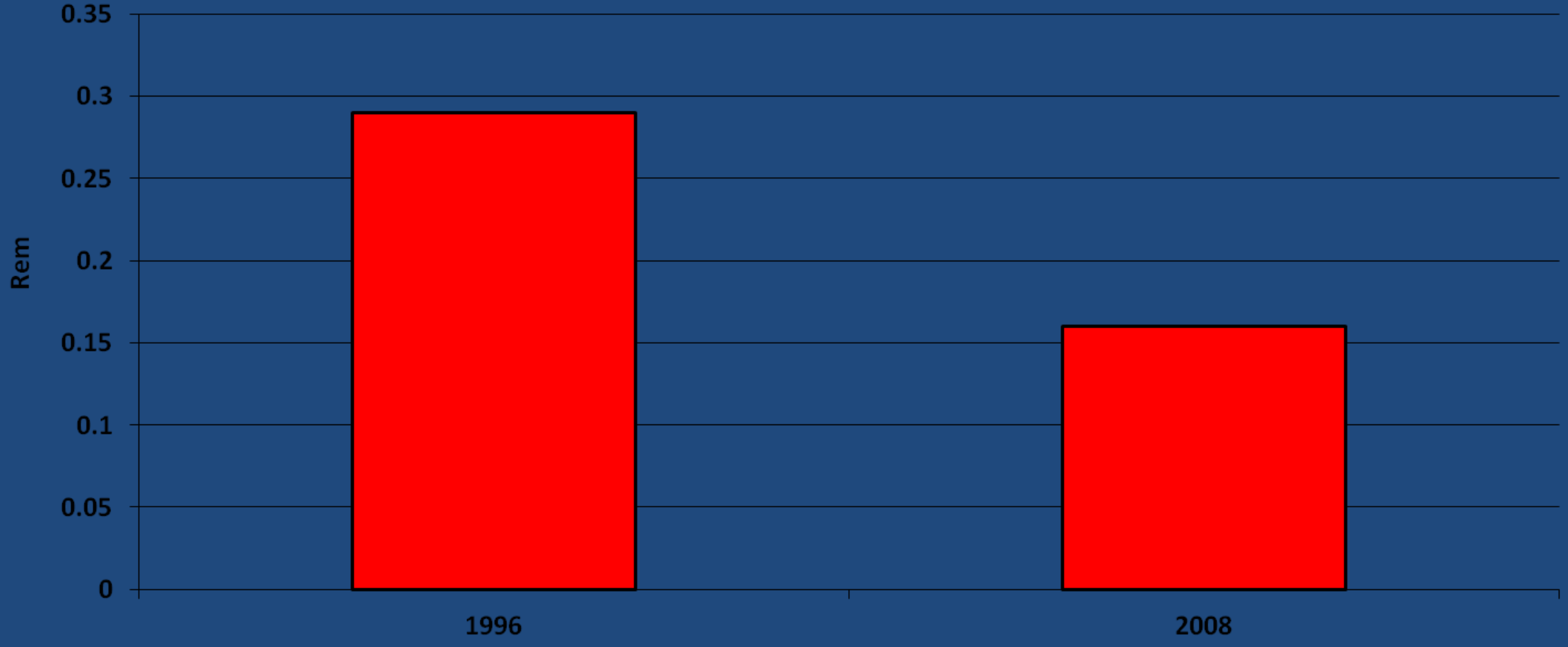
Key Process Indicator
Average Annual Number of Actuations Per Reactor



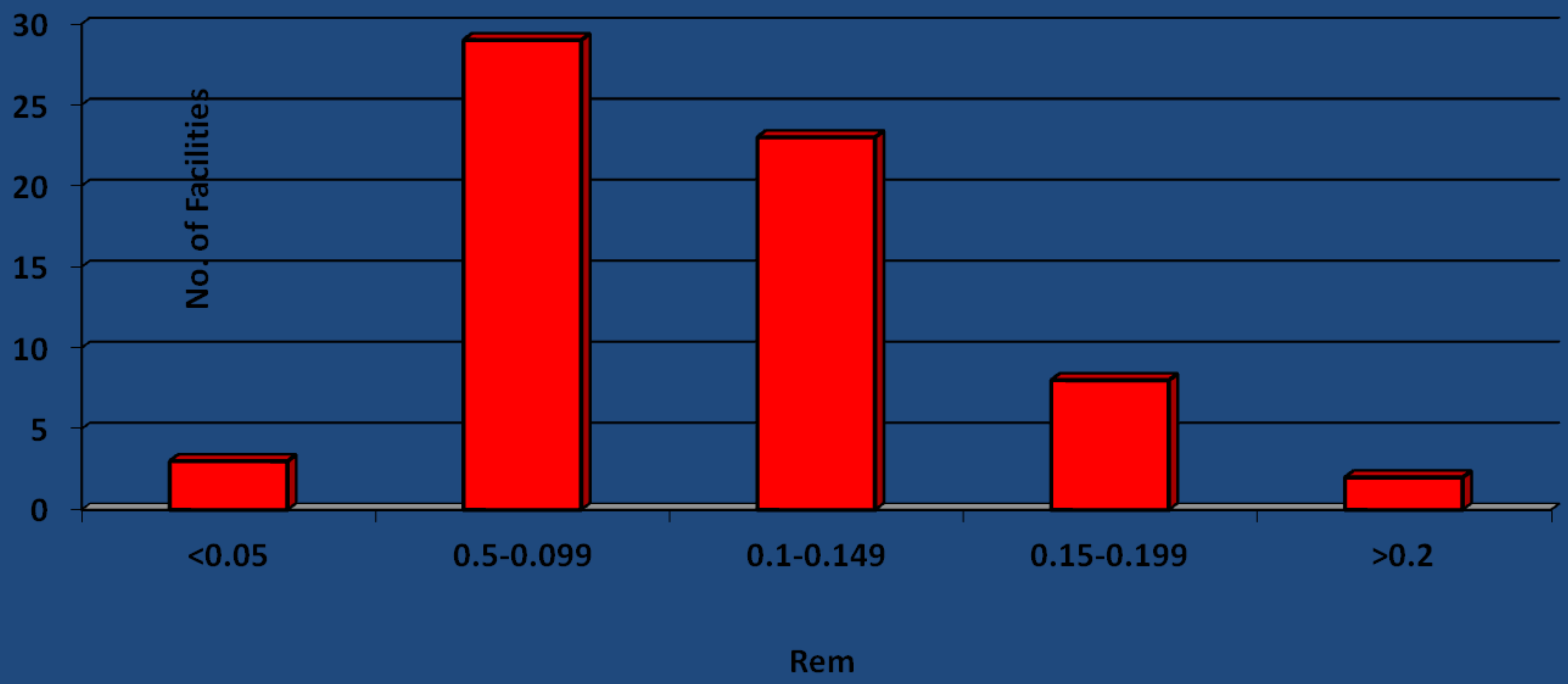
Average Annual Radiation Dose per Worker with any Dose in Rem (1 rem=0.01 Sv / 1 Sv=100 rem)



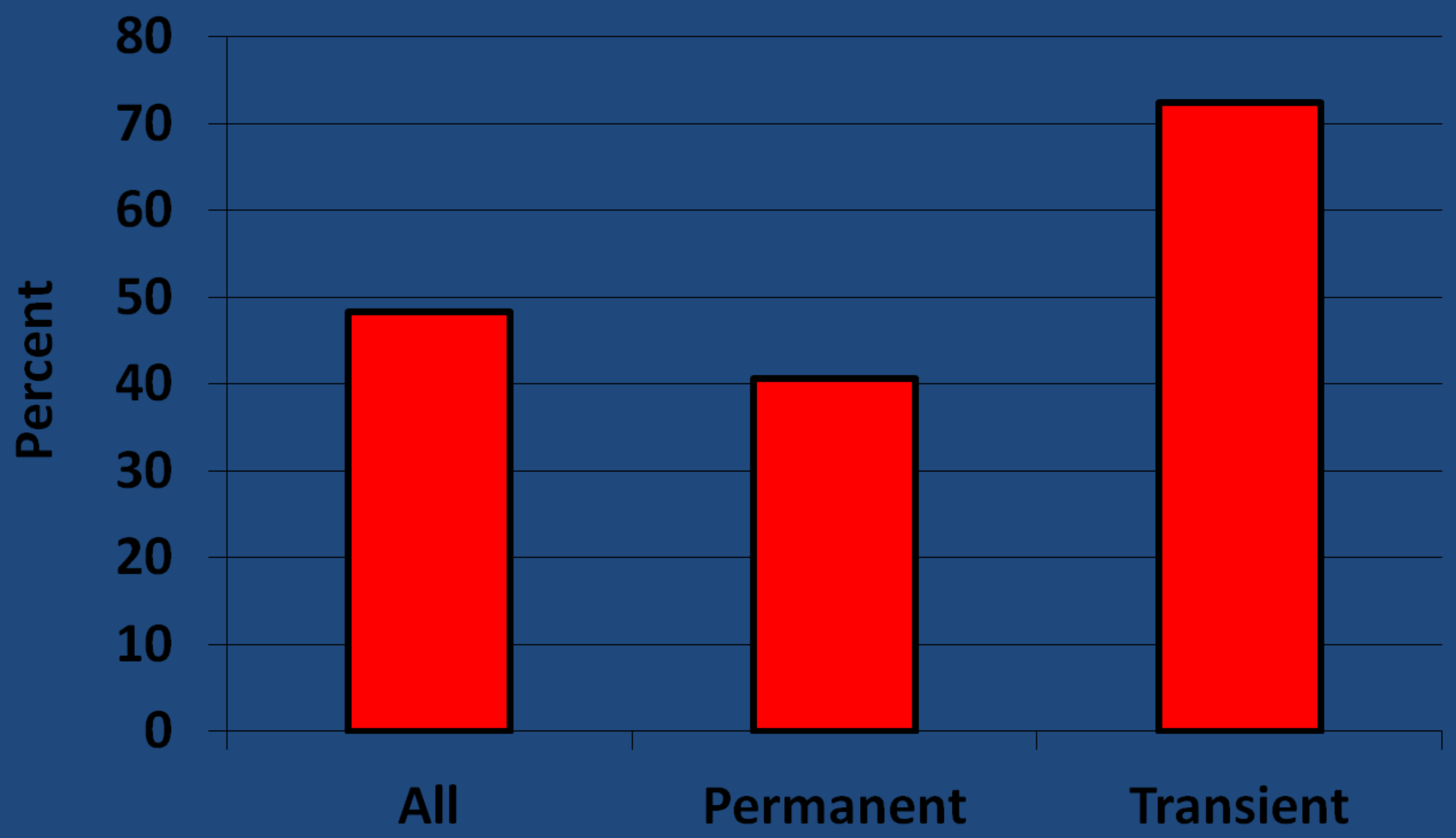
Average Annual Dose, Reactors



Distribution of Average Annual Dose by facility



Percent of Workers with Measurable Radiation Dose Permanent v. “Transient,” 2008



Average Annual Dose, Permanent v. "Transient," 2008

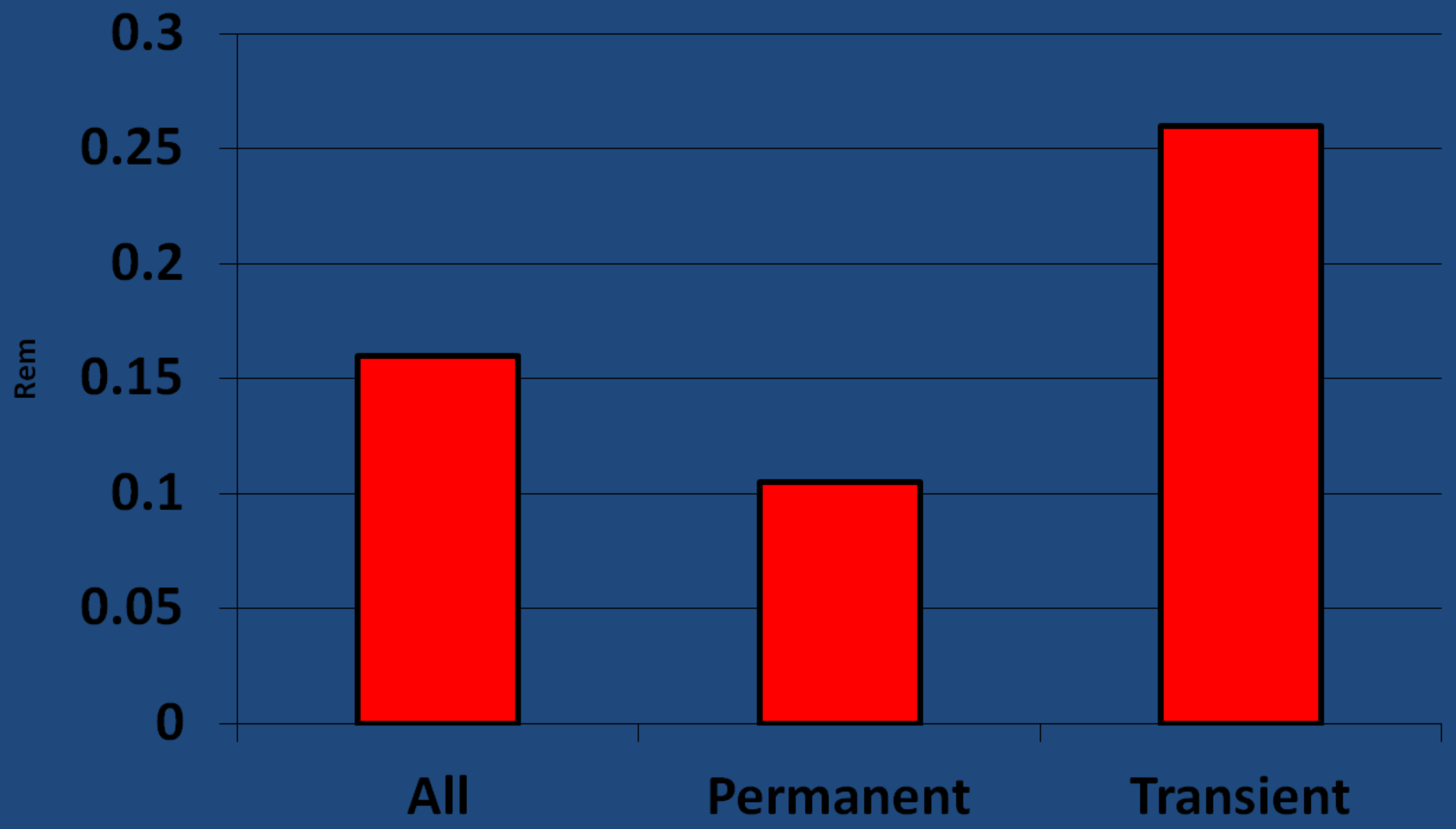


Table 9.4: Average Individual Dose 1991-2000

Category	Rem/Person
Routine Operations and Surveillance	0.139
Plant Maintenance	0.243
In-Service Inspection	0.173
Special Maintenance	0.156
Waste Processing	0.130
Refueling	0.134
All Categories	0.193

OCCUPATIONAL SAFETY: OSH PERFORMANCE IN NUCLEAR COMPARED TO FOSSIL, HYDRO AND OTHER

Major Energy OSH Events, US, 2010

Date	Facility	Type	Fatalities
Feb	Kleen Energy, CT	Gas fired power plant	6
April	Tesoro, WA	Refinery	6
April	Massey Energy, WV	Coal mine	29
April	BP Deepwater, LA	Oil rig	11

Table 8.3: Annual Number of Fatal Occupational Injuries by Utility Sector, 2003-2008

Year	Number of Fatal Injuries Reported				
	Hydro	Fossil	Nuclear	Other	Total
2003	1	5	0	2	8
2004	2	9	0	1	12
2005	5	4	0	2	11
2006	8	6	0	0	14
2007	2	5	0	0	7
2008	2	3	0	0	5
Total	***20***	***32***	***0***	***5***	***57***

Table 8.3: Annual Number of Fatal Occupational Injuries by Utility Sector, 2003-2008

Year	Number of Fatal Injuries Reported				
	Hydro	**Fossil**	**Nuclear**	**Other**	**Total**
2003	1	5	0	2	8
2004	2	9	0	1	12
2005	5	4	0	2	11
2006	8	6	0	0	14
2007	2	5	0	0	7
2008	2	3	0	0	5
Total	***20***	***32***	***0***	***5***	***57***

Had the nuclear plants operated at the same risk level during the period 2003-2008 as:

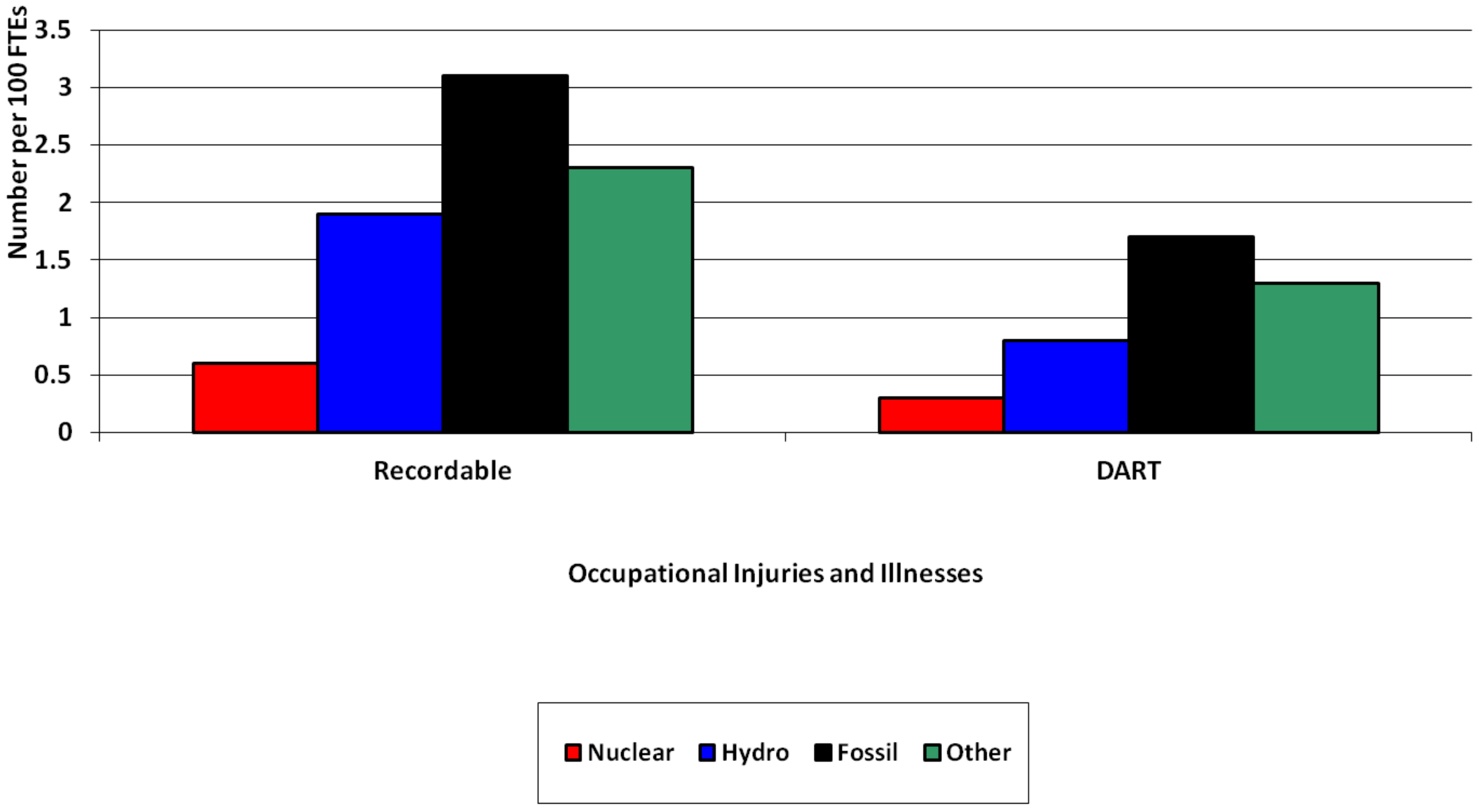
- hydro plants =29 fatalities,
- fossil fuel plants = 13 fatalities

Table 8.1. Rates of Reportable Injuries and Illnesses for Select Industries, 2009

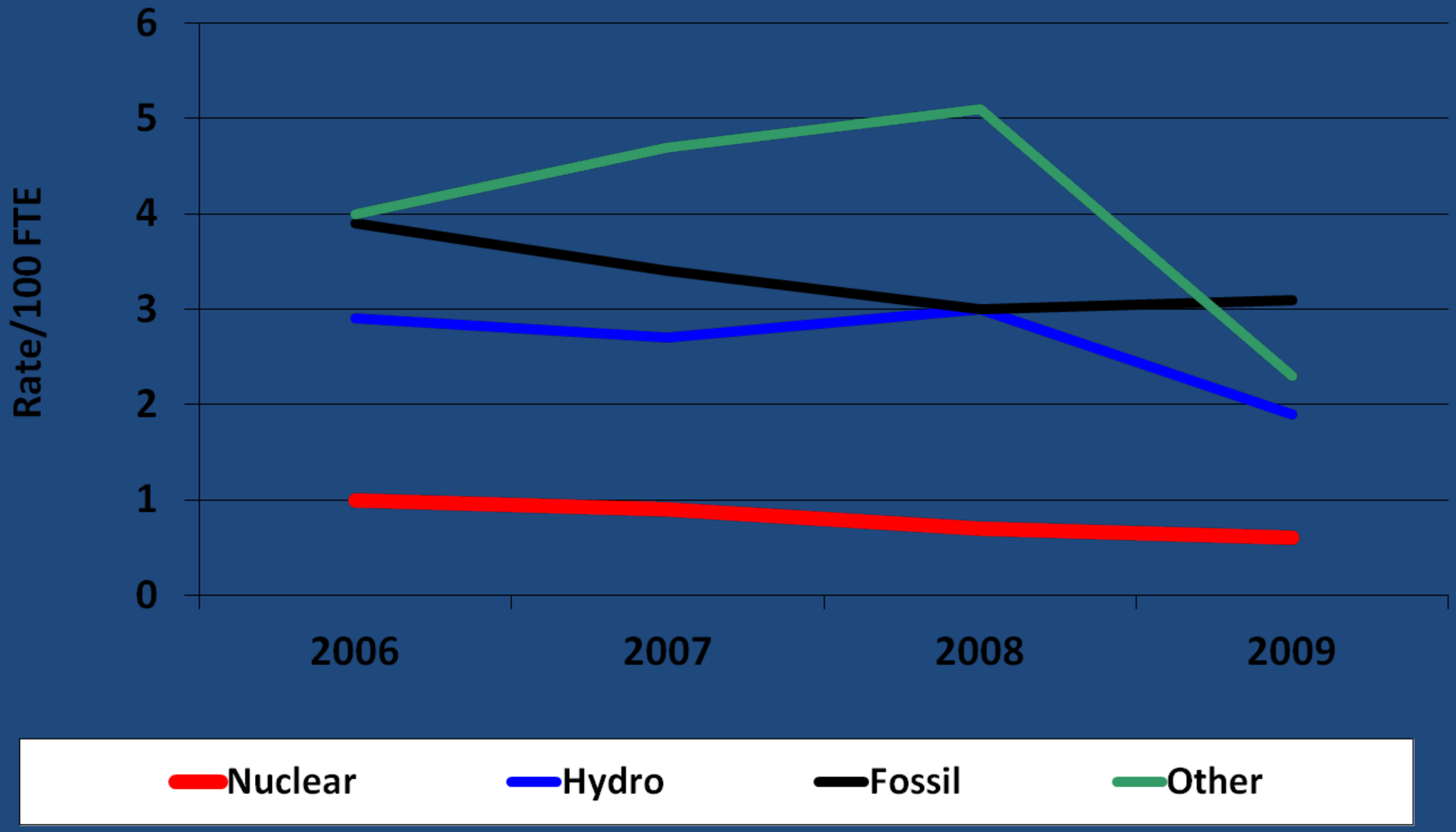
Industry	NAICS	Injury and Illness Rates**	
		Recordable	DART
Nuclear Facilities	221113	0.6	0.3
Computer Storage Device Mfg	334112	0.8	0.2
Finance and Insurance	52	0.8	0.2
Pharmaceutical Manufacturing	3254	2.0	1.1
Chemical Manufacturing	325	2.3	1.4
Aerospace Manufacturing	3364	3.3	1.8
All Manufacturing	31-32	4.3	2.3
Hospitals	6221	7.3	2.8
Steel Products Manufacturing	3312	7.6	3.5
Average for All Private Industry	**-**	***3.6***	***1.8***

**Number per 100 FTE workers in industry

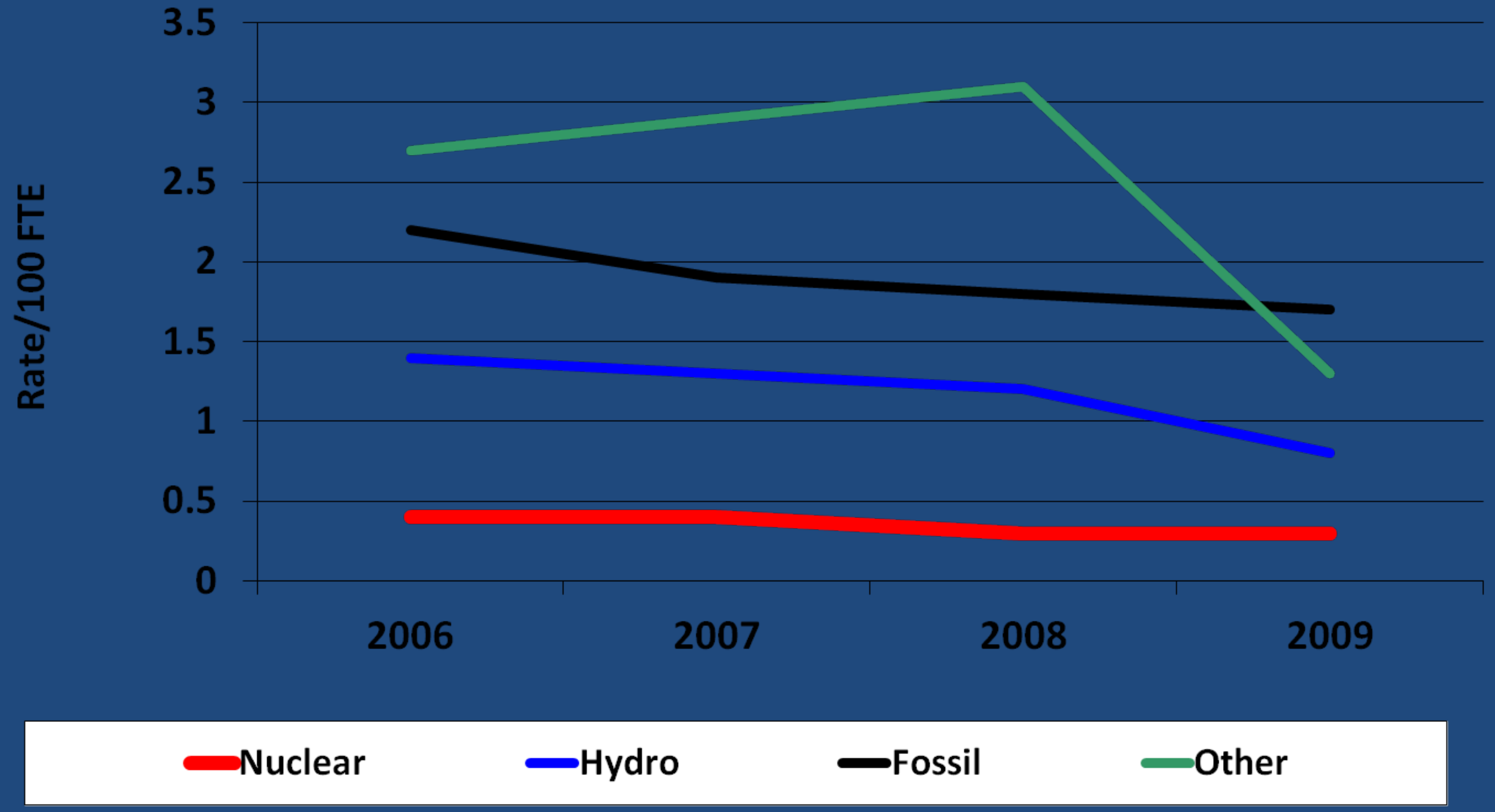
OII Data, 2009



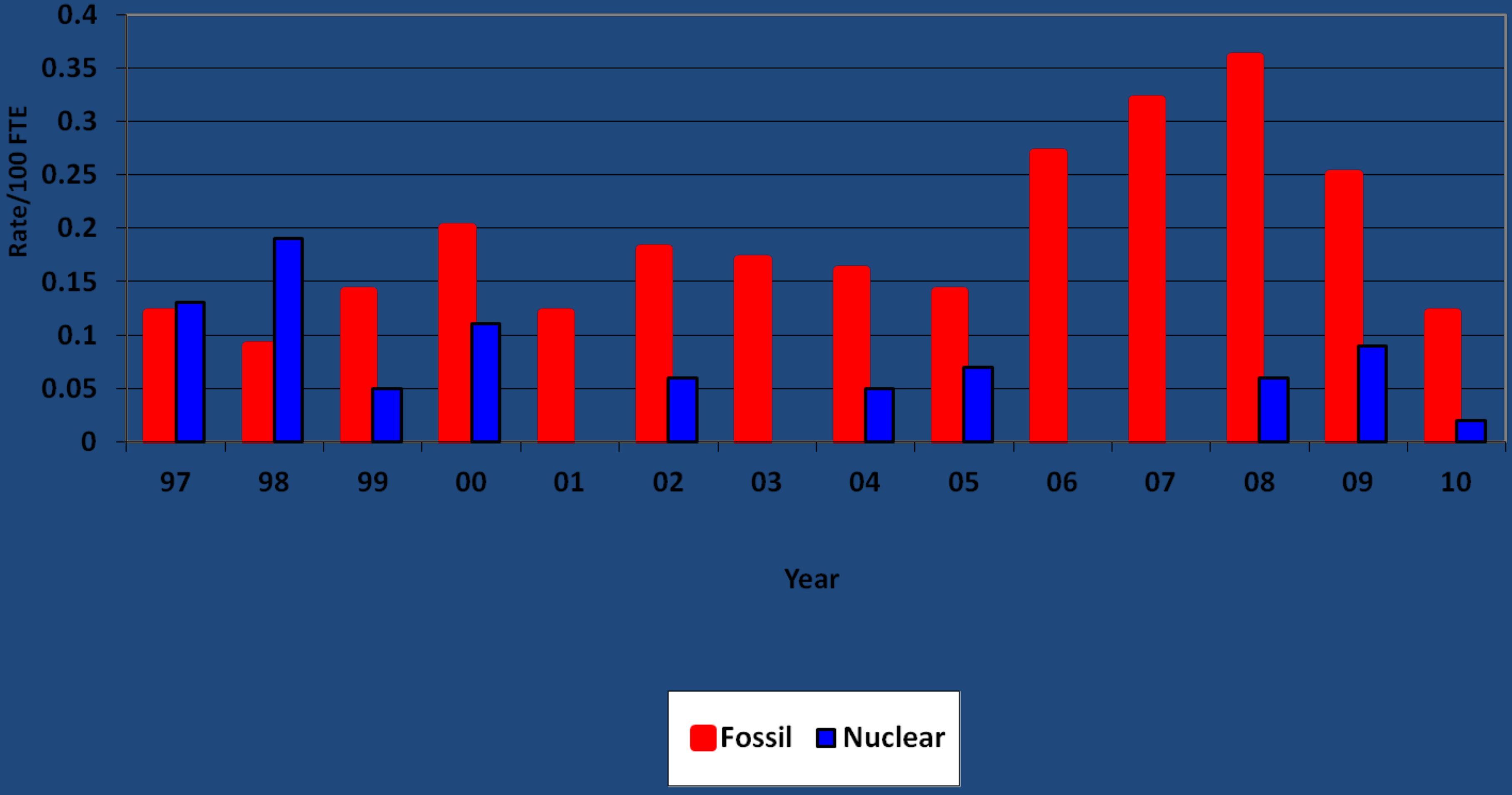
Recordable Injury Rate by Sector



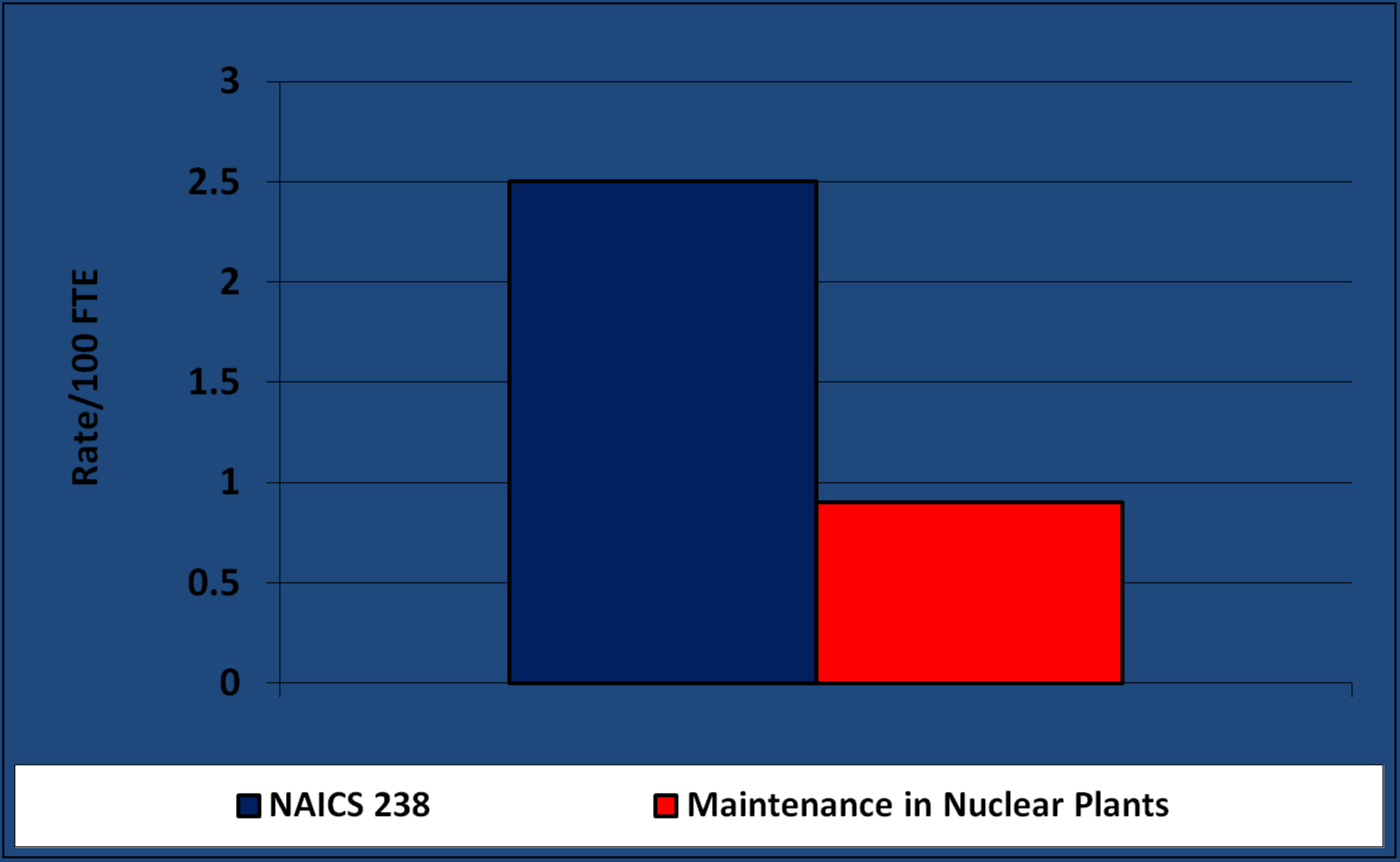
DART Rates by Sector



DART for Outage Work 1997-2010



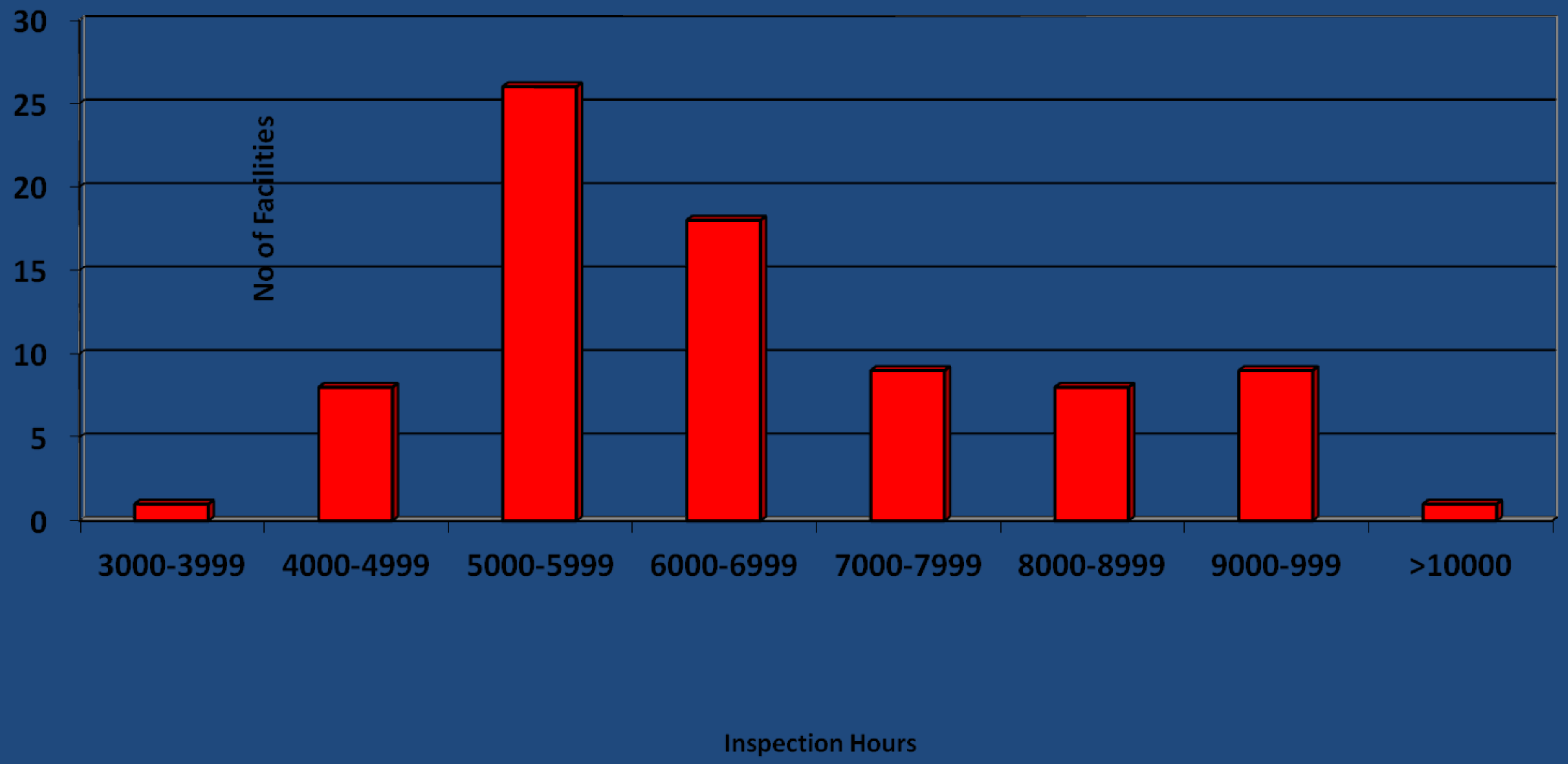
Maintenance: Nuclear v. All



To what Can Improved Safety be Ascribed

- Fear of regulation
- Market forces
- Regulation
- Self regulation: INPO

NRC Annual Inspection Hours Per Plant, 2008



FINDING NO. 2
ADVERSE EVENTS MAR SAFETY RECORD

The Seven Highest Ranked Nuclear Power Events Since 1979, USA

Rank	Nuclear Power Plant	Year	Event
1	Three Mile Island	1979	Partial core meltdown
2	Davis-Besse	1985	Feedwater loss
3	Brunswick	1981	Heat exchanger damage
4	Shearon Harris	1991	Unavailability of high pressure injection pump
4	Wolf Creek	1994	Drainage of reactor cooling water during outage
4	Catawba	1996	Loss of off-site electrical power feed
4	Davis-Besse	2002	Cracking and corrosion of reactor vessel head

Principal *Significant* Risks

- Risk of *inexperience*
- Risk of *overconfidence*
- Risk of *complacency/negligence*
- Risk of *risk-taking*

Davis Besse Vessel Head

FINDING NO 3:
SAFETY CULTURE SHOULD BE IMPROVED

Safety Culture

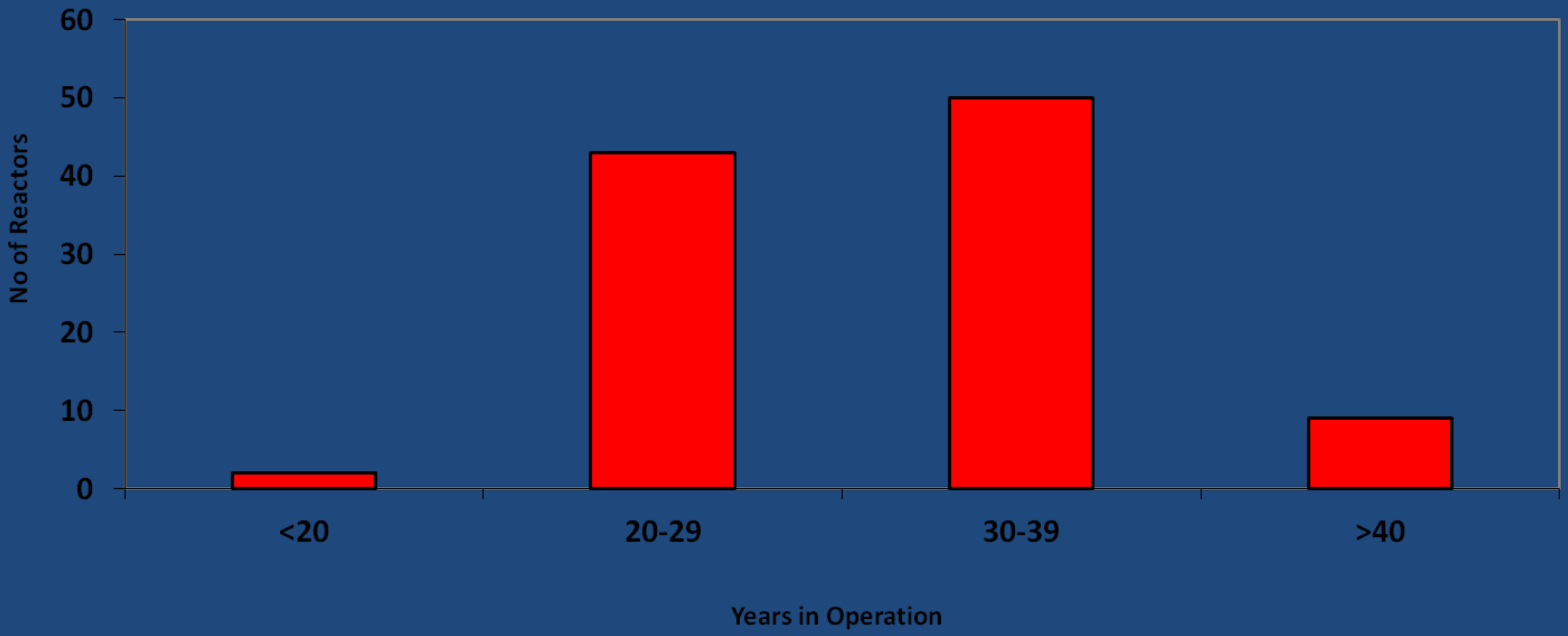
- More worker involvement
  - Workers as vulnerable population
- Adopt North Sea safety case approach
- Revamp NRC regulatory program/ROP

FINDING NO 4-7:
OTHER FINDINGS

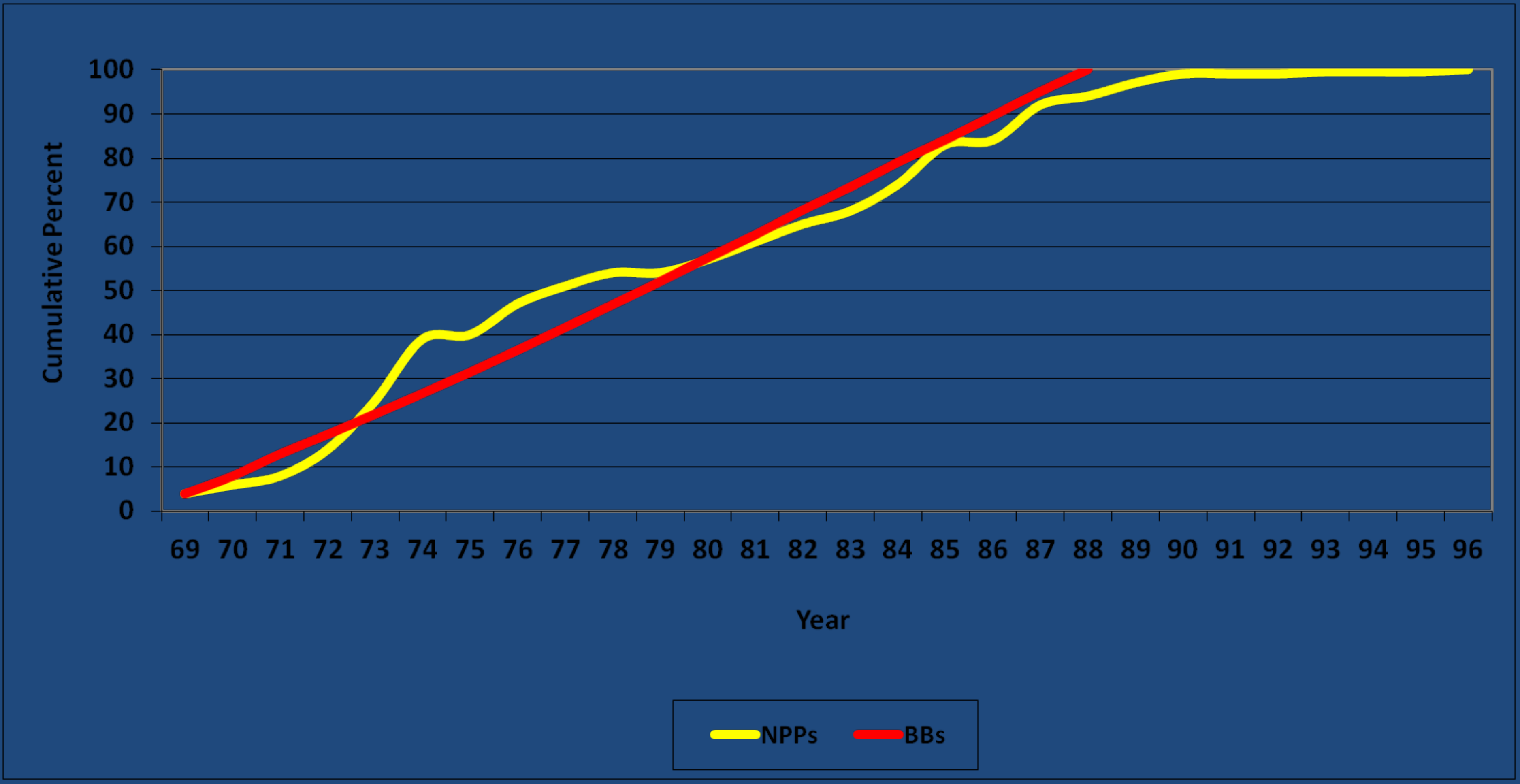
Other Findings

4. Strengthen OSH during outage work
    a. Add codes to REIRS
5. Strengthen OSH on front end (especially mining)
6. New OSH Hazards
    a) Aging facilities
    b) Aging workforce/skills shortage
    c) New materials: BE and Nano
7. Back end poses no unmanageable risks

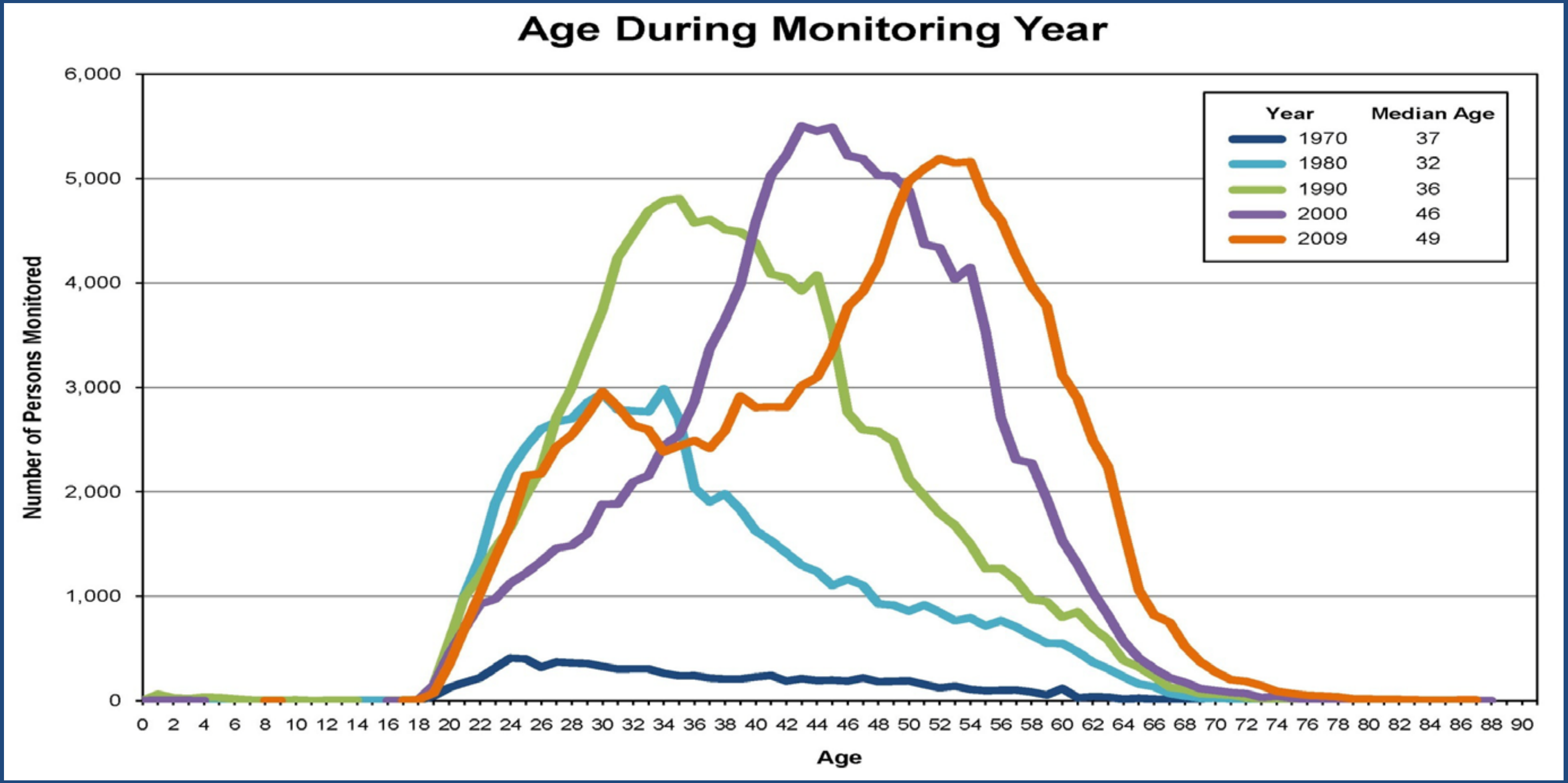
Age of Nuclear Reactors (2010)



Nuke Plants and Baby Boomers



Ageing Workforce



Conclusions

- It is hard to see how US can meet energy needs and climate change objectives without nuclear

- Renewable sources much too inefficient to be considered viable alternatives to fossil or nuclear

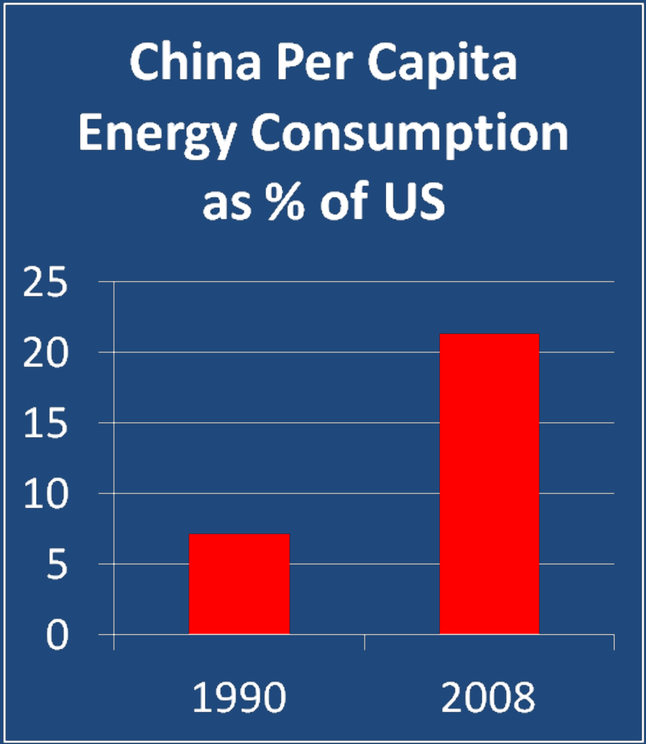
- All our major sources of energy -- nuclear, fossil, hydro and gas -- require the most careful management of very high risks

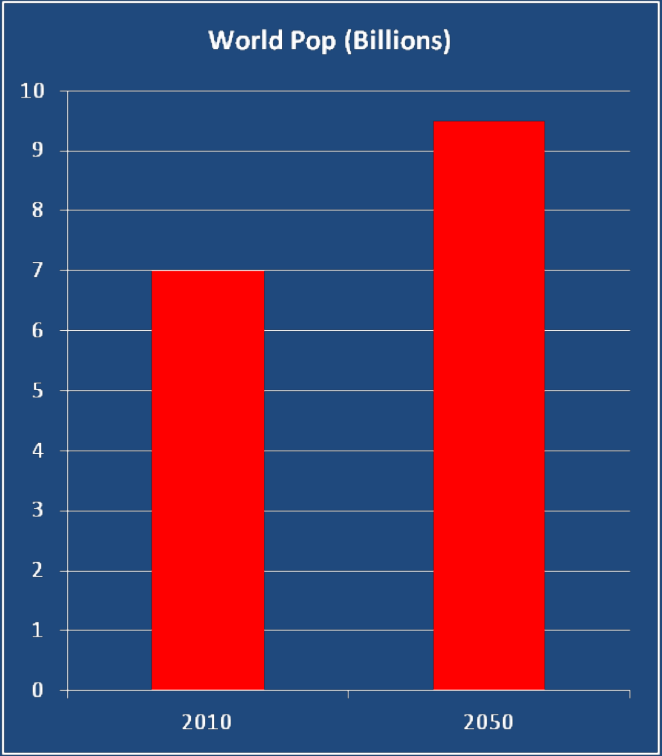
- Nuclear energy should be judged on the basis of its ***relative risk*** compared to other sources of energy, for workers, the public, energy security and climate change

- Based on outcomes since 1980, in terms of occupational and public safety and health, nuclear plants have performed very well

The Global Dimension

- How do you meet future global energy needs and Copenhagen CO-2 goal without nuclear power?





In 2009, Japan got 25% of electricity from nuclear
Japan's only viable alternative to nuclear is coal

Recommendation to Collegium

- Form a working group
- Draft a statement on public health of energy production
- For distribution to Fellows one month before next year's meeting