Japan's Fukushima Nuclear Disaster and the US Nuclear Power Industry

SCAMPS 2011

Gary Mullis, PE
UTEC

Special Thanks

Steve Nesbit
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General Manager

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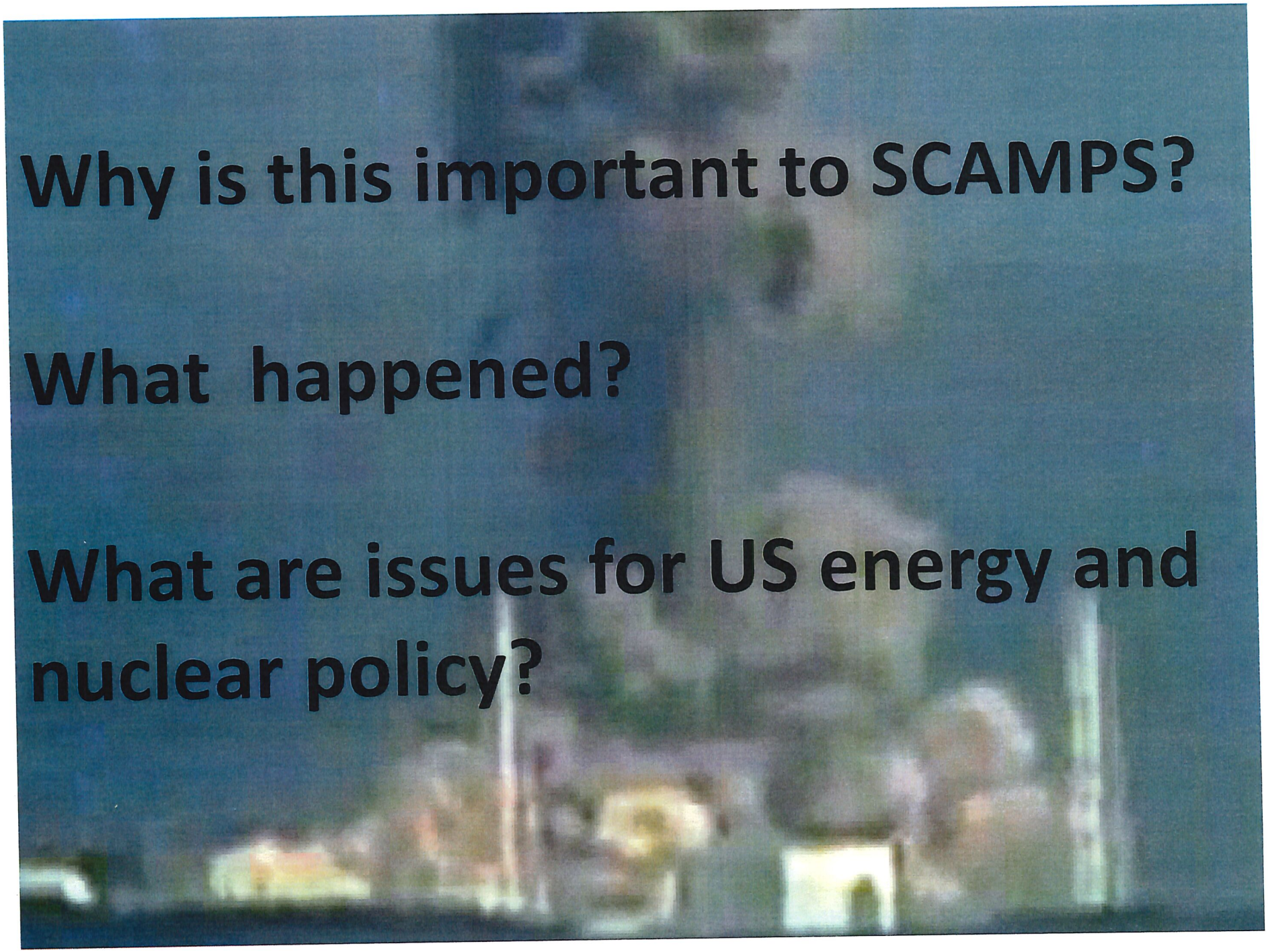
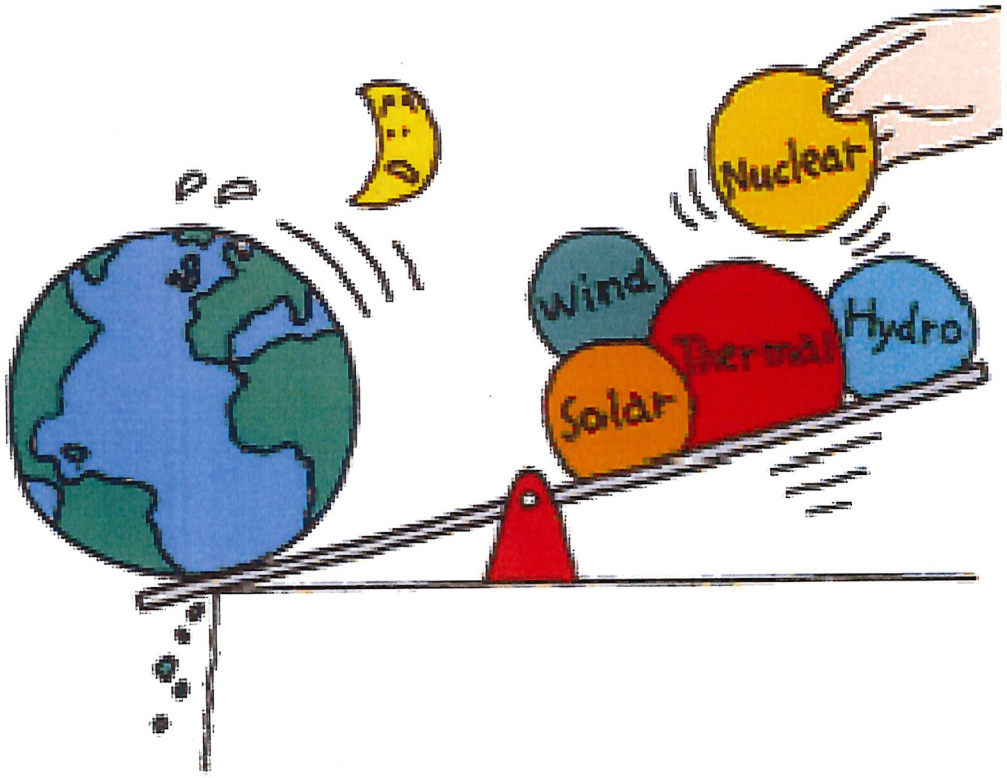
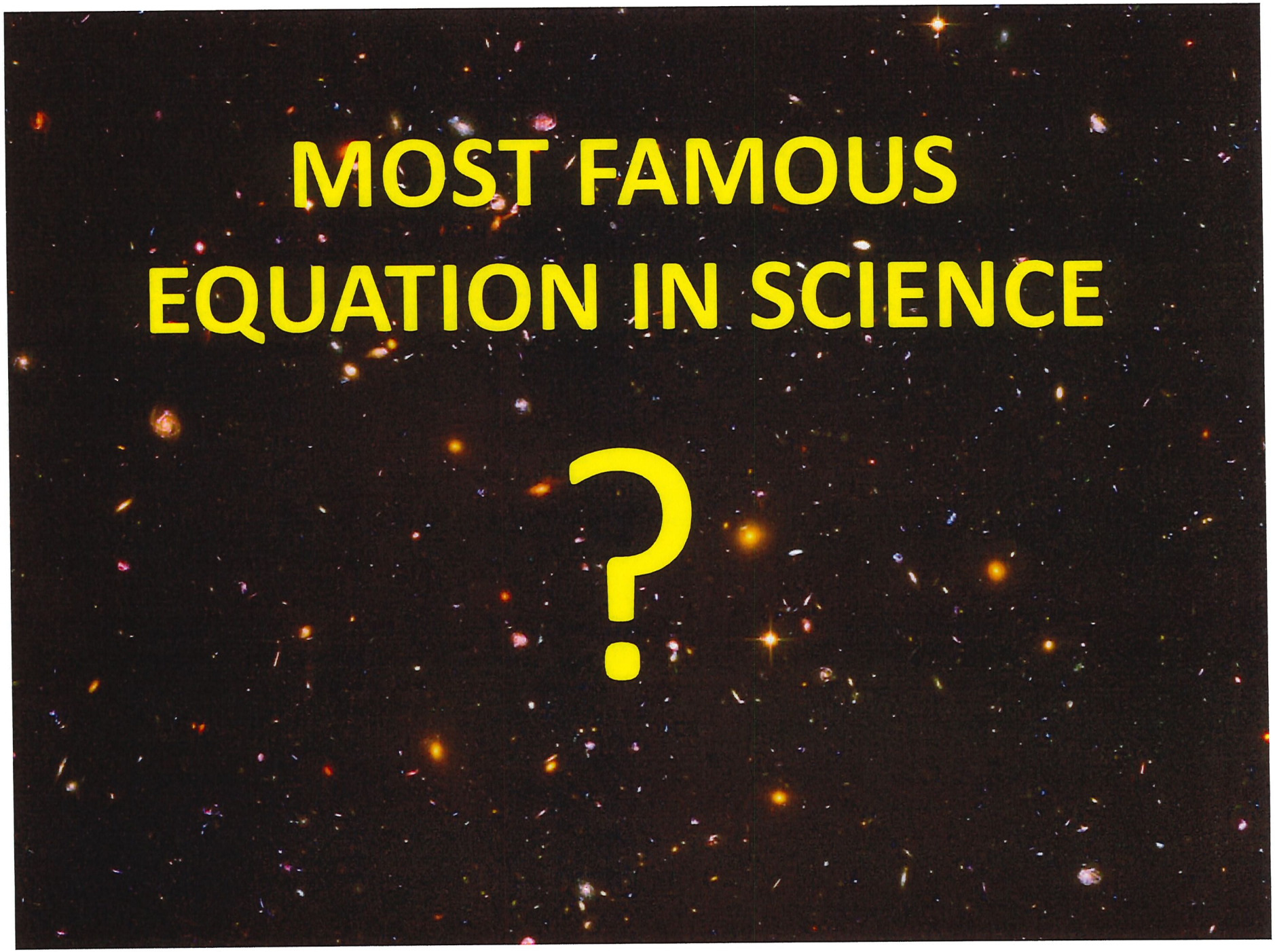
Lead Generation Communications Specialist

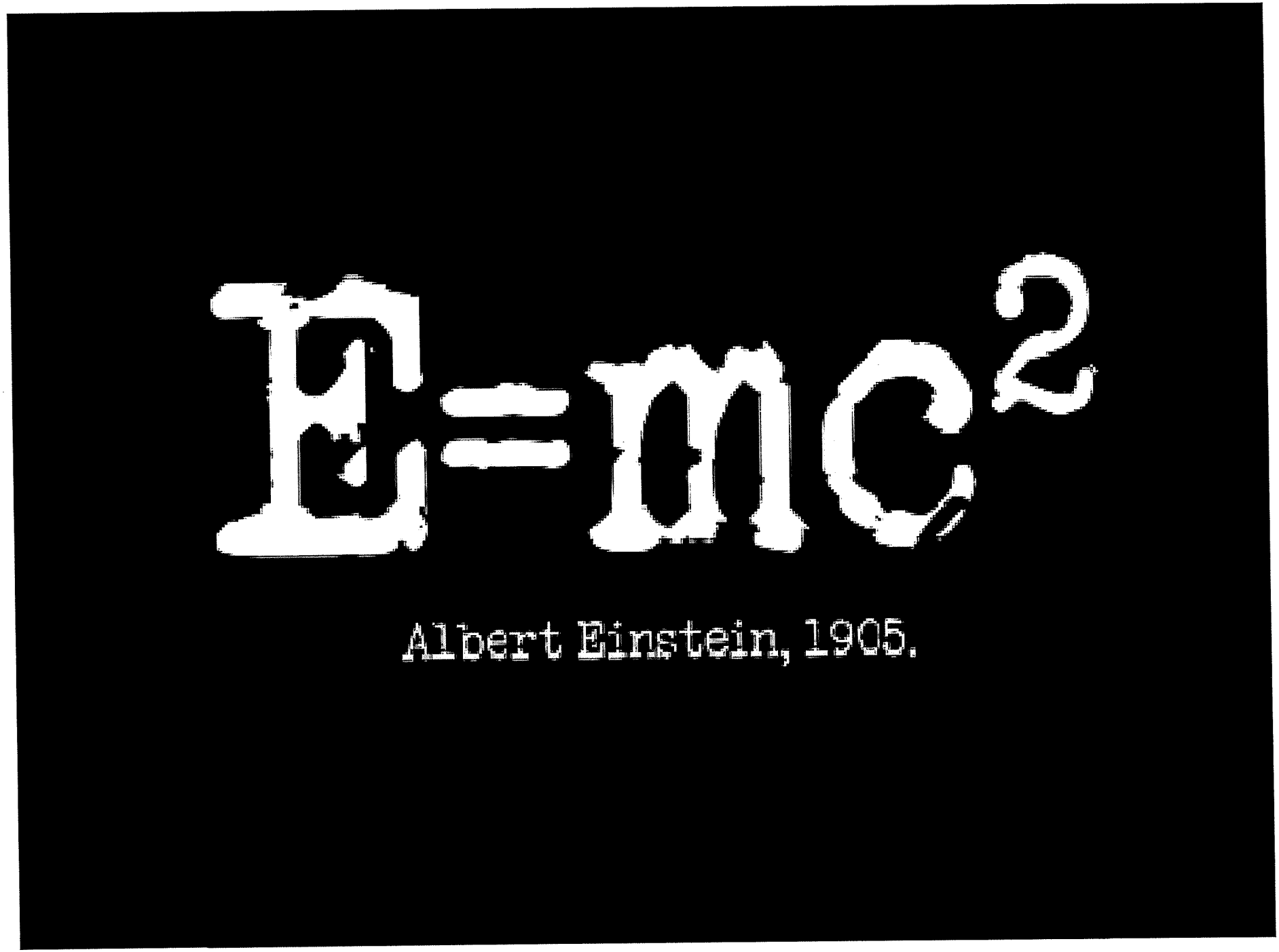

Why is this important to SCAMPS?
What happened?
What are issues for US energy and nuclear policy?

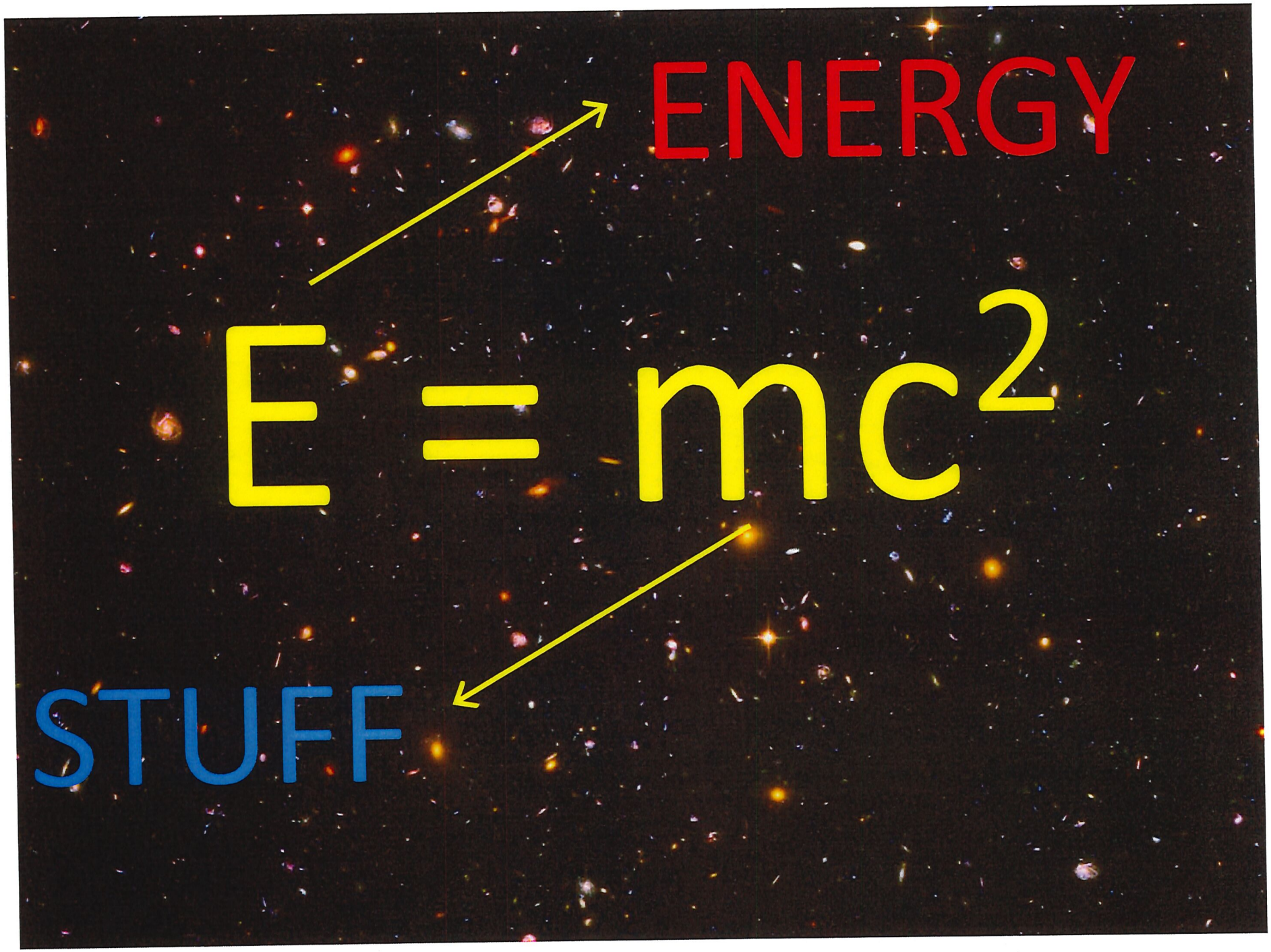
As Local Leaders in
Power Industry

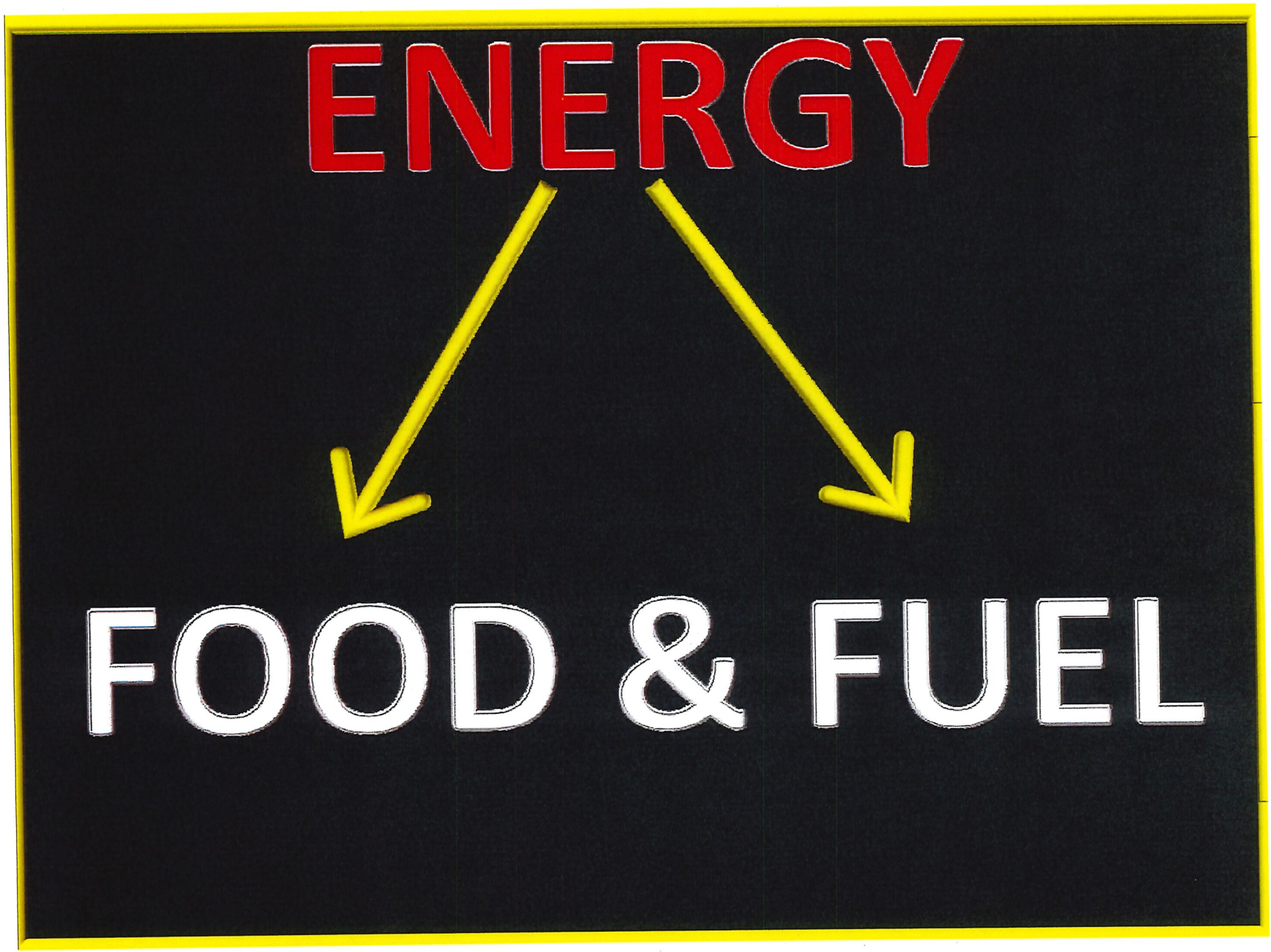


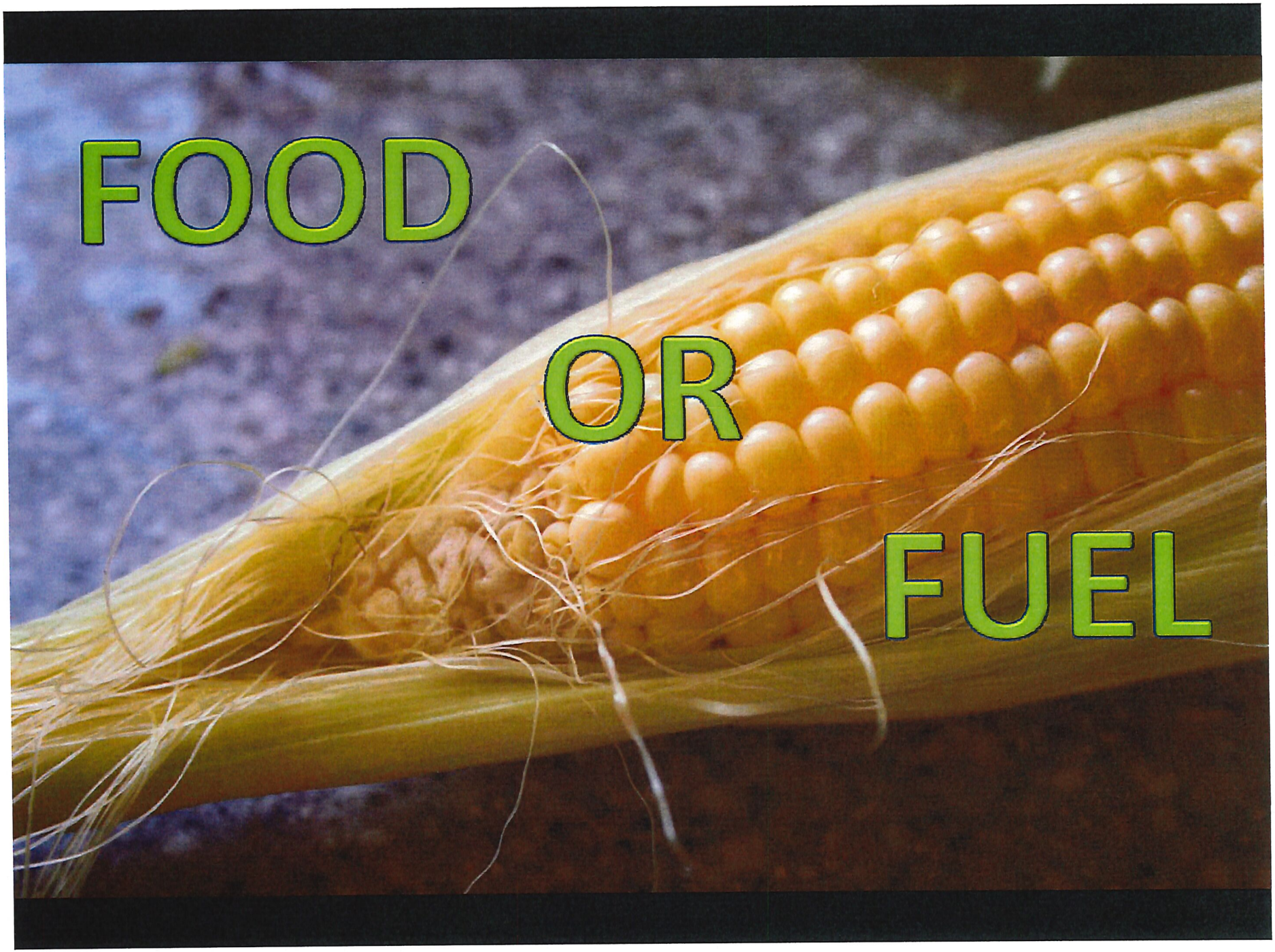
Inform and Influence
National Power Policy Discussion


MOST FAMOUS
EQUATION IN SCIENCE
?


E=mc²
Albert Einstein, 1905.

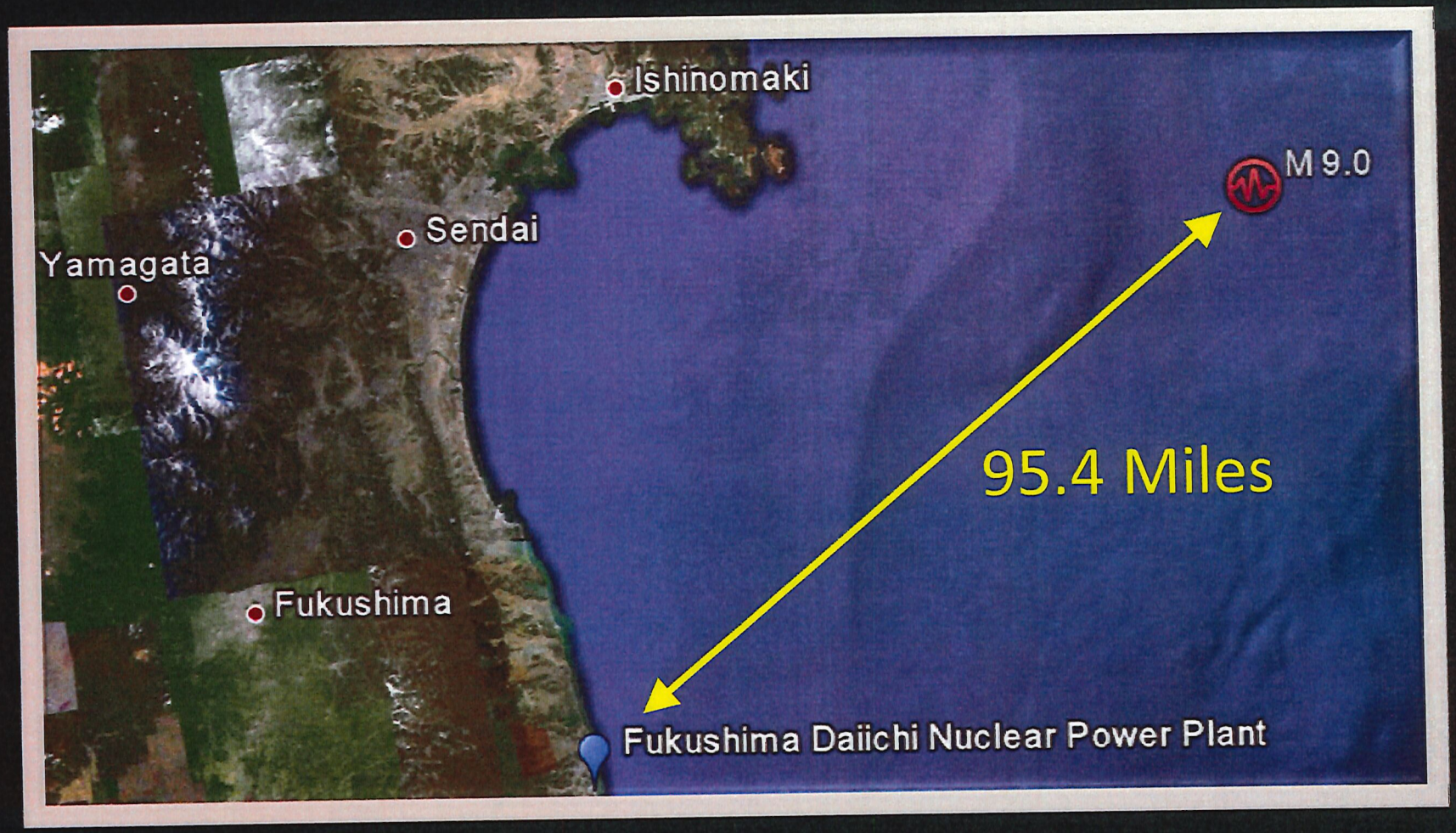

ENERGY
E = mc²
STUFF


ENERGY
FOOD & FUEL

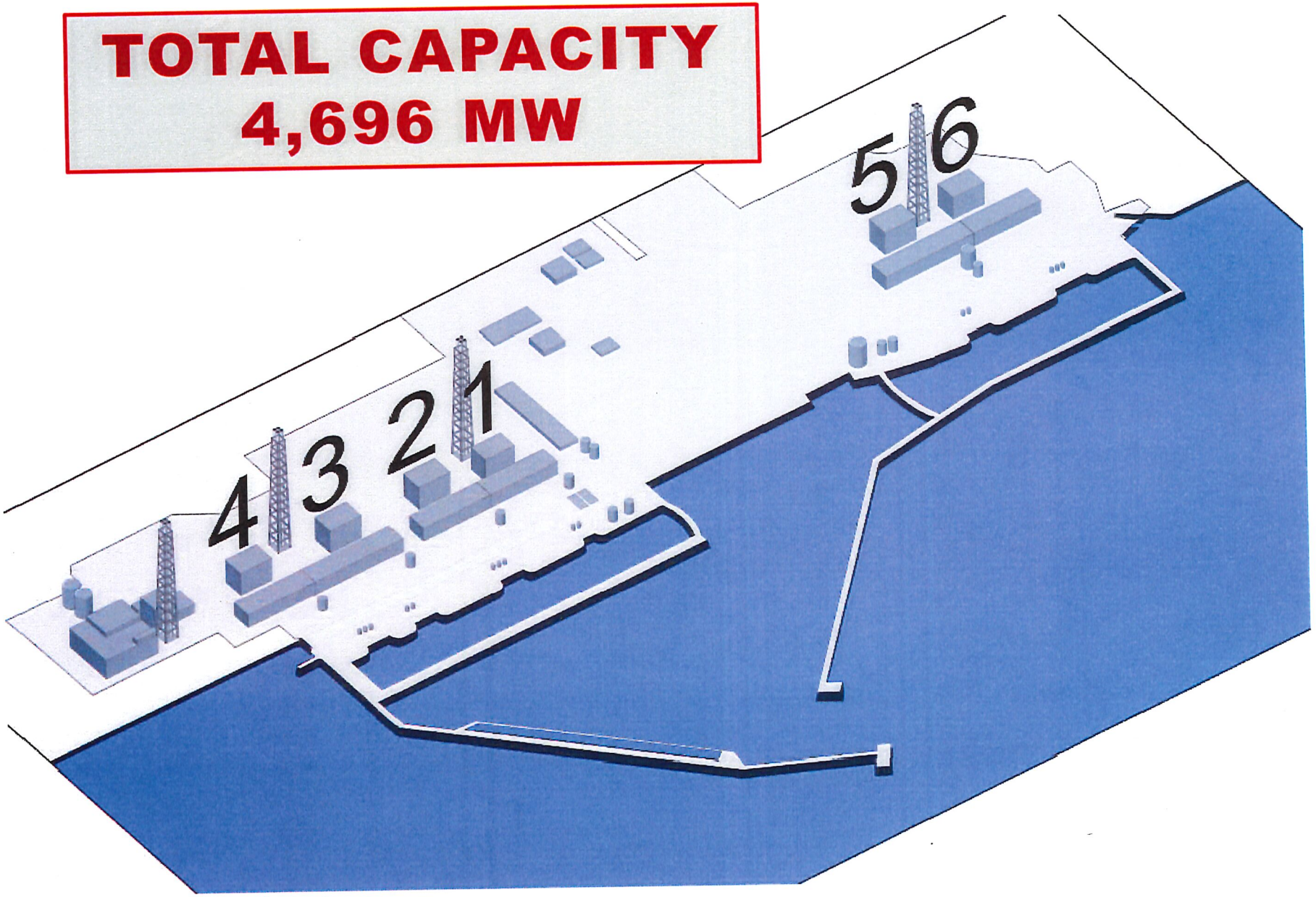

FOOD
OR
FUEL

9.0 M_W March 11, 2011 2:46 PM

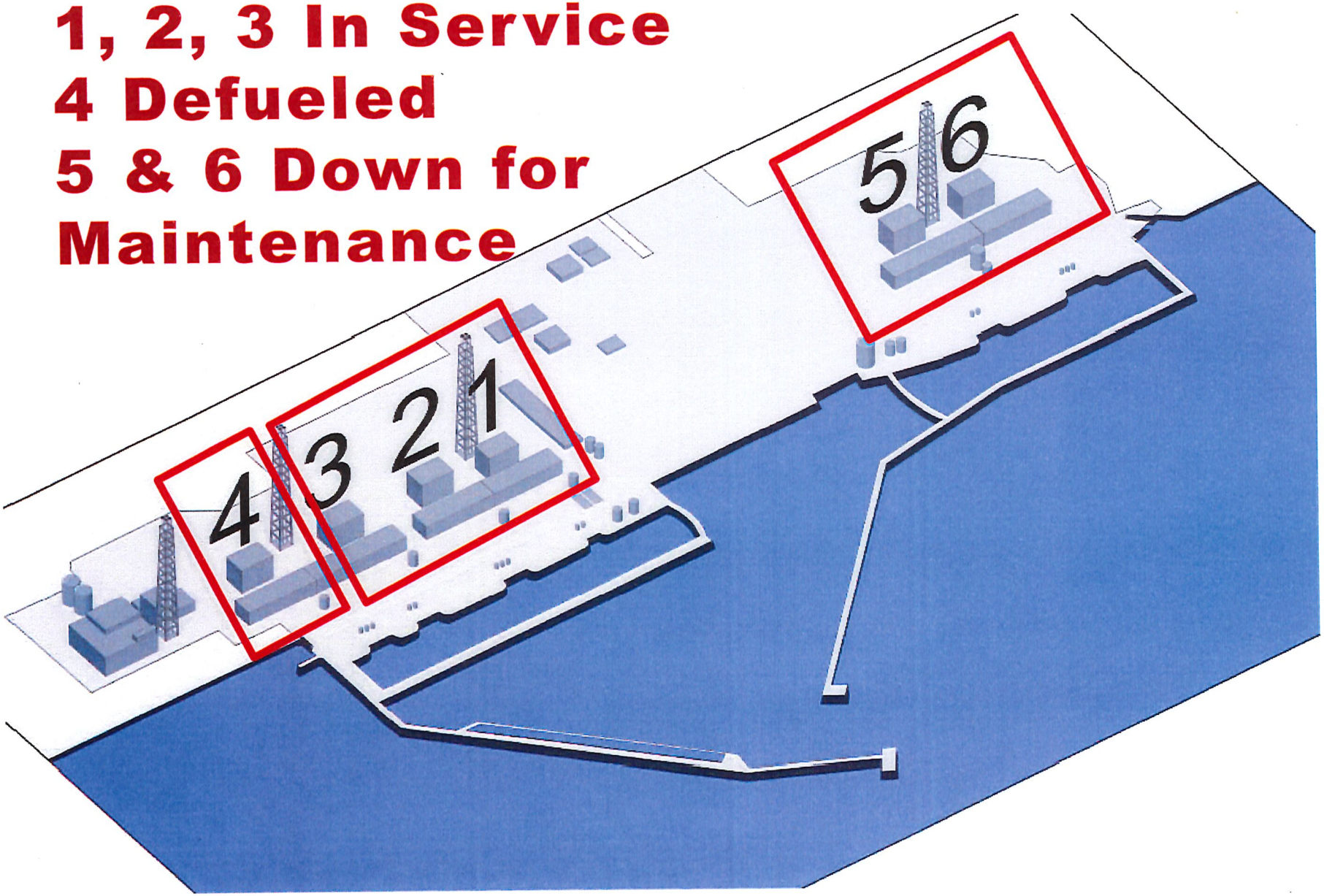
Friday, March 11, 2011 at 2:46:23 PM



TOTAL CAPACITY
4,696 MW

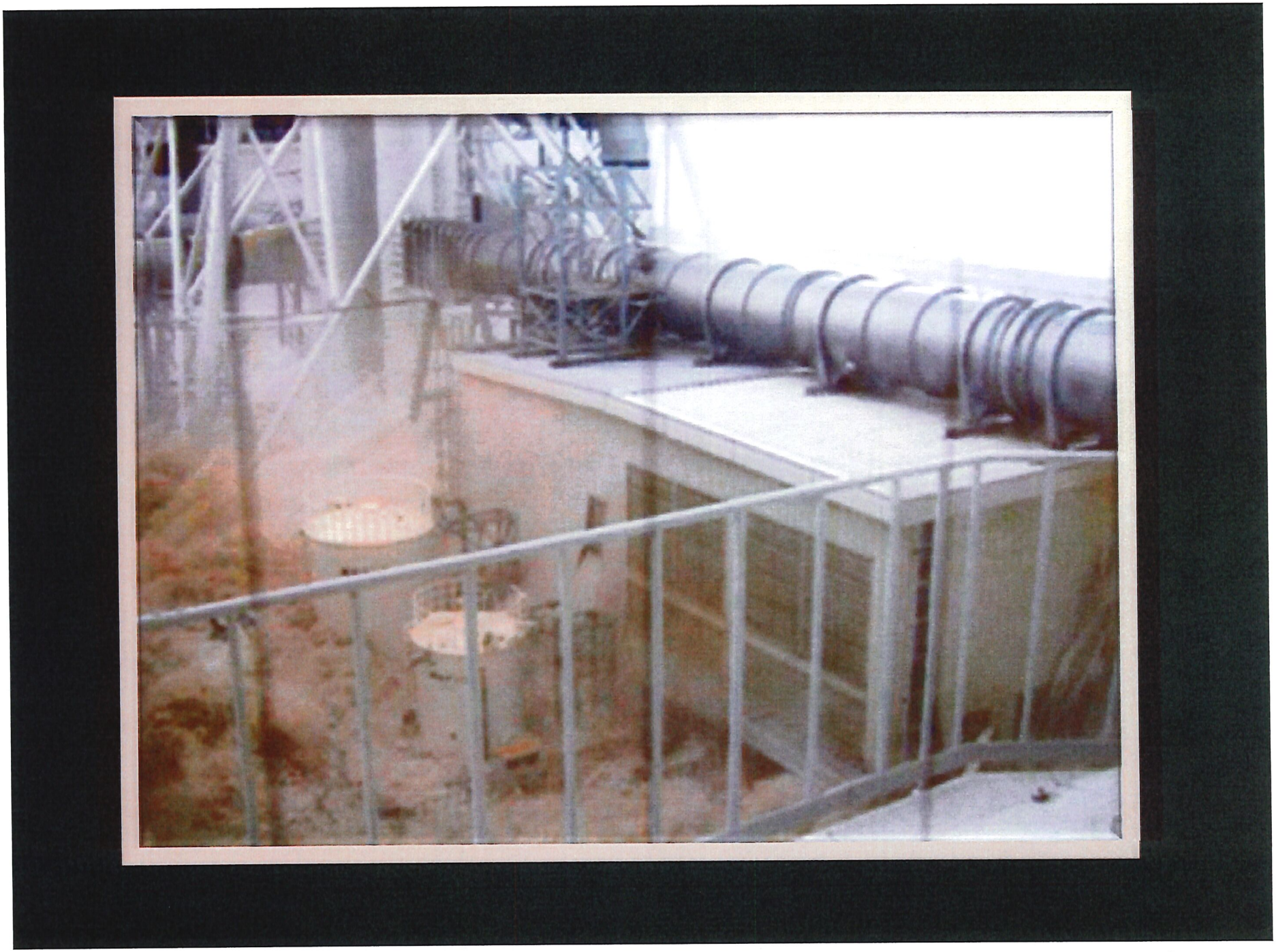


1, 2, 3 In Service
4 Defueled
5 & 6 Down for Maintenance



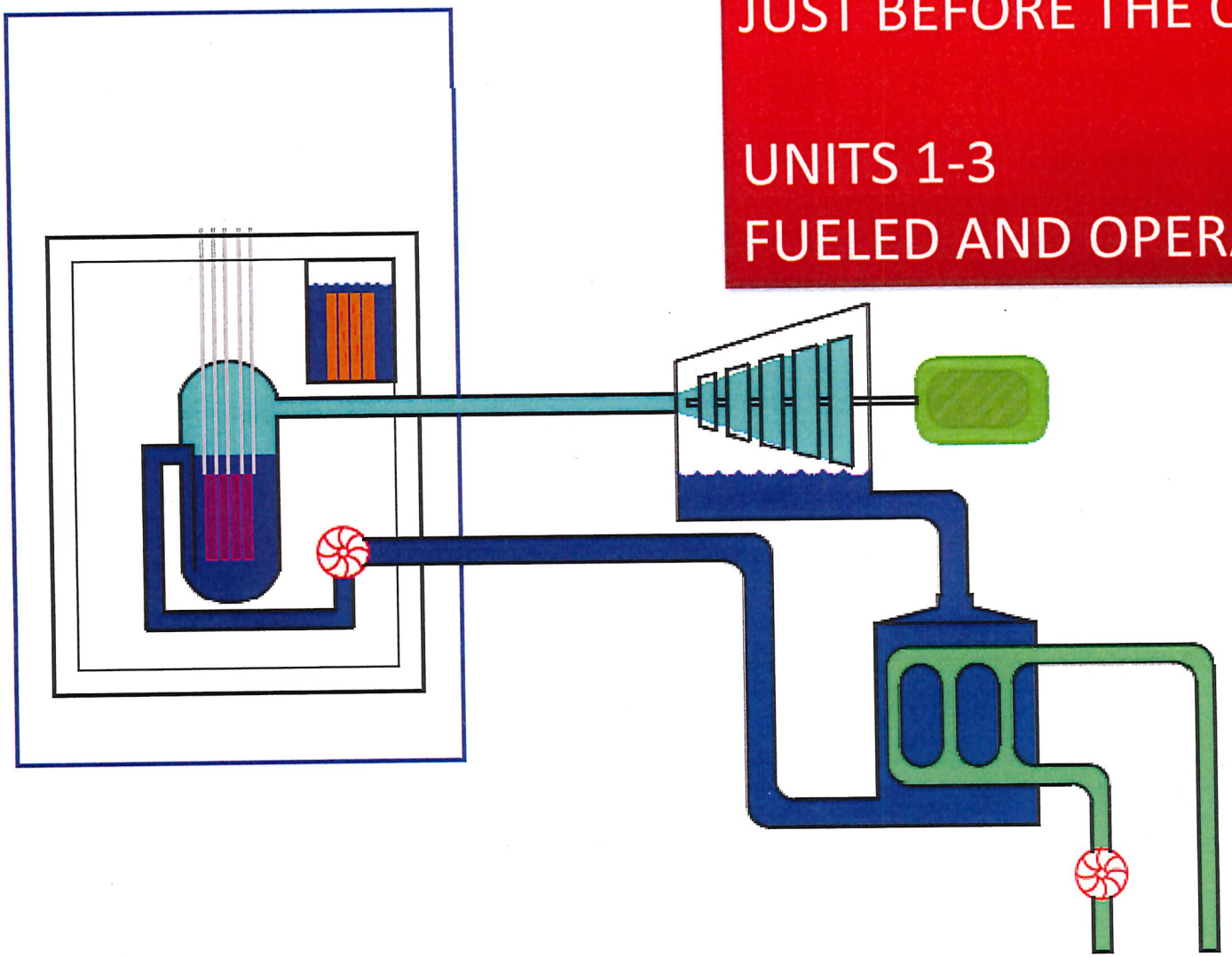
3:27 PM 5.7 meters (18.7 Feet) above the sea surface

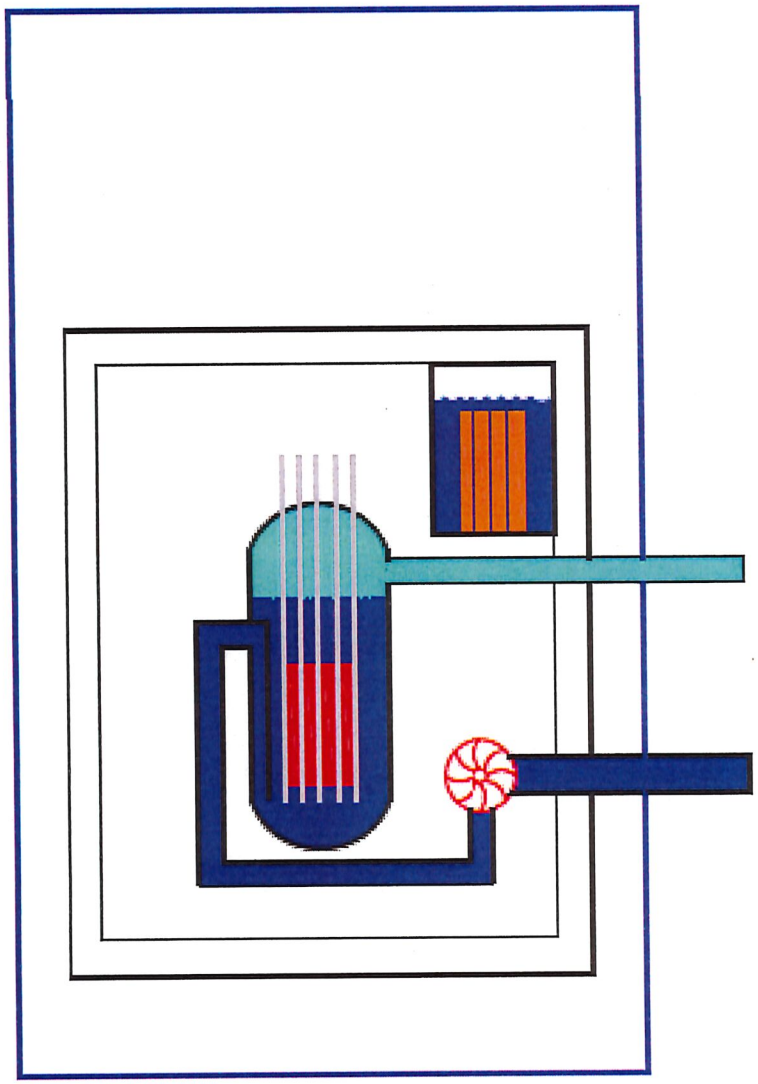
3:46 - 14-metre (46 ft)



JUST BEFORE THE QUAKE

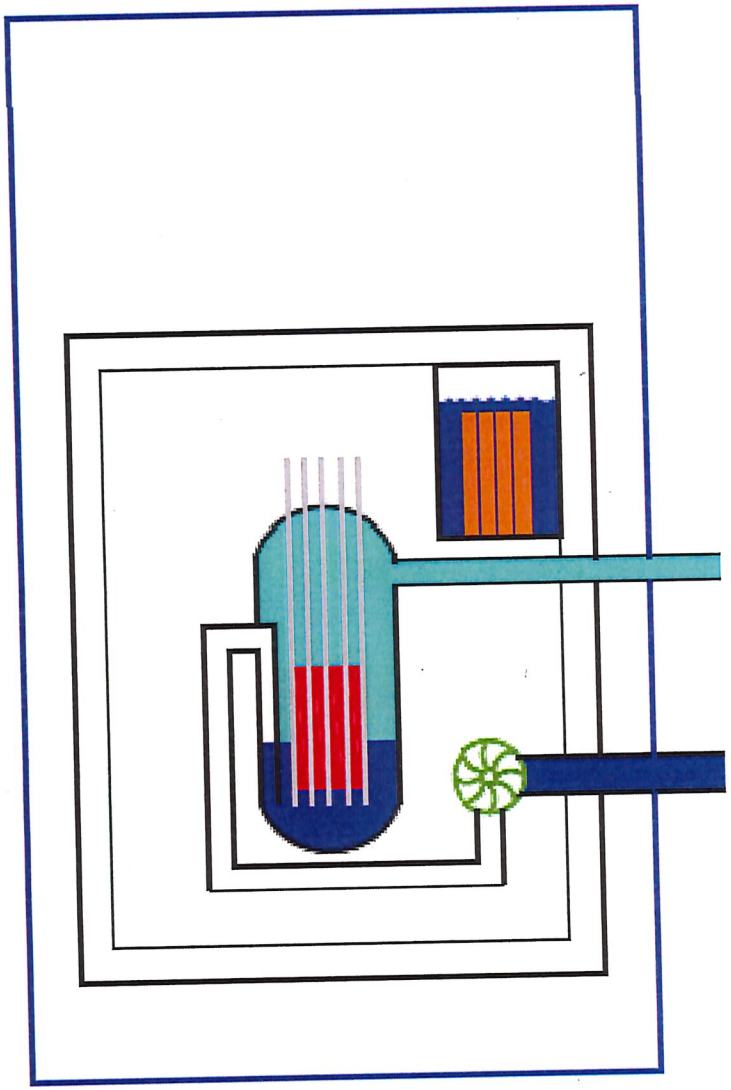
UNITS 1-3
FUELED AND OPERATING





JUST AFTER THE QUAKE

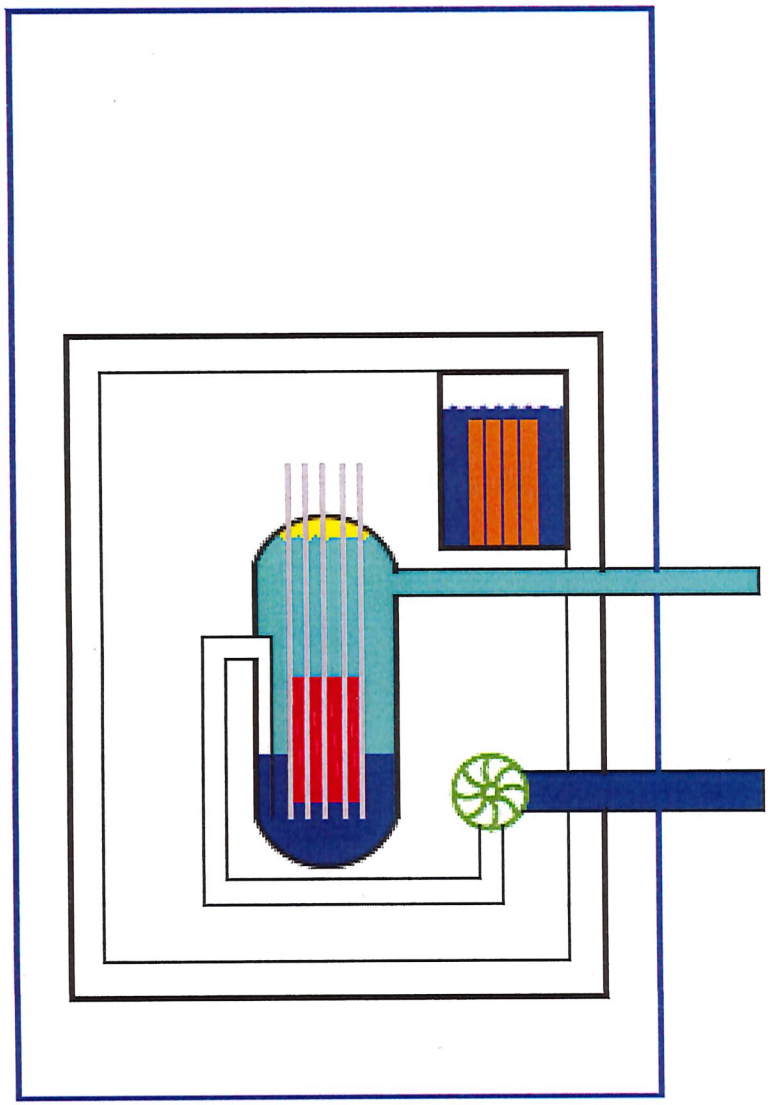
SEISMIC ALARMS PROMPTED CORE SHUTDOWN (LIKELY AUTOMATICALLY)



FIRST HOUR AFTER THE QUAKE

OFF SITE POWER LOST

EMERGENCY SYSTEMS WORKED AS DESIGNED

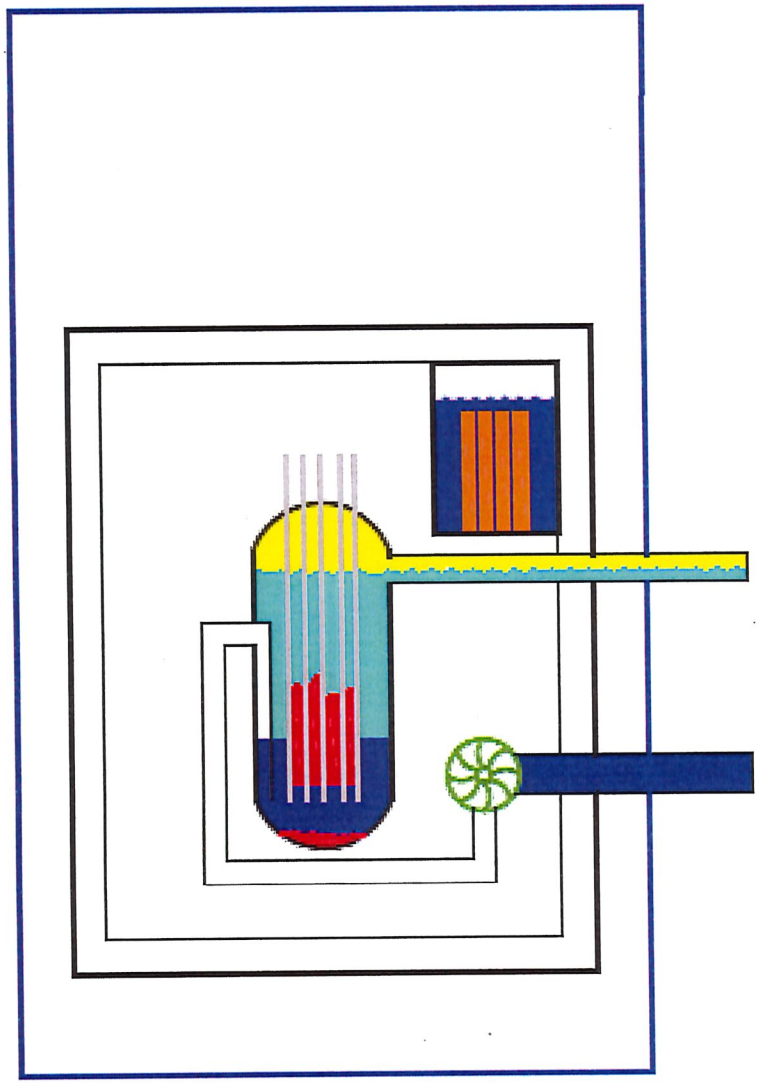


TSUNAMI

SAFETY FOR BACK-UP GENERATORS WASHED AWAY

PUMP SWITCHGEAR FLOODED

FEED WATER PUMPS FAILED



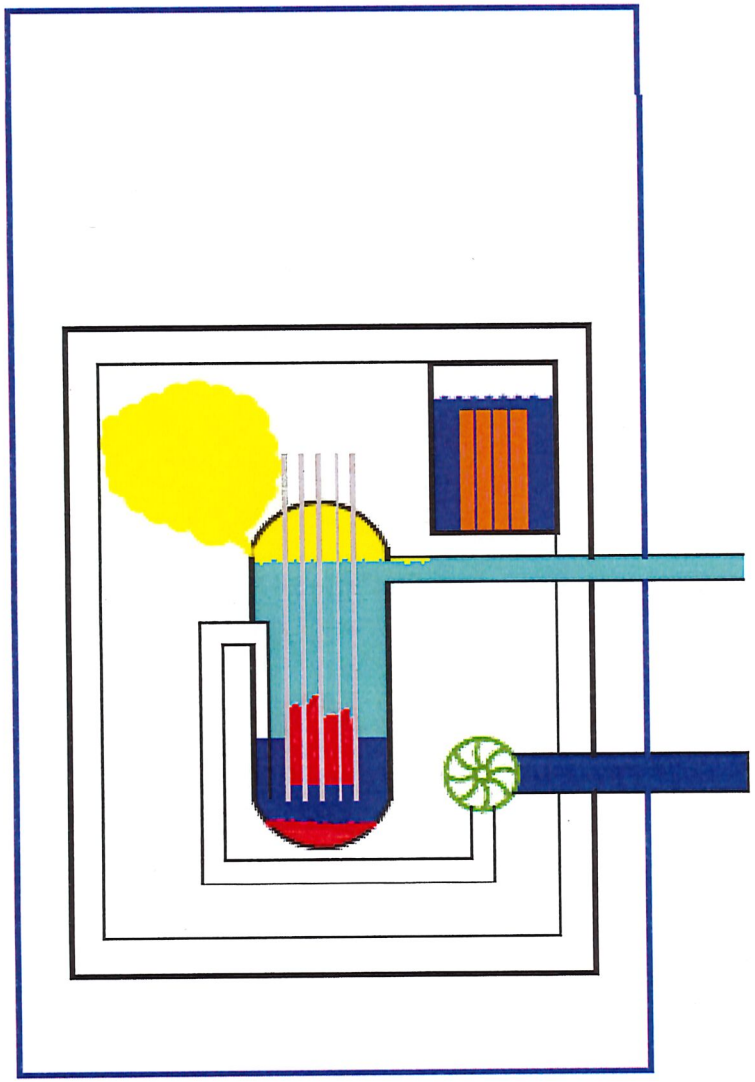
AFTER TSUNAMI

COOLING WATER DROPPED
SAFETY RODS EXPOSED

DECAY HEAT BUILT UP

ZIRCONIUM ALLOY CLADDING ON SAFETY RODS OXIDIZED

HYDROGEN GAS BUILT UP IN THE REACTORS



BATTERY POWER LOST

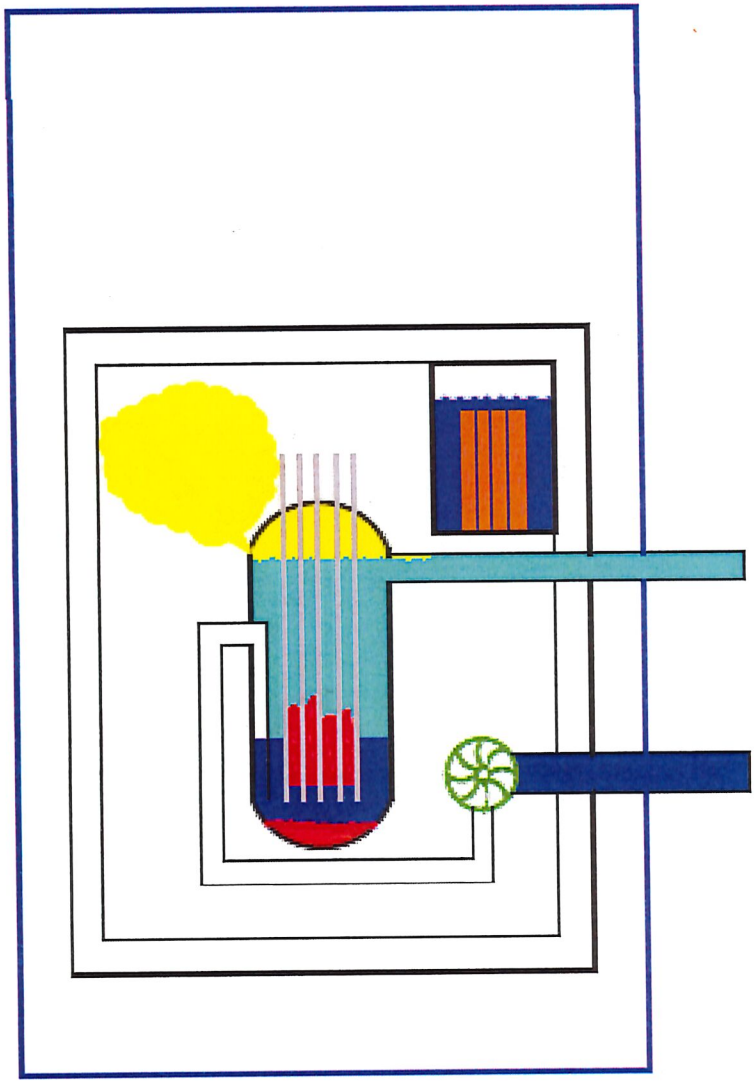
NO POWER TO OPEN VALVES

PRESSURE IN REACTOR BUILDS

HYDROGEN GAS CONTINUED TO BUILD

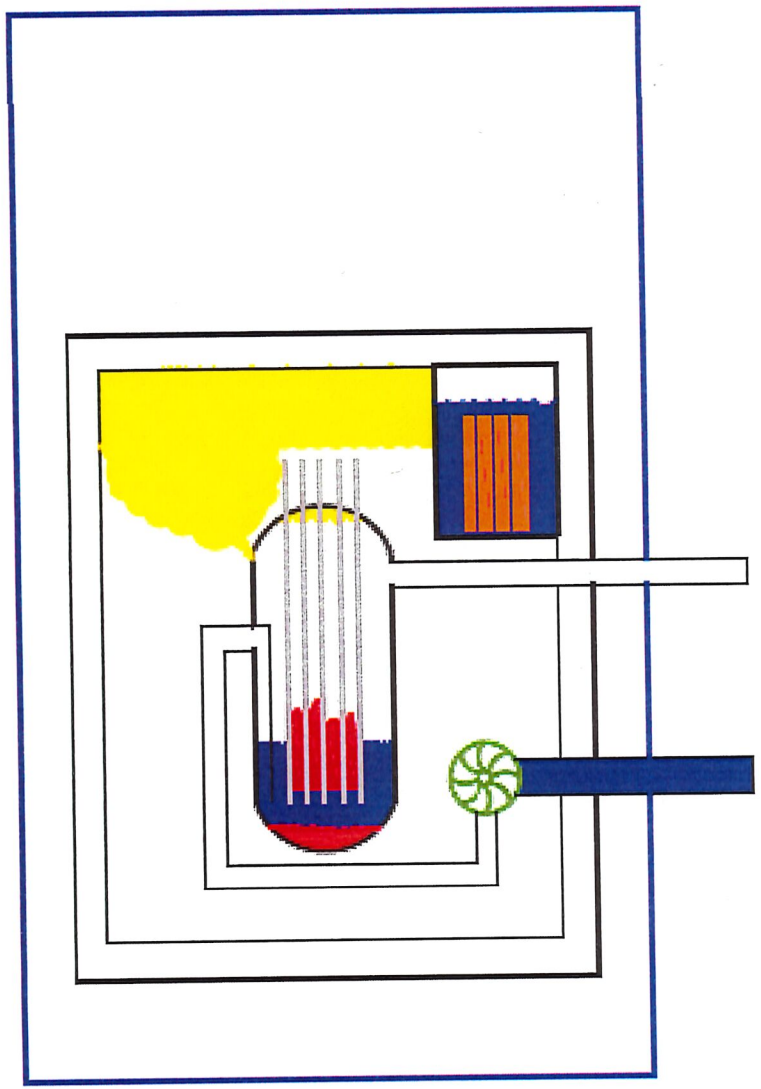
WATER LEVEL CONTINUED TO DROP

RODS START TO MELT



REACTOR PRESSURE BUILDS

AUTOMATIC PRV VENTED HYDROGEN, STEAM, AND RADIOACTIVE MATERIAL

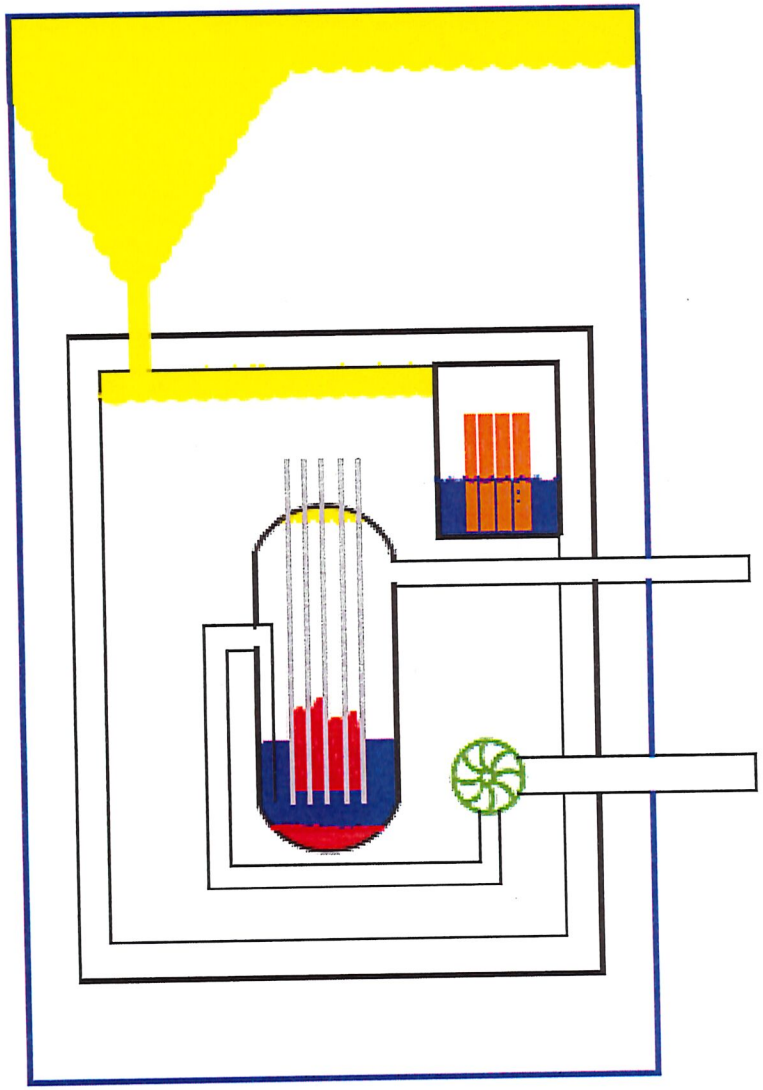


CONTAINMENT STRUCTURE

PRESSURE BUILDS IN CONTAINMENT STRUCTURE

HYDROGEN CONCENTRATION RISES

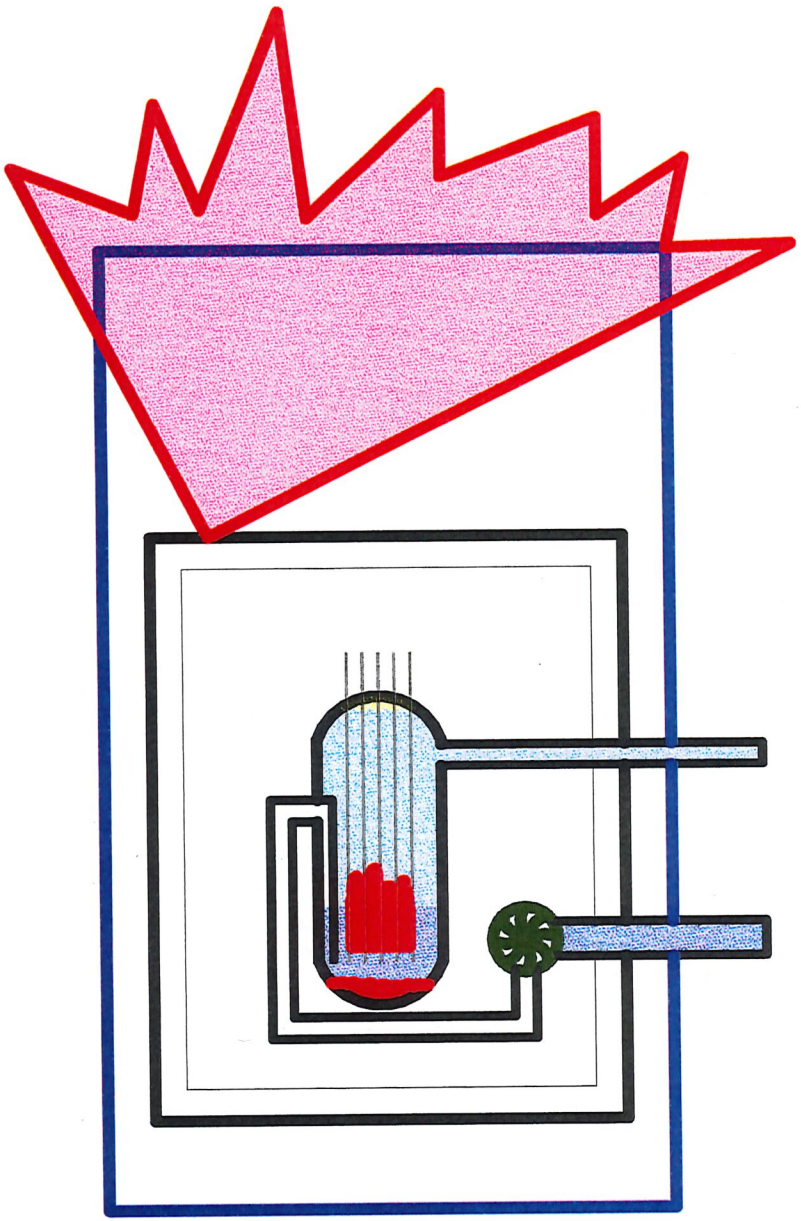
MORTON'S FORK



REACTOR BUILDINGS

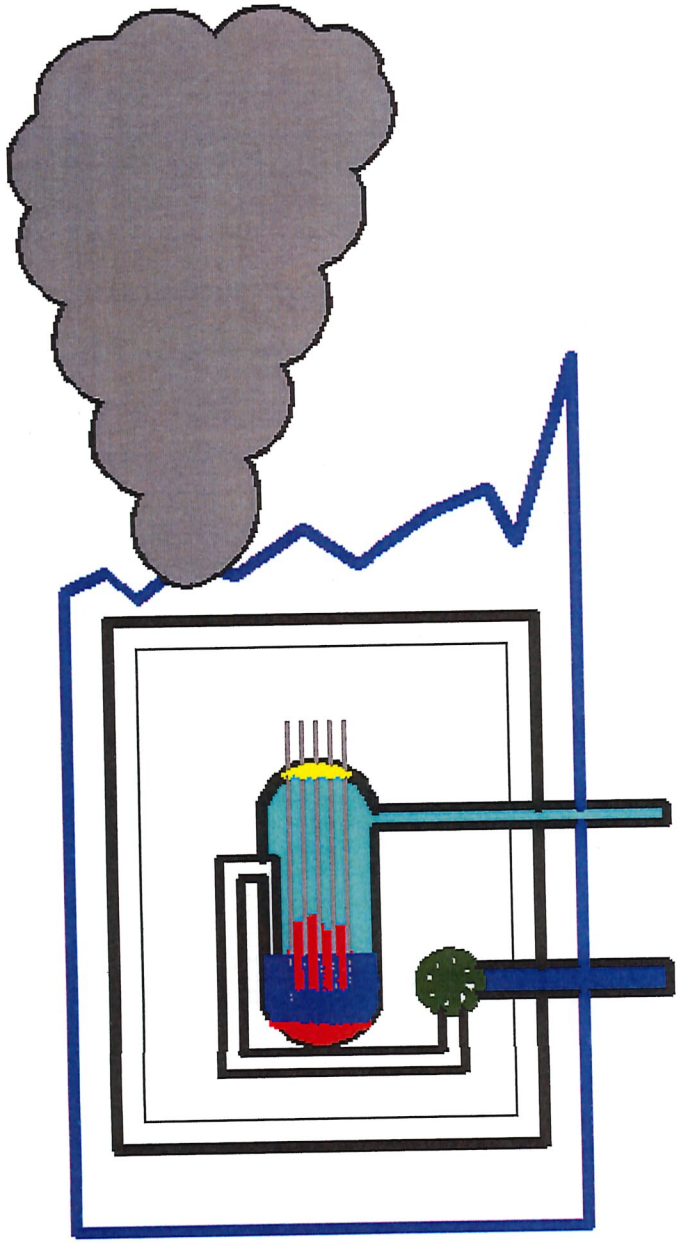
HYDROGEN GAS ACCUMULATED IN 1,2,3, & 4

GAS IN UNIT 4 WAS FROM UNIT 3



EXPLOSIONS

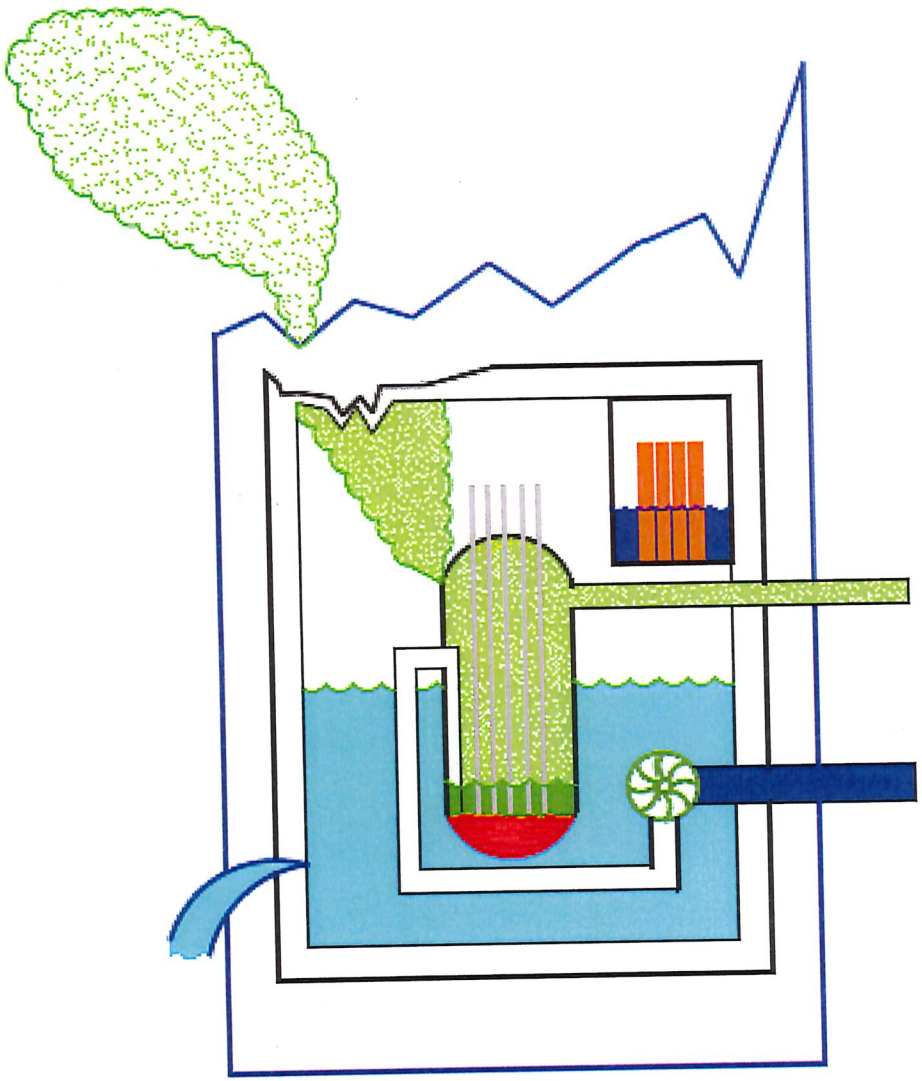
12TH 15:36 UNIT 1
14TH 11:15 UNIT 3
15TH 06:00 UNIT 4
15TH 06:14 UNIT 2



EXPLOSIONS

SOME INITIAL SPECULATION THAT SPENT FUEL RODS WERE BURNING

BEST EVIDENCE DOES NOT SUPPORT THIS THEORY



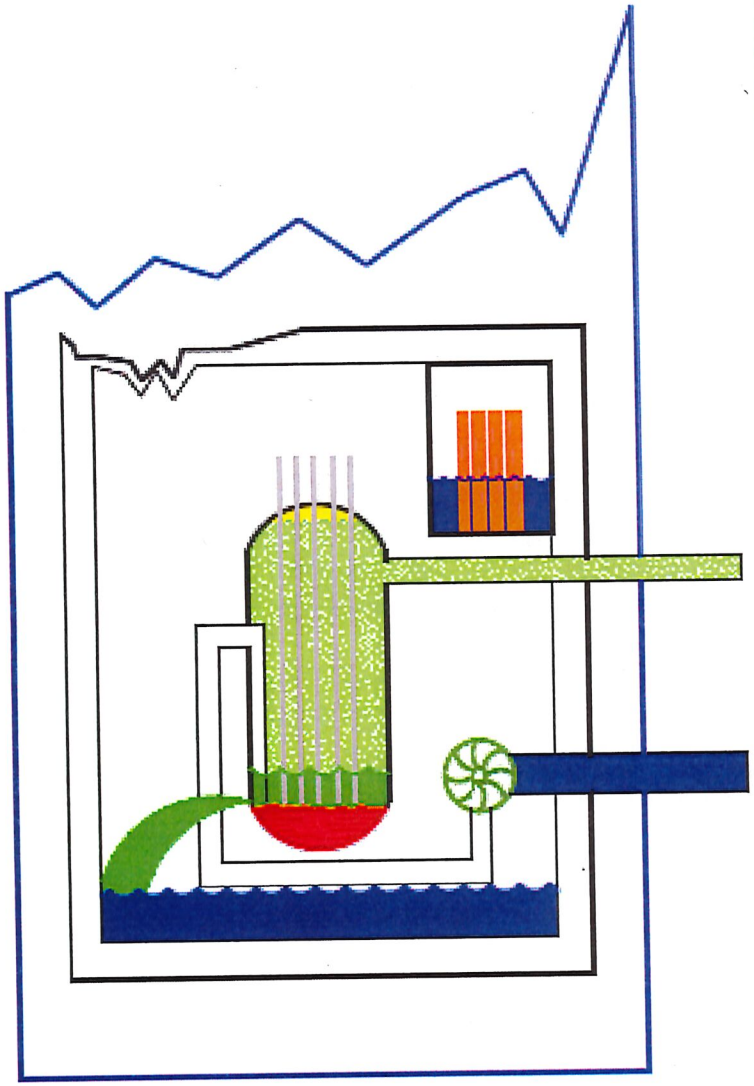
DAMAGE

UNIT 1

- CORE - MELTED
- REACTOR - DAMAGED (LEAKING?)
- CONTAINMENT - DAMAGED

UNIT 2

- CORE - MAJOR DAMAGE
- REACTOR DAMAGED - (LEAKING?)
- CONTAINMENT - NOT DAMAGED



DAMAGE

UNIT 3

- CORE - MAJOR DAMAGE
- REACTOR - DAMAGED (LEAKING?)
- CONTAINMENT - NOT DAMAGED

UNIT 4

- POSSIBLE SPENT FUEL ROD DAMAGE
- REACTOR – NOT DAMAGED
- CONTAINMENT - NOT DAMAGED

UNIT 1 HYDROGEN EXPLOSION

DAMAGE TO UNIT 3 AND 4

PIEDMONT MUNICIPAL POWER AGENCY

121 VILLAGE DRIVE • GREER, SOUTH CAROLINA 29651 • (864) 877-9632

To show that I have an excellent grasp of the obvious, the Fukushima Daiichi catastrophe will have an impact on nuclear power resources' planning and regulation. However, PMPA has not received pressure, as yet, from any of its stakeholders regarding their concerns as to the future operation of PMPA's nuclear resources. It should be noted that the Fukushima Daiichi plant consists of boiling water reactors, where
reactors. Not that there is any inherent, greate
that many of the new regulations resulting fro
of reactor.

Sincerely,

Coleman F. Smoak, Jr.

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General Manager

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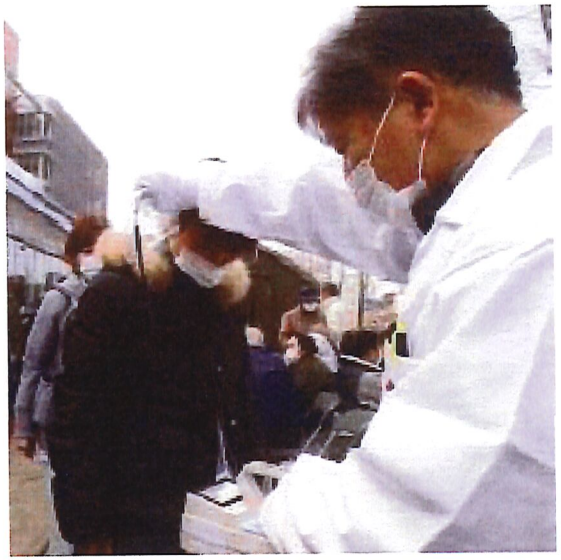
The New
REPUBLIC

Published on *The New Republic* (http://www.tnr.com)

Do We Really Need Nuclear Power?

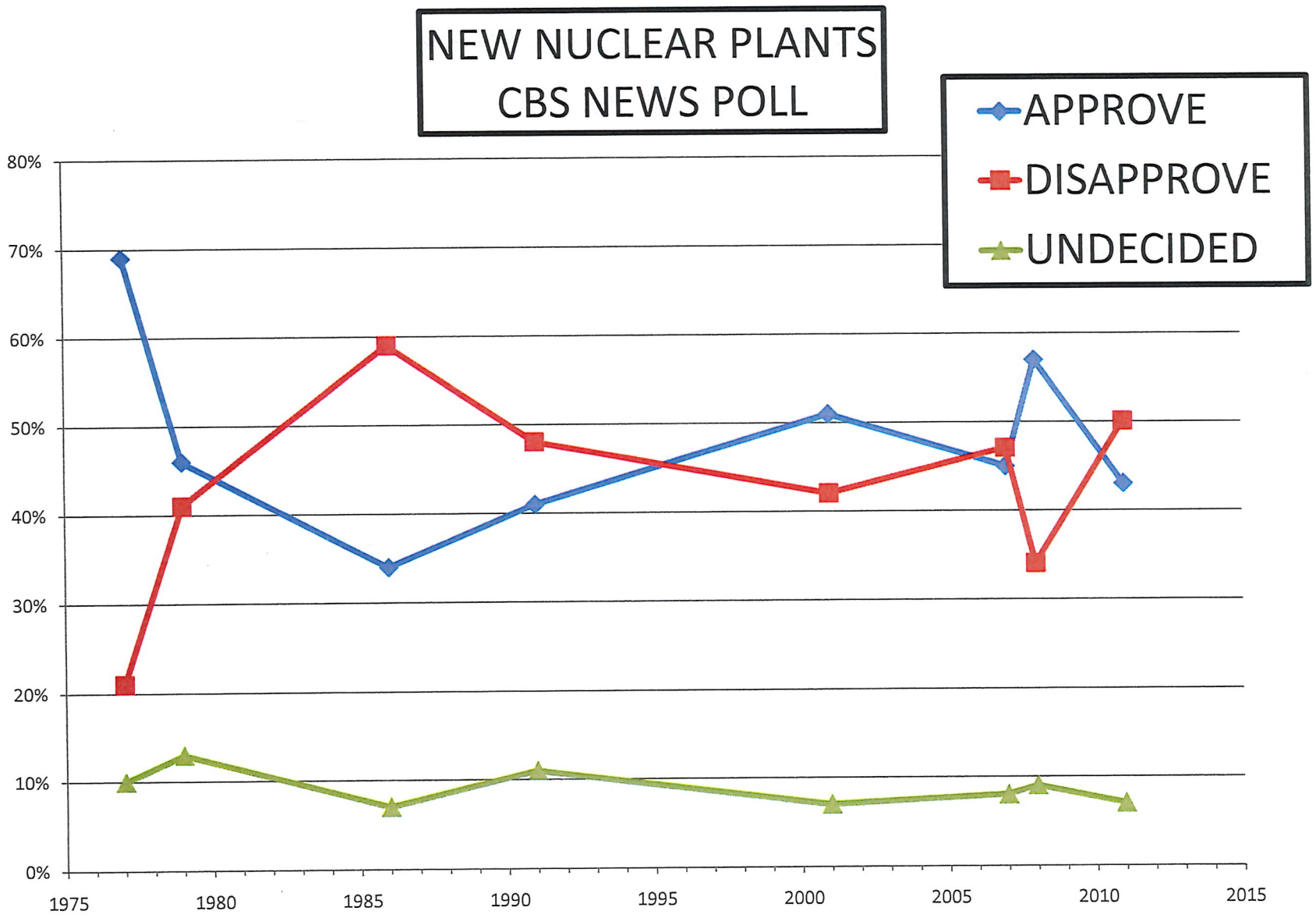
After Japan, everyone's asking the question—and the answer is more complicated than you think.

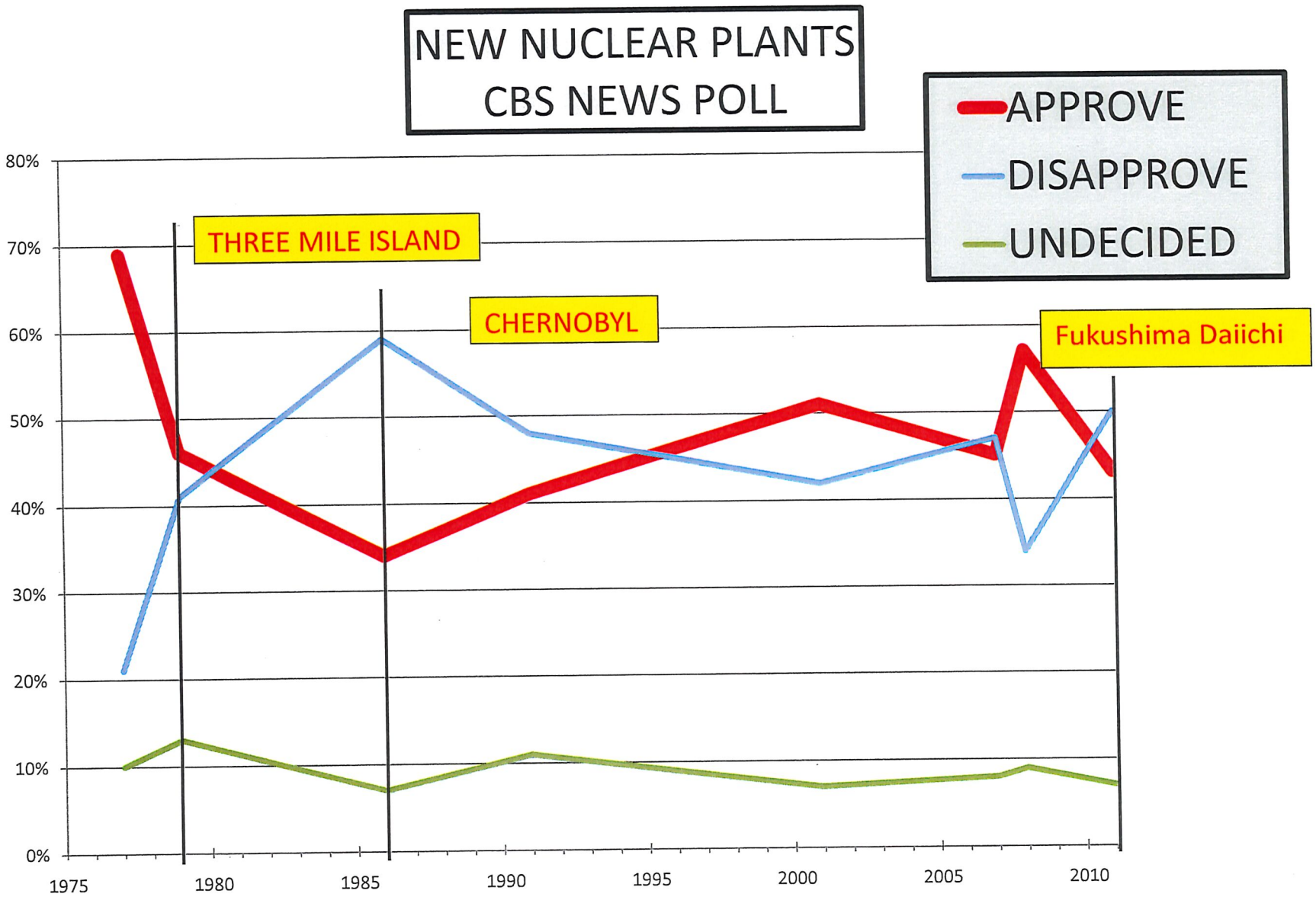
Bradford Plumer March 16, 2011 | 12:08 am



Just how necessary *is* nuclear power? Lately, politicians around the globe have been asking themselves that question as they watch a small handful Japanese technicians race to prevent three reactors from spewing out radiation at the quake-ravaged Fukushima Daiichi plant. In recent years, a consensus had taken hold that the world needed many, many more nuclear plants to meet its low-carbon energy needs and avoid drastic global warming. (All told, 220 reactors are currently being built or planned worldwide, with another 324 on the drawing board.) Suddenly, though, those plants don't seem like such no-brainers.

Germany, for one, has just suspended a decision to extend the life of its 17 nuclear power plants while it conducts safety checks. "During the moratorium, we will examine how we can accelerate the road to the age of renewable energy," said Prime Minister Angela Merkel.


NEW NUCLEAR PLANTS
CBS NEWS POLL
APPROVE
DISAPPROVE
UNDECIDED
80%
70%
60%
50%
40%
30%
20%
10%
0%
1975
1980
1985
1990
1995
2000
2005
2010
2015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APPROVE
DISAPPROVE
UNDECIDED
THREE MILE ISLAND
CHERNOBYL
Fukushima Daiichi
80%
70%
60%
50%
40%
30%
20%
10%
0%
1975
1980
1985
1990
1995
2000
2005
2010

FOUR KEY ISSUES

- **COST**
- **SAFETY**
- **PROLIFERATION**
- **WASTE**

COST: AT THE METER

- **Capital**
- **Construction**
- **Fuel**

$ PER kWH

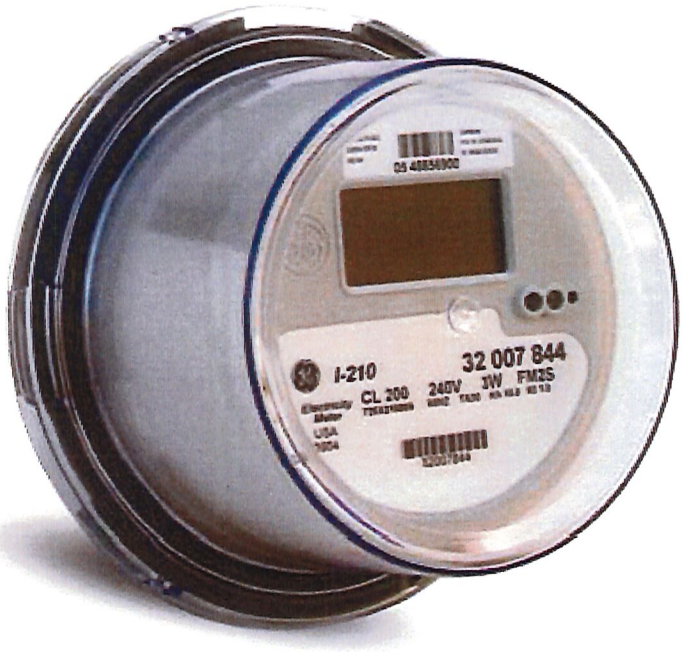

Table 1: Costs of Electric Generation Alternatives

			LCOE		
	Overnight Cost	Fuel Cost	Base Case	w/ carbon charge $25/ tCO_2	w/ same cost of capital
	$/kW	$/mmBtu	¢/kWh	¢/kWh	¢/kWh
	[A]	[B]	[C]	[D]	[E]
MIT (2003)					
$2002					
[1] Nuclear	2,000	0.47	6.7		5.5
[2] Coal	1,300	1.20	4.3	6.4	
[3] Gas	500	3.50	4.1	5.1	
Update					
$2007					
[4] Nuclear	4,000	0.67	8.4		6.6
[5] Coal	2,300	2.60	6.2	8.3	
[6] Gas	850	7.00	6.5	7.4	

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FOUR KEY ISSUES

- COST

INVESTORS

FOUR KEY ISSUES

- COST
- **SAFETY**
- PROLIFERATION
- WASTE

SAFETY

- Containment
- Cooling
- Contingency

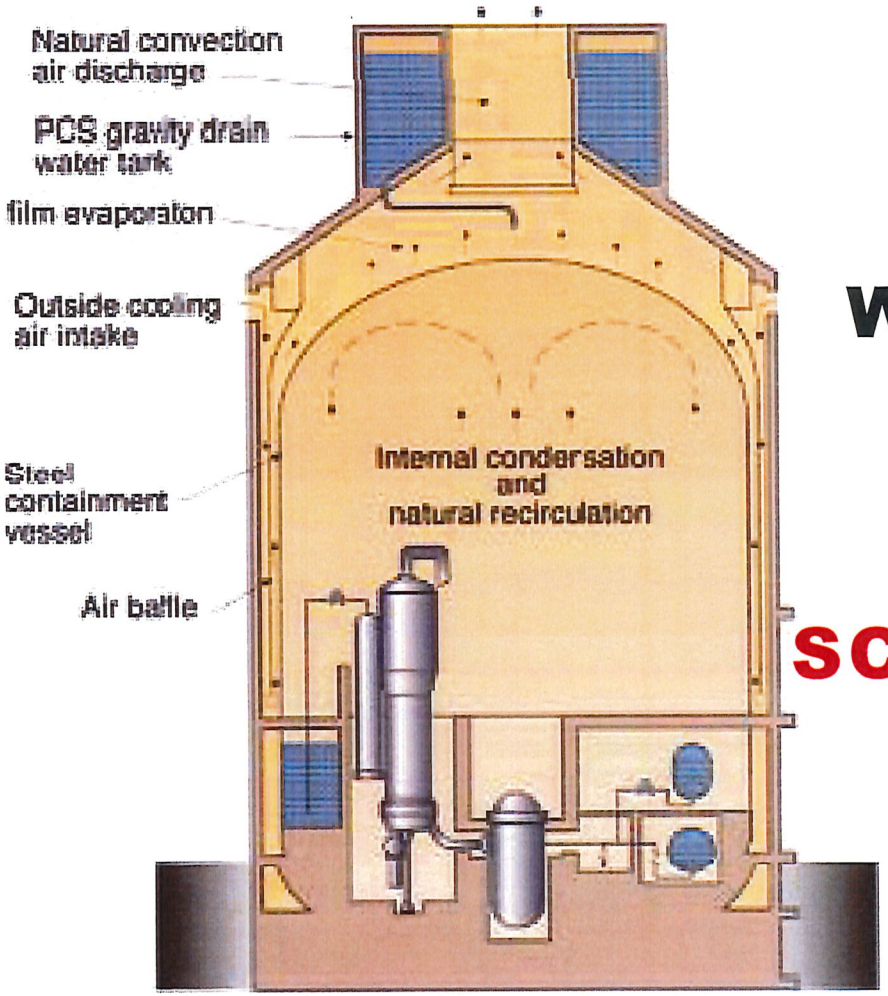


Figure 3. AP600 Passive Containment Cooling System

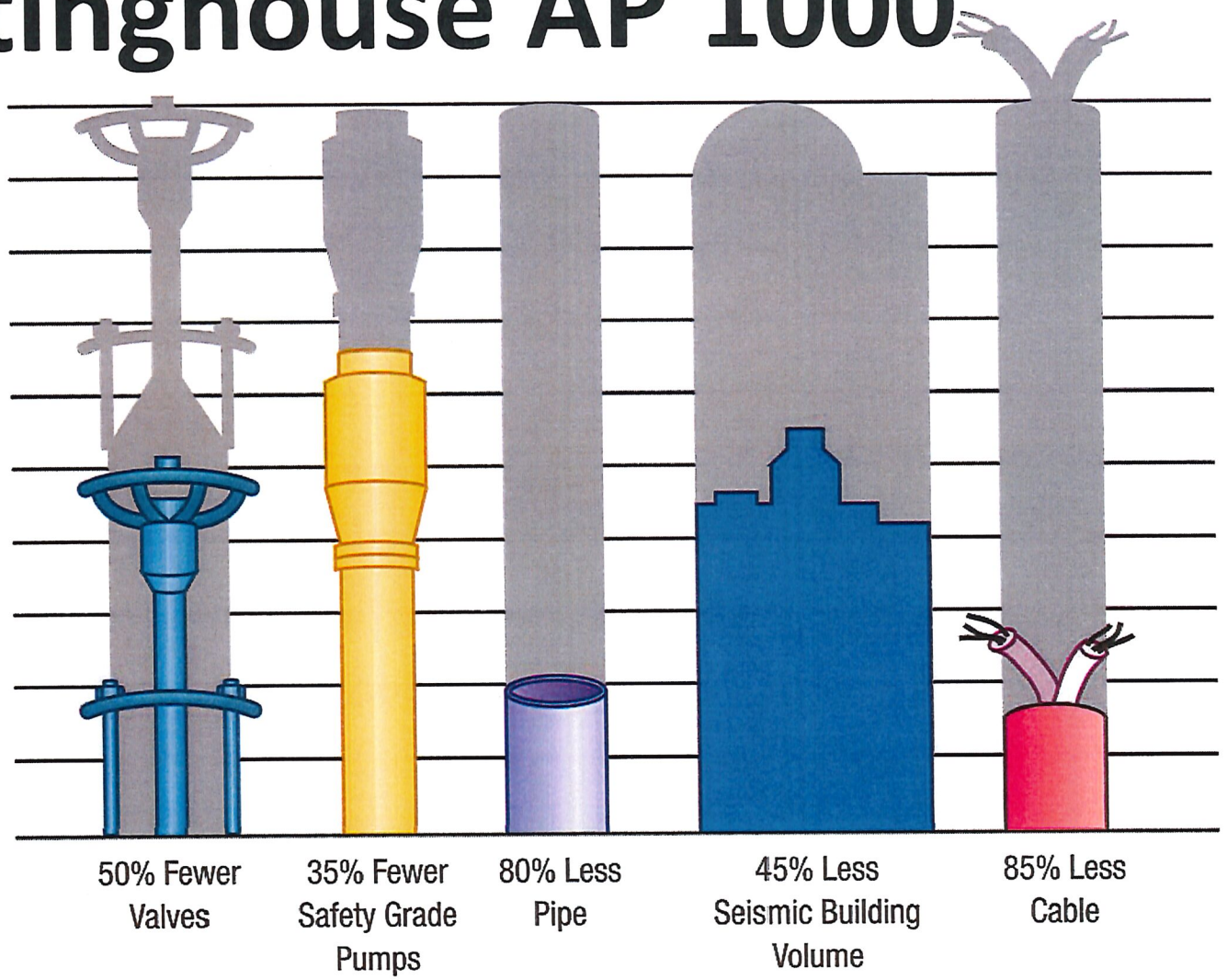
Shearon Harris
Progress Energy

William States Lee III
Duke Energy

Virgil C. Summer
SCE&G, Santee Cooper

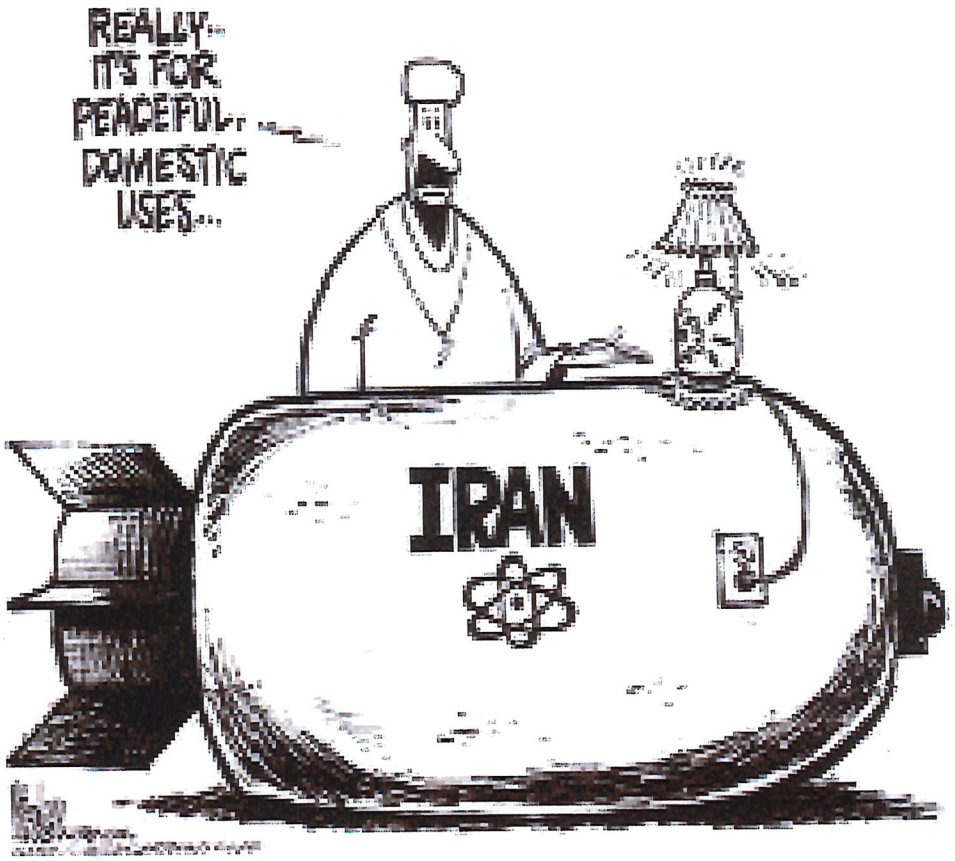
Vogtle
Southern Company

Better Design
Westinghouse AP 1000



FOUR KEY ISSUES

- **PROLIFERATION**



PROLIFERATION

- **Uranium Natural**
  - (U_{238} 99.2 % U_{235} 0.8 %)
- **Weapons Grade**
  - (U_{235} 20-85 %)
- **Reactor Grade**
  - (U_{235} 3-5 %)

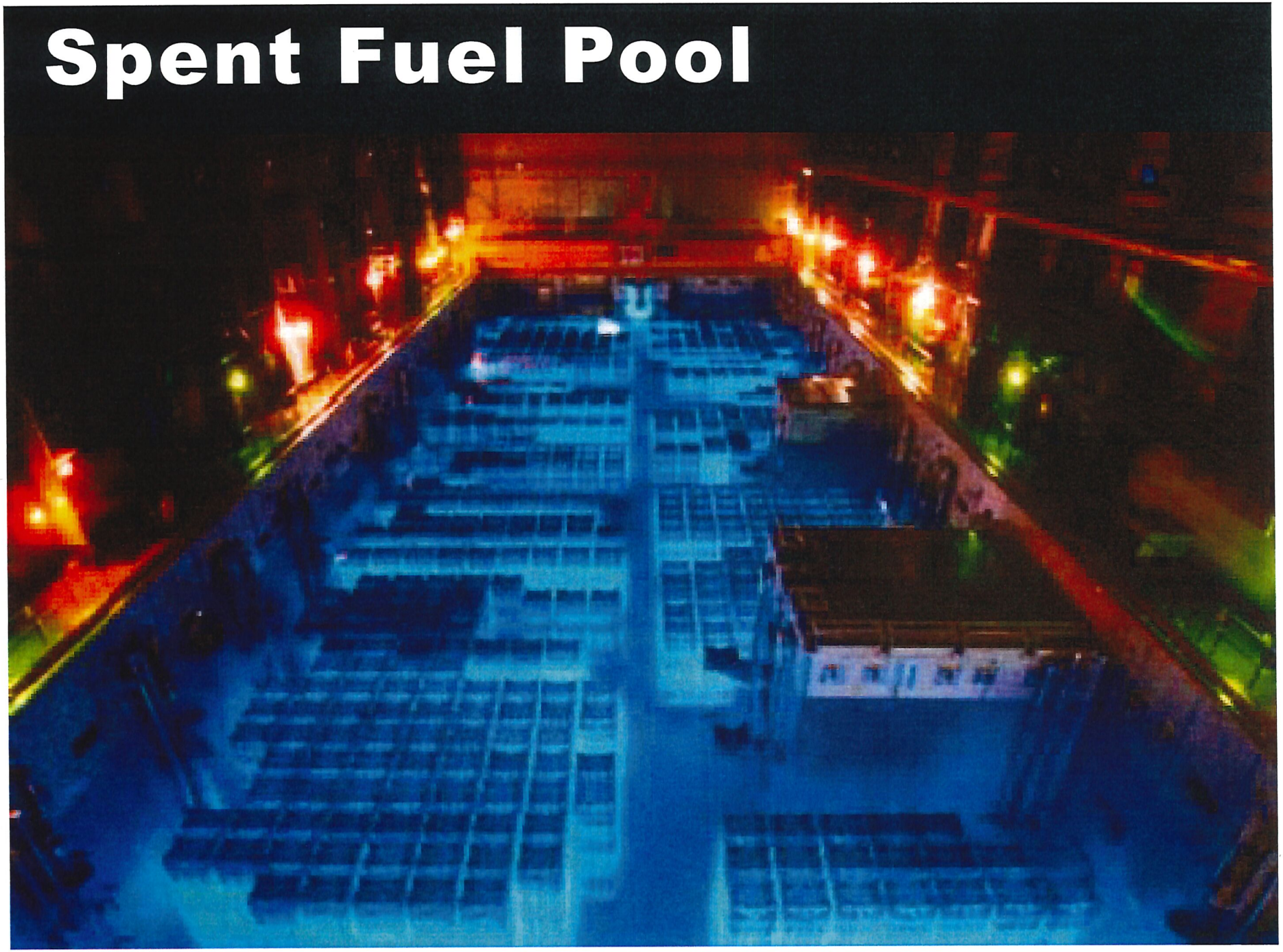
FOUR KEY ISSUES

- COST
- SAFETY
- PROLIFERAT
- **WASTE**

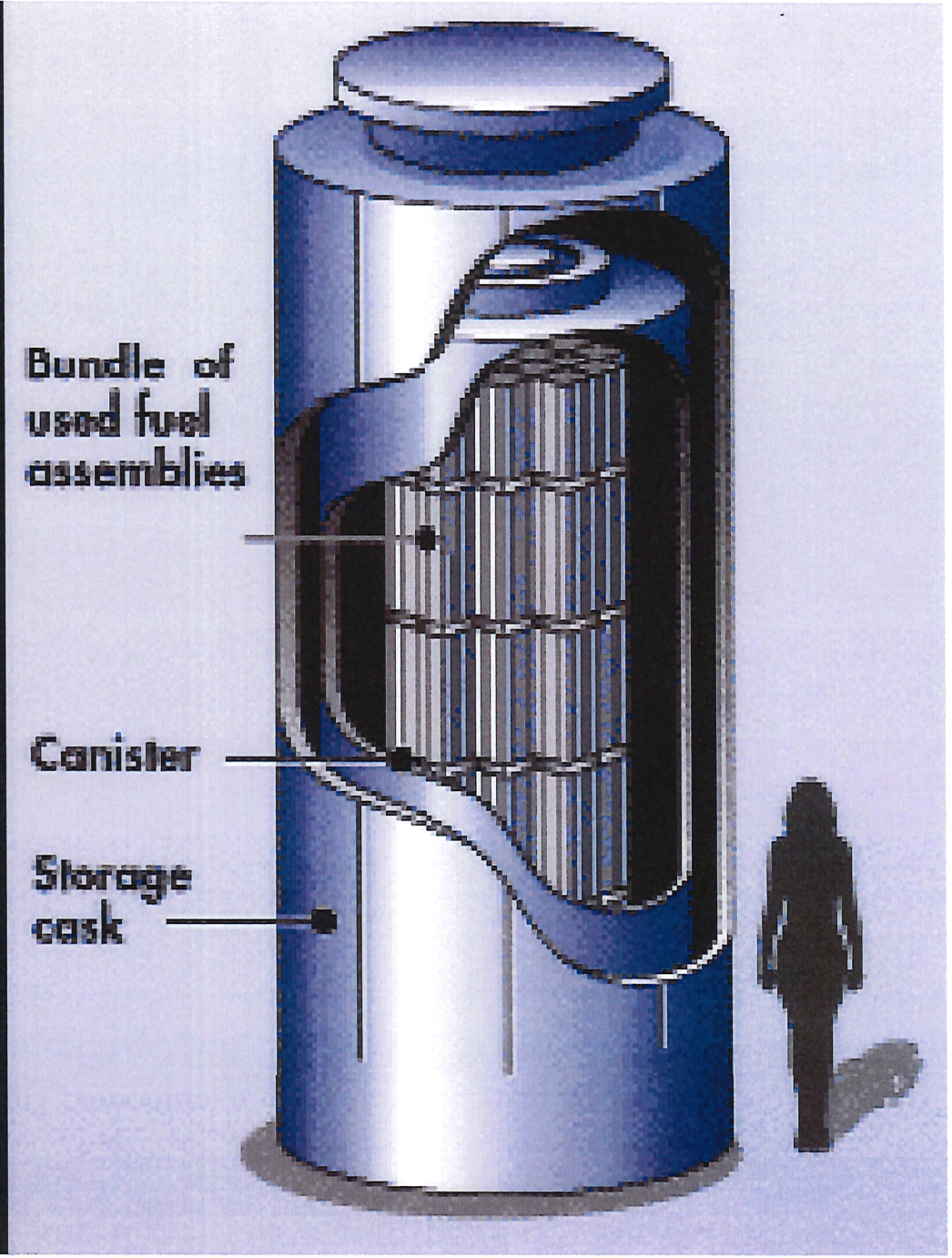
WASTE

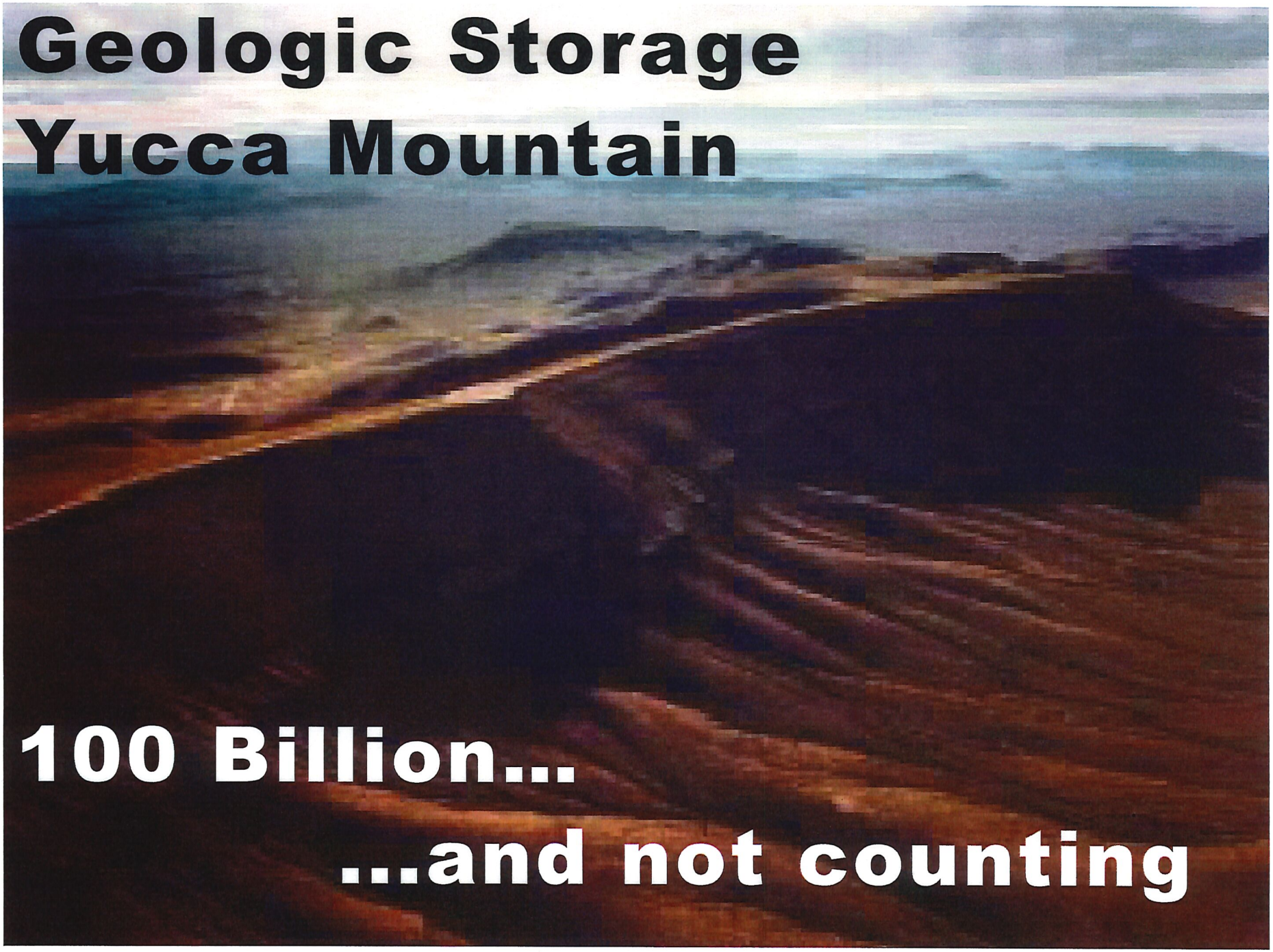
- Short Term 2-3 yrs
- Dry 3-100 years
- Long Term 100- Forever

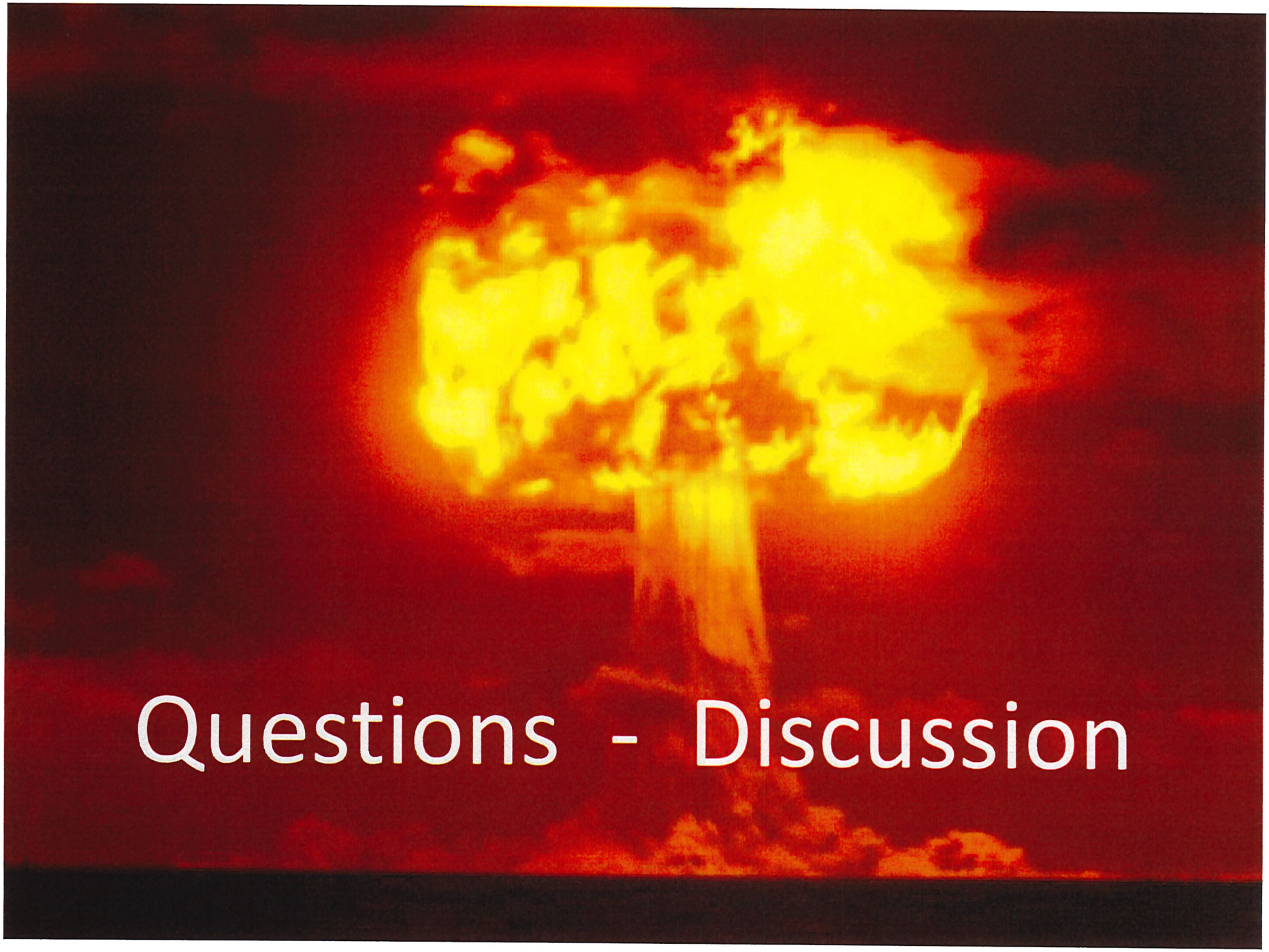
Spent Fuel Pool



Dry On-Site Storage




Geologic Storage
Yucca Mountain
100 Billion...
...and not counting


Questions - Discussion