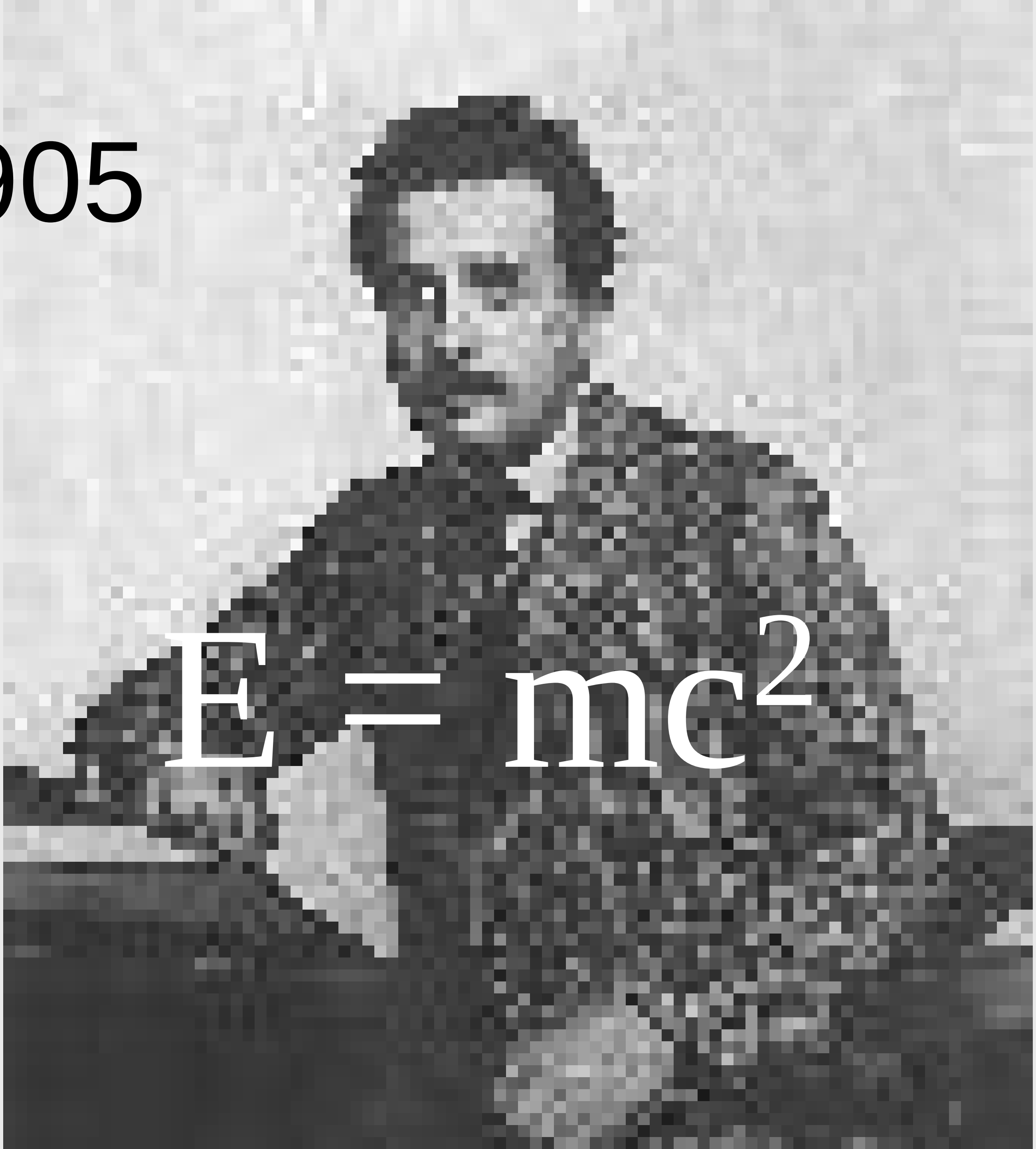
Terrestrial Energy

Power for the 21st Century

1905



$$E = mc^2$$


E=MC²
MARIAH

Matter and Energy are Interchangeable

$$E = mc^2$$

$$E = \frac{1}{2} mv^2$$

Energy Density

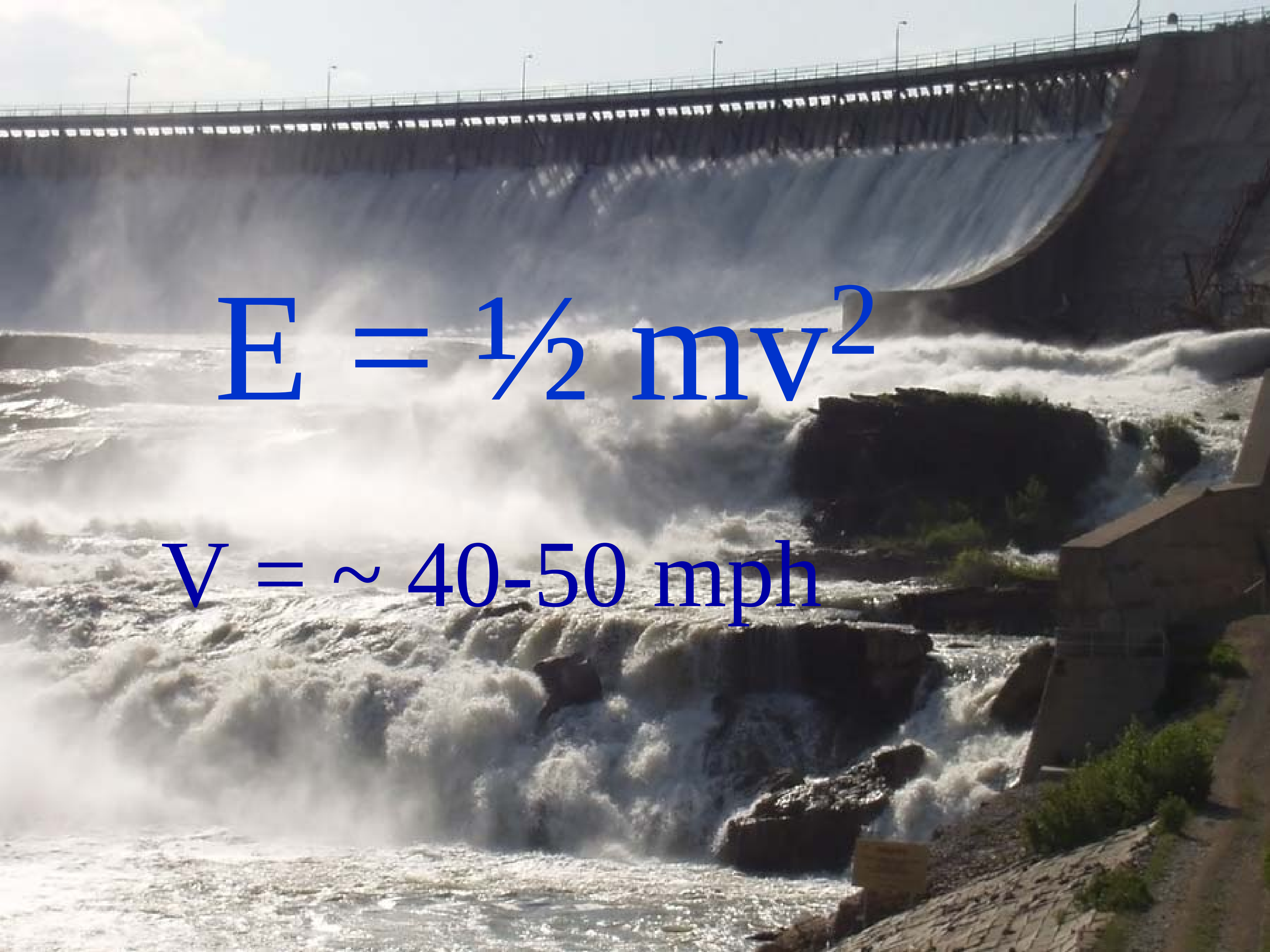
$$E = mC^2$$

$$E = \frac{1}{2} m v^2$$

$$(186{,}000 \text{ miles/second})^2$$

Ten quadrillion

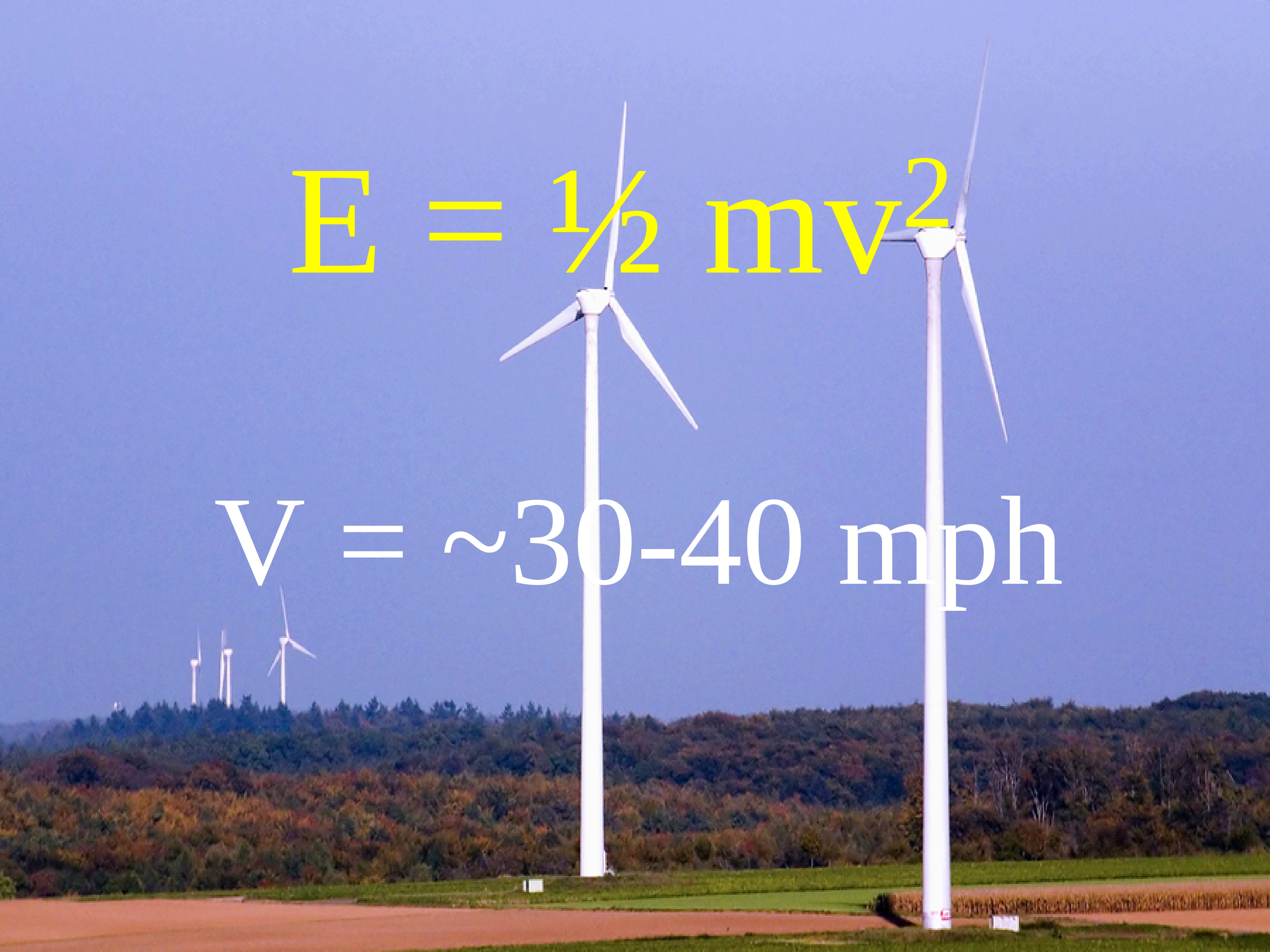
A very, very small amount of matter transforms into a very, very large amount of energy.



$$E = \frac{1}{2} m v^2$$

$$V = \sim 40\text{-}50 \text{ mph}$$

Lake Powell, behind Hoover Dam, covers 250 square miles to produce 1000 megawatts.


$E = \frac{1}{2} mv^2$
$V = \sim 30\text{-}40$ mph

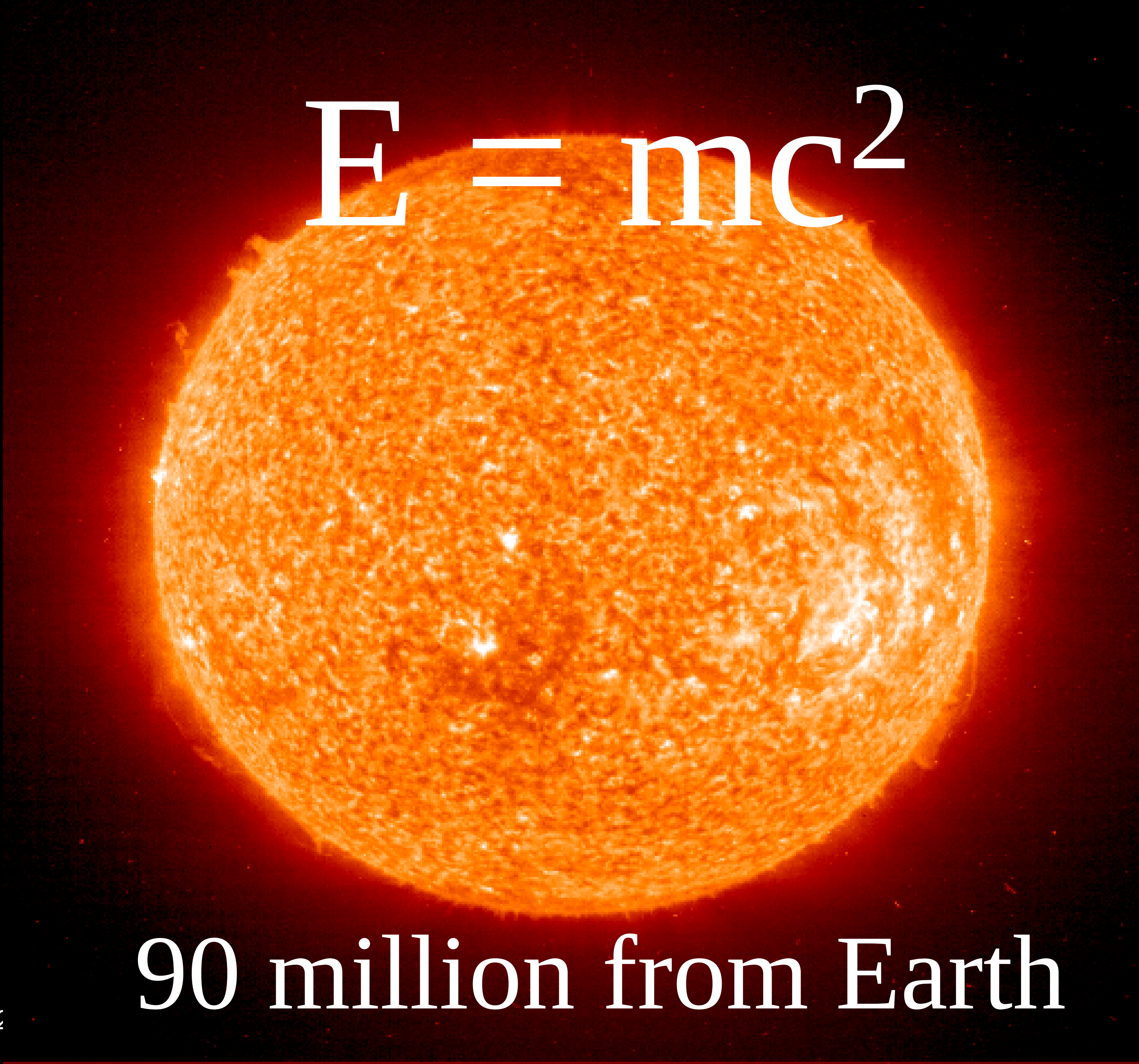

Biggest Ever?
125 square miles for 1000 MW

Tidal and Wave Energy

$$E = \frac{1}{2} mv^2$$

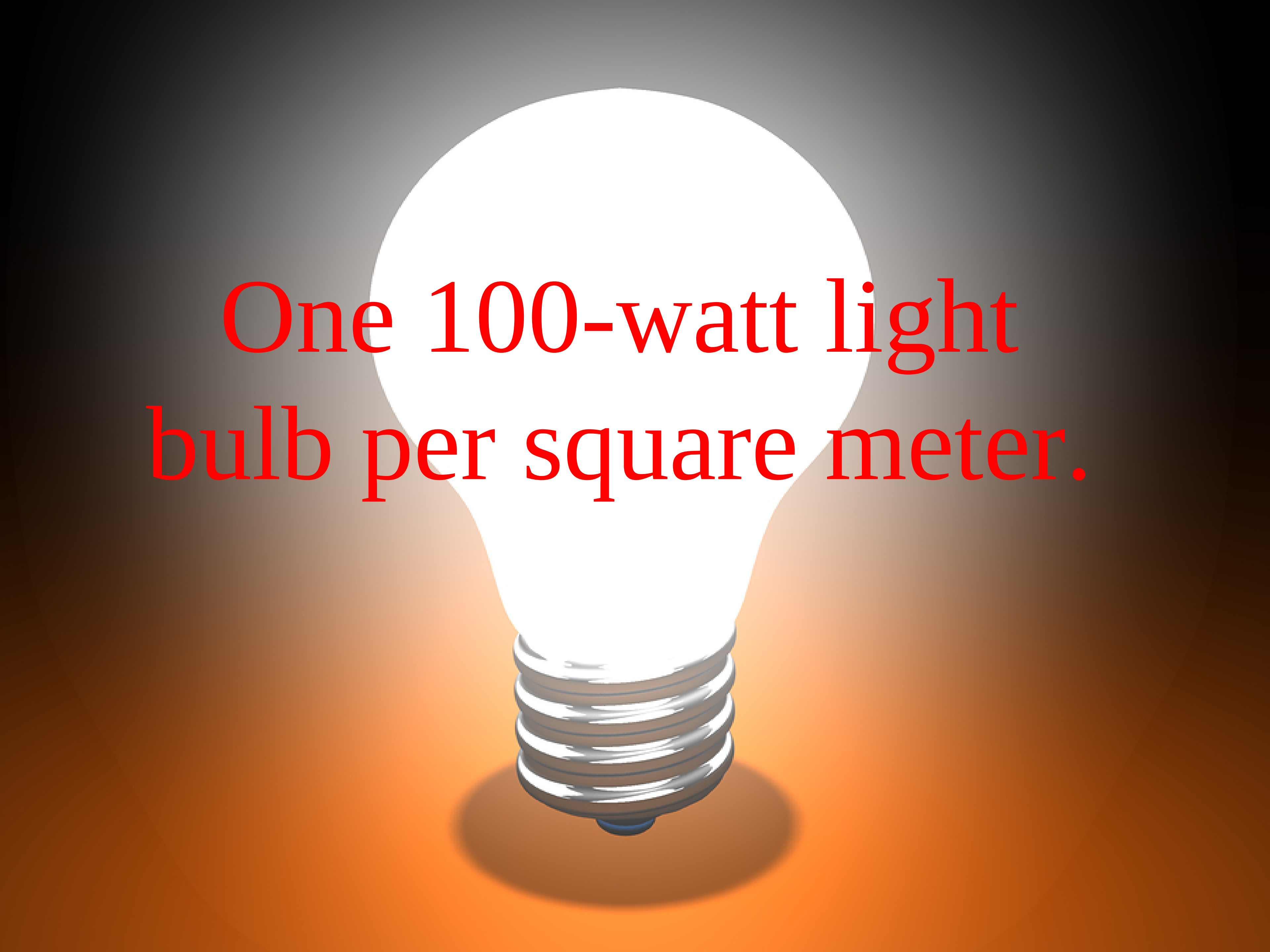
V = ~ 5-7 mph


1000 mw =
Dozens of
miles of
coastline.


$E = mc^2$
90 million from Earth

Solar energy hits the earth at an average of 400 watts

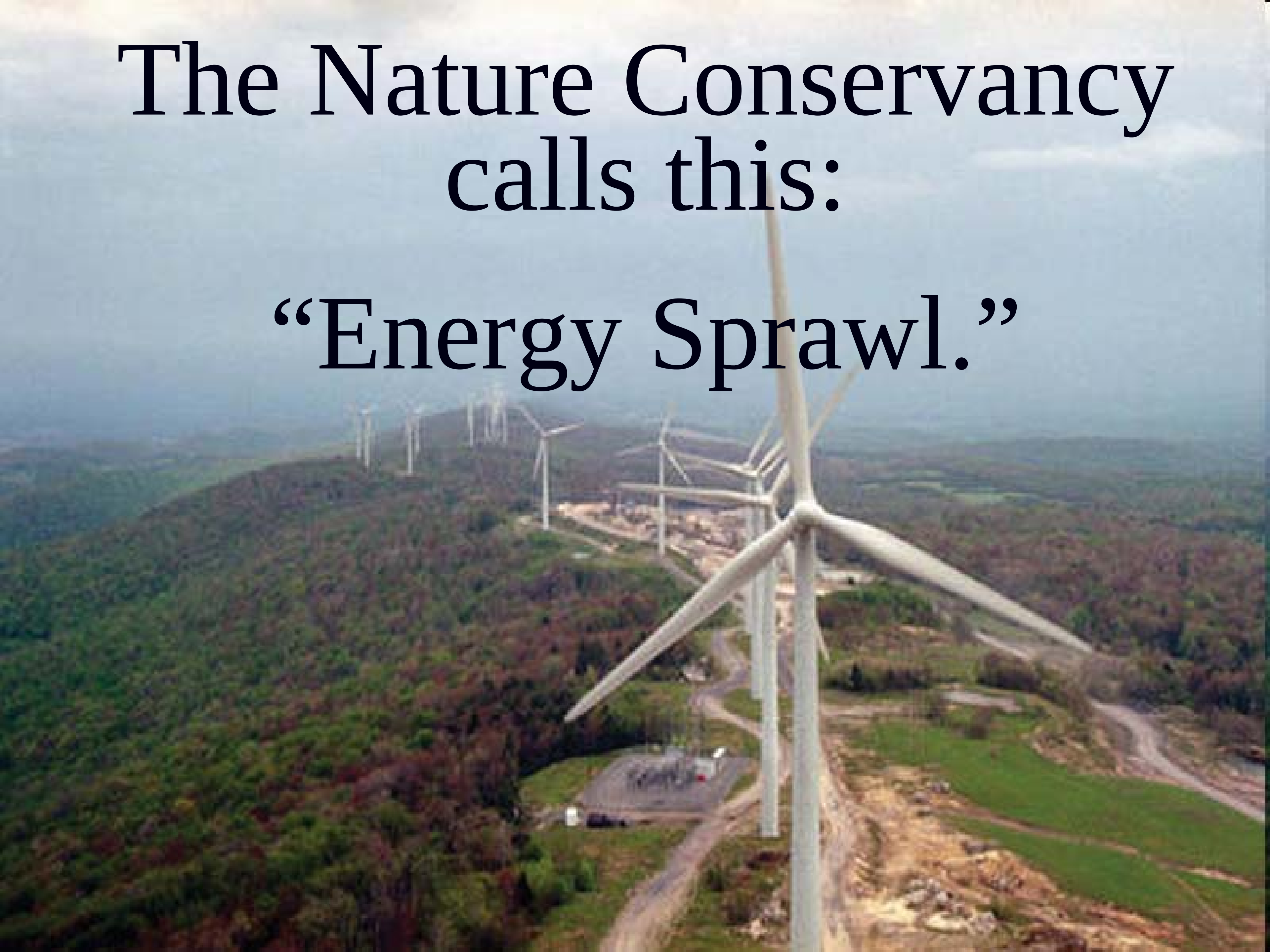
Solar conversions take place at best at ~ 20 percent


One 100-watt light
bulb per square meter.

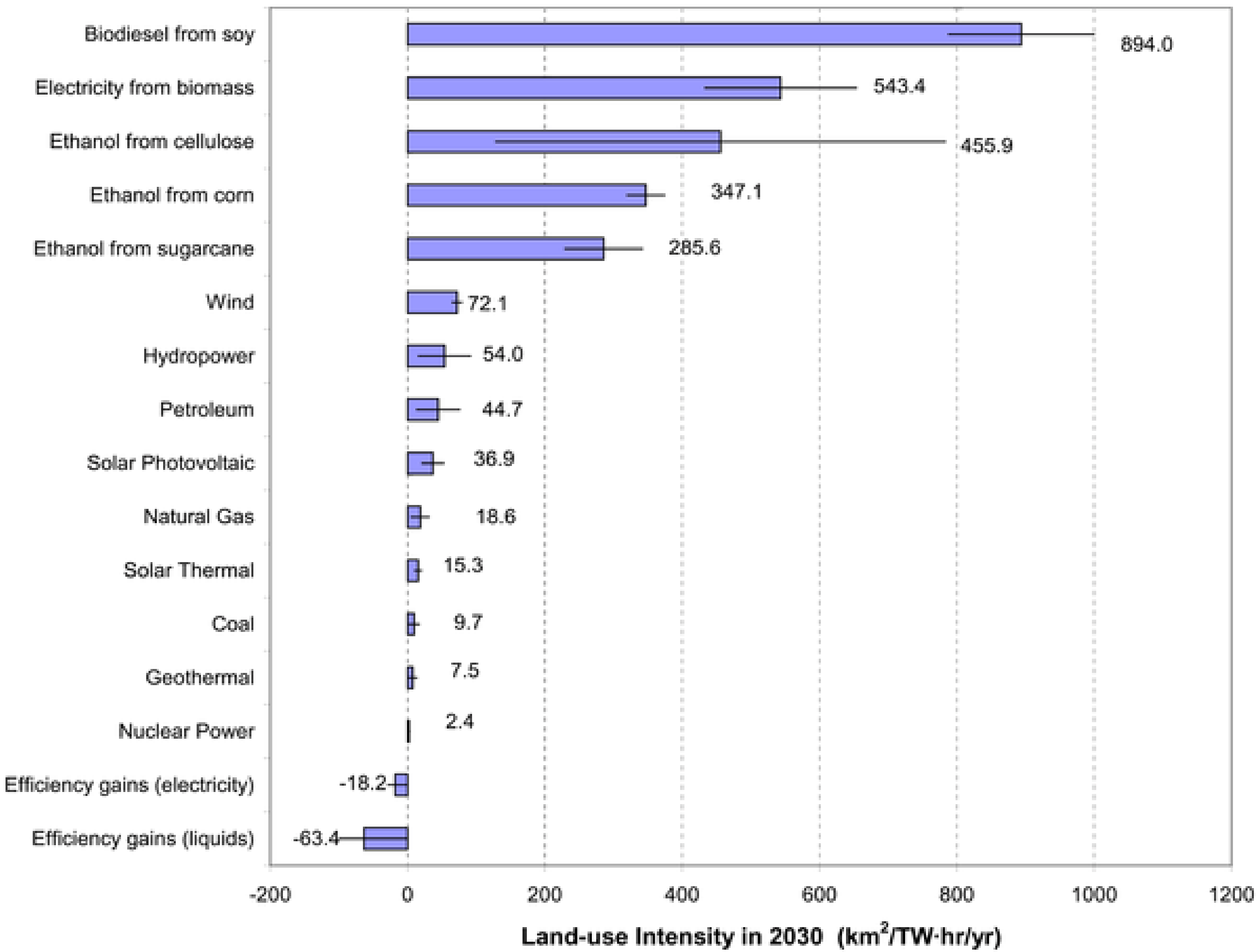
Solar Thermal

10 Megawatts – 1/5 sq. mile

46,000 square miles of western desert

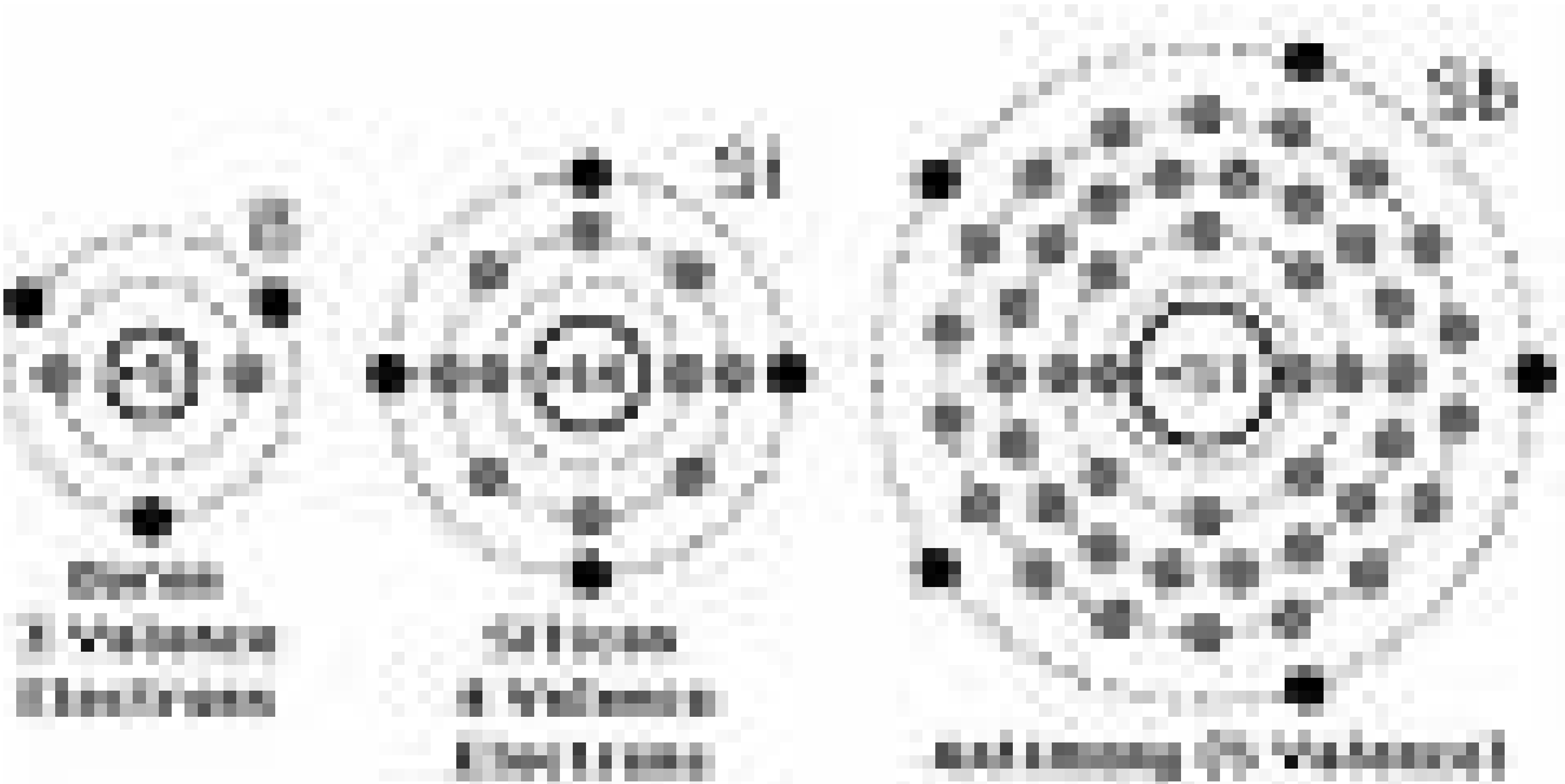

The Nature Conservancy calls this:
"Energy Sprawl."

Energy Density

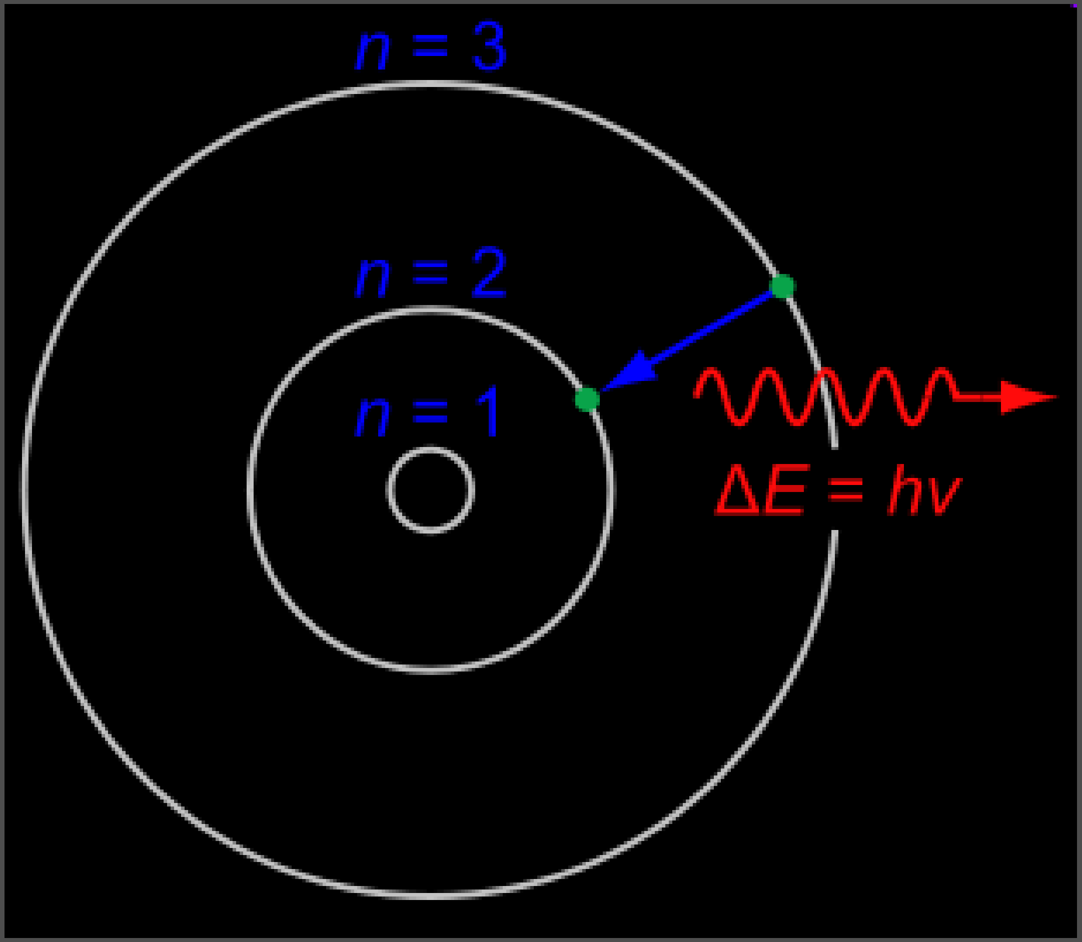


Is there any source of energy that involves. . .

Chemistry

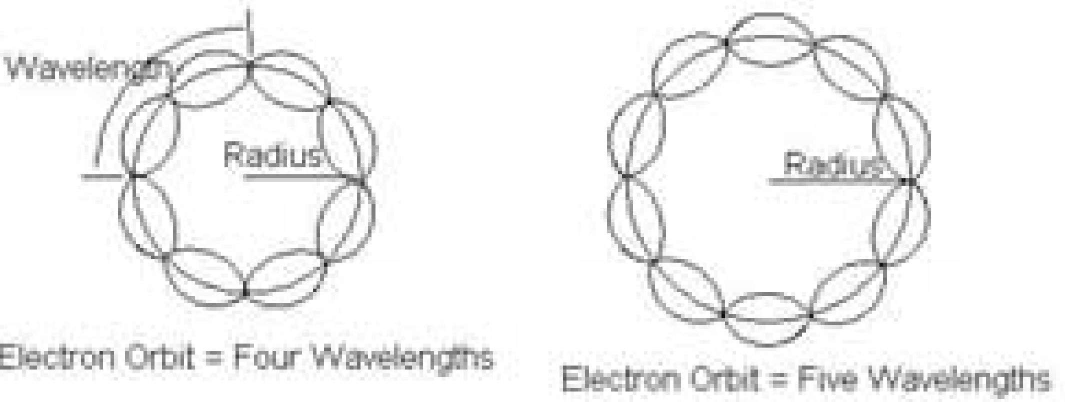


Quantum Theory

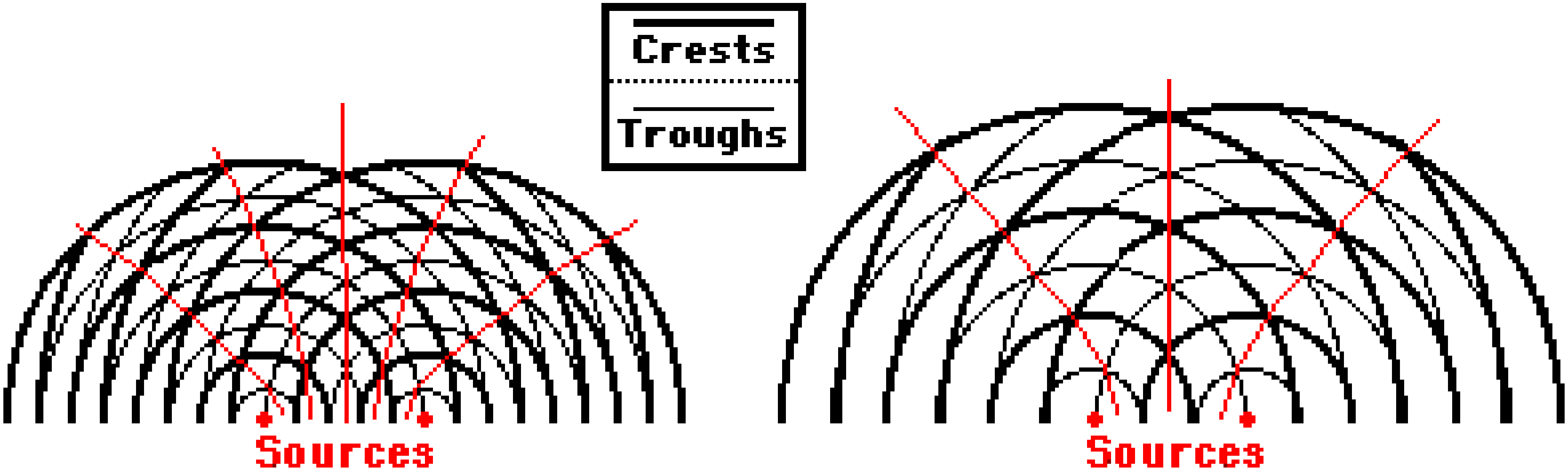


Niels Bohr 1885-1962

Electrons as Particle/Waves

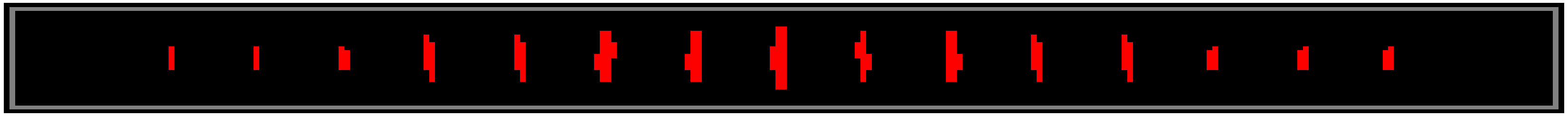


Louis de Broglie 1892-1987



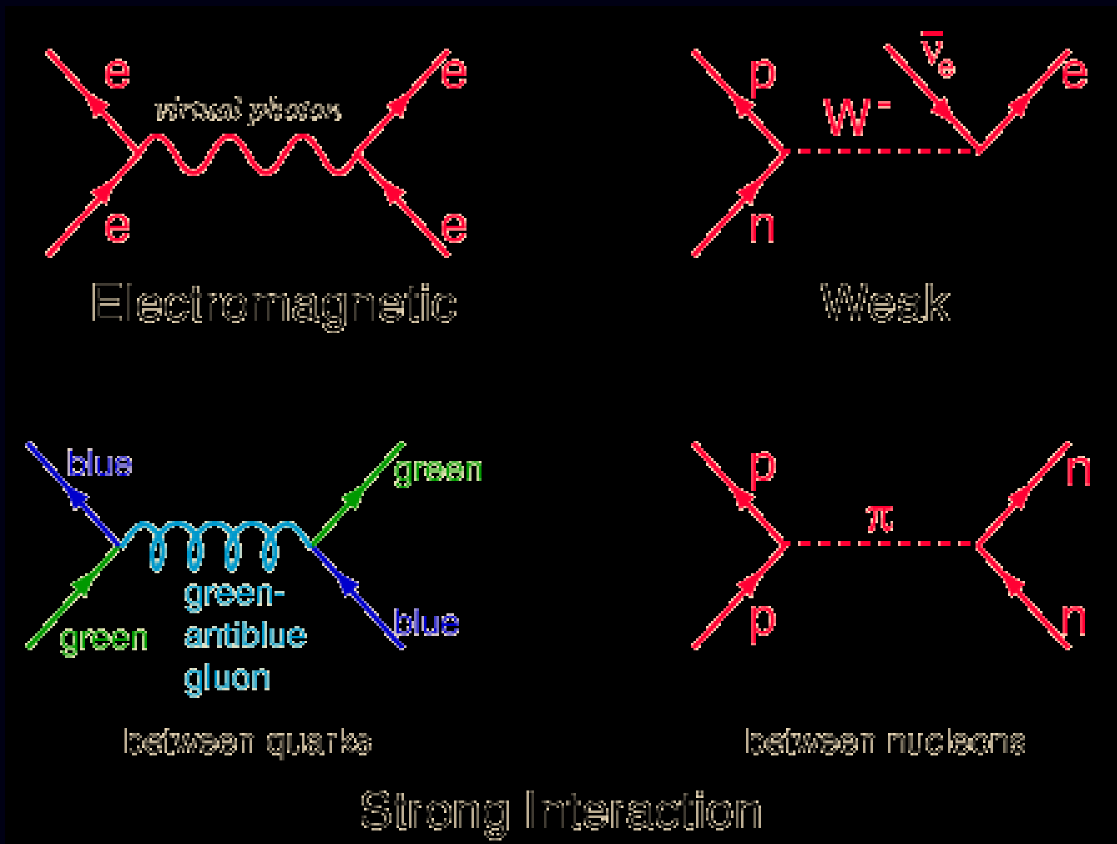
The proximity of the anti-nodal lines in a two-point source interference pattern is dependent upon the wavelength of the waves.

Two-Point Source Interference Pattern



The projection of an interference pattern onto a screen results in an alternating pattern of bright (anti-nodes) and dark (nodes) bands.

Matter = Energy



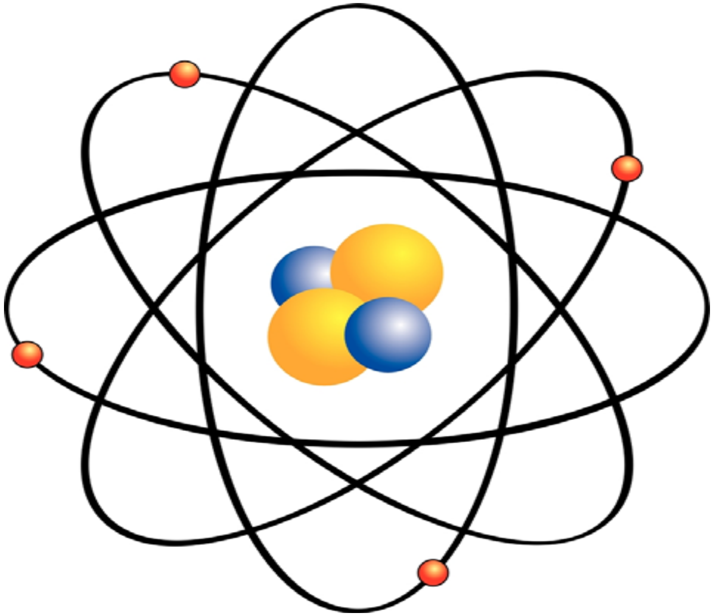
Richard Feynman 1918-1988

One billionth of the mass.

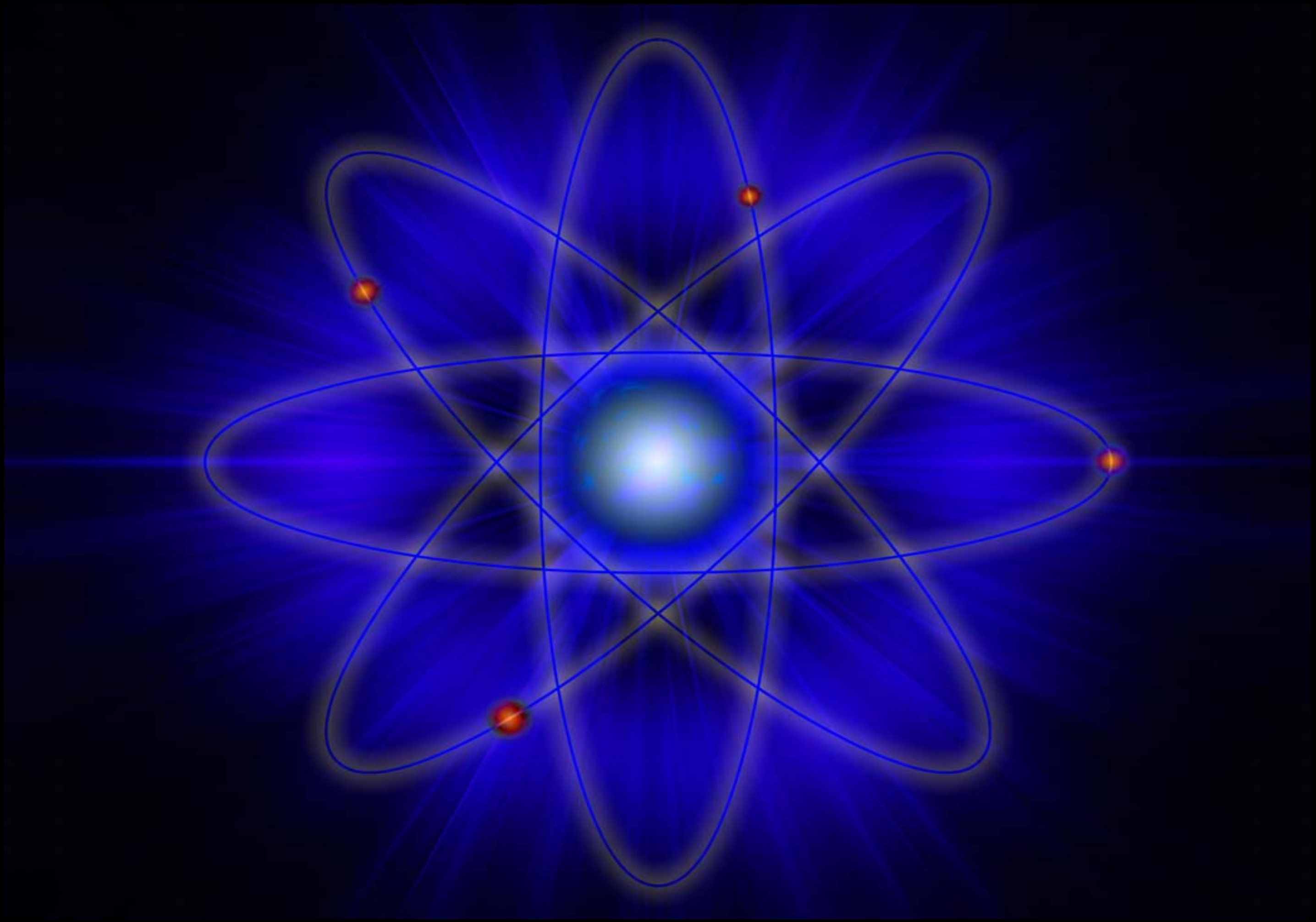
2000 pounds for 30 miles.

Is there any other concentration of matter in the universe other than the electron?

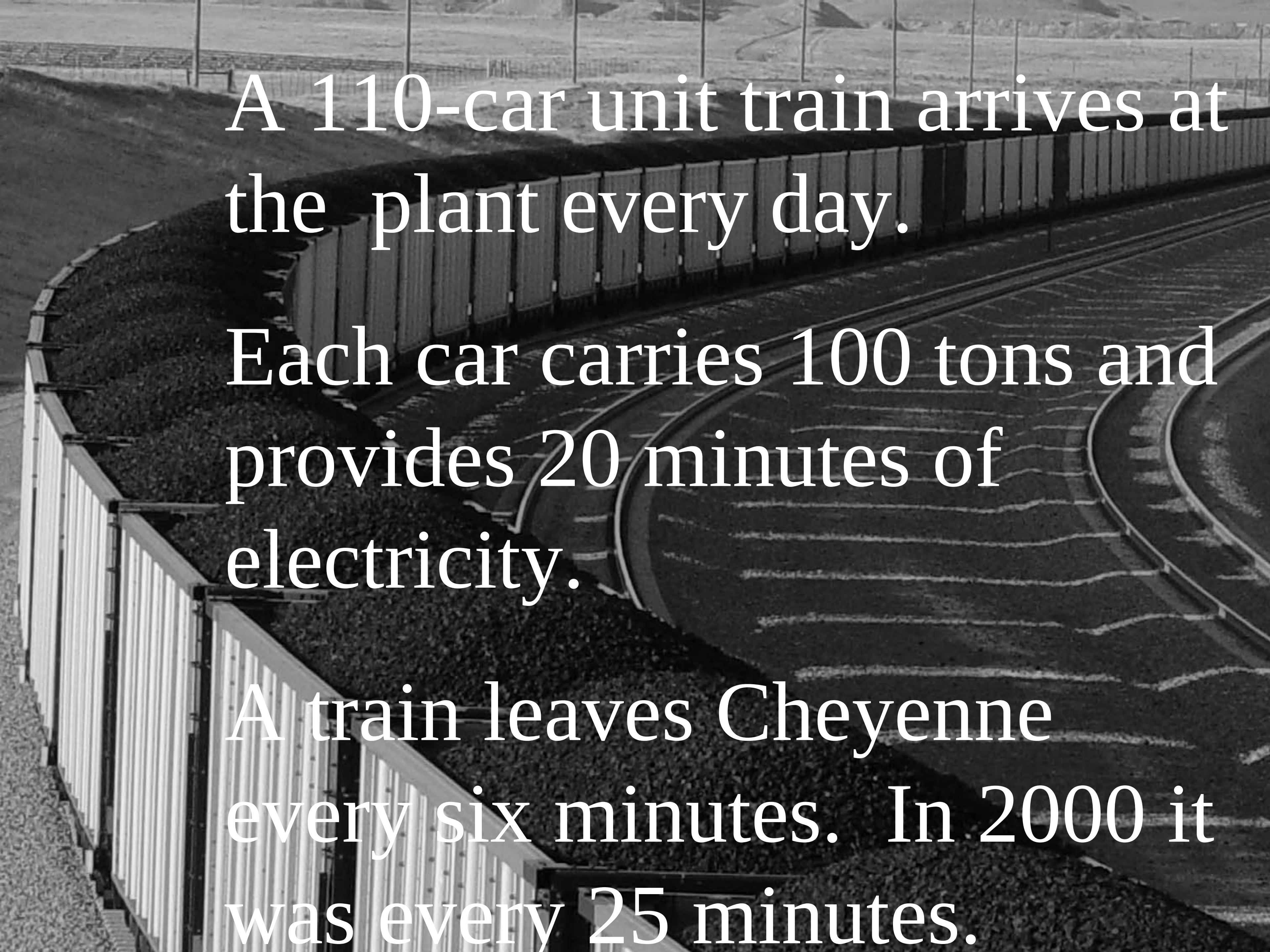
Only 1/1800th of the mass is in the electrons.



The remainder is in the nucleus.



The energy release from splitting a uranium atom is ***2 million*** eV.



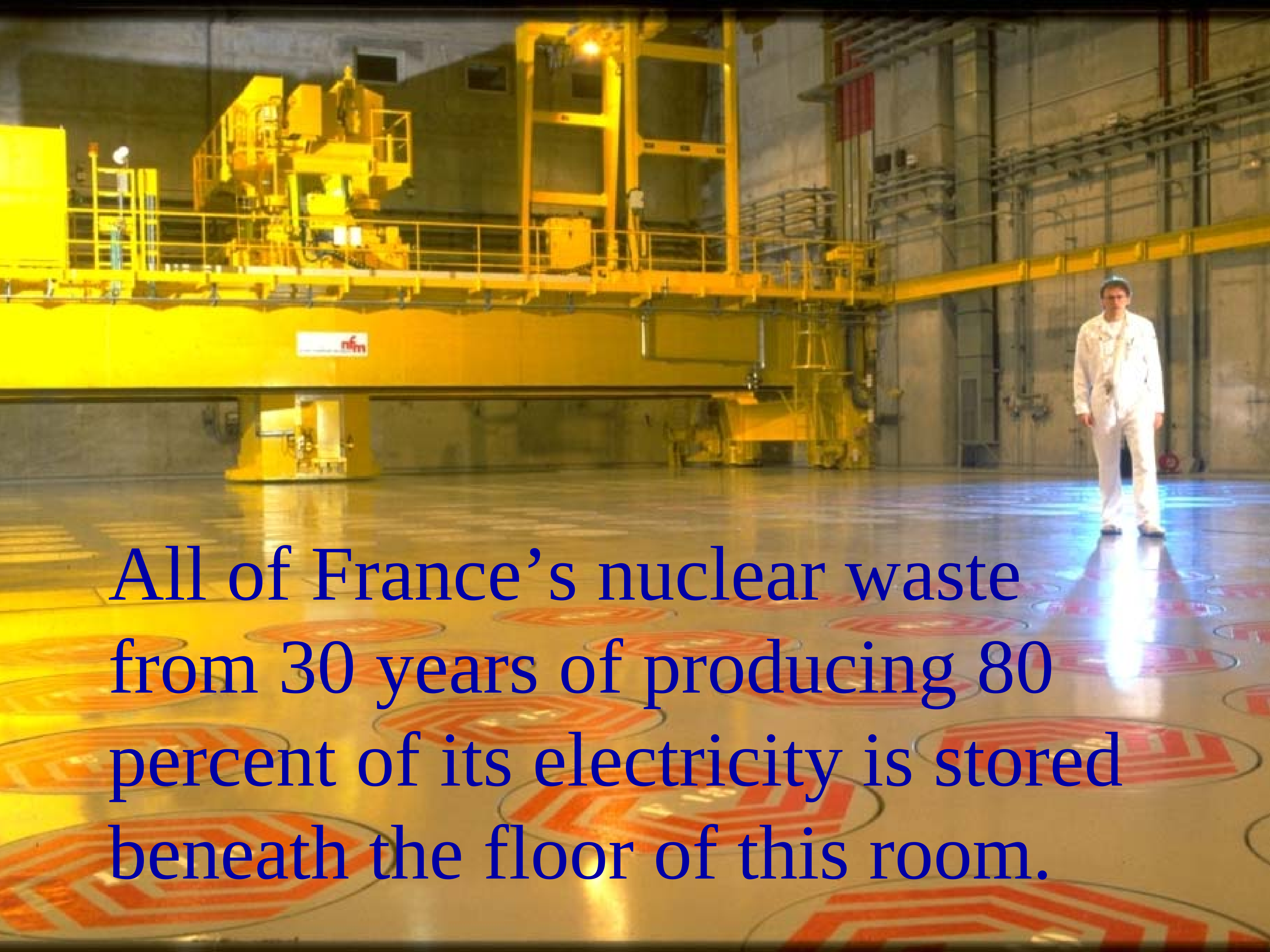
A 110-car unit train arrives at the plant every day.

Each car carries 100 tons and provides 20 minutes of electricity.

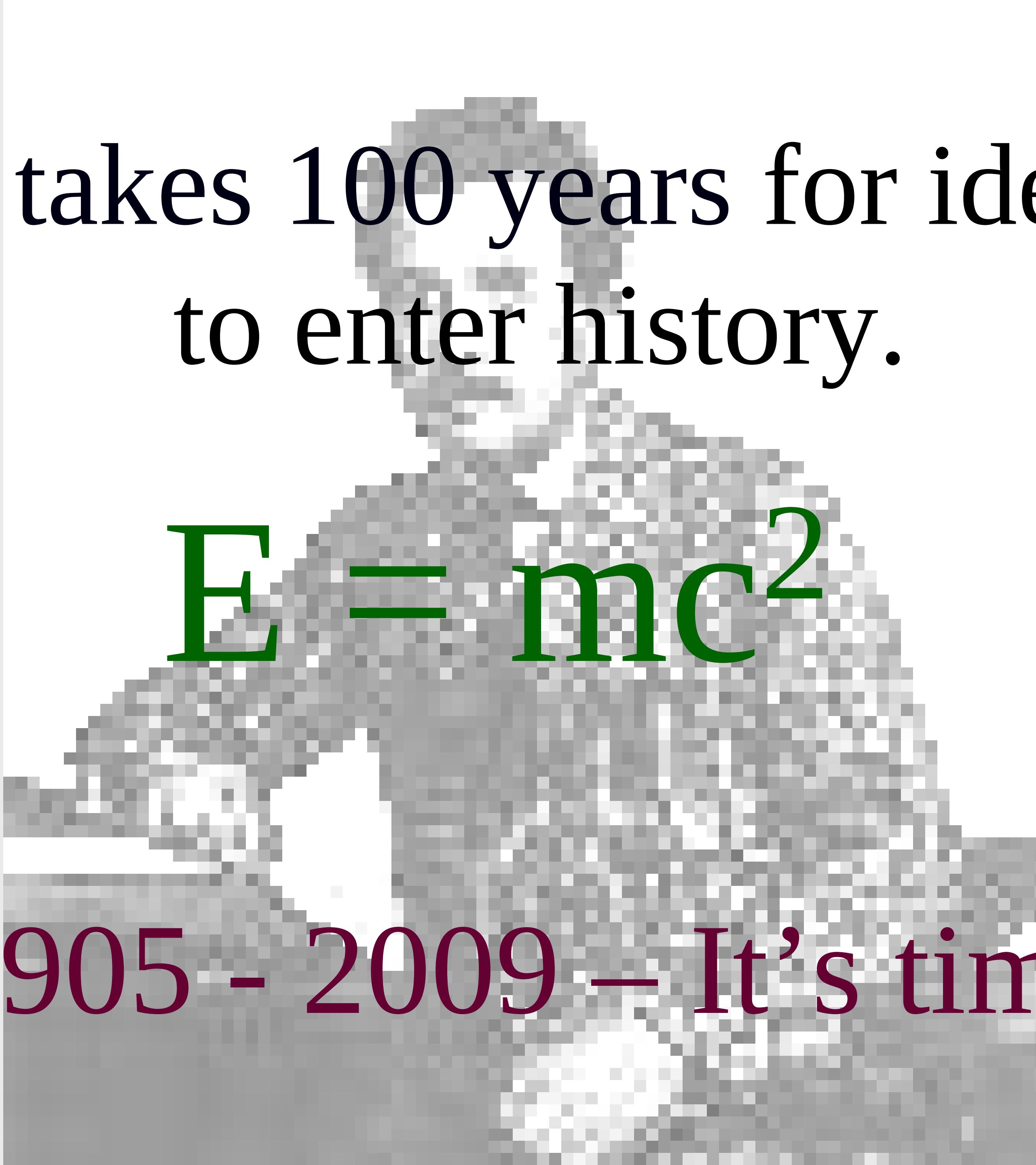
A train leaves Cheyenne every six minutes. In 2000 it was every 25 minutes.

Two years worth of electricity.


Four years' worth of nuclear waste.



All of France’s nuclear waste from 30 years of producing 80 percent of its electricity is stored beneath the floor of this room.

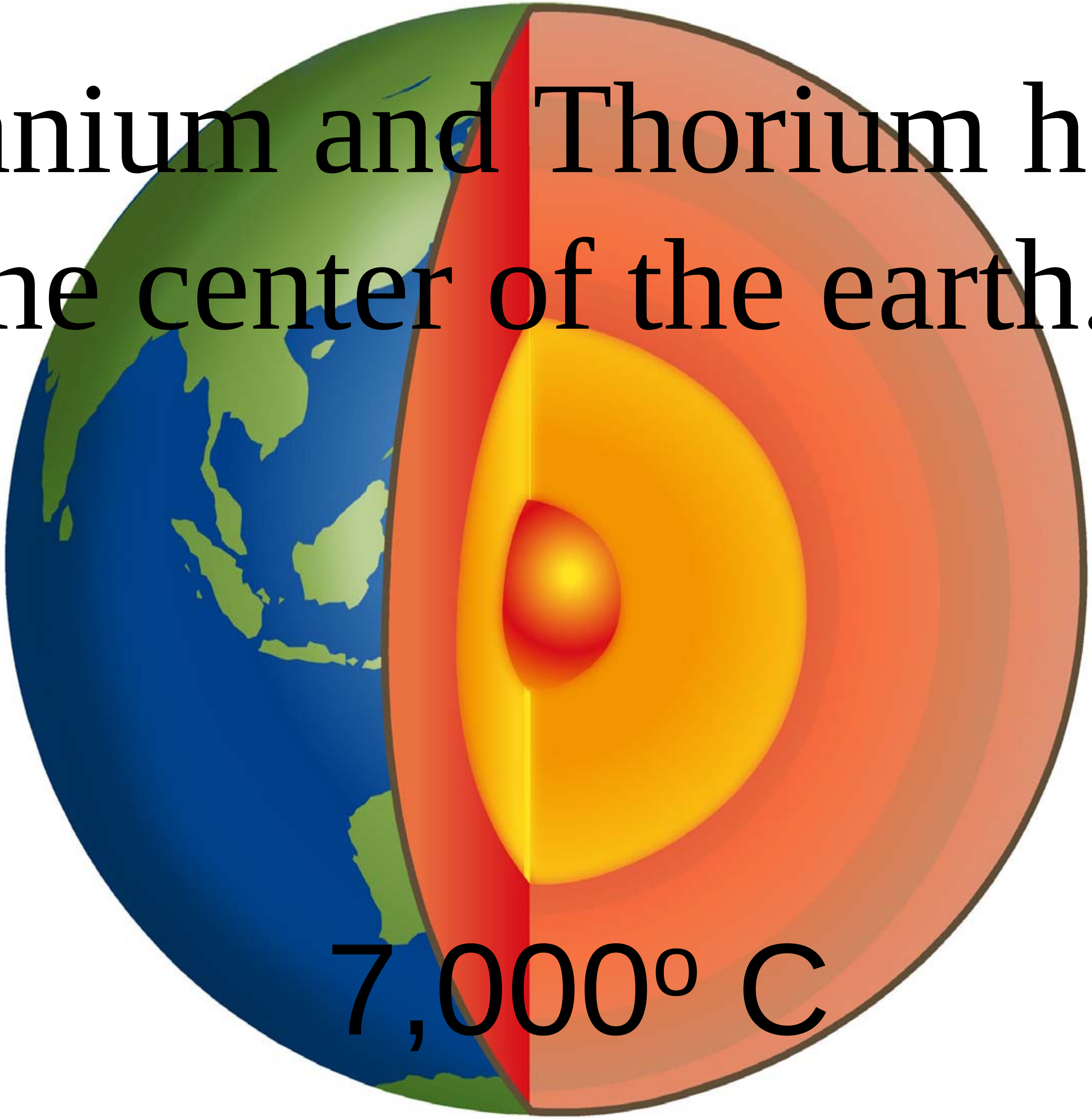


It takes 100 years for ideas to enter history.

$$E = mc^2$$

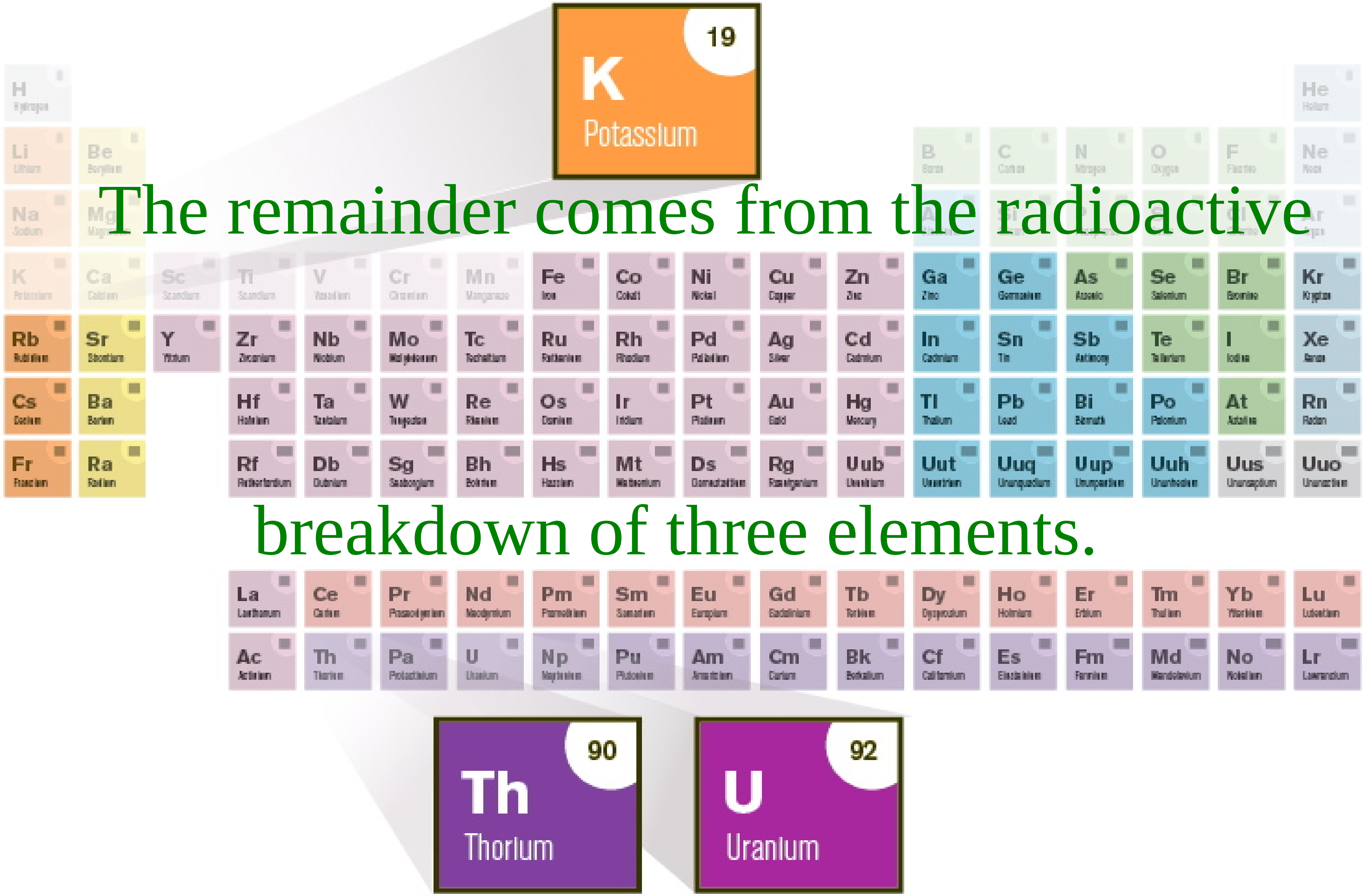
1905 - 2009 – It's time!!

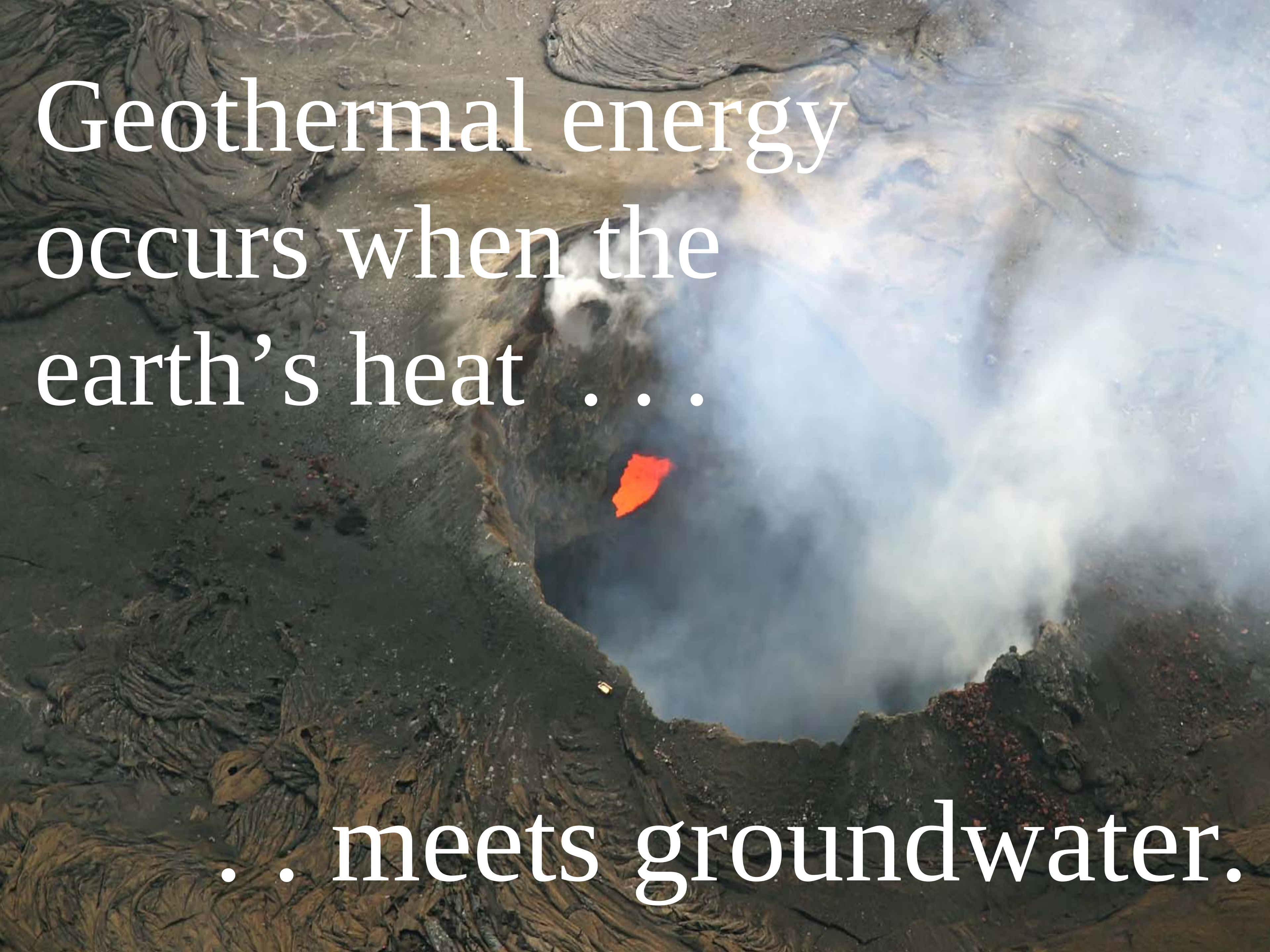
Uranium and Thorium heat the center of the earth.



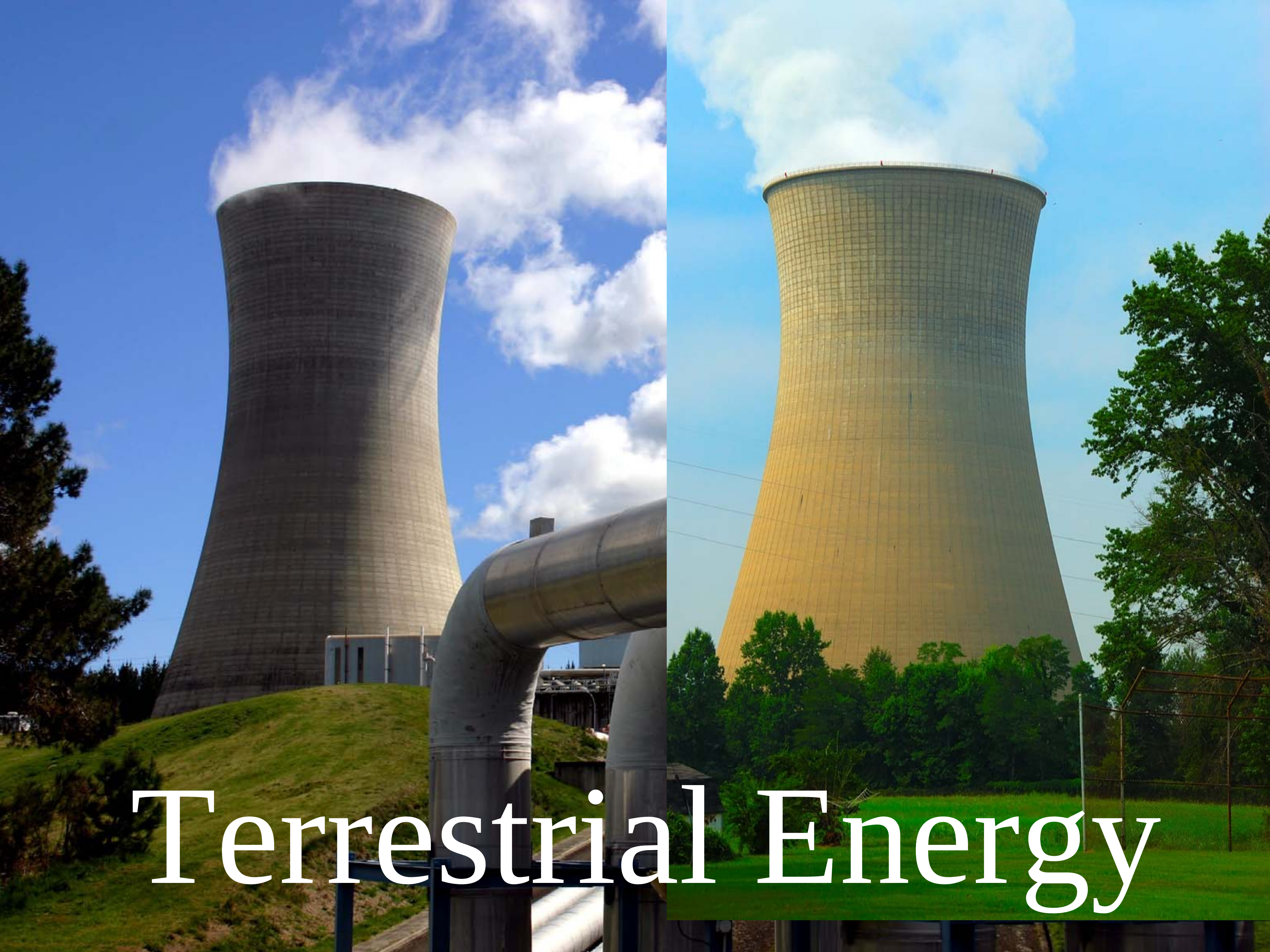
7,000° C

The remainder comes from the radioactive breakdown of three elements.

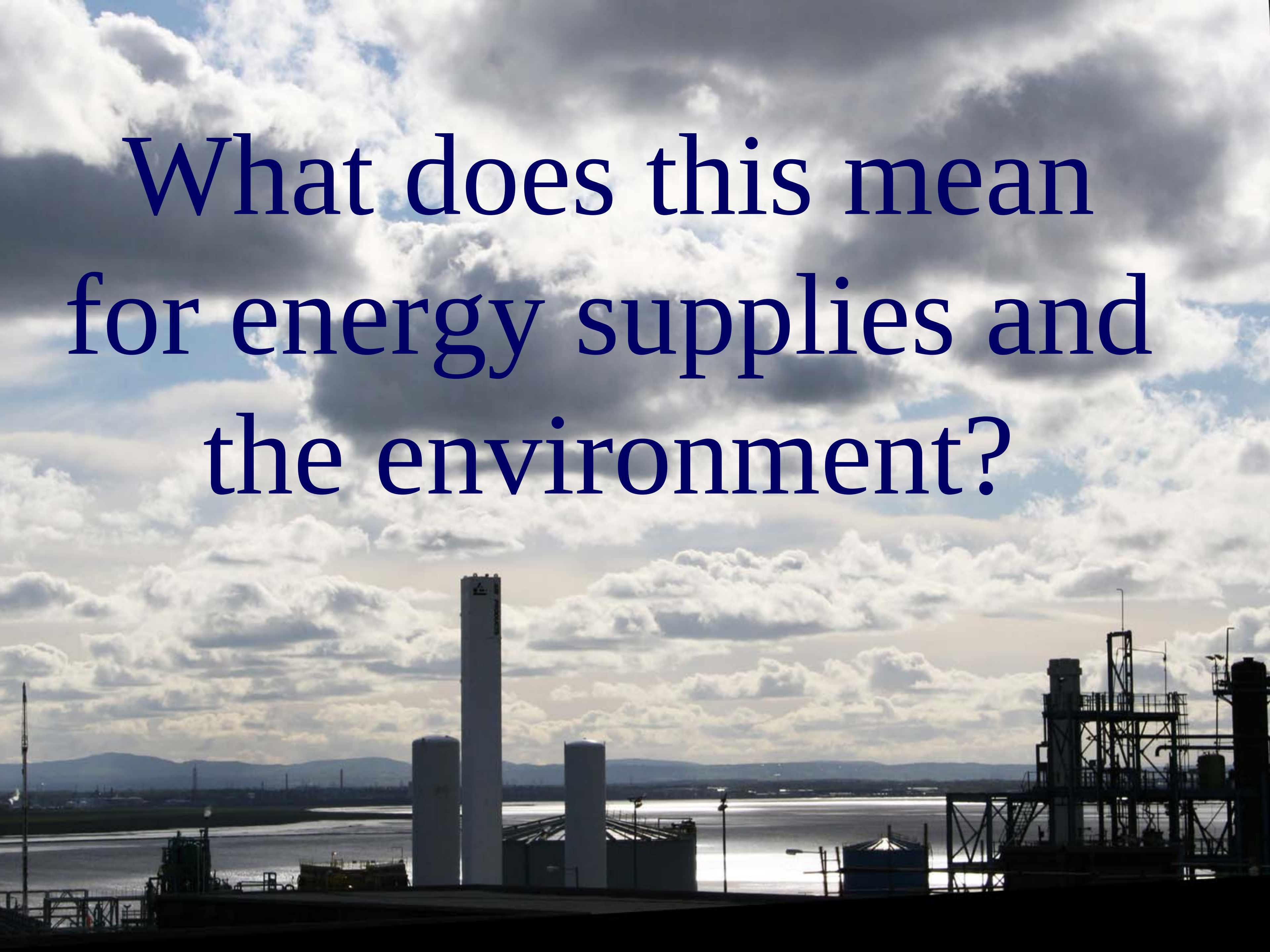


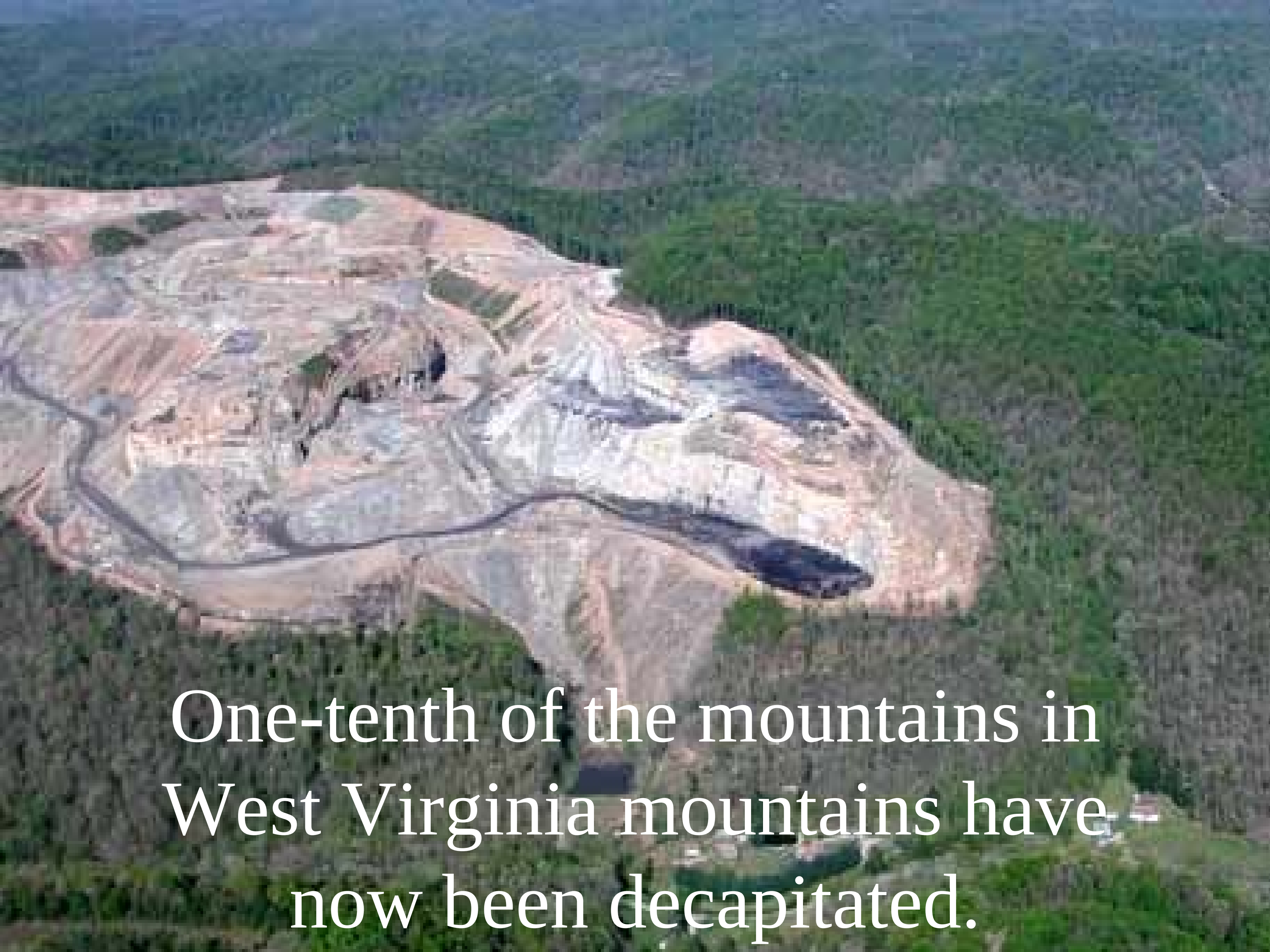

Geothermal energy
occurs when the
earth's heat . . .
. . . meets groundwater.

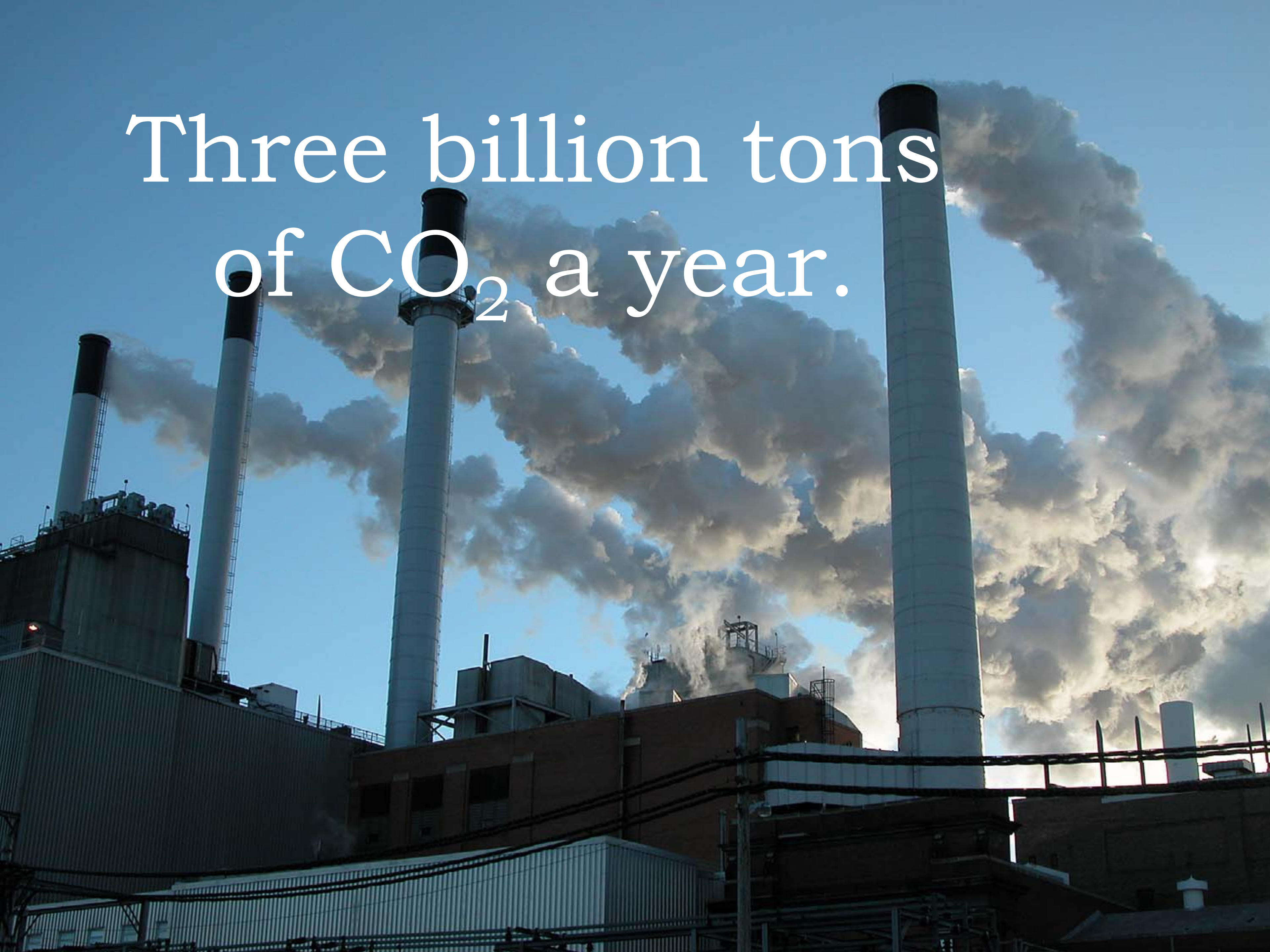

Geothermal energy - Iceland


Terrestrial Energy

What does this mean for energy supplies and the environment?




One-tenth of the mountains in
West Virginia mountains have
now been decapitated.

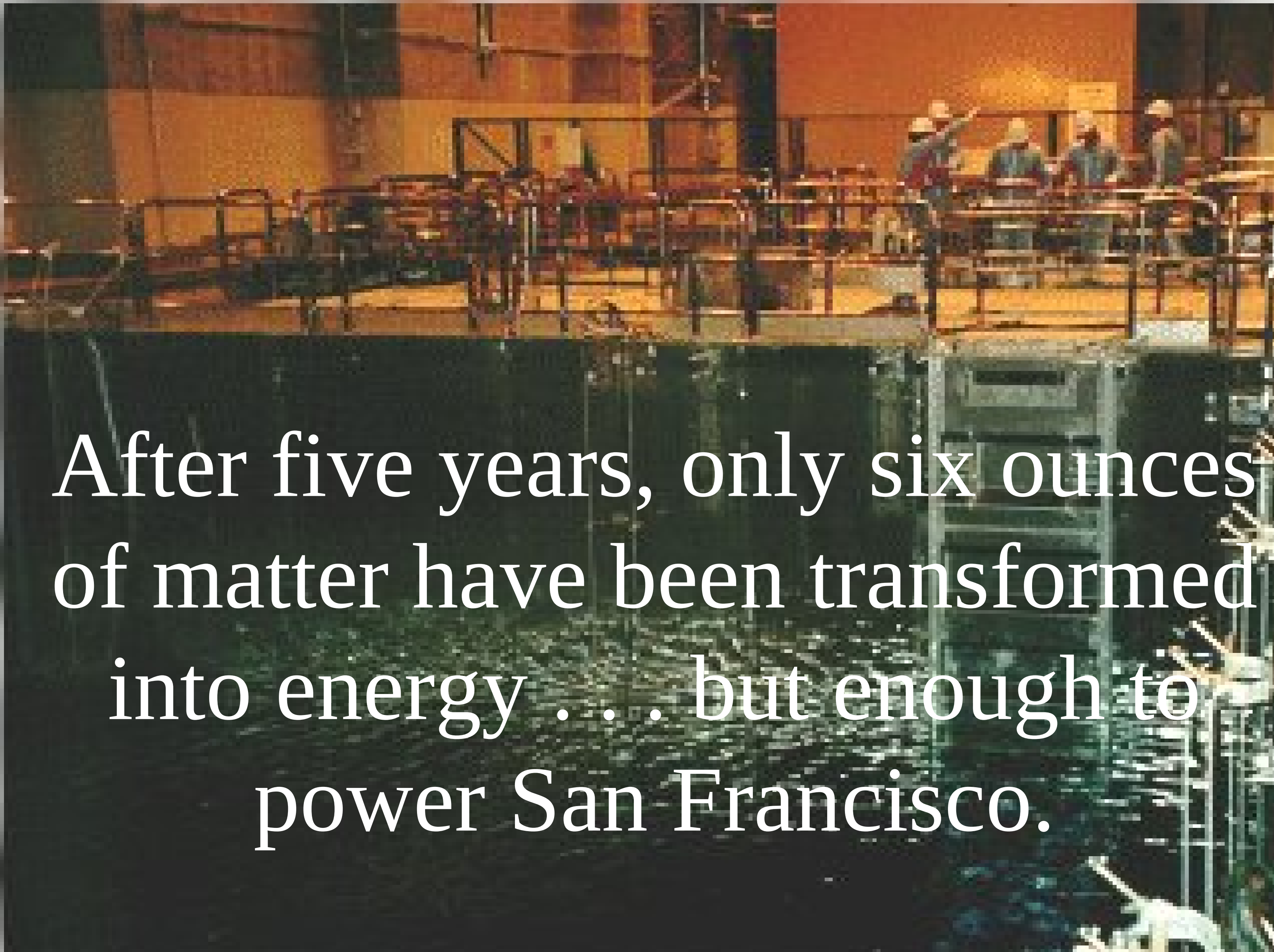

Three billion tons
of CO_2 a year.

“Fifteen homes like this one in Harriman, Tenn., were flooded with fly ash sludge on Monday after a storage pond wall broke.”

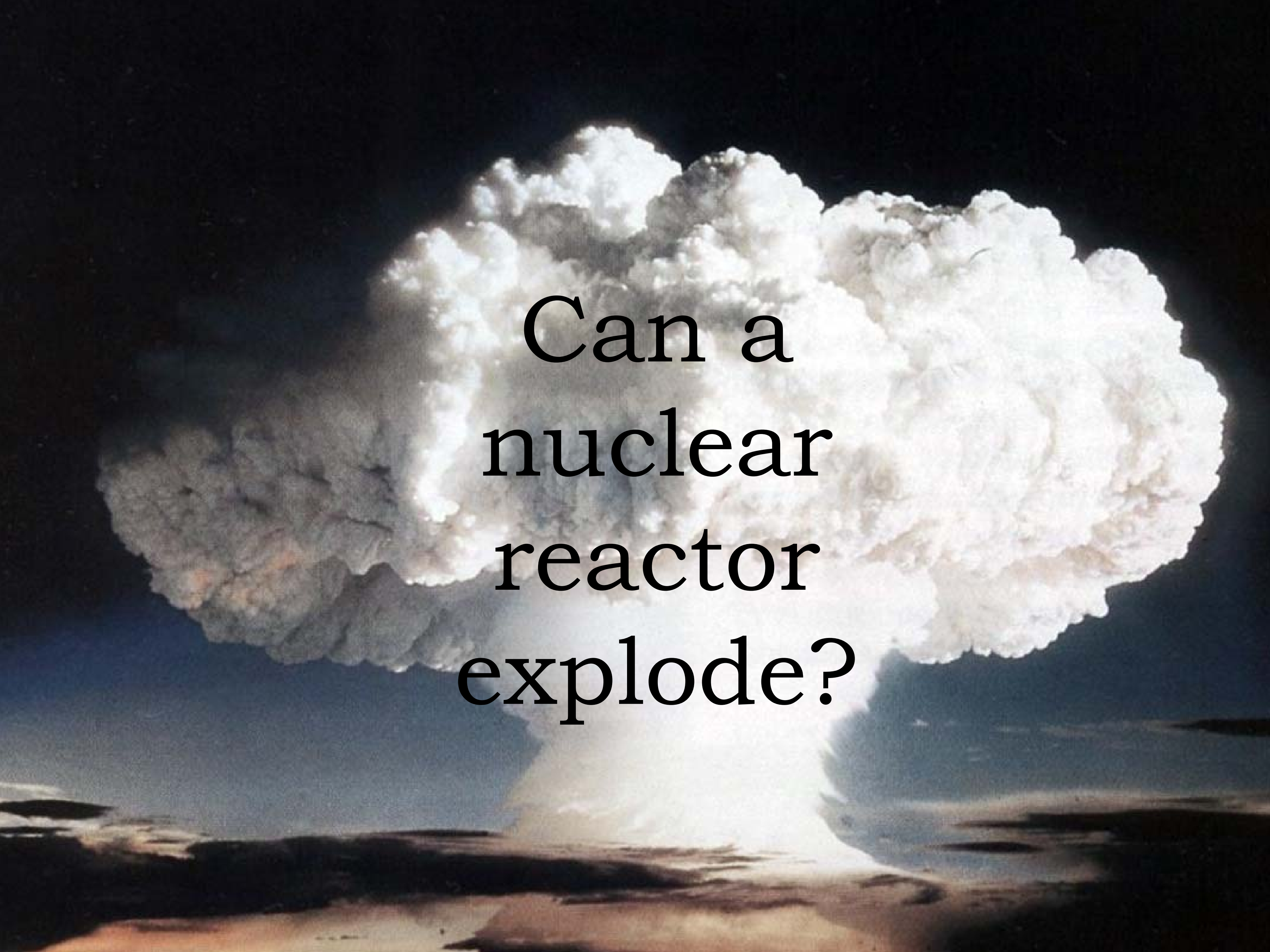
— *New York Times*, December 24, 2008

What happens at a nuclear reactor?


No CO_2 emissions.

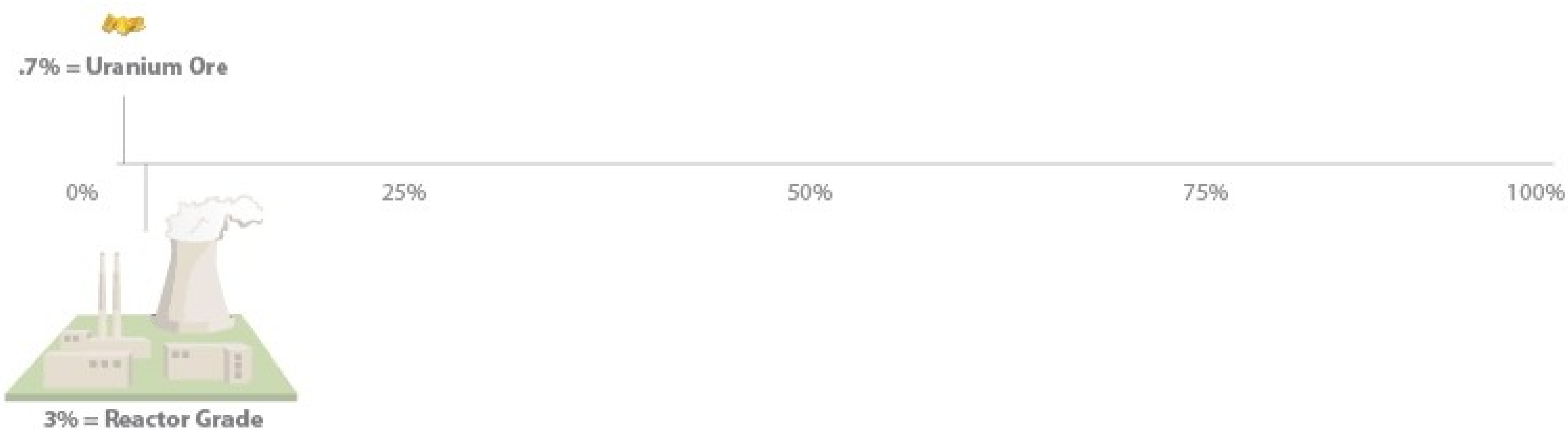

After five years, only six ounces of matter have been transformed into energy . . . but enough to power San Francisco.

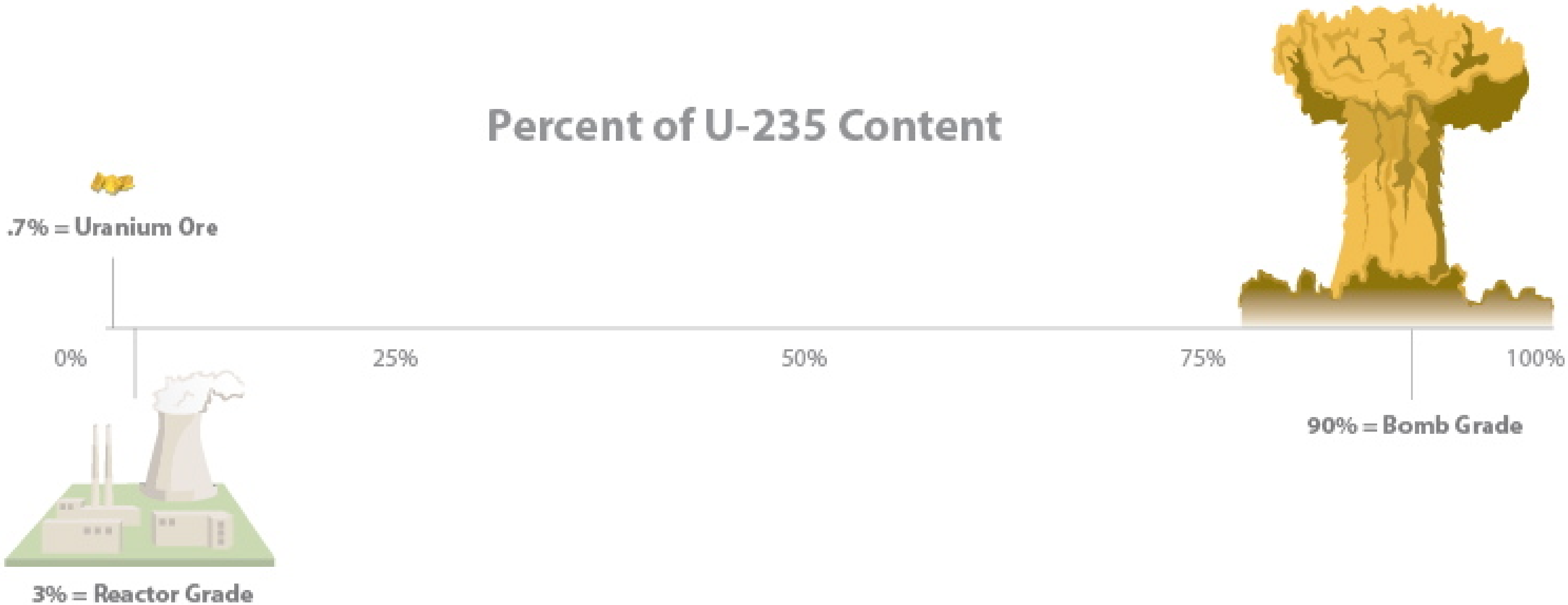
Can a nuclear reactor explode?



THE UNTHINKABLE

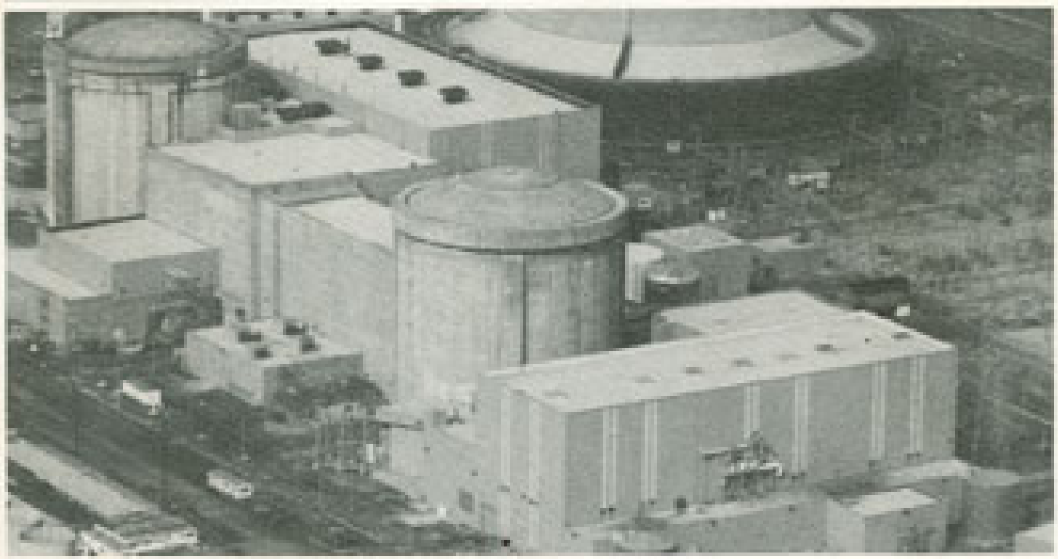
Percent of U-235




Percent of U-235 Content
.7% = Uranium Ore
0%
25%
50%
75%
100%
90% = Bomb Grade
3% = Reactor Grade

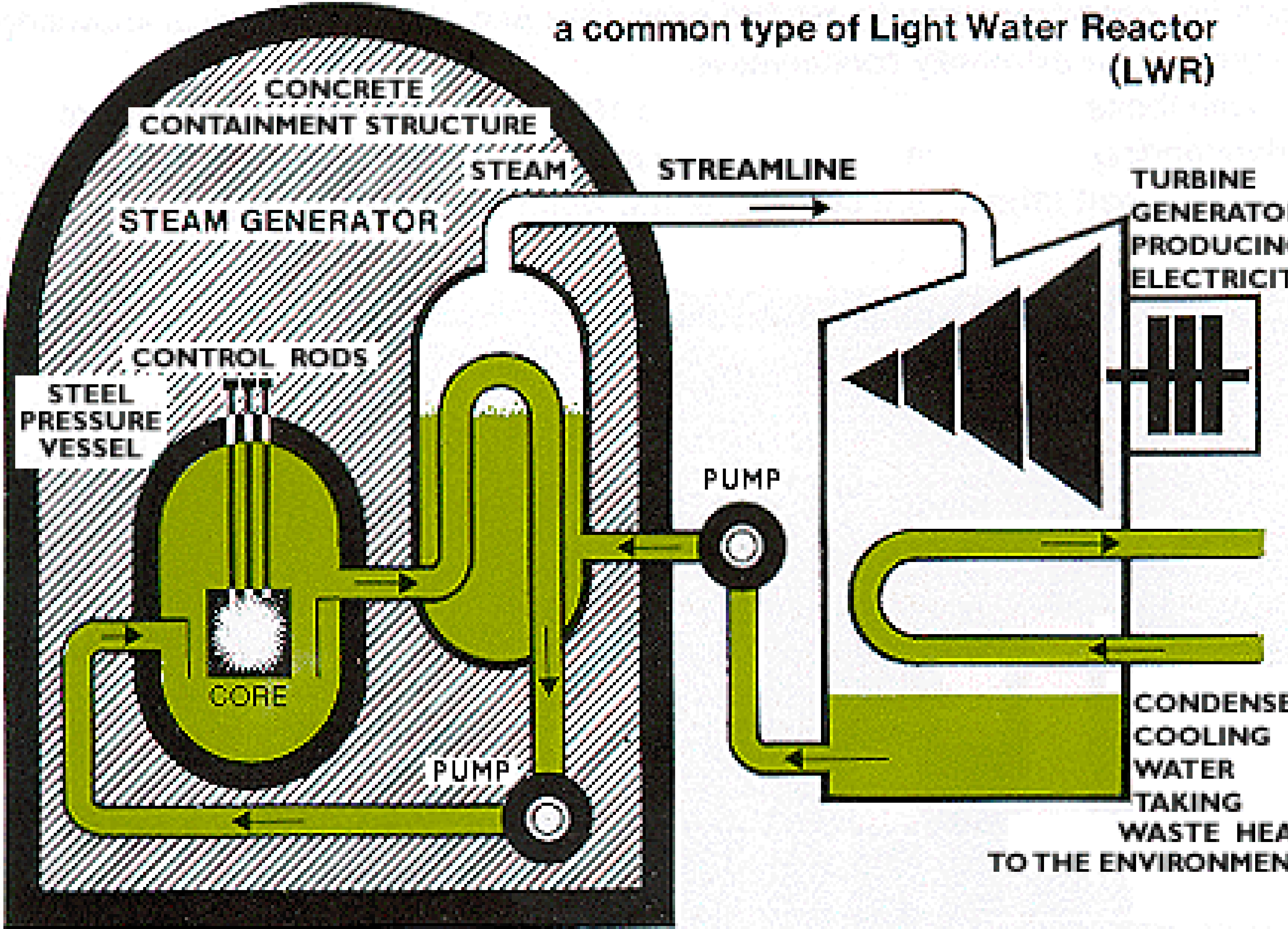
Report Of
The President's Commission On

THE ACCIDENT AT THREE MILE ISLAND



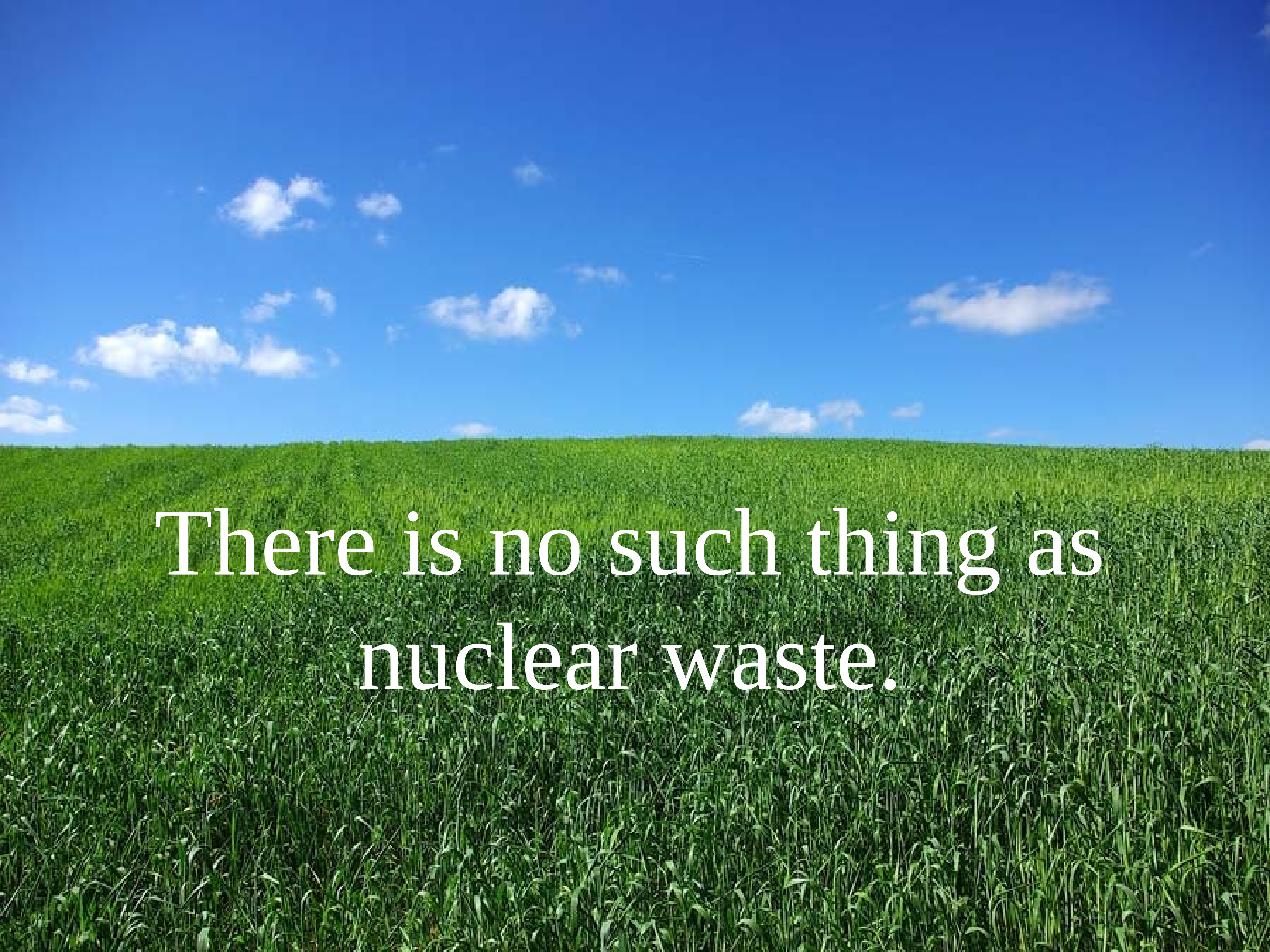
The Need For Change:
The Legacy Of TMI

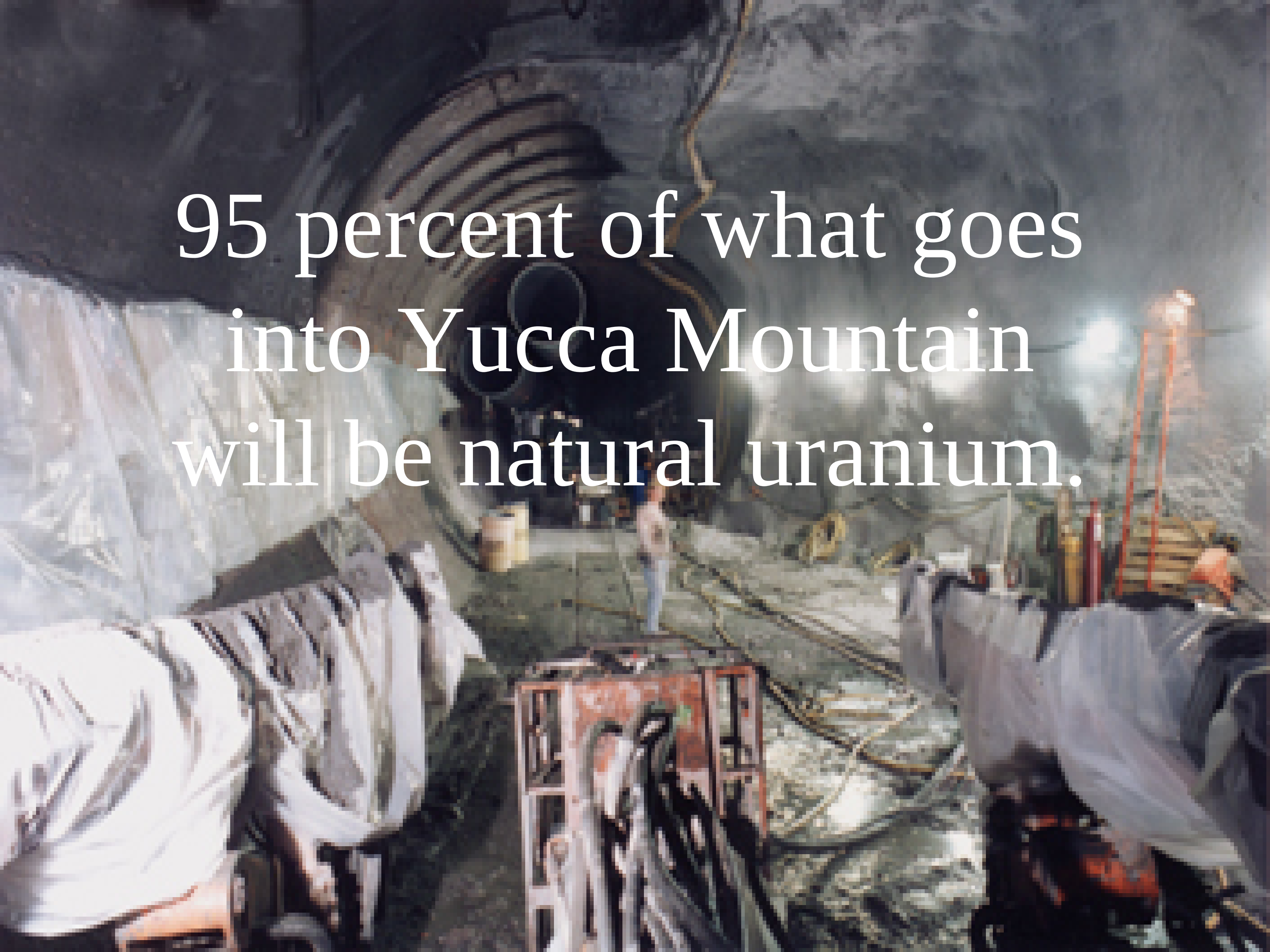
Pressurized water reactor — a common type of Light Water Reactor (LWR)



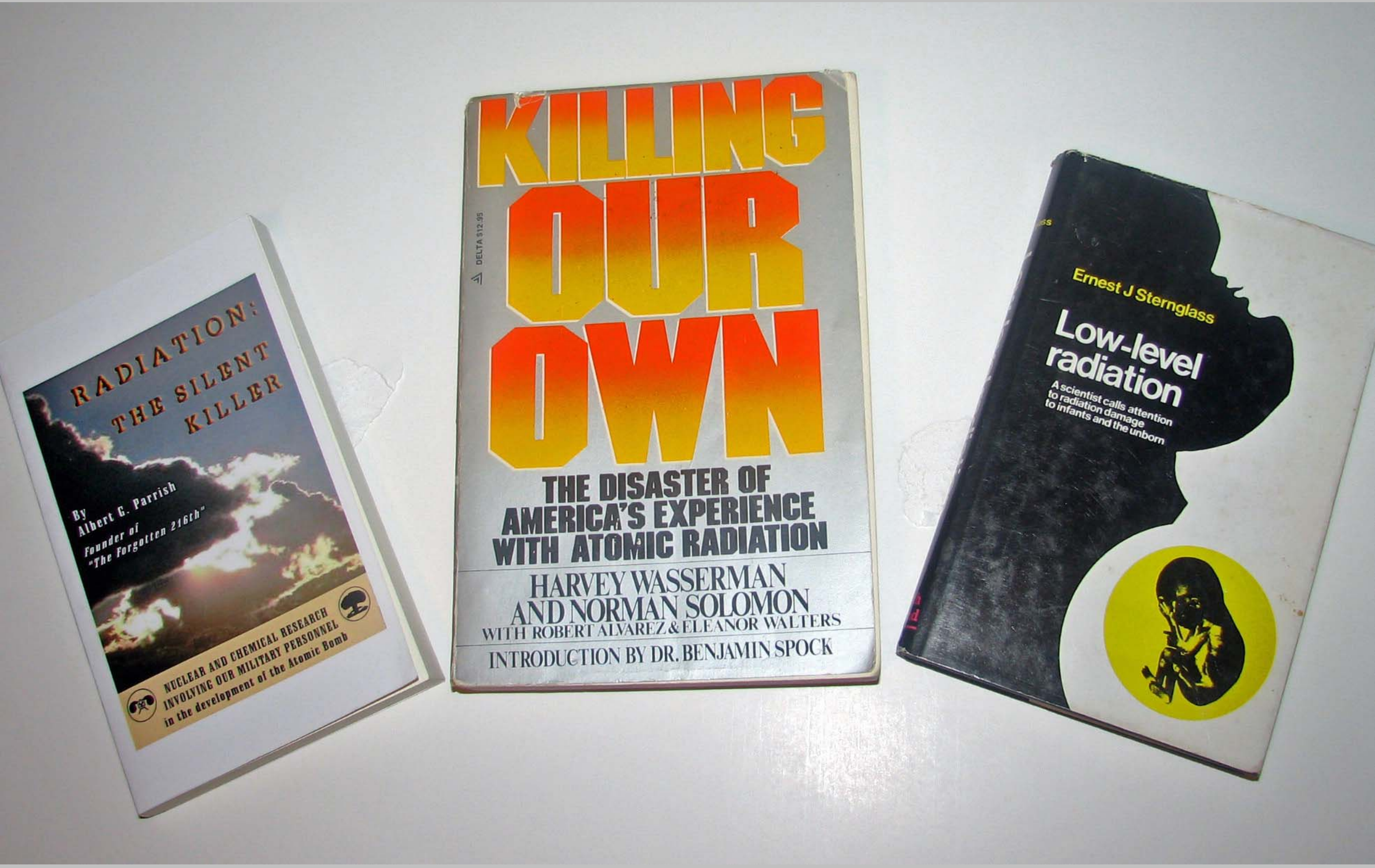

BELORUSSIA
WOLVES LAND
UKRAINE

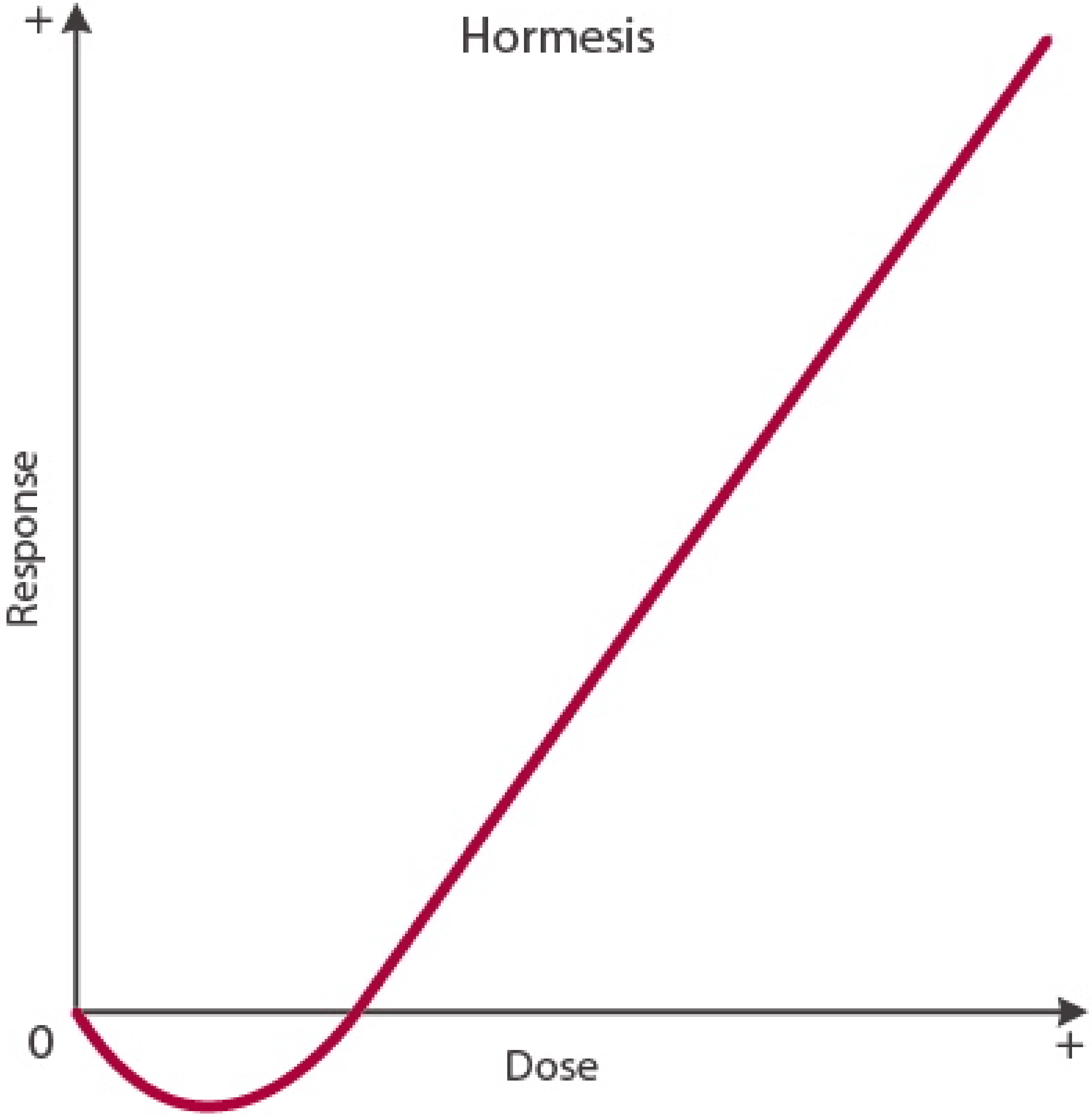
“What are we going to do with the waste?”


There is no such thing as
nuclear waste.


95 percent of what goes
into Yucca Mountain
will be natural uranium.

Hippies versus Nazis


RADIATION: THE SILENT KILLER
By Albert G. Parrish
Founder of "The Forgotten 216th"
NUCLEAR AND CHEMICAL RESEARCH INVOLVING OUR MILITARY PERSONNEL in the development of the Atomic Bomb
DELTA $12.95
KILLING OUR OWN
THE DISASTER OF AMERICA'S EXPERIENCE WITH ATOMIC RADIATION
HARVEY WASSERMAN AND NORMAN SOLOMON
WITH ROBERT ALVAREZ & ELEANOR WALTERS
INTRODUCTION BY DR. BENJAMIN SPOCK
Ernest J Sternglass
Low-level radiation
A scientist calls attention to radiation damage to infants and the unborn


Hormesis
+
Response
0
Dose
+

“Is Chronic Radiation an Effective Prophylaxis Against Cancer?”

W.L. Chen, et al. Journal of American Physicians and Surgeons, Spring 2004

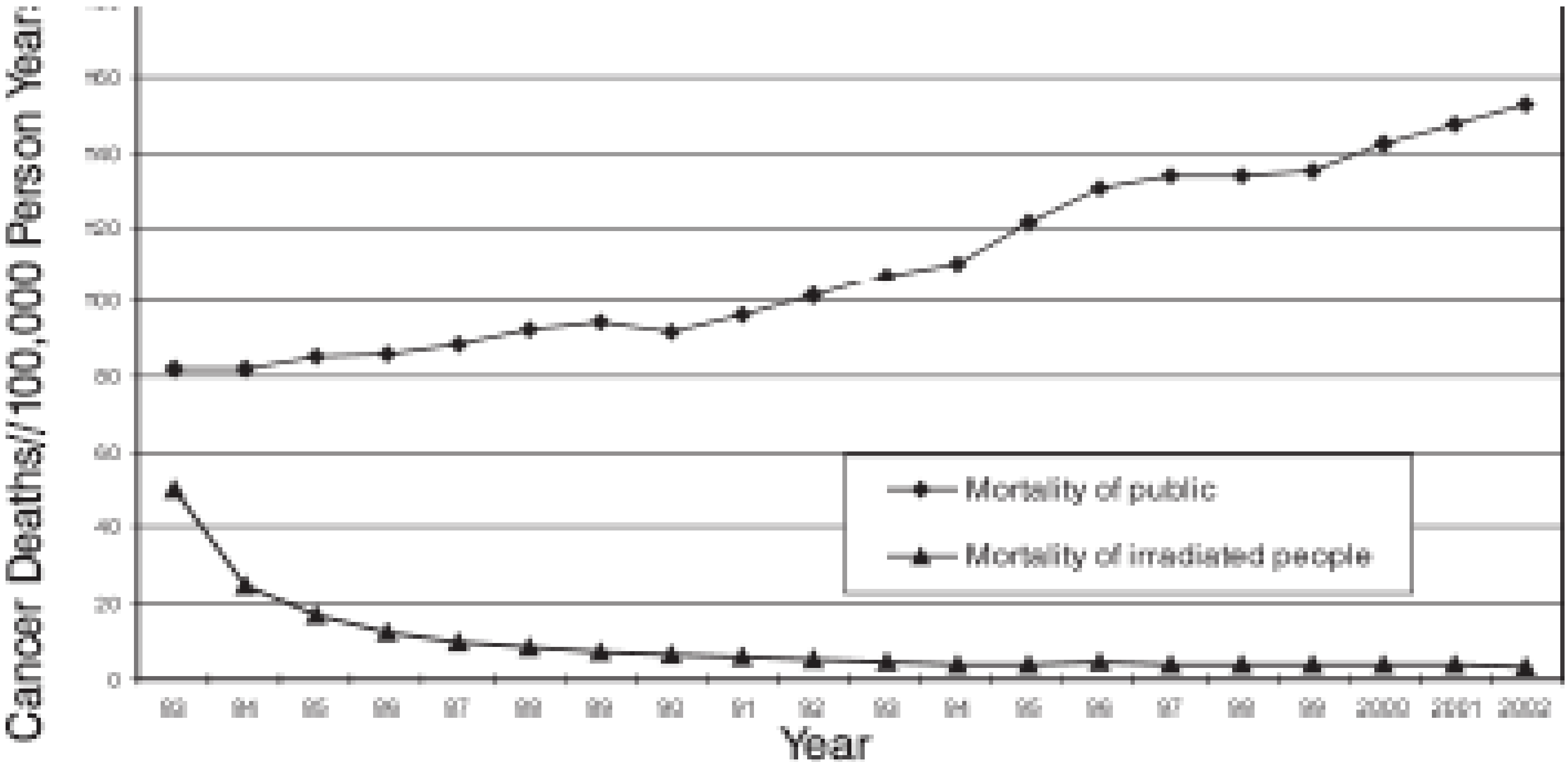
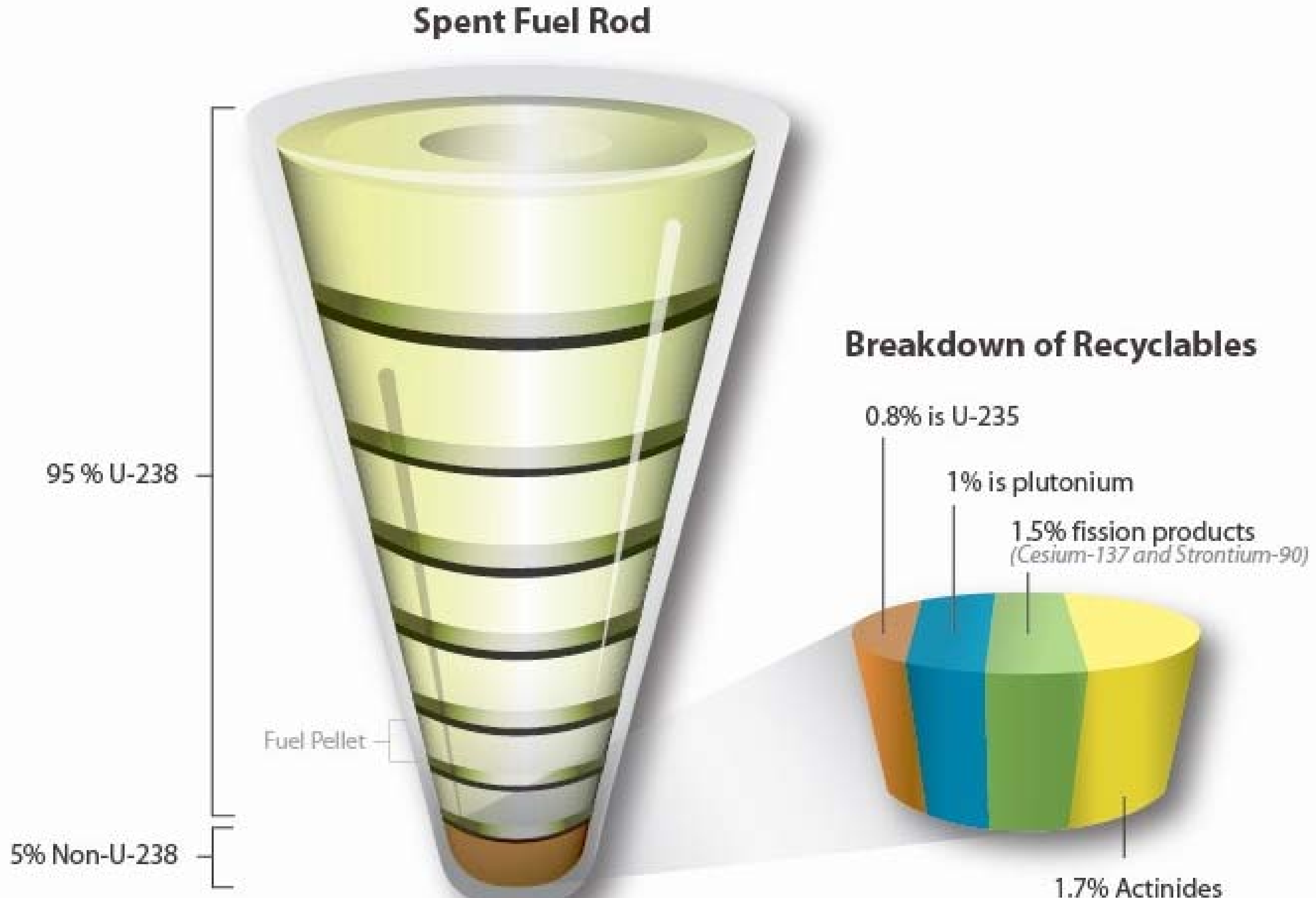
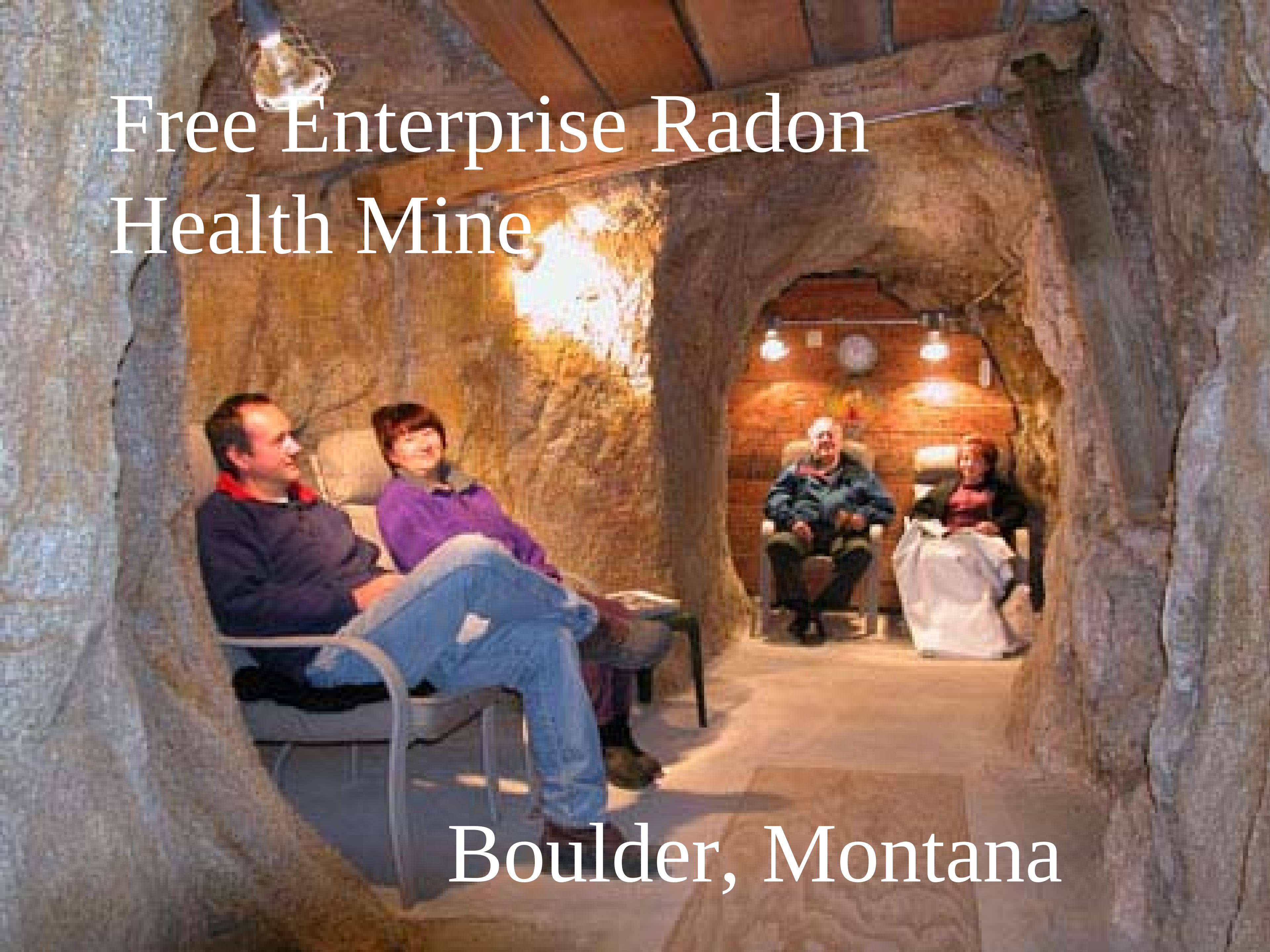


Figure 1. Cancer Mortality of the General Population and of the Exposed Population

Reprocessing reduces nuclear waste by 97 percent.




Free Enterprise Radon
Health Mine
Boulder, Montana

What are the problems with nuclear?

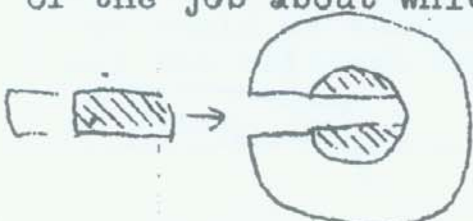
Centrifuges must run for more than a year to get bomb-grade material.

concentration of impurities in 25 may be 10^4 times that in 49 for the same background, which is not at all difficult of attainment.

To summarize: 49 will be extremely difficult to work with from the stand-point of neutron background whereas 25 without U tamper will be not very difficult.

20. Shooting

We now consider briefly the problem of the actual mechanics of shooting so that the pieces are brought together with a relative velocity of the order of 10^5 cm/sec or more. This is the part of the job about which we know least at present.



One way is to use a sphere and to shoot into it a cylindrical plug made of some active material and some tamper, as in the sketch. This avoids fancy shapes and gives the most favorable shape, for shooting; to the projected piece whose mass would be of the order of 100 lbs.

The highest muzzle velocity available in U. S. Army guns is one whose bore is 4.7 inches and whose barrel is 21 feet long. This gives a 50 lb. projectile a muzzle velocity of 3150 ft/sec. The gun weighs 5 tons. It appears that the ratio of projectile mass to gun mass is about constant for different guns so a 100 lb. projectile would require a gun weighing about 10 tons.

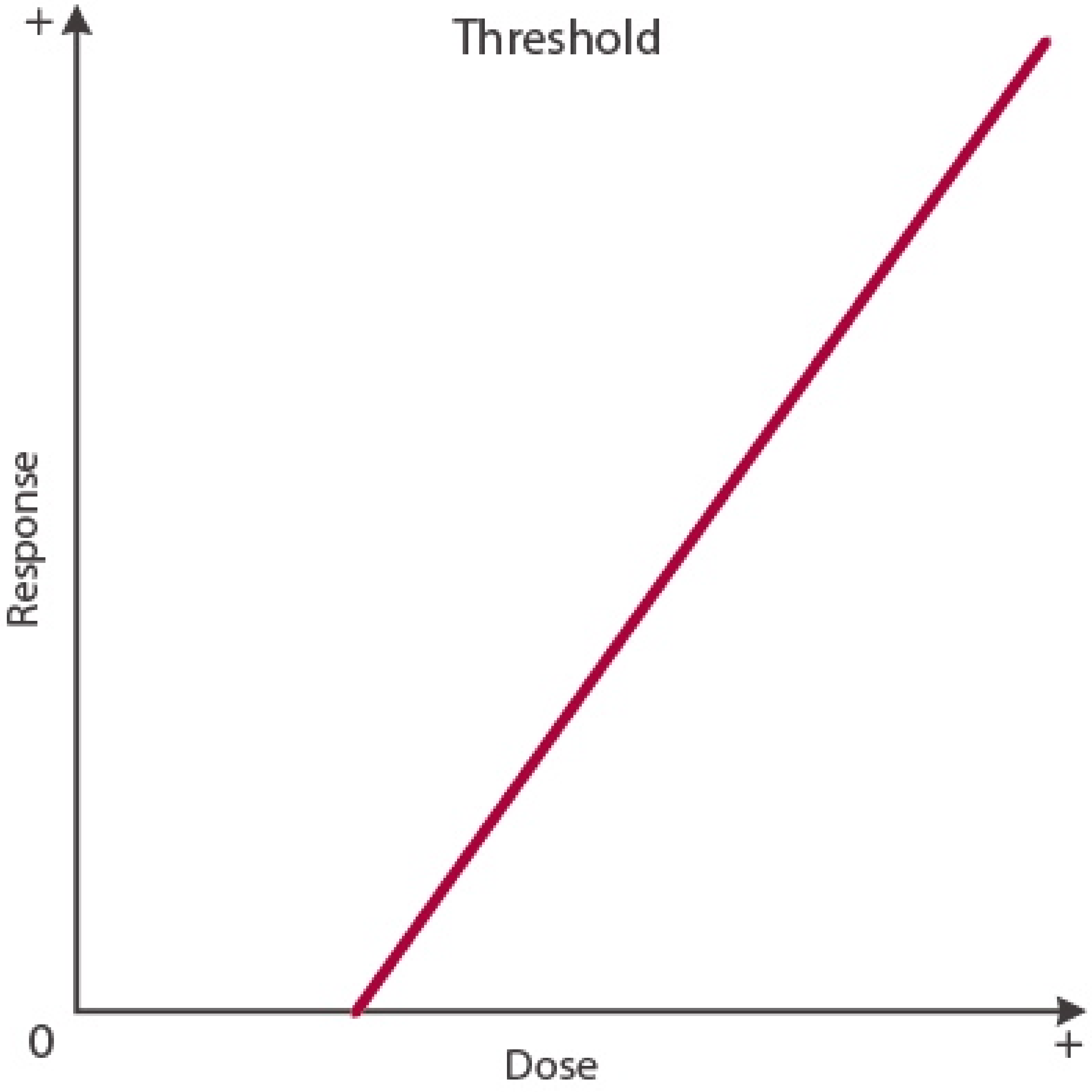
The weight of the gun varies very roughly as the cube of the muzzle velocity hence there is a high premium on using lower velocities of fire.

There is no safe dose of radiation.

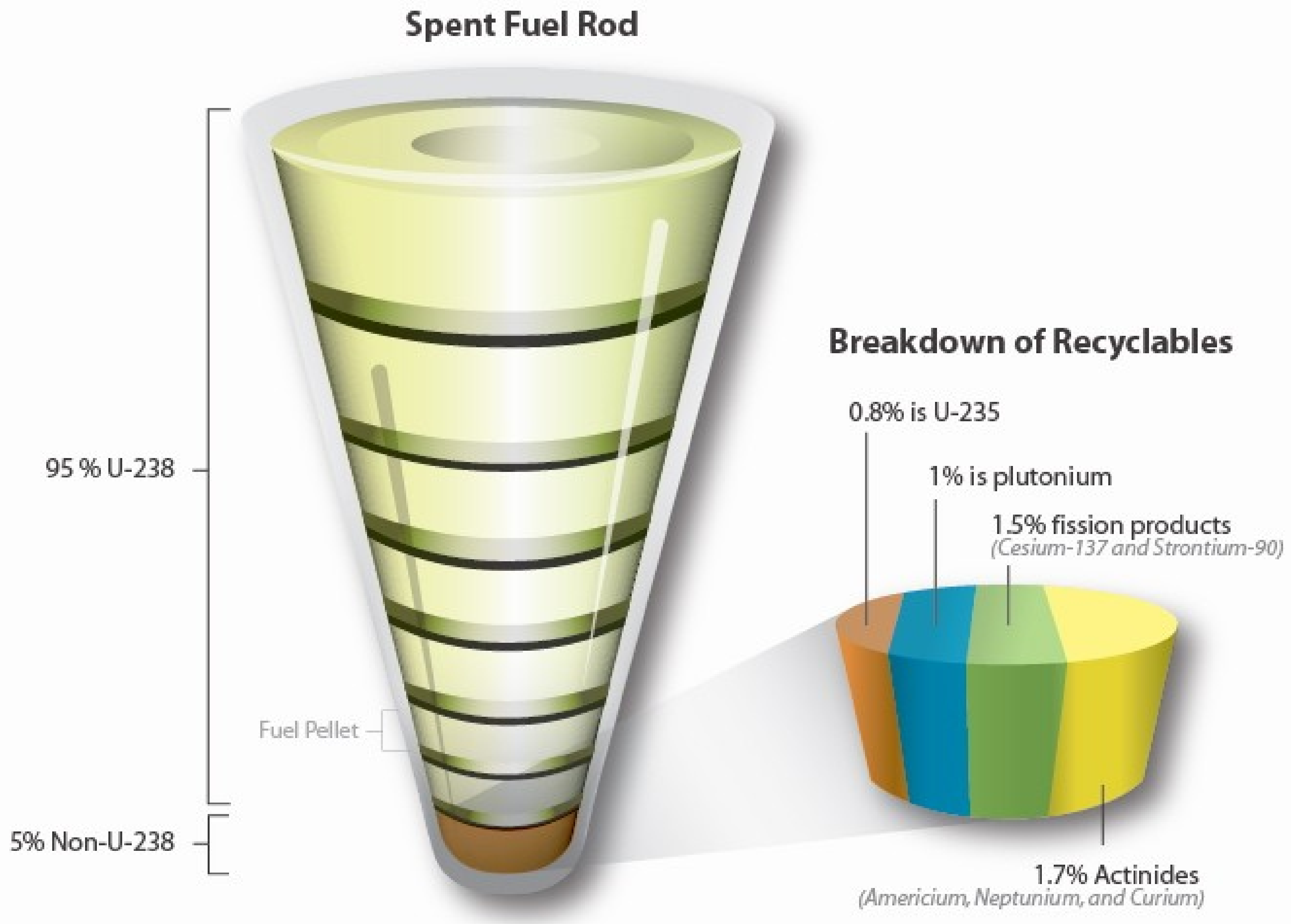
Radiation

(not invented in 1946)


No Safe Dose
+
Response
0
Dose
+

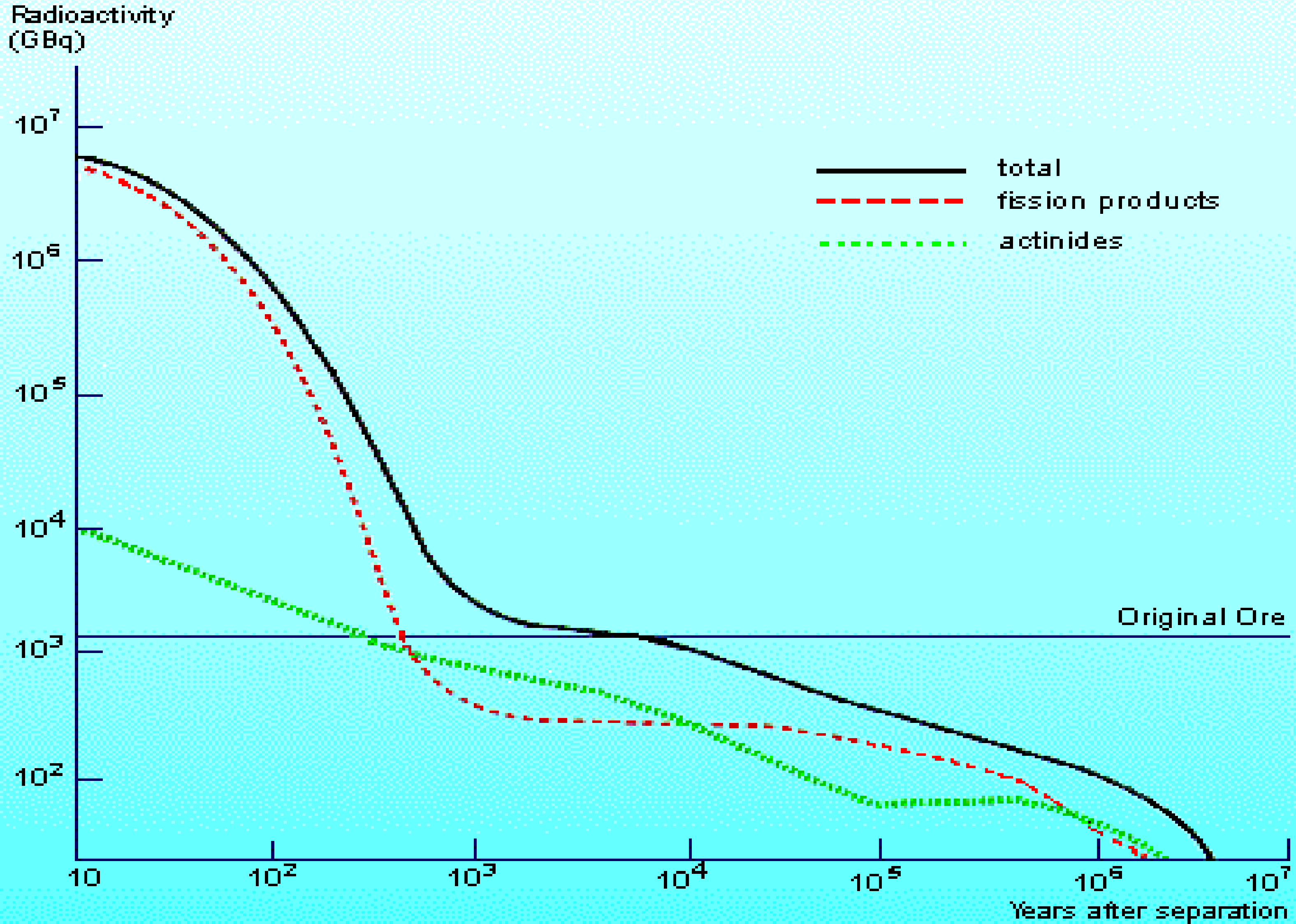

Threshold
+
Response
0
Dose
+

“What are we going to do with the waste?”


Spent Fuel Rod
95 % U-238
Fuel Pellet
5% Non-U-238
Breakdown of Recyclables
0.8% is U-235
1% is plutonium
1.5% fission products
(Cesium-137 and Strontium-90)
1.7% Actinides
(Americium, Neptunium, and Curium)

Decay in radioactivity of high-level waste

from reprocessing one tonne of spent PWR fuel

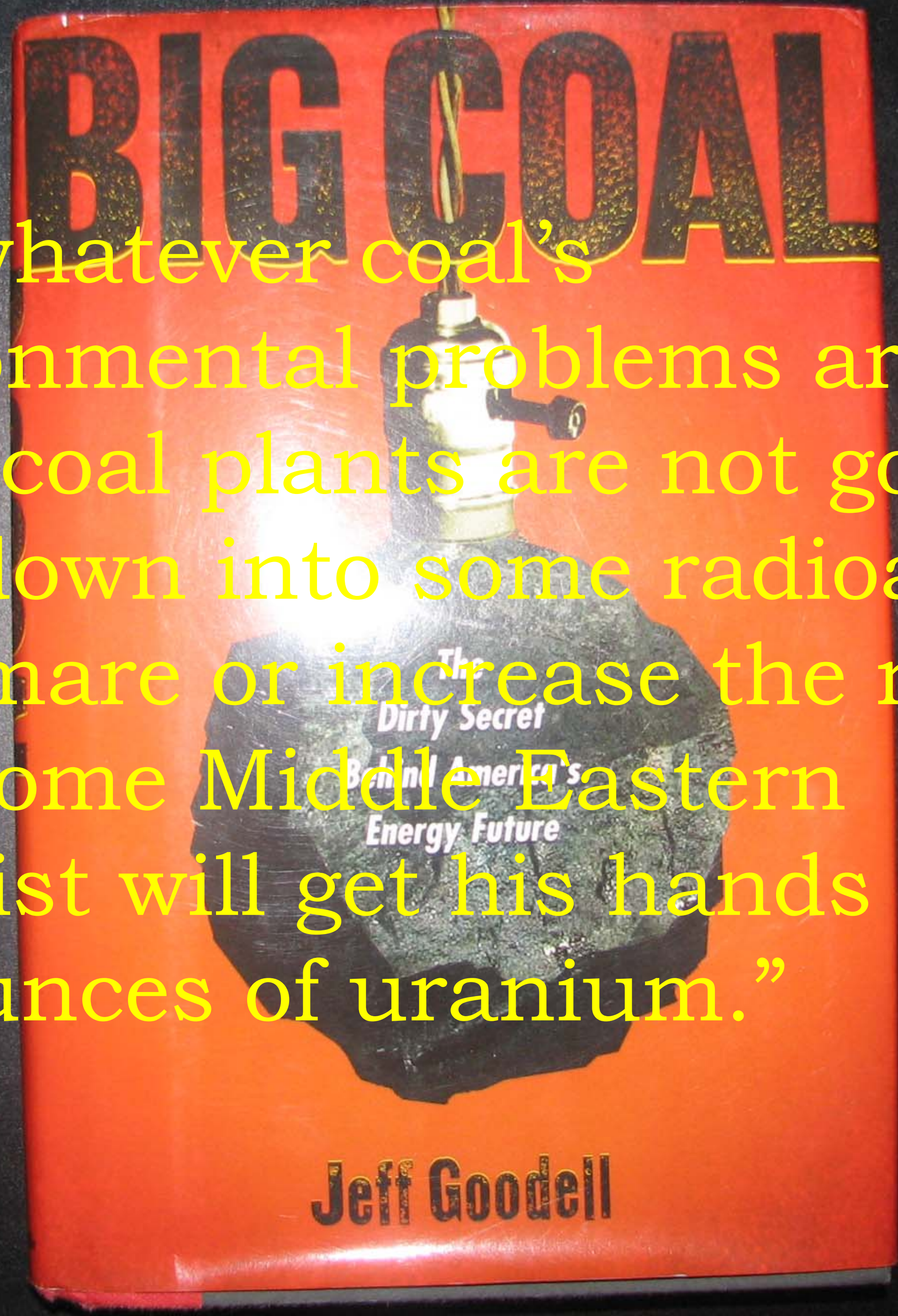


Gbq = 10^9 becquerel
The straight line shows the radioactivity of the corresponding amount of uranium ore.
NB both scales are logarithmic.
Source: OECD NEA 1996, *Radioactive Waste Management in Perspective*.


Nuclear France:
materials and sites
MARY BYRD DAVIS

Hippies versus Nazis

“. . . whatever coal’s environmental problems are, at least coal plants are not going to melt down into some radioactive nightmare or increase the risk that some Middle Eastern terrorist will get his hands on a few ounces of uranium.”




Nuclear’s biggest supporter.

Reactors Prone to Long Closings, Study Finds

By MATTHEW L. WALD

WASHINGTON, Sept. 17 — An analysis of nuclear reactors by a safety group has found that they are prone to costly, lengthy shutdowns for safety problems regardless of their age or the experience of their managers. The finding could have implications for companies considering building new reactors.

The analysis, by David Lochbaum, a nuclear engineer at the Union of Concerned Scientists, counted 51 times that a reactor had been closed for a year or more. Thirty-six of those shutdowns were to restore an adequate level of safety by fixing flaws in equipment, procedures or training; 11 were to replace major components required for operations and safety; and 4 were for damage recovery. In all, of the 130 power reactors ever licensed, 41, were closed for at least a year. Ten were closed twice.

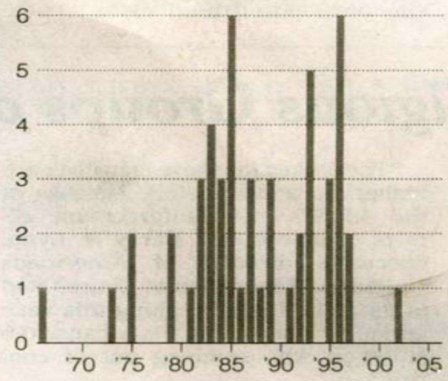
Mr. Lochbaum said the most common reason for a shutdown was for an "attitude adjustment" for workers and managers, so they would be more attuned to safety. He said he was surprised by some of his findings, which are scheduled to be released Monday. "I expected that the first plant off an assembly line would have been challenged, or troubled, but that there was a learning curve, and the fourth or fifth or sixth plant for a company would have avoided these problems," he said. "But it wasn't the case."

But a vice president of the industry's trade association, Marvin Fertell of the Nuclear Energy Institute, said that the industry had, in fact, learned from its errors, and that only experienced operators would build new plants. And at the Nuclear Regulatory Commission, Stuart A. Richards, deputy director of the division of inspection, said his agency had improved its inspections, to focus on "risk-significant areas," and was now able to find problems more promptly.

Extended shutdowns would be a bigger problem for future plants be-

Reactors on Ice

Number of nuclear reactors shut down for more than a year, plotted by the year the shutdown began.



Source: Union of Concerned Scientists

The New York Times

shutdown.

"This is the wrong way to do business, from a safety standpoint and an economic standpoint," he said in a telephone interview.

Mr. Fertell, of the industry trade group, agreed.

The only reactor currently in an extended shutdown is the Tennessee Valley Authority's Browns Ferry Unit 1, in Alabama. It last ran in 1985. The shutdown of more than a year that ended most recently was at Davis-Besse, near Toledo, Ohio, where workers found that an acid used in

Persistent safety problems are found at nuclear plants of every age.

the plant, boron, had corroded a 70-

gineers later found that crucial pumps that used water for lubrication were prone to break down because of debris in the water. Discovery of decades-old design problems is common during lengthy shutdowns.

While Mr. Lochbaum, a longtime adversary of the nuclear industry, is often critical of the companies that operate reactors, he said regulators were the problem in this area. The rules require reactors to have Corrective Action Programs to keep track of physical and procedural problems, and each lengthy shutdown is an indication that the program itself is flawed, he said. Regulators monitor the physical condition of reactors, he said, but are not good at observing the quality of the corrective programs. For example, the commission gave high marks to the program at Davis-Besse less than a year before inspectors found that operators had let acid eat through six inches of steel, bringing the plant close to a catastrophic rupture.

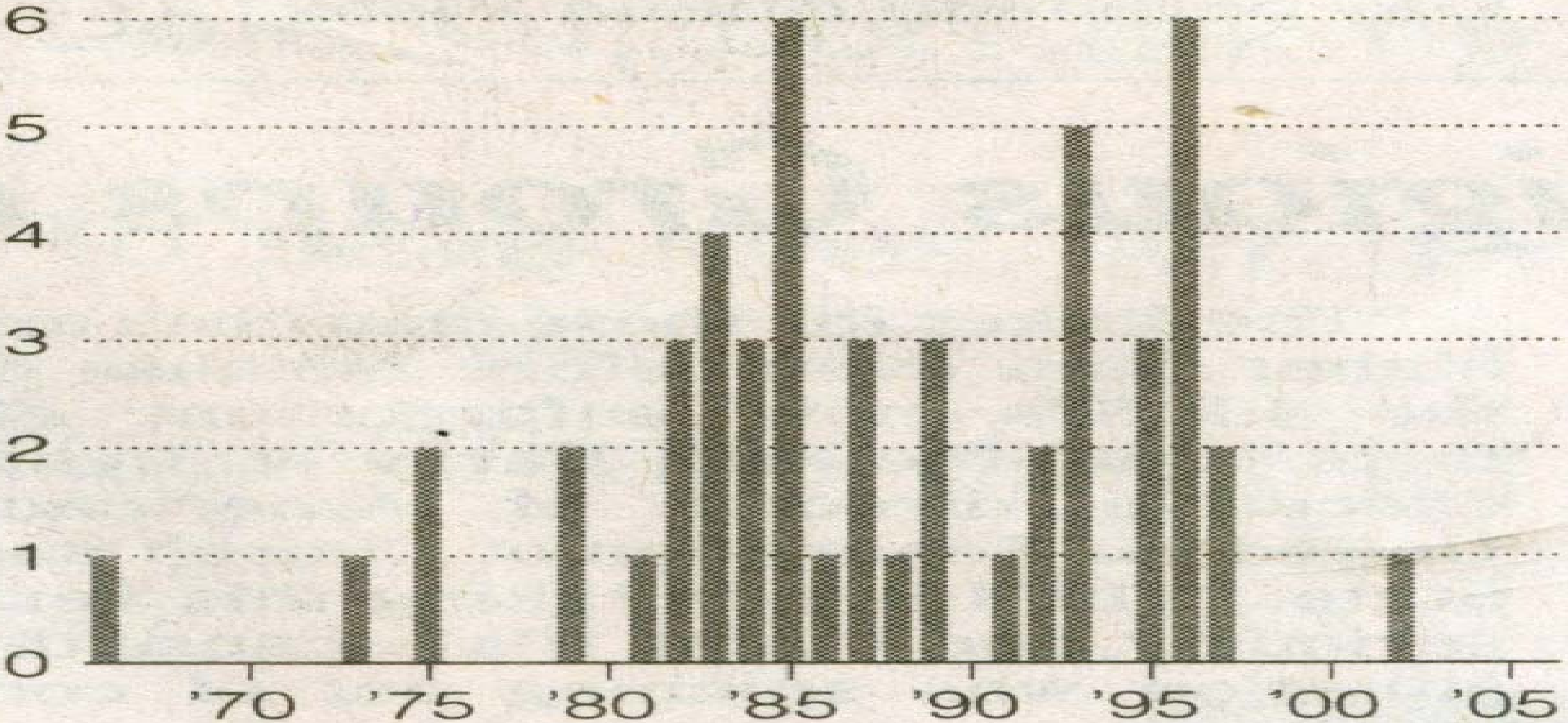
Mr. Richards said he had not seen the report but acknowledged errors by the commission in handling the Davis-Besse case. But he said N.R.C. inspections had been improved using a new process, of which the Corrective Action Program itself was a major component. And, he said, the commission had previously penalized reactors for accumulations of minor violations, adding them up to count for a major problem; now it focuses only on major problems.

Mr. Lochbaum said that after a reactor was shut down for one reason, other problems were often discovered. In an extended shutdown at the Crystal River plant, in Florida, workers found design defects even though the plant had been running for nearly 20 years. He said the problems included that, in an emergency, the pumps would not have worked as intended and piping would have exposed workers and the public to radiation.

"Did the plant's owner bring in

Reactors on Ice

Number of nuclear reactors shut down for more than a year, plotted by the year the shutdown began.



Source: Union of Concerned Scientists

The New York Times

Entergy®
THE POWER OF PEOPLE™

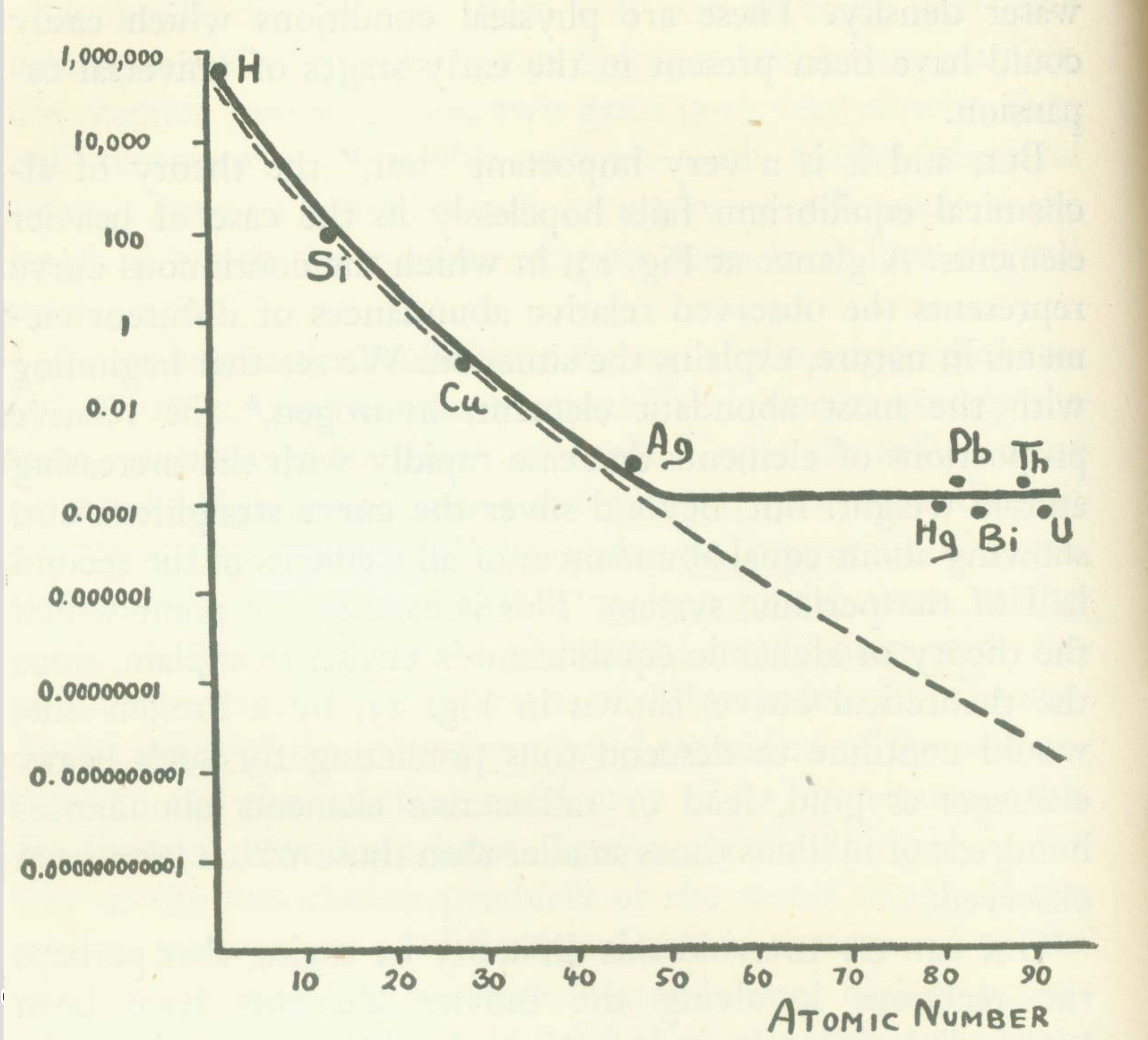
Duke Energy®

Progress Energy

Dominion®
It all starts here.®

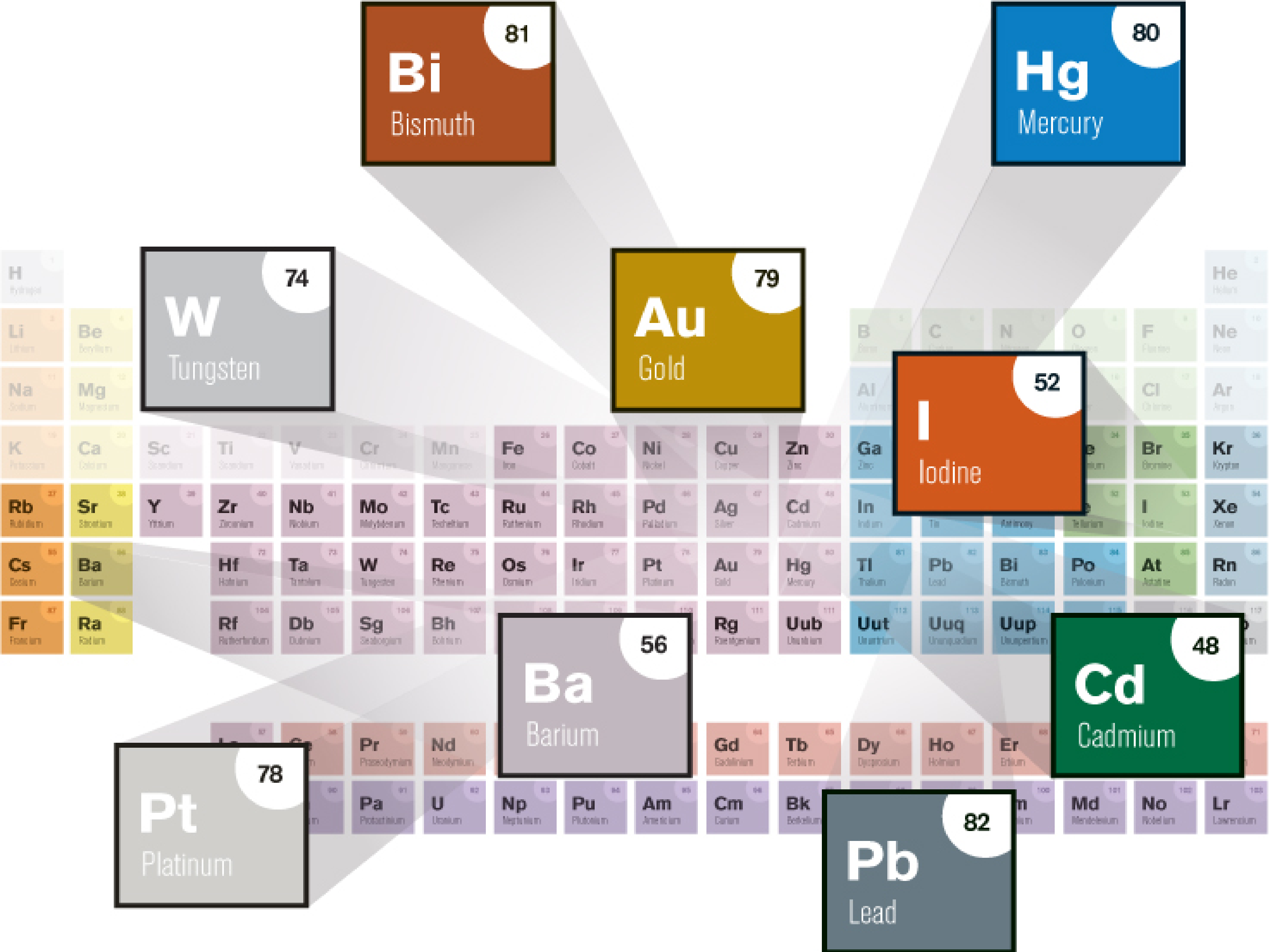
Exelon®

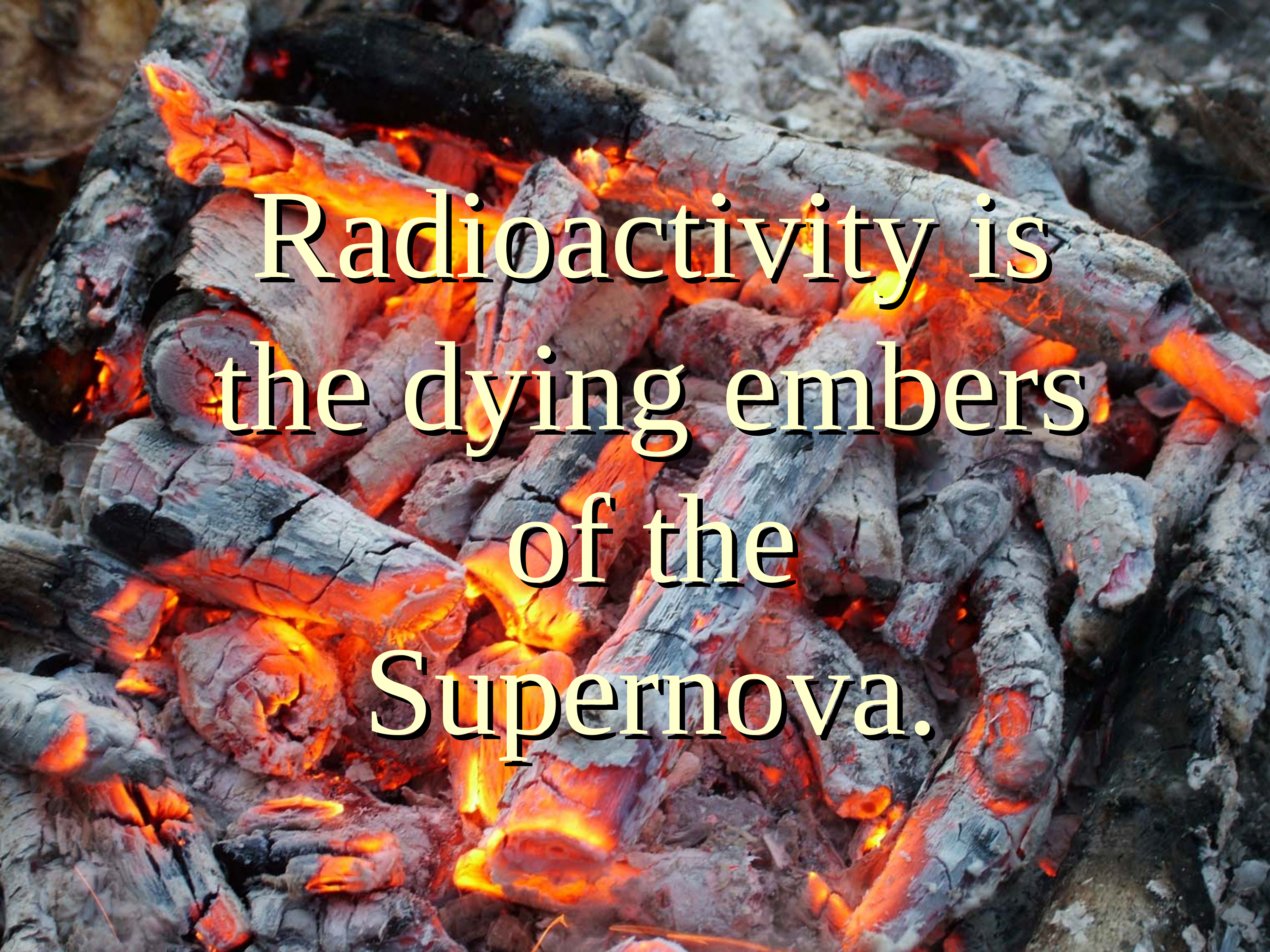
Where does all this energy come from?


1,000,000
10,000
100
1
0.01
0.0001
0.000001
0.00000001
0.0000000001
0.000000000001
H
Si
Cu
Ag
Pb
Th
Hg
Bi
U
10
20
30
40
50
60
70
80
90
ATOMIC NUMBER

Supernova!

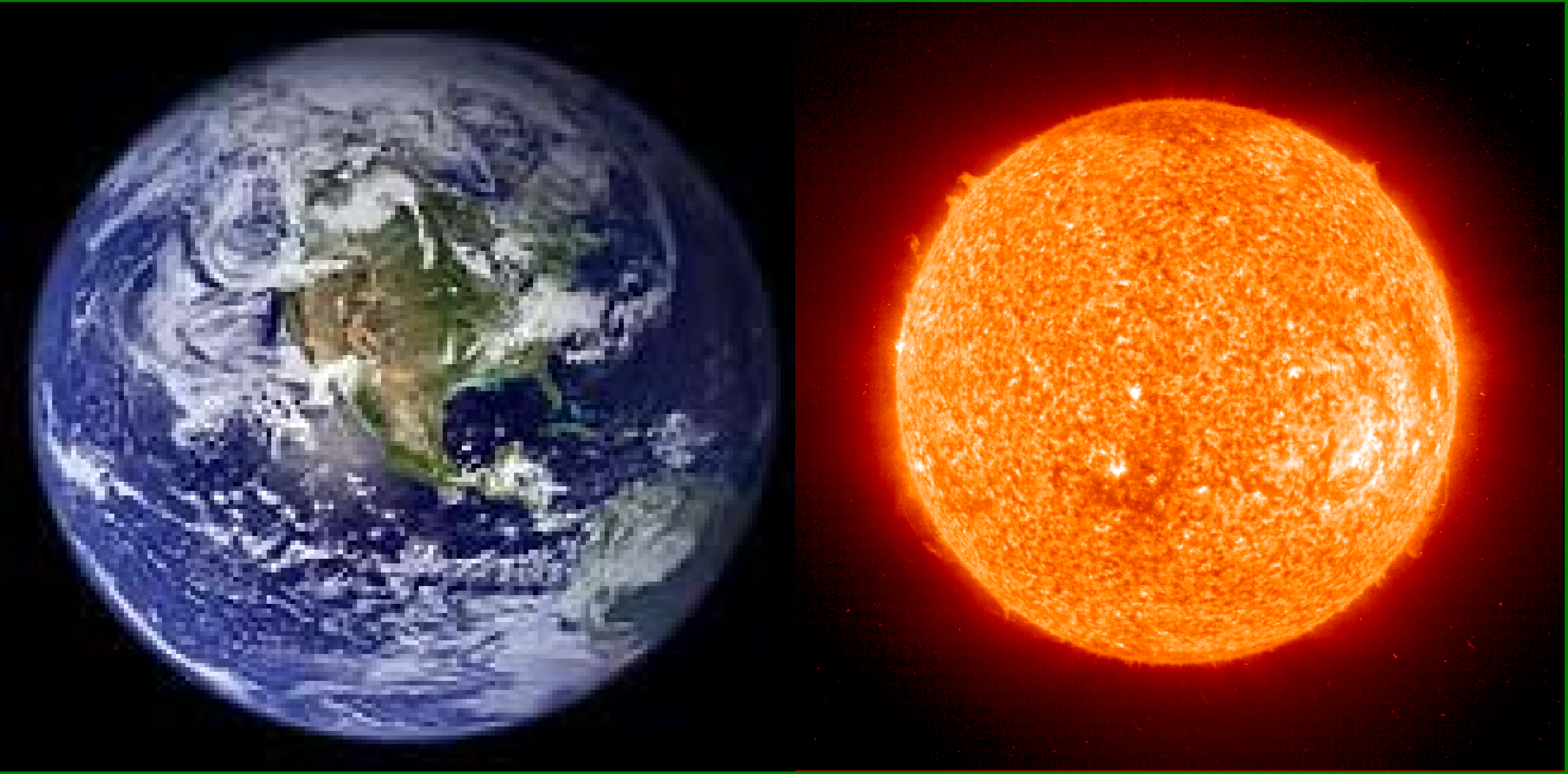
The seeds of our solar system.


81 Bi Bismuth
80 Hg Mercury
74 W Tungsten
79 Au Gold
52 I Iodine
56 Ba Barium
48 Cd Cadmium
78 Pt Platinum
82 Pb Lead



Radioactivity is the dying embers of the Supernova.

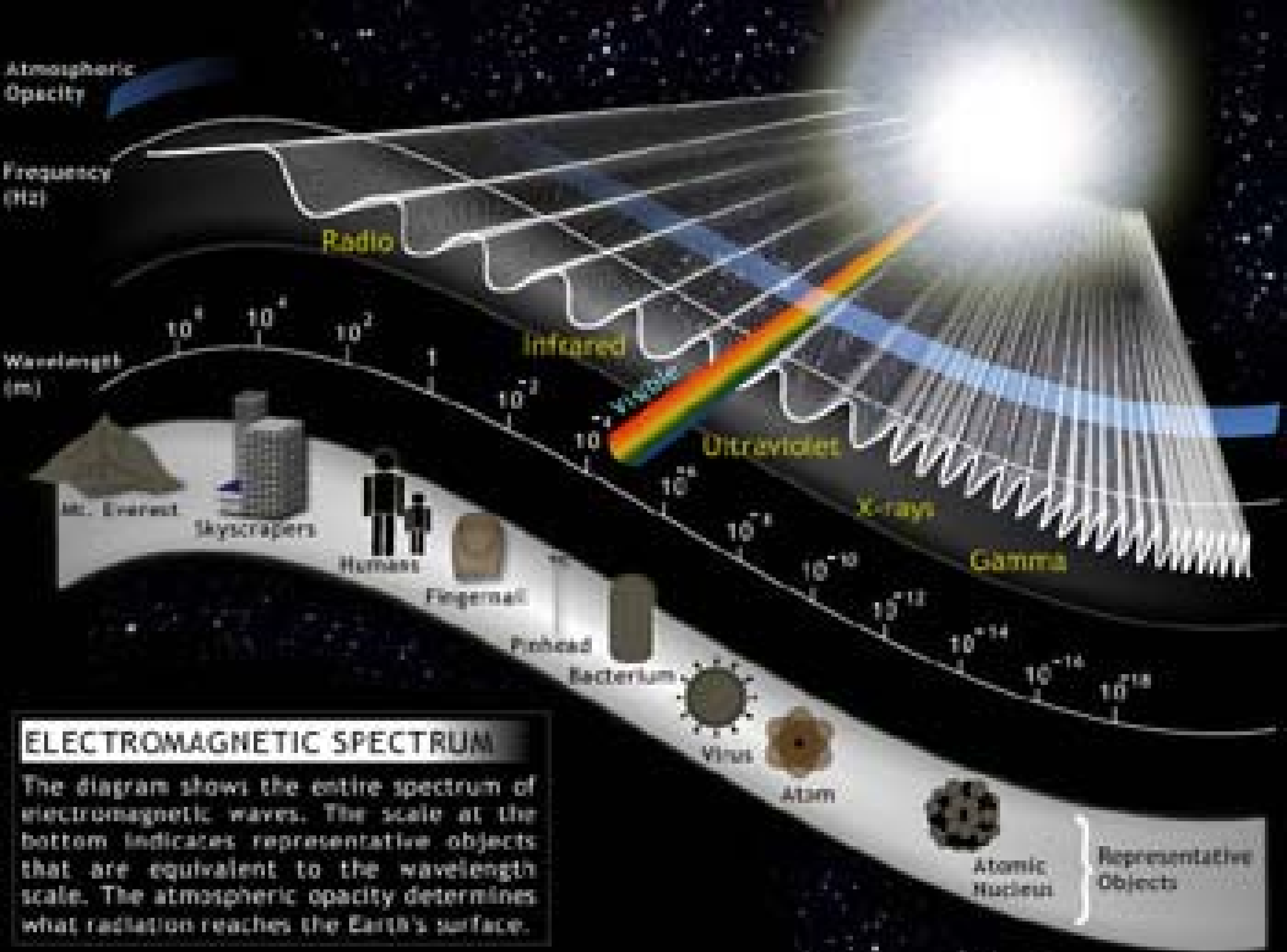
The Marriage of Heaven and Earth



Energy for the 21st Century.

•

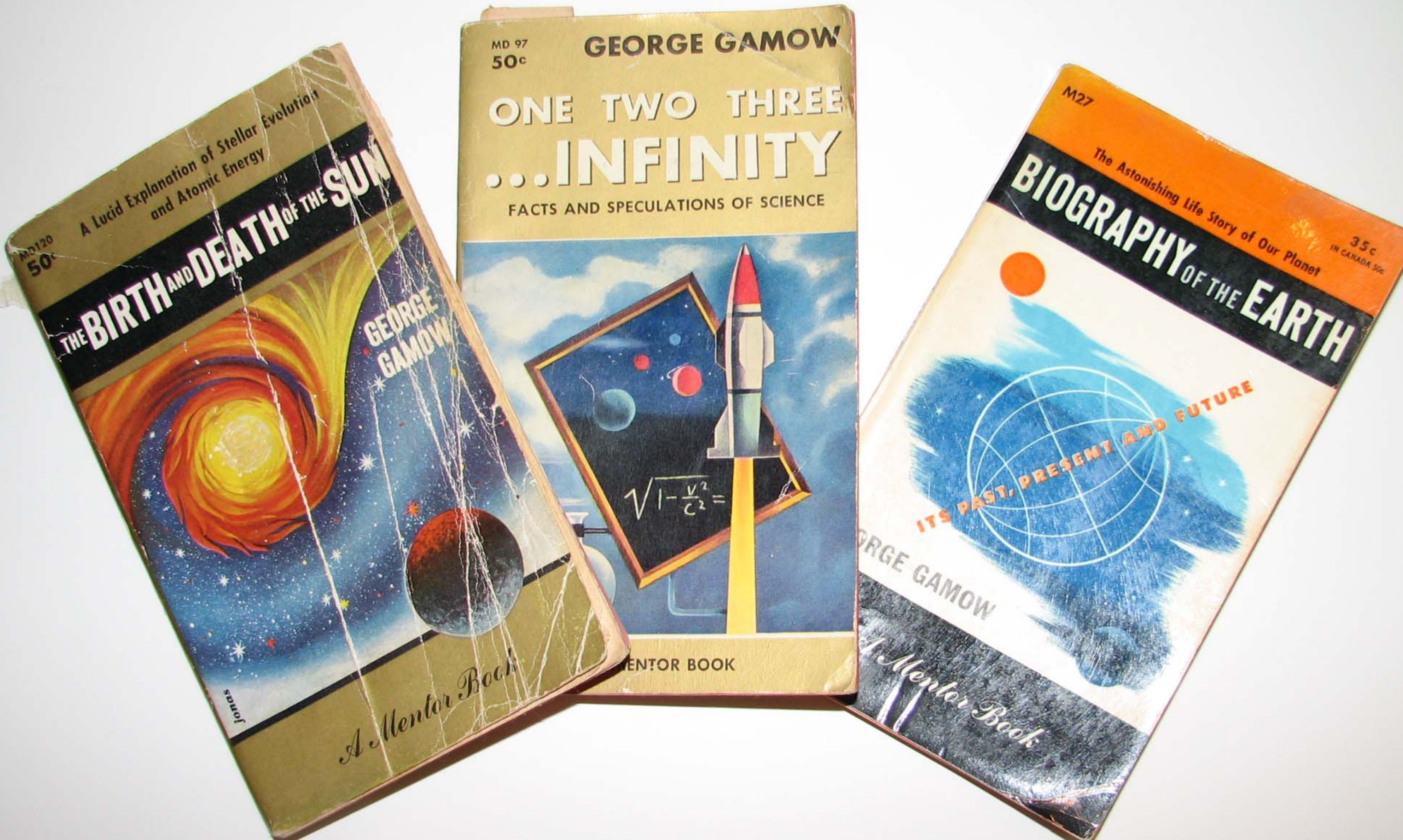
Following slides are excess

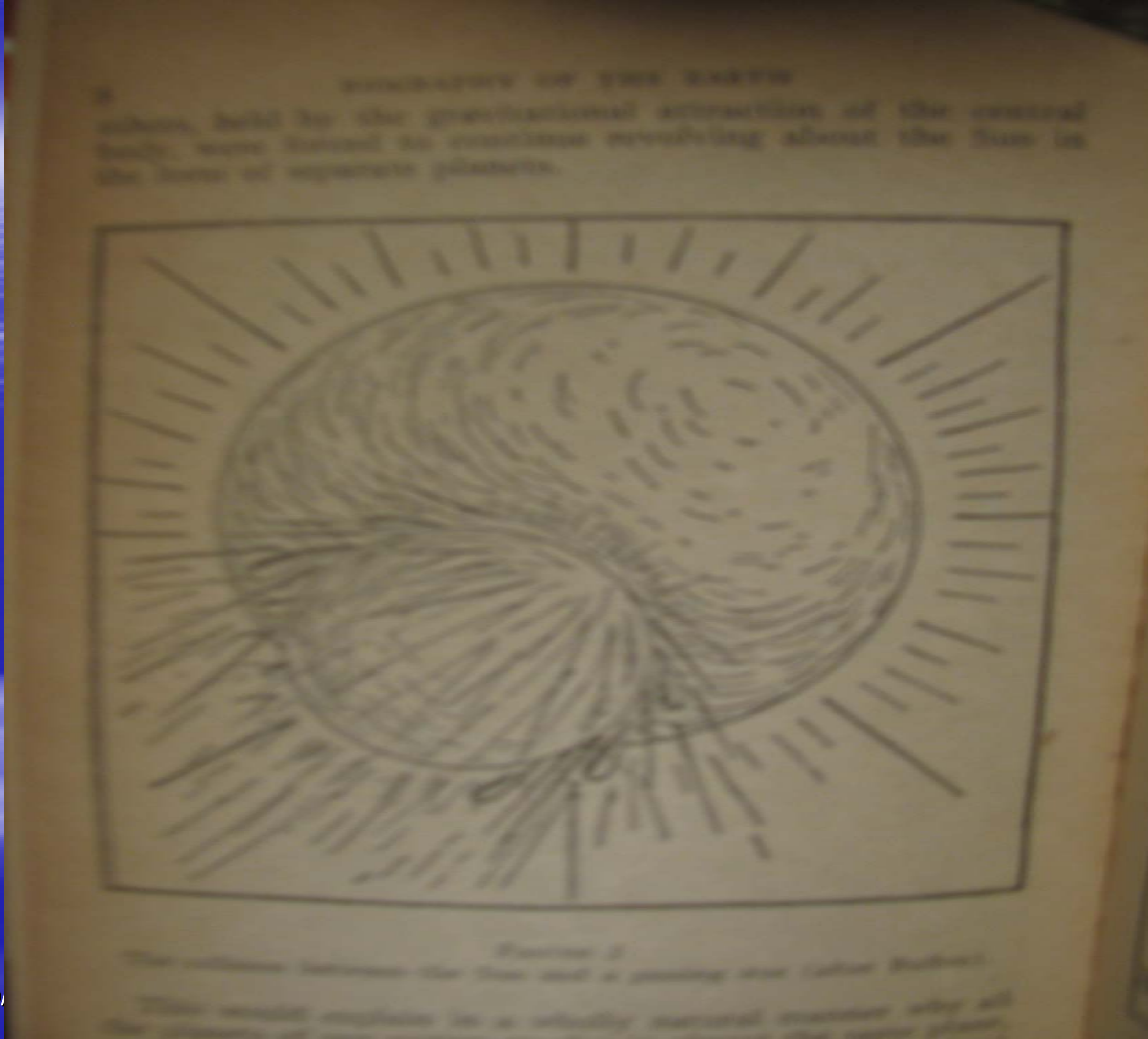

Atmospheric Opacity
Frequency (Hz)
Radio
Infrared
Visible
Ultraviolet
X-rays
Gamma
Wavelength (m)
Mt. Everest
Skyscrapers
Humans
Fingernail
Pinhead
Bacterium
Virus
Atom
Atomic Nucleus
Representative Objects
ELECTROMAGNETIC SPECTRUM
The diagram shows the entire spectrum of electromagnetic waves. The scale at the bottom indicates representative objects that are equivalent to the wavelength scale. The atmospheric opacity determines what radiation reaches the Earth's surface.

$$E = mc^2$$

$$E = \frac{1}{2} mv^2$$

George Gamow, 1904-1968


MD120
50¢
A Lucid Explanation of Stellar Evolution and Atomic Energy
THE BIRTH AND DEATH OF THE SUN
GEORGE GAMOW
jonas
A Mentor Book
MD 97
50¢
GEORGE GAMOW
ONE TWO THREE ...INFINITY
FACTS AND SPECULATIONS OF SCIENCE
ENTOR BOOK
M27
The Astonishing Life Story of Our Planet
35¢
IN CANADA 50¢
BIOGRAPHY OF THE EARTH
ITS PAST, PRESENT AND FUTURE
RGE GAMOW
A Mentor Book



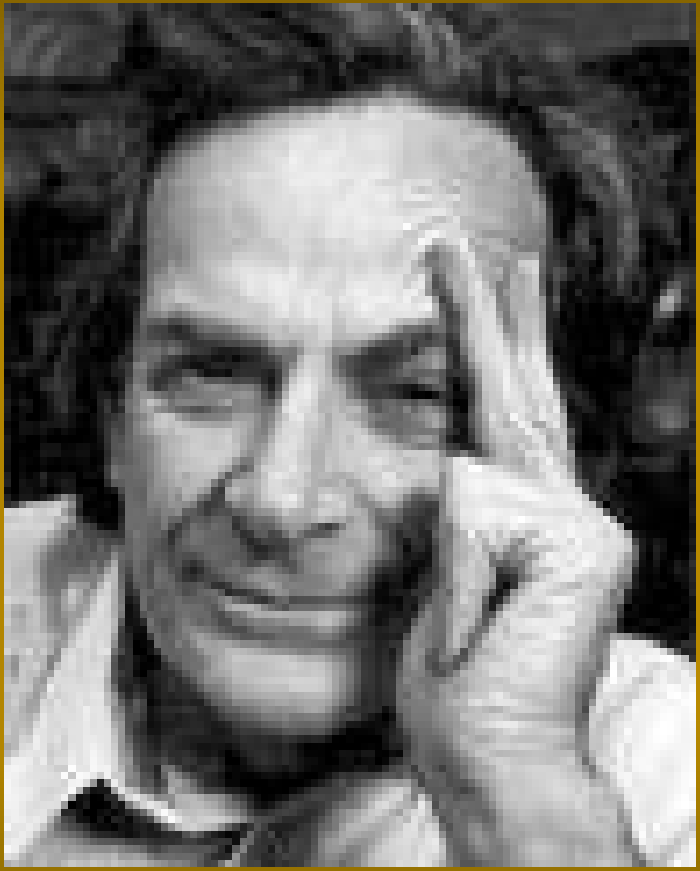
Room temperature ~ 1/40th electron-volt

Photon ~ 1.77- 3.10 electron-volts

Chemical bonds ~ 1 electron-volt

When matter is completely transformed into energy it becomes . . .

Richard Feynman - 1918 - 1988



"There's Plenty of Room at the Bottom."

December 29, 1959

50 mph = 74 feet/sec

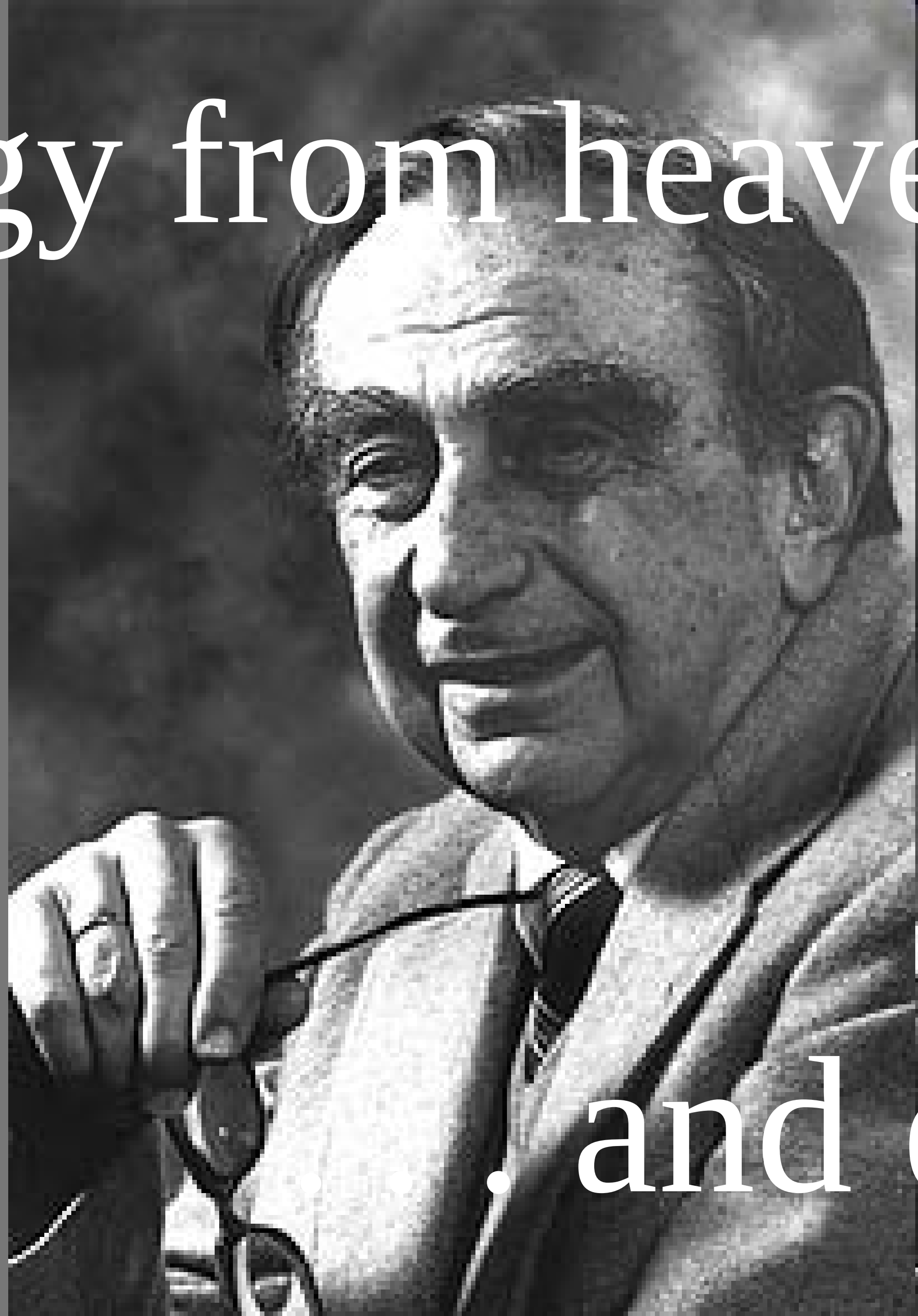
5.4×10^{3} feet/sec^{2}

186,000 miles/sec

9.8×10^{17} feet/sec^{2}

Factor of 180 quintillion

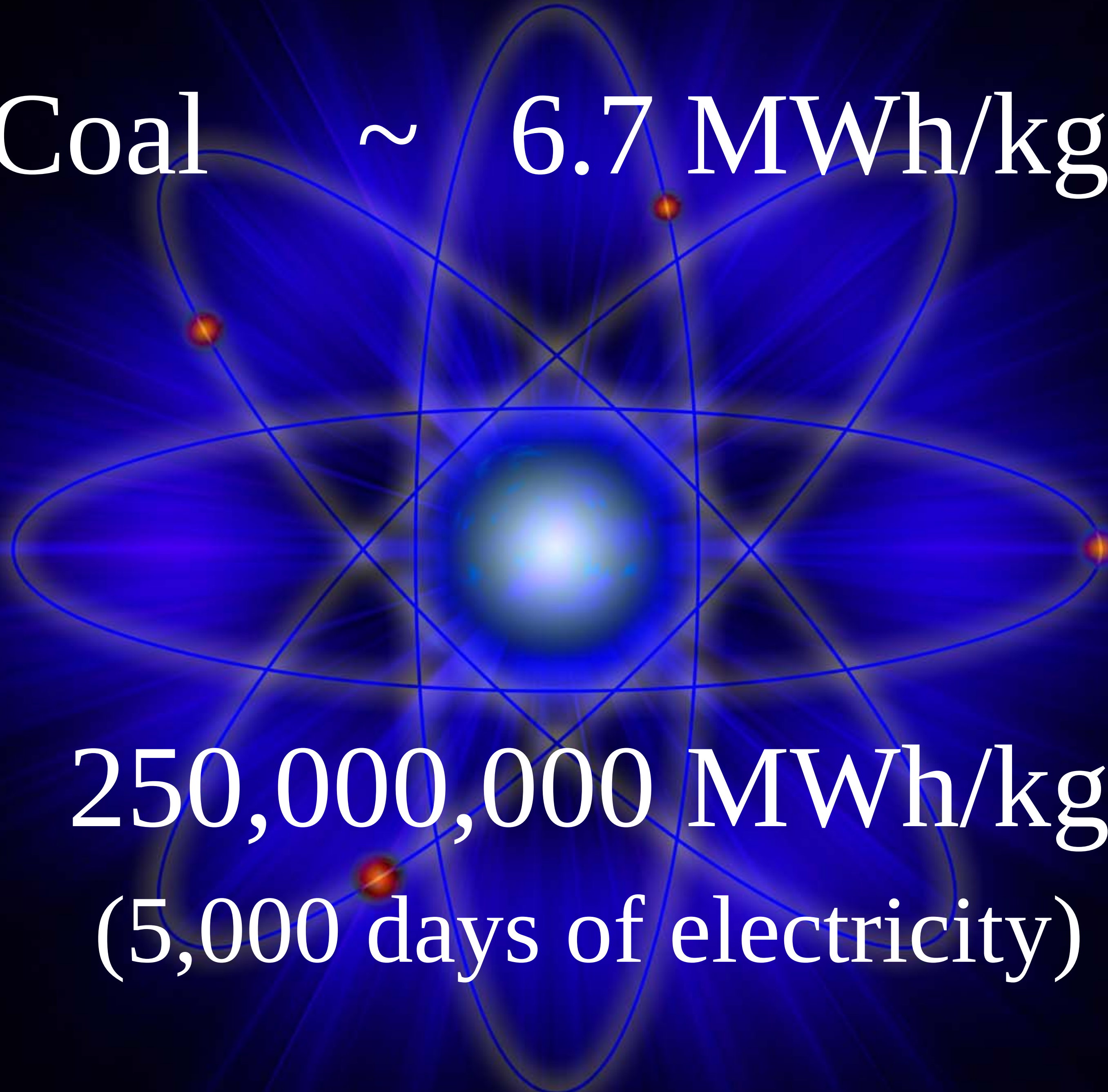
Energy from heaven . . .



. . . . and earth.


A World Lit
Only By Fire . . .


Things have changed . . .
. since the industrial revolution.



Coal ~ 6.7 MWh/kg

250,000,000 MWh/kg

(5,000 days of electricity)

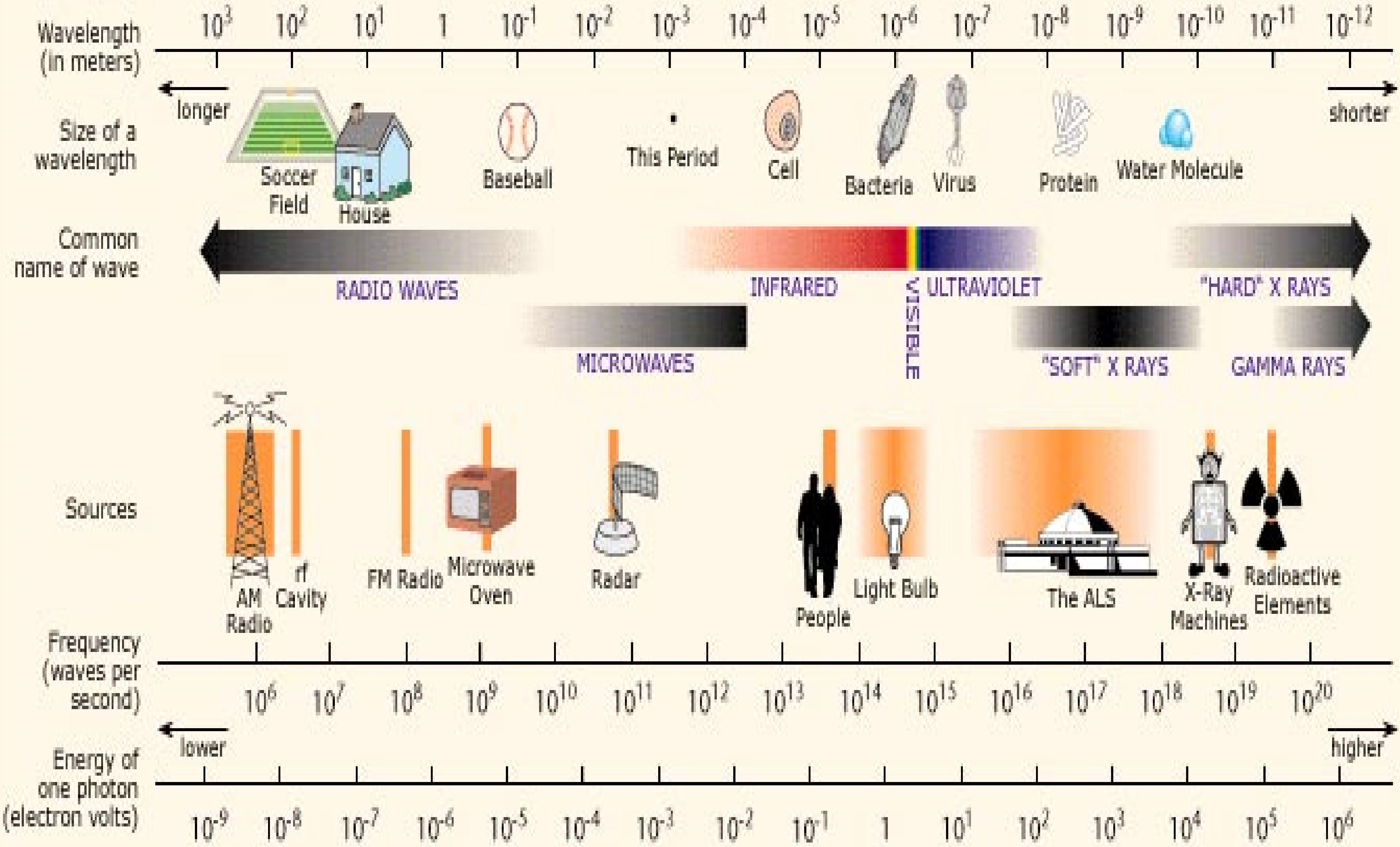
One carbon bond = 1 eV

One photon ~ 1-2 eV

One uranium atom =

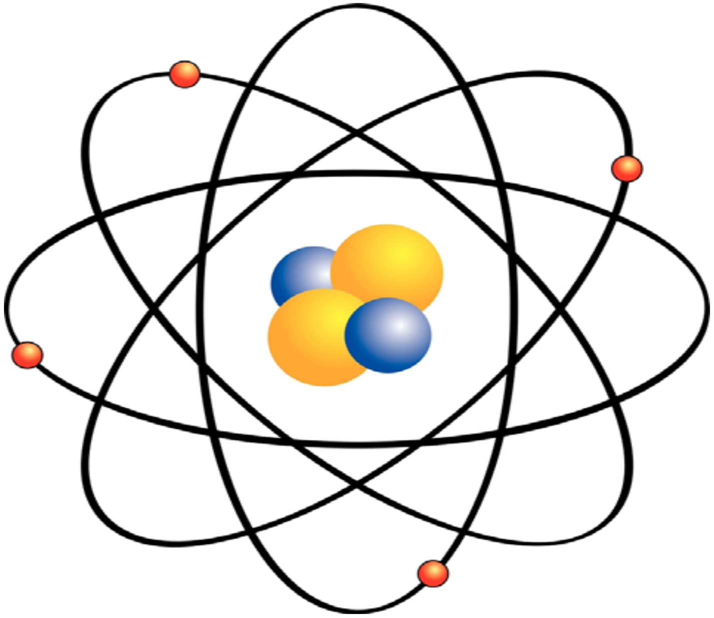
200,000,000 eV

THE ELECTROMAGNETIC SPECTRUM




First tamed
700,000 years ago.

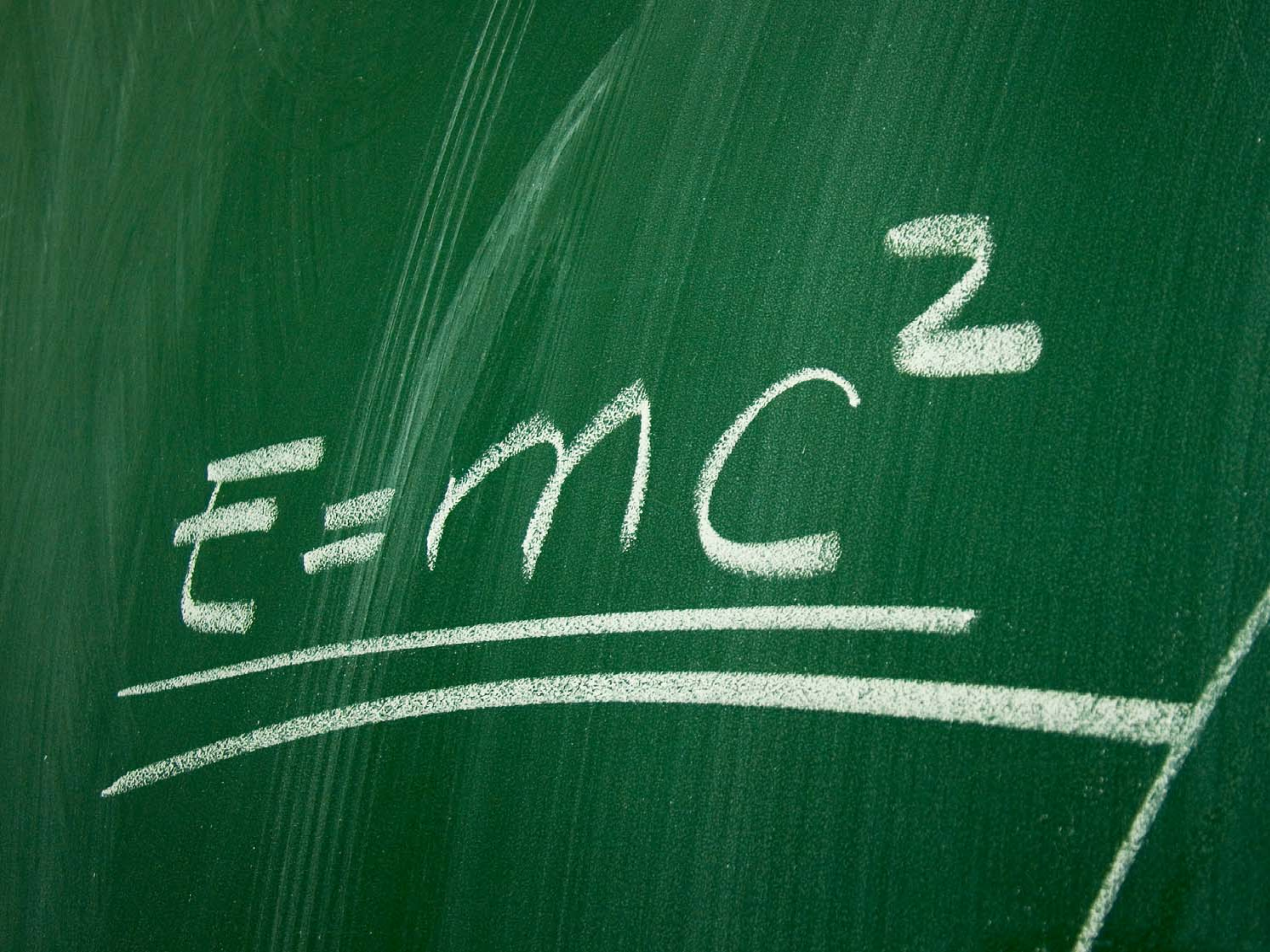
Only 1/1800th of the mass is in the electrons.



Mass of electron - 9.109 x 10^{-31} kg

Mass of proton - 1.673 x 10^{-27} kg

Mass of neutron - 1.675 x 10^{-27} kg


$E=mc^2$