Port Hope
where the future lies
(or does it?)

by Dr. Gordon Edwards, Ph.D.

with photographs and graphics by
Robert Del Tredici

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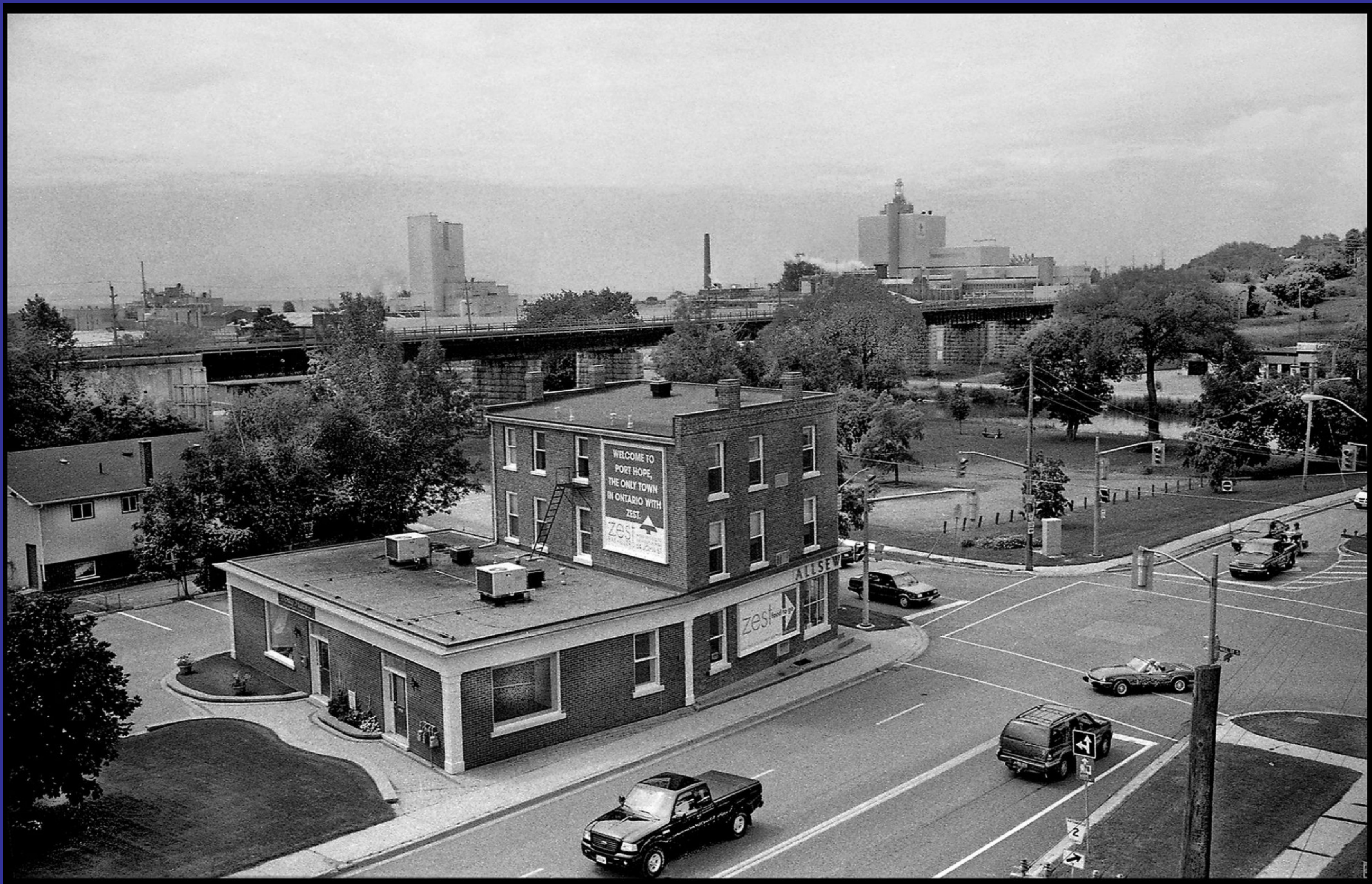
PORT HOPE is known to the world as the "uranium capital" of Canada.



Downtown Port Hope, with the Cameco uranium hexafluoride conversion facility in the right central background – one of only five in the western world.

Photo: Robert Del Tredici

Port Hope

Great expectations?

The Wesleyville site in Port Hope, Ontario (Credit: OPG)

OPG has said the Wesleyville site could house up to 10,000 megawatts of nuclear capacity. That is 60 % larger than the Bruce Nuclear Complex, the largest operating nuclear power plant In the world.

A portion of the Bruce Nuclear Complex near Lake Huron

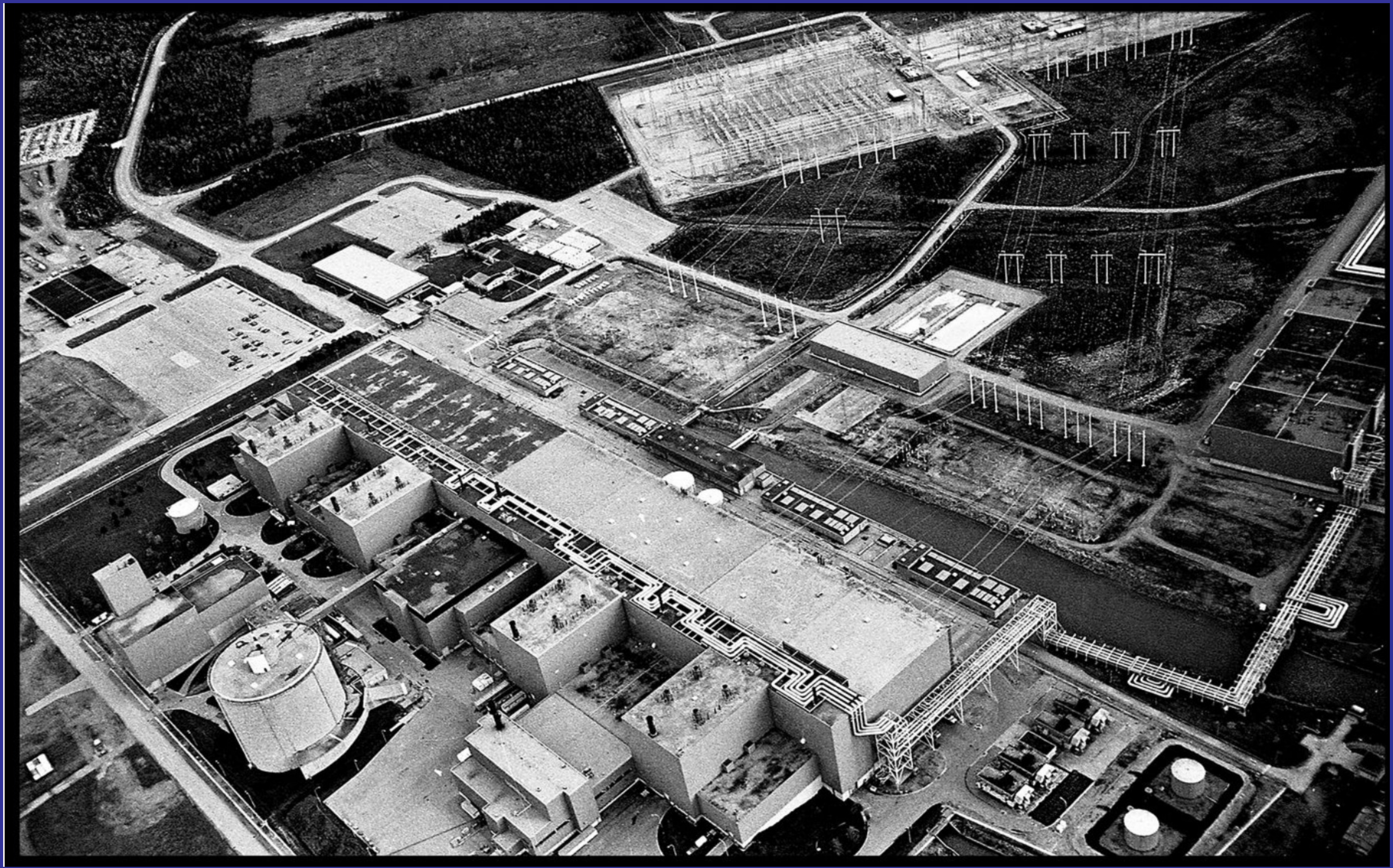


Photo:
Robert Del Tredici

It has eight large CANDU reactors and
an extensive waste management facility
– Wesleyville would be significantly larger.

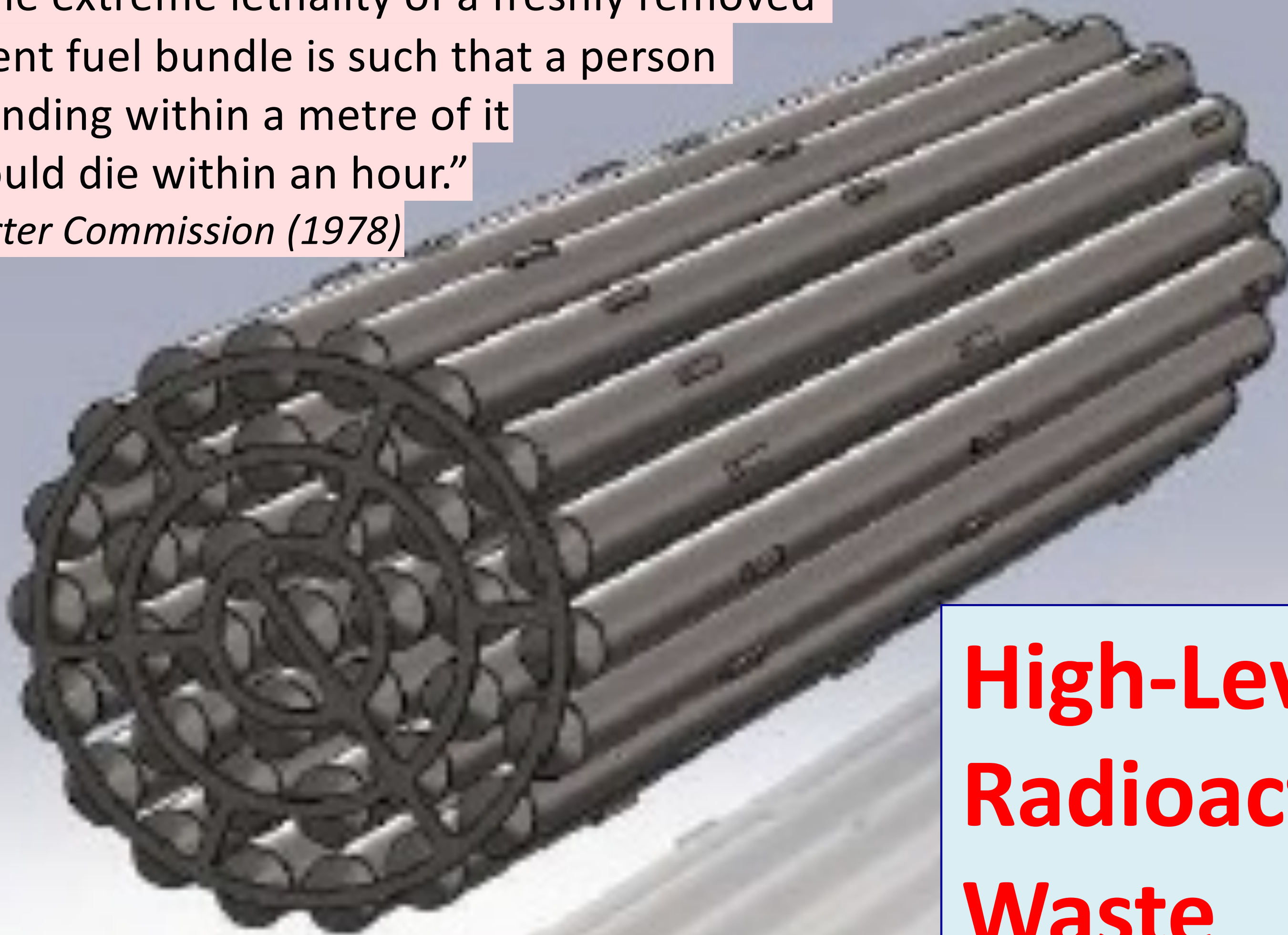
Wesleyville : 53 percent larger than Bruce A and Bruce B combined

Wesleyville : 10,000 MW; *Bruce A and Bruce B combined : 6,550 MW*

Bruce power requires extraordinary security.
Their SWAT team is permitted to use “prohibited weapons” –
assault-style, fully automatic military-grade weapons

Bruce won US NATIONAL SWAT CHAMPIONSHIP COMPETITION multiple times.

"The extreme lethality of a freshly removed spent fuel bundle is such that a person standing within a metre of it would die within an hour."
Porter Commission (1978)



High-Level Radioactive Waste

A fuel bundle looks solid, but radioactive materials leak out through tiny pin-holes and cracks. Severe fuel damage causes massive leaks. Fuel undergo corrosion, distortion, and embrittlement in the reactor.

Irradiated nuclear fuel is so radioactive it continues to generate heat for many years

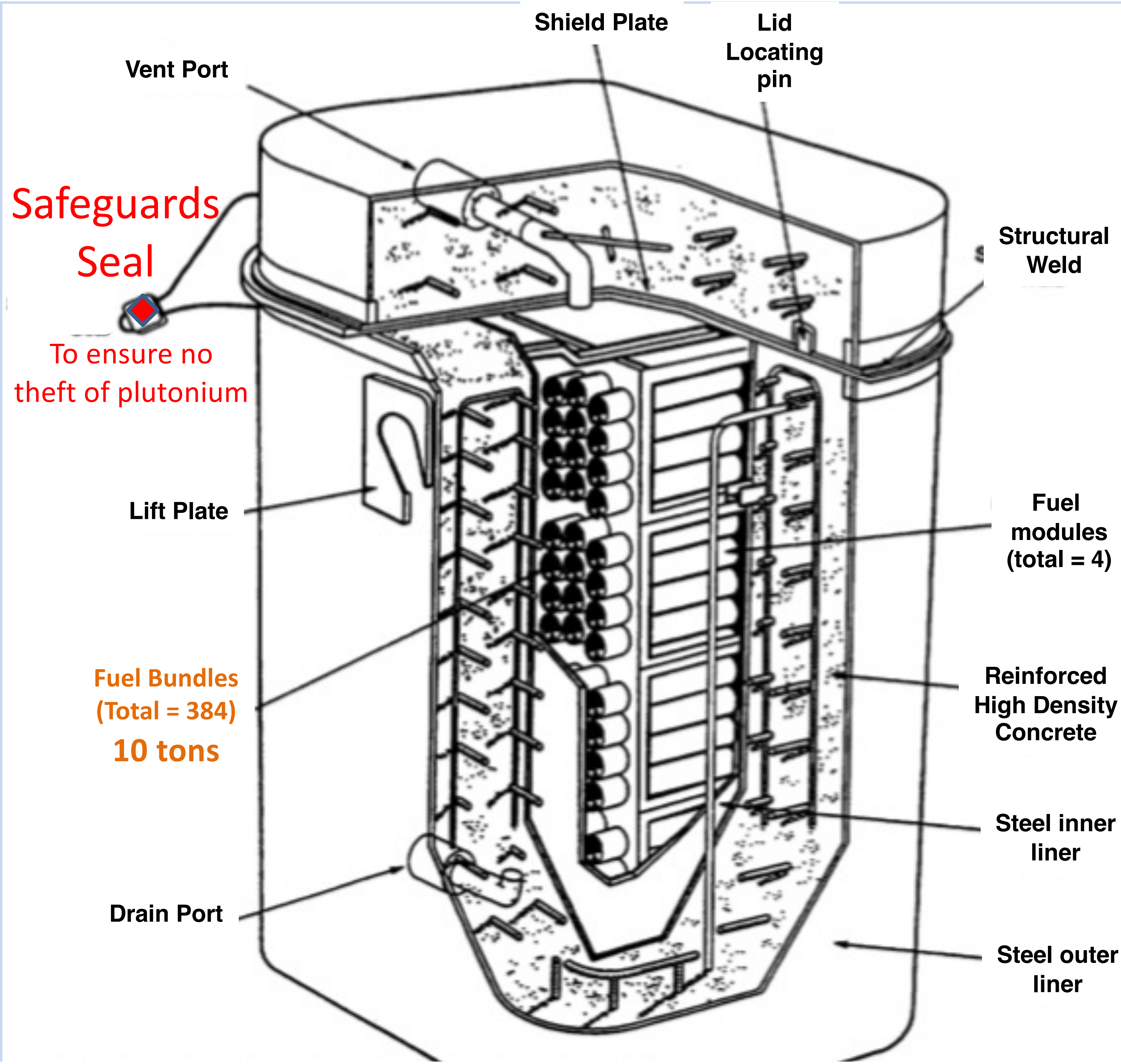
Photo: Robert Del Tredici

CANDU used fuel must be cooled in a pool of circulating water for at least 10 years.

Pickering Dry Storage Cask

60 tons empty
70 tons full

40 kilos of Plutonium (enough for 6-7 A-Bombs)

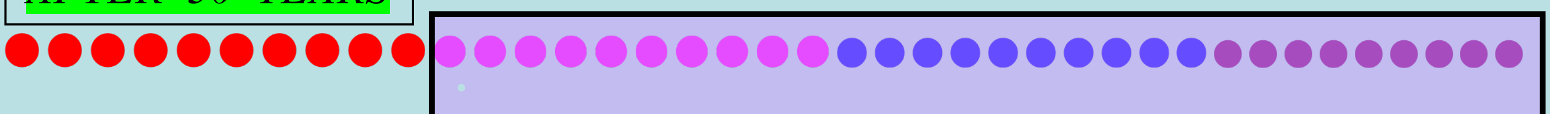


Nuclear Waste has NOWHERE to go!
Most of it will stay at Wesleyville > 100 years.

NWMO does not plan to move any waste less than 30 years old

Every reactor will have 30 years wirth os waste on-site.
LOOK at the picture.   Each red dot is 30 years of waste.

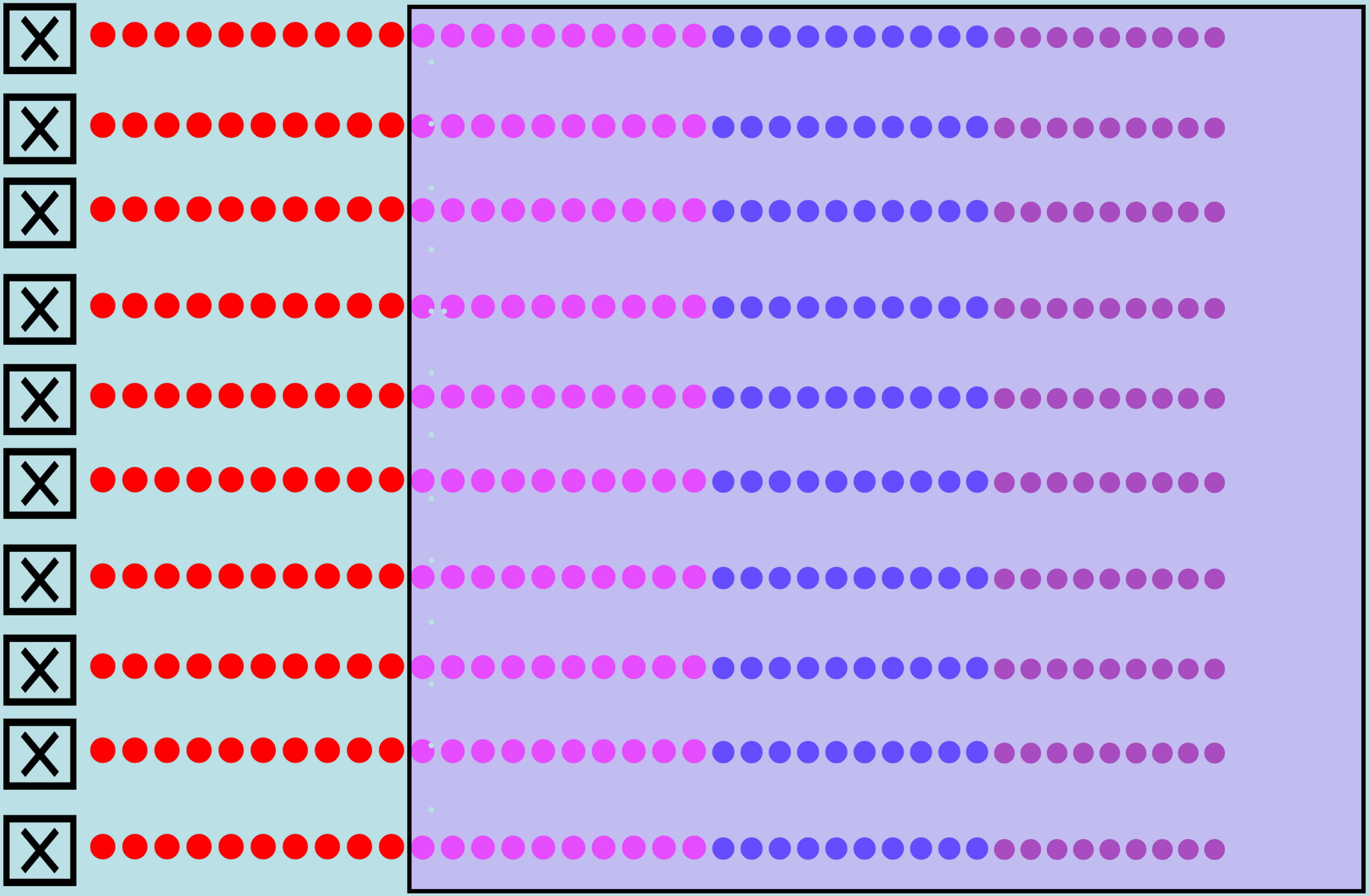
AFTER 30 YEARS



THIS OLDER PORTION MAY BE BURIED -- HOORAY

THE ONSITE HAZARD
IS NOT ELIMINATED by BURYING THE OLD STUFF

EVEN WITH GEOLOGIC DISPOSAL



YOU HAVE AN EVER- GROWING INVENTORY OF UNBURIED WASTE

NUCLEAR WASTE:
An Unsolved Problem

"If a problem is too difficult to solve,

you cannot claim it is solved

by pointing to all the efforts made to solve it"

Nobel Prize winning physicist

Hannes Alfvén, 1977

Big nuclear at Wesleyville

What happened to “small”reactors?

“Small Modular Nuclear Reactors”

S M R

“Small Modular Nuclear Reactors”

S M R

(Spending Money Recklessly)

TAKE A TRIP BACK TO THE FUTURE

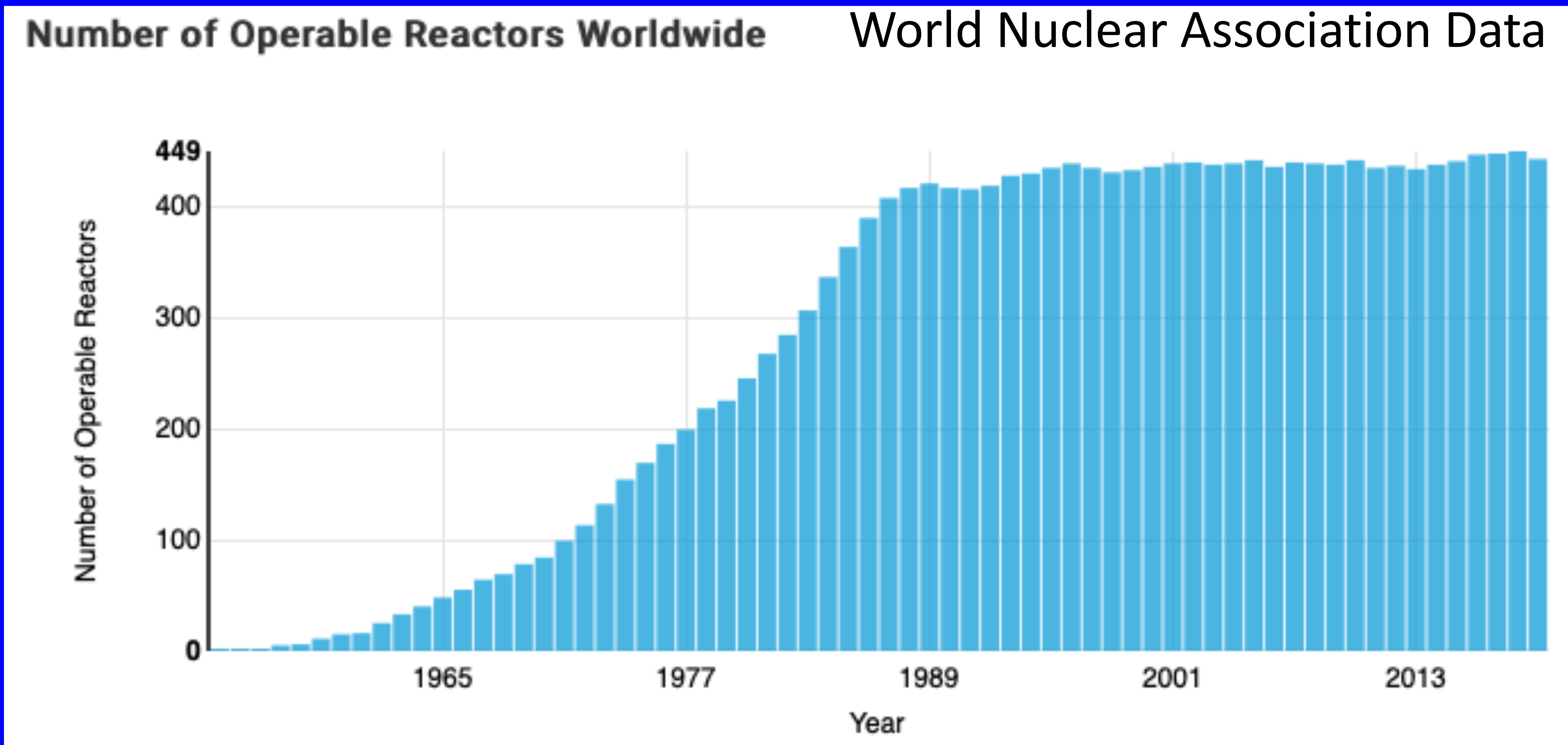
2018: Canada's Road Map for SMRs

motivated by the

sad state of the nuclear industry

following 25 years of stagnation

In 2019: The nuclear industry had been stagnant for about 25 years



1996 – 438 reactors
17% of global electricity
(< 3.3% of global energy)

2019 – 442 reactors
10% of global electricity
(< 2% of global energy)

“The State of Affairs [2019]

“The International Atomic Energy Agency (IAEA), looking ahead to 2050, sees the most optimistic global electricity market share for nuclear as only about 5 percent, down from 10 percent today . . .

“. . . and in the United States and Europe, it steadily declines to between 3 and 5 percent of the market, constituting a potential for market ‘failure’.”

ASME – The American Society of Mechanical Engineers (Nov 2019)

The First Nuclear Renaissance (2001):

a litany of failures

Collapse of French giant Areva (2014-2017)

Olkiluoto reactor (1400 Mwe) Finland – begun in 2005.

Plan: operational in 3 years, at a cost of 3 billion euros.

Started up - March 2022, 19 years later, cost >11 billion euros

Took 6 times longer to build **than promised and** cost 4 times more $$.

Olkiluoto 3 pictured in the summer of 2016 (Image: TVO)

- ***one of the "stars" of the "Nuclear Renaissance"***
- ***this "bankrupted" Areva – it was absorbed by Electricté de France.***

Bankruptcy of Westinghouse (2017)

Westinghouse Electric filed for bankruptcy in 2017 with $9 billion in losses from new nuclear projects –

mainly the four AP 1000 reactors: Vogtl in Georgia, V C Summer in S Carolina.

S Carolina abandoned the project, Georgia did not.

• *The US government gave $8.3 billion in loan guarantees on the financing of the four reactors*.

VOGTLE

construction licence : 2012.

Estimated cost: $14 billion
Actual cost: $35 to $36 billion

Est. completion: 2016-17
Actual completion: 2023-24

Vogtle units 3 and 4
cost per kilowatt installed is
$15,700 – costliest in the world

COST MORE THAN DOUBLED
TIME TO BUILD TRIPLED

2023 - Westinghouse bought by 2 Canadian firms Cameco (49%) & Brookfield (51%)

The Second Nuclear Renaissance (~ 2018):

“small modular reactors”

SMR

“small modular reactors”

Second Make-Believe Renaissance

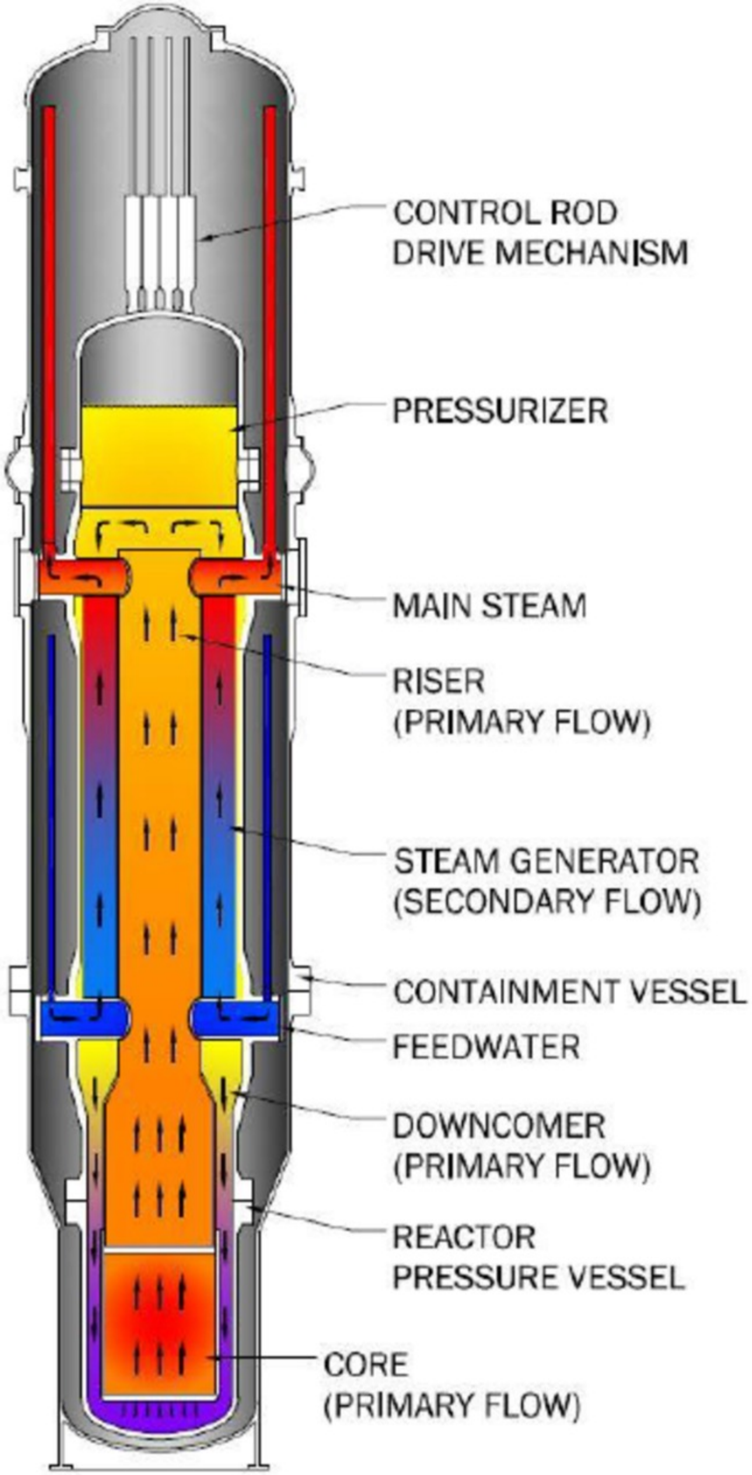
Problems for Small Modular Nuclear Reactors

- *Very costly : mass production is needed!!*
- *Too much competition ~ impossible to standardize*
- *Funding hard to find: public money is easier*
- *Few markets and slow deployment*
- *More vulnerable to threats - less robust containment:*

Problems for Small Modular Nuclear Reactors

- *THEY ARE NOT SO SMALL*
- *THEY ARE NOT SO MODULAR*
- *THEY ARE NOT SO AFFORDABLE*
- *THEY ARE, HOWEVER, NUCLEAR!!*

*They are SM**N**Rs, not SMRs.*



Schematic of a NuScale power module.

IDAHO

NuScale PWR

The NuScale Power Module
- licensed for construction
- when projected power costs doubled, clients backed out.

CANCELLED – 2023

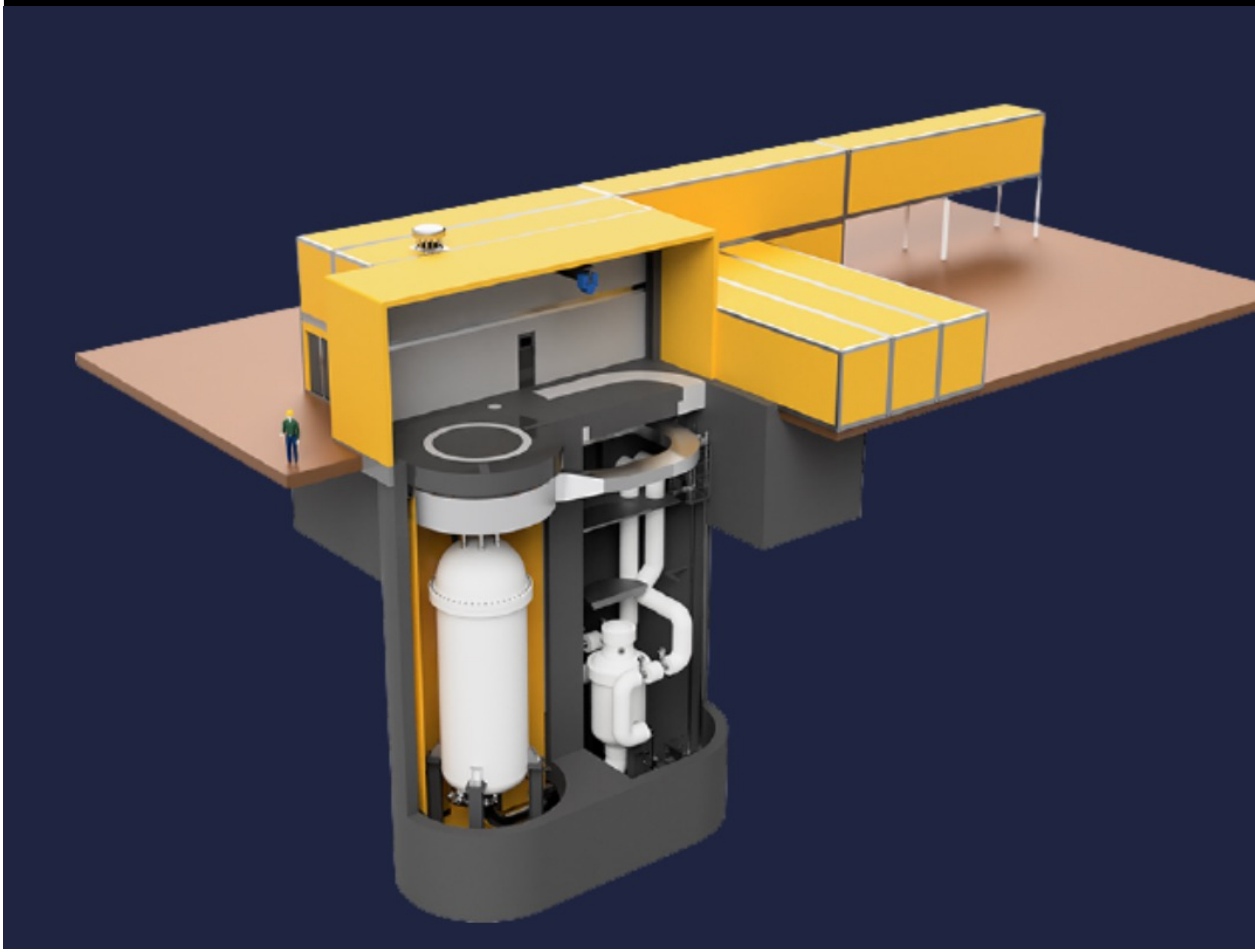
This is a 77 megawatt light-water reactor – PWR – with steam generators (boilers) and passive safety features.

passive means no power required

CHALK RIVER ONTARIO

The Ultrasafe Micro Modular Reactor is a gas-cooled 5 megawatt reactor with a molten salt heat storage system. Ultrasafe filed for bankruptcy in 2024 and so the project is

PAUSED



It is intended for the Chalk River site in Ontario.

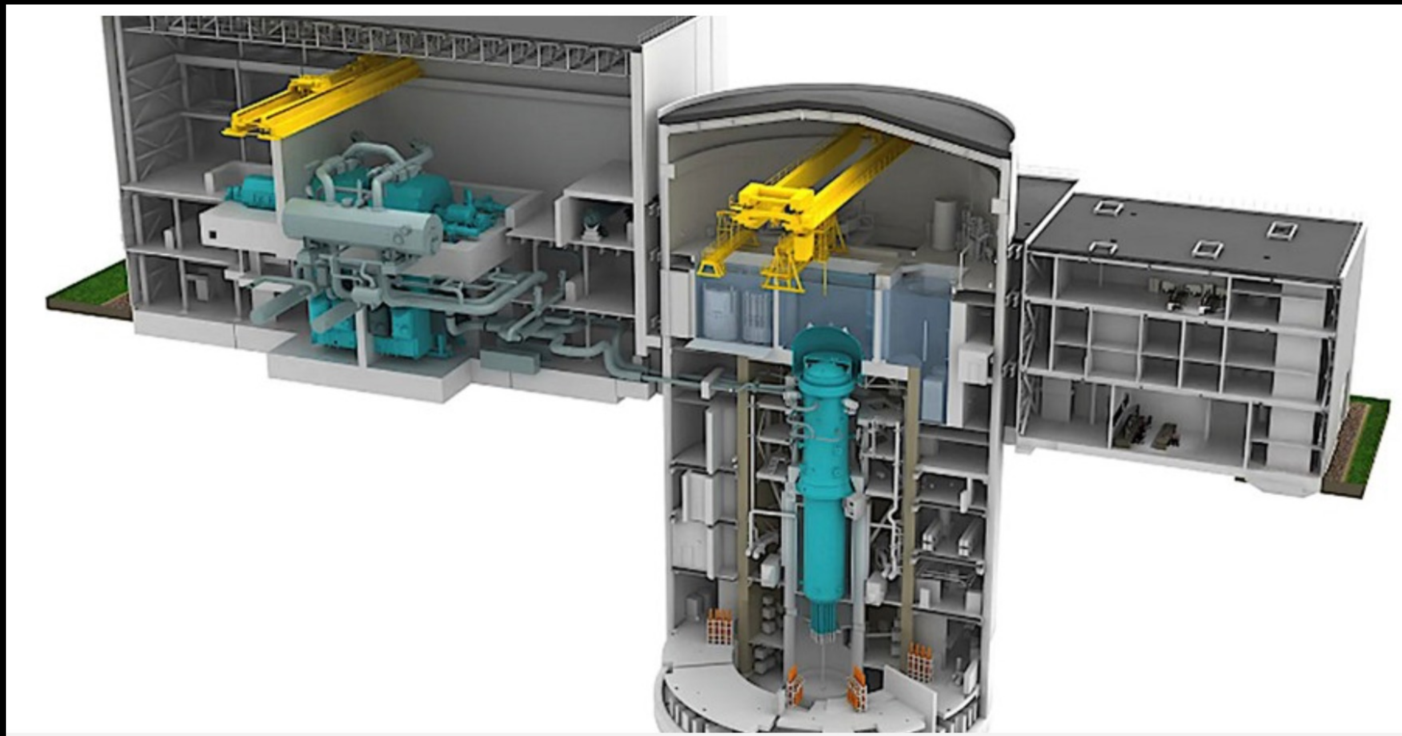
DARLINGTON

The BWRX-300 is a Boiling Water Reactor (300 megawatts) estimated to cost $6.5 billion Canadian – equal to the cost per MW of Vogtle.

UNDER CONSTRUCTION

The Canadian regulator CNSC has given a construction licence for the first of four units to be built east of Toronto at Darlington.

A closer look reveals that the BWRX-300 is 21 stories high; 10 stories above-ground and another 11 stories below ground. Not so small.



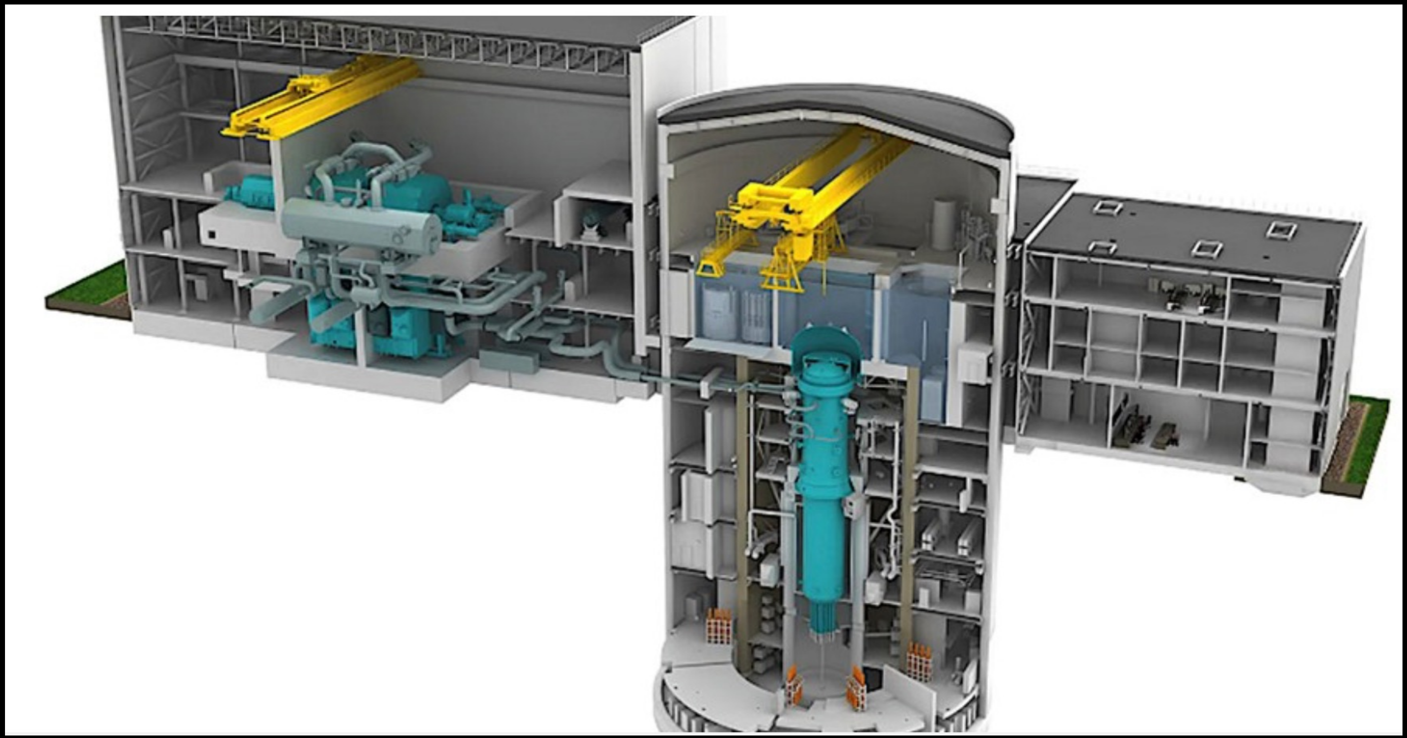
And not so modular either. A work force of up to 4000 has been cited by the Prime Minister who has invested federal money in it.

“SMALL” Modular Reactor under construction at Darlington.

Those are cars & trucks on the ground! Ralph says it’s “The size of a mall, and the lead time of a cathedral”

Licence to prepare site given to OPG in 2011

COST OF FIRST 300 MW UNIT IS $6.5 BILLION



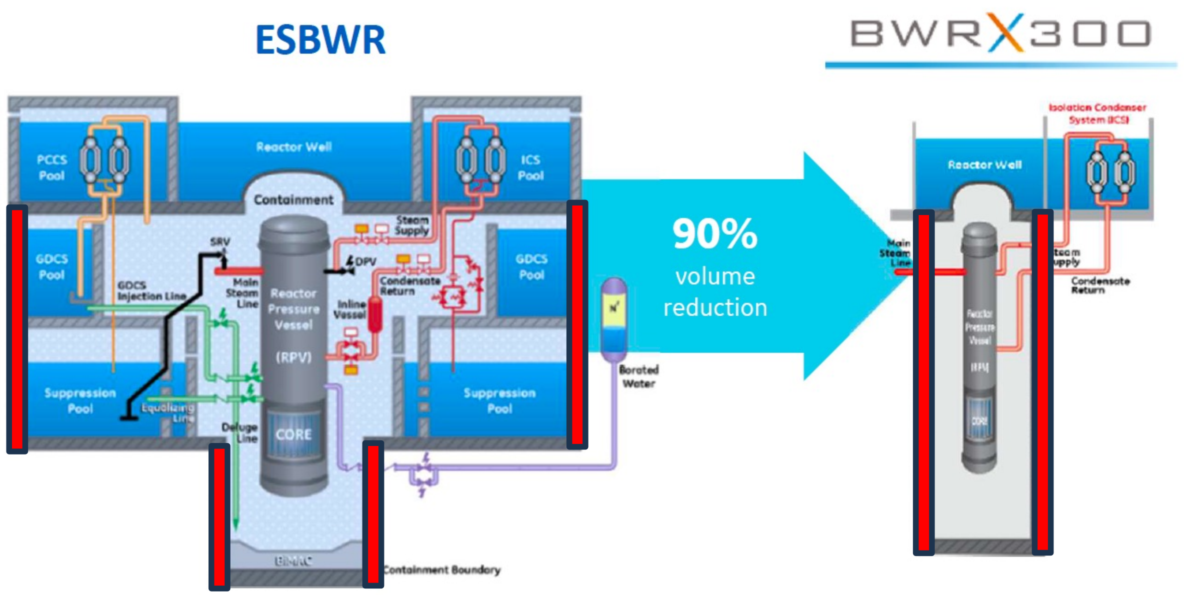
Cost per kilowatt = $21,666 C = $15,500 USD
(corresponding figure for Vogtle: $15,700 USD)

VERY EXPENSIVE ELECTRICITY

"The BWRX-300 … leverages the design and licensing basis of the… ESBWR boiling water reactor, certified by the US Nuclear Regulatory Commission." – World Nuclear News 2021

Simplicity drives cost reduction

HITACHI



Systems/components eliminated:

- Suppression Pool
- GDCS Pool
- Safety Relief Valves & Spargers
- Depressurization Valves
- BiMac (core catcher)

Systems/components simplified:

- Passive Containment Cooling (PCCS)
- Containment (use of SC)
- Boron injection
- Security (built into design)
- Turbine
- Generator (air cooled)

>50% building volume reduction/MW
>50% less concrete/MW

Reduction in size is due in part to elimination of safety systems.

NEW NUCLEAR PLANS ARE NOT SMALL AT ALL!

Plans for new LARGE nuclear plants in Canada:	
• Peace River New Nuclear :	4,800 MW
• Bruce C New Nuclear :	4,800 MW
• Wesleyville New Nuclear :	10,000 MW
Total large nuclear plants :	19,600 MW

Plans for new SMALL nuclear plants in Canada:	
• BWRX-300 x 4 at Darlington:	1,200 MW
• ARC-100 at Point Lepreau:	100 MW
Total SMRs planned so far:	1,300 MW

LARGE nuclear reactor plans are 15 TIMES more than SMR plans

Is the promise of SMRs just a way of “rehabilitating” nuclear?

Yesterday – newspaper article in New Brunswick

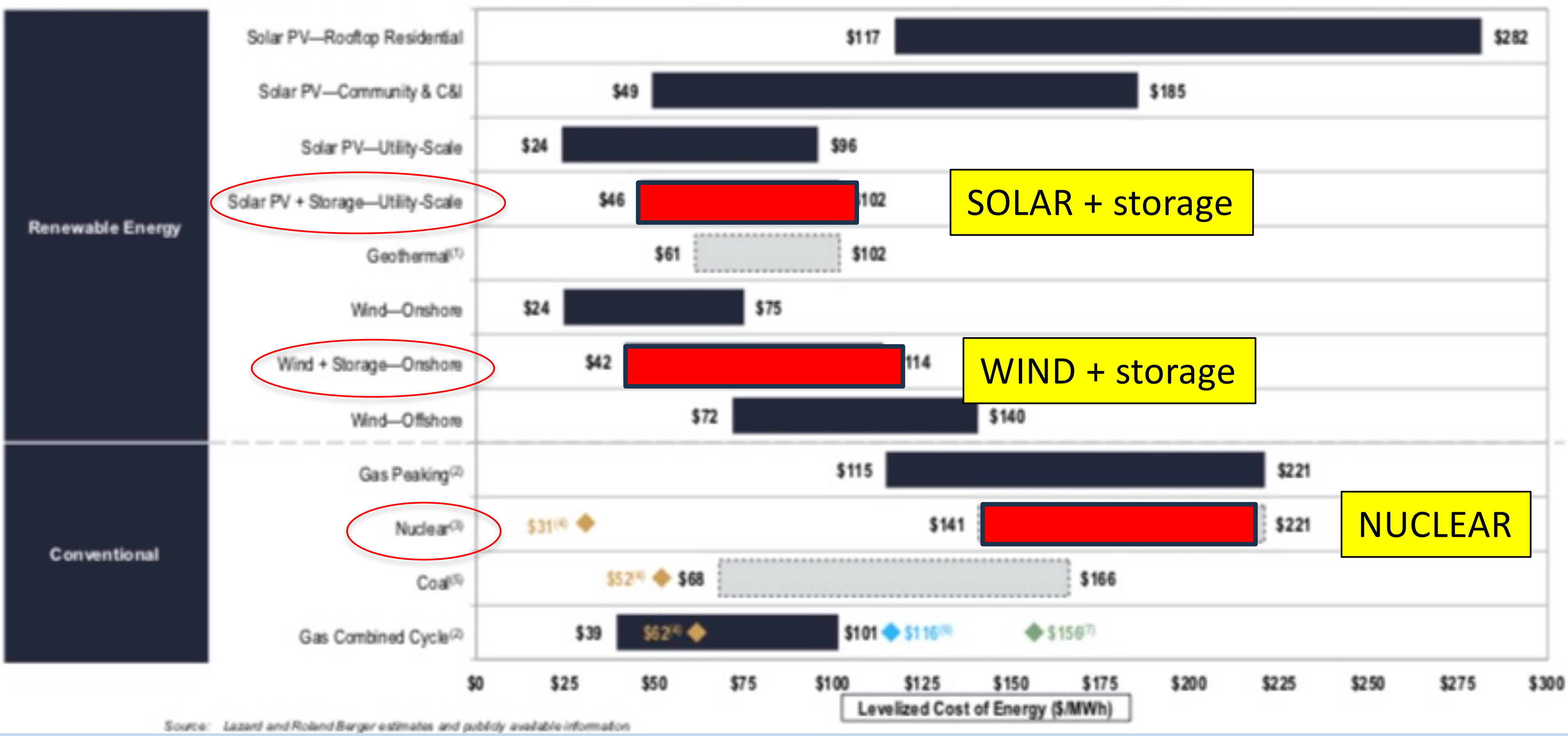
The Competition:

The Status of Renewable Energy

Levelized Cost of Energy Comparison—Unsubsidized Analysis

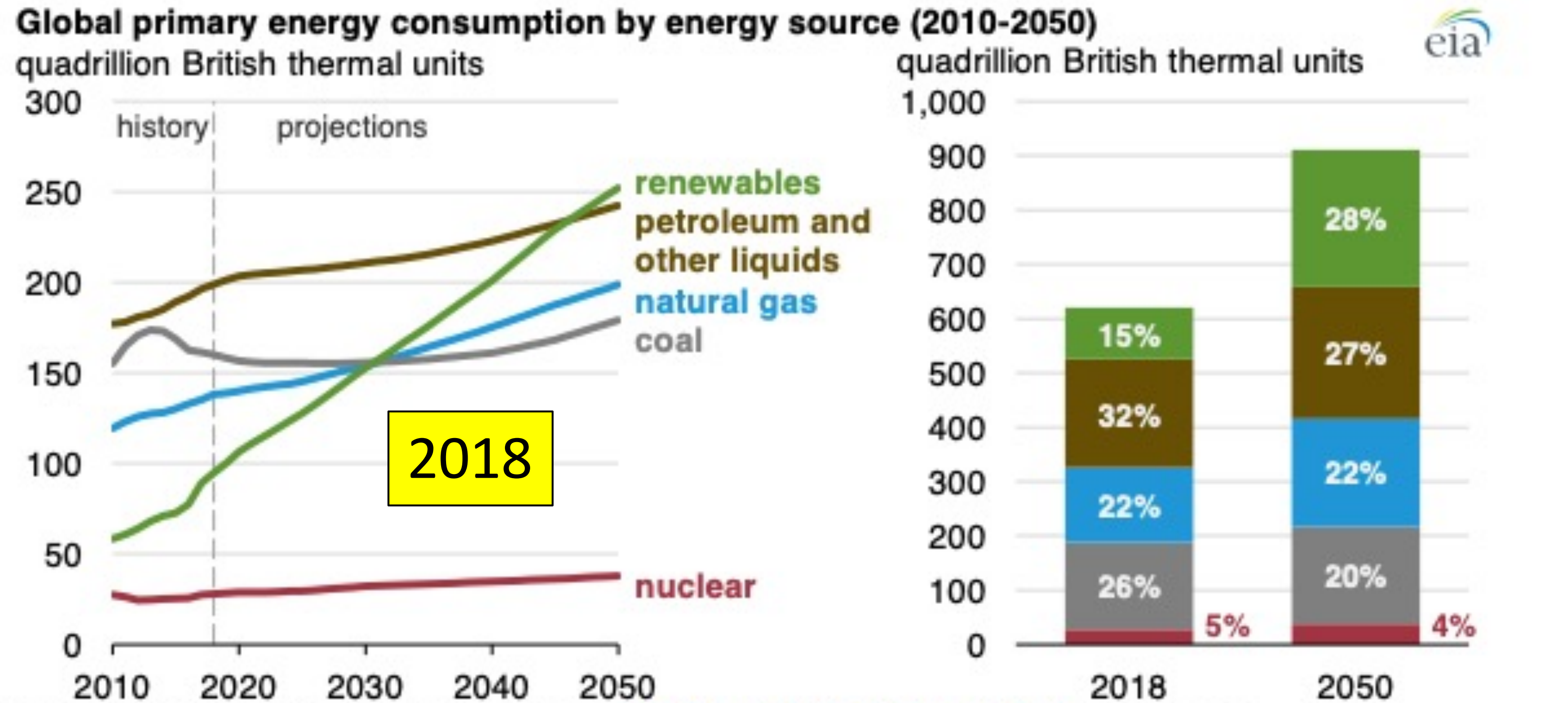
Lazard. April 2023

Selected renewable energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances



The HIGHEST cost for renewable with storage is far less than the LOWEST cost for nuclear.

US Energy Information Administration (EIA)



Source: U.S. Energy Information Administration, *International Energy Outlook 2019* Reference case

With the rapid growth of electricity generation, renewables—including solar, wind, and hydroelectric power—are the fastest-growing energy source between 2018 and 2050, surpassing petroleum and other liquids to become the most used energy source in the Reference case. Worldwide renewable energy consumption increases by 3.1% per year between 2018 and 2050, compared with 0.6% annual growth in petroleum and other liquids, 0.4% growth in coal, and 1.1% annual growth in natural gas consumption.

COP 28 (2023):

1. *Triple renewables and double energy efficiency by 2030*
(~200 nations, official pledge)

2. *Triple nuclear power by 2050*
(25 nations, unofficial aspiration ~ photo-op)

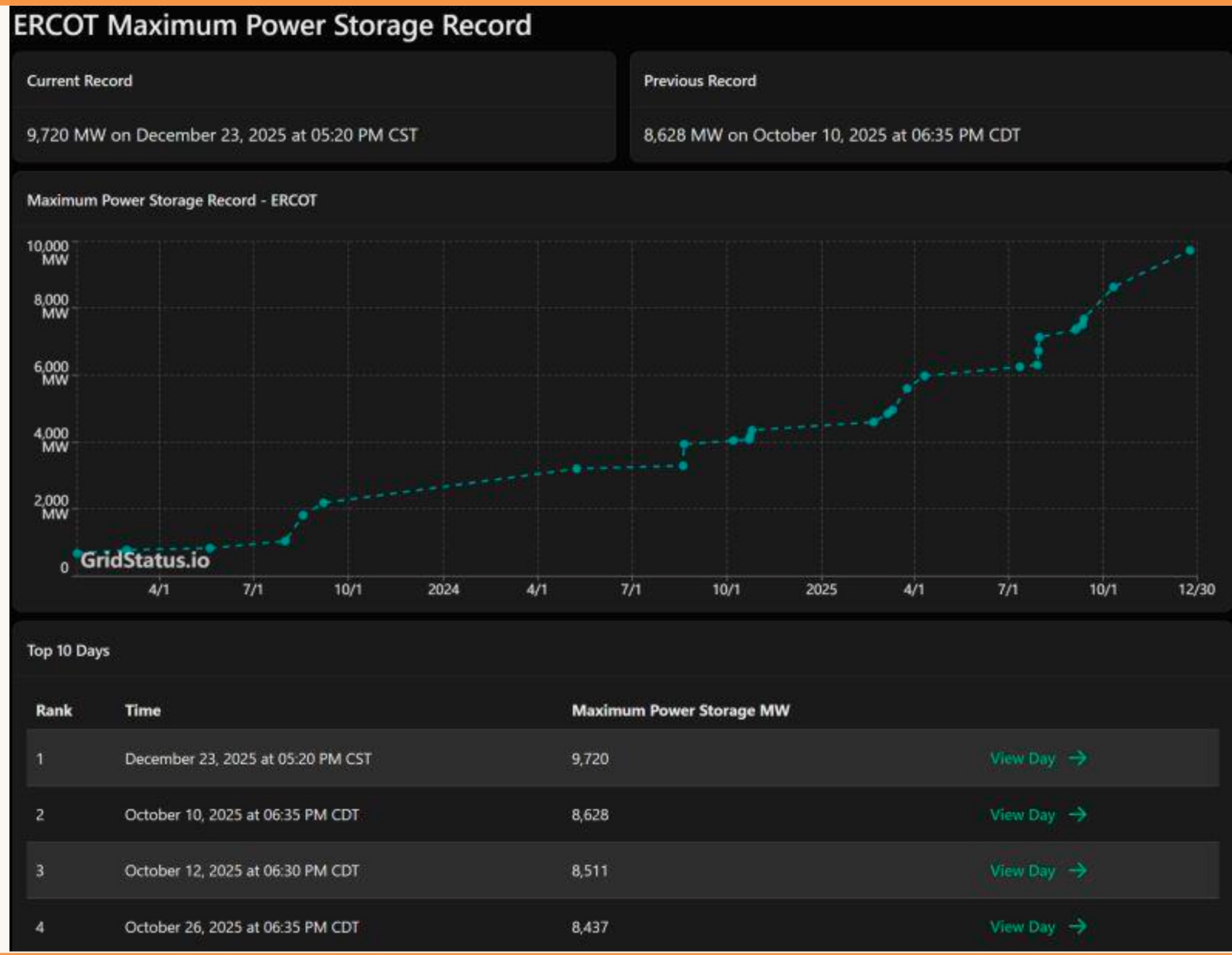
Astomishing improvements in energy storage

CASE STUDY TEXAS – Record Battery Discharge of 10 GW in December 2025

Instant Battery Discharge reaches almost 10 GW on ERCOT's grid in Texas in December 2025:

• then covering a record 18 percent of the load

• then close to twice the operating capacity of the state's four nuclear reactors'



Rank	Time	Maximum Power Storage MW	
1	December 23, 2025 at 05:20 PM CST	9,720	View Day →
2	October 10, 2025 at 06:35 PM CDT	8,628	View Day →
3	October 12, 2025 at 06:30 PM CDT	8,511	View Day →
4	October 26, 2025 at 06:35 PM CDT	8,437	View Day →

Source: Grid Status 2026, see https://www.linkedin.com/posts/grid-status_last-week-ercot-seta-new-recordfor-instantaneous-activity-7411476640809144320-azjb

Slide courtesy of Mycle Schneider, World Nuclear Industry Status Report - 2026

WNISR2025

GERMANY FOCUS – Energy Sector GHG Emissions Dropped by 50% Since 2010

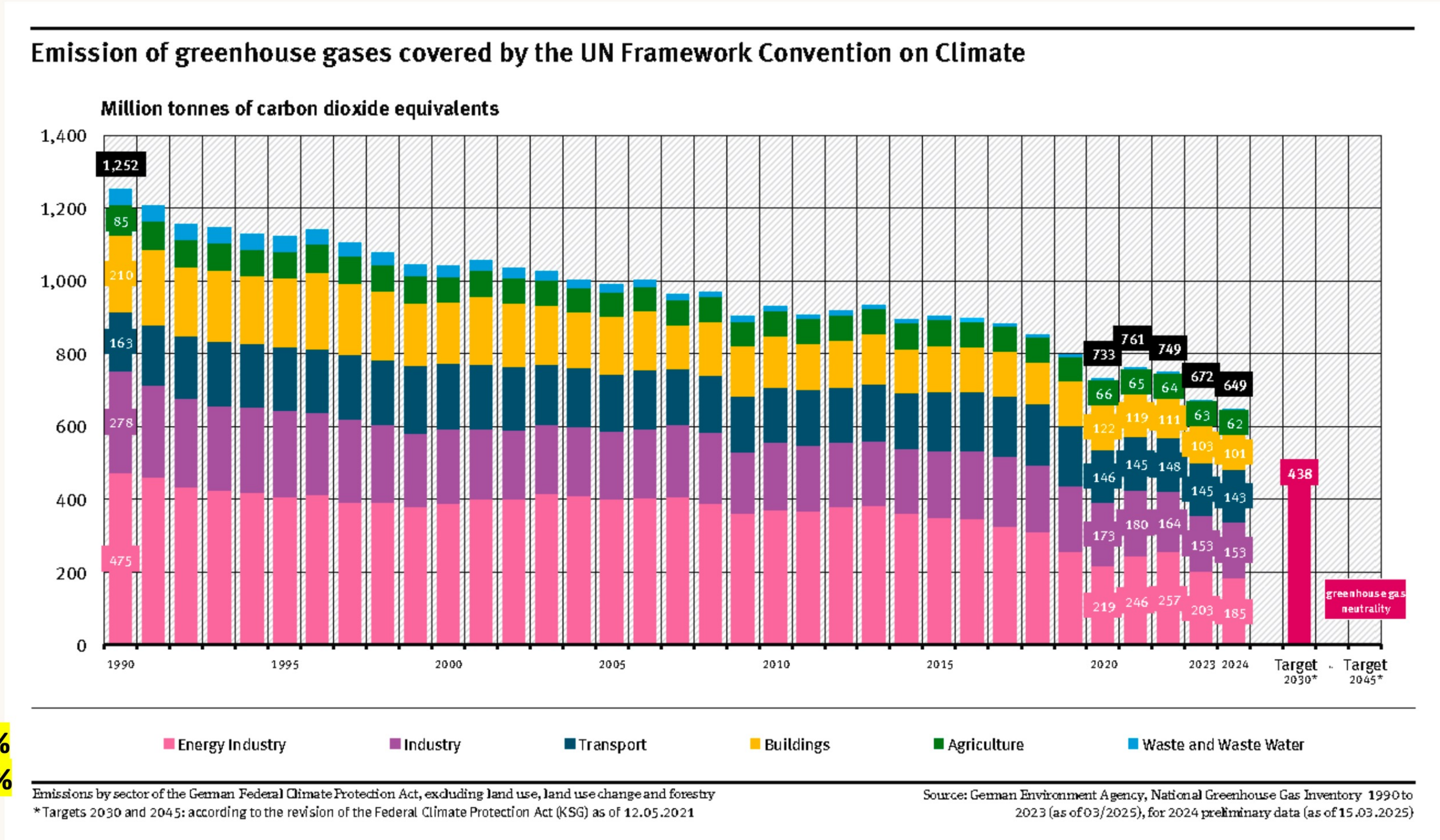
German Greenhouse Gas Emissions

2010–Pre-Nuclear Phaseout Decision:
Total Emissions
930 million t of CO2e
of which
Energy Sector
373 million t of CO2e

versus

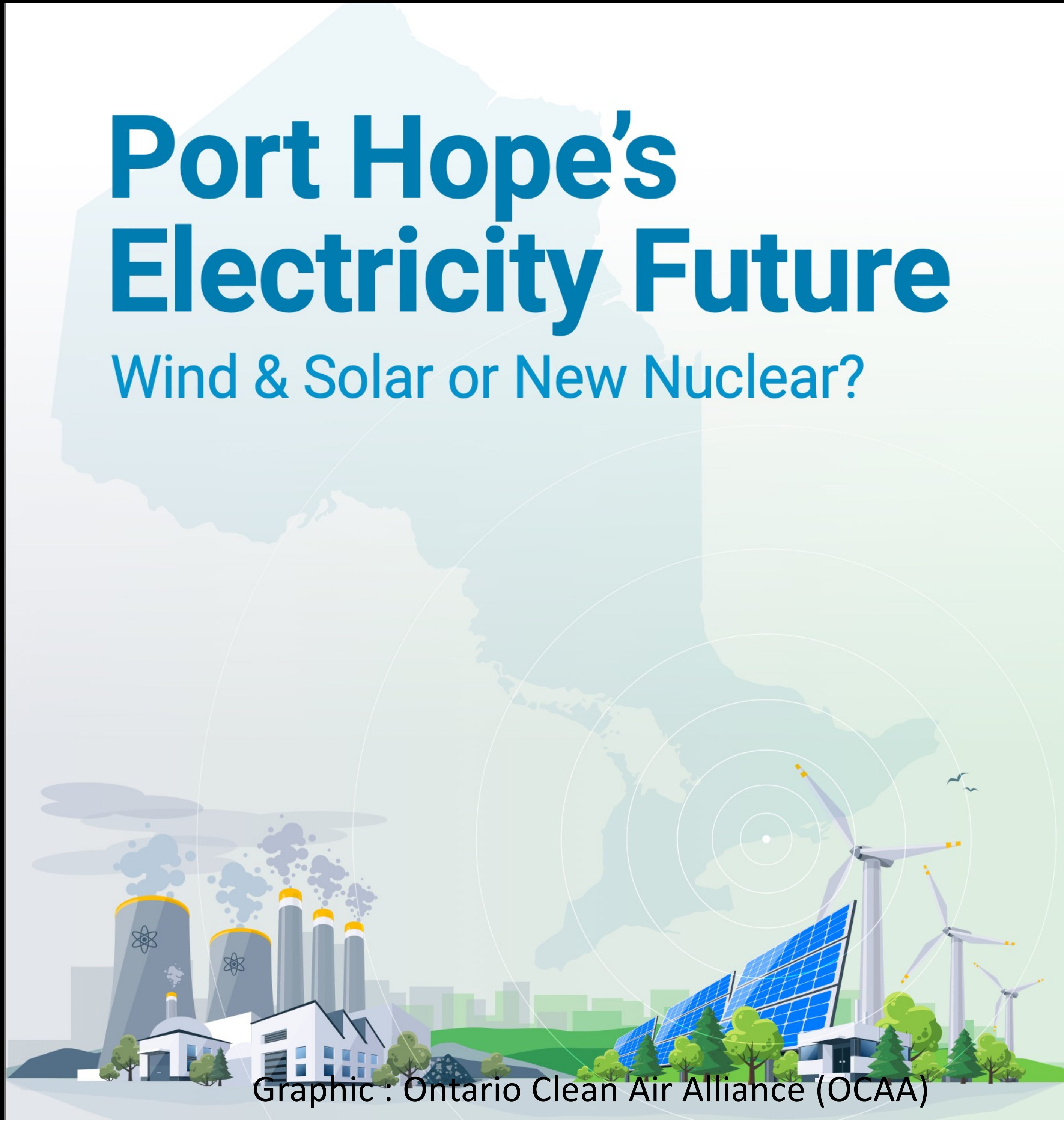
2024–One year After Last Reactor Closed:
Total Emissions
649 million t of CO2e
of which
Energy Sector
185 million t of CO2e

Total Emissions: -30 %
Energy Sector: -50 %



Source: German Federal Environment Agency, see https://www.umweltbundesamt.de/en/data/environmental-indicators/indicator-greenhouse-gas-emissions#at-a-glance

Slide courtesy of Mycle Schneider, World Nuclear Industry Status Report - 2026



Graphic : Ontario Clean Air Alliance (OCAA)

[redacted]

Table 1 | Cost per kWh (2024 US$)

	Cents per kWh
Utility-Scale Solar	4.1
Onshore Wind	2.7 – 4.3
Great Lakes Offshore Wind	8.6 – 9.3
Nuclear	20.6 – 22.6
Nuclear SMR First of a Kind	21.1 – 23.2
Nuclear SMR Nth of a Kind	15.9 – 17.4

[redacted]

[redacted]

Table 2 | Construction Times for Solar and Wind[22]

Residential Rooftop Solar PV	9 months
Utility-Scale Solar PV	12 months
Onshore wind	12 months
Offshore wind	36 months

[redacted]

Radioactivity at Port Hope

It all started with RADIUM

Henri Becquerel 1896

discovered radioactivity of uranium & thorium
~ invisible energy given off ceaselessly ~

1896

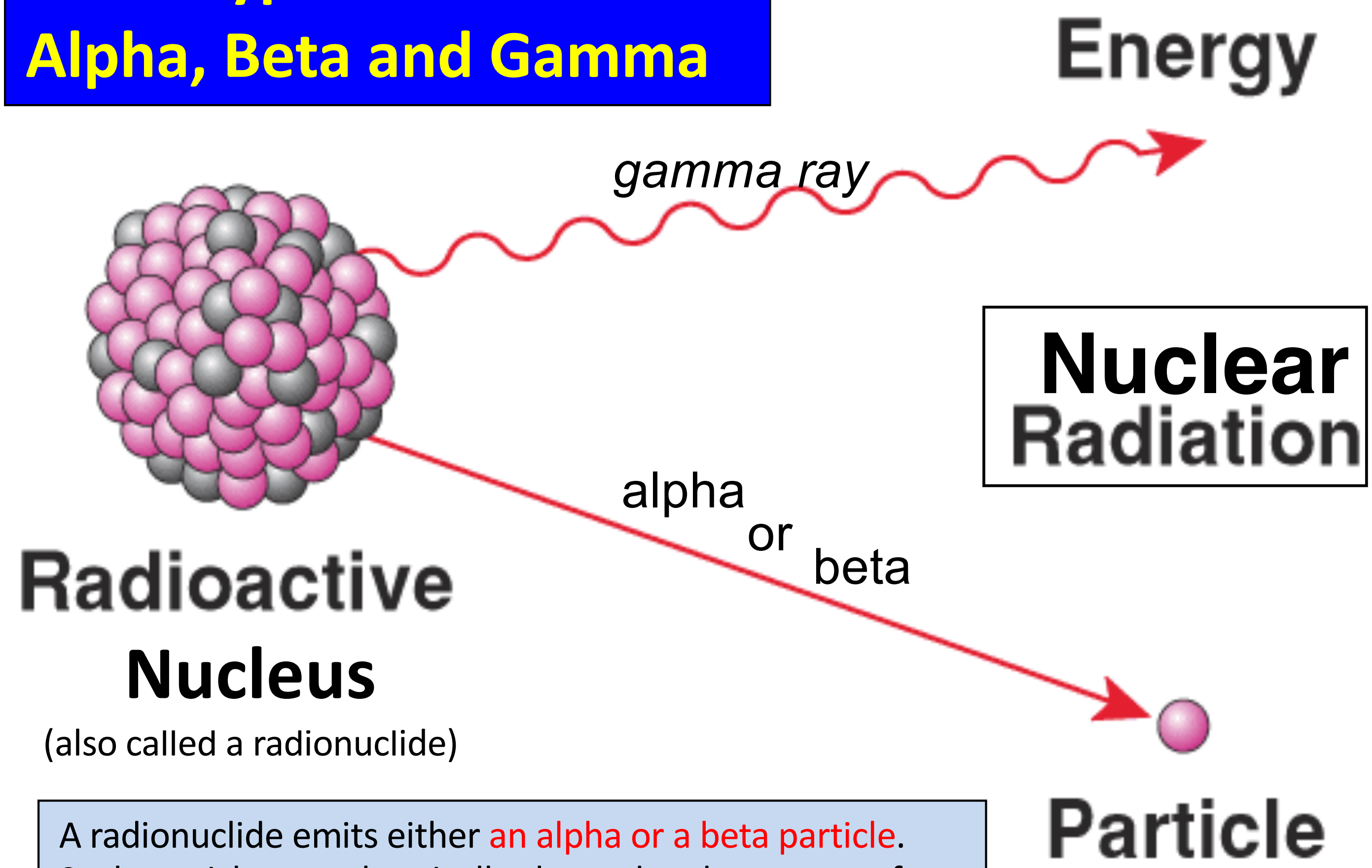
Uranium and Radioactivity

- invisible energy from ores
- exposes photographic plates
- causes "ionization"
- causes radiation burns
- **cannot be shut off**

You cannot see radioactivity

In a “cloud chamber” you can see the tracks of radioactive emissions from uranium ore.

Three types of emissions: Alpha, Beta and Gamma



A radionuclide emits either an alpha or a beta particle.
Such particles are electrically charged and move very fast.
In some cases a powerful gamma ray is also given off.
All three forms of atomic radiation damage living cells.

Marie Curie

1898

Marie Curie discovered other radioactive materials – radium and polonium – byproducts of uranium – as well as radon gas

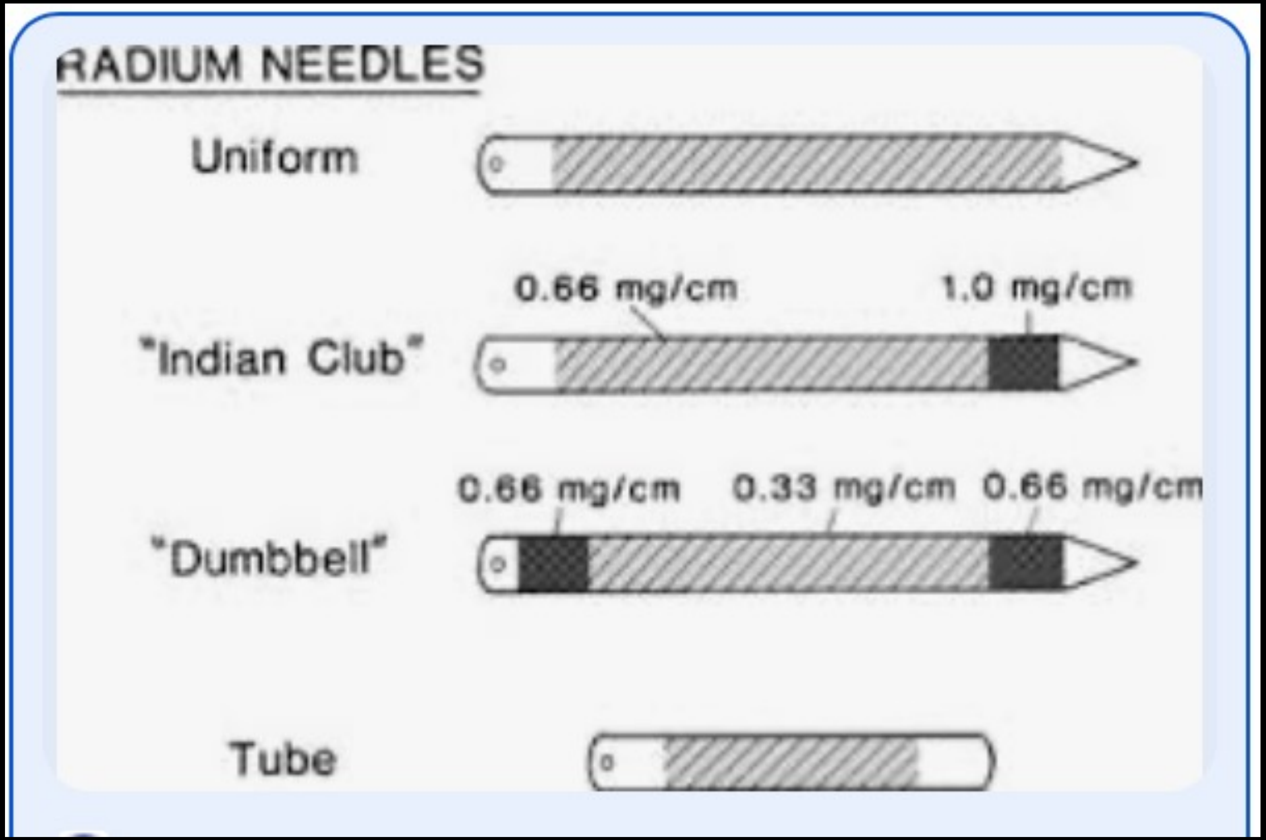
We now know that uranium atoms disintegrate, giving off ionizing radiation, and changing into a series of other unstable elements.

RADIUM

Marie Curie realized that the harmful effects of atomic radiation can be used to destroy tumours.

From 1910 radium needles became a preferred treatment for shrinking solid tumours.

PROBLEM: Radium has a half-life of 1600 years!! What to do with leftovers?



1920

Girls hired to use radium-based paint to make numerals on watch dials glow in the dark …

… ingested minute amounts of radium when they licked the tips of their brushes to get a very fine point .

Radium Dial Painters

radium

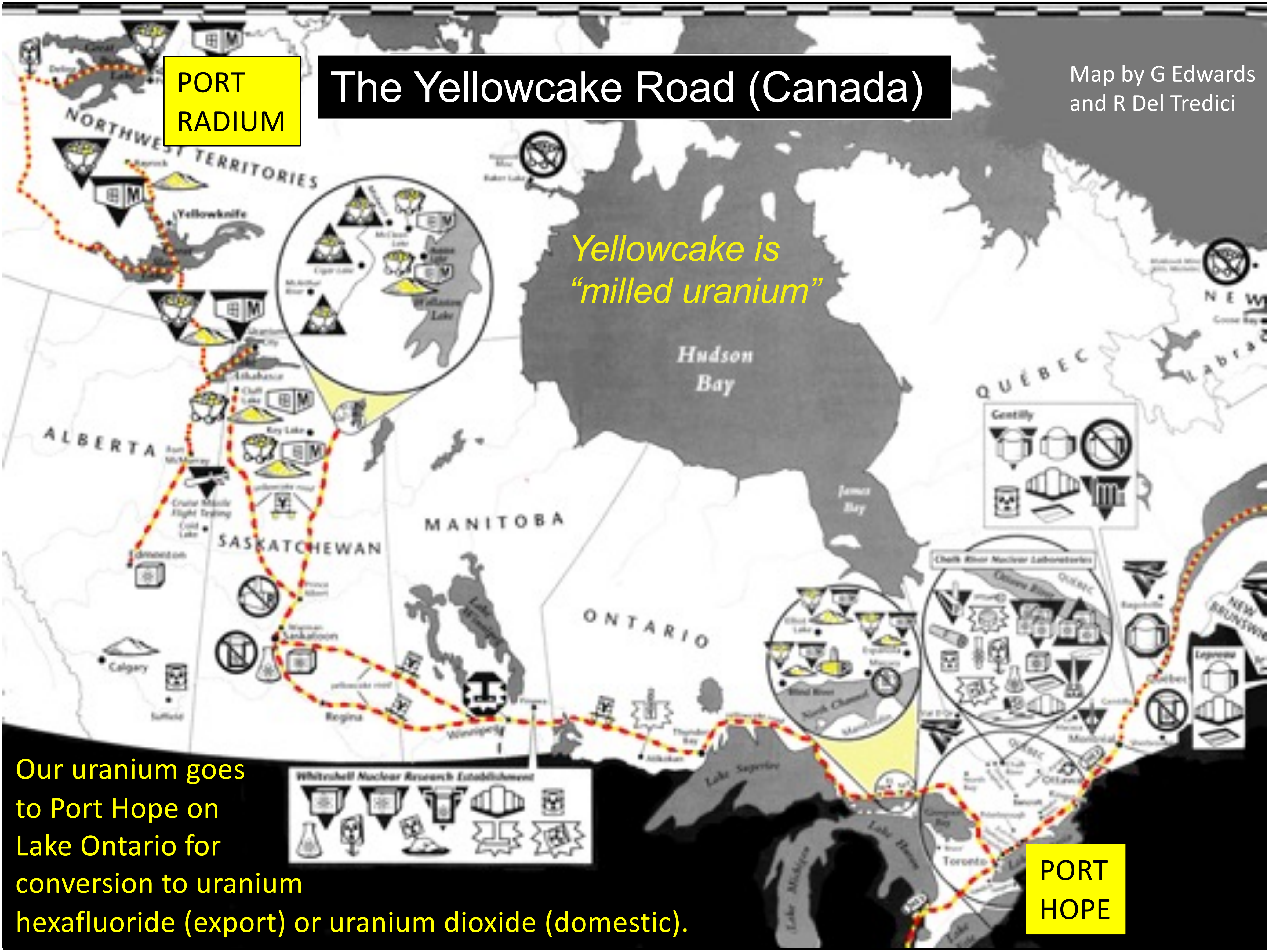
deaths from
Fatal anemia
Bone cancers
Head cancers

1930

Radioactive Radon Gas

- radioactive **radon gas** is produced when radium atoms disintegrate
- radon is the leading cause of **lung cancer** among non-smokers
- radon causes lung cancers and other lung diseases in **uranium miners**
- radon gas deposits solid **radioactive materials** in lung tissue
- radon is seven times **heavier than air** and travels great distances …

The Yellowcake Road (Canada)



Our uranium goes to Port Hope on Lake Ontario for conversion to uranium hexafluoride (export) or uranium dioxide (domestic).

Photo:
Robert Del Tredici

Dene man standing over discarded radium ore sacks at Port Radium, NWT

In the Sahtu-Dene Village of Deline, Great Bear Lake, NWT

Photo: Robert Del Tredici

1934

MARCEL POCHON

Marel Pochon studied with
MARIE CURIE.

He designed the Port Hope
RADIUM REFINERY - 1932

He was aware of the harmful
effects of atomic radiation.

BLOOD

Marie Curie died in 1934
of “anemia” caused by radium.

Her daughter Irene Curie died
of leukeia fromatomic radiation.

Macel Pochon had a large family.

Atomic Radiation ~ Lessons from Science

Chronic exposure increases the incidence of cancer, leukemia, genetic damage, strokes, heart attacks, and low intelligence

For cancer there is a "latency period" :

. . . the onset of disease occurs years or decades after exposure.

The targets of low-level radiation exposures are populations – the larger the population dose, the greater the damage.

Graphics: Robert Del Tredici

Radioactive materials enter into the air, water and soil.
They get into fish, plants, animals, and humans.

Graphics: Robert Del Tredici

A small fraction of the population will develop cancer, years later. Infants and children are especially vulnerable.

Graphics: Robert Del Tredici

If a larger population is exposed to the same level of contamination, we say that the “population dose” is greater.

Graphics: Robert Del Tredici

The greater the population dose, the more cases of adverse heath effects – like cancer – will be seen.

Graphics: Robert Del Tredici

Nuclear Fission:
the nature of the beast

1939 – NUCLEAR FISSION IS DISCOVERED

Enough energy is given off in a few 1000 years to destroy the Earth ~ but there's no trigger

Model of a Uranium Atom

Oak Ridge TN

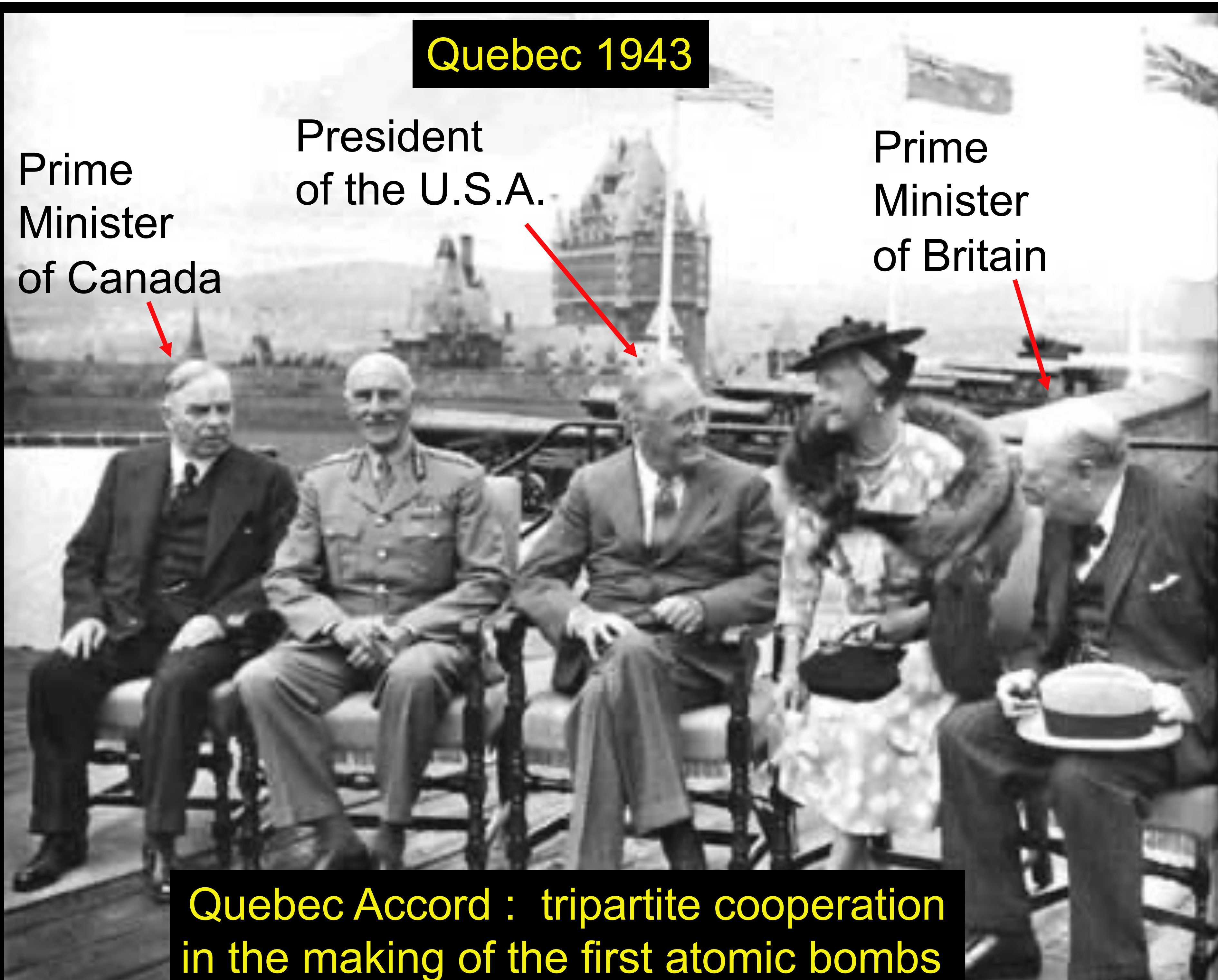
Uranium is the key element in all nuclear fission technology

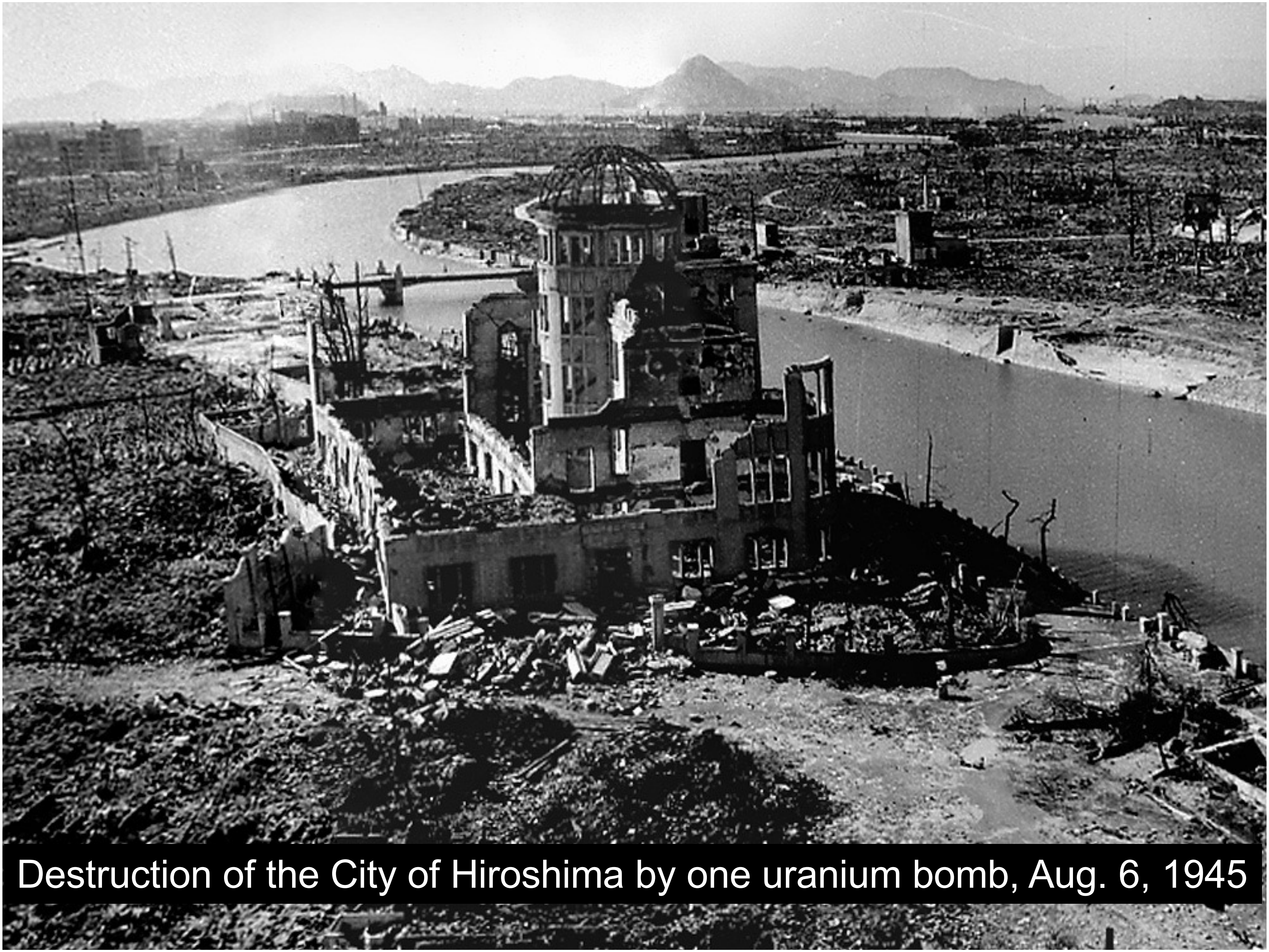
Without it there would be

1) NO Nuclear weapons

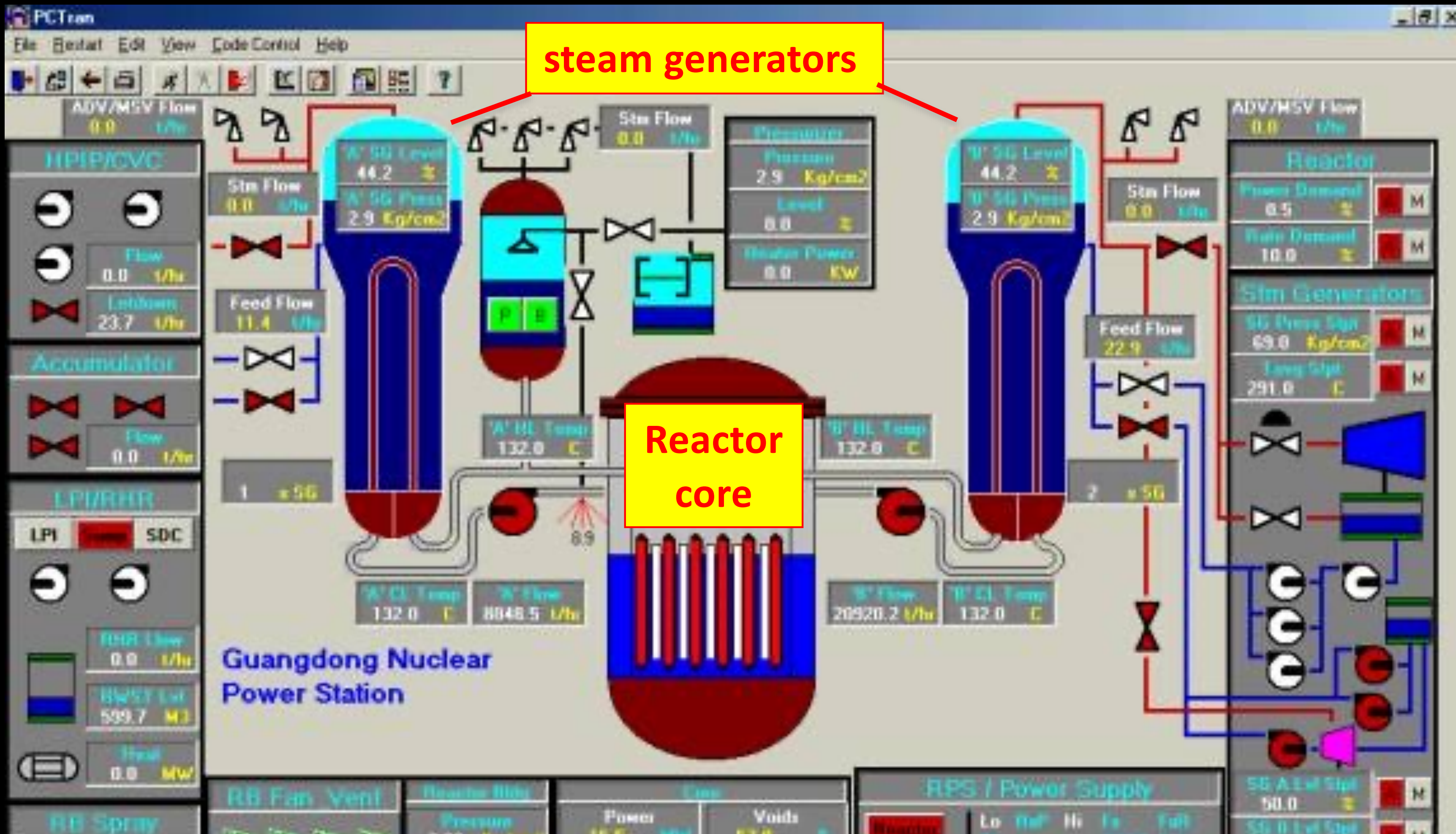
2) NO Nuclear reactors

Photo: Robert Del Tredici


Quebec 1943
Prime Minister of Canada
President of the U.S.A.
Prime Minister of Britain
Quebec Accord : tripartite cooperation in the making of the first atomic bombs



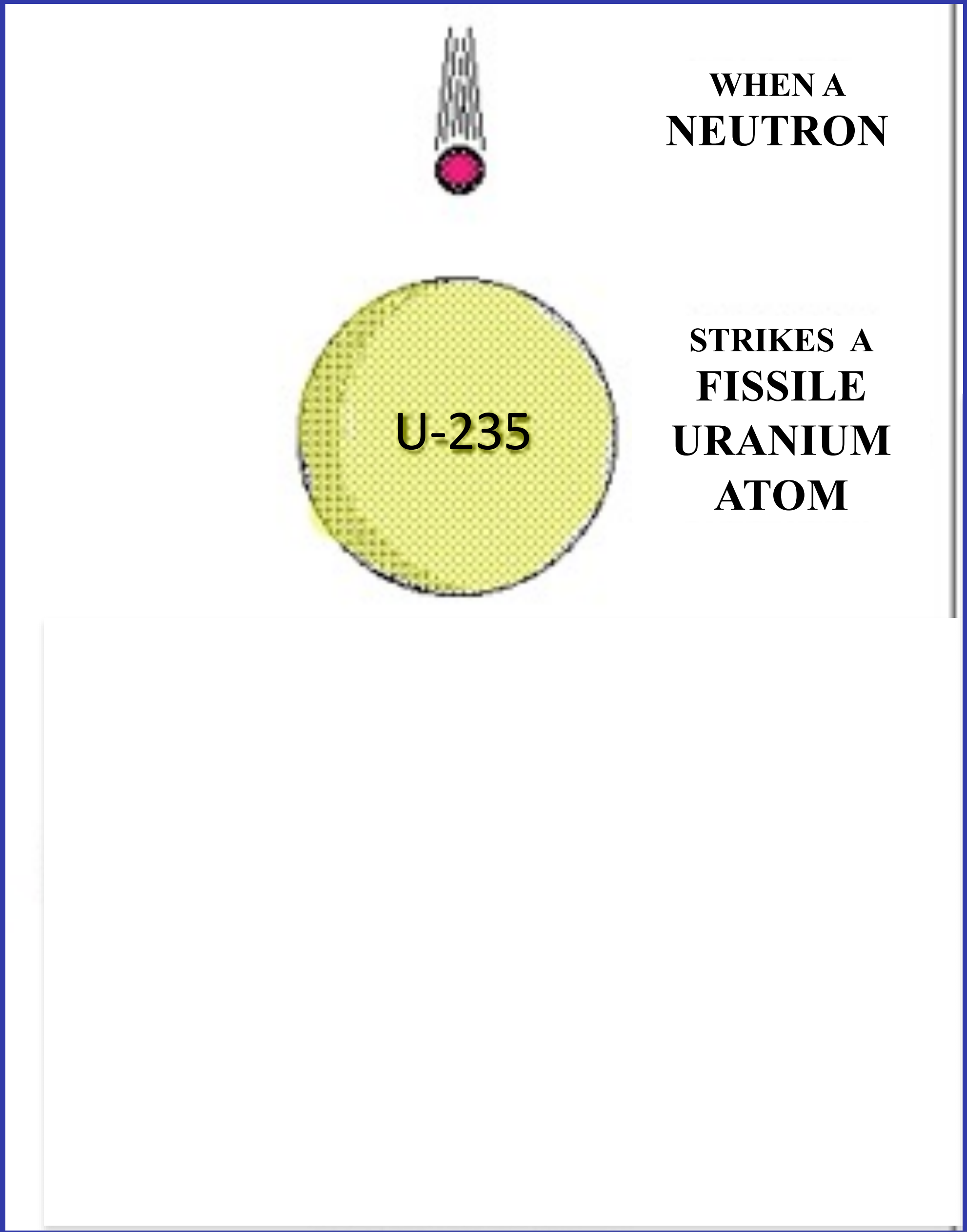
Destruction of the City of Hiroshima by one uranium bomb, Aug. 6, 1945



1. In the core, uranium atoms are split, releasing heat.
2. The heat boils water in vessels called steam generators
3. The steam is used to spin a turbine to generate electricity.
4. *Meanwhile **hundreds of unwanted radioactive byproducts are created**.*

What is Nuclear Fission?

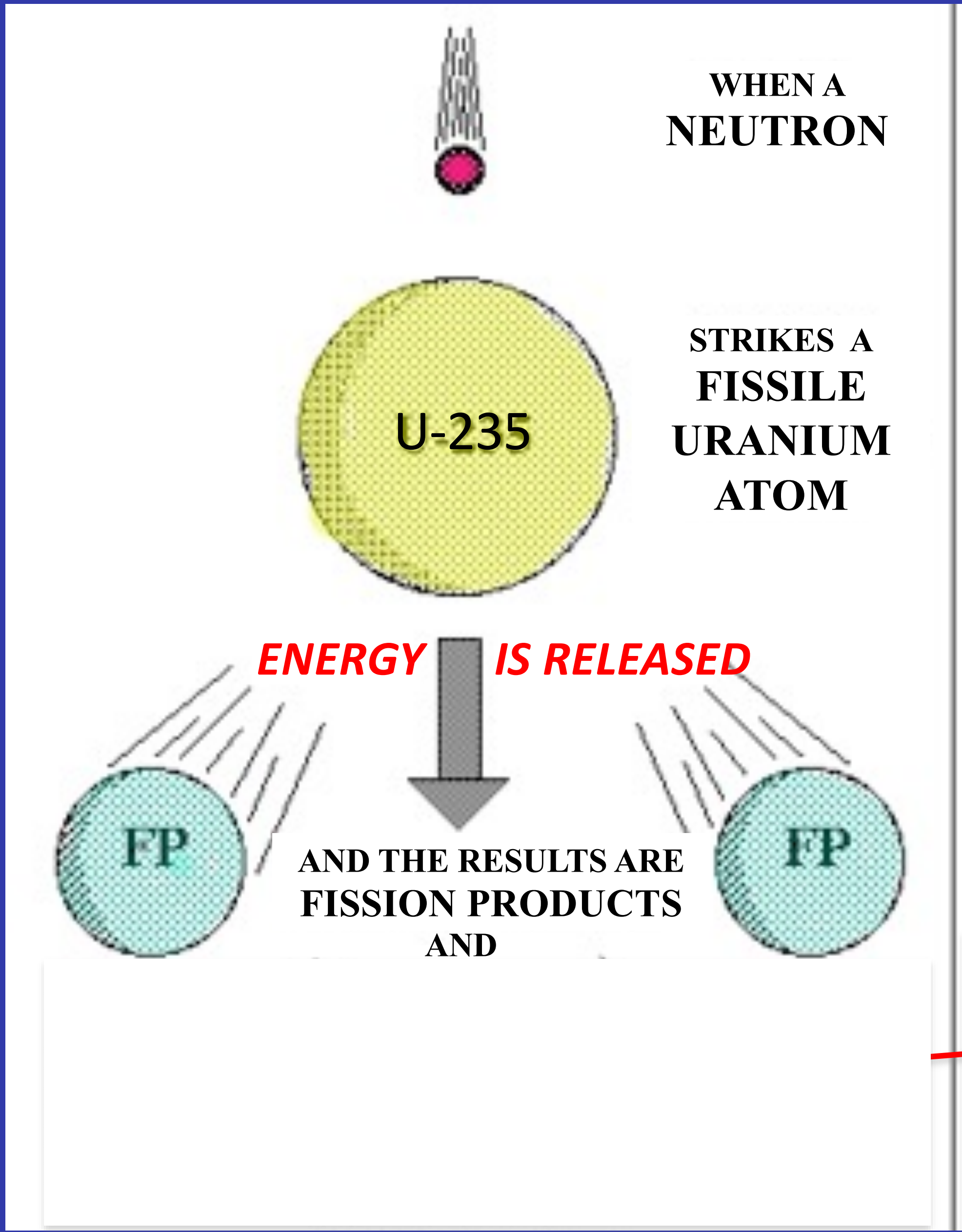
1938-39



A subatomic projectile called a neutron starts a nuclear chain reaction by splitting a nucleus of "fissile uranium" (U-235).

Splitting the Nucleus

1938-39



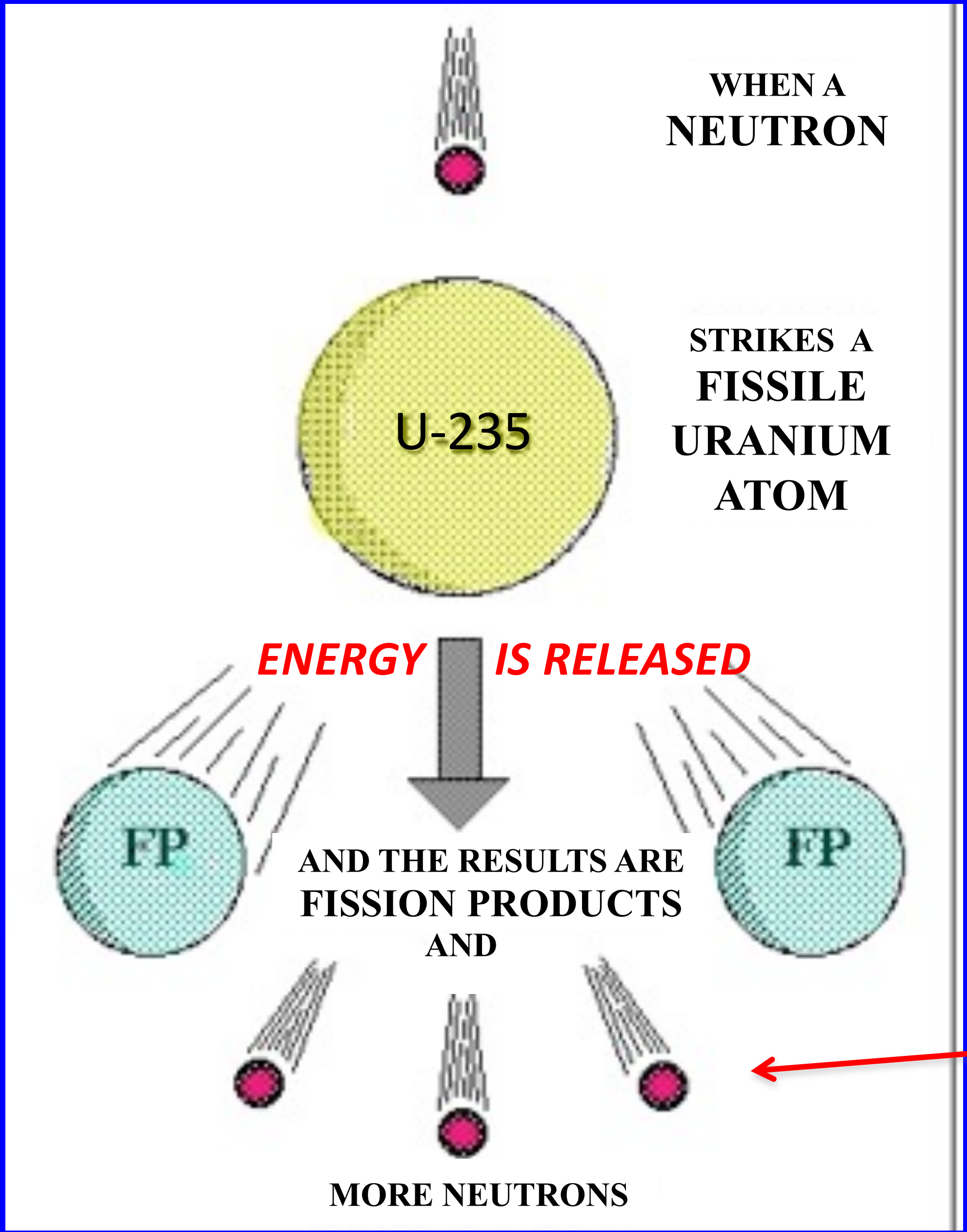
A subatomic projectile called a neutron starts a nuclear chain reaction by splitting a nucleus of "fissile uranium" (U-235).

The atom splits into two smaller atoms and energy is released – along with 2 or 3 extra neutrons.

The 2 smaller atoms are new radioactive materials called "fission products".

Chain Reaction

1938-39



The atom splits into fragments In hundreds of ways.

The broken pieces are mostly toxic radioactive atoms that constitute the bulk of the waste in the used nuclear fuel.

More neutrons trigger more fissions, and some go on to produce more radioactive byproducts.

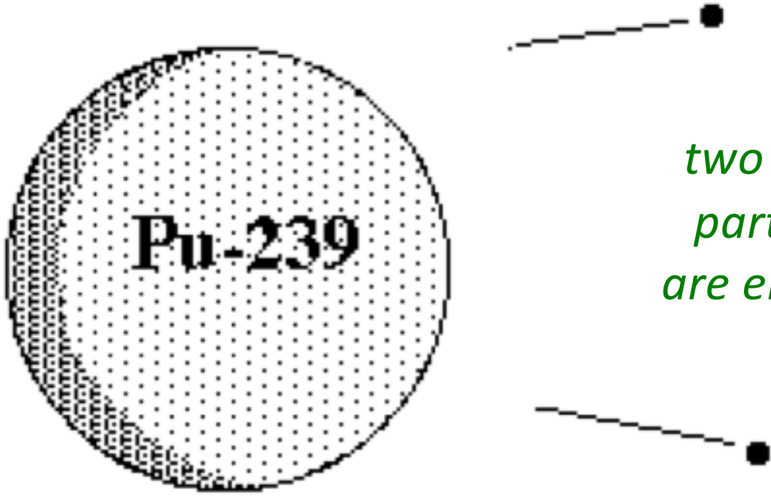
What do the extra neutrons do?

- *They keep on producing more fission products*
- *They turn some uranium into plutonium*
- *They "activate" everything in the core*

Creation of plutonium inside a nuclear reactor …

. . . when an atom of uranium-238 absorbs a neutron

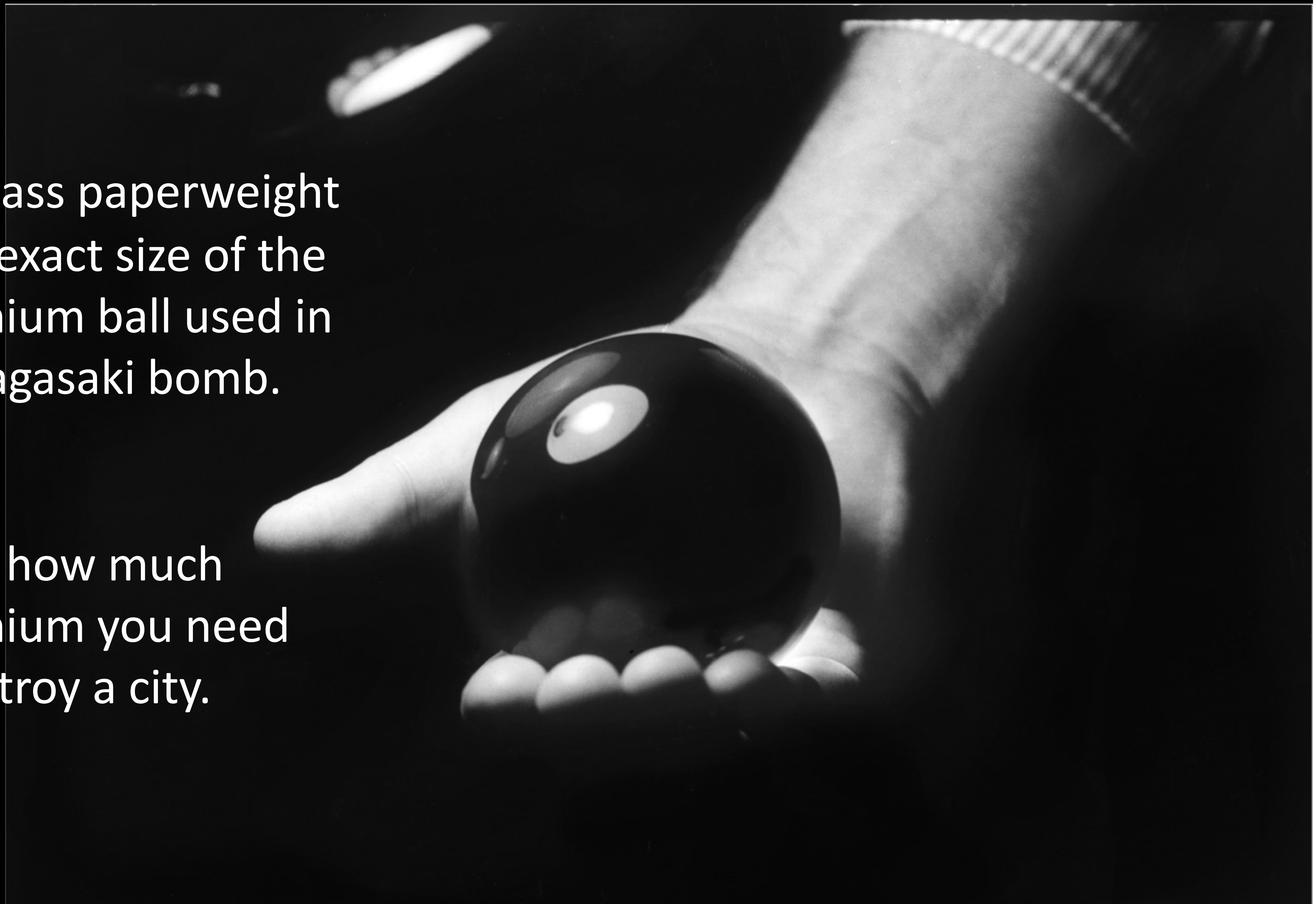
Absorption of a neutron creates a heavier ("transuranic") element



. . . it is transformed into an atom of plutonium-239

Other transuranic actinides are produced in a similar way.

This glass paperweight is the exact size of the plutonium ball used in the Nagasaki bomb.



That’s how much plutonium you need to destroy a city.

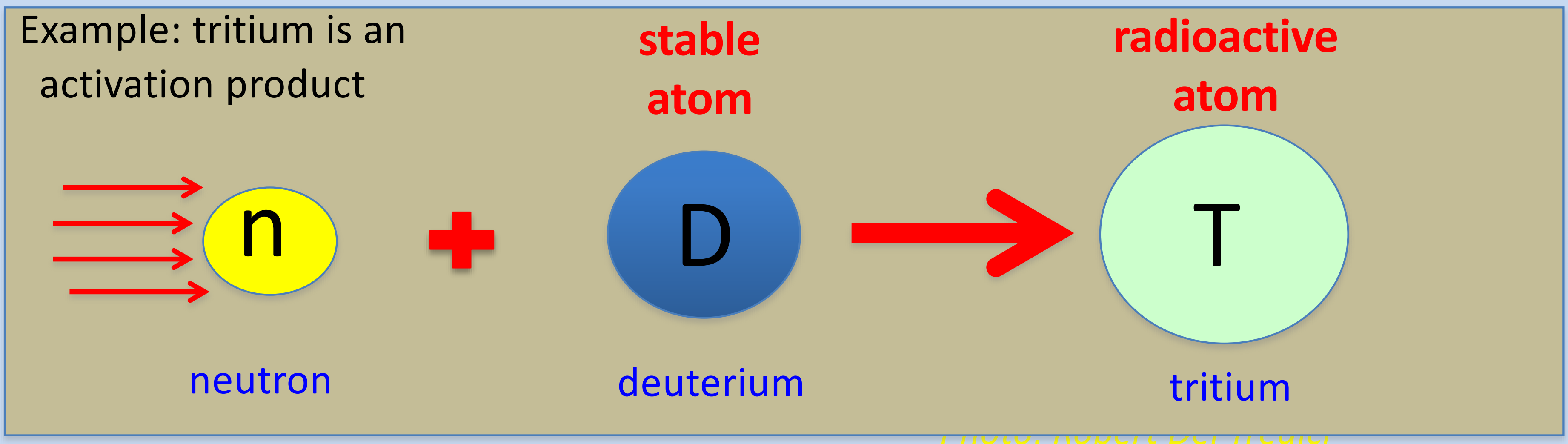
Photo: Robert Del Tredici

Howard Morland with model of an H-bomb (thermonuclear bomb) showing the plutonium ball needed to raise the temperature to 100 million degrees so that nuclear fusion can start.

Photo: Robert Del Tredici

What is an Activation Product?

When a stray neutron is absorbed by a non-radioactive atom the result is often a radioactive atom – an “activation product”.



The diagram shows how a non-radioactive atom of deuterium becomes a radioactive atom of tritium when it absorbs a stray neutron.

What gets activated?

Water is activated and produces radioactive tritium (T) (chemically identical to ordinary hydrogen, but radioactive)

Air is activated and produces radioactive carbon-14 (C-14).

All organic molecules have carbon and tritium in them, so these radioactive varieties become incorporated into our DNA.

Even the **structural materials** in the core area of the reactor become radioactive waste, dangerous for 1000s of years.

Steel, concrete, zirconium, and other materials are activated – so **cannot be recycled** – but must be stored as radioactive waste.

Impurities in the fuel and in the cladding are also activated.

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

F.I.A.P. = fuel impurity activation product   Z.A.P. = zirconium cladding activation product   [source: AECL]

Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)
H (T)	Hydrogen (Tritium)	3	¥¥¥	¥	¥	
Be	Beryllium	10		¥	¥	
C	Carbon	14		¥¥¥	¥¥¥	
Si	Silicon	32		¥	¥	
P	Phosphorus	32		¥	¥	
S	Sulphur	35		¥		
Cl	Chlorine	36		¥		
Ar Ar	Argon Argon	39 42		¥ ¥	¥ ¥	
K K	Potassium Potassium	40 42		¥	 ¥	
Ca Ca	Calcium Calcium	41 45		¥	 ¥	
Sc	Scandium	46		¥		
Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)
V	Vanadium	50			¥	
Mn	Manganese	54		¥	¥¥¥	
Fe Fe	Iron Iron	55 59		¥¥¥	¥¥¥ ¥	
Co Co	Cobalt Cobalt	58 60		¥ ¥¥¥	¥ ¥¥¥	
Ni Ni	Nickel Nickel	59 63		¥ ¥¥¥	¥¥¥ ¥¥¥	
Zn	Zinc	65		¥	¥	
Se	Selenium	79	¥¥¥			
Kr Kr	Krypton Krypton	81 85	¥ ¥¥¥			
Rb	Rubidium	87	¥			
Sr Sr	Strontium Strontium	89 90	¥ ¥¥¥	 ¥	¥ ¥	
Y	Yttrium	90	¥¥¥	¥	¥	

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

Y	Yttrium	91	¥		¥	
Zr	Zirconium	93	¥¥¥	¥	¥¥¥	
Zr	Zirconium	95	¥	¥	¥	
Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)
Nb	Niobium	92			¥	
Nb	Niobium	93m	¥¥¥	¥	¥¥¥	
Nb	Niobium	94	¥	¥	¥¥¥	
Nb	Niobium	95	¥	¥	¥	
Nb	Niobium	95m	¥		¥	
Mo	Molybdenum	93		¥	¥	
Tc	Technetium	99	¥¥¥	¥	¥	
Ru	Ruthenium	103	¥			
Ru	Ruthenium	106	¥¥¥			
Rh	Rhodium	103m	¥			
Rh	Rhodium	106	¥¥¥			
Pd	Palladium	107	¥¥¥			
Ag	Silver	108	¥	¥	¥	
Ag	Silver	108m	¥	¥¥¥	¥	
Ag	Silver	109m	¥	¥	¥	
Ag	Silver	110	¥	¥	¥	
Ag	Silver	110m	¥	¥	¥	
Cd	Cadmium	109	¥	¥	¥	
Cd	Cadmium	113	¥		¥	
Cd	Cadmium	113m	¥¥¥		¥	
Cd	Cadmium	115	¥			
Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)
In	Indium	113m			¥	
In	Indium	114	¥	¥	¥	
In	Indium	114m			¥	
In	Indium	115			¥	
Sn	Tin	113			¥	
Sn	Tin	117m	¥	¥	¥	
Sn	Tin	119m	¥¥¥		¥¥¥	
Sn	Tin	121m	¥		¥¥¥	
Sn	Tin	123	¥		¥	

F.I.A.P. = fuel impurity activation product *Z.A.P. = zirconium cladding activation product* *[source: AECL]*

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

Sn	Tin	125	¥¥¥		¥	
Sn	Tin	126				
Sb	Antimony	124	¥		¥	
Sb	Antimony	125	¥¥¥		¥¥¥	
Sb	Antimony	126	¥		¥	
Sb	Antimony	126m	¥¥¥			
Te	Tellurium	123	¥		¥	
Te	Tellurium	123m	¥		¥	
Te	Tellurium	125m	¥¥¥		¥¥¥	
Te	Tellurium	127	¥		¥	
Te	Tellurium	127m	¥		¥	
I	Iodine	129	¥		¥	
Standard Chemical Symbol	**Common Name of element**	**Atomic Mass Number**	**F.P.** Fission Product	**F.I.A.P.** Activation Product	**Z.A.P.** Activation Product	**Actinide** (includes progeny)
Cs	Cesium	134	¥			
Cs	Cesium	135	¥¥¥			
Cs	Cesium	137	¥¥¥			
Ba	Barium	137m	¥¥¥			
La	Lanthanum	138	¥			
Ce	Cerium	142	¥			
Ce	Cerium	144	¥¥¥			
Pr	Praseodymium	144	¥¥¥			
Pr	Praseodymium	144m	¥¥¥			
Nd	Neodymium	144	¥			
Pm	Promethium	147	¥¥¥			
Sm	Samarium	147	¥			
Sm	Samarium	148	¥	¥		
Sm	Samarium	149	¥			
Sm	Samarium	151	¥¥¥			
Eu	Europium	152	¥¥¥	¥		
Eu	Europium	154	¥¥¥	¥		
Eu	Europium	155	¥¥¥	¥		
Standard Chemical Symbol	**Common Name of element**	**Atomic Mass Number**	**F.P.** Fission Product	**F.I.A.P.** Activation Product	**Z.A.P.** Activation Product	**Actinide** (includes progeny)
Gd	Gadolinium	152	¥	¥		
Gd	Gadolinium	153	¥	¥		
Tb	Terbium	157		¥		

F.I.A.P. = fuel impurity activation product Z.A.P. = zirconium cladding activation product [source: AECL]

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

Tb	Terbium	160		¥		
Dy	Dysprosium	159		¥		
Ho	Holmium	166m	¥	¥		
Tm	Thulium	170		¥		
Tm	Thulium	171		¥		
Lu	Lutetium	176			¥	
Lu	Lutetium	176			¥	
Lu	Lutetium	176			¥	
Hf	Hafnium	175			¥	
Hf	Hafnium	181			¥	
Hf	Hafnium	182			¥	
Ta	Tantalum	180			¥	
Ta	Tantalum	182			¥	
Standard Chemical Symbol	**Common Name of element**	**Atomic Mass Number**	**F.P.** Fission Product	**F.I.A.P.** Activation Product	**Z.A.P.** Activation Product	**Actinide** (includes progeny)
W	Tungsten	181			¥	
W	Tungsten	185			¥	
W	Tungsten	188			¥	
Re	Rhenium	187			¥	
Re	Rhenium	188			¥	
Os	Osmium	194			¥	
Ir	Iridium	192			¥	
Ir	Iridium	192m			¥	
Ir	Iridium	194			¥	
Ir	Iridium	194m			¥	
Pt	Platinum	193			¥	
Tl	Thallium	206			¥	
Tl	Thallium	207				¥
Tl	Thallium	208				¥
Tl	Thallium	209				¥
Pb	Lead	204			¥	
Pb	Lead	205			¥	
Pb	Lead	209				¥
Pb	Lead	210				¥
Pb	Lead	211				¥
Pb	Lead	212				¥
Pb	Lead	214				¥
Standard	**Common Name of**	**Atomic Mass**	**F.P.**	**F.I.A.P.**	**Z.A.P.**	**Actinide**

F.I.A.P. = fuel impurity activation product   Z.A.P. = zirconium cladding activation product   [source: AECL]

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

Chemical Symbol	element	Number	Fission Product	Activation Product	Activation Product	(includes progeny)
Bi	Bismuth	208			¥	
Bi	Bismuth	210			¥	¥
Bi	Bismuth	210m				¥
Bi	Bismuth	211				¥
Bi	Bismuth	212				¥
Bi	Bismuth	213				¥
Bi	Bismuth	214				
Po	Polonium	210			¥	¥
Po	Polonium	211				¥
Po	Polonium	212				¥
Po	Polonium	213				¥
Po	Polonium	214				¥
Po	Polonium	215				¥
Po	Polonium	216				¥
Po	Polonium	218				¥
At	Astatine	217				¥
Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)
Rn	Radon	219				¥
Rn	Radon	220				¥
Rn	Radon	222				¥
Fr	Francium	221				¥
Fr	Francium	221				¥
Ra	Radium	223				¥
Ra	Radium	224				¥
Ra	Radium	225				¥
Ra	Radium	226				¥
Ra	Radium	228				¥
Ac	Actinium	225				¥
Ac	Actinium	227				¥
Ac	Actinium	228				¥
Th	Thorium	227				¥
Th	Thorium	228				¥
Th	Thorium	229				¥
Th	Thorium	230				¥
Th	Thorium	231				¥
Th	Thorium	232				¥

F.I.A.P. = fuel impurity activation product Z.A.P. = zirconium cladding activation product [source: AECL]

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

Th	Thorium	234				¥¥¥
Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)
Pa	Protactinium	231				¥
Pa	Protactinium	233				¥¥¥
Pa	Protactinium	234				¥
Pa	Protactinium	234m				¥¥¥
U	Uranium	232				¥
U	Uranium	233				¥
U	Uranium	234				¥¥¥
U	Uranium	235				¥
U	Uranium	236				¥¥¥
U	Uranium	237				¥¥¥
U	Uranium	238				¥¥¥
U	Uranium	240				¥
Np	Neptunium	237				¥¥¥
Np	Neptunium	238				¥
Np	Neptunium	239				¥¥¥
Np	Neptunium	240				¥
Np	Neptunium	240m				¥
Pu	Plutonium	236				¥
Pu	Plutonium	238				¥¥¥
Pu	Plutonium	239				¥¥¥
Pu	Plutonium	240				¥¥¥
Pu	Plutonium	241				¥¥¥
Pu	Plutonium	242				¥¥¥
Pu	Plutonium	243				¥
Pu	Plutonium	244				¥
Standard Chemical Symbol	Common Name of element	Atomic Mass Number	F.P. Fission Product	F.I.A.P. Activation Product	Z.A.P. Activation Product	Actinide (includes progeny)
Am	Americium	241				¥¥¥
Am	Americium	242				¥¥¥
Am	Americium	242m				¥¥¥
Am	Americium	243				¥¥¥
Am	Americium	245				¥
Cm	Curium	242				¥¥¥
Cm	Curium	243				¥¥¥

F.I.A.P. = fuel impurity activation product *Z.A.P. = zirconium cladding activation product* *[source: AECL]*

A LIST OF SELECTED RADIONUCLIDES IN IRRADIATED NUCLEAR FUEL

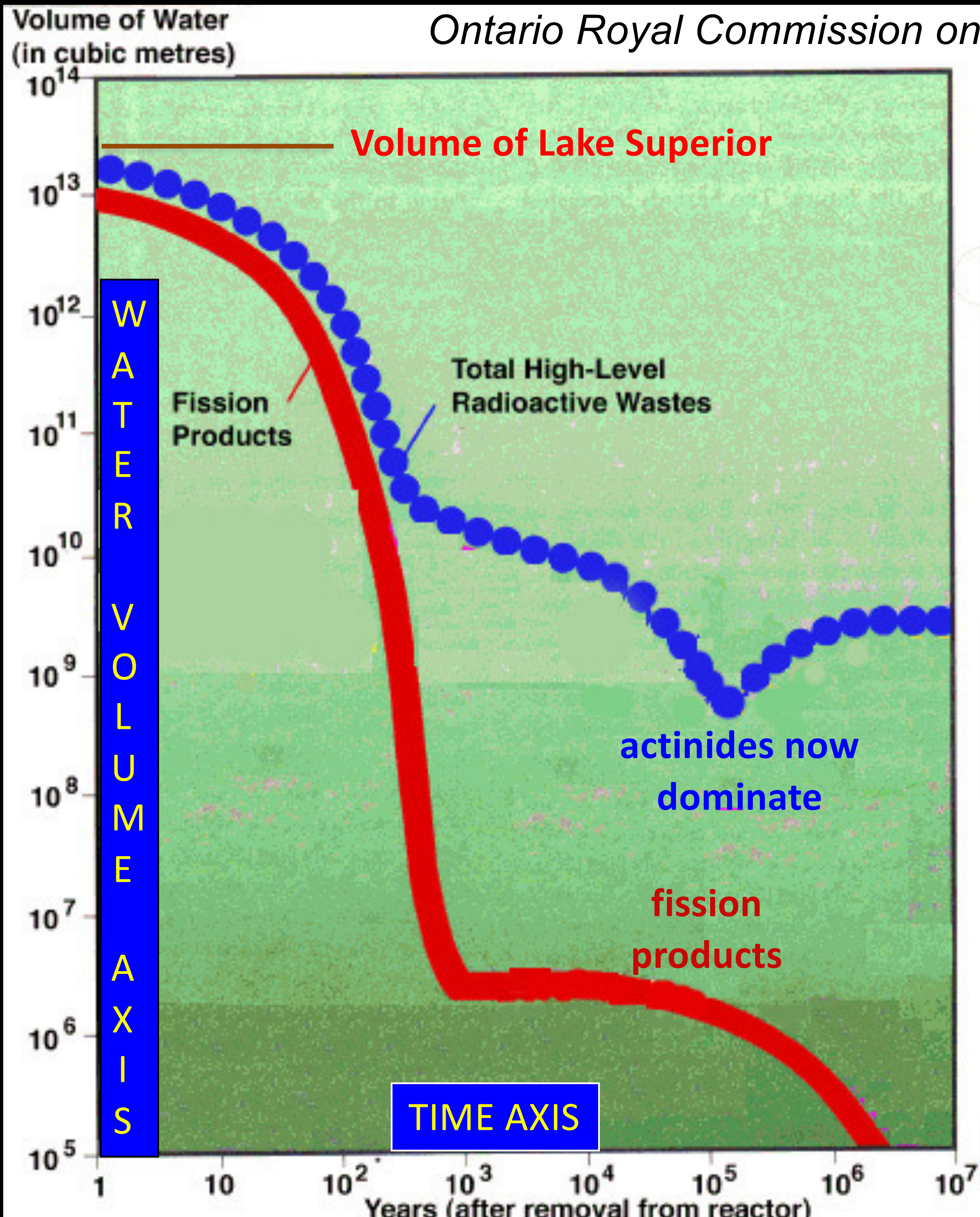
Cm	Curium	244				¥¥¥
Cm	Curium	245				¥
Cm	Curium	246				¥
Cm	Curium	247				¥
Cm	Curium	248				¥
Cm	Curium	250				¥
Bk	Berkelium	249				¥
Bk	Berkelium	250				¥
Cf	Californium	249				¥
Cf	Californium	250				¥
Cf	Californium	251				¥
Cf	Californium	252				¥
Standard Chemical Symbol	**Common Name of element**	**Atomic Mass Number**	**F.P.** Fission Product	**F.I.A.P.** Activation Product	**Z.A.P.** Activation Product	**Actinide** (includes progeny)

F.I.A.P. = fuel impurity activation product   *Z.A.P. = zirconium cladding activation product*   *[source: AECL]*

This list of 211 man-made radionuclides contained in irradiated nuclear fuel is by no means complete (AECL)

[AECL = Atomic Energy of Canada Limited]

Ontario Royal Commission on Electric Power Planning (1978)



For the first 500 – 1000 years, fission products are the deadliest components of nuclear fuel waste.

After 1000 years, actinides are the deadliest components of nuclear fuel waste.

The blue line shows radio-toxicity for a period of 10 million yrs

Royal Commission Report, 1978

ROUTINE RADIOACTIVE RELEASES

Annual tritium release from the Bruce A nuclear plant :
880 terabecquerels (3275 MWe). [tera = trillion = million million]

That’s 0.255 terabecquerels of tritium per megawatt of electricity

Wesleyville annual tritium emissions are estimated:

0.255 terabecquerels x 10,000 Mwe =
2,550 terabecquerels of tritium (per year)

Very discouraging for farmers, especially ORGANIC farmers.
(Brief story: elderly couple in Pembroke – organic veggies kaput.)

HOW MUCH WATER CAN YOU CONTAMINATE?

Maximum allowed = 7000 becquerels of tritium per litre (Let's call this "one slug").
One "slug" is how much tritium will compromise one litre of drinking water.

For Wesleyville plant : 2,550 trillion becquerels / 7 thousand becquerels = 364 billion "slugs".

So the annual emissions of tritium from the Wesleyville plant are enough, in principle, to compromise 364 billion litres of drinking water per year, or about one billion litres per day.

That's 68% over the daily water consumption in Montreal with a population of 1.95 million people.

ODWAC (Ontario Drinking water advisory council) says max. tritium in drinking water should be no more than 20 becquerels per litre.

Using that standard, yearly tritium emissions from Wesleyville could compromise an amount of water 350 times larger – contaminating the daily water use of 350 x 3.3 = 1.2 BILLION people

These girls are learning for the first time that radioactive liquid waste (reprocessing) was dumped into the Techa River causing deaths and illnesses: called "vegetative syndrome"

Photo: Robert Del Tredici

The End

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