Evaluating the Three Motivations for Reprocessing

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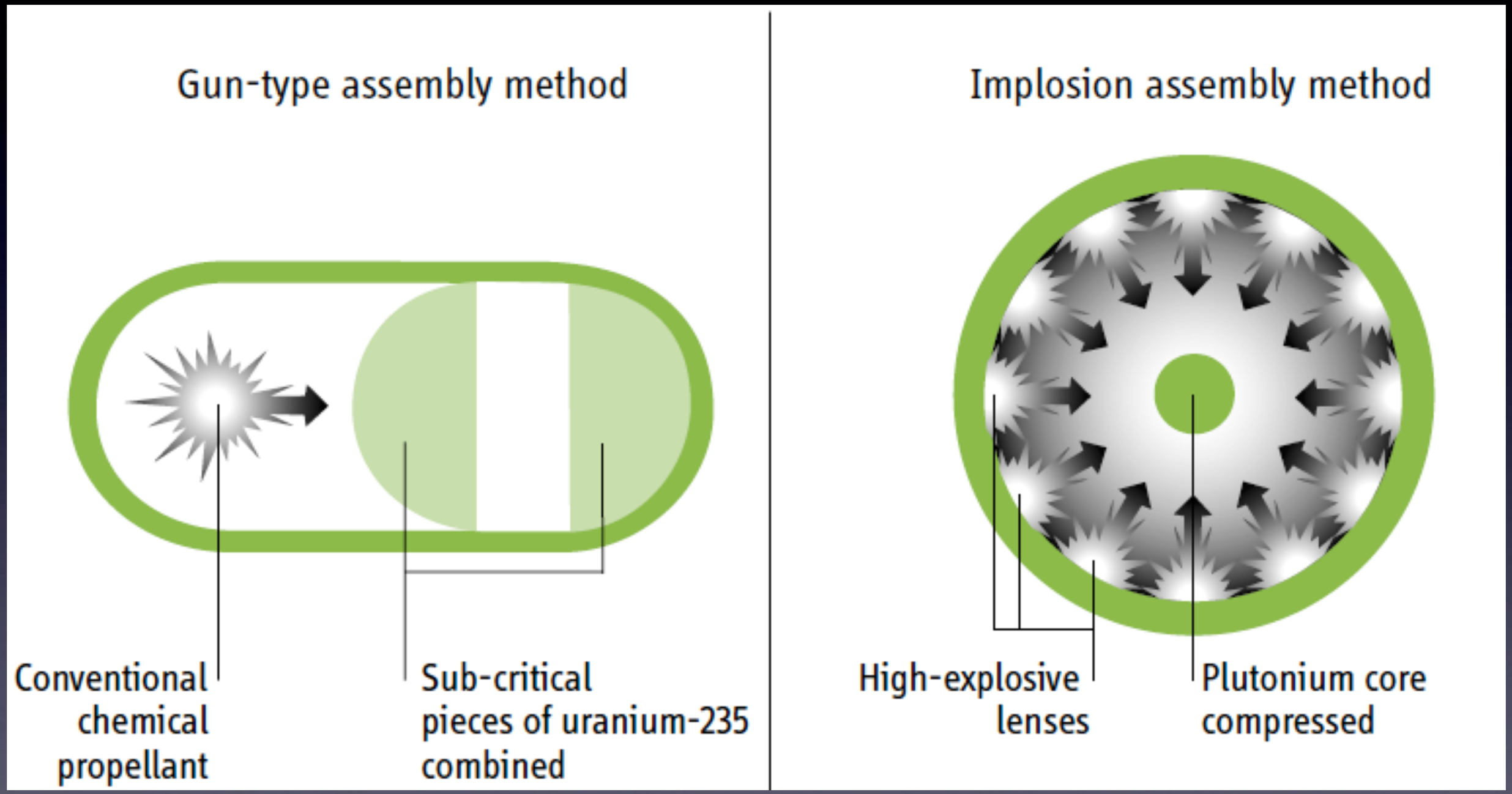
The University of British Columbia is located on the traditional, ancestral, and unceded territory of the Musqueam (xʷməθkʷəy̓əm) people

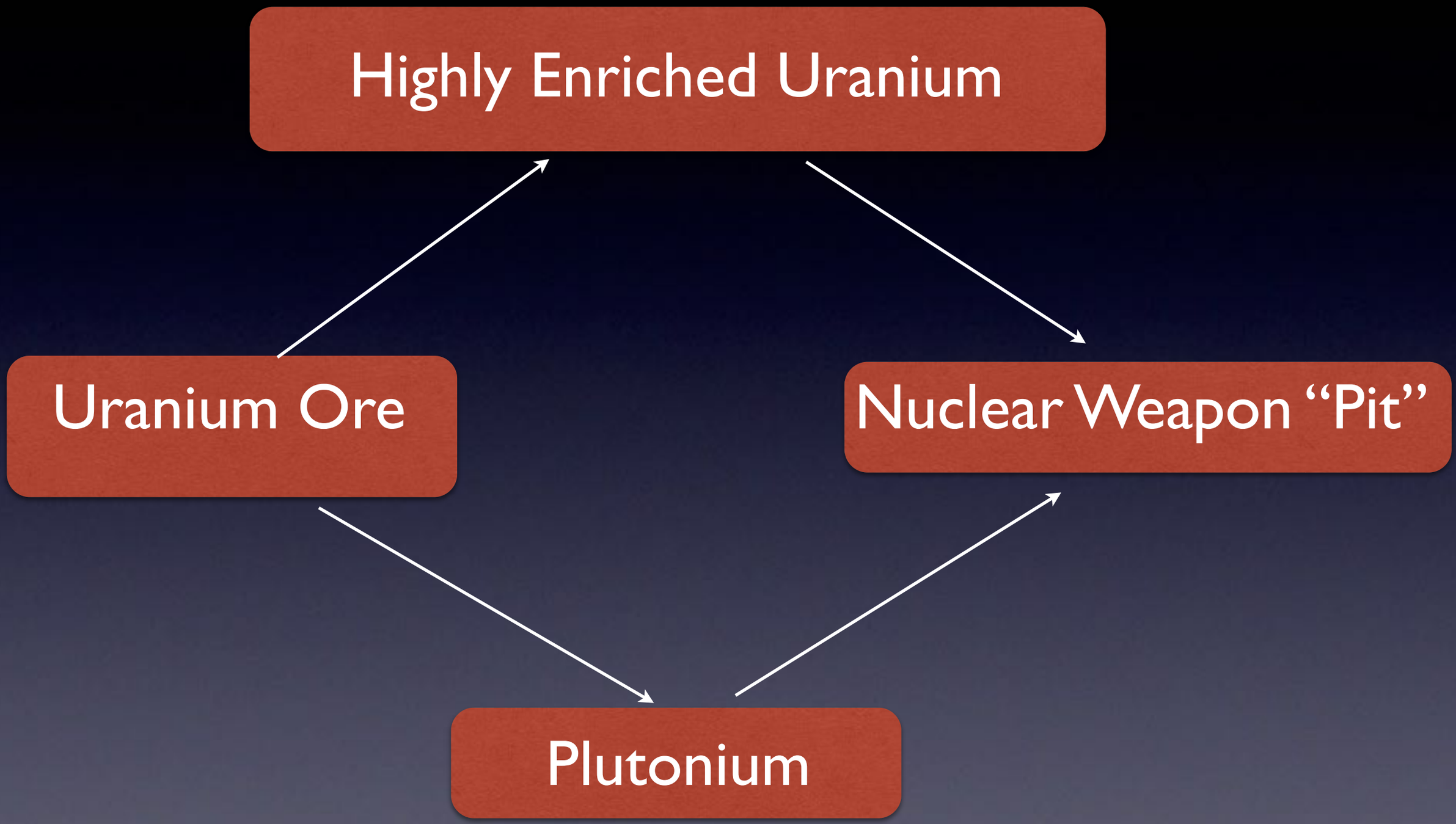
Webinar organized as part of
Ban Plutonium Reprocessing in Canada
campaign, 19 January 2023

The Original Motivation: Nuclear Weapons

Two Routes to a Nuclear Explosion



Source: Global Fissile Material Report 2006. Princeton: International Panel on Fissile Materials.


Highly Enriched Uranium
Uranium Ore
Nuclear Weapon “Pit”
Plutonium

Hanford B Reactor

Source: http://www.hanford.gov/page.cfm/BReactor#

First production reactor built between 1943 and 1944
Plutonium used in first nuclear test (July 1945 Trinity)

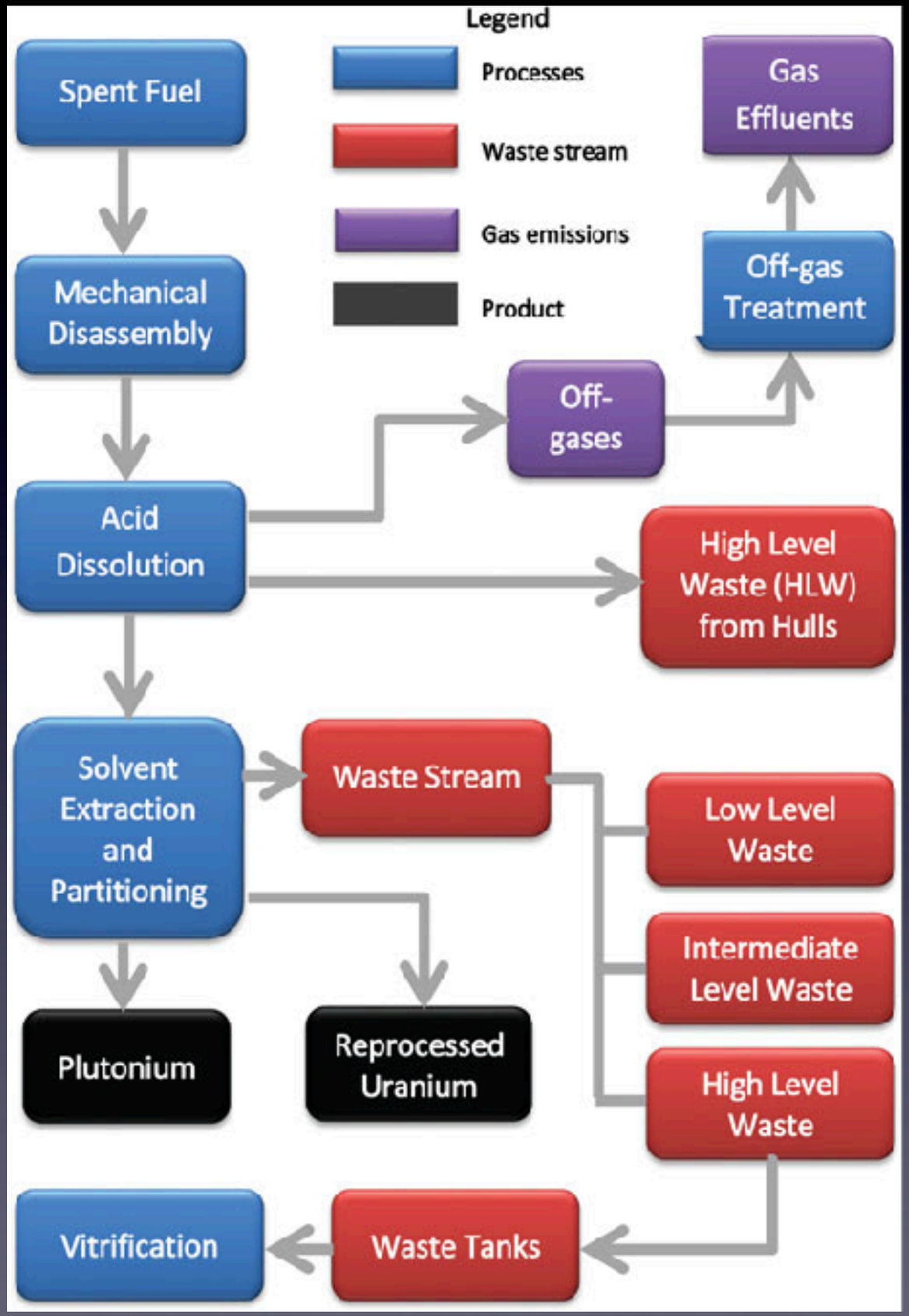
Reprocessing

The T Plant was the world's first reprocessing canyon. In 1944, it dissolved spent fuel from the Hanford B Reactor and chemically extracted the plutonium, which was then used to form the core of the Trinity and Nagasaki bombs. It continued reprocessing until 1956. Today, the plant is used to decontaminate equipment. *Hanford Site, Washington. July 11, 1994.*

Closing the Circle on the Splitting of the Atom: Environmental Legacy of Nuclear Weapons Production. in the United States and What the Department Of Energy Is Doing About It. Washington, D. C.: U.S. Department of Energy, 1995.

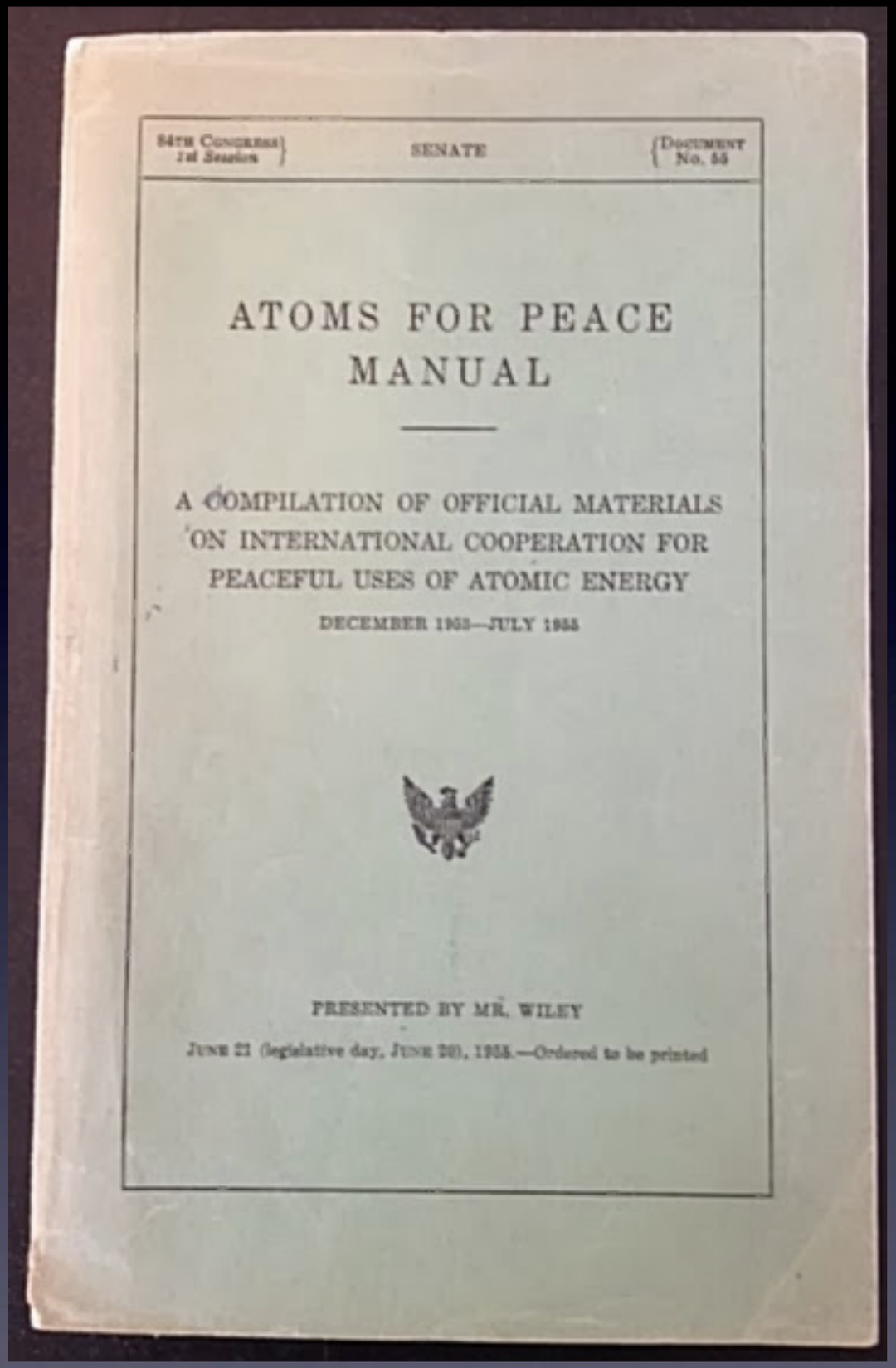
Trinity Test

Image Source: https://upload.wikimedia.org/wikipedia/commons/6/61/Trinity_Test_-_Oppenheimer_and_Groves_at_Ground_Zero_001.jpg



Flowchart for Traditional PUREX Process

Source: M.V. Ramana, A. H. Nayyar, and Michael Schoeppner. "Nuclear High-Level Waste Tank Explosions: Potential Causes and Impacts of a Hypothetical Accident at India's Kalpakkam Reprocessing Plant." Science & Global Security 24, no. 3 (September 2016): 174–203. https://doi.org/10.1080/08929882.2016.1237661.



84TH CONGRESS, 1st Session — SENATE — DOCUMENT No. 55

ATOMS FOR PEACE MANUAL

A COMPILATION OF OFFICIAL MATERIALS ON INTERNATIONAL COOPERATION FOR PEACEFUL USES OF ATOMIC ENERGY

DECEMBER 1953—JULY 1955

PRESENTED BY MR. WILEY

JUNE 22 (legislative day, JUNE 20), 1955.—Ordered to be printed

http://4.bp.blogspot.com/-O5vfnvdDAGg/UqIWrBZ-YpI/AAAAAAAAC4c/Ddmhc80VtNA/s1600/Atoms4PeaceManualFRT.jpg

Heavy Water Reactors

India's BARC Complex with CIRUS
Photograph by KH-7
reconnaissance satellite
19 February 1966
Canadian design

Israel's Dimona Reactor
Photograph by M. Vanunu
in or prior to 1985
French design

Trombay Reprocessing Plant and CIRUS

Source: Bhabha Atomic Research Centre

http://media2.intoday.in/indiatoday/images/stories//2015December/raj-4_121015061338.jpg

http://nsarchive.gwu.edu/nukevault/ebb333/

DECLASSIFIED
Authority NND 52947
By SE NARA Date 5/15/10

SECRET

DEPARTMENT OF STATE
WASHINGTON

April 2, 1977

SECRET

MEMORANDUM FOR: THE PRESIDENT

FROM: Warren Christopher, Acting

SUBJECT: Reprocessing Negotiations with Pakistan: A Negotiating Strategy

JIMMY CARTER

XXXIX *President of the United States: 1977-1981*

Nuclear Power Policy Statement on Decisions Reached Following a Review.

April 7, 1977

we will defer indefinitely the commercial reprocessing and recycling of the plutonium produced in the U.S. nuclear power programs

we will continue to embargo the export of equipment or technology that would permit uranium enrichment and chemical reprocessing

http://www.presidency.ucsb.edu/ws/?pid=7316

Motivation 2: Uranium is scarce and we will run out

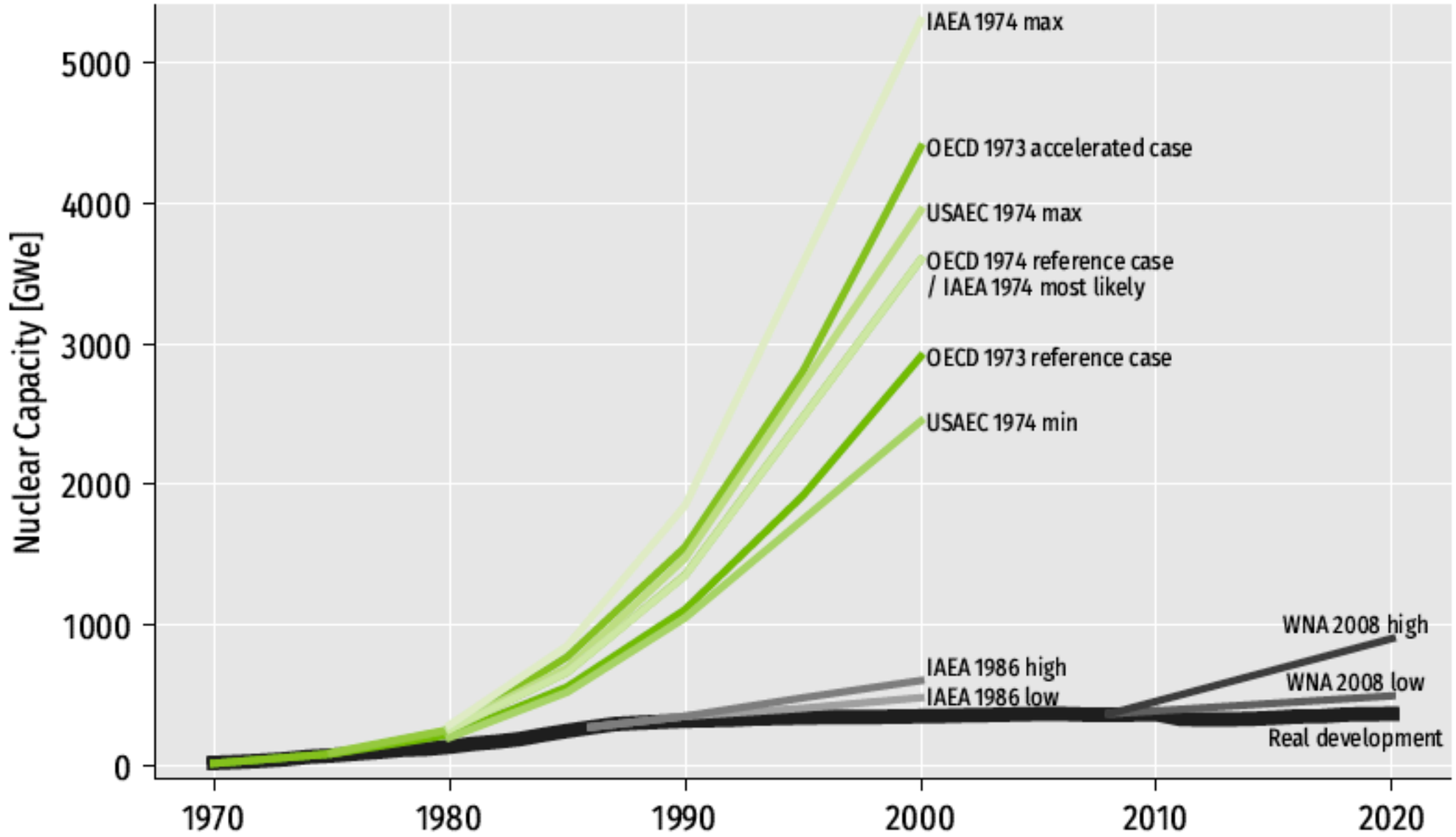


Figure 10. Operating nuclear capacity projections by U.S. and international organizations. Early projections covered time frames until 2000, later projections and development until 2020 shown for comparison.[58]

Source: IPFM. "Global Fissile Material Report 2022." Princeton: International Panel on Fissile Materials, 2022. https://fissilematerials.org/publications/2022/07/global_fissile_material_r.html.

Country	Facility	Design capacity (metric tonsU/yr)	Years of operation
Belgium	Eurochemic	30	1966–75
China	Jiuquan pilot plant	50	2010–
France	UP1 UP2 UP3	400 1000 1000	1958–97 1966– 1989–
Germany	WAK	35	1971–90
India (heavy water reactors [HWRs])	Tarapur I Tarapur II Kalpakkam	100 100 100	1982– 2011– 1996–
Italy (research & HWR)	EUREX	Pilot plant	1970–83
Japan	Tokai Rokkasho	200 800	1977–2014 2006–8, 2016?–
Soviet Union / Russia	RT1	200–400	1976–
United Kingdom (B204 and B205 for graphite-moderated reactors)	B204 B205 THORP	300 1500 1200	1952–73 1964–2020? 1994–2020?
United States	West Valley	300	1966–72

Table 1.1. Past and current civilian reprocessing plants.[28] All plants reprocessed light water reactor fuel except where indicated. Belgium, Germany, Italy, Japan, the Netherlands, Spain, Sweden, and Switzerland are former customers of France's reprocessing services and United Kingdom. Only the Netherlands has renewed. Armenia, Bulgaria, Czechoslovakia, East Germany, Finland, Hungary and Ukraine are former customers of the reprocessing services provided by Russian/Soviet facilities. Design capacity is also often expressed as tons of heavy metal per year (tHM/y). For natural or low-enriched uranium fuel, the heavy metal refers to the uranium in the original fuel. For MOX fuel, it refers to the plutonium and uranium originally in the fuel.

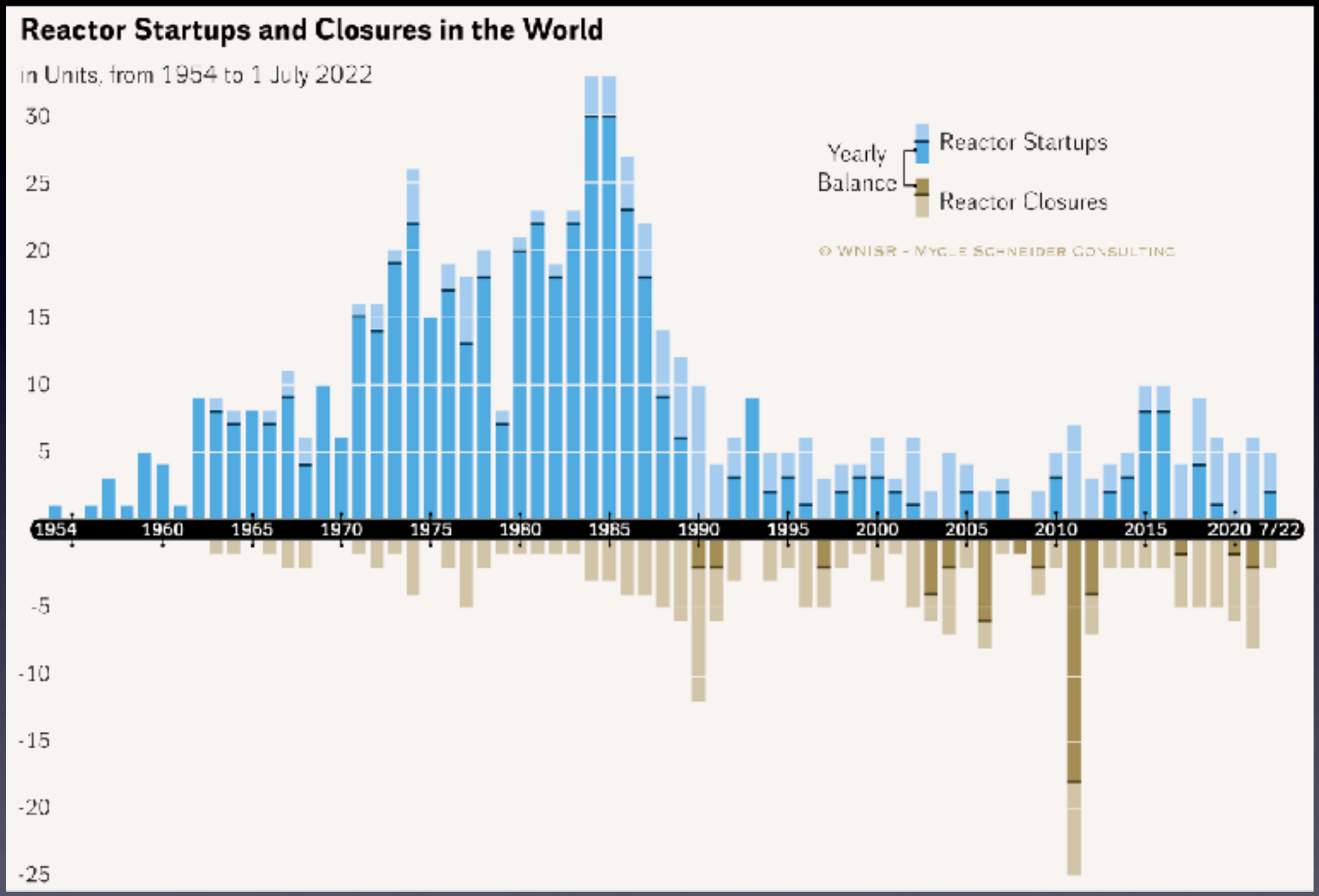
IPFM
INTERNATIONAL PANEL ON FISSILE MATERIALS

International Panel on Fissile Materials

Plutonium Separation in Nuclear Power Programs

Status, Problems, and Prospects of Civilian Reprocessing Around the World

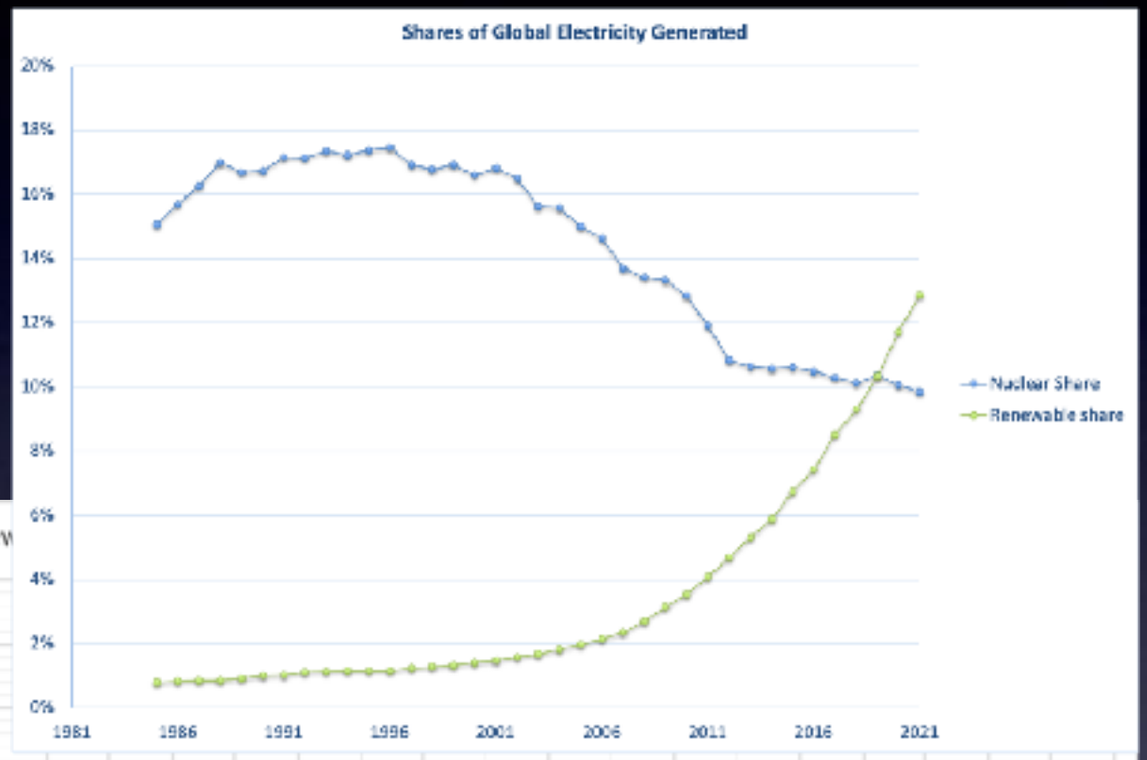
The best days of nuclear construction are over three decades ago

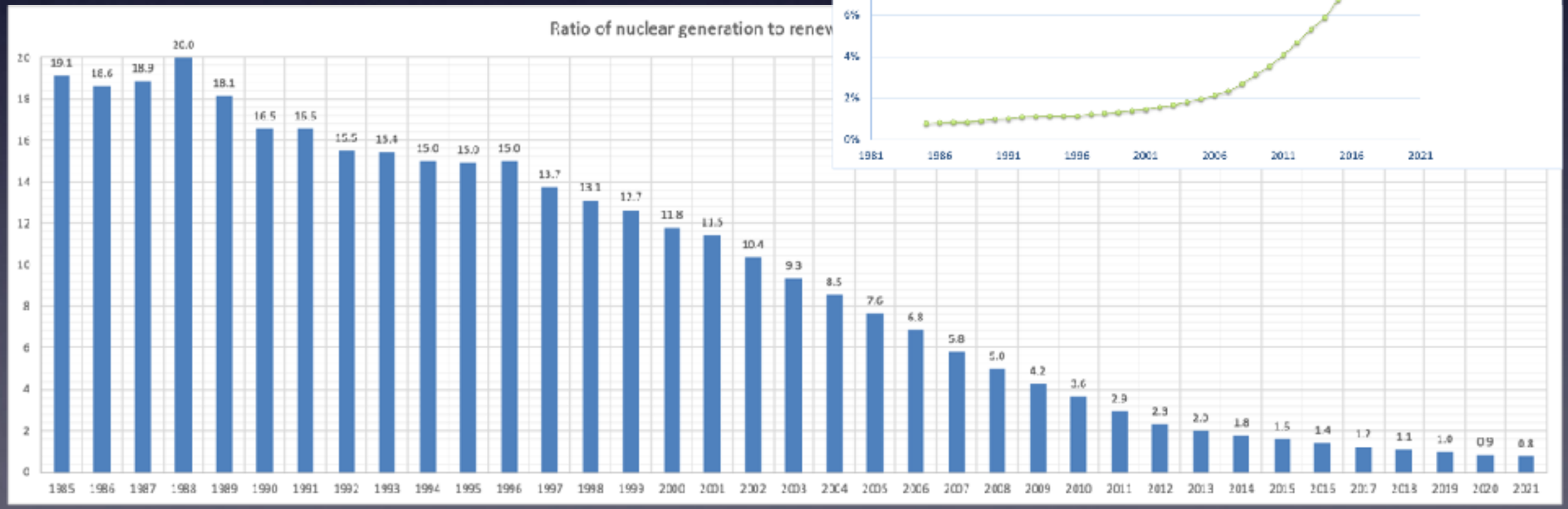


Source: World Nuclear Industry Status Report, 2022, Mycle Schneider Consulting.

Share of Electricity

About 40 percent below historical maximum of 17.6 percent in 1996





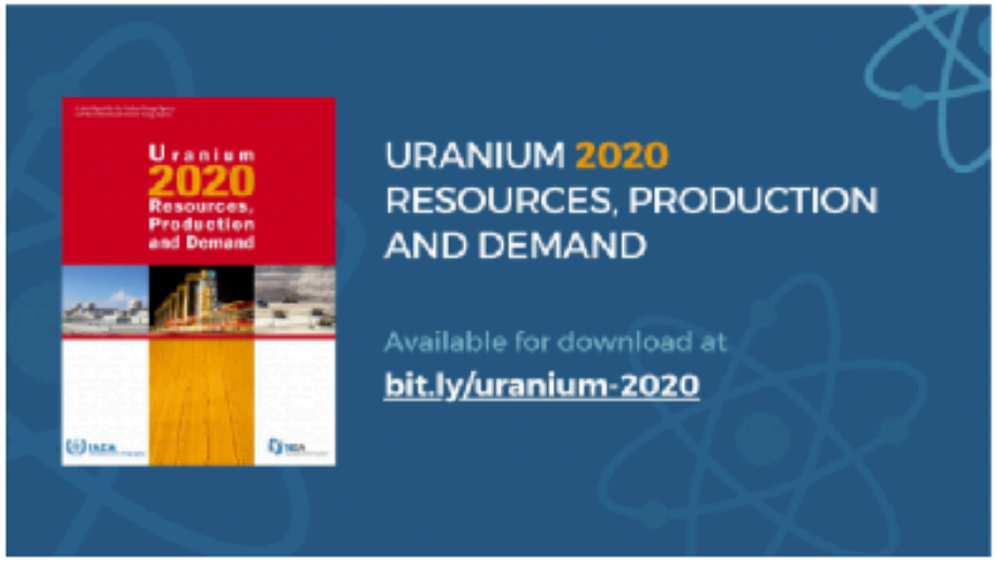
Source: Calculations using data from BP's Statistical Review of World Energy 2022

World's Uranium Resources Enough for the Foreseeable Future, Say NEA and IAEA in New Report

41/2020

Vienna, Austria

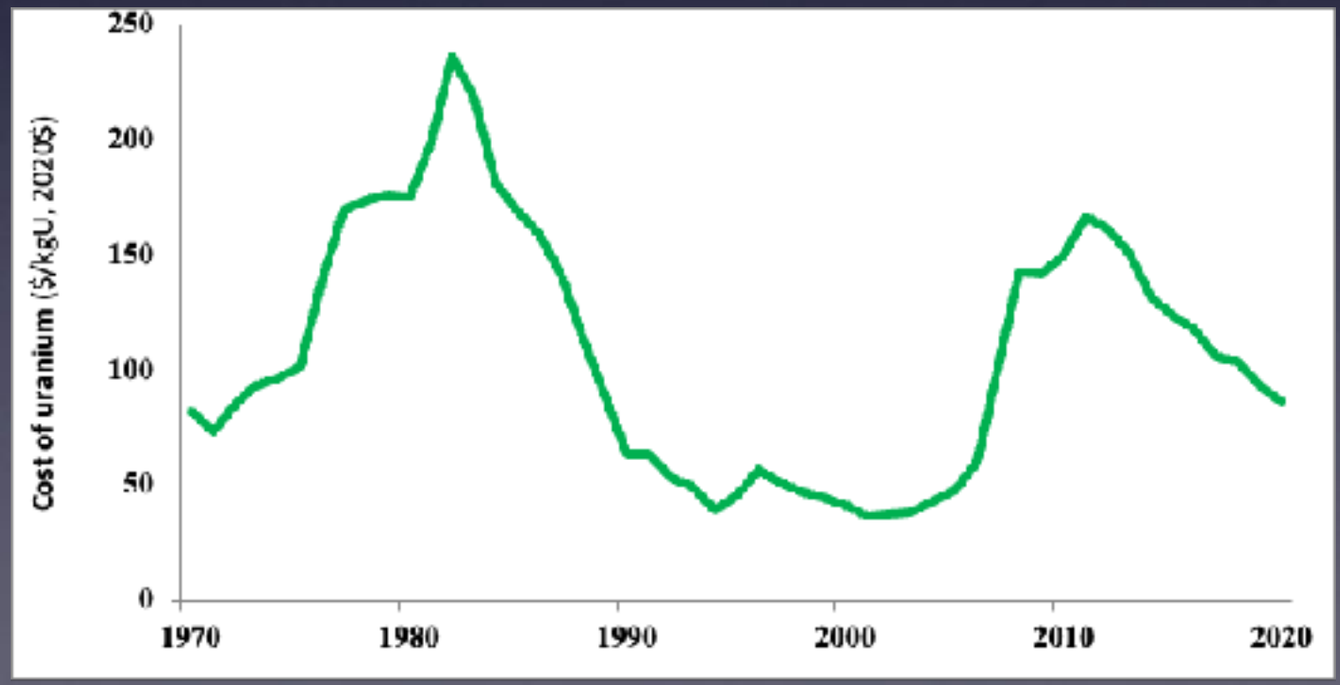
DEC
23
2020



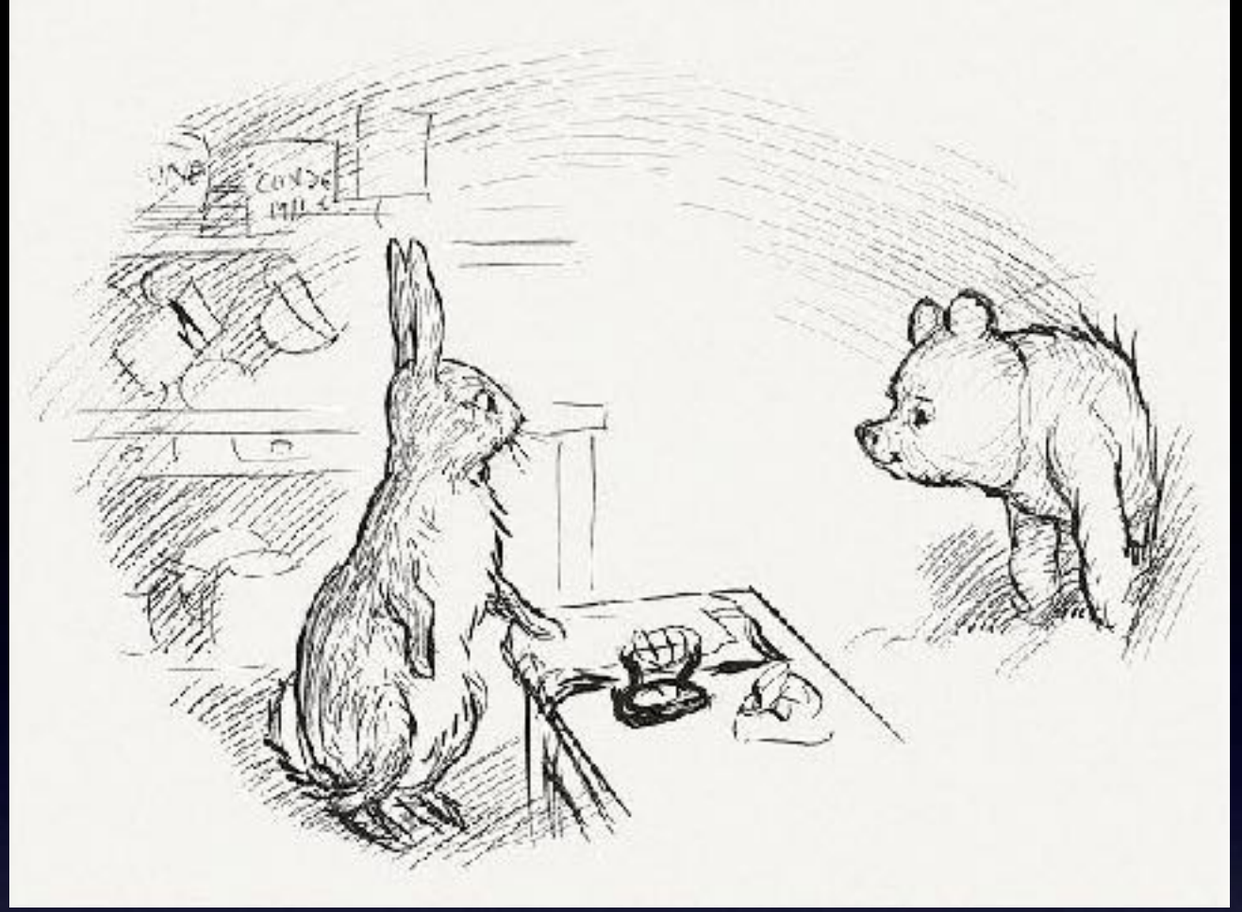
Related resources

- Uranium Resources
- Energy
- Department of Nuclear Energy

Source: https://www.iaea.org/newscenter/pressreleases/worlds-uranium-resources-enough-for-the-foreseeable-future-say-nea-and-iaea-in-new-report



Source: Webinar presentation by Frank von Hippel, 16 February 2022



“I don't see much sense in that,” said Rabbit.

“No,” said Pooh humbly, “there isn’t. But there was going to be when I began it. It’s just that something happened to it along the way.”

- A. A. Milne in *Winnie the Pooh*

Motivation 3:

Reprocessing will help deal with nuclear waste

WILEY WIREs ENERGY AND ENVIRONMENT

ADVANCED REVIEW

Technical and social problems of nuclear waste

M. V. Ramana

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M. V. Ramana, Liu Institute for Global Issues, School of Public Policy and Global Affairs, University of British Columbia, 6476 NW Mar Drive, Vancouver, BC, Canada V6T 1Z2.
Email: m.v.ramana@ubc.ca

Despite decades of effort, the nuclear industry does not yet have a working solu-

nuclear energy, nuclear weapons

1 | INTRODUCTION

Nuclear waste is controversial. Many consider it highly dangerous, "the least acceptable of hazardous wastes" in the words of a group of researchers who have been at the forefront of research on public attitudes towards risks of all kinds (Flynn et al., 1995, p. 8). Many also see the problem of dealing with it as negating any benefits that nuclear energy might produce. As one activist put it, "Electricity is but the fleeting byproduct from atomic reactors. The actual product is forever deadly radioactive waste" (Kamps, 2016). There is also an extensive literature that highlights various ethical problems associated with nuclear waste (Andren, 2012; Hannis & Rawles, 2013; Shrader-Frechette, 2000; Taebi, 2012).

An Enduring Problem: Radioactive Waste From Nuclear Energy

BY M. V. RAMANA
Program on Science and Global Security, Princeton University, Princeton, NJ, USA

Energy Policy 61 (2013) 196–206

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Shifting strategies and precarious progress: Nuclear waste management in Canada

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Nuclear Futures Laboratory and Program on Science and Global Security, Princeton University, 221 Nassau Street, Floor 2, Princeton, NJ 08542, USA

commercial reactors are finally going to be constructed. In November 2015, the ruling center-right party in Finland became the first government to grant a construction license for such a repository [1]. The U.S. Department of Energy is pursuing a consent-based process to set up a similar repository. Do these developments mean that a long-sought solution to the problem of nuclear waste is imminent?

As this article will argue, there are many fundamental reasons why dealing with radioactive waste is a special and enduring challenge. Even if a repository is constructed in one or two countries, those examples are by no means generalizable. The continuing problem of radioactive waste disposal, in turn, is another reason to be wary of a large-scale expansion of nuclear power.

Digital Object Identifier 10.1109/JPROC.2017.2661518

I. GEOLOGICAL DISPOSAL: THE PROMISE AND THE REALITY

Some of the radioactive elements produced during the operation of nuclear reactors have extremely long half-lives, and have to be isolated from human contact for hundreds of thousands of years (see Fig. 1). This requirement for stewardship is unprecedented in human history. Since the 1950s, nuclear establishments have advocated dealing with these radioactive wastes by constructing an underground repository in a suitable geological medium and placing the waste there, within special containers. Much attention from the technical community has been focused on finding a suitable location because the choice of geological media (e.g., granite, volcanic tuff, or clay) will influence the behavior of radionuclides when they escape from the container [2]. The question is one of "when," not "if"; because of corrosion, radionuclides will migrate into the biosphere over the long periods of time it would take for them to decay. As Allison Macfarlane, former Chair of the U.S. Nuclear Regulatory Commission put it, no "site will…contain nuclear waste indefinitely. The goal is to select a site and engineered features, such as the waste canister, which maximize the amount of time the waste is isolated" [3, p. 84].

Nevertheless, confidence in the idea of a repository remains high. The U.S. National Academy of Sciences'


THE DISPOSAL
of
RADIOACTIVE WASTE
ON LAND
Report of the
Committee on Waste Disposal
of the
Division of Earth Sciences
April 1957
NATIONAL ACADEMY OF SCIENCES
LIBRARY
DEC 4 1957
NATIONAL RESEARCH COUNCIL


ONE STEP AT A TIME
The Staged Development of Geologic Repositories for High-Level Radioactive Waste
Principles and Operational Strategies for Staged Repository Systems

Decide
Announce
Defend

Abandon!

THE HINDU

KARNATAKA

No plan to dump nuclear waste in Kolar Gold Fields: Minister

PTI

WIN! Nuclear waste dump ruled out for Saskatchewan

March 4, 2015 - 11:25am

The Executive for Future Generations receives the Award of the Year award in Saskatoon.

Jay Weatherill changes mind on nuclear dump ahead of election

South Australian Premier Jay Weatherill. Picture: AAP

Enter Moltex, and others

moltex energy
safer, cheaper, cleaner

Moltex Energy Canada Inc.
100 King Street West, Suite 1600,
Toronto M5X 1G5
www.moltexenergy.com

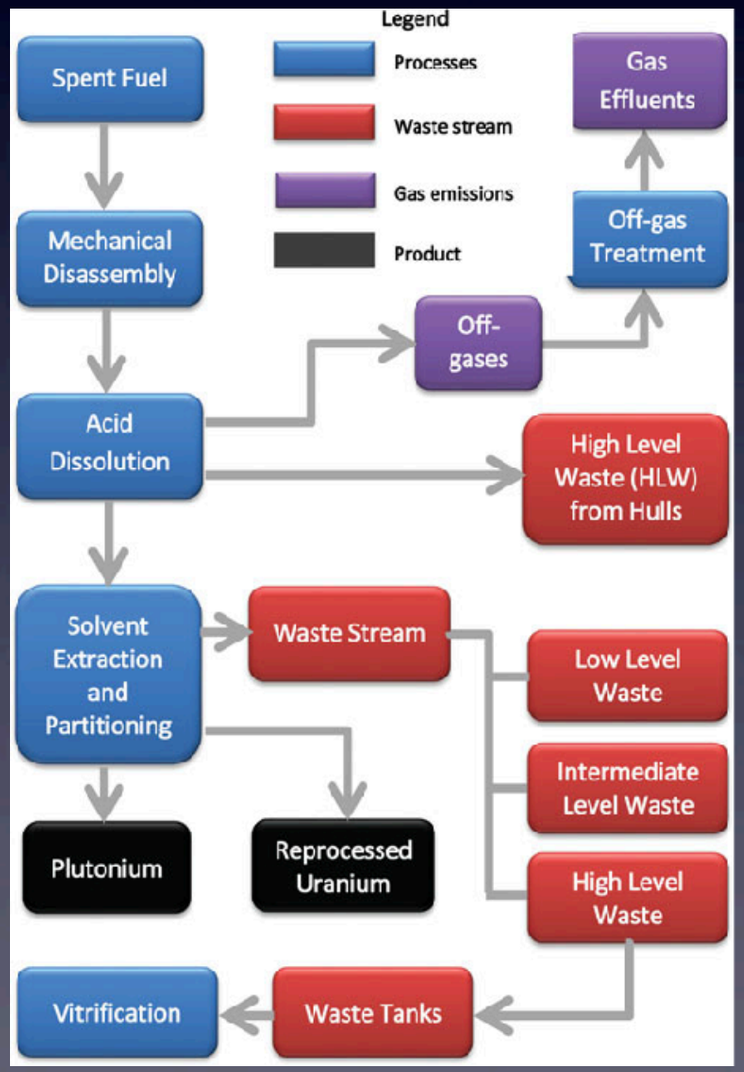
Net reduction in Nuclear Waste to produce limitless, carbon free energy, from Moltex

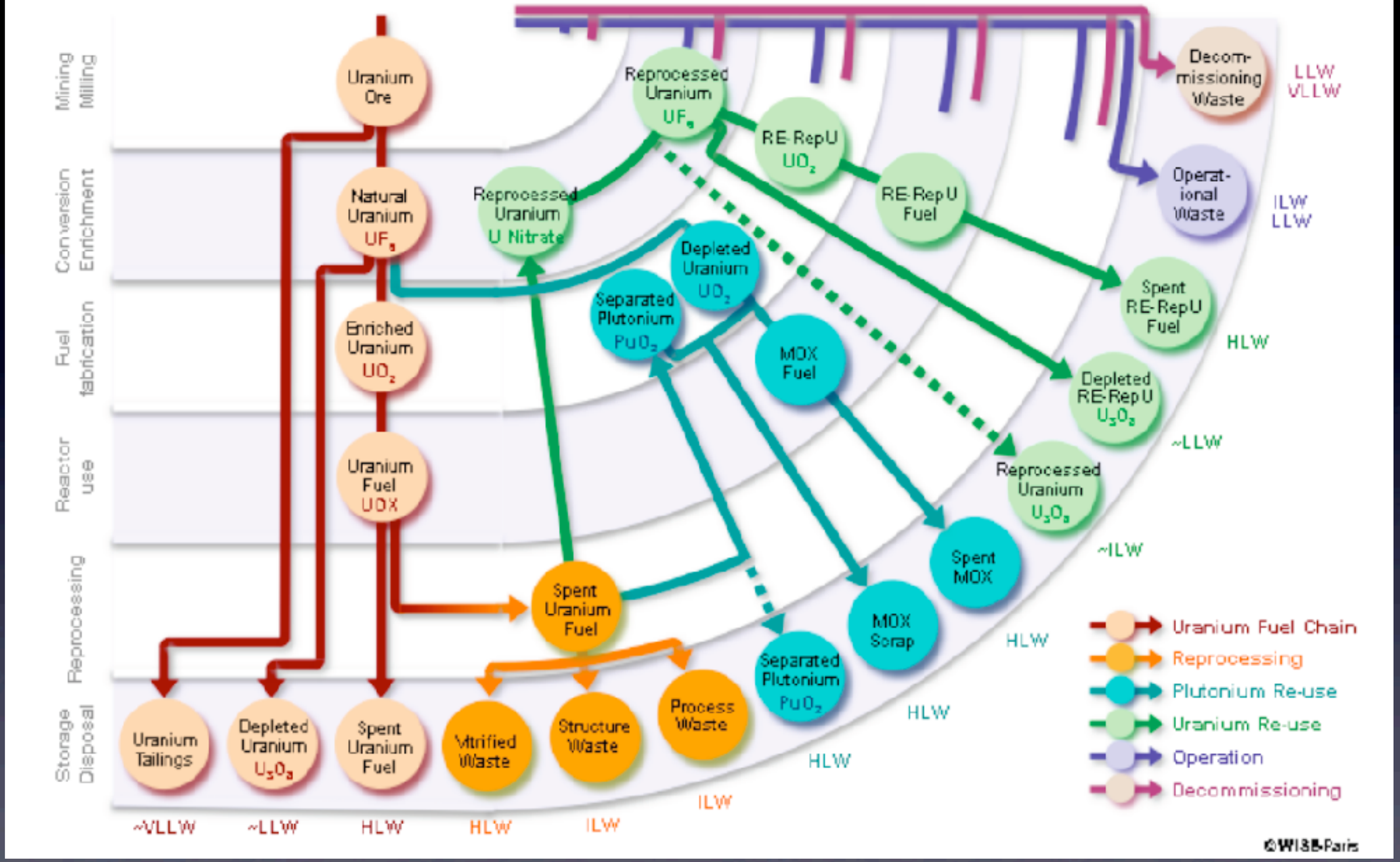
Moltex has invented an extraordinary new method for economically converting spent conventional nuclear waste into fuel for its fast spectrum molten salt reactor, known as WATSS (WAste To Stable Salt). The Moltex Stable Salt Reactor Wasteburner (SSR-W) utilises spent CANDU fuel (or any oxide fuel) converted to chloride form to produce low cost electricity.

Reprocessing Wastes

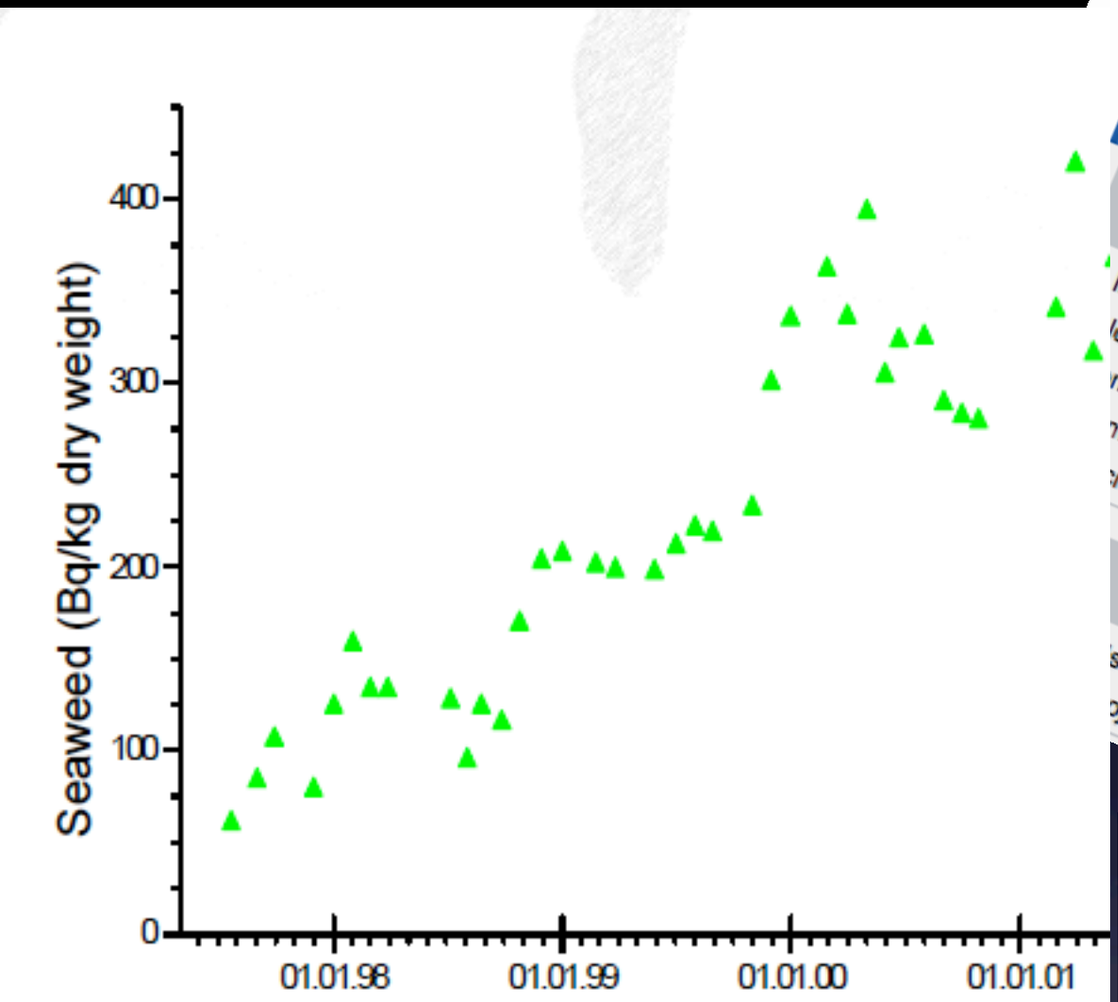
Reprocessing - chemical process to separate out different kinds of materials in spent fuel

Radioactivity doesn't go away - just gets split into different waste streams





Source: Mycle Schneider & World Information Service on Energy (WISE), Paris

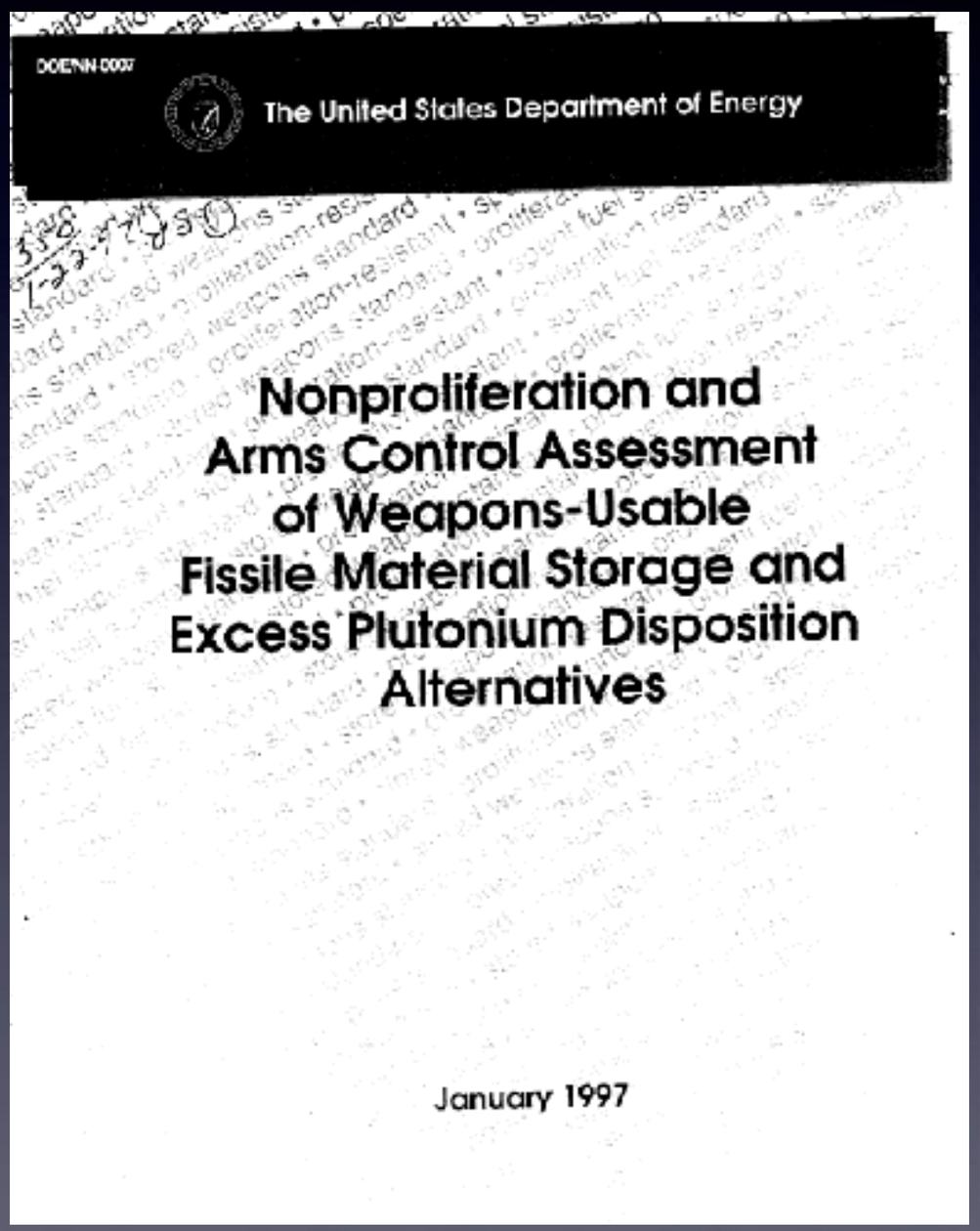


Trend in ^{99}Tc concentrations in bladder wrack Hillesøy in Troms county after the increased discha at Sellafield.

The Norwegian Radiation Protection Authority

Counter-arguments

Reactor Grade Plutonium cannot be used to make nuclear weapons - not true



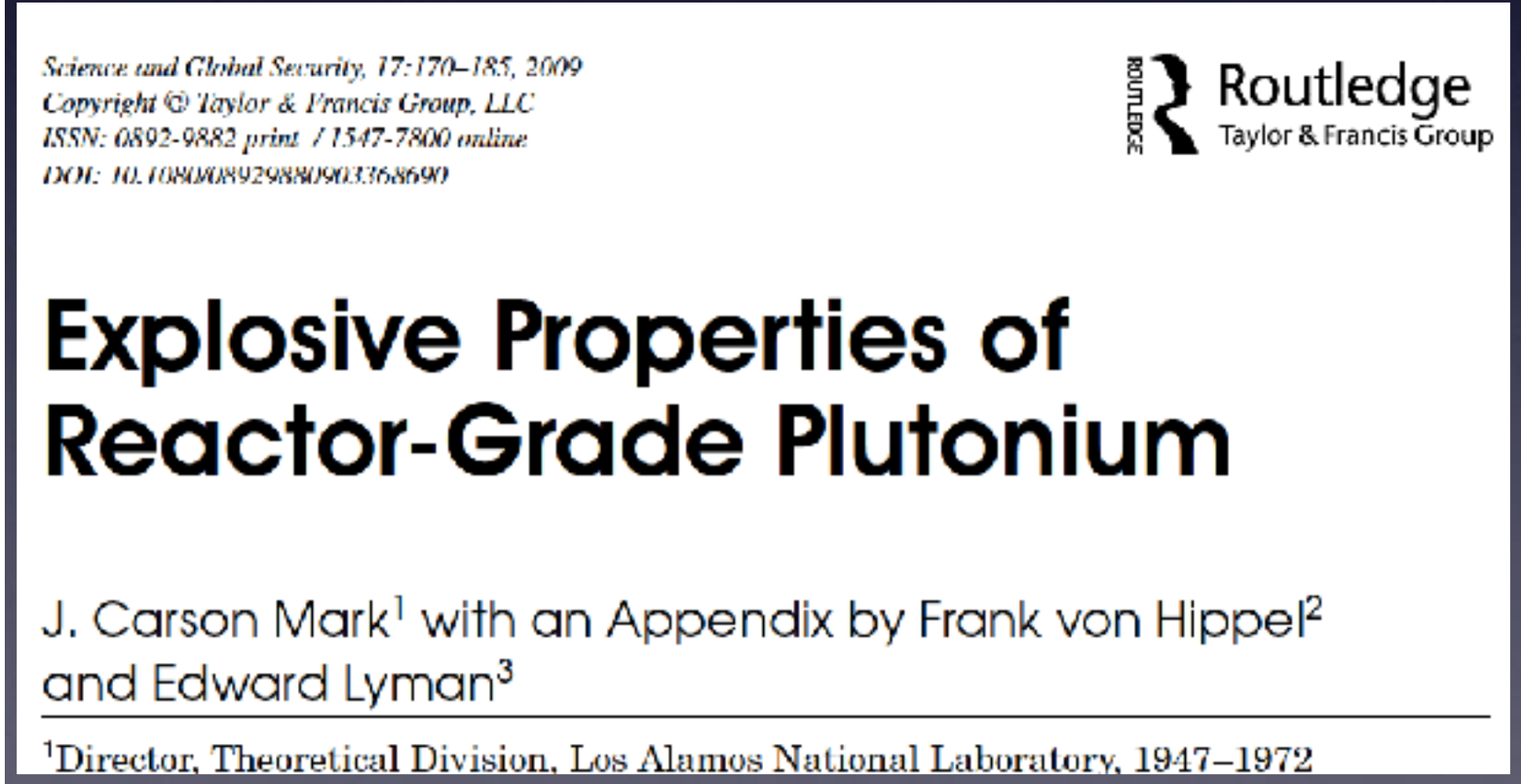
DOE/NN-0007

The United States Department of Energy

Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives

January 1997

"virtually any combination of plutonium isotope … can be used to make a nuclear weapon … reactor-grade plutonium is weapons usable,whether by unsophisticated proliferators or by advanced nuclear weapon states"



Science and Global Security, 17:170–185, 2009

ISSN: 0892-9882 print / 1547-7800 online
DOI: 10.1080/08929880903368690

Routledge
Taylor & Francis Group

Explosive Properties of Reactor-Grade Plutonium

J. Carson Mark[1] with an Appendix by Frank von Hippel[2] and Edward Lyman[3]

[1]Director, Theoretical Division, Los Alamos National Laboratory, 1947–1972

Reprocessing plants will be safeguarded - yes, but…

https://www.iaea.org/sites/default/files/styles/photo_essay_photo__810x540_/public/photoessays/2015/safeguards-peace-security.jpg?itok=U76938rE

Diversion Potential: Safeguards cannot ensure that small amounts (~1%) cannot be surreptitiously removed

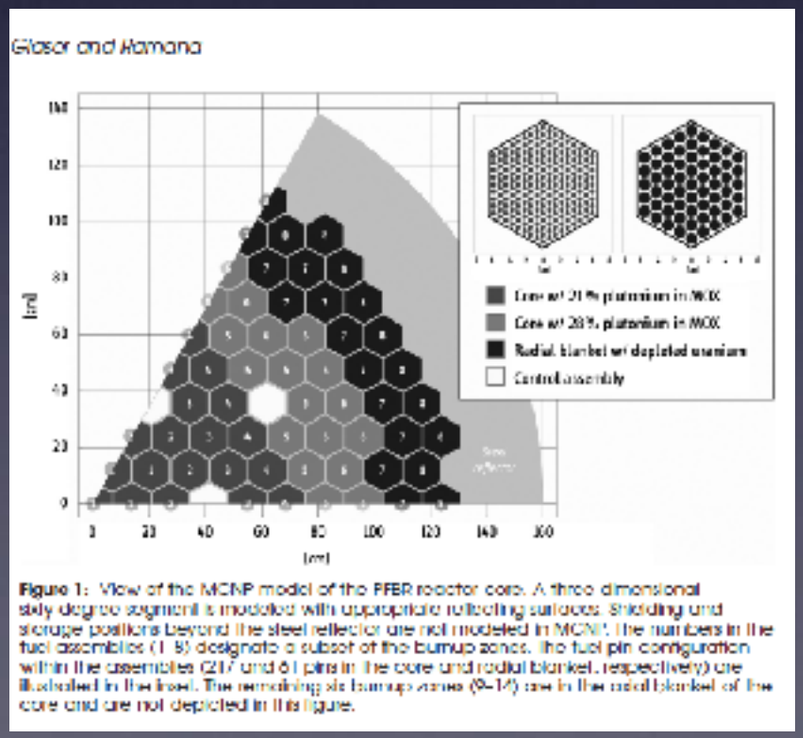


Figure 1: View of the MCNP model of the PFBR reactor core. A three dimensional sixty degree segment is modeled with appropriate reflecting surfaces. Shielding and storage positions beyond the steel reflector are not modeled in MCNP. The numbers in the fuel assemblies (1–9) designate a subset of the burnup zones. The fuel pin configuration within the assemblies (217 and 61 pins in the core and radial blanket, respectively) are illustrated in the inset. The remaining six burnup zones (9–14) are in the radial blanket of the core and are not depicted in this figure.

Glaser, Alexander, and M.V. Ramana. "Weapon-Grade Plutonium Production Potential in the Indian Prototype Fast Breeder Reactor." Science & Global Security 15, no. 2 (October 2007): 85–105.

Breakout Potential: Initial loading of fuel for India's 500 MW PFBR contains enough RG plutonium for about 125 weapons

Ours is a different process: yes, but…

No matter what process, there will still be waste streams

a. Higher actinide depleted uranium/iron

b. Noble gas fission products, vented continually to atmosphere

c. Spent calcium chloride based electrolyte containing the majority of the fission products

Riley, Brian J., Joanna McFarlane, Guillermo D. DelCul, John D. Vienna, Cristian I. Contescu, and Charles W. Forsberg. "Molten Salt Reactor Waste and Effluent Management Strategies: A Review." Nuclear Engineering and Design 345 (April 2019).

Much of the radiation dose of concern is from fission products

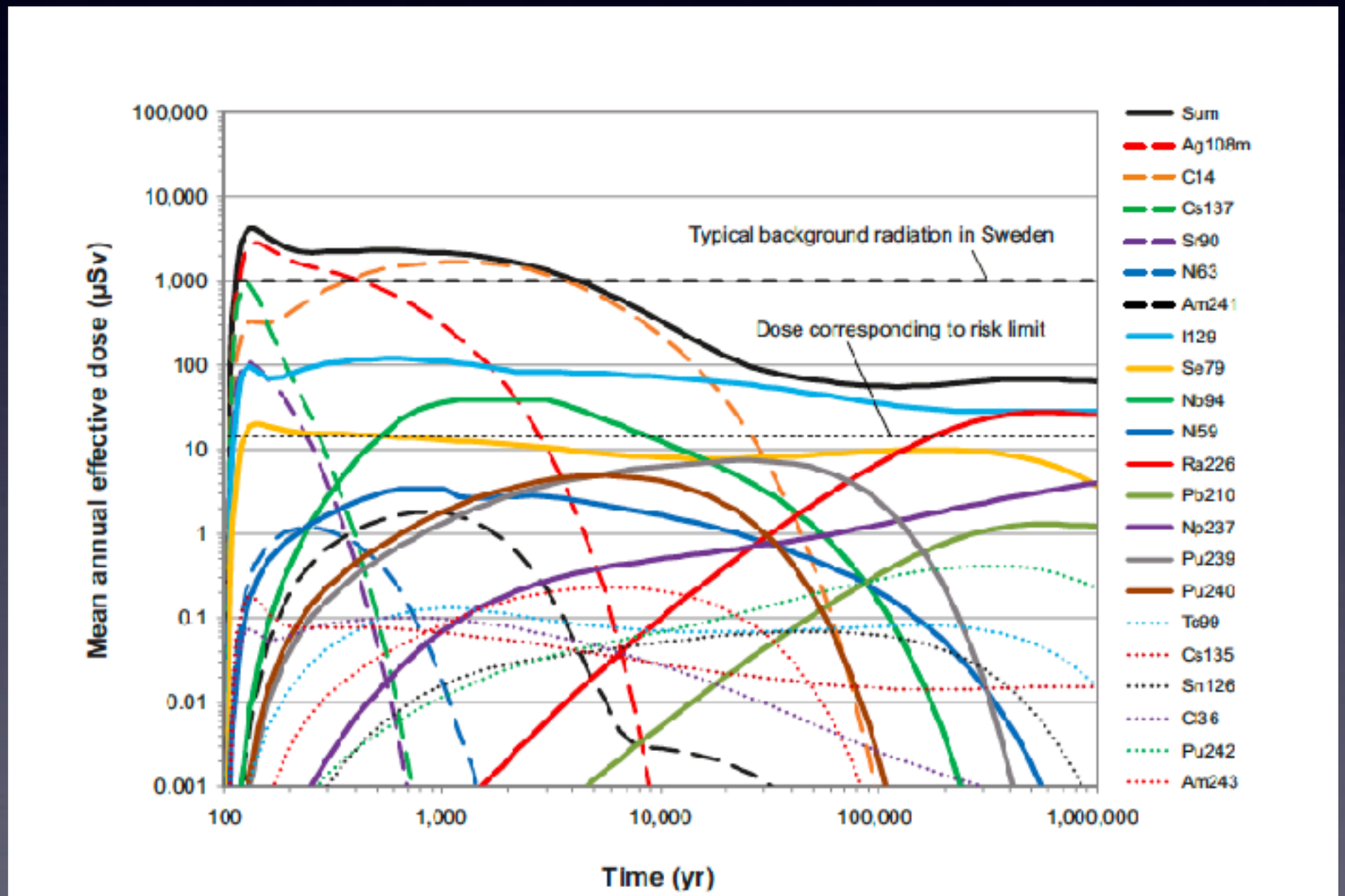


Figure 13-64. Far-field dose for case D, i.e. all canisters have an initial large defect and the buffer is

Summary

Three motivations for reprocessing - two don’t meet reality test

Third motivation still holds… over to Ray to explain why that is a bad motivation!