June 17, 2026

Seth Kanter, CHP
INL Health Physics and Radiological Engineering Manager

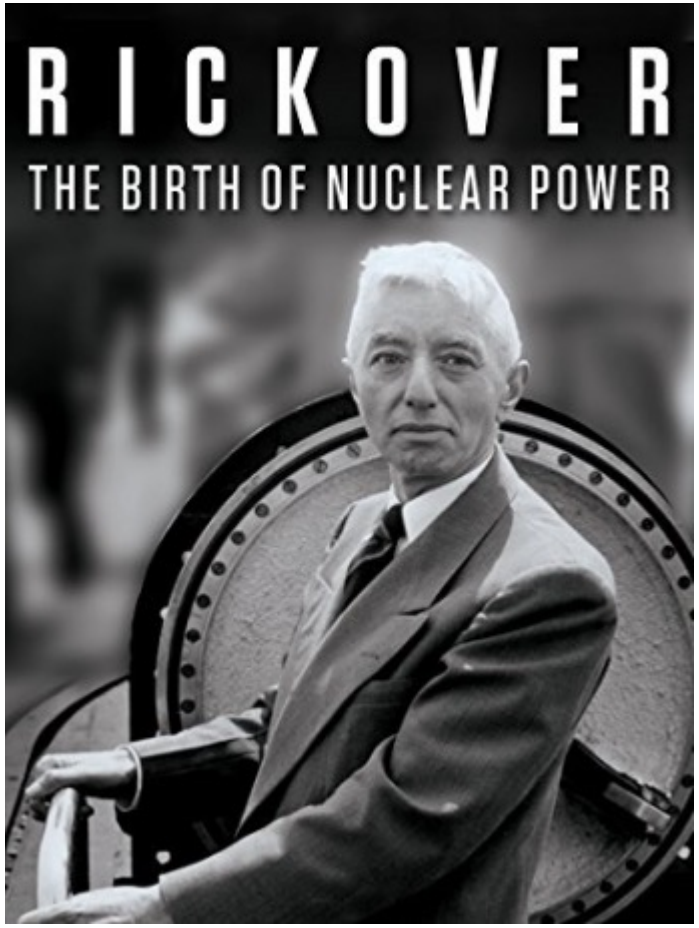
Changes to Federal Radiation Safety Regulations and ALARA-LNT

Mirion Connect June 2026

Battelle Energy Alliance manages INL for the
U.S. Department of Energy's Office of Nuclear Energy

Idaho National Laboratory

About the presenter – 49 Nuclear Years



- US Nuclear Navy 1977 – 1985
  - Fast Attack submarine and Submarine Tender
- Palo Verde Nuclear Generating Station 1985 – 2013
  - Final construction, start-up, 50 refueling outages, 3 steam generator & reactor head replacement outages
- Argonne National Laboratory 2013 – 2015
  - Responsible for NE post-Fukushima containment structural testing
- Idaho National Laboratory 2015 – present
  - Health Physics & Radiological Engineering Manager (26 Health Physicists)
- Notable Experience
  - Lead Author for EPRI Remote Monitoring and Training Guide and Guidelines
  - First MG Users Conference 1995 Atlanta

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Commercializing Advanced Nuclear: Perspectives from Industry, National Labs, and Developers

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Antares XR Demonstrations

- Antares Mark-0 Test Dry criticality experiment completed on June 4th, 30 ahead of the July 4th goal!!!
  - Mark-1 Test: Full R1 reactor test – 2028
  - First Novel Reactor in US to achieve criticality in 50 years!
- Antares eXperiment Reactor (XR) Reactor
  - Sodium cooled heat pipe reactor
  - TRISO Fuel: 19.75% enriched U-235 with graphite moderated core
  - 1.5 MW_{th} and scalable

DOE selected advanced reactor projects to move technologies towards deployment

Aalo

TERRESTRIAL ENERGY

OKLO

RADIANT

ANTARES

Natura Resources

LAST ENERGY

VALAR ATOMICS

DEEP FISSION

ATOMIC ALCHEMY

"President Trump's Reactor Pilot Program is a call to action. These companies aim to all safely achieve criticality by Independence Day, and DOE will do everything we can to support their efforts."

James P. Danly,
Deputy Secretary of Energy

DOE Advanced Nuclear Fuel Line Pilot project selections

TRISO

OKLO

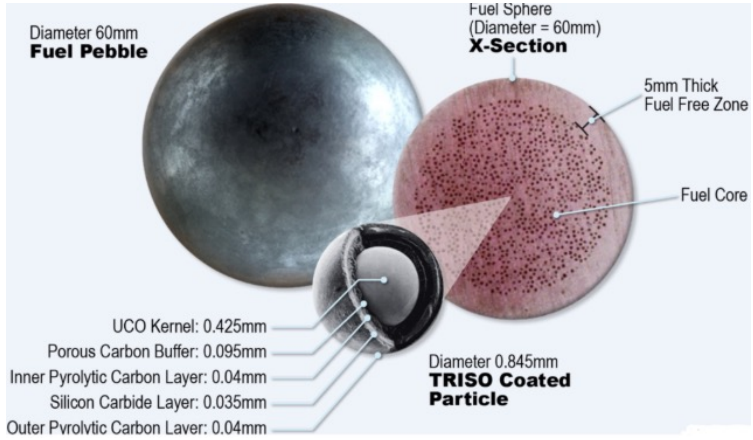
TERRESTRIAL ENERGY

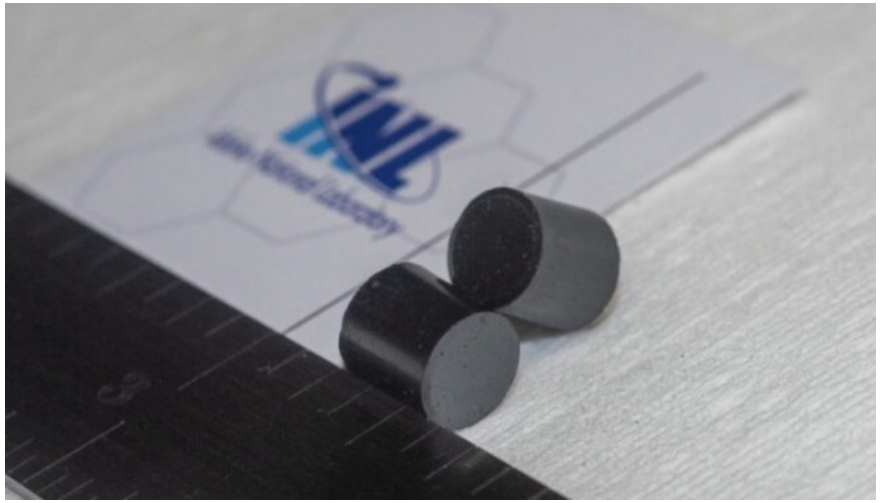
STANDARD NUCLEAR

VALAR ATOMICS

The Fuel Line Pilot Program supports the Reactor Pilot Program by establishing a domestic nuclear fuel supply chain for testing new reactors. It uses DOE authorization to build and operate nuclear fuel production lines for research, development, demonstration, and expedited commercial licensing.

Fuel Fabrication & ARDP Support Lines





X-energy TRISO-X Fuel (Xe-100 Program)

- **Type:** TRISO particle fuel (graphite-matrix HALEU)
- **Status:** Manufacturing scale-up; irradiation qualification ongoing at INL ATR
- **Criticality Link:** Supports future Xe-100 demos (not an INL reactor)
- **Regulator: DOE fuel qualification** now; **NRC licensing** for Xe-100 later

Kairos Power Hermes 1

- **Type:** Fluoride-salt-cooled reactor using TRISO pebbles
- **Status:** NRC construction permit; HALEU contracted; pebble fabrication underway
- **Criticality Link:** No INL siting, but HALEU and TRISO supply chain overlaps
- **Regulator: NRC-licensed**

TerraPower Natrium Fuel Line

- **Type:** Metallic HALEU fast-reactor fuel
- **Status:** Dedicated Natrium fuel-fab development and material prep ongoing
- **Criticality Link:** Supports Natrium demo plant (not sited at INL)
- **Regulator: NRC-licensed**

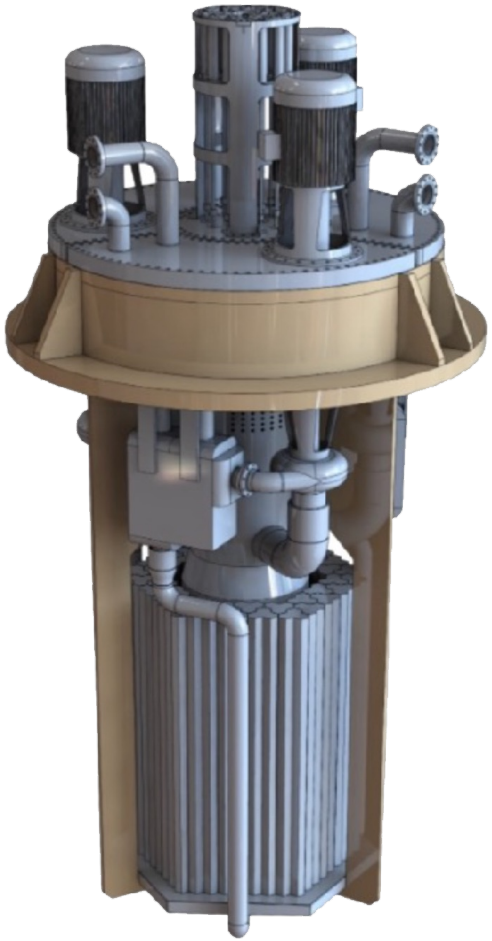
INL-Based HALEU Recovery & Supply

- **Type:** HALEU recovered from EBR-II and other inventories
- **Status:** Processing, purification, and allocation to ARDP and pilot projects
- **Criticality Link:** Material feedstock for MARVEL, Aurora, KDU, and early microreactors
- **Regulator: DOE**

On-site Demonstrations

NRIC National Reactor Innovation Center

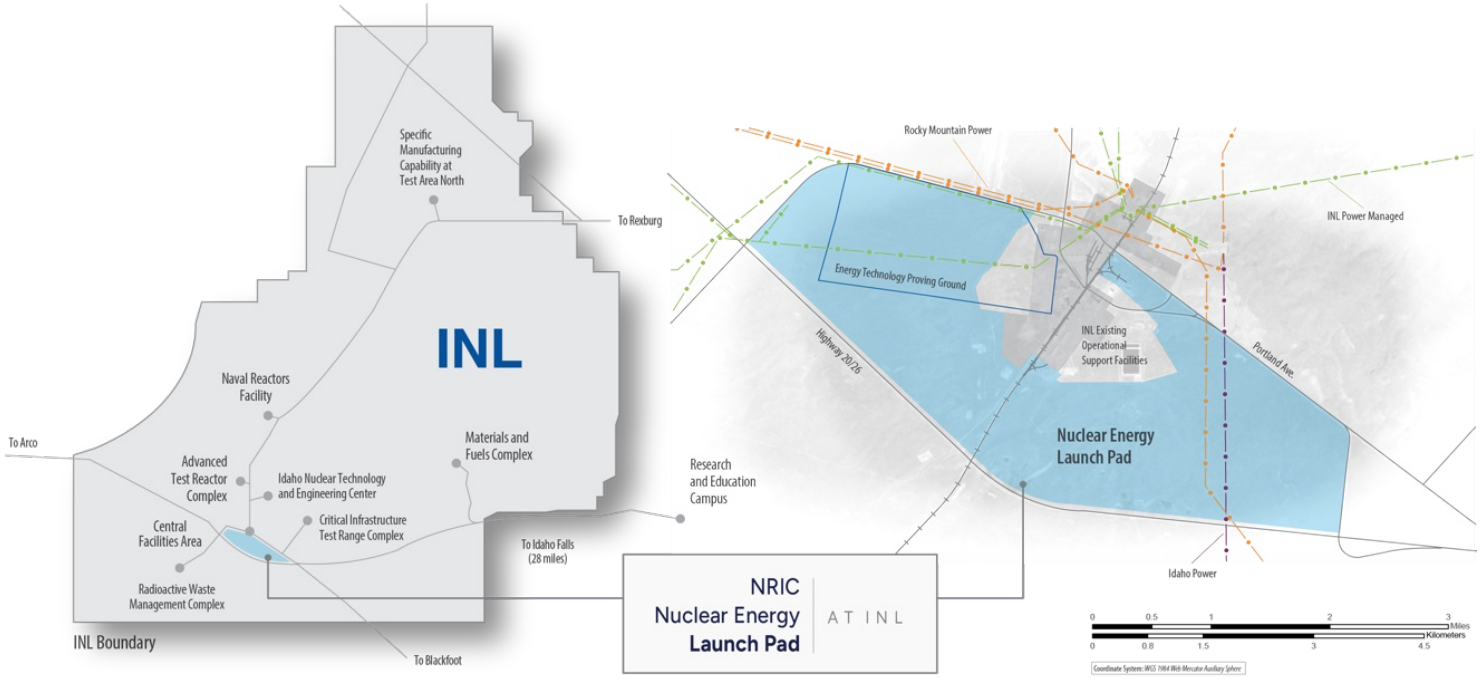
- Aalo-X Reactor
  - Liquid Metal Reactor, Sodium Cooled Thermal 30 MWth Reactor
- Oklo Aurora Reactor
  - 75 MWe sodium-cooled fast reactor based on proven INL EBR-II technologies
- Atomic Alchemy
  - Versatile Isotope Production Reactor (VIPR), 15 MW_{th} light-water, pool-type reactor fueled by UO_2.



Nuclear Energy Launch Pad INL

"From Concept to Criticality, Faster"

- About **2000 Acres** for privately funded advanced nuclear prototypes: first-of-a-kind reactors, enrichment, fuel fabrication, recycling, and emerging technologies
- Offers building sites, established infrastructure connections, proven regulatory pathways, and access to INL's world-class nuclear expertise



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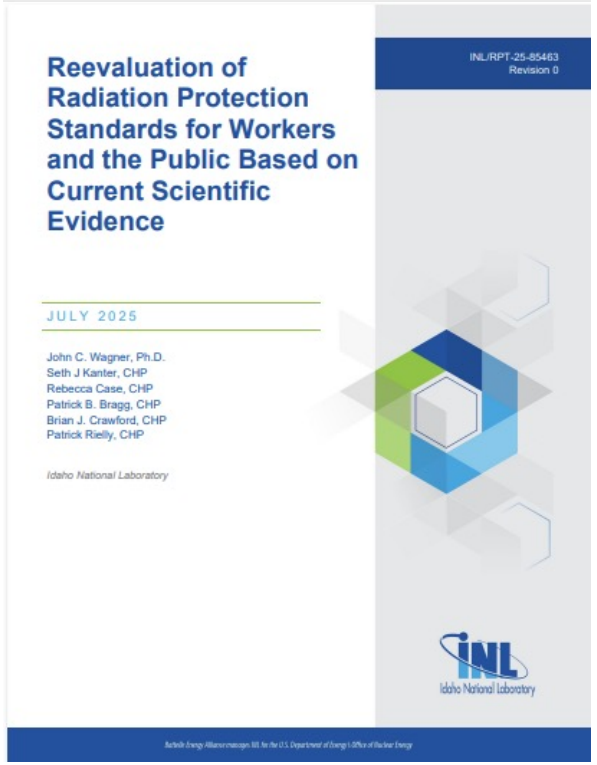
Why Now: The Regulatory Inflection Point

- U.S. radiation protection philosophy has undergone only two fundamental revisions:
  - 1977 following ICRP-26
  - Early 1990s following ICRP-60
  - EO 14300 (May 2025) initiated the third
- EO 14300 §5 directed NRC to undertake wholesale revision of regulations and guidance:
  - Reconsider reliance on LNT as a regulatory model
  - Reconsider ALARA, which is predicated on LNT
  - Consult with DOD, DOE, and EPA



- Primary driver: overly conservative standards have been impeding nuclear energy deployment and inflating costs with little to no demonstrable safety benefit
- INL Report RPT-25-85463 *(Wagner, Kanter, et al., July 2025)* provided the scientific foundation underpinning this reform — a technical evidence review, not a policy document
- Concurrently, EO 14301 directed DOE to undertake a parallel effort targeting 10 CFR 835 to support Advanced Reactor Demonstration Projects

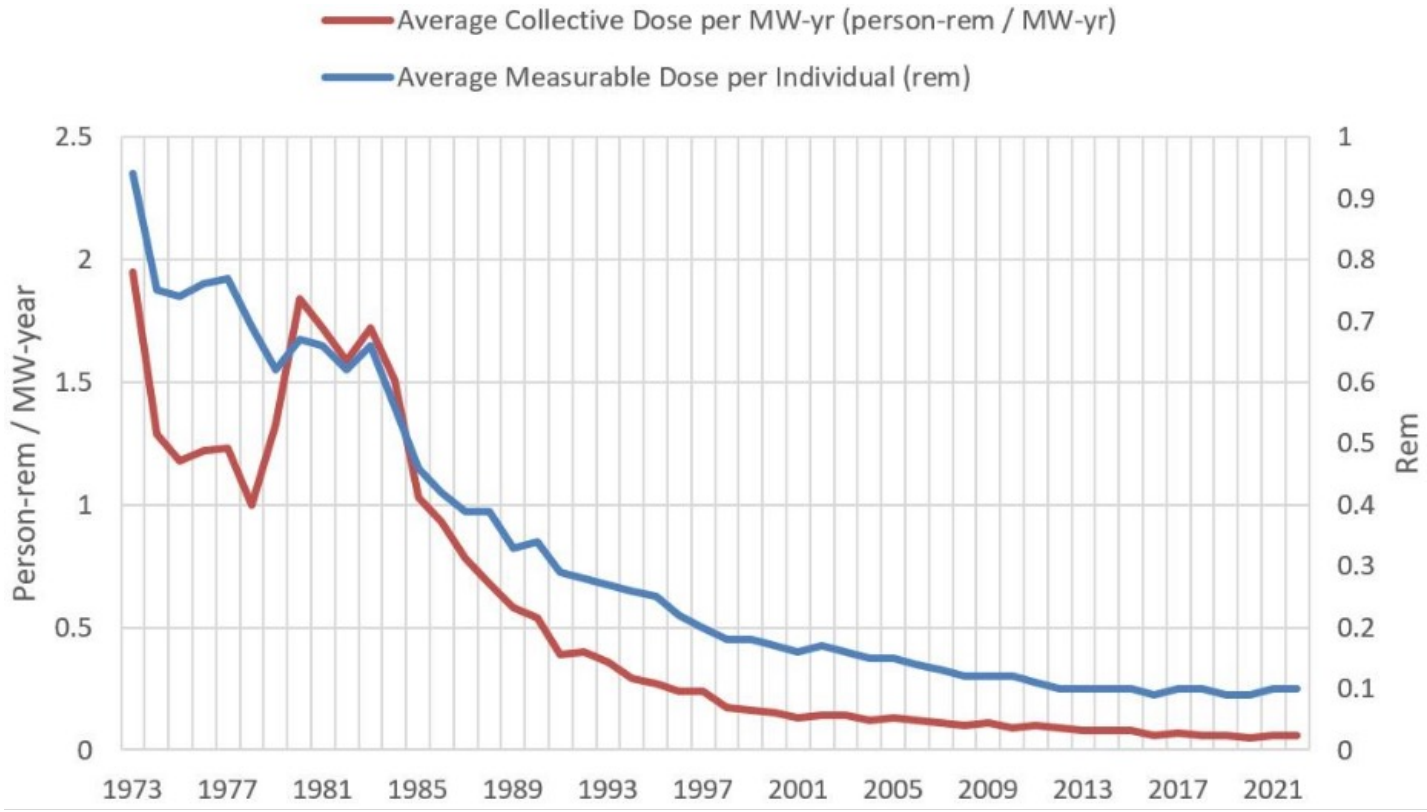
What INL/RPT-25-85463 Contributes

- Represents the first systematic technical evidence review to underpin regulatory reform at a national level
- Set a scientific foundation that distinguishes policy assumptions from biological evidence
- Provided a starting point that the DOE and NRC could utilize in the current regulatory reform effort

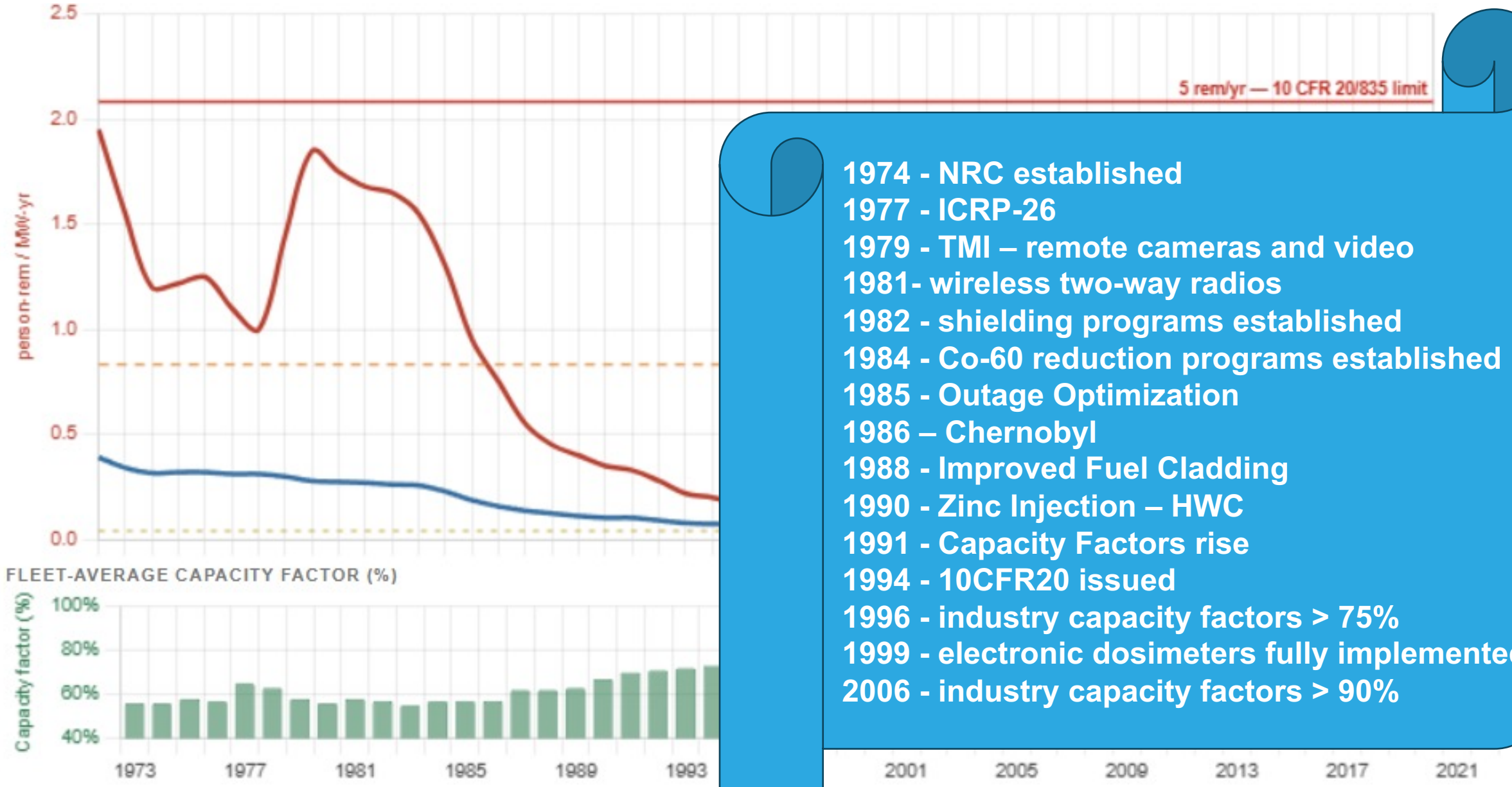
> "What began as a cautionary, conservative policy has evolved over time into an increasingly restrictive regulatory regime. The practical interpretation of ALARA has shifted from 'reasonably achievable' to 'as low as possible' — driving the implementation of administrative control limits and similar requirements that go well beyond the original intent of the principle." — Wagner et al., INL/RPT-25-85463, §1 (2025)

The primary driver for addressing ALARA is the gap between *as defined* and *as implemented*

- In practice, the standard drifted:
  - "Reasonably achievable" became "as low as possible"
  - Good ALARA performance redefined as zero dose, regardless of cost or benefit
  - Administrative control limits drove doses toward zero with no clear compliance threshold
  - Collective Radiation Exposure (CRE) adopted as a program health metric — an inappropriate proxy for program quality



Between 1975 and 1994, dose dropped dramatically — not because of regulatory pressure to hit zero, but because of aggressive source term efforts, fuel clad performance, shorter outage durations, and better planning. That's optimization working as intended."



1974 - NRC established
1977 - ICRP-26
1979 - TMI – remote cameras and video
1981- wireless two-way radios
1982 - shielding programs established
1984 - Co-60 reduction programs established
1985 - Outage Optimization
1986 – Chernobyl
1988 - Improved Fuel Cladding
1990 - Zinc Injection – HWC
1991 - Capacity Factors rise
1994 - 10CFR20 issued
1996 - industry capacity factors > 75%
1999 - electronic dosimeters fully implemented
2006 - industry capacity factors > 90%

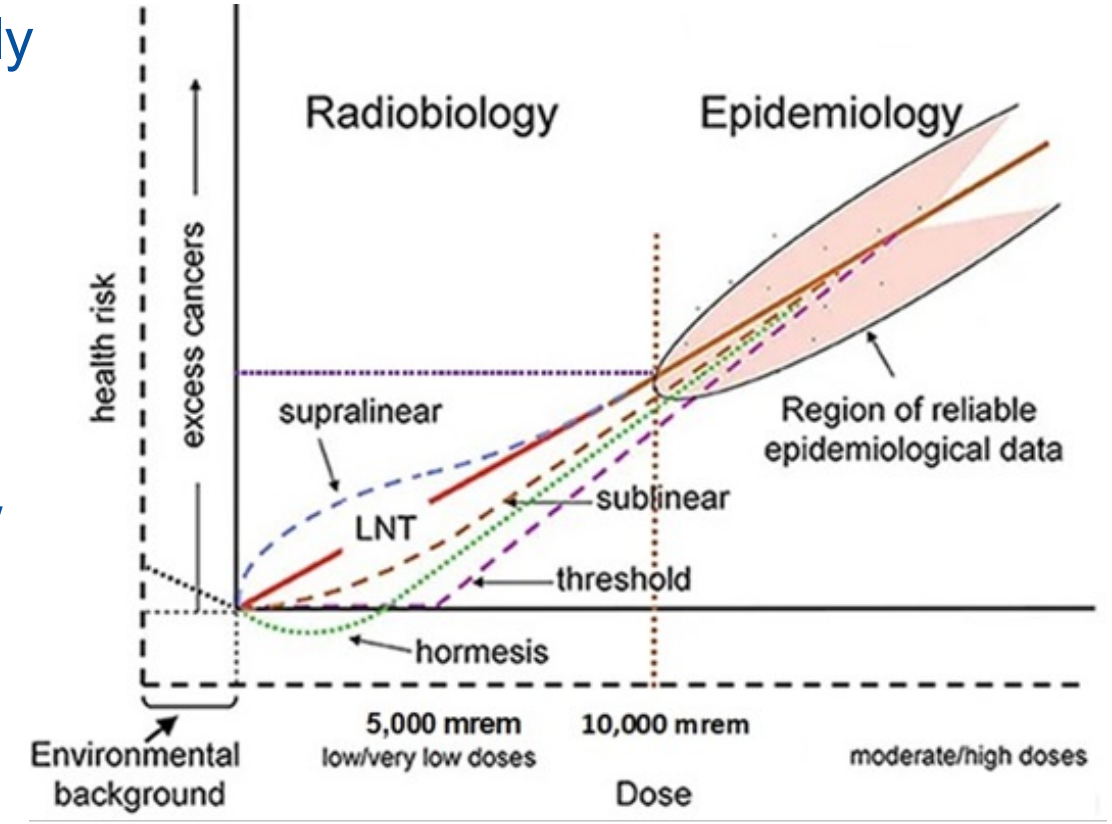
Impetus for Proposed Regulatory Changes

- **In May 2025 EO 14300 directed the NRC to significantly reform its processes…including regulations…like radiation models.**
- **Specifically, Sec. 5: Reforming and Modernizing the NRC's Regulations.**

  The NRC… shall undertake a review and wholesale revision of its regulations and guidance documents…
  - **(b) Adopt science-based radiation limits. In particular, the NRC shall reconsider reliance on the linear no-threshold (LNT) model for radiation exposure and the "as low as reasonably achievable" standard, which is predicated on LNT. Those models are flawed, as discussed in section 1 of this order…**
  - …and in doing so shall consult with the Department of Defense (DOD), the **Department of Energy (DOE)**, and the Environmental Protection Agency.

LNT Is a Predictive Regulatory Assumption, Not a Proven Biological Reality: the need to distinguish science vs. policy assumptions

- LNT is a “practical approximation”, not an empirically demonstrated model: it was adopted as a **“temporary tool”** pending better data.
  - Decades of research have not demonstrated linearity below ~10,000 mrem, in fact, most biological data show curvilinear (not linear) dose-response
  - The low-dose ceiling of 10,000 mrem sits at the threshold of epidemiological detectability; below this level, LNT cannot be validated or refuted.
  - Statistically significant effects occur only above ~20 Rem
  - ICRP-60 recognizes LNT limitations (Annex C) especially epidemiological detection thresholds.
    - Threshold, hormesis, and linear-quadratic models carry equal or greater biological plausibility below 10,000 mrem.



Below 5,000 mrem, risks are ***"too small to observe and may be nonexistent"*** – *HPS statement*

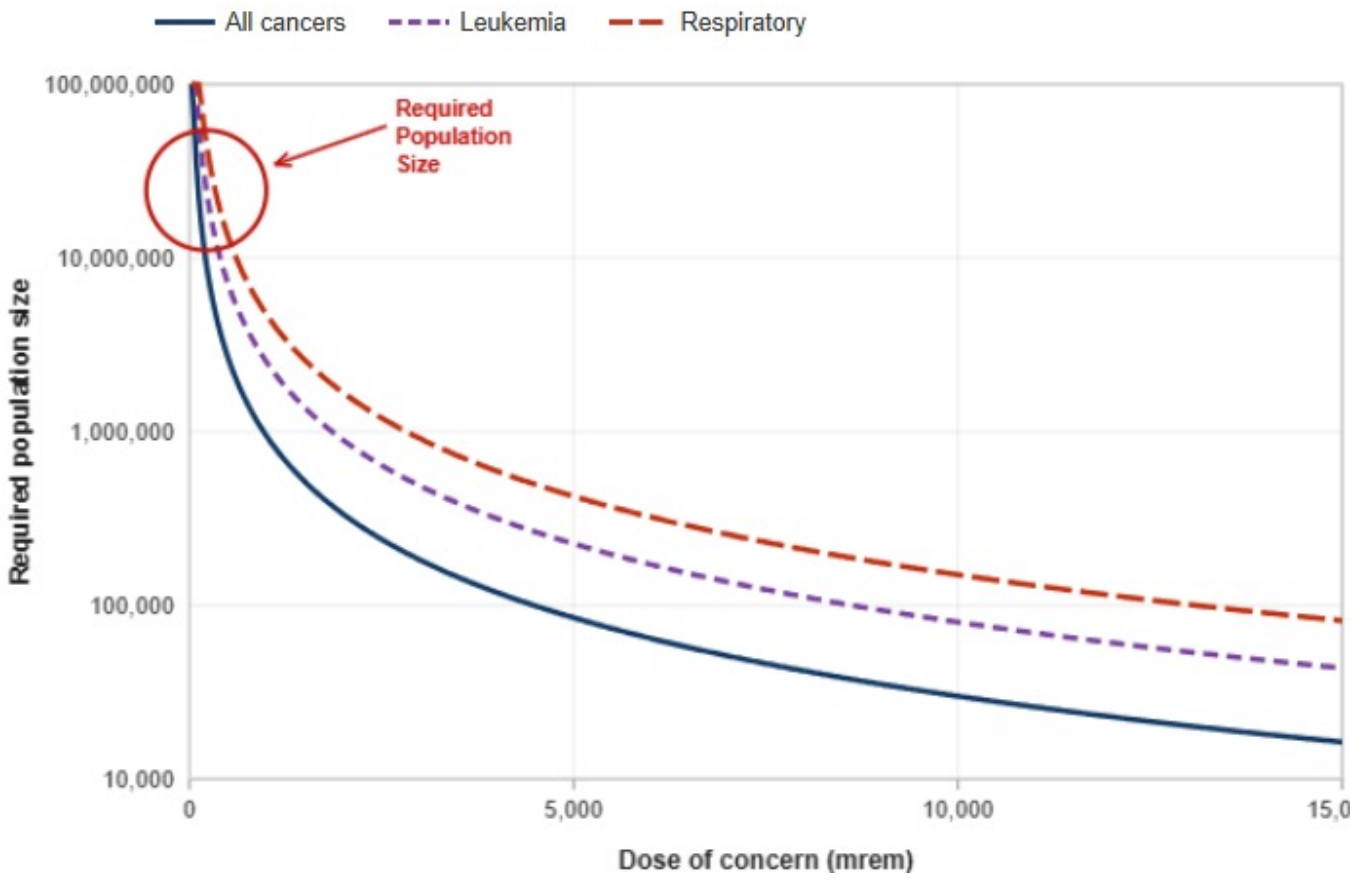
Population size needed, after a lifetime of monitoring, to detect an increase in cancer mortality from radiation exposure above background[1]

Theoretically, to detect an effect at:

- **100 mrem** would require analysis of ~6% of the world's population (~500,000,000 people).
- **10 mrem** would require analysis of ~6 times the total population of the earth (~50,000,000,000 people).

∴ Doses < 1 millirem

- Have been called negligible,
- ***Because the risk cannot be seen or measured.***



[1] Adapted from NCRP MPS. Required population sizes derived under the linear no-threshold (LNT) model — a contested dose-response framework at low doses.

"What Replaces ALARA in Practice“

- Removing ALARA language from the regulations simply eliminates the regulatory driver; not the operational need for structured dose reduction programs.
  - Well-established radiological control practices need to remain intact
- **ALARA as defined vs. ALARA as presently implemented has driven a "zero dose" culture with CRE being used as a metric of radiological program health**
  - This has allowed 'reasonable’ to drift to 'as close to zero as possible at any cost.

Reasonable ≠ Zero

DOE Approach to ALARA: Revisiting ICRP-60

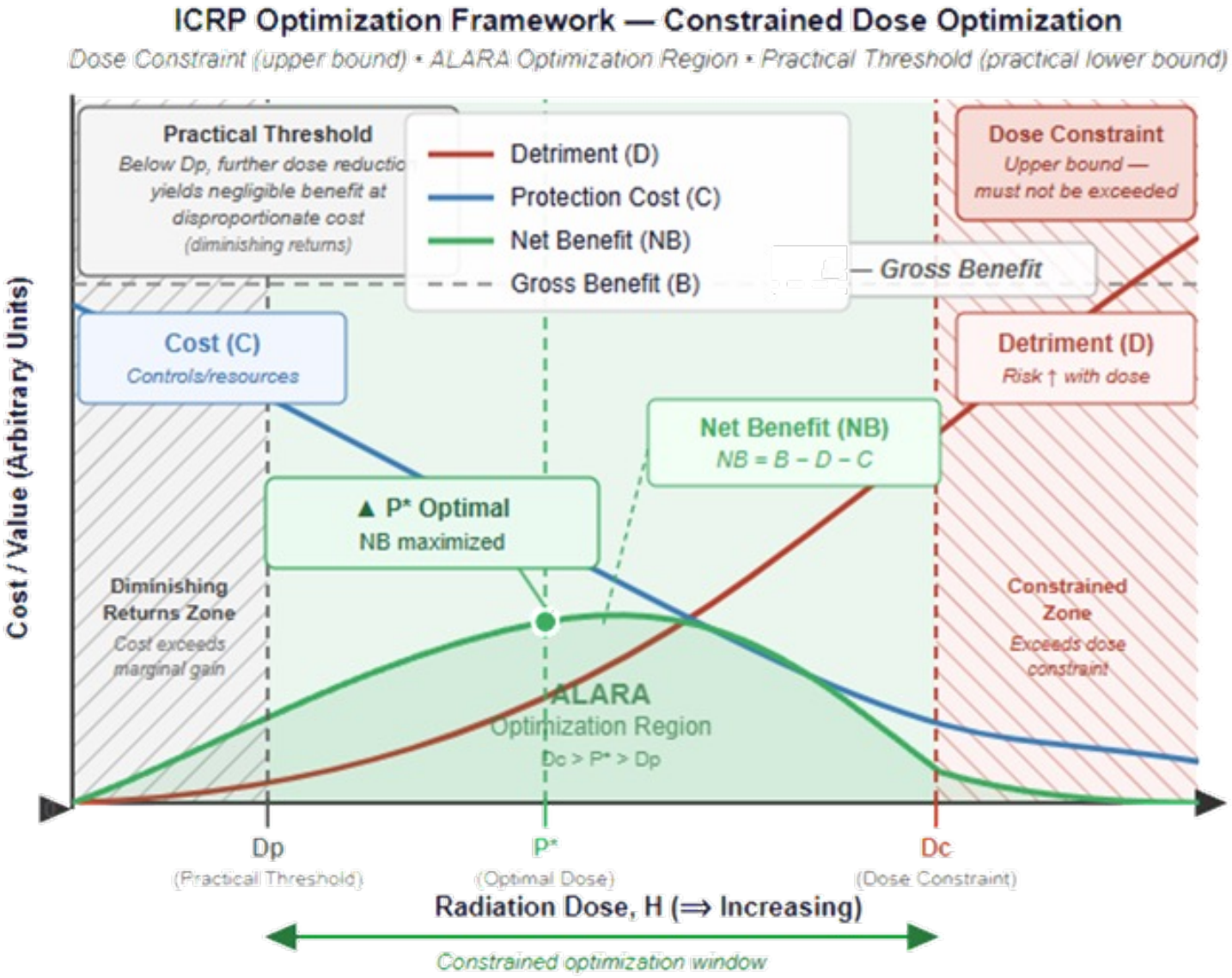
- Gold Standard of Science was applied citing NCRP Statement 8's explicit warning that ALARA application has been

  "inappropriately exaggerated"

  "ALARA requires **"social and economic judgements..."**

  …as well as scientific" ones that acknowledge **little direct evidence of harm** near current dose limits."

Below a certain dose level, marginal cost of further reduction exceeds any plausible health benefit



Aligned Perspectives

- During congressional hearing in February 2026, NEI President and CEO Maria Korsnick had this to say about ALARA:
  - **Design & New Construction:** Korsnick supported removing the ALARA requirement for the design of new plants, arguing that it imposes costly, unnecessary, and "not real" requirements that hinder development.
  - **Existing Operations:** Conversely, she supported keeping ALARA in place for existing power plant operations.
- These positions aligns very well with the INL report, they were proposed primarily to support the development of Advanced Reactor Demonstration Projects (EO14301) where ALARA and MEI drive shielding costs.
- **For day-to-day operations and especially outages appropriate dose reduction practices using sound health physics judgement are expected to continue.**

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