Indian Point Relative Risks

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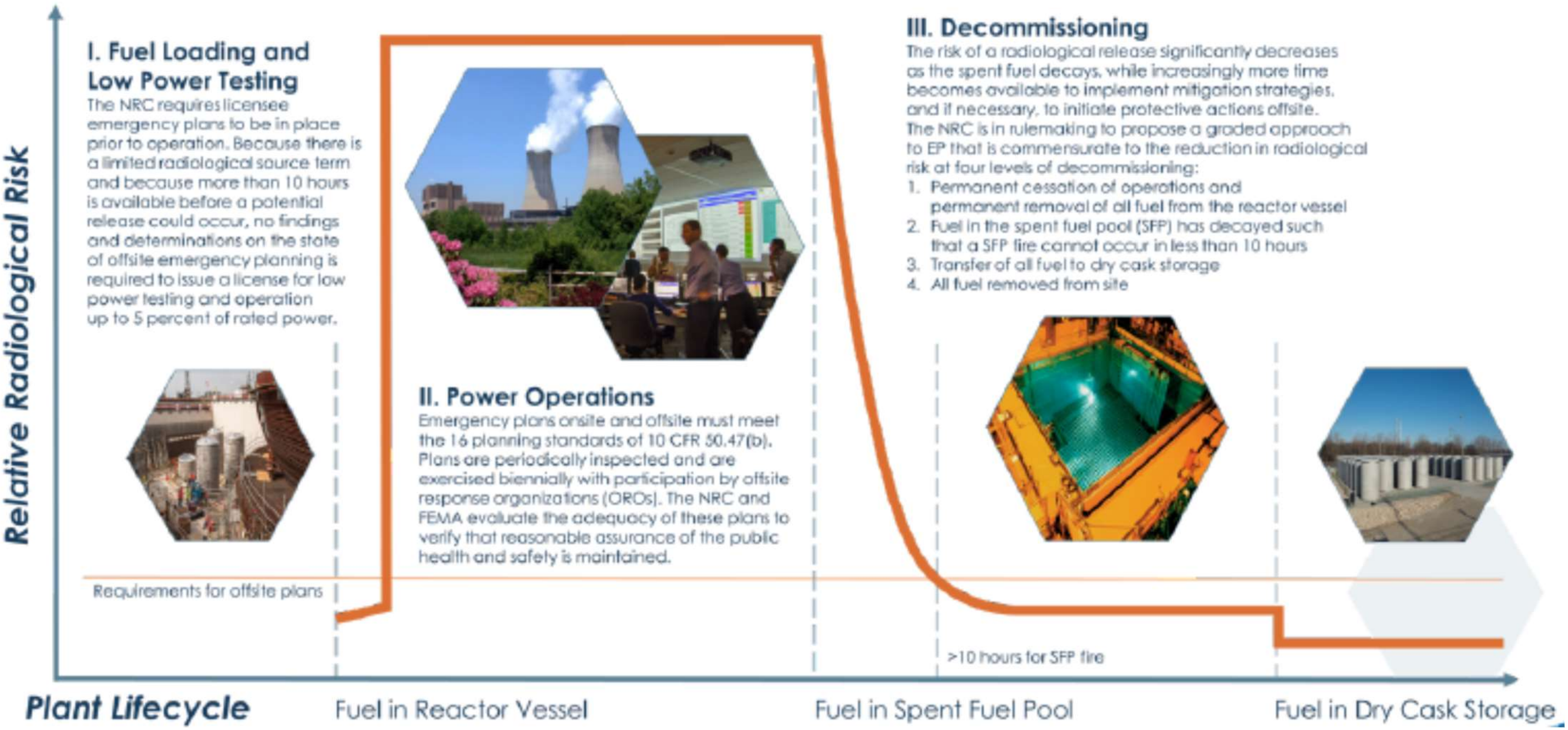


Source: NRC Webinar, "Reactor Decommissioning: A look into Emergency Preparedness and Security Requirements," November 30, 2022. (ML22329A077)

NRC presented this graph showing the relative risks from operating reactors, spent fuel pool storage, and dry cask storage. To help put this info in context, here's some background on risk analysis.

RISK SIDEBAR

Risk is defined as the product of the probability of an event and its consequences.

Event A:
Occurs once a quarter resulting in one bad outcome

Risk A = 4 events/year * 1 outcome/event = 4 outcomes per year

Event B:
Occurs once a decade resulting in 40 bad outcomes

Risk B = 1 event/10 years * 50 outcomes/event = 4 outcomes per year

Thus, Events A and B have equivalent risk.

Event frequency (i.e., probability) and consequences vary when irradiated fuel is in the reactor core, spent fuel pool, and dry storage due primarily to energy levels and fuel inventories.

Indian Point Power Levels

Indian Point Unit 2 Rated Thermal Power Level 3,216 Mwt
Indian Point Unit 3 Rated Thermal Power Level 3,216 Mwt

Source: NRC Information Digest (ML21300A290)

Indian Point Unit 2 SFP Thermal Power Level 2.33 Mwt

Source: Indian Point Updated Final Safety Analysis Report Chapter 9 (ML16280A206)

Indian Point Unit 3 SFP Thermal Power Level 2.33 Mwt

Source: Indian Point Updated Final Safety Analysis Report Chapter 9 (ML19282B046)

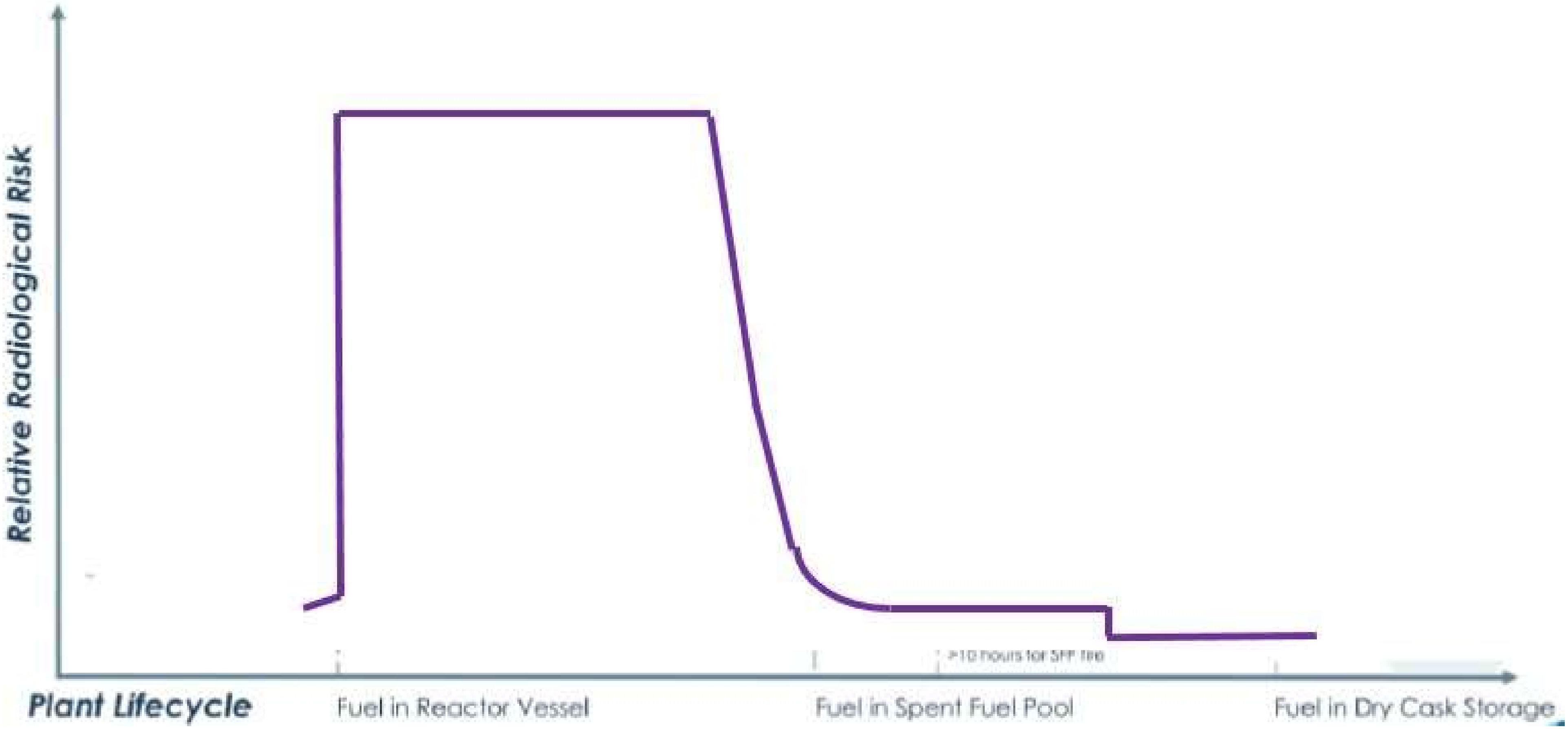
HI-STORM 100 MPC-32 Cask Thermal Power Level 21 Kw

Source: Certificate of Compliance (ML2118A871)

HI-STORM 100 MPC-32M Cask Thermal Power Level 38 Kw

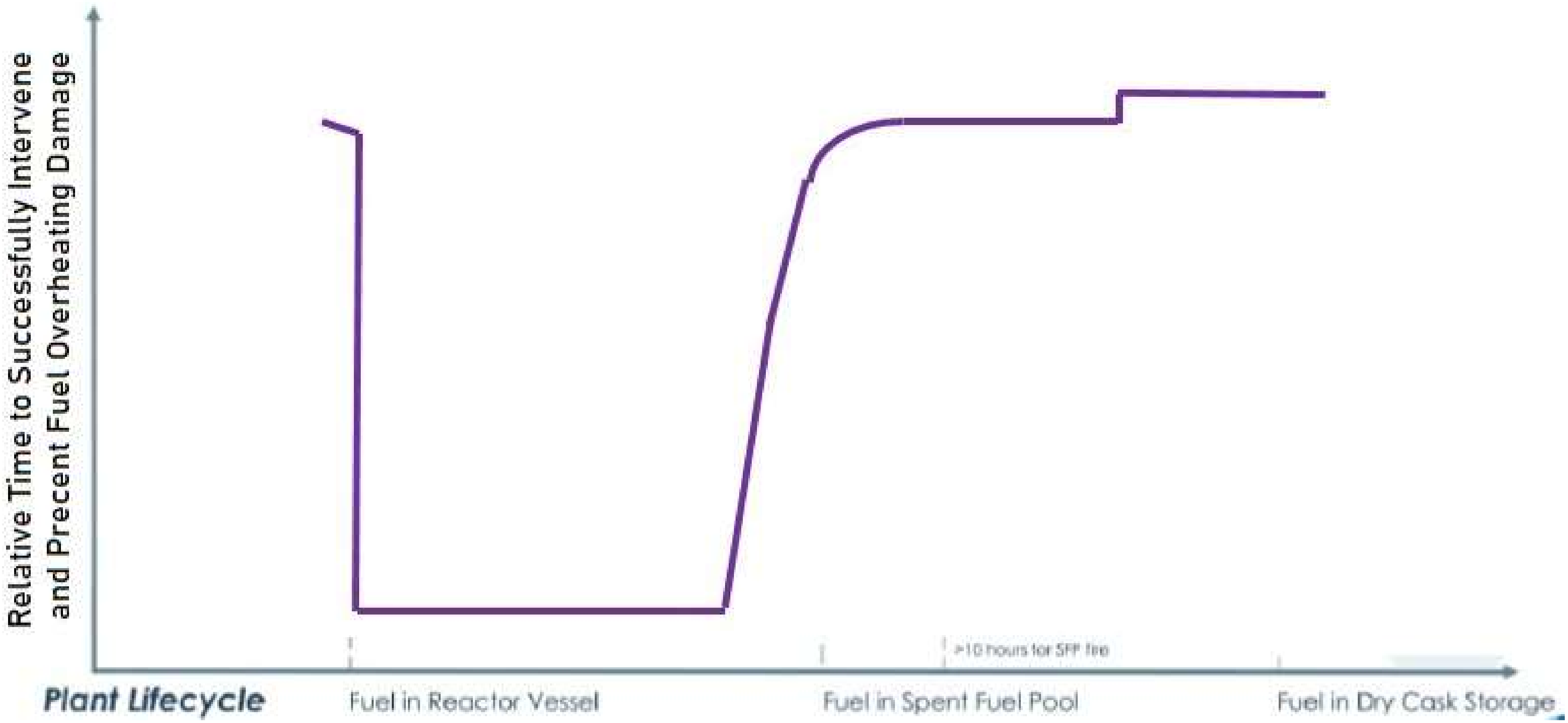
Source: Certificate of Compliance (ML2118A871)

SFP = spent fuel pool, Mwt = megawatts thermal, Kw = kilowatts

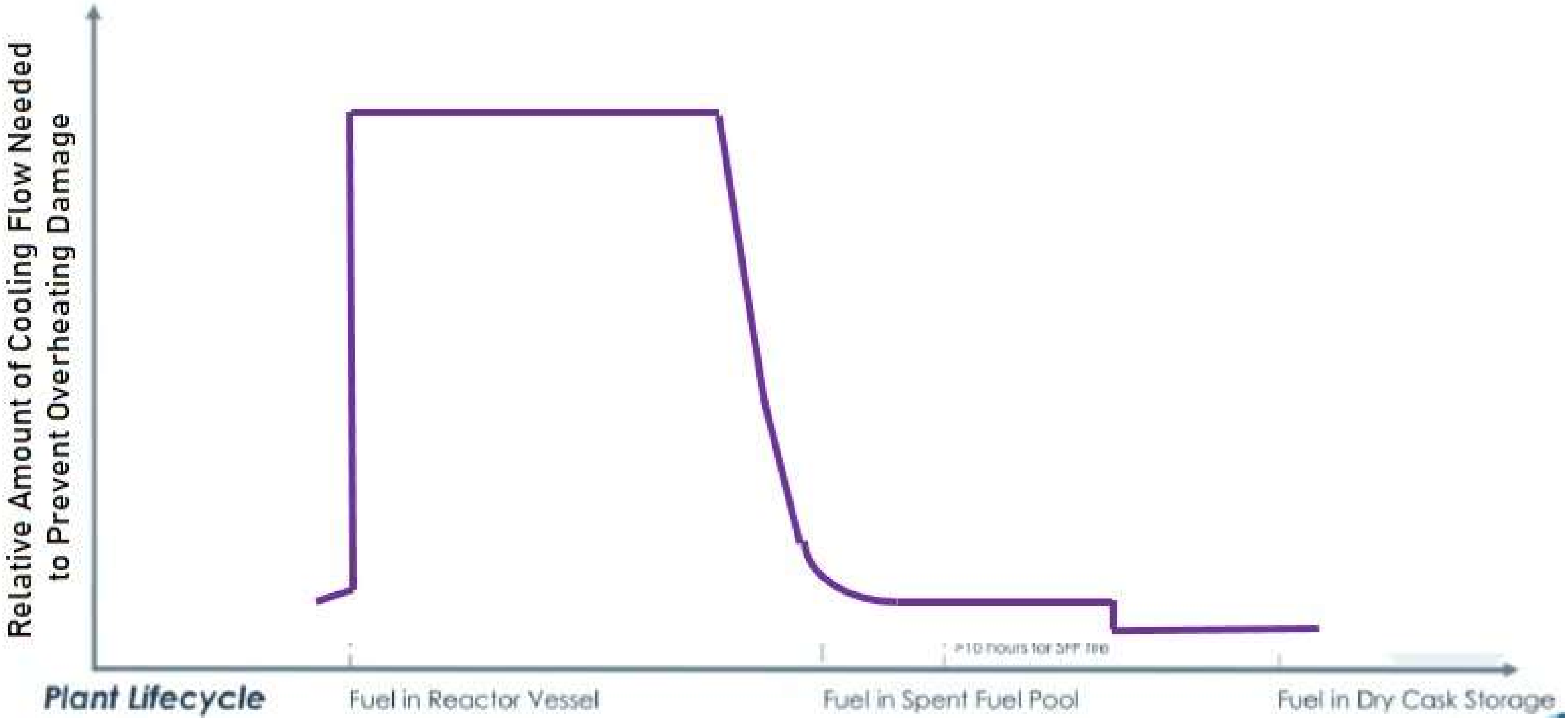


How do the different power levels affect risk?

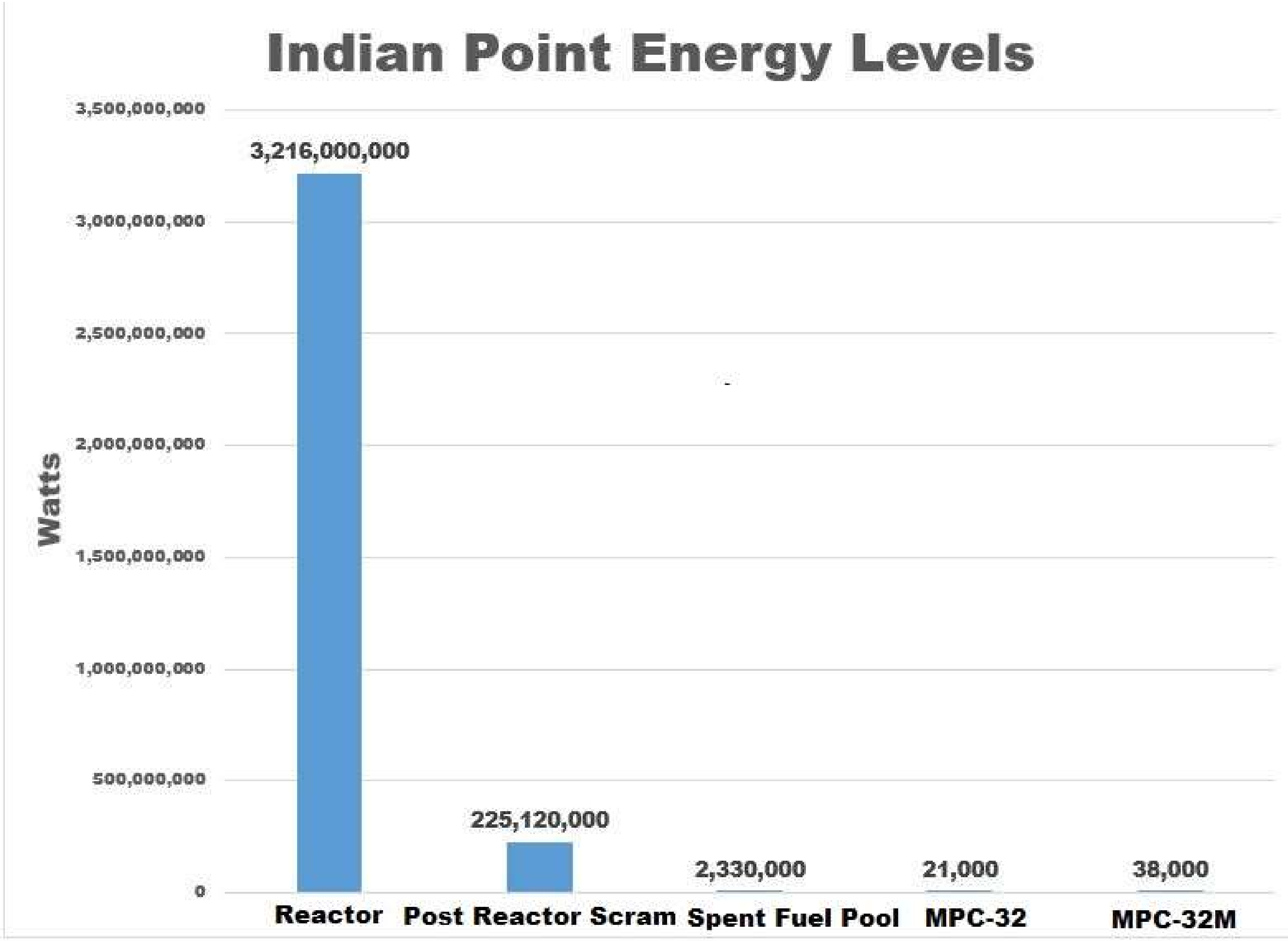
The power level affects the probability that an event results in fuel damage.



If an event causes loss of fuel cooling in the reactor, spent fuel pool, or dry cask, the relative time available to restore cooling is essentially the inverse of the relative power level – the higher the power, the lower the time available to successfully respond.



The power level further complicates the time challenge (i.e., beat the meltdown clock). The higher the power level, the greater the amount of cooling flow needed to prevent overheating damage. The greater the amount of cooling flow needed, the fewer number of options (e.g., pumps) capable of delivering that needed flow.

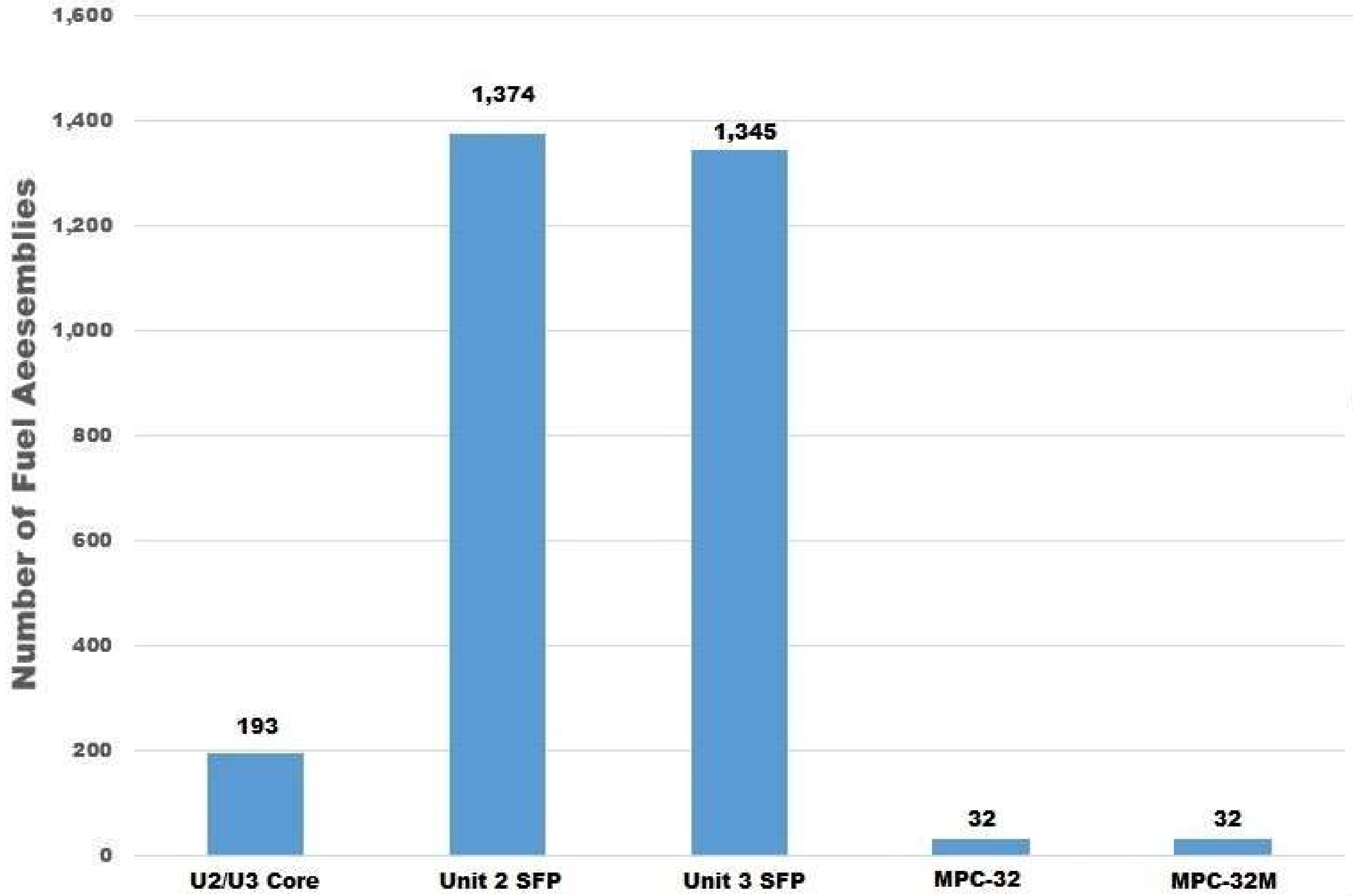


Immediately after a scram from full power, a reactor core produces about 7% of rated power, which is about 100 times larger than the maximum spent fuel pool power level which is in turn about 100 times higher than one dry cask power level.

Indian Point Fuel Capacities

Unit 2 Reactor Core Capacity	**193 assemblies** Source: ML18212A190
Unit 3 Reactor Core Capacity	**193 assemblies** Source: ML18212A190
Unit 2 Spent Fuel Pool Capacity	**1,374 assemblies** Source: ML13256A086
Unit 3 Spent Fuel Pool Capacity	**1,345 assemblies** Source: ML13256A086
MPC-32 Capacity	**32 assemblies**
MPC-32M Capacity	**32 assemblies**

Indian Point Fuel Storage Capacities



Each Unit 2 and 3 spent fuel pool could hold nearly seven times as much fuel as in the reactor core, which held nearly six times as much fuel as a dry cask.

How do the different fuel capacities affect risk?

The amount of fuel affects the consequences from an event resulting in fuel damage.

The larger the amount of fuel damaged, the greater the amount of radioactive materials released to the environment.

Operating reactors have higher power levels (hence higher probability of fuel damage) than spent fuel pools, but spent fuel pools have larger fuel capacities (hence greater consequences from fuel damage) than reactor cores.

The following case study illustrates the relative risks from a real event at a plant with operating reactors, spent fuel pools, and dry casks.

CASE STUDY:

Fukushima Daiichi

Fukushima Power Levels

Fukushima Unit 1 Rated Thermal Power Level	**1,380 Mwt**
Fukushima Unit 2 Rated Thermal Power Level	**2,381 Mwt**
Fukushima Unit 3 Rated Thermal Power Level	**2,381 Mwt**
Fukushima Unit 4 Rated Thermal Power Level	**2,381 Mwt**
Fukushima Unit 5 Rated Thermal Power Level	**2,381 Mwt**
Fukushima Unit 6 Rated Thermal Power Level	**3,293 Mwt**

Source: Institute for Nuclear Power Operations (INPO), "Special Report on the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station," page 49, November 2011 (ML11347A454).

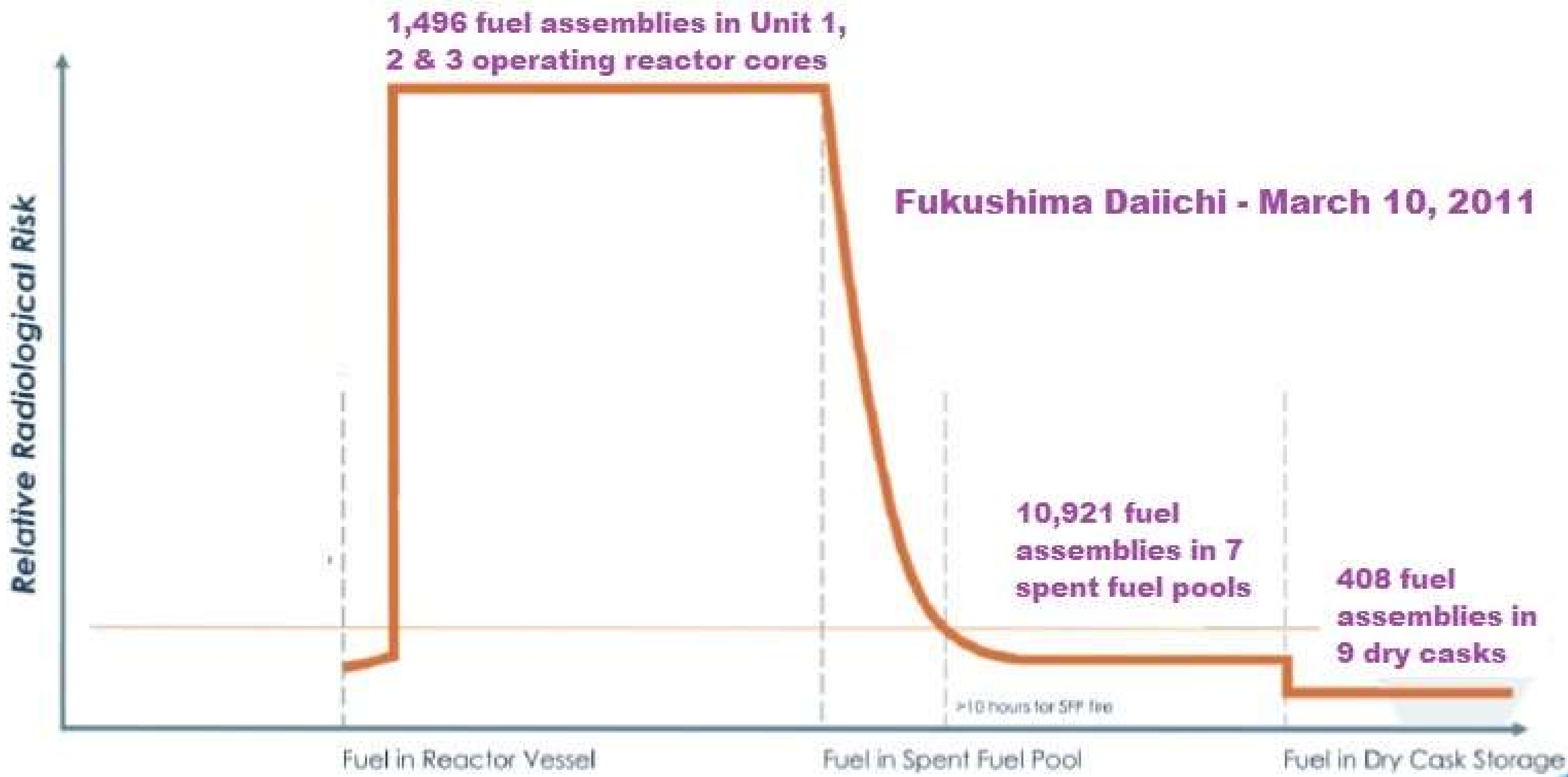
Fukushima Fuel Capacities

Unit		1	2	3	4	5	6
Number of fuel assemblies							
	In the reactor	400	548	548	0	548	764
	Spent fuel assemblies in the spent fuel pool	292	587	514	1,331	946	876
	New fuel assemblies in the spent fuel pool	100	28	52	204	48	64
Water volume (ft^3)		36,021	50,323	50,323	50,323	50,323	52,866

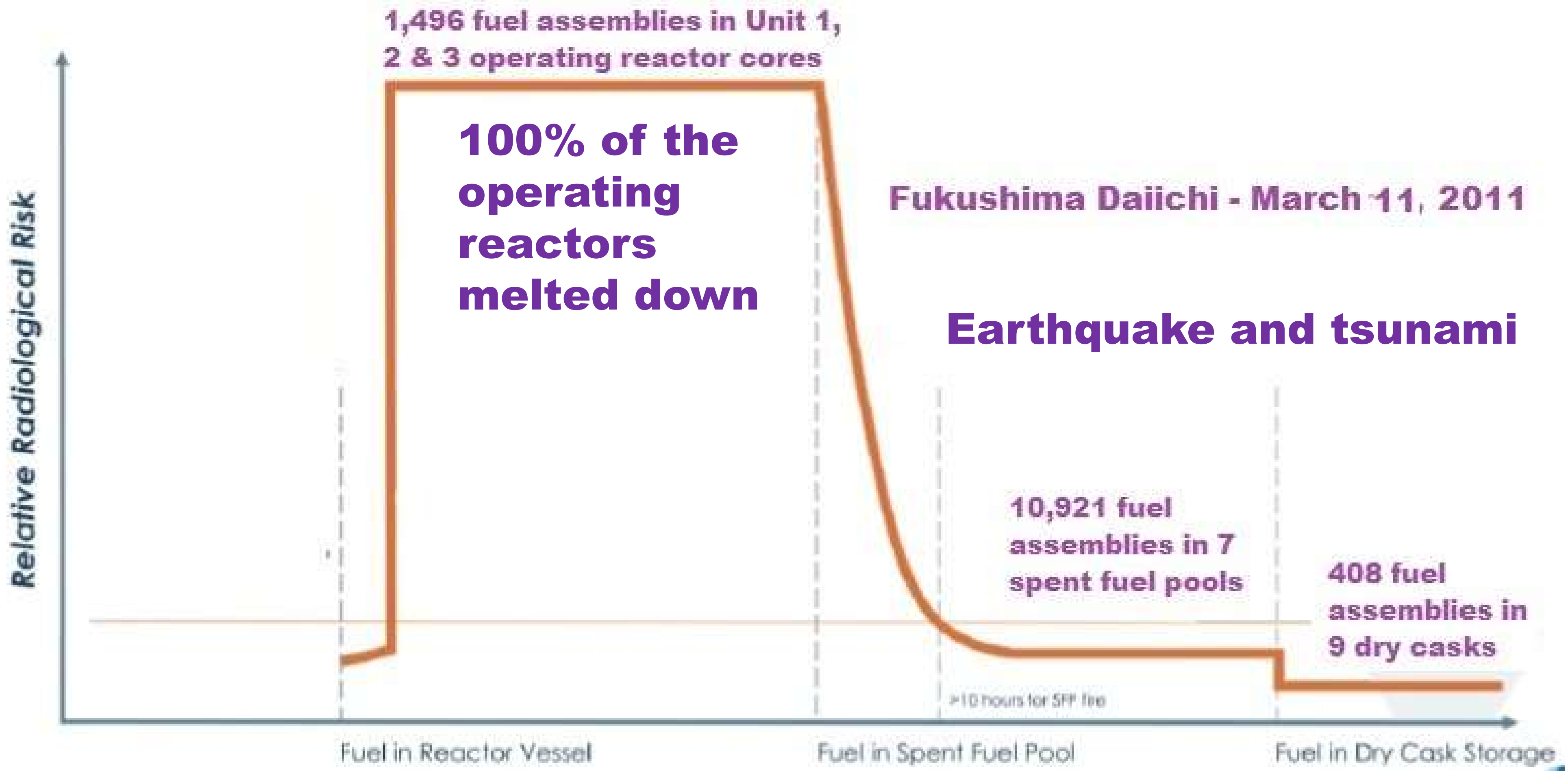
Source: Institute for Nuclear Power Operations (INPO), "Special Report on the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station," Table 4.5-1, November 2011 (ML11347A454).

"Approximately 60 percent of the spent fuel on site is stored in a separate building in a common spent fuel pool. This pool contained 6,375 fuel assemblies."

Source: Institute for Nuclear Power Operations (INPO), "Special Report on the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station," page 35, November 2011 (ML11347A454).

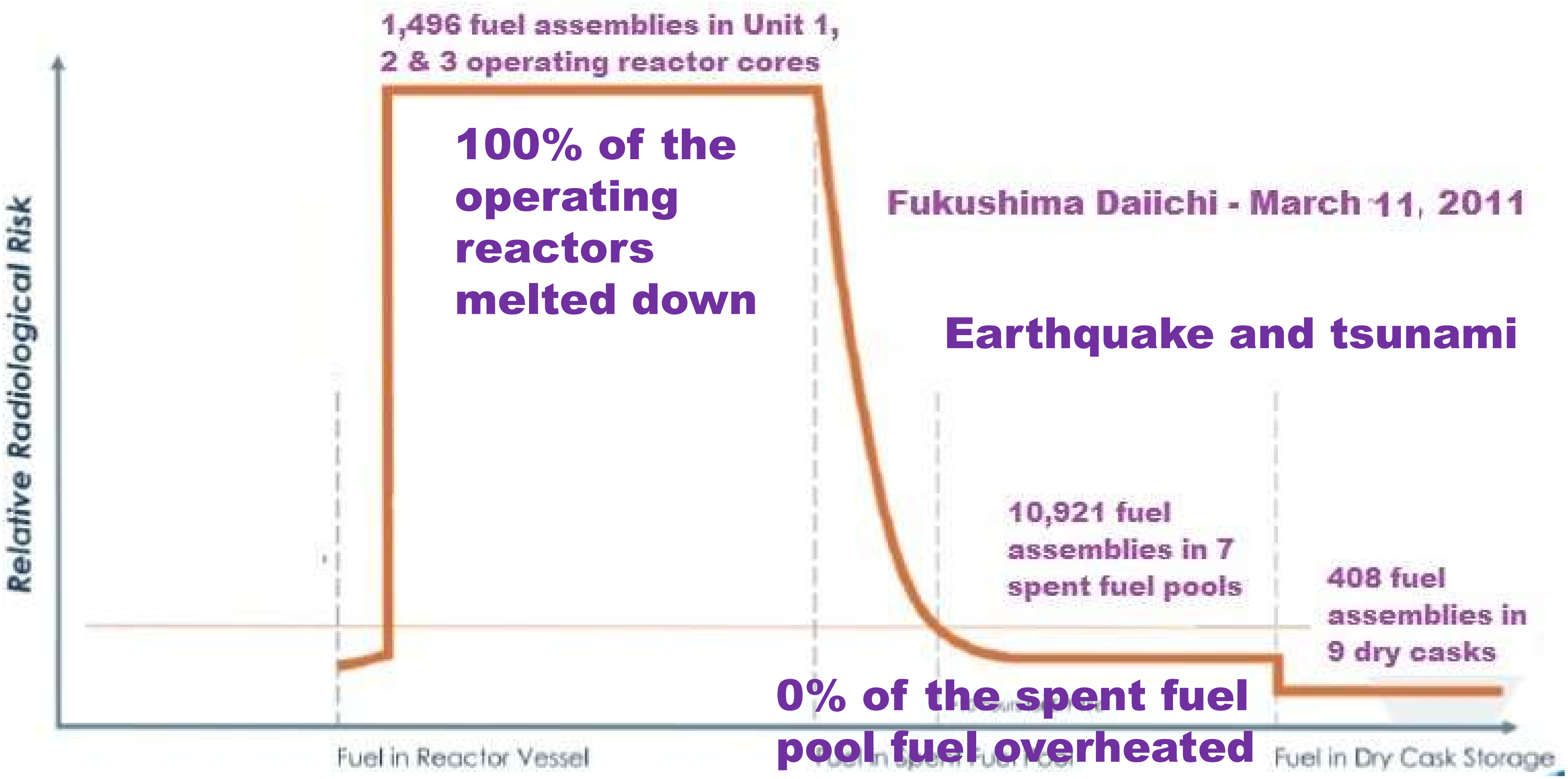


On March 10, 2011, Fukushima Units 1, 2, and 3 were operating at or near full power. Units 4, 5, and 6 were shut down for refueling/maintenance outages. Over 10,000 spent fuel assemblies resided in seven spent fuel pools (one per unit and one shared pool). Nine dry casks held 408 spent fuel assemblies onsite.

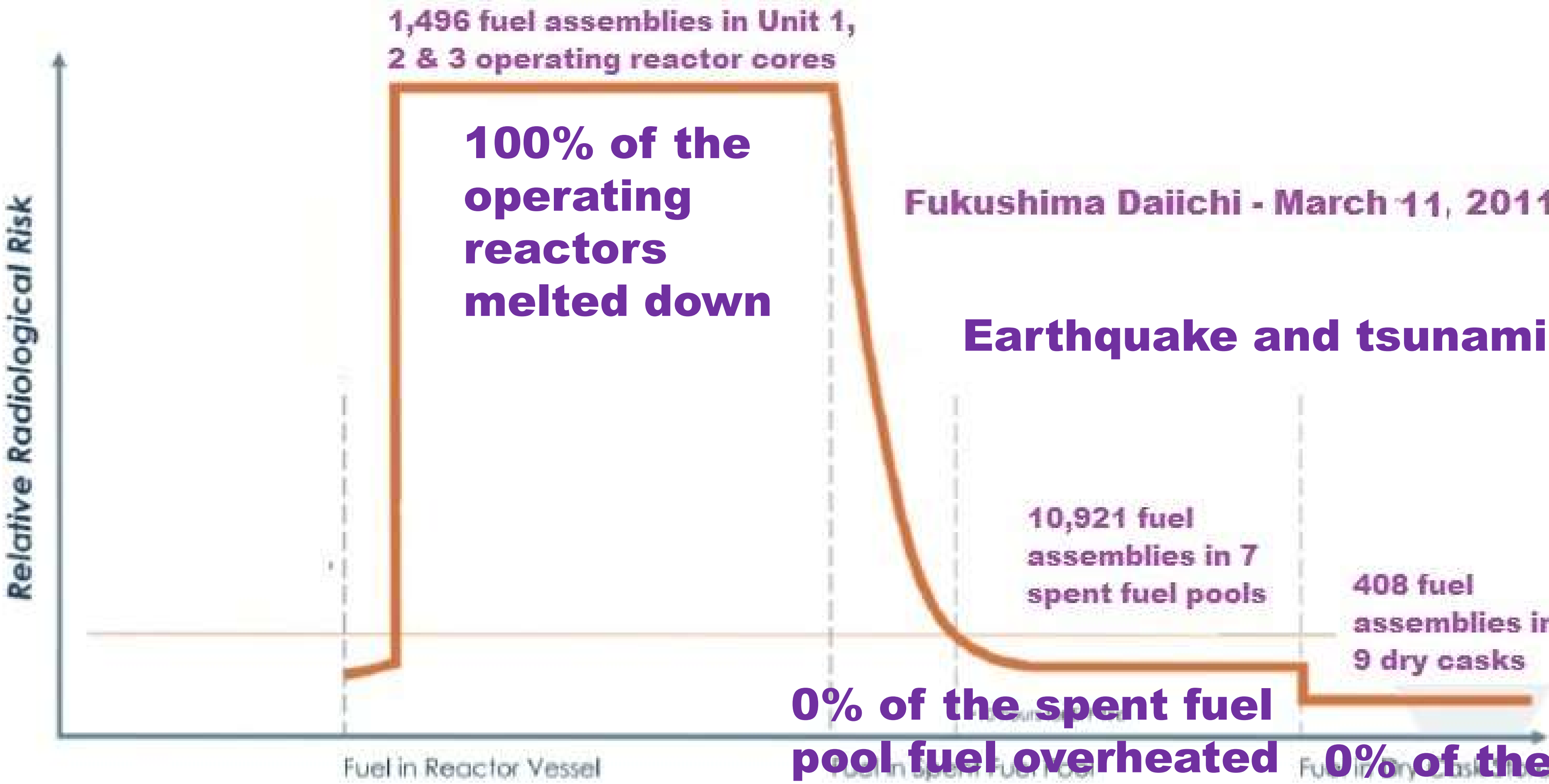


On March 11, 2011, Fukushima Units 1, 2, and 3 were operating at or near full power when an earthquake disabled electrical power to non-emergency equipment and about 45 minutes later a tsunami disabled electrical power to emergency equipment.

All three reactor cores melted down.



None of the fuel assemblies in the seven spent fuel pools was damaged by overheating, although helicopters dropped water from above and fire trucks sprayed water from below to ensure the pools had sufficient water.



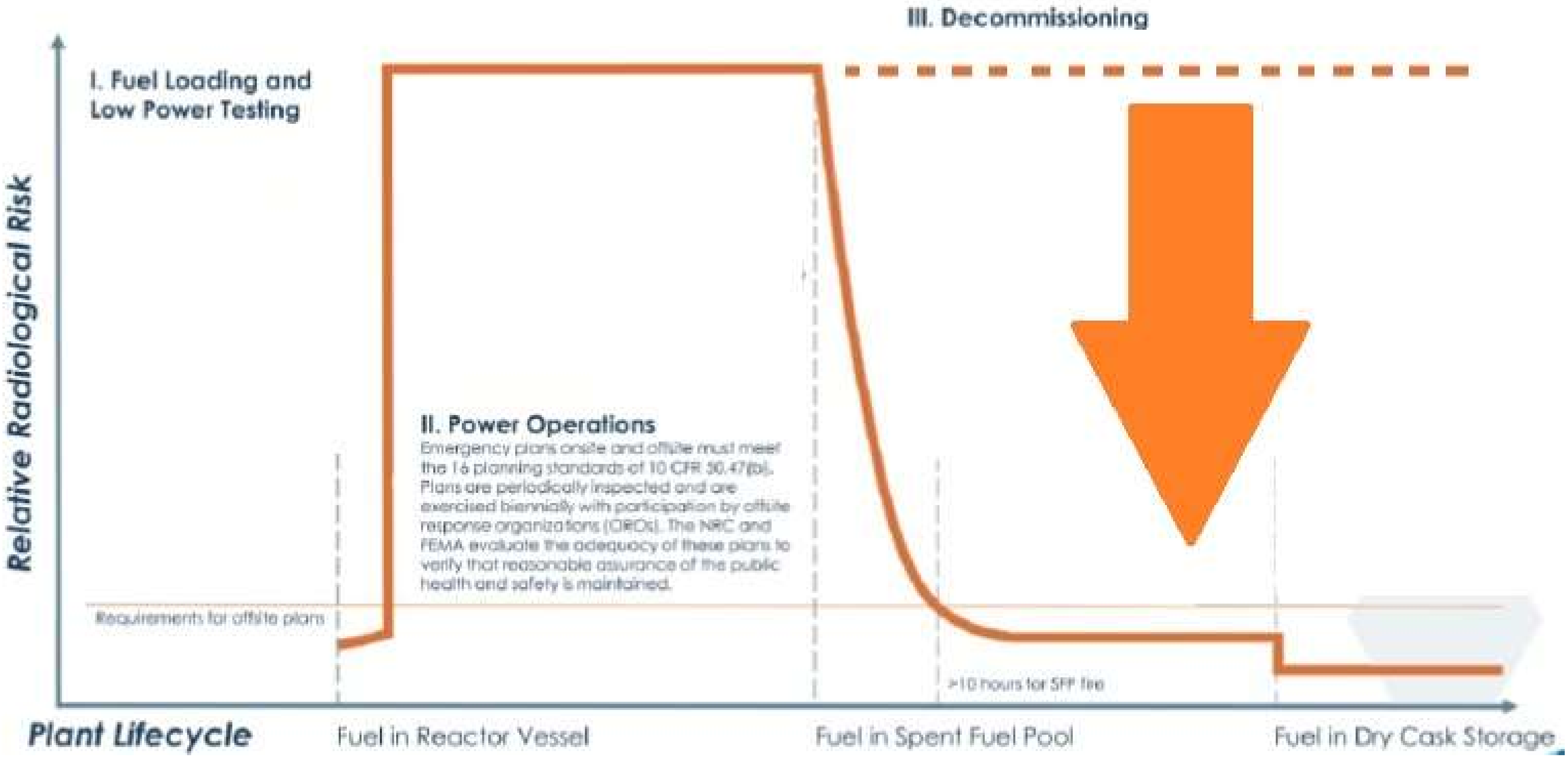
100% of the operating reactors melted down

Earthquake and tsunami

0% of the spent fuel pool fuel overheated

0% of the dry cask fuel overheated

None of the fuel assemblies in the nine dry casks was damaged with no special measures needed to achieve that outcome.



The NRC's Relative Risk chart has been annotated.

The dotted line does not represent risk. Instead it indicates that the NRC's regulations for emergency planning, liability insurance, security, et al were developed to manage operating reactor risks. Past exemptions and future rulemaking seek to better align requirements with risks.