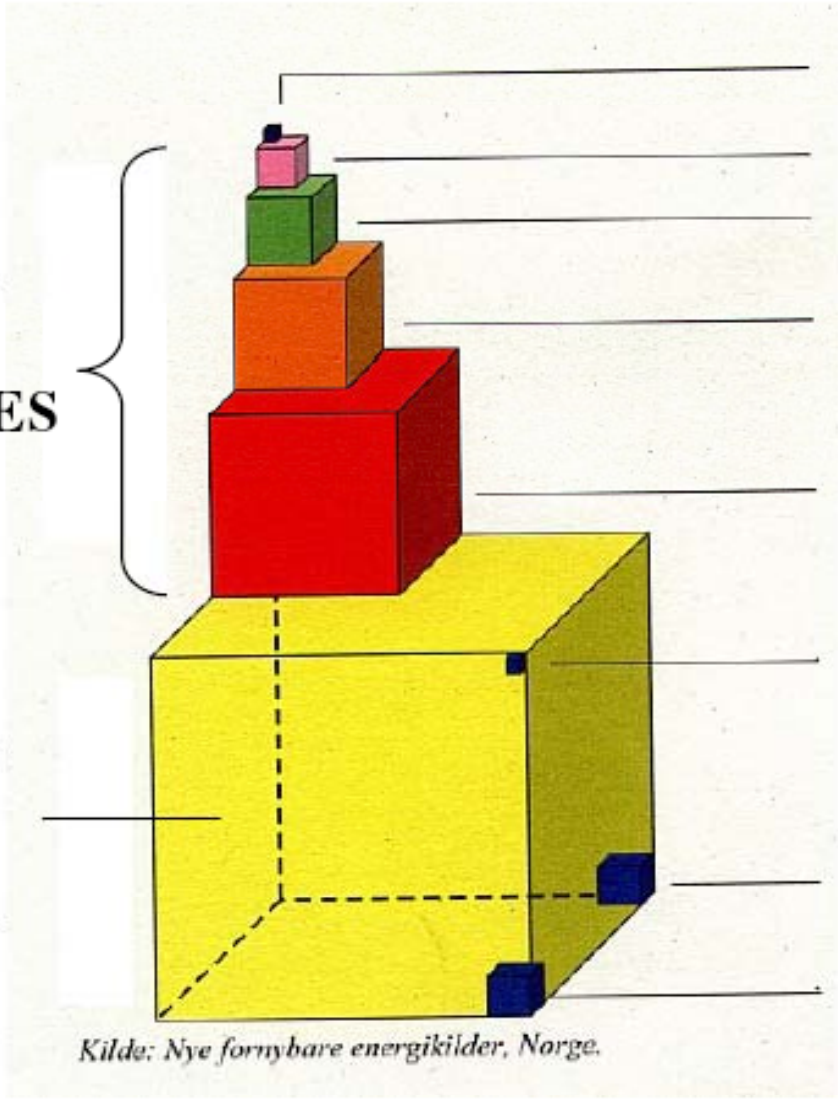
Small Scale Nuclear Power: an Option for Alaska?

Gwen Holdmann, Director
Alaska Center for Energy and Power
University of Alaska

Overview of Presentation

- What is nuclear energy?
- History of Nuclear Power (worldwide)
- History in Alaska
- Technology Update
- Barriers to Implementation (permitting, liability, environmental concerns)
- What should Alaska do now?

World Energy Resources



World's annual energy consumption

Gas reserves

Oil reserves

Uranium reserves

Coal reserves

Hydro (usable)

Fotosynthesis

Wind energy

Kilde: Nye fornybare energikilder, Norge.

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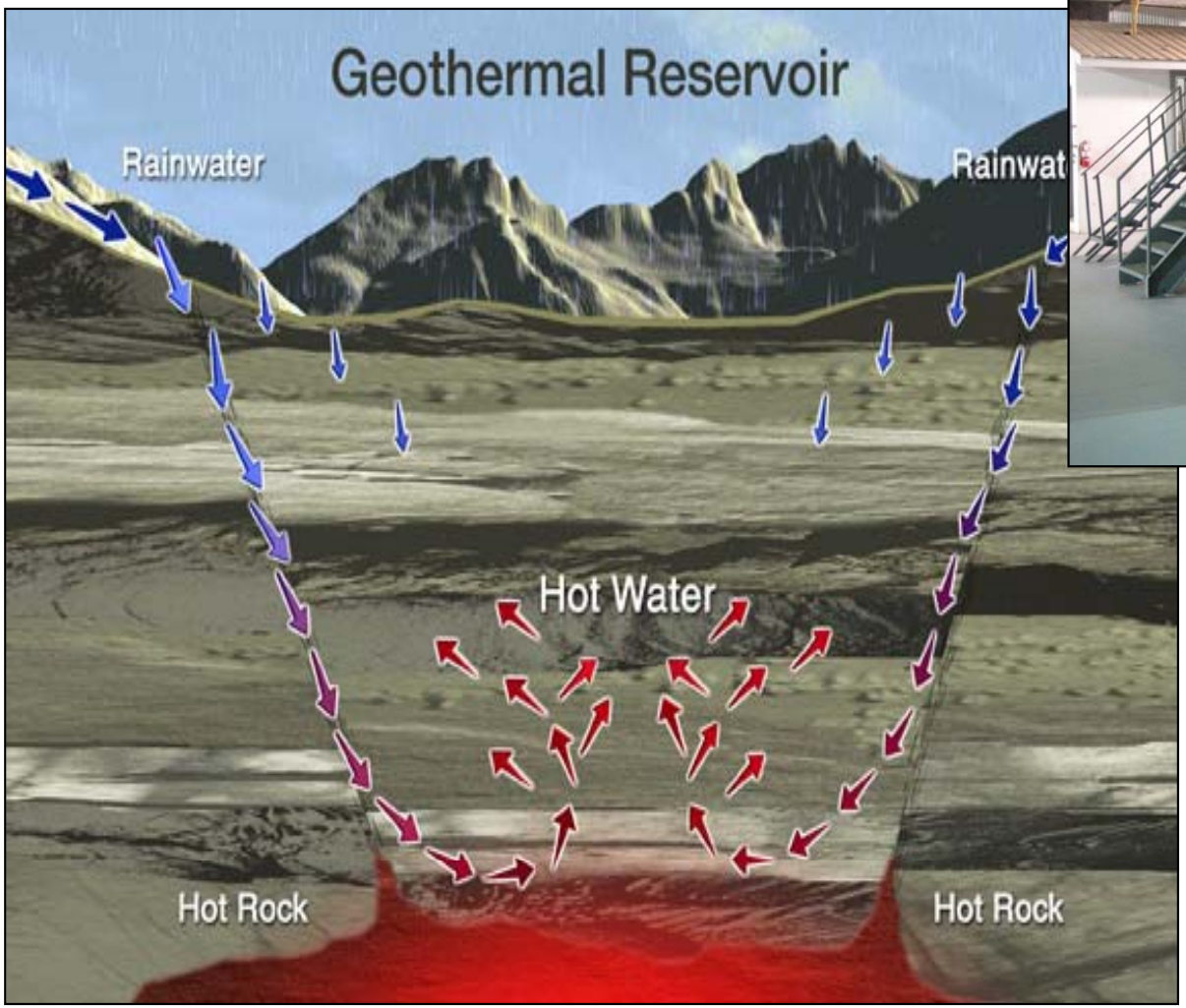

Naturally occurring radioactive decay in granitic rocks generates heat in some geothermal systems, such as Chena Hot Springs.

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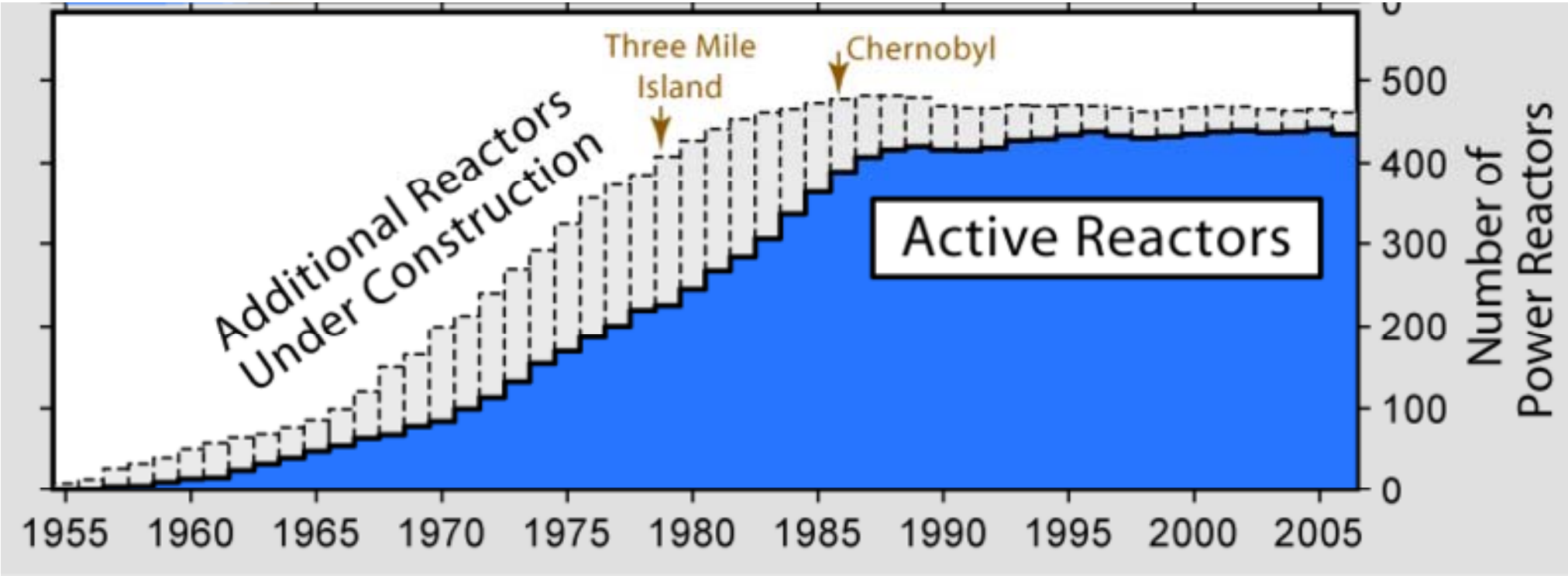
History of Nuclear Energy

- Ernest Rutherford first split atom in 1917
- First man-made reactor developed in 1942 as part of the Manhattan Project, ultimately resulting in first nuclear weapons used on towns of Nagasaki and Hiroshima during WWII
- First experimental nuclear power plant built in Arco, Idaho (100kW, 1951)
- Obninsk Nuclear Power Plant in Russia became first power plant connected to an electric grid (5MW, 1954)

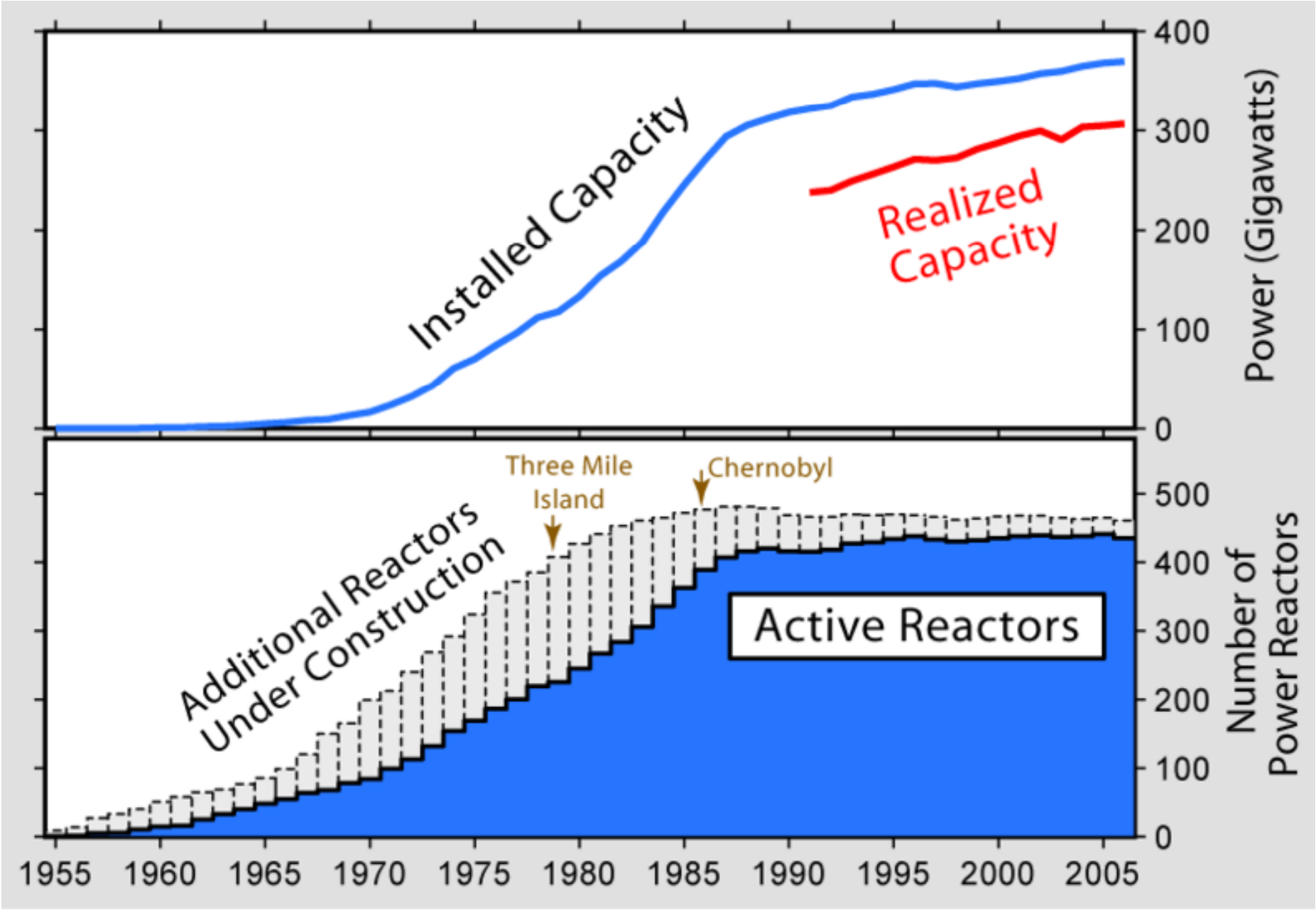
Arco, Idaho experimental facility

History of Nuclear Power Industry

- Nuclear power generation increased quickly from 1960's through 1980's.
- Three Mile Island and Chernobyl accidents slowed construction of new reactors considerably.



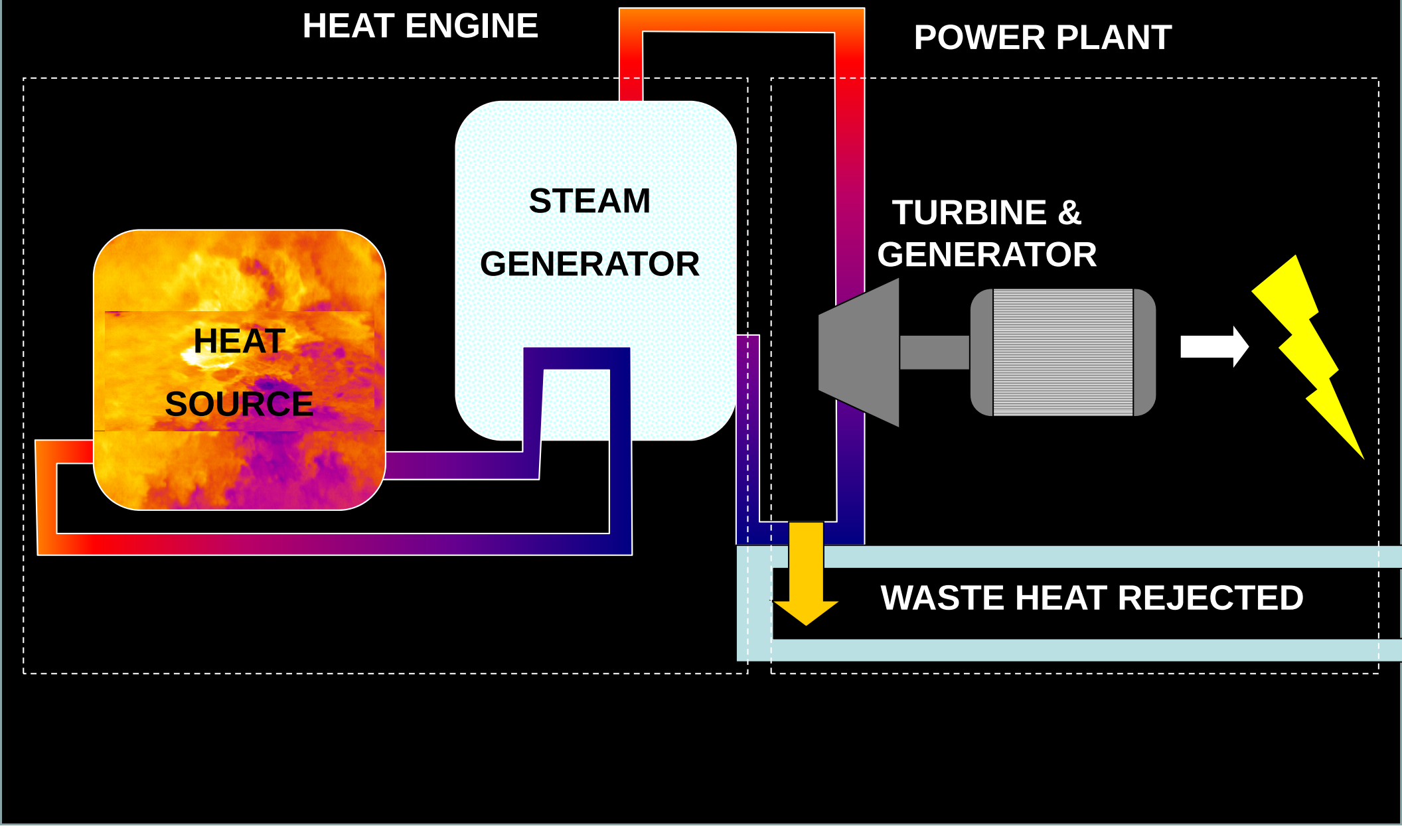
History of Nuclear Power Industry



Nuclear Energy Today

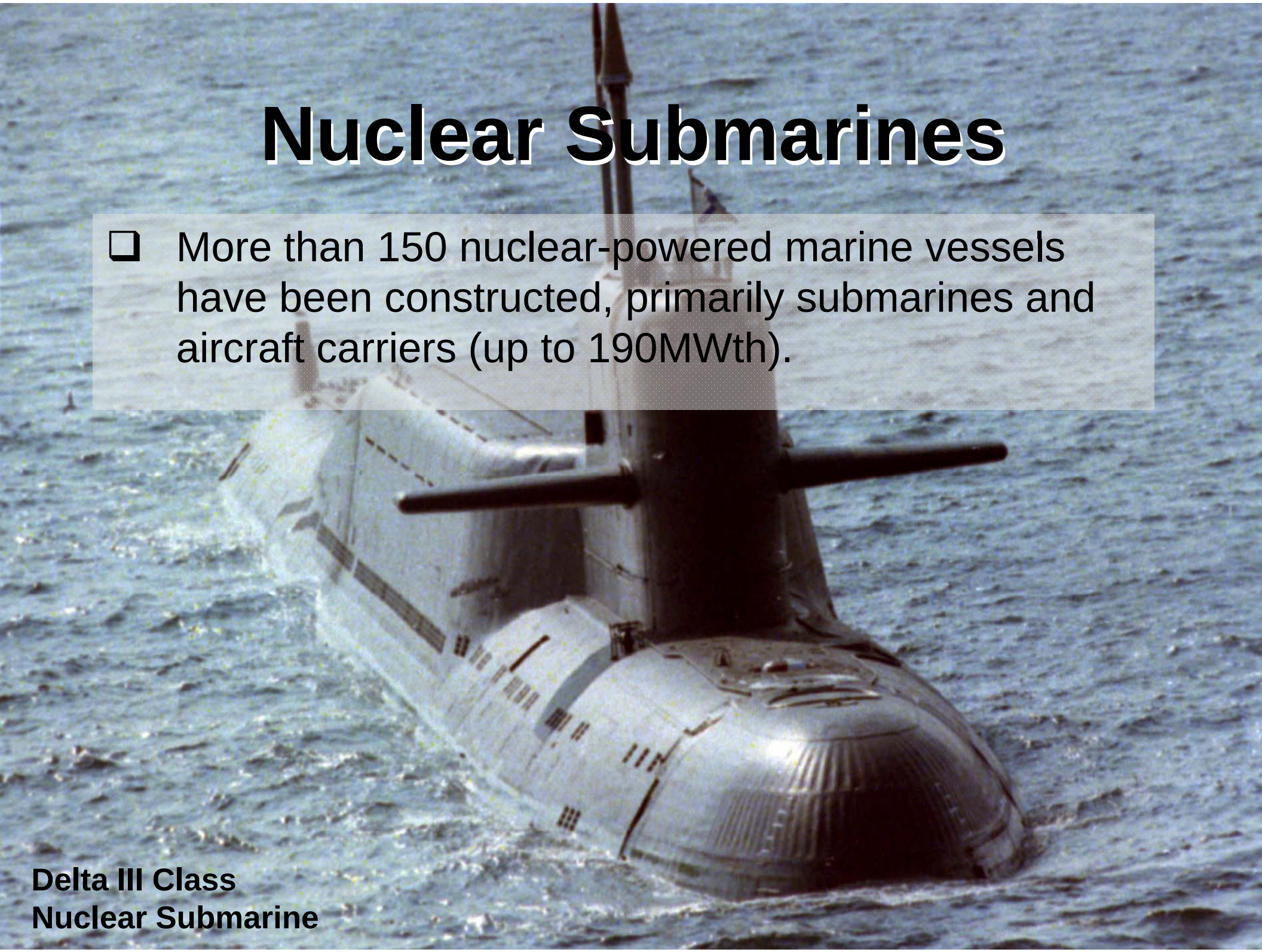
- 15% of world-wide electric power generation from nuclear power.
- U.S., France, and Japan are largest producers but 439 nuclear power reactors operating in 31 countries today.
- Size of facilities has grown from 60MW to 1600MW with corresponding economies of scale (Railbelt grid has 1470 MW of installed capacity).
- Typical power plant employs about 1000 people.

Nuclear Power Generation



Nuclear Submarines

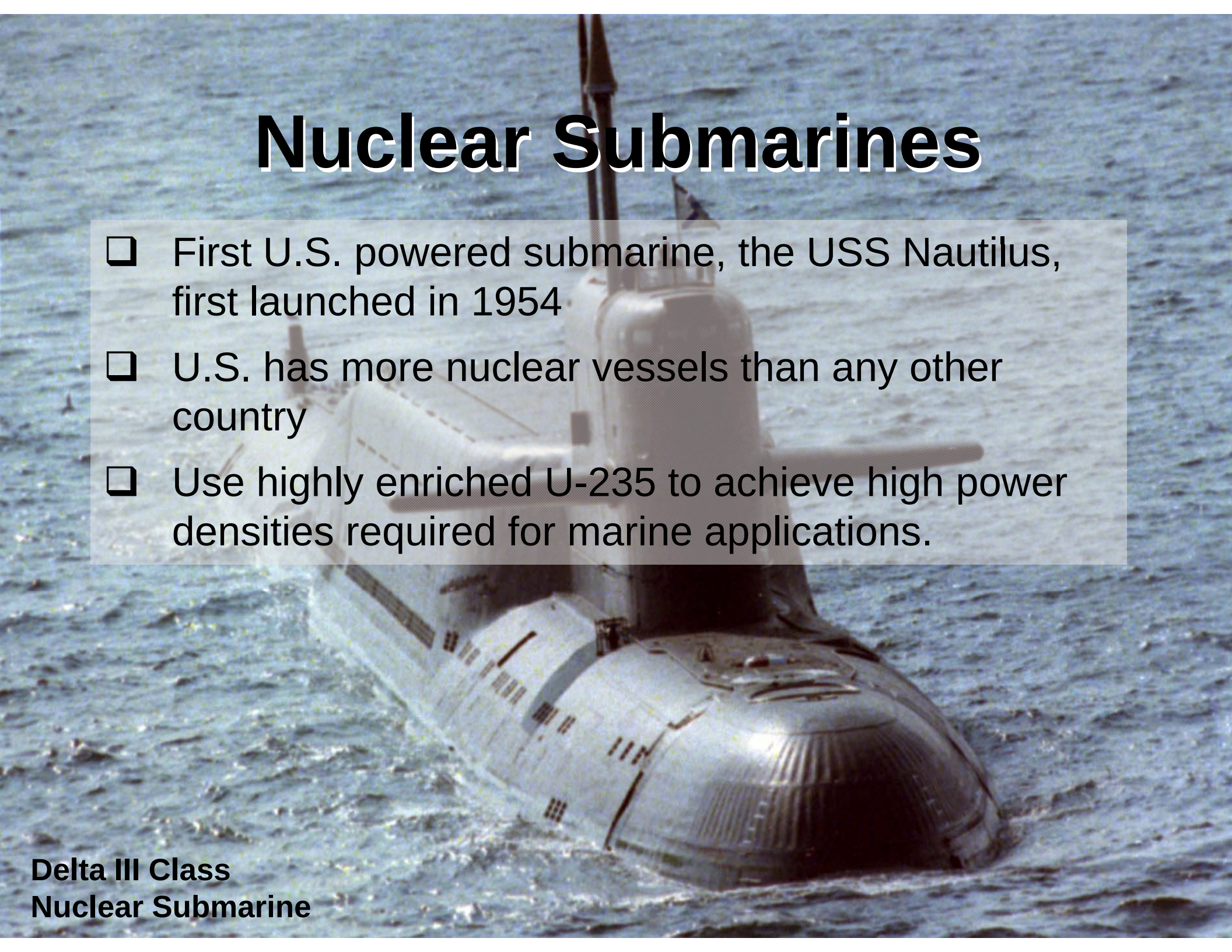
- More than 150 nuclear-powered marine vessels have been constructed, primarily submarines and aircraft carriers (up to 190MWth).



Delta III Class Nuclear Submarine

Nuclear Submarines

- First U.S. powered submarine, the USS Nautilus, first launched in 1954
- U.S. has more nuclear vessels than any other country
- Use highly enriched U-235 to achieve high power densities required for marine applications.



Delta III Class Nuclear Submarine

Army Nuclear Power Program

- Active from 1954-1974
- Small scale reactors for heat and power for military installations
- 8 total reactors constructed, including Fort Greely

SM-1 Nuclear Reactor in Ft. Belvoir Virginia. First nuclear power plant developed under the ANPP, and the first plant connected to a commercial electric grid. 2MWe project (1957-1973).

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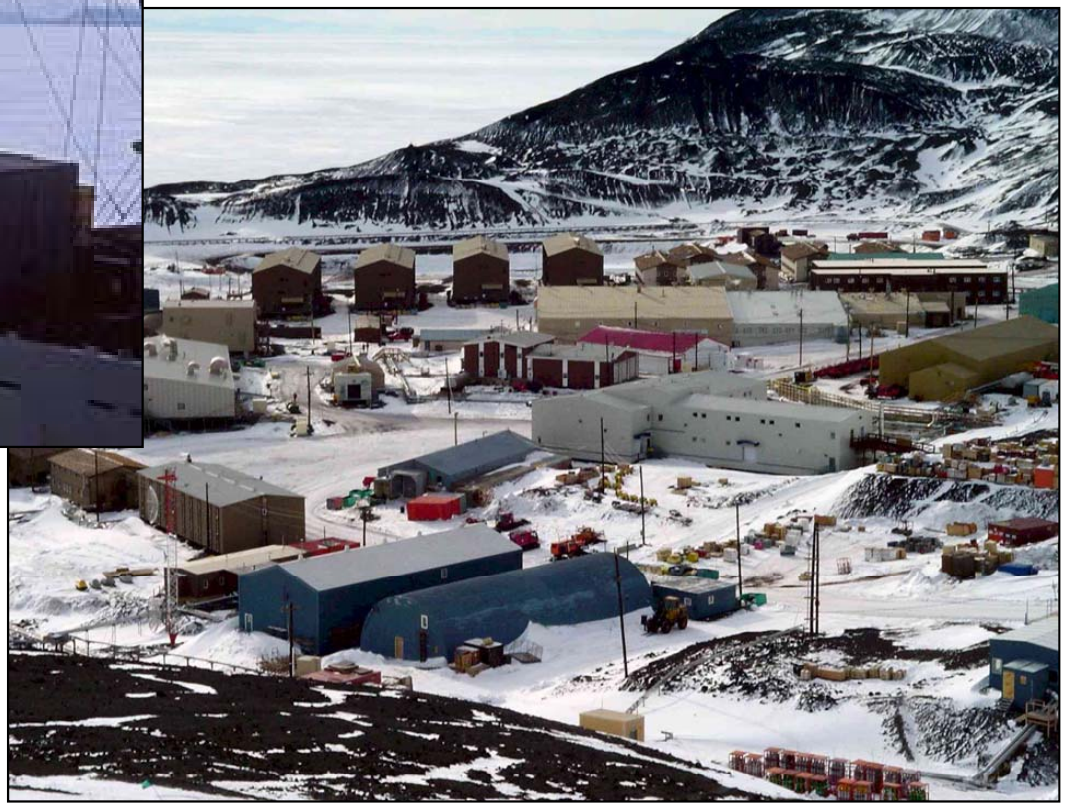
Army Nuclear Power Program Objectives

- Reduction or elimination of dependence on fossil fuel sources.
- Reduction or elimination of logistic burden necessary to support conventional power plants.
- Reliable operation.
- Infrequent refueling and maintenance.
- Reduced crew size, with ultimate goal of unattended operation.
- Transportability, mobility, and reaction times compatible with the mission or equipment to be supported.
- Improved cost-effectiveness.

Army Nuclear Power Program



McMurdo Nuclear Power Plant (Antarctica) delivered in 1962, decommissioned in 1972 after experiencing a series of problems.

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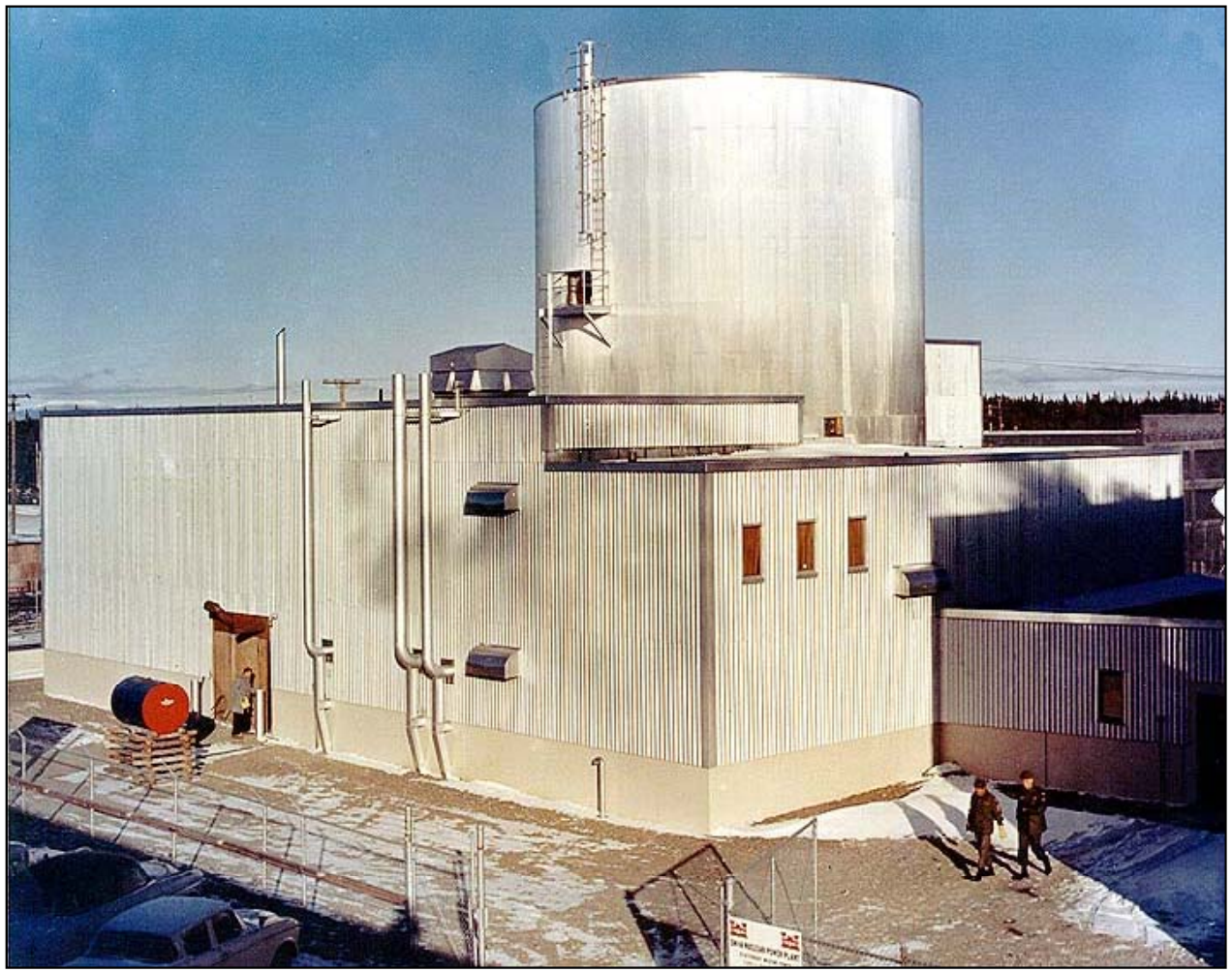
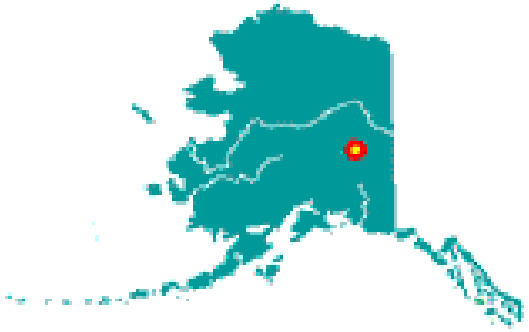
Fort Greely SM-1A Reactor





Fort Greely primary reactor facility. Commissioned in 1962, decommissioned in 1972.

Fort Greely Project

- Total output was 20.2MWth, generated 1.6kWe as well as steam for post heating at Fort Greely (500 times smaller than typical 1MW commercial reactors).
- SM-1 reactor designed to be transported by air, quickly installed, and operated under extreme environmental conditions. Fort Greely was selected as the first field installation.
- Used highly enriched Uranium (93% U-235), required refueling every 2 years.

Modern Small Scale Nuclear Power

- Defined by IAEA as under 300 MW.
- Several exist and are operating in India, Pakistan, China, and Siberia, elsewhere.
- Many new designs proposed. Most advanced modular project is in China (Chinergy).
- Russia's KLT-40S is a reactor well proven in icebreakers and now proposed for wider use in desalination and, on barges, for remote area power supply (50 MWt unit for desalination or district heating).
- In South Africa PBMR and Eskom have been developing the Pebble Bed Modular Reactor of 165 MWe.

Bilibino (Siberia) Power Plant

- Includes 4 small 62MWth units (each produce 11MWe)
- Used for co-generation of electricity and heat since 1976.
- Have generated energy much more cheaply than fossil fuel alternatives in the Arctic region.

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Modern Small Scale Nuclear ‘Batteries’

- Typically defined as under 50MWe
- Sealed concrete cylindrical reactor buried 50-100 feet underground.
- Passive system (no internal mechanic parts, minimal maintenance requirements).
- No refueling required.
- Shipped intact back to manufacturer at end of operating lifetime (~30yrs).

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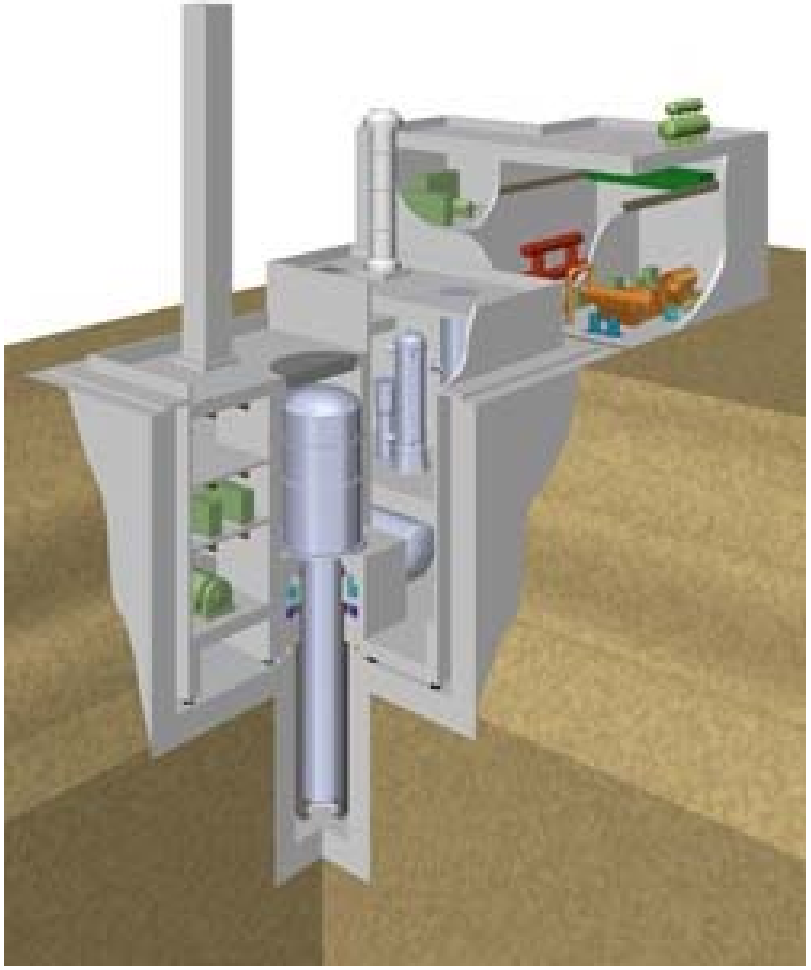
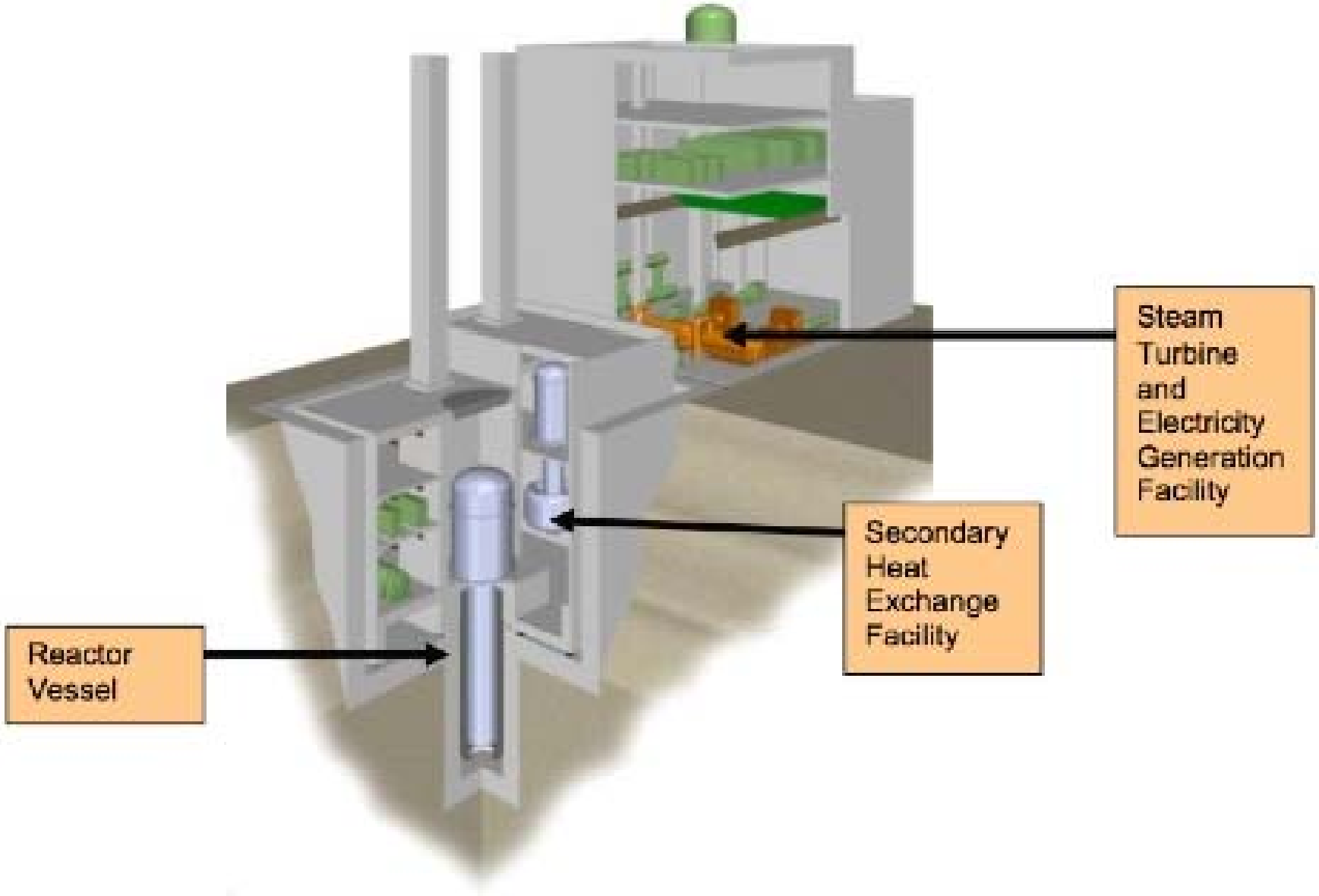
Applications for Nuclear ‘Batteries’

- Modular units for larger Giga-watt scale plants.
- Remote mining operations (require 10-100 MW+).
- Remote communities?
- Pipeline pumping stations (require ~20-25MW).
- Desalinization facilities.
- Hydrogen production.

Toshiba 4S

- 4S stands for super safe, small, and simple nuclear reactor.
- Liquid sodium heated in reactor to produce steam (~500 ºC).
- Steam drives aboveground conventional turbine.
- 10 MWe capacity, also 50MW unit proposed.
- $2500/kW capital cost projected (5-7¢ per kW-hr).




Steam
Turbine
and
Electricity
Generation
Facility
Secondary
Heat
Exchange
Facility
Reactor
Vessel

Proposed Galena Project

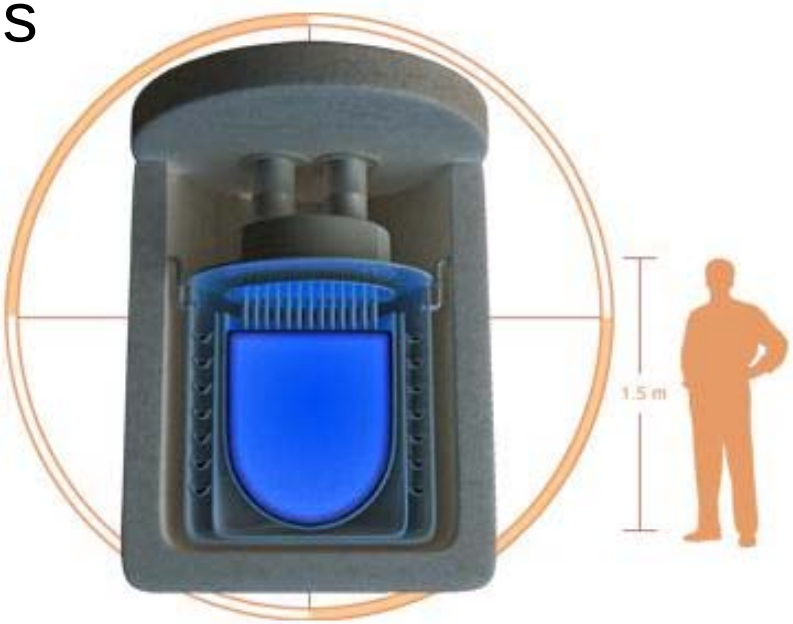
- City of Galena accepted a proposal from Toshiba in 2004-05 (Toshiba handles regulatory work and pays for installation, Galena responsible only for site permitting and operating costs).
- Opposition to proposal by other Yukon River villages is based on environmental/safety concerns.
- Proposed prior to Galena Air Force Base closure (would have provided additional load and potentially contained area).
- Estimated electricity cost: $.05 to $.17 per kW/hr excluding non-fuel costs (currently ~20¢ per kWhr).

Galena Project Timeline

- Formal application for design approval to NRC planned for 2009, now delayed until at least 2011 (Office of New Reactors at Nuclear Regulatory Commission has announced focus only on large-scale reactors at least through this year).
- Assuming design approval granted on 2-year timeframe following application, site approval and environmental review to follow (taking up to 10 years).
- At this time, estimated timeline would bring the project on-line in 2025.
- Galena is also pursuing other options.

Hyperion Nuclear Reactor

- 70MWth, 20MWe output.
- Original design pioneered by Los Alamos National Lab.
- 5-10 year operation before refueling.
- Estimated cost of $25-$30M
- About 20 tons, ‘hot-tub’ sized reactor.
- Not as far along in permitting process as Toshiba.



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Environmental Concerns

- Perception of the danger of nuclear power plants.
  - Three Mile Island (1979) and Chernobyl (1986) disasters.
  - Record in US has been good.
- Fear of radiation
  - We are constantly exposed to natural radiation (radon, cosmic radiation, x-rays, jet travel).
  - Above ground testing in 1950's resulted in some high exposure levels and government denial has led to mistrust.
- Long term storage of radioactive waste
  - Nuclear waste includes isotopes with a half-life of tens of thousands to millions of years.
  - Currently no long term storage for high level waste in the US.
  - Reprocessing of fuel can be done and is becoming more common, meaning fuel can be recycled and used again.

Problematic Licensing Requirements

- Need for emergency evacuation routes.
- Need for plant owner willing to take on responsibility for financing, insurance, licensing process, employee training, and plant security.
- Specially trained personnel on-site.
- Many others.

New Push for Nuclear Energy in U.S.

- President's FY 2011 budget includes $54 billion in loan guarantees for six or seven new nuclear plants.
- $8.3 billion in loan guarantees announced (Feb 2010) for two new plants in Georgia (the first to be built in the U.S. in three decades).
- President has established commission to study how to deal with nuclear waste.
- Nuclear Regulatory Commission currently considering 13 applications, all for large plants.

What Should Alaska Do?

- Maintain active monitoring effort to stay abreast of developments in the nuclear power industry.
- Provide input to NRC on unique needs, circumstances in Alaska.
- Identify mechanism to address ownership/insurance issue.
- Remove barriers in state statutes (SB220 and HB305).

For more information visit:

www.uaf.edu/acep

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