
# Pu-238 Production – Restoring a Reliable Supply

Alice Caponiti

Program Director for
Infrastructure Capabilities

Space and Defense
Power Systems

February 2011

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

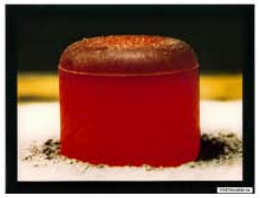
# DOE RPS Responsibilities

- Maintain RPS production infrastructure capability
- Develop, produce and deliver RPS for mission applications
  - Design, development, fabrication, evaluation, testing, delivery to meet overall system requirements, specifications, schedules and interfaces as agreed to by NASA and DOE
  - Manage and direct system integration contracts
  - Manage and direct national laboratories
- Manage Pu-238 inventories to meet customer needs
- Conduct nuclear safety analyses in support of NEPA and nuclear launch approval
- Provide nuclear liability indemnification for damages resulting from a nuclear incident

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

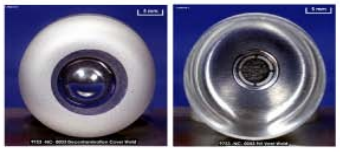
# Existing RPS Manufacturing Infrastructure

Plutonium Oxide ($PuO_2$) Fuel Pellet Production
**LANL**

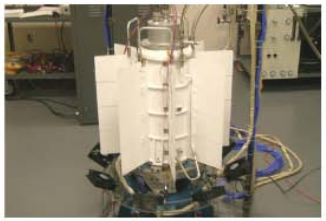


Fuel Pellet Encapsulation
**LANL**

Iridium Component Fabrication
**ORNL**



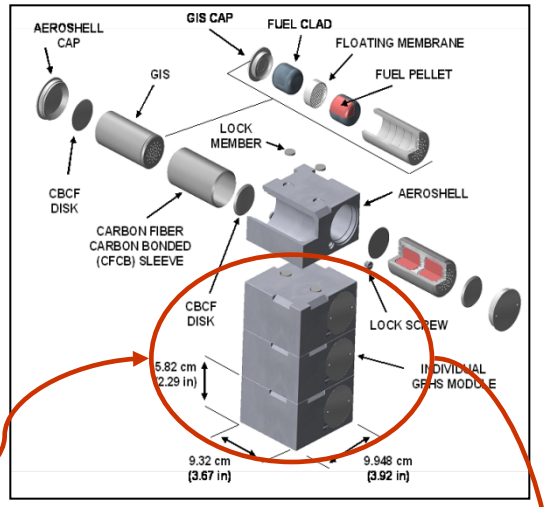
Generator
**Design Architect/System Integration Contractor (DA/SIC)**



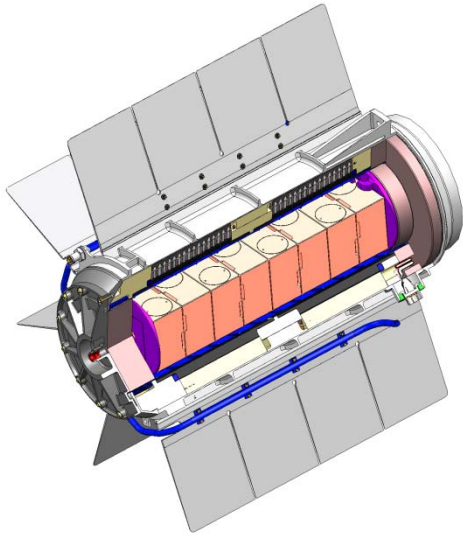
General Purpose Heat Source Module Assembly
**INL**

RPS Assembly and Testing
**INL**

RPS Shipment to KSC
**INL**




General Purpose Heat Source Module



**Pu-238 Required to Sustain Capability**

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

# Managing Pu-238 Supply

- DOE maintains Pu-238 inventory for multiple Federal user applications
  - NASA is the most visible user with highest current demands
- NASA provides long-term mission planning sets for missions potentially enabled or enhanced by RPS
  - NASA provides mission requirements – power, mission timeline
- DOE makes commitments on a mission-by-mission basis as to whether mission requirements can be met, based on:
  - Other mission priorities
  - Potential constraints of nuclear infrastructure

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

# Managing Pu-238 Supply – cont'd

- Mission planning sets do shift from year to year
- However, two universal constants:
  - Regardless of any specific mission planning set, Pu-238 has been used on a consistent basis (historic use averaged 5 kg/year)
  - Radioisotope power systems remain vital for meaningful exploration of the majority of the solar system, including significant portions of the Moon and Mars

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

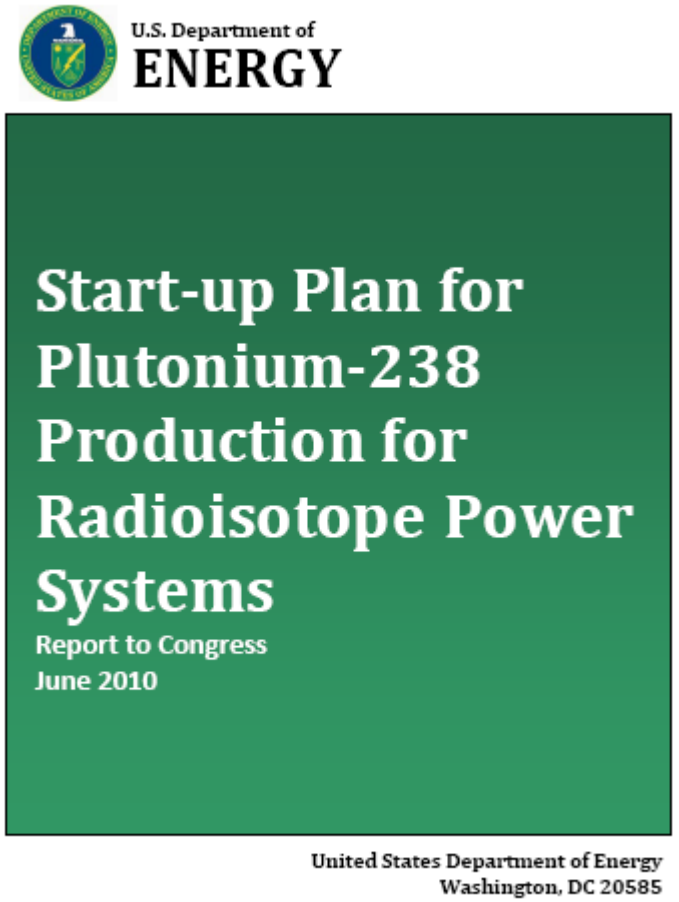
# Why Pu-238 as a Heat Source?

- Long half-life- 87.7 years
- High power density/specific power ~ 0.57 watts/gram
- Low radiation levels – primarily an alpha emitter
  - Limit radiation exposures of operating personnel during production, fabrication, testing and delivery
  - Low-mass configurations for space applications offer very little self shielding
  - Compatibility with sensitive instrumentation for space exploration
- High thermal stability – oxide form with high melting point
- Low solubility rate in the human body and environment
- Producibility in sufficient quantities and schedule to meet mission needs
- Other isotopes considered and dismissed over the years
  - Investigated several times in response to concerns over supply

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

# Pu-238 Start-up Plan to Congress

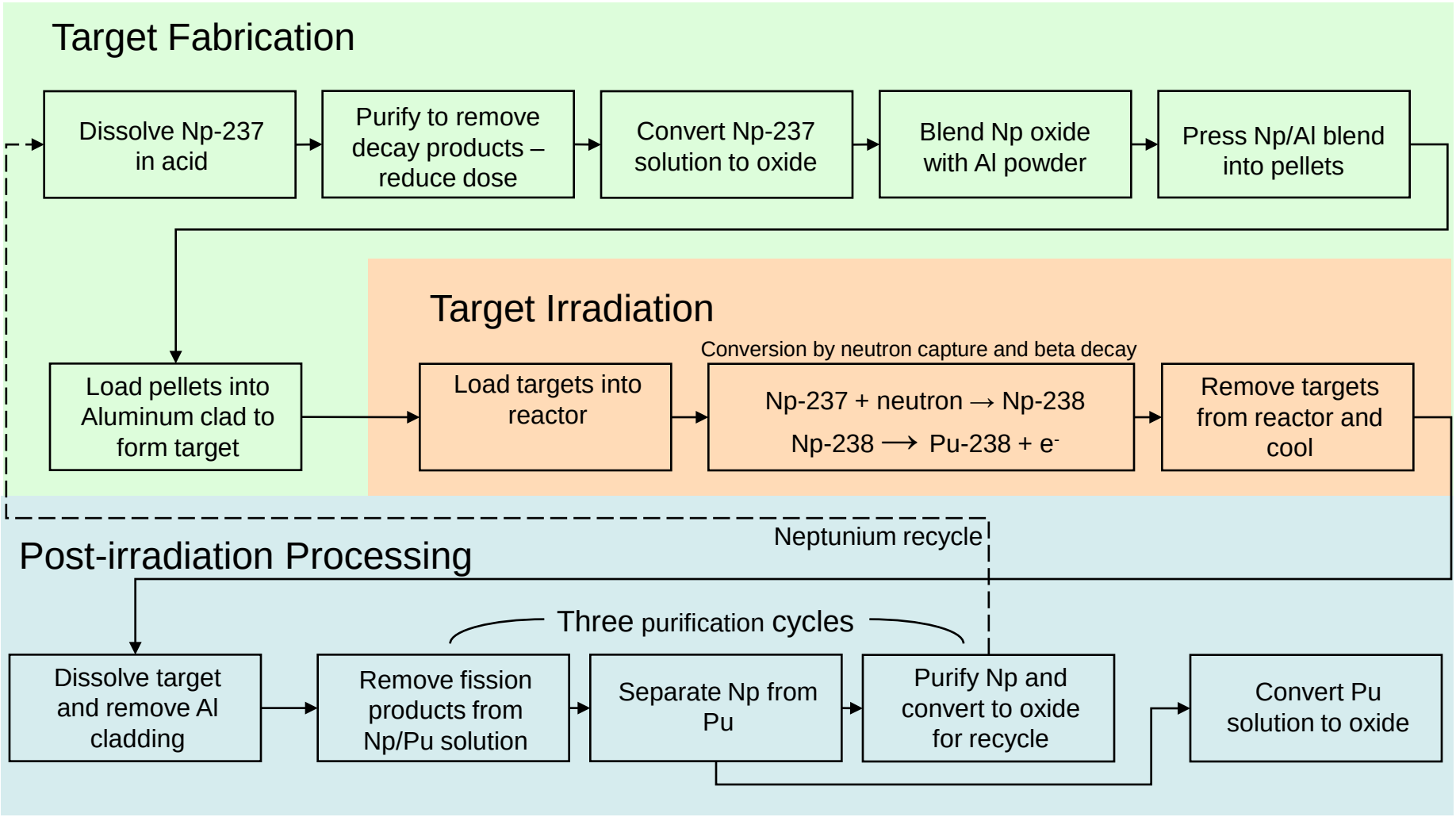
- Prepared by DOE with NASA coordination and input from other user agencies
- Affirms mission need, including production rate to meet future user demands for Pu-238
  - Up to 2 kg/year to meet projected NASA needs and allow some flexibility to meet future priorities
- Describes steps to reestablish Pu-238 production capability
- Defines roles of DOE and NASA, including management and funding responsibilities




http://nuclear.energy.gov/doclibrary/congressionalreports.html

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

# Pu-238 Production Process




**Product is plutonium dioxide powder with an isotopic content of Pu-238 greater than 80%. Each production cycle converts 10-15% Np-237 to Pu-238 with remainder of Np recycled.**

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

# Planned Approach

- Project will reestablish target fabrication and target processing capabilities
  - Phased approach to allow early irradiation of targets while target processing capability is brought online
- Pu-238 recovery rate of up to 2 kg/year can be achieved in existing, operating radioisotope production facilities at Oak Ridge National Laboratory
  - Preliminary cost range estimate: $75 – 90 million
  - Other facility options will be considered as part of formal project management process
- Target irradiation in existing DOE research reactors
  - High Flux Isotope Reactor at Oak Ridge National Laboratory
  - Advanced Test Reactor at Idaho National Laboratory
- Schedule – approximately five to six years, once funded
  - No new material available before 2016 timeframe

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

# Pu-238 Production Project Status

- FY 2011 Congressional budget request (DOE and NASA)
  - $30 million to begin establishing a Pu-238 production capability
    - $15 million in DOE's request (manages project and facilities)
    - $15 million in NASA's request (principal user of material)
  - Congress has not finalized FY 2011 budget; DOE and NASA are operating under a continuing resolution
- DOE conducting planning studies to inform initial project execution once the project is funded

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

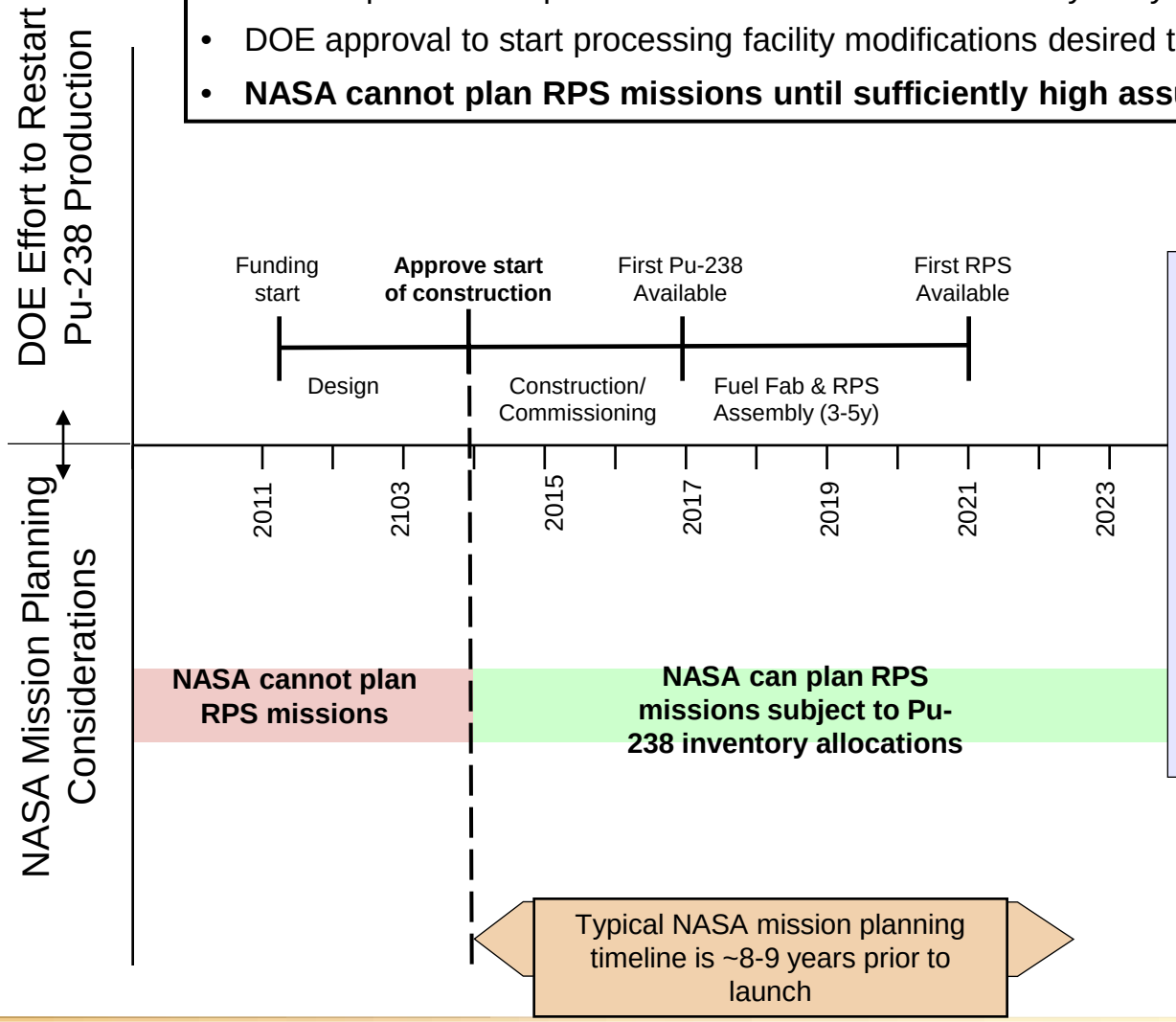
# Initial Steps for FY 2011 – FY 2012

- Target fabrication and separations process development
  - Finalize target design and fabrication using existing laboratory facilities and equipment
  - Initiate separations process development
- Reactors
  - Evaluate ATR and HFIR internal core configurations for optimal neutronics to produce Pu-238
  - Prepare documentation for developmental and full production target irradiation in ATR and HFIR
- Environmental Reviews
  - Update environmental analyses, as necessary
- Project Management
  - Prepare conceptual designs studies to support selection of alternatives
  - Perform technical reviews of conceptual design.
  - Support independent cost reviews
  - Develop documentation to support CD-1, Alternative Selection and Cost Range
    - Alternatives Analysis
    - Cost and schedule estimates of alternatives
  - Obtain approval of CD-1

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

# RPS Mission Planning Already Impacted

- Next major flagship mission will exhaust remaining existing inventory for NASA missions
- Mission planners require assurance of Pu-238 availability early in the planning process
- DOE approval to start processing facility modifications desired to sufficiently retire risk
- **NASA cannot plan RPS missions until sufficiently high assurance of project completion**




**Known Impacts**

**Missions precluded from using RPS:**

- Juno
- Solar Probe
- New Frontiers III

**Mission power/capabilities reduced or restricted:**

- Int'l Lunar Network

Source: Briefing chart for the Radioisotope Power Systems Committee of the National Research Council, December 2008