# Radwaste Summit
**Savannah GA. June 2025**

# Technology Development and Application to Support Recycling of Radioactive Materials


## Timothy N. Milner CTO
**Energy*Solutions.***

# Society is Changing

# Decommissioning Nuclear Plants

- >30% of the cost of decommissioning a nuclear plant is waste disposal
- 95% of decommissioning waste is LLW / Disposal
- << 1% is radioactive, only the thin film of contamination on the surface (less than 1% of the volume) makes the bulk of the material LLW

Imagine if waste isn't waste ?

Reuse / Recycle / Reduce

# D&D
## A Waste Liability or a Mine of Valuable Resources

LLW
Storage & Disposal

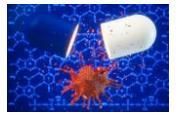
Currently

Waste
Minimization
&
Packing
Facility

NPP D&D

Recycle
Facility

Aerospace



Radiopharmaceutical

Automotive

Batteries EV's

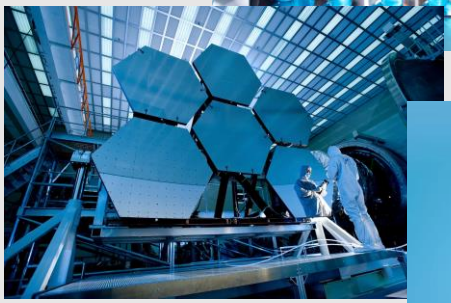
Particle Accelerators

Concrete backfill

Paradigm Shift

# Technology Types

- Enabling Technology
- Disruptive Technology
- Transformational Technology
- Digital Technology



# Enabling Technology

Stewards of the environment

ENERGYSOLUTIONS

## Core Technology We Apply To Win Work

- Decontamination
- Sort & Seg
- Size Reduction
- LWP – IX, RO, UF, SEDS, ALPS, HIC's
- Remote Tooling / Robotics
- Digital Twins
- Steam Reforming
- Metal Melting
- Waste Containers & Transportation

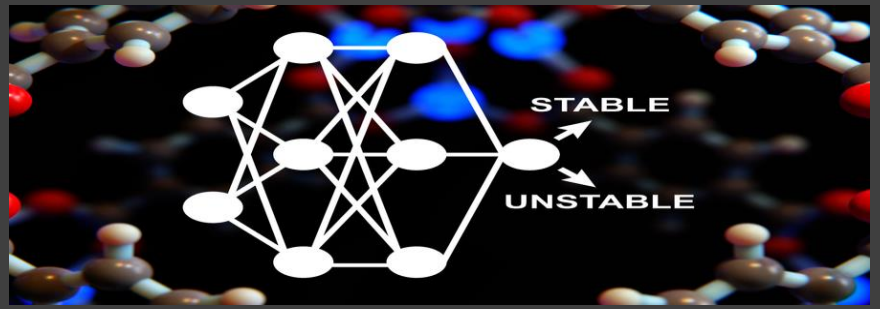
## Current Patent Portfolio

"Electrowinning Electrode, Cell and Process"
"Apparatus for Gasifying Organic Materials"
"Electrochemical Leaching of Soil"
"Robust Technetium Removal Method and System"
"Method for Treating Radioactive Waste Water" (SAFE Technology)
"System and Method for Processing Spent Nuclear Fuel"
"Shielded Packaging System for Radioactive Waste"
FLUID TREATMENT METHODS AND SYSTEMS
SYSTEMS AND METHODS FOR ISOTOPIC WATER SEPARATION
METHODS RELATING TO ISOTOPIC WATER FILTRATION
SYSTEM FOR FILLING A CONTAINER WITH HAZARDOUS WASTE
"Lid Lifter"
"Panel Filter System
"System and Method for the Removal of Radioactive Particulate From Liquid Waste"
"Integrated Steam Reforming Operation for Processing Organic Contaminated Sludges and System"
"Method and System for Treating Radioactive Waste Water" (SAFE System)
"Process and System for Treating Radioactive
Waste Water to Prevent Overloading Demineralizer Systems" (SMART System)
"Fluid Conveyed Material Collection System
"Waste Water Treatment System With Slip Stream"
"Metal Decontamination Process and Systems for Accomplishing Same"
"Apparatus, Methods, and Systems for Assaying Materials"
"Method for Detecting Hydrogen in Waste Compounds"

# *Disruptive* Technology

New Technology We Apply to Enter New Markets

- Robotics and Automation (ALARA)
- Waste Valorization
- Electrowinning
- Ion Selective Media
- Computation Reaction Modelling
- Thermal Destruction of Organics
- Innovative Chemical Flowsheets
- Additive Manufacturing
- Laser Cutting / Decontamination



# Transformational Technology

Technology We Develop to Transform Markets

- High Value Metal Recycling – EV Batteries
- Rare Earths from Waste – Ce, Nd, Sc, etc
- Medical Isotope Harvesting from Nuclear Waste
- Ionic Sieving
- Photovoltaics – Ni63, Am241, C 14 batteries
- Radio-Thermal Generators - Mars Mission
- Carbon Capture / Credits from recycle
- Fusion Energy Waste Management
- SMR – D&D and WM / Recycle

# Digital Technology

Core IT Role to Improve Business Functions However, for D&D & WM the Following are needed

- Drone Point Cloud Data – Digital Twins
- Machine Learning - AI
- Paperless Manufacturing
- Virtual Reality (Mock Ups)
- VR Augmentation (Hololens)
- AI Sort & Seg

# Robotics at Three Mile Island

https://vimeo.com/969930746

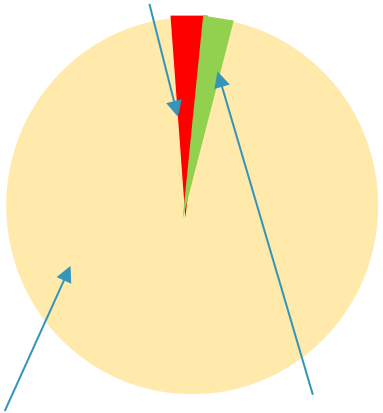
# Balanced Technology Portfolio

- 70% Enabling Technology. ➡ Maintains Revenue
- 20 % Disruptive Technology. ➡ Improves Revenue
- 10% Transformational Technology. ➡ Transforms Revenue

# Technology Driven Transition

## USA Model

ILW to Disposal

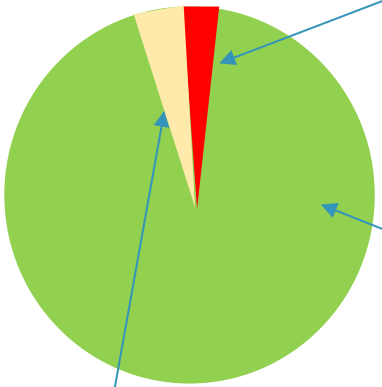


LLW / Disposal

Decon for FR or MM

## International Model

ILW to Disposal



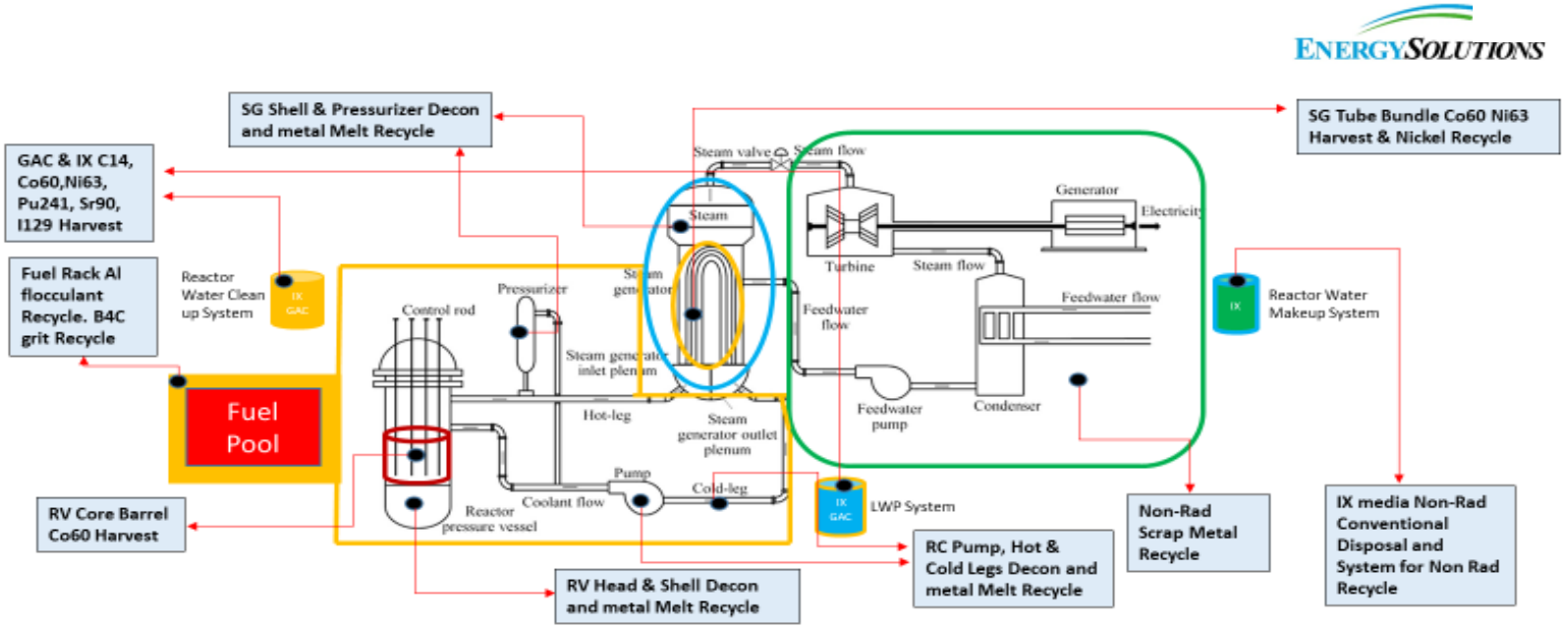
- Recycled metal for products
- Harvest high value metal for beneficial reuse
- Recycled metal for release and reuse
- Recycled concrete for backfill
- Recycled concrete for release and reuse
- Harvested radionuclides for beneficial reuse

LLW / Disposal

Target < 1%

LLW Recycle

# Future PWR Recycle Examples



# USA Recycle Facilities

We are Investing in new infrastructure and facility upgrades to deploy our patented, innovative, sustainable solutions technology

- Three Key Recycle Facilities in USA
  - BEAR CREEK Oak Ridge Tn.
    - Metal Melting
    - Products
  - ERWIN Tn.
    - Nuclide Harvesting, Resin Recycle & Thermal Destruction of Organics
  - MEMPHIS Tn.
    - Decontamination and size reduction radiometric assay and free release

# Large Component Metal Mining

**Imagine One SG:**

- Between 600 and 1,500 tonne carbon footprint reduction
- Enough metal to produce > 250 cars
- Enough Ni for > 100 EV Batteries

# Nuclide Harvesting from "*Waste to Recycle*"

- Recycling redundant nuclear plant yields a range of useful nuclides that themselves can be recycled.
- Based on current processing rates it results in 1000-5000 curies per year of Co60, Cs137, Ni63, Sr90 and C14 being made available for reuse
- Development programs operating with Academia and industry globally to develop flowsheet and new extraction / purification media
- Now developing collaboration with SME's in isotopic purification and isotope production for radiopharmaceuticals

# Nuclides Saving Lives

## Radioisotopes in Medicine

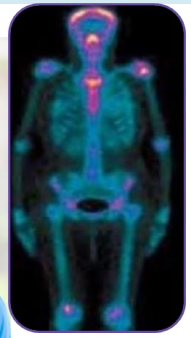
Enabling next-generation cancer therapeutics

**~40%**
Approximately 2-in-5 Americans will be diagnosed with cancer in their lifetimes

**Radiotherapeutics**
Researchers & drugmakers using radioisotopes to target and kill cancer cells with precision

**Rare Isotope Harvesting**
Nuclear energy waste stream contains life-changing rare isotopes that can be collected for medical and industrial use

NUSANO



**DIAGNOSTICS IMAGING**
Ingesting radioisotopes to detect illness

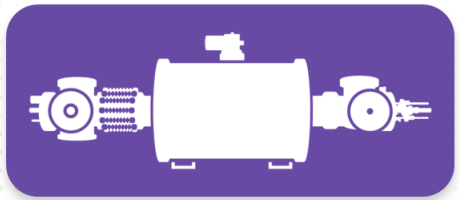
**THERAPEUTICS**
Using radioisotopes to kill cancer cells

# Technology Collaboration - Nusano

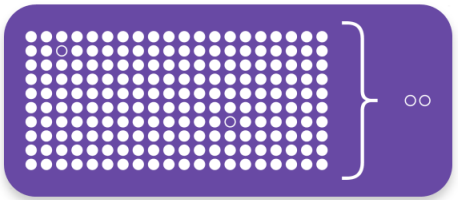
# Impactful Technology

**2025**

Commercializing **core technologies** to support the **nuclear renaissance**



**BREAKTHROUGH ION SOURCE**



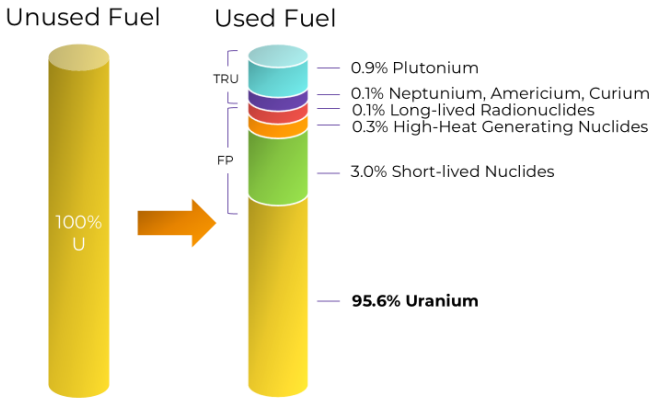
**PROPRIETARY SEPARATION PROCESS**

NUSANO

# Transformational Innovation



## Plasma Enrichment Process:
Unlocking **value** from used nuclear fuel



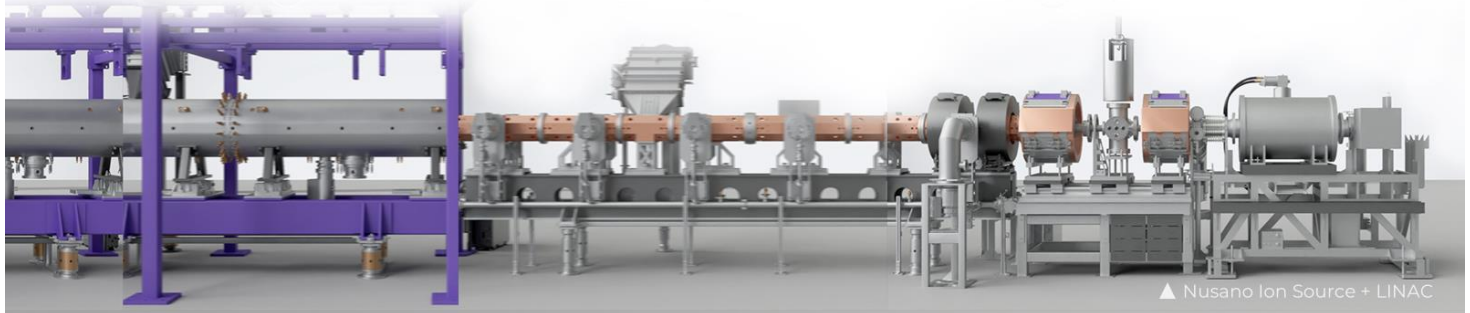

- **Capture Unused U-235**
  Eliminating U-236 penalty for higher recycling efficiency
- **Harvest Rare Isotopes**
  Unlocking new commercial value in critical industries
- **Reducing Waste**
  Leaving less volume and only real waste product

# Sustainability

NUSANO ENERGY SOLUTIONS

SEPARATION | ION SOURCE

## **Proprietary Ion Source + Accelerator:** reducing the burden of nuclear waste



▲ Nusano Ion Source + LINAC

- **Runs continuously with high-power particle beam**
- **Generates sustain neutron flux critical for transmutation**
- **Converts long-lived transuranics into stable or short-lived isotopes**
- **Achieves up to 700x more output than traditional accelerators**

# Summary

- Creating a paradigm shift in the back end of the nuclear industry
- Decommissioning becomes a valuable source of scarce resources
- Money is spent on “creating an asset” not “reducing a liability”
- Positive closure of NPP life cycle
- Delivering on Sustainability, Circular Economy and Carbon Footprint Reduction

**Building Partnerships to Deliver Sustainability Globally**