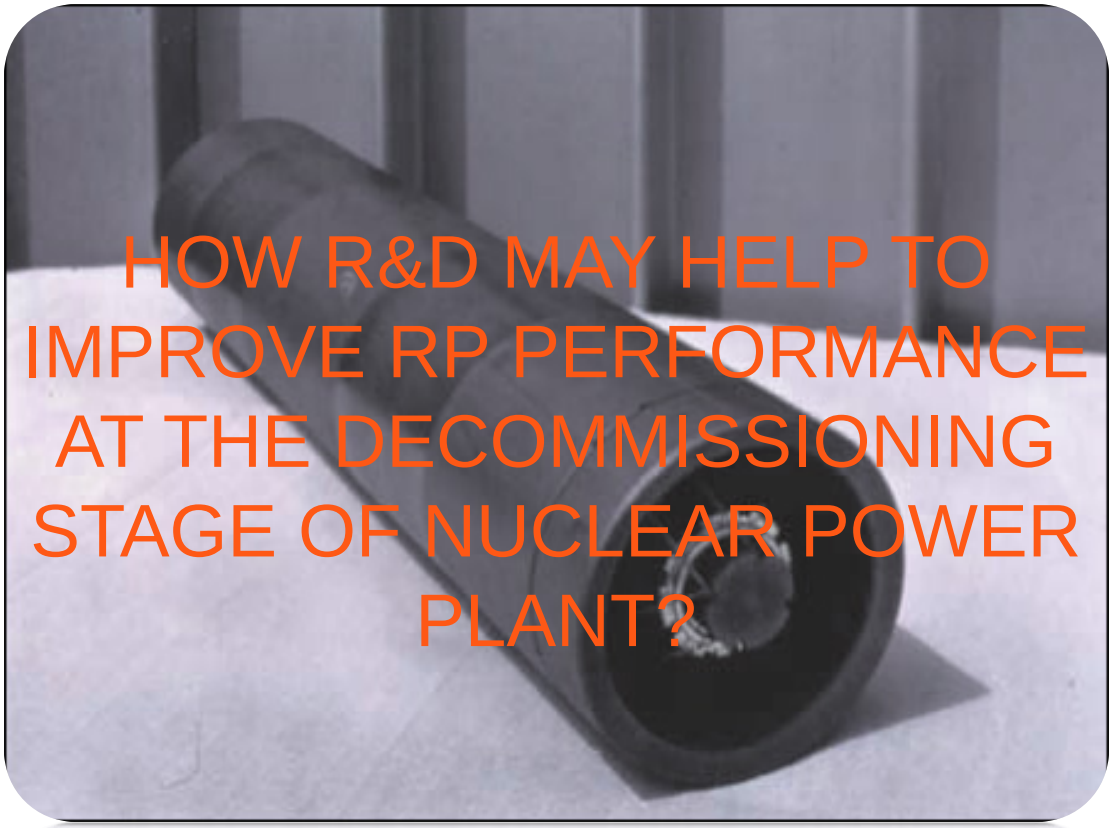

HOW R&D MAY HELP TO IMPROVE RP PERFORMANCE AT THE DECOMMISSIONING STAGE OF NUCLEAR POWER PLANT?

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ISOE Symposium, Rio, May 2015

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   - REMOTELY OPERATED EQUIPMENT TESTING

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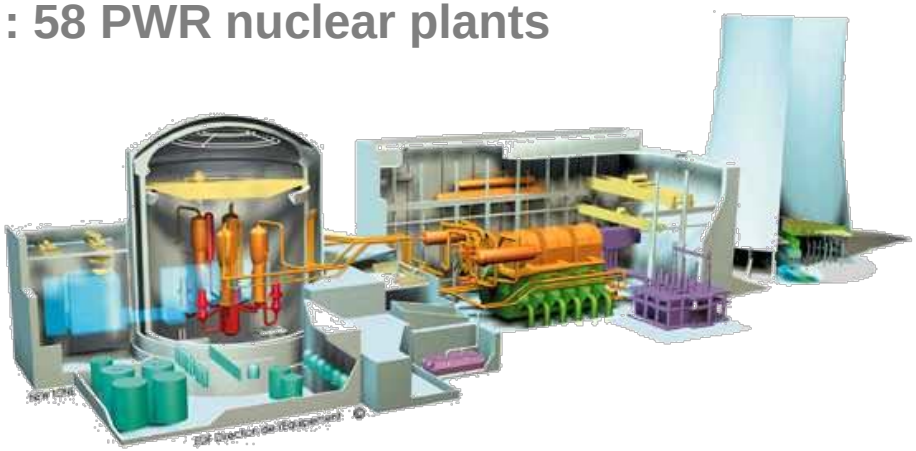
EDF NUCLEAR PLANTS IN FRANCE

In operation : 58 PWR nuclear plants



34 PWR 900 MW

20 PWR 1300 MW

4 PWR 1450 MW

On 19 sites

PWR : Pressurized water Reactor

EDF NUCLEAR PLANTS UNDER DECOMMISSIONING

- **9 reators under decommissioning**

1 ¨Pressrized water reactor (PWR)

Chooz A (300MW) : 1967-1991

1 Heavy water reactor

Brennilis (70 MW) : 1967-1985 (EDF/CE

6 Gaz graphite reators (UNGG)

Chinon A1 (70MW) : 1963-1973

Chinon A2 (200MW) : 1965-1985

Chinon A3 (480MW) : 1966-1990

Saint-Laurent A1 (480MW) : 1969-1990

Saint-Laurent A2 (515MW) : 1971-1992

Bugey 1 (540MW) : 1972-1994

1 Fast Breeder reactor

Creys-Malville (1240MW) : 1986-1997

- **Graphite sleeves silos at St Laurent A**

1. CONTEXT

- **How to improve current and future dismantling projects?**
  - Develop BAT from ‘outside nuclear’ or NEW technologies for safer and faster D&D,
  - Get these technologies in the supply chain and in the field at actual D&D projects to start and maintain continuous improvement cycle.
  - Try to choose the fine strategy to reduce the dose,
  - **Try to improve D&D preparation during transition time (vs from operation until dismantling).**

2. GENERAL STRATEGY

- **Various strategies may be engaged: immediate, differed, safe store, internals first, cold and dark and influence in different ways RP performances during NPP dismantling.**
- **Current EDF choice: immediate.**
  - Facility knowledge may help to improve characterisation stage which is crucial for waste management and occupational RP.
- **If differed strategy (ex gas-graphite in UK) is favoured:**
  - An important step is to define the perimeter of immediate things to do to shorten the future dismantling and to guarantee the safety (chemical decontamination, fuel removal, removal of big components, etc.).
  - According to EPRI, differed dismantling is associated to a decrease of the average dose rate close to 14 after 20 years.
- **Need for further studies to analyse the pros and the cons associated with the different strategies taking into feed back experiences.**

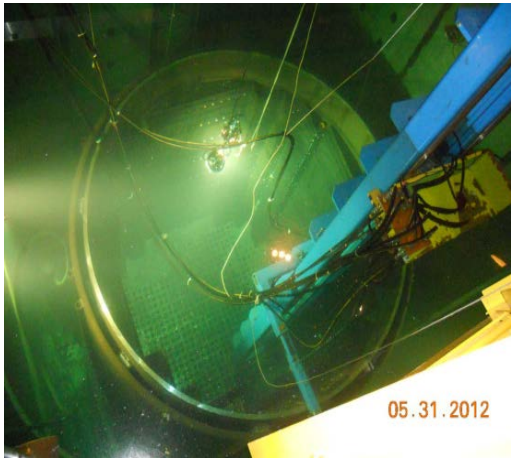
2. General STRATEGY

Choice of strategy:

Important example to study: ‘Internals first’

As long as the internals and vessel are in place we cannot move forward on Reactor Building dismantling, long operation, therefore critical, so to be done at the beginning.

- If internals are dismantled first:
  - The radioactive inventory decreases, thus there is a potential benefit for occupational RP.
  - The management of contaminated water may not remain an issue (decreased of associated exposures + radioactive wastes).
- But: you may be in position to store on site or in dedicated storage facilities the dismantled internals.



2. GENERAL STRATEGY

Transition time : the 'corner stone' for future D&D succesful!

Agreement to establish a new WPDD NEA Task Group on Preparation for Decommissioning during Operation and after Final Shutdown

All the teams involved confirms that P-MAD (operations just before and after final shutdown) control is the key to successful dismantling.

Need to continue our educational approach of operating people on this subject and in particular on preparing the final rod drop.

Manage the change of zoning for operating time to dismantling time is crucial

Dismantling the SGs in P-MAD (like in USA) should remain an option not to be ruled out.

2. General STRATEGY

‘Rip and ship’ strategy

The idea of metal waste rail transport (D&D of ZION feedback) is worth looking into.

On local ‘Rip and Ship’ (ie create a waste management facility on the site), see in Europe Reference Belgian (SCK, EBR 3 and DOEL) and German (Greiswald)

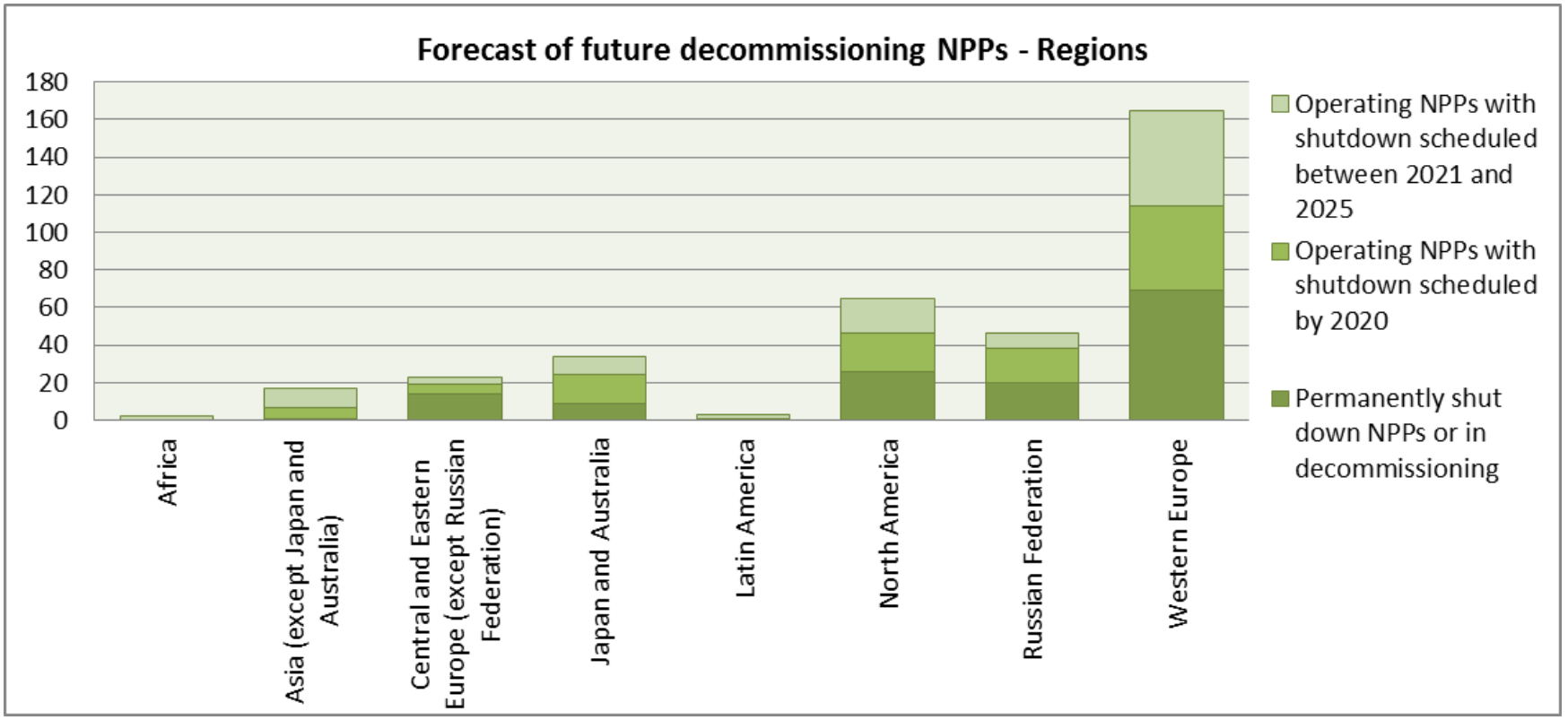
The idea of the ‘Rip and Ship’ concept is to create a discoupling factor between two different areas of business: dismantling versus waste managing and conditionning and to give them to expertised people.

Following this way we can save doses and money

2. GENERAL STRATEGY

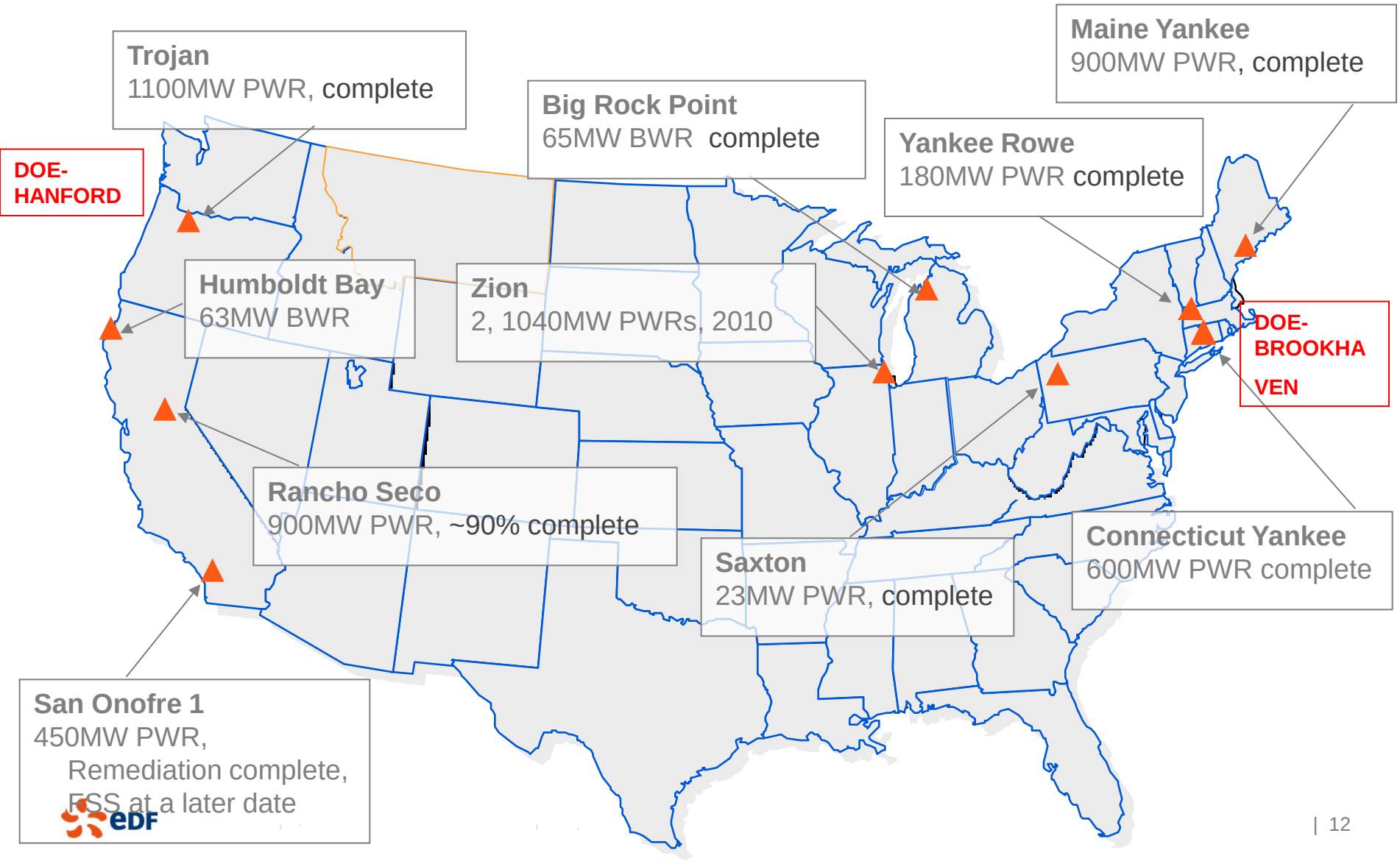
- **Whatever is the strategy you choose, on RP aspects, pay particular attention to the following issues:**
  - **Alpha emitters** - can make FSD difficult because you produce radioactive waste with high alpha emitters content -.
  - **H3 concentration** device like those studied now for Fukushima may help to decrease 3H inventory in the facilities and potentially 3H inhalation.
  - **‘Geostatistical’ approach** may help to optimize soil and concrete remediation and thus associated occupational RP and safety.
  - **Water management**: try to minimize water fluxes and so associated treatment and residual wastes.

3- D&D:INTERNATIONAL FEEDBACK AND FUTURE



10 US DECOMMISSIONING PLANT STATUS

FUEL IN DRY STORAGE



Worldwide decommissioning feedback

DATA ON CUTTING OF INTERNAL REACTOR COMPONENTS

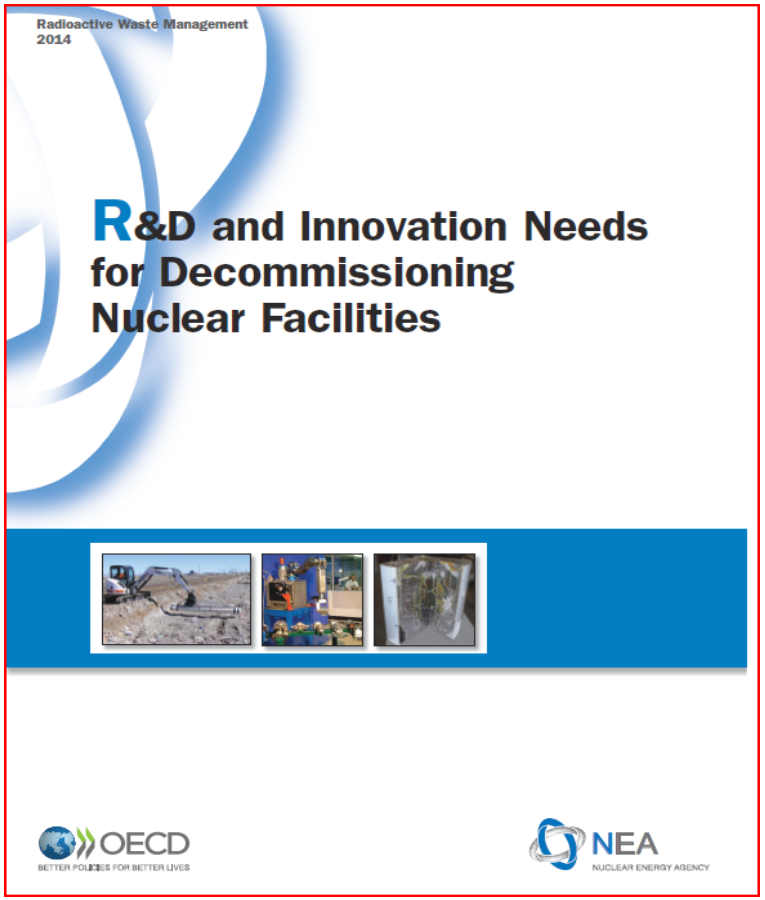
Power plant	Cutting method	RPV radioactivity Ci (Bq)	Length of cut ft (m)	Radiation exposure	Waste volume ft^3 (m^3)	Filtration flow gpm (L/min)
Yankee Rowe	Plasma arc, metal disintegration machining (MDM)	0.9 MCi (3.4×10^{16} Bq)	Cut All internal components	100 rem (1 Sv)	Cannot be compared. All internal components, except those of class greater than C, disposed of as waste.	75 gpm (284 L/min)
Conn Yankee	Water jet cutter, MDM	0.8 MCi (3.0×10^{16} Bq)	1,800 ft (550 m)	205 rem (2.05 Sv)	1,250 ft^3 (35.4 m^3)	Approx. 250 gpm (950 L/min)
Maine Yankee	Ultra-high-pressure water jet, mechanical cutting	2 MCi (7.4×10^{16} Bq)	1,170 ft (355 m)	50 rem (0.5 Sv)	1,700 ft^3 (48 m^3)	1000 gpm (3,785 L/min)
SONGS Unit 1	Water jet cutter, MDM	0.4 MCi (1.4×10^{16} Bq)	813 ft (248 m)	23 rem (0.23 Sv)	254 ft^3 (7.2 m^3)	1500 gpm (5,700 L/min)
Rancho Seco	Mechanical cutting, cutting by hydraulic pressure	0.07 MCi (2.7×10^{15} Bq)	Cut into large sections	20 rem (0.2 Sv)	Approx. 1,130 ft^3 (32 m^3), All class A waste disposed of	Not available

EDF

4. R&D and innovations needs for D&D.

R&D Key development areas

- **Characterisation / site monitoring**
- **Segmentation and dismantling**
- **Surface decontamination**
- **Materials and waste management**



4.1 CHARACTERISATION AND SURVEY PRIOR TO DISMANTLING

- **Evaluate and test or develop Laser-Induced Breakdown Spectroscopy (LIBs) and Laser Ablation Molecular Isotopic Spectrometry (LAMIS)**
  - Purpose
    - Reduce reliance on chemical separation and counting techniques for hard-to-detect (HTD) nuclides
    - Supplement and verify Monte Carlo predicted concentrations
    - More samples and data on HTD spatial distributions
  - Desired features:
    - Evaluate feasibility of use based on available spectral data for common suite of nuclides of concern
  - Path forward:
    - Evaluate feasibility and use for high activity (e.g. activated materials, HLW, etc.) and low activity common end state materials (e.g., soils and concrete)
    - H-3, C-14, Ni-63, Sr-90, Tc-99, I-129, also Eu-155 in neutron activated concrete, Cl-36 in activated graphite and for facilities with significant failed fuel histories Np-237, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-243, Cm-244.
    - Evaluate systems for field and laboratory use
    - Deploy and test systems at decommissionings if capable systems are available

4.1 CHARACTERISATION AND SURVEY PRIOR TO DISMANTLING

- **Update MARSSIM, MARSAME (site release and materials clearance methodologies) for use of geostatistics**
  - Purpose:
    - Enable best use of emergent mapping and data logging and RFID sample tracking capabilities with x,y,x,t to understand distribution and concentration of contaminants
    - More efficient characterization, higher certainty
    - Provide guidance for characterization and final status survey design and implementation to verify compliance with site clearance criteria.

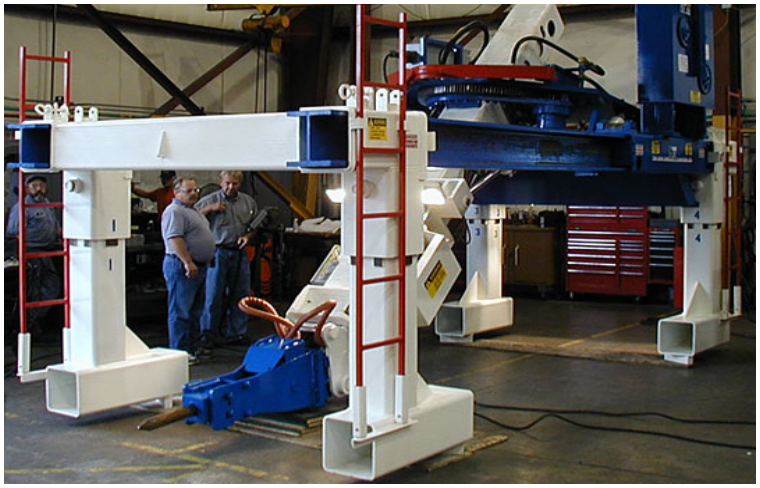
- **Increase sensitivity of alpha camera through advances in UV cameras and laser induced fluorescence**
  - Purpose
    - Reduce reliance on chemical separation and counting techniques for hard-to-detect (HTD) nuclides Current system sensitivity to high 1 kBq (60,000 dpm) to detect loose surface alpha contamination hazards
    - Alpha sensitivities below 0.1 to 0.5 Bq/cm^2
    - Couple with Gamma Camera and 3D Mapping in Location Aware Network
    - Reduce doses: less samples to take, decrease human staying close to the sources

4.2 WIRELESS COMMUNICATIONS AND DATA SHARING TECHNOLOGIES

- **Wireless Nuclear Instruments**
  - Objective
    - To develop wireless monitoring and reporting capabilities for decommissioning laboratory and field equipment
  - Purpose
    - Incentivize teaming of nuclear lab and field instrument manufacturers and Wireless Lab Research Groups to develop nuclear D&D capable system and instruments
    - Allow automated monitoring and data management for more efficient data reporting and use
    - Enable detailed mapping, tracking and data analysis
    - Create a paperless system where data can also be linked 4D (x, y, z, and time) to enable efficient use of geostatistics and real time monitoring

4.3 REMOTELY OPERATED EQUIPMENT TESTING

- **Initiate use of remotely operated equipment (and evaluate economics)**
  - Purpose
    - Subsidize, incentivize use of remotely operated equipment for D&D at actual decommissioning,
    - Study use under typical D&D conditions,
    - Study total use economics for differences in execution time, and resources required to plan and support work,
    - Start continuous improvement cycle and path to autonomous capabilities.



6. CONCLUDING REMARKS

- **Proposed BAT from ‘outside Nuclear’ or R&D initiatives may help to reduce occupational risks associated with NPP dismantling among other advantages: decrease costs and length of the project, reach an industrial approach of the activity, etc.**
- **Need to implement these proposals as fast as possible and to analyze carefully their outcomes.**
- **Transition period is the corner stone for a succesful D&D,**
- **Choice of strategy too,**
- **Exchange of experience and benchmarking is a key point.**