

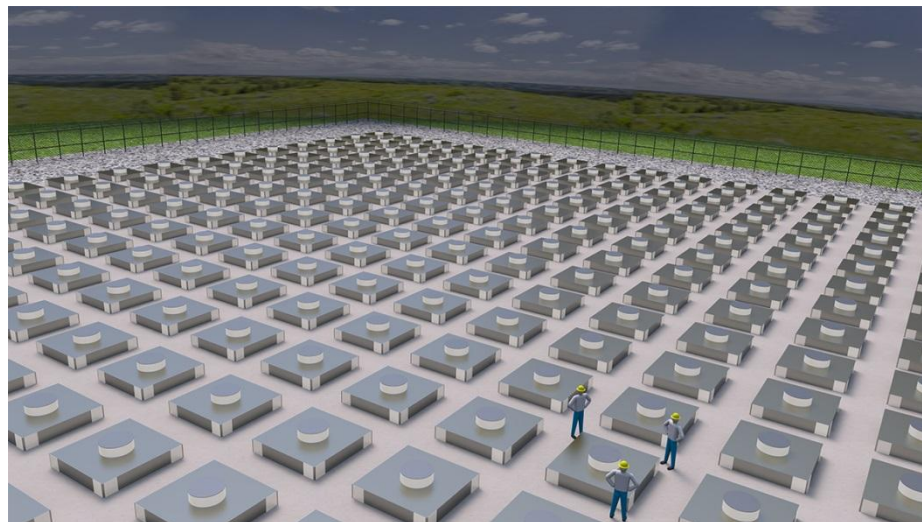
The Evolution of Spent Nuclear Fuel Storage Policy and Technology in the US

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Outline of Presentation

- **Development of U.S. Policy for Spent Nuclear Fuel**
- **Development of Storage Technology in the US vs Europe, Japan and Russia**
- **Development of US Storage Technology**
 - **First Generation Multi-Purpose Canister Storage and Transport Technology**
 - **Large Capacity – High Heat Load Multi-Purpose Canister Storage Systems**
 - **Underground Multi-Purpose Canister Storage Technology**
- **Consolidated (Central) Interim Spent Fuel in the U.S.**

Development of U.S. Policy Concerning Spent Nuclear Fuel

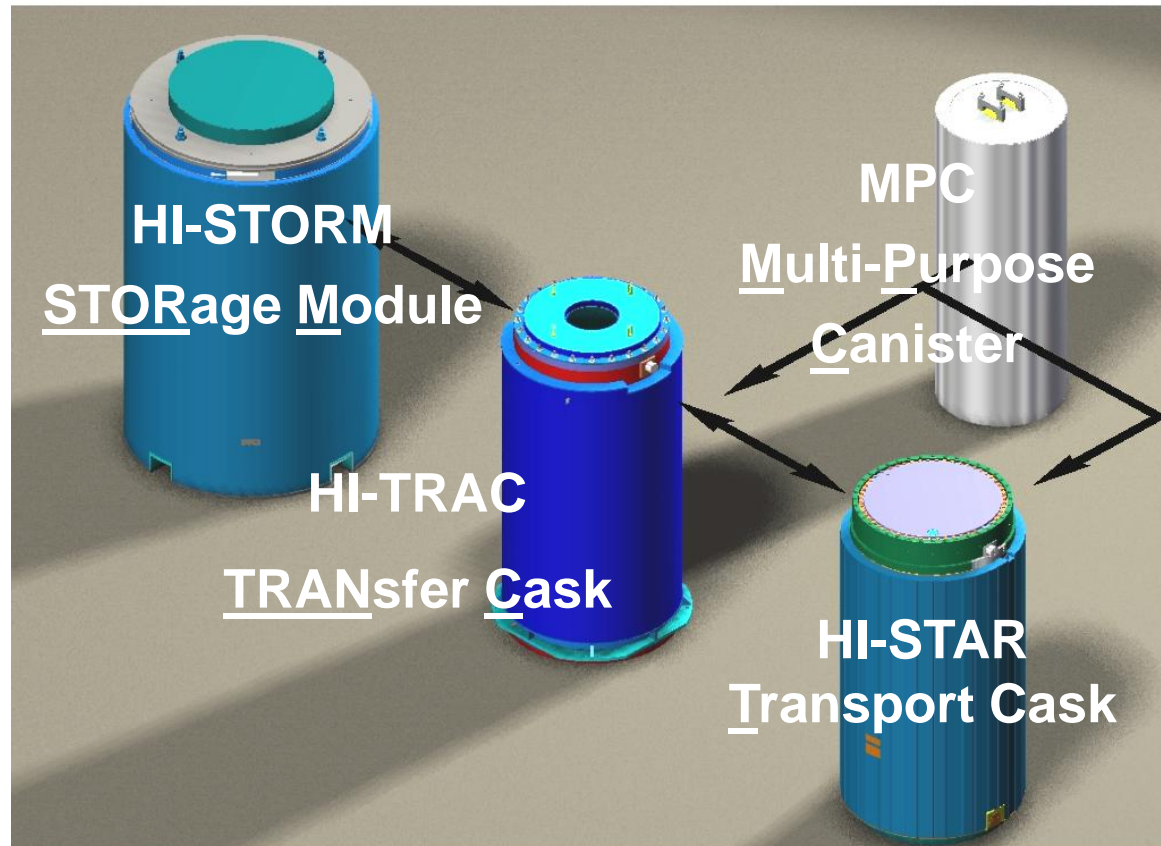
- **1954:** The Atomic Energy Act provided the fundamental U.S. law on both civilian and military uses of nuclear energy.
 - It enabled private companies to participate in the development of nuclear technology
 - It covers the laws for the development, regulation, and disposal of nuclear materials and facilities in the United States.
- **1976:** President Gerald Ford issued a Presidential Directive to suspend the commercial reprocessing and recycling of plutonium in the U.S.
- **1977:** US President Jimmy Carter set the US policy for non proliferation which determined that the US would not reprocess spent fuel as was being done in Europe, Russia, and Japan
- **1982:** The US Congress passed the Nuclear Waste Policy Act set the policy that the U.S. government would be responsible for providing permanent disposal of U.S. utility's spent fuel with the vision of developing a permanent disposal facility.
- The US Department of Energy was tasked with the development of a repository that, starting in **1998**, would provide for the final disposal of spent fuel without reprocessing. The Yucca Mountain site was selected for the final repository.

Development of Dry Spent Fuel Storage in the US vs Europe, Japan and Russia

- The United Kingdom, France, Japan and Russia proceeded with reprocessing and developed transport cask technology to move spent fuel from reactor sites to reprocessing facilities. When dry storage became necessary the transport casks served the dual purpose to store fuel as well.
- In the U.S. it became evident that Yucca Mountain would not be ready in 1998 and in the early 1990's the US Department of Energy proposed a dual purpose fully-welded, multi-purpose canister based system to store spent fuel on a reactor's site in economical "storage only" overpacks while maintaining the capability of transporting the spent fuel at a later date to the final repository in transport casks that would house the same spent fuel canister.
- The flexibility of this concept, to store fuel on site for a long period and transport it at a later date, was a very attractive. The concept was commercialized by several companies and it became the system of choice for US utilities to store spent fuel when their reactor pools neared full capacity.
- Over the past decade the multi-purpose canister storage technology has been selected by other non US utilities in Spain, Ukraine, Mexico, Slovenia, Brazil and the United Kingdom.

How Multi-Purpose Canister Systems Work

- The Multipurpose Canister is loaded with spent fuel in the plants existing spent fuel pool
- The canister is fully welded shut in the spent fuel building
- The Transfer cask is then used to transfer the canister from the nuclear plant to the storage facility where it is placed a storage overpack
- The Transfer cask protects the plant workers during the loading and transfer
- The over pack protects workers and public
- At a later date the canister can be transferred to a Transport Cask and transported to the final repository
- The Canister both stores and transports the fuel, hence it is termed Multipurpose



Multipurpose Canister Technology

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- > **Stainless Steel Canisters provide containment of fuel, failed fuel, and fuel debris**
- > **Benefits of Canisters**
 - > Welded lids provide highest level of protection of material
 - > Canisters are transportable without repackaging
 - > Fuel handled one time (minimizes chance for damage)
 - > Contents are retrievable using provide weld removal technology
- > First generation canisters held 24 or 32 PWR assemblies and 68 BWR assemblies
- > First Generation heat load less than 37 kW

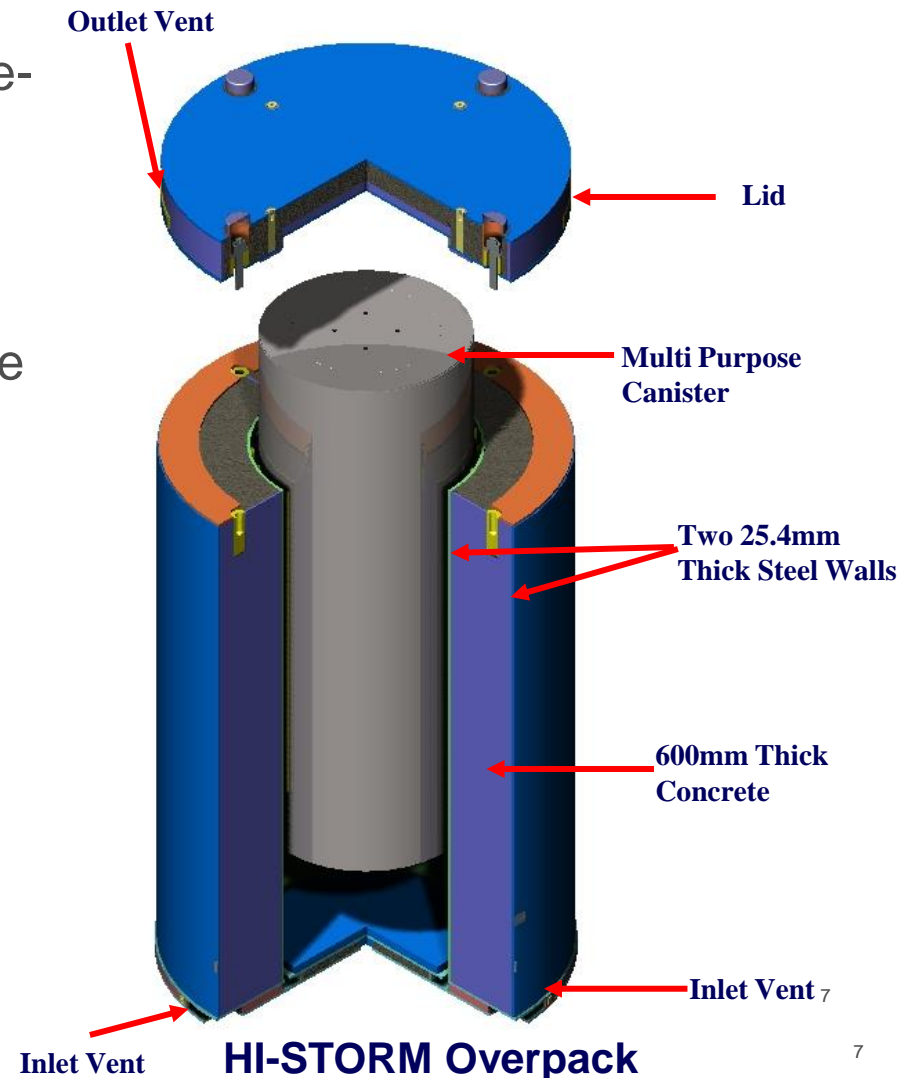


Holtec's Single Wall Canister

Storage Overpacks Protect the Canisters and Shield the Environment

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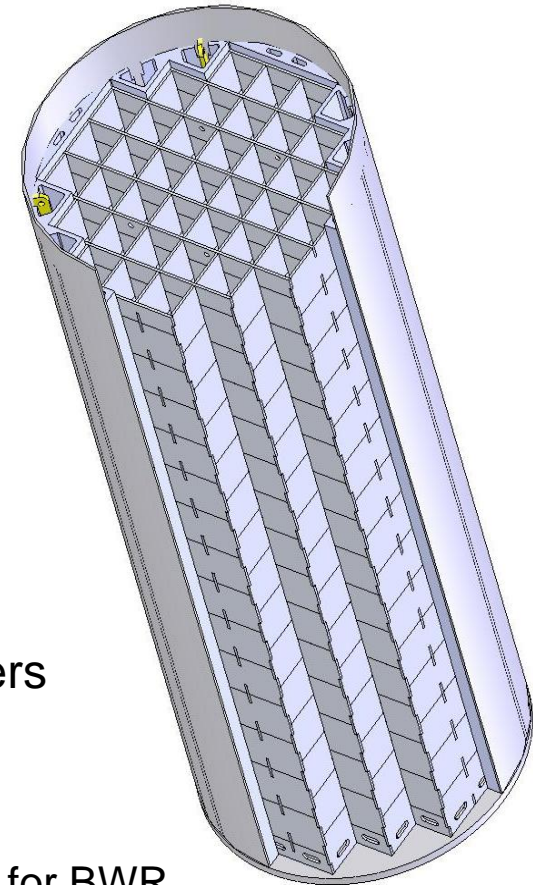
- The canister is placed in a storage overpack that is made of steel-concrete-steel construction
- The system is passively cooled using natural convection. Air enters the bottom vents, passes over the outside of the canister and exits the vents in the lid.
- The overpack lid is bolted onto the overpack covering the canister
- The concrete protects workers and public from the radiation inside the canister
- The loaded system weights 180 tons and it will not tip over in an earthquake
- The system is safe in tornados, tsunamis and is safe in case of an aircraft crash



High Capacity, High Heat Load Multi-Purpose Canisters

- > Fully welded SS containment
- > Baskets manufactured entirely from Metamic-HT
 - > High conductivity to support high head load fuel (~10xSS)
 - > Low weight allows more shielding for giving crane/floor limits
- > Large storage cell openings to prevent fuel binding
- > System Capacity of 37 PWR, 89 *BWR assemblies* or 31 *VVER 1000 assemblies*
- > Also stores
 - > Damaged fuel
 - > Fuel debris

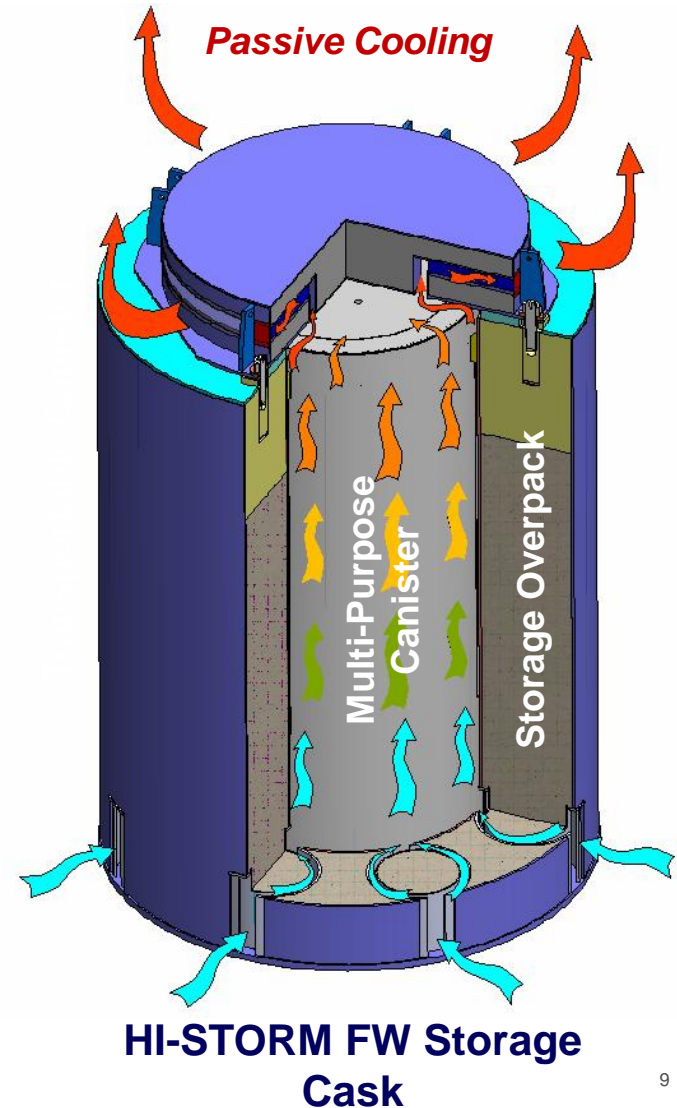
In 12 PWR, 16 BWR or 6 VVER 1000 failed fuel containers
- > Designed for Modern Fuel Cycles
 - > Max. Heat Load – 46.36 kW
 - > Max. Burn-up – 65 GWD/MTU for PWR and 68.2 GWD/MTU for BWR
 - > Max. Initial Enrichment – 5 %U²³⁵
 - > Min. Cooling Time – 3 years



Improved High Capacity Spent Fuel Storage Overpacks

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- > Same Robust Structural Integrity (Steel-Concrete-Steel)
 - > Impervious to natural events (wind, wind-driven debris, flood, etc)
 - > Withstands aircraft impact
 - > Stable under high seismic loads (up to 1.2g's,)
 - > Robust against postulated non-mechanistic tip over
 - > Concrete sealed in steel structure is protected from the environment
- > Larger Canister with increased capacity
 - > 37 PWR assemblies, 89 BWR assemblies
- > Added Inlet vents that reduce effects of winds and eliminates effects of floods

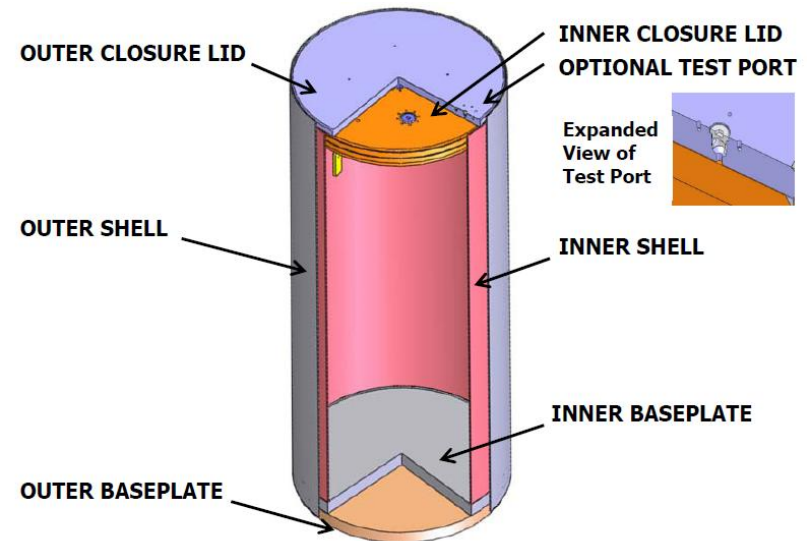


Double Walled Canister Technology

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> Double Wall Canisters

- > Developed for Chernobyl damaged fuel
- > Two independent barriers to protect contents
- > Inner canister and annulus between inner and outer canisters filled with inert helium gas
- > Interior stainless steel canister is protected from the environment (no stress corrosion cracking possible)
- > Selected by the UK for the Sizewell B plant and the new Hinkley C plant
- > Selected for Ukraine's Central Storage facility



Holtec's Double Wall Canister

The Latest Development is Underground Storage for Maximum Security and Safety

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HI-STORM UMAX at Callaway

HI-STORM UMAX – Underground Storage System

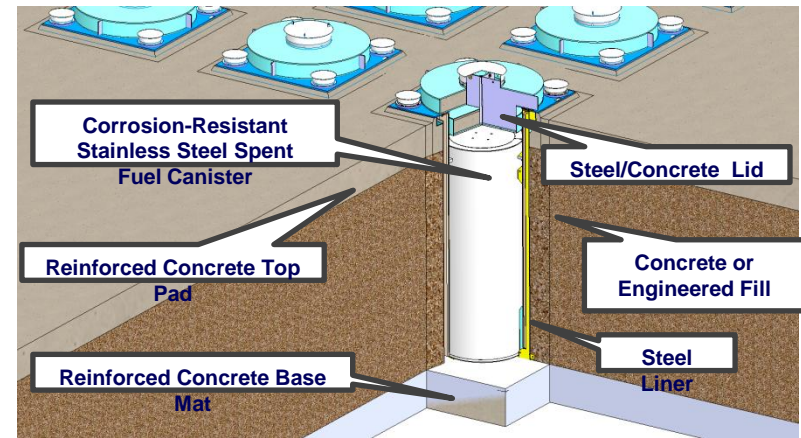


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HI-STORM UMAX provides excellent protection from physical threats from nature and mankind and protects the environment.

Underground storage Provides:

- Constraint during seismic events
- Protection from airborne missiles during tornados, hurricanes and tsunamis
- Protection from aircraft crashes
- Protection from terrorist threats
- Protection from fire and flood
- Low radiation dose to public and workers



HI-STORM UMAX Design Features
(acronym for Underground MAXimum security)



Holtec's HI-STORM UMAX is Now Being Built for US Utilities

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- Southern California Edison selected the HI-STORM UMAX, for storing the used nuclear fuel from the Decommissioned San Onofre NPP in December 2014
- HI-STORM UMAX was selected because it is robust, can withstand the enhanced earthquake conditions, low sight line, and was flexible in layout design
- HI-STORM UMAX has already been Loaded at the US Calloway Plant
- HI-STORM UMAX is the technology that is being proposed for the Holtec/ELEA Facility in New Mexico



HI-STORM UMAX ISFSI Location at the San Onofre Site



Completed HI-STORM UMAX ISFSI at the Calloway NPP Site

Underground Storage Has the Highest Resistance to the Threat of Earthquakes

- > The threat of tip over and damage from a seismic event does not exist.
- > The intensity of the seismic acceleration for which the HI-STORM UMAX is qualified is **2.5g** which far exceeds any other licensed system.
- > The Canister is supported laterally at its top and bottom preventing it from moving under seismic loads.

**Loaded HI-STORM UMAX
Systems at the U.S. Calloway
NPP Site**



HI-STORM UMAX is Very Secure with an Extremely Low Profile



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HI-STORM UMAX:
Below grade



HI-STORM 100:
Aboveground

HI-STORM UMAX is more secure from external threats by nature or terrorists. Storing the fuel underground provides superior protection.

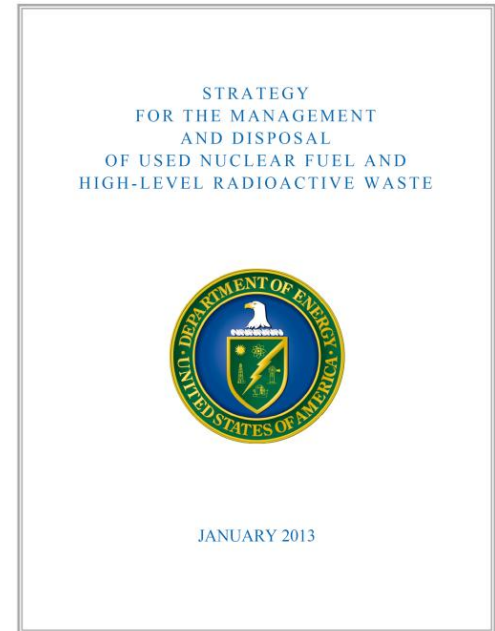
HI-STORM UMAX: Extremely Low Dose

- > Dose emissions at the inlet and outlet vents of loaded HI-STORM UMAX systems have been measured to be in the ***0.1 - 0.2 mRem/hr (1-2 μ Sv/h)***
- > ***50-100 times lower*** than the maximum surface dose of any other storage system with concrete
- > ***More than 1000 times less*** the dual purpose metal systems in the market.



The Next Step - Consolidated (Central) Spent Fuel Storage in the US

- In 2010 the development of Yucca Mountain site was terminated by President Obama
- A Blue Ribbon Committee (BRC) was established to conduct a comprehensive review and recommend a new plan to manage and dispose of the nation's used fuel.
- The result is a new path forward for DOE that begins with consolidated interim storage facilities to be implemented in the next decade (Pilot then full-scale) to start taking the US utility's used fuel while a permanent disposal site is developed and established by 2048.
- Included in the framework of the BRC recommendation is to employ a **consent based siting process** that could result in multiple sites for consolidated Interim Storage.



Holtec is Working to Construct a Consolidated (Central) Interim Spent Fuel Storage Facility in the U.S.

- Holtec has joined with Eddy Lea Energy Alliance (ELEA) to design and build an *underground* Consolidated Interim Storage Facility in New Mexico incorporating Holtec's HI-STORM UMAX spent fuel storage system
- This facility will be able to store all of the US spent fuel (75,000 mT) including fuel stored in non-Holtec Canisters on 1,000 acres



Summary

- > The U.S. Government Policy for non Proliferation set the stage for the canister based dry spent fuel storage systems in the U.S.
- > The policy was set to develop a final repository for permanent storage of spent fuel in a deep geological site.
- > In the interim, U.S. utilities have selected the flexible canister based systems to store spent fuel on site.
- > For economy and safety, high capacity, high heat load canister systems have been developed.
- > Most recently the underground canister system is being deployed which is the safest system for seismic conditions, the lowest dose and most resistant to external threats.
- > Holtec is working to deploy the HI-STORM UMAX underground system at a central U.S. site to store all of the U.S. commercial spent nuclear fuel.



Thank You for Your Attention

Any Questions?

