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Underground Interim Storage of Spent Nuclear Fuel – HI-STORM UMAX

A Presentation to the IAEA Conference on Management of Spent Fuel from Nuclear Power Reactors

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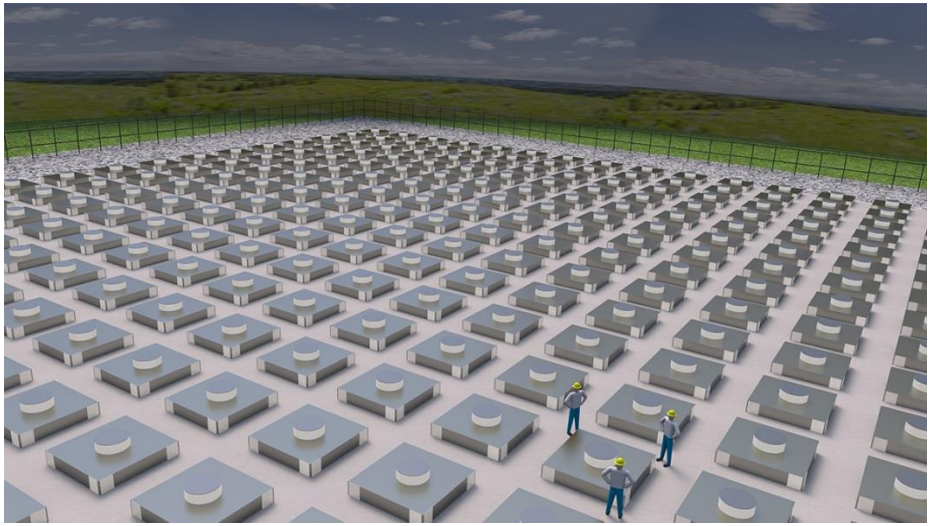

HI-STORM UMAX Underground Interim Spent Fuel Storage

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- Background and Evolution
- How it Works
- Benefits
- Deployment
- Summary

Evolution of Dry Storage Technologies

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- **Early Designs (1990's)**
  - Concrete Storage-Only Systems (not transportable)
  - Horizontal Canister Storage
  - Vertical (Concrete-Only) Canister Storage
- **Next-Generation Designs (2000's)**
  - Holtec last to U.S. Market for Dry Storage
  - **HI-STORM 100** Steel-Concrete-Steel Vertical Storage System for MPCs
  - **HI-STAR HB** Underground Storage at Humboldt Bay (for MPCs)
- **Modern Designs**
  - Events of 9/11 added heightened sense of safety to protect stored spent fuel from terrorist attack.
  - In response to the need for further hardening of storage systems Holtec developed the **HI-STORM 100U** underground system that was compatible with **the HI-STORM 100** above ground system. It was licensed in 2009.
  - The tsunami at Fukushima in 2011 reinforced the need for protection for beyond design basis threats and for storing spent fuel in dry storage systems at the earliest point in time.
  - To further advance the underground storage technology, Holtec developed a high capacity, high heat load underground interim spent fuel storage system termed the **HI-STORM UMAX** to be compatible with the high performance **HI-STORM FW** system above ground system.
  - The **HI-STORM UMA**X was licensed by the U.S. NRC in April of this year.

HI-STORM 100

HI-STAR HB Underground

HI-STORM UMAX

Holtec's HI-STORM Canister-based Systems Above Ground and Below Ground Systems

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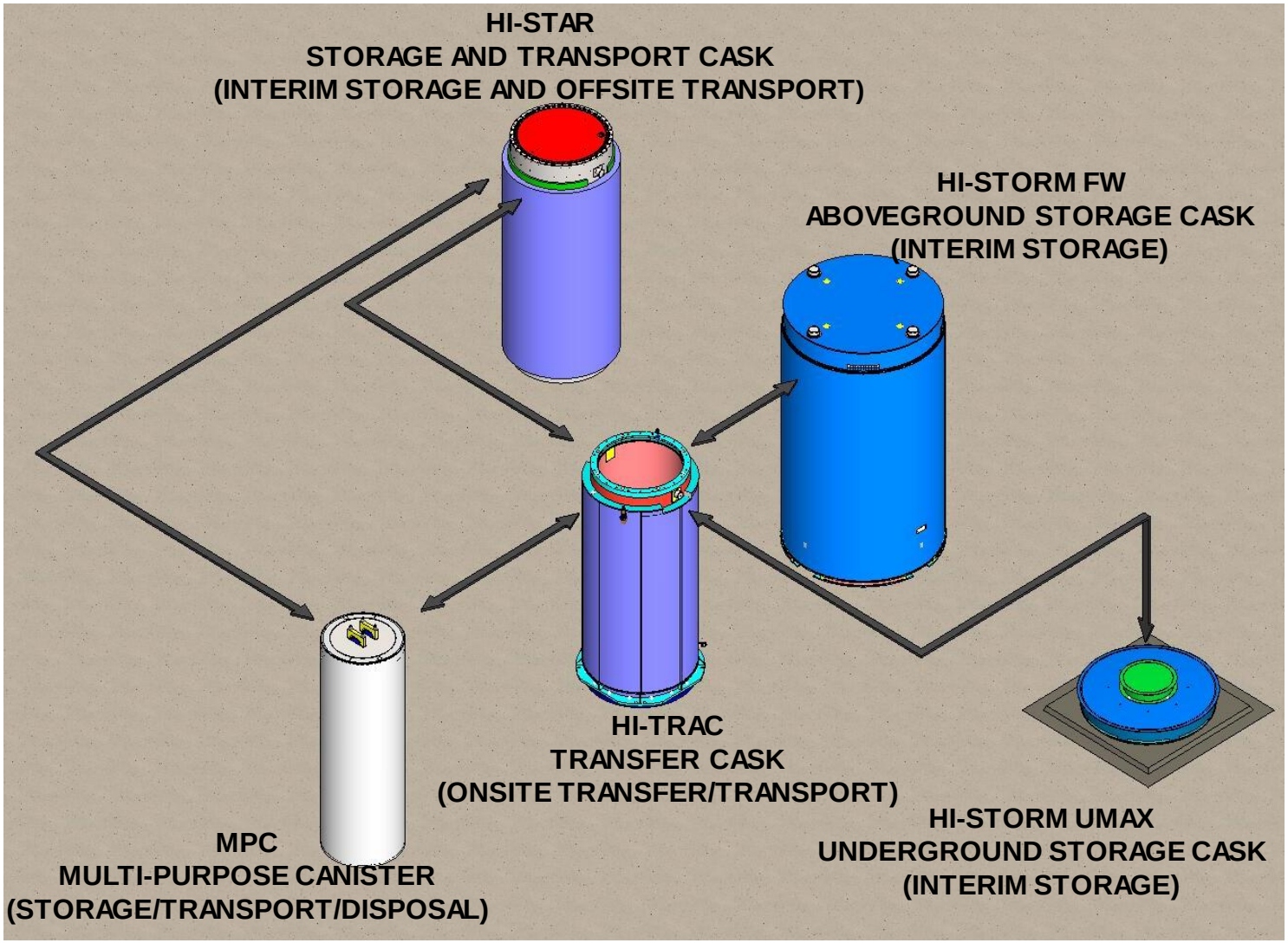

HI-STORM UMAX Components

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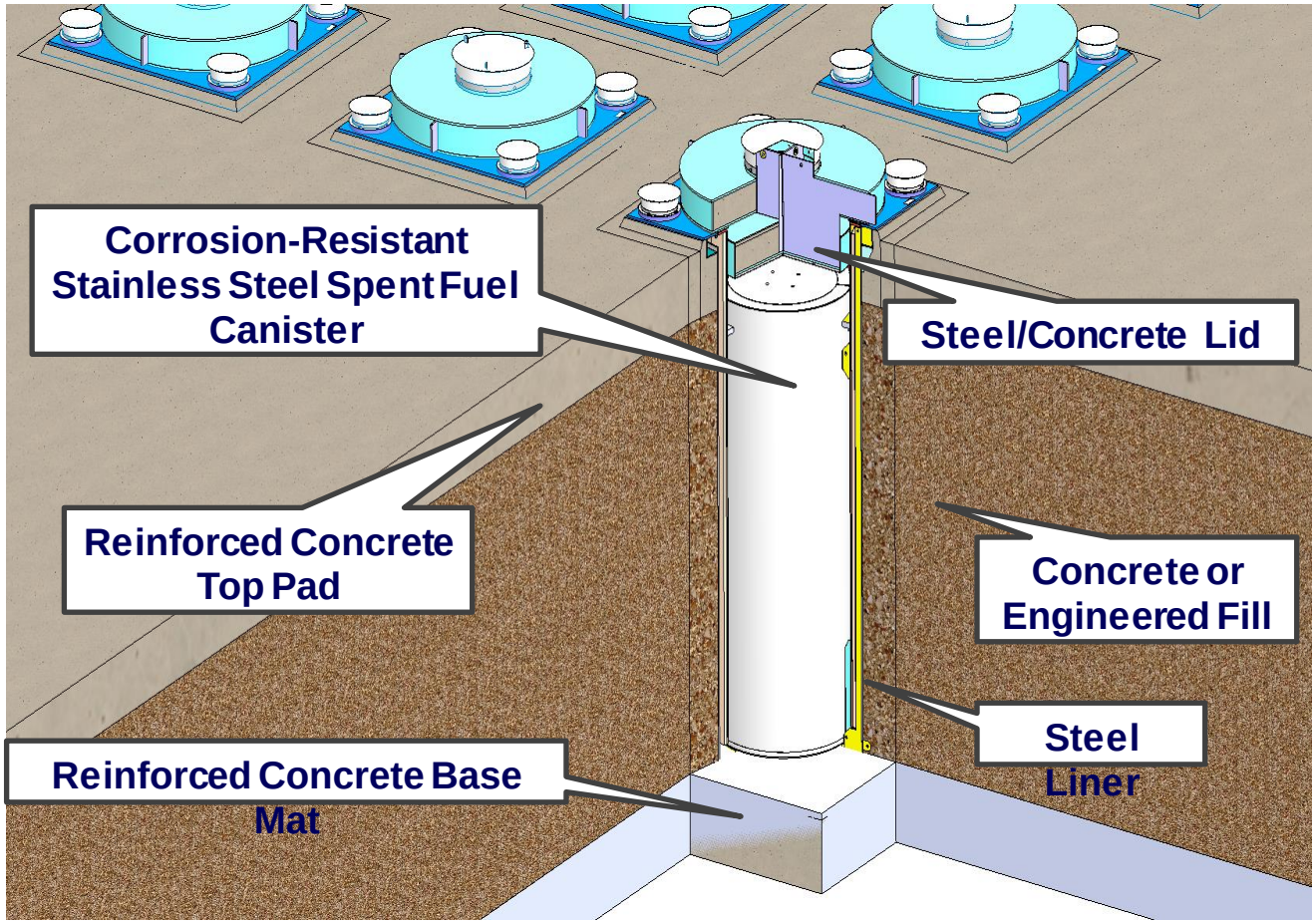

HI-STORM UMAX Design Features
(acronym for *Underground MAXimum* security)

HI-STORM UMAX Operates in a Completely Passive Mode Using Natural Convection to Cool the Spent Fuel

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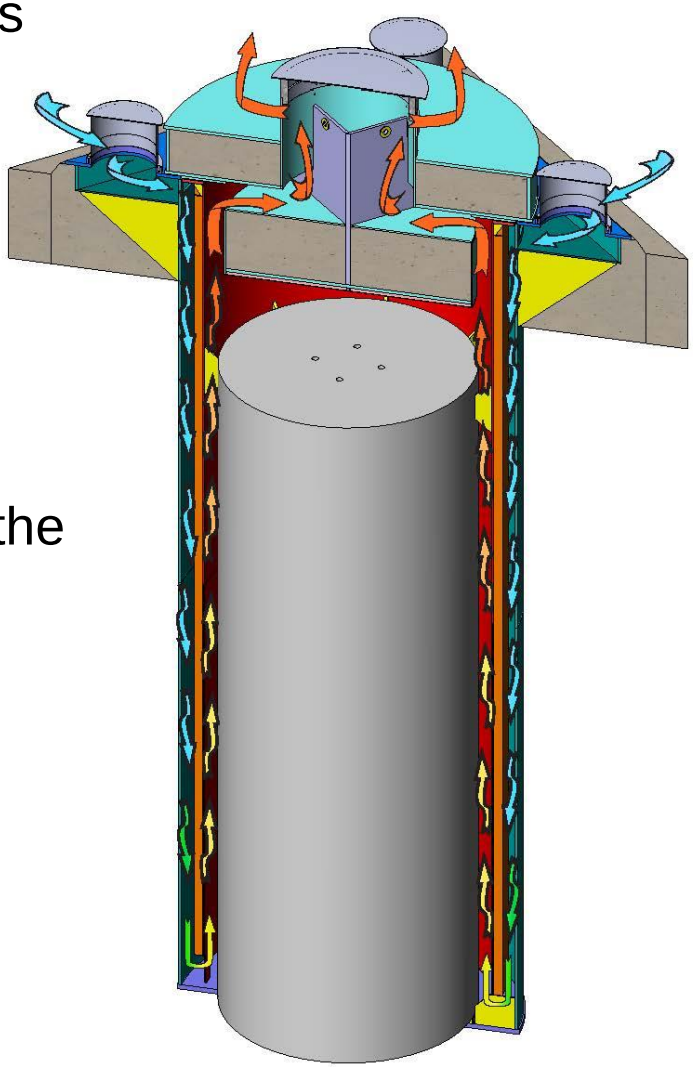
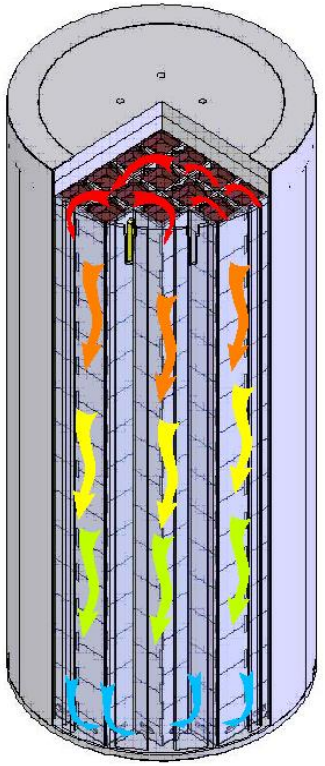
- Cooling air enters lid.
- Air flows down through a downcomer.
- Air flows up adjacent to canister cooling the outside canister wall.
- Air is ejected through the lid.



- Within the canister internal convective flows cool the fuel and transfers the heat to the inside of the canister wall.



Conduction also Plays a Major Role in Transferring Heat from the Fuel to the Canister Wall

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- The HI-STORM UMAX utilizes a high conductivity METAMIC-HT basket for transferring heat from the center of the basket to the inside canister wall.
- METAMIC-HT is a metal matrix composite composed of aluminum and boron carbide and as such has conductivity close to aluminum and almost 10 times that of stainless steel.
- METAMIC-HT has structural strength at spent fuel storage temperatures and performs the function of structural support for the fuel during storage and transport of the canister.
- The boron carbide content in METAMIC-HT enables it to perform the function of insuring subcriticality during storage.

Completed METAMIC-HT Basket Prior to Insertion in a Canister

HI-STORM UMAX is a High Performance System

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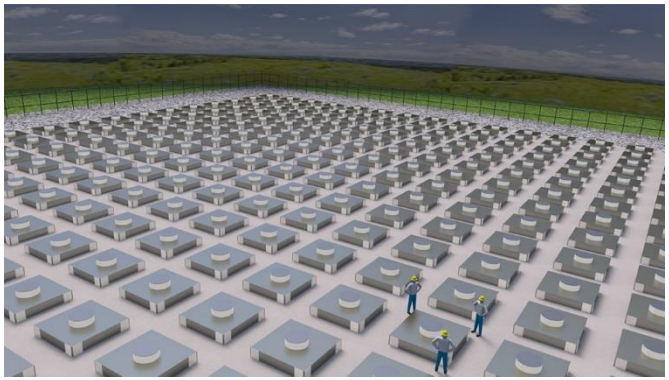
System	HI-STORM UMAX
System Type	Belowground Storage
System Capacity (PWR/BWR)	37/89 fuel assemblies
Damaged Fuel or Fuel Debris Capacity (PWR/BWR)	Up to 12/16
Maximum Heat Load	Up to 37 kW
Maximum Initial Enrichment (PWR/BWR)	5.0/5.0 wt. % U^{235}
Maximum Acceptable Fuel Burnup	68.2 $^{GWD}/_{MTU}$
Minimum Fuel Cooling Time	3 years
Service Life	> 100 years



Rendition of a Large UMAX Facility

Callaway NPP UMAX Facility in the U.S.

Benefits to HI-STORM UMAX Underground Storage

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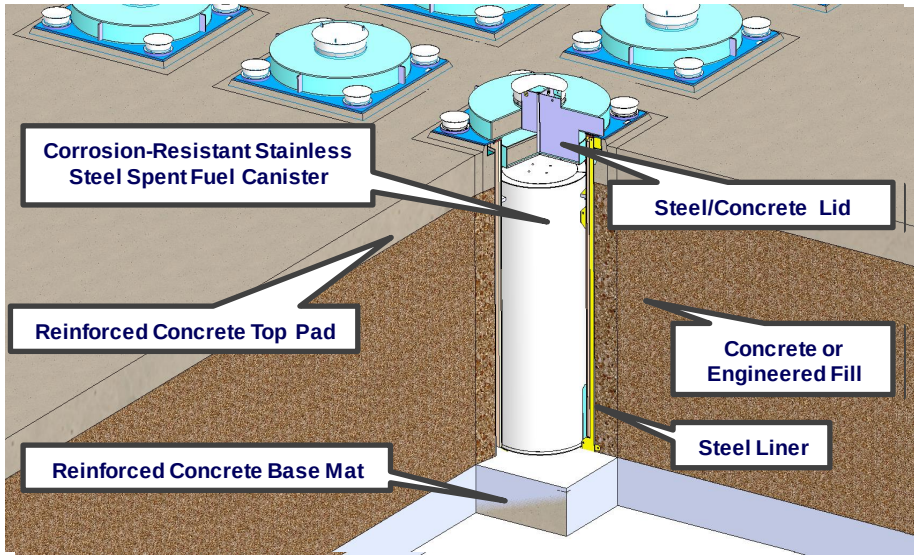
By virtue of being underground, HI-STORM UMAX provides excellent protection from all physical threats and protects the environment.

- The facility is virtually invulnerable to seismic events even under liquefaction scenarios.
- Fuel is virtually inaccessible from impacts by aircraft or airborne missiles from tornados, hurricanes and tsunamis for superior containment.
- Shielding by the surrounding earth for superior protection to workers and public from radiation dose.
- Floods will not challenge the heat removal from the spent fuel.
- Combustion of flammable materials inside the cavity cannot be sustained.



HI-STORM UMAX Design Features
(acronym for *Underground MAX*imum security)

Benefits to Facilities and Operations

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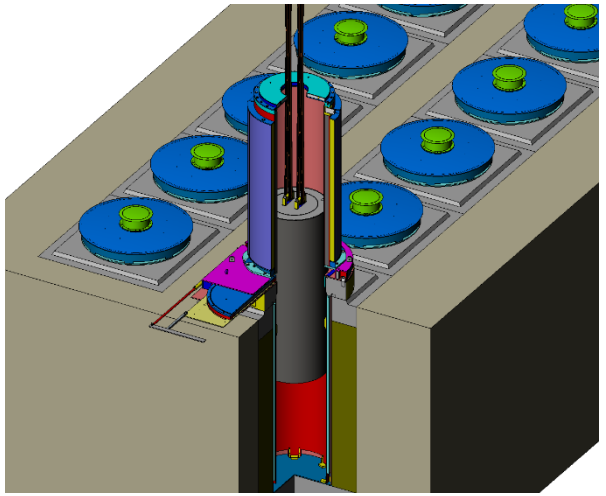
- Canisters at any UMAX location can be loaded or unloaded independently from all other locations.
- The facility footprint is small which only has to enable the cask transporter to traverse between cavities.



Lowering a Multi Purpose Canister from a transfer cask into a HI-STORM UMAX cavity

Benefits to Facilities and Operations

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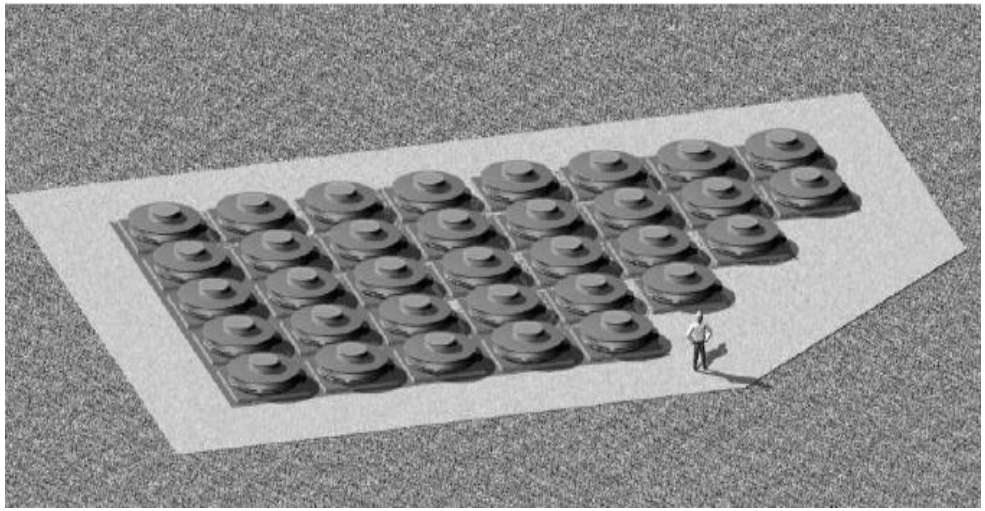

- Inspection of inlet and outlet ducts is easy because they are near ground level.
- The ISFSI pad need not be rectangular and can be shaped to fit accommodating spaces.

Some Example ISFSI Pad Sizes

Width (Casks)	Length (Casks)	Total Casks	Pad Width (m)	Pad Length (m)
3	7	21	19	38
5	31	155	29	151

HI-STORM UMAX is Being Deployed in the U.S.

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- HI-STORM UMAX has already been constructed at Calloway NPP in the U.S.
- 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.

Completed HI-STORM UMAX ISFSI at a US NPP Site

HI-STORM UMAX ISFSI Location at San Onofre Site

The Need for Consolidated Storage in the U.S.

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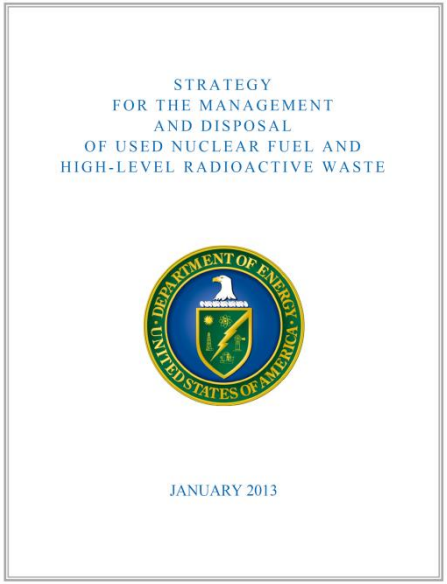
- With the Nuclear Waste Policy Act of 1982 the U.S. government assumed the responsibility of providing permanent disposal of U.S. utility's spent fuel with the vision of developing a permanent disposal facility that manifested in the selection of the Yucca Mountain site.
- In 2010 the development of Yucca Mountain site was stopped and 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 U.S. Central Consolidated Interim Spent Fuel Storage Facility

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- 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).
- HI-STORM UMAX is the technology that is being proposed for the Holtec/ELEA Facility in New Mexico.

The HI-STORM UMAX Can Store All of U.S. Used Fuel

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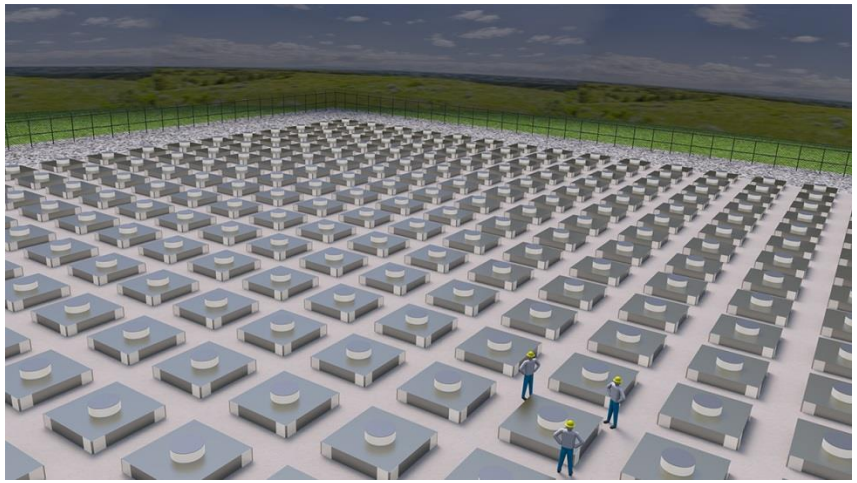
- An array of 60 by 60 HI-STORM UMAX storage systems can safely store 75,000 metric tons of spent nuclear fuel.
- The size of a consolidated storage site will be 360 x 360 m (less than four football fields on a side).
- The HI-STORM UMAX can be licensed to store all current commercially available dry storage canisters and fuel types making it an ideal technology for storing used fuel in a consolidated interim storage facility.



The above ground height of the HI-STORM UMAX is below waste height making the facility visibly inconspicuous

Summary

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- HI-STORM UMAX is a high performance underground interim spent fuel storage system that serves today's need for heighted security and safety:
  - Very Low Dose
  - Constrained in seismic events
  - High heat loads (up to 37 kW)
  - Small cooling times in pool (as low as three years)
  - High Capacity (37 PWR, 89 BWR)
  - High Burn Up (up to 68.2 GWD/MT)
  - Flood and Wind resistant
  - Robust against threats
  - Very stable in seismic events
- Currently being deployed in the U.S.

Thank You for your Attention

Any Questions?