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Holtec SMR-160 Technology

Safe, Secure, Reliable, Flexible, Economical

Clean Energy to Support the World's Energy Needs

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Sofia, Bulgaria

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SMR-160… A natural progression for Holtec's technology portfolio started over 10 years ago…

Heat Transfer Equipment

Designer and manufacturer of heat transfer equipment with projects in over 35 countries

Horizontal Steam Generator

Air Cooled Condensers

NSSS and BOP Equipment Design

SMR-160 (160 Mwe net)

Development and licensing of walk-away-safe small modular reactor with passive safety

SMR-160

Manufacturing, Construction, Site Services

Three US Manufacturing Facilities and International Site Construction and Site Services Business

Holtec's Advanced Manufacturing Division

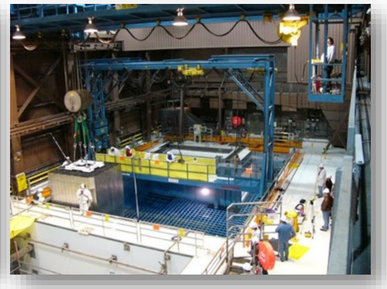
Holtec's Site Services and Site Construction

Design Input from Manufacturing, Construction, Site Experience

Spent Fuel and Waste Management

Over 40% of the world's commercial spent nuclear fuel is stored using Holtec's technologies

Nuclear Fuel Storage and Transport

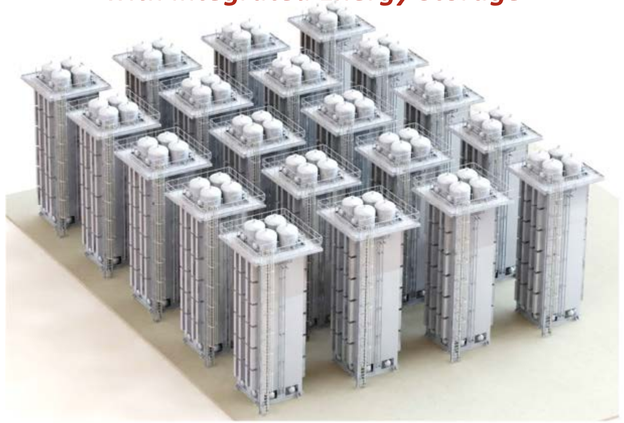


High Capacity Fuel Storage Racks

Fuel Design and Management Expertise

District Heating systems

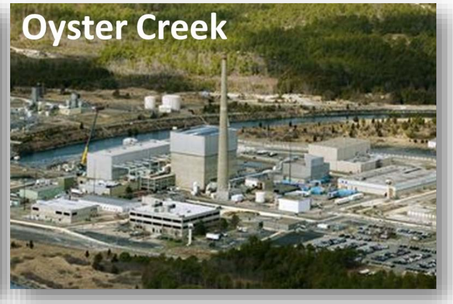
HI-HEAT Modular electric district heating system with integrated Energy Storage



20 UNIT ARRAY (PIPING NOT SHOWN)

Safe, Efficient and Compliant Decommissioning

Owner and Licensee of Pilgrim, Oyster Creek, Indian Point 1-3 with 8-year decommissioning plans and Palisades acquisition pending in 2022



Part 50 License Holder, Public Engagement, Security Services, Waste, NPP Operations

SMR-160 Program Overview

- **Self-funded for first 10-years of development**
  - SMR-160 funded by Holtec and Strategic Partner R&D Budget for first 10 years of development, demonstrating commitment to the program and technology
  - MELCO and others have invested
- **Supported by US Department of Energy**
  - U.S. DOE Grant for Integral & Separate Effects T/H Testing (ISET) Program to Validate Passive Safety Systems with Idaho National Labs (INL)
  - U.S. DOE Advanced Reactor Demonstration Program (ARDP) Risk Reduction Pathway for Preliminary Safety Analysis Report (PSAR) and Standard Design Completion
  - $7.4 Billion Nuclear Build Program Submitted to the Loan Programs Office of the DOE
- **Completion of Detailed Design and Construction Specification for US Reference Site according to US Codes and Standards (ongoing)**
- **What's unique about Holtec's SMR-160 Program**
  - **Technology** – inherently safe and practical to operate SMR based on proven & flexible PWR technology and existing LWR licensing basis
  - **Team** – proven companies in respective work areas each with strong financial balance sheets and owner/financing options
  - **Delivery Model** – contract for turnkey delivery, control majority of costs within scope of delivery team, provide private financing options, ability to bring partners for plant operations

U.S. DEPARTMENT OF ENERGY
Office of NUCLEAR ENERGY

Clean. Reliable. **Nuclear.**

ARDP

Holtec's Advanced Manufacturing Division (AMD) Designed and Constructed for Fabrication of SMR-160

SMR-160's Proven Project Delivery Team

- **Holtec International – Technology Provider and Nuclear Manufacturer**
  - **Scope:** Technology Developer, Project Management, Supplier/Manufacturer of Safety Significant Components
  - **Reference**: see presentation
- **Hyundai Engineering & Construction – Proven International EPC**
  - **Scope**: BOP Detailed Design, Construction, Commissioning
  - **Reference**: Constructed 18 Plants in Korea and Barakah 1-4 in UAE
- **Kiewit – Proven Constructor in North America**
  - **Scope**: Construction in North America
  - **Reference**: Constructed 70% of Combined Cycle Plants in North America and Major DOE Nuclear Facility Projects
- **Mitsubishi Electric – Proven I&C Systems**
  - **Scope**: MELTAC Control System and licensing support
  - **Reference**: NRC acceptance in U.S. & proven use in Japan, China
- **Framatome – Proven Fuel Supplier and Standard Fuel Type**
  - **Scope**: Fuel design and licensing support
  - **Reference**: Standard 17x17 PWR Nuclear Fuel Assembly

HOLTEC INTERNATIONAL

SMR-160 Technology Provider/Prime Contractor

HYUNDAI ENGINEERING & CONSTRUCTION + Kiewit + **Local Partners**

BOP Design, Plant Construction, Commissioning

HOLTEC INTERNATIONAL + **Local Partners**

NSSS Manufacturing

framatome + **Local Partners**

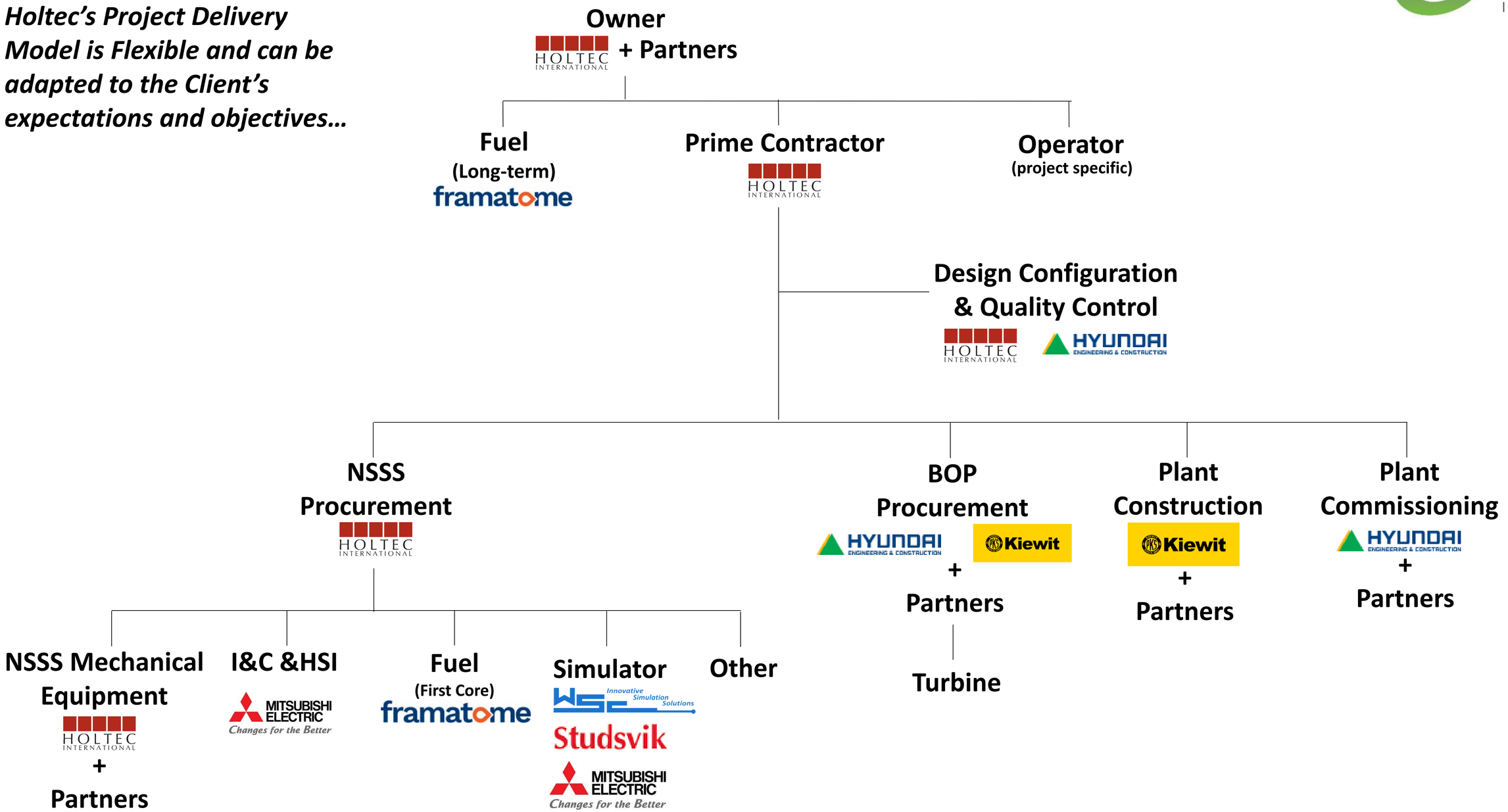
Fuel Fabrication

MITSUBISHI ELECTRIC *Changes for the Better* + **Local Partners**

I&C

SMR-160 Standard Project Delivery Structure

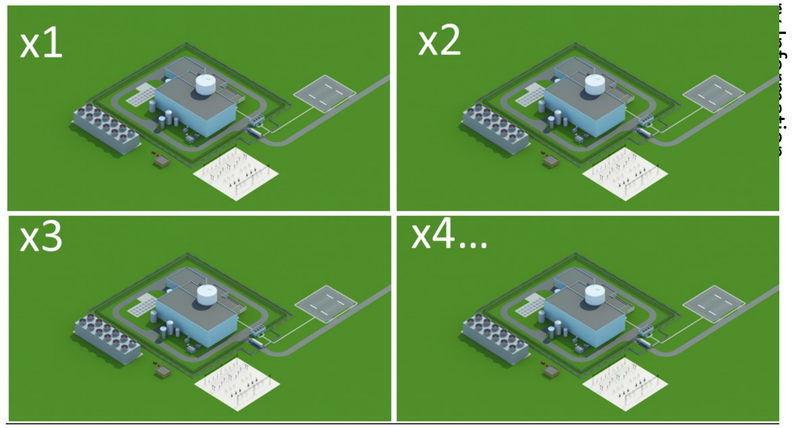
Holtec's Project Delivery Model is Flexible and can be adapted to the Client's expectations and objectives…



SMR-160 Design: Basic Parameters

- **PWR Reactor Type**
  - PWR technology is the most widely accepted technology deployed around the world
  - Low radiological operational dose to workers
  - Flexible applications for steam, such as process heat, district heat, hydrogen generation
  - Licensing effort benefits from the established body of USNRC regulations
  - A robust supply chain and globally recognized partners
- **Small Power Units (in terms of power and land-use)**
  - Each SMR-160 is designed as a standalone single unit plant
  - Compact Footprint:
    - Single Unit: 7 acres [3 hectares]
    - Four-Unit Block: 20 acres [8 hectares]
    - Physical boundary intended to match EPZ (pending regulatory approval)
  - Small component sizes (fabrication and shipping flexibility)
  - Smaller capital investment and shorter construction duration for each unit
- **Modular/Modern Power Units**
  - Multiple SMR-160 power units can be deployed at a single site
    - Market Demand: Power and electricity demands from grid
    - Siting: Space, layout, water limitations, proximity to population centers
  - Standardization of plant design under bounding site and environmental parameters
  - Modern design and construction practices (used in other industries)

Type	PWR
Thermal Power	525 MWth
Electrical Power	160 MWe (net)
Design Life	80 years
Moderator	Light water
Primary Circulation	Gravity-driven
System Pressure	2250 psia
Fuel Type	17x17 (standard)
Fuel Cycle	2 years
Control	Boron and RCCA



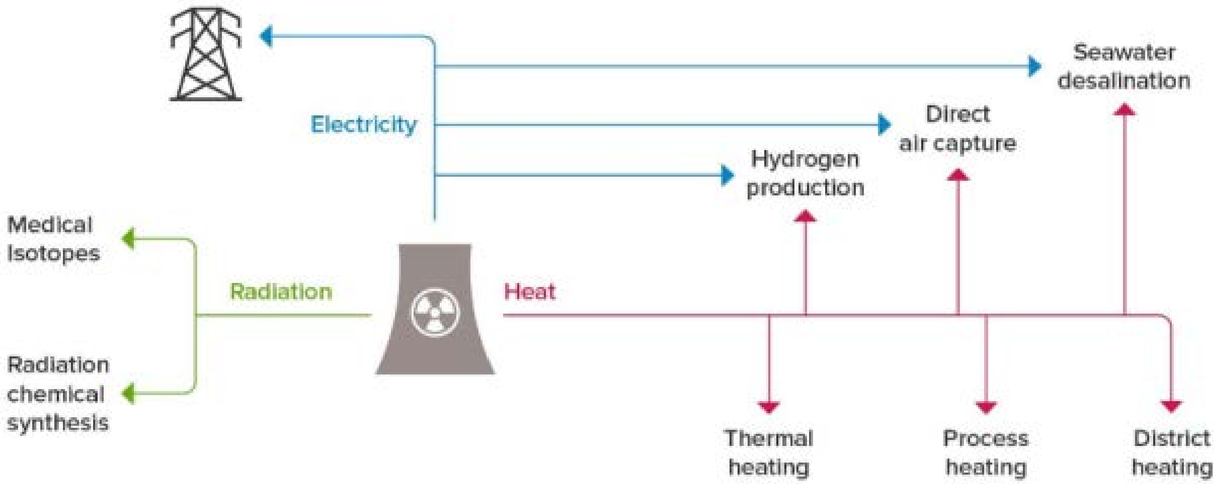
SMR-160 Power Units Deployed to Meet Power Demands and Siting Needs

SMR-160 Applications and Operations Modes

Applications

- Electricity Generation: 160 MWe Net

- Industrial Process Heat & Hydrogen Production
  - ✔ Bypass conditions determined by application
  - ✔ Standard SMR-160 plant produces over 750 MT/hour of superheated steam
  - ✔ Eliminates need for load following where steam or hydrogen production applications are profitable



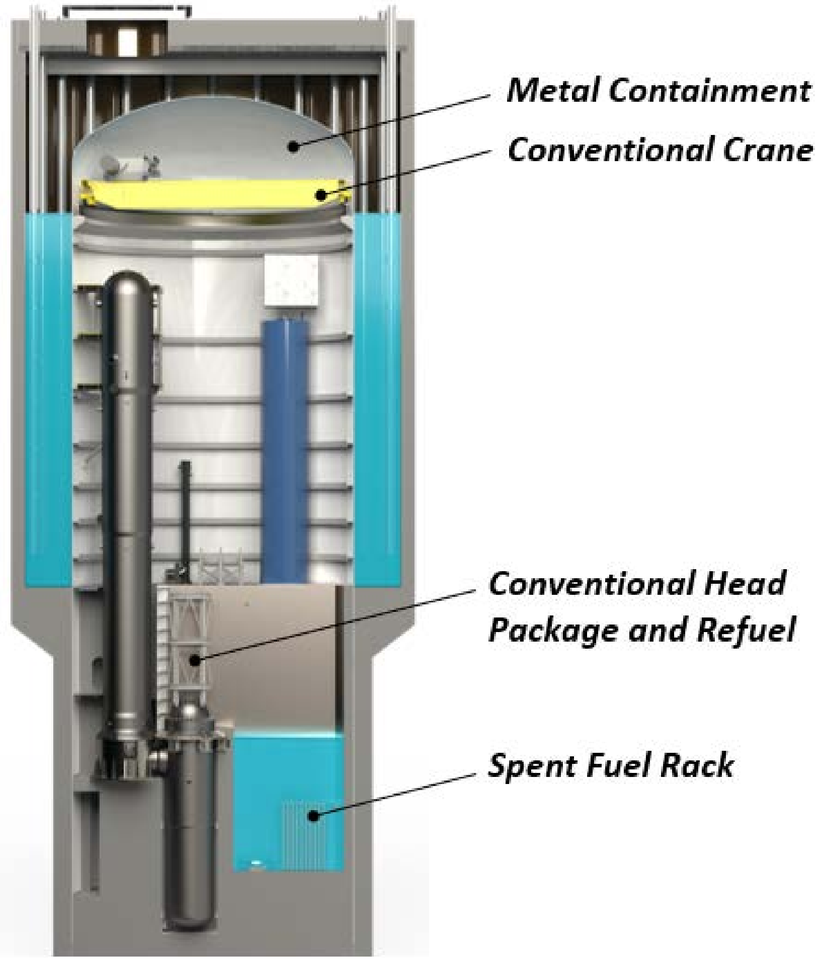
Operational Flexibility

- Island Mode (operates when grid goes down), enabled by self-powering house loads
- Black-Start (starts without grid), enabled by standby diesel generators and black-start source (base electrical design, source add-on)
- Load Following Capability (can adjust power level to meet grid demands), enabled by BOP Design and turbine selection

SMR-160 Design: Practical Operations

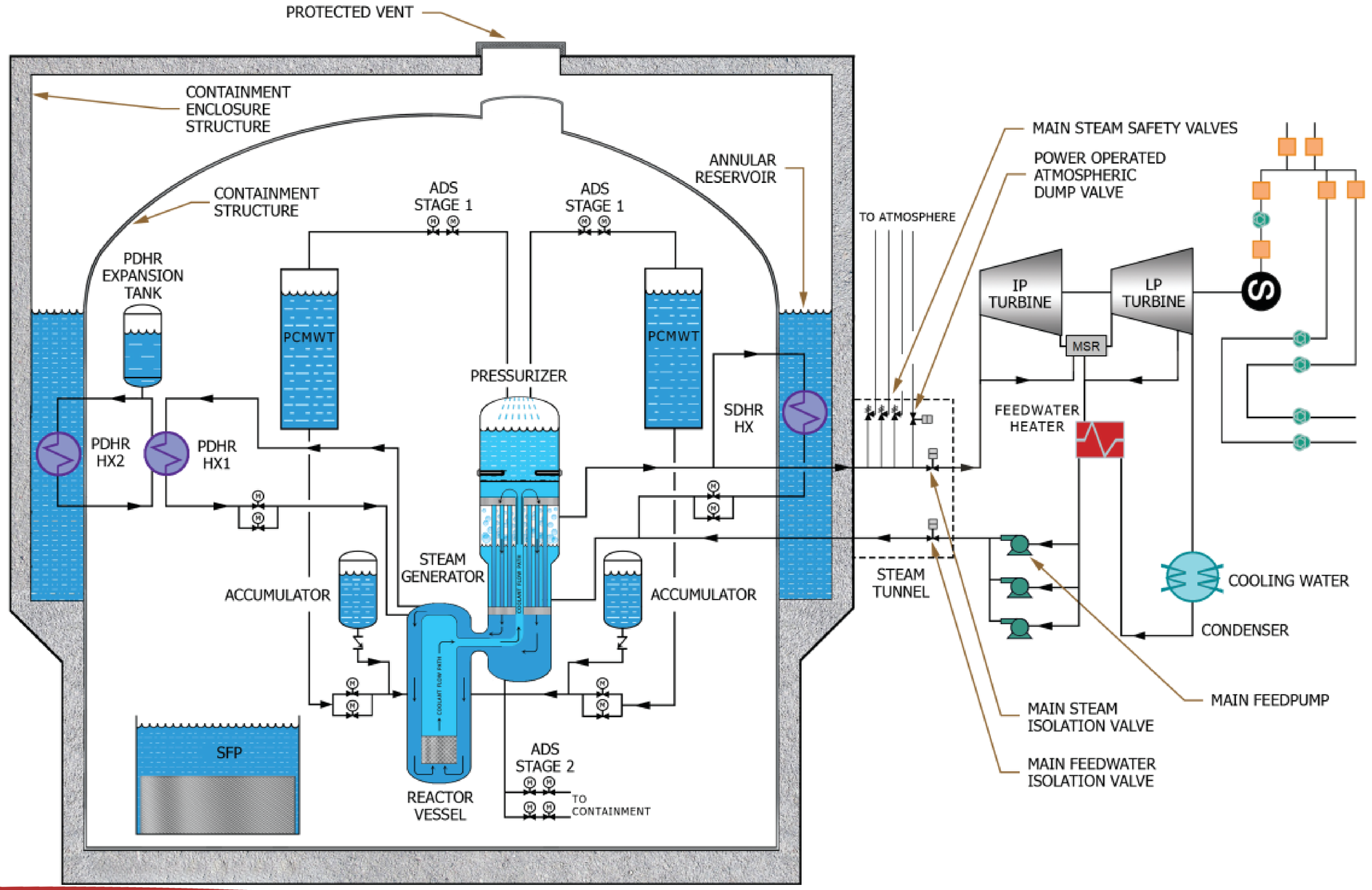
If you don't build things, its difficult to design things that can be built…

- Holtec is a practical design company because we manufacture equipment, install equipment, and operate equipment inside of nuclear power plants.
- **<u>Key design features that enable SMR-160 practical operation</u>**
  - ✔ Steam Generator (SG) offset from Reactor Pressure Vessel (RPV) to enable practical refueling without disconnection, relocation, and reassembly
  - ✔ No fuel channel necessary for refueling; fuel pool is located adjacent to reactor core to enable reloading with a fuel handling crane
  - ✔ Existing PWR operating experience incorporated into the design and maintenance planning for the plant
    **SMR-160 falls within the existing PWR operating envelope of pressures and temperatures*
  - ✔ Plant is designed with adequate space for maintenance and inspections
  - ✔ Removal and simplification of systems



SMR-160 Reactor Pressure Vessel and Steam Generator Configuration

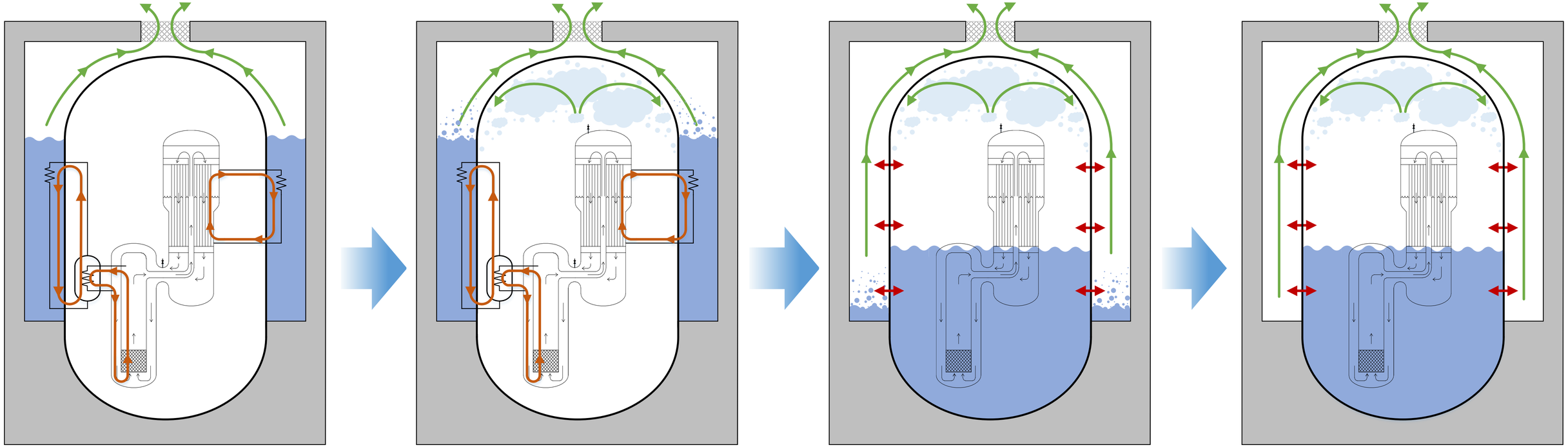
SMR-160 Systems Arrangement



SMR-160 is *unconditionally walk-away* safe

- **Designed for the extreme** – automatically achieves and maintains a safe shutdown state

  no operator actions -- **no** external water -- **no** external power -- **no** pumps



After postulated LOCA, passive cooling from Passive Core Cooling System (PCCS)

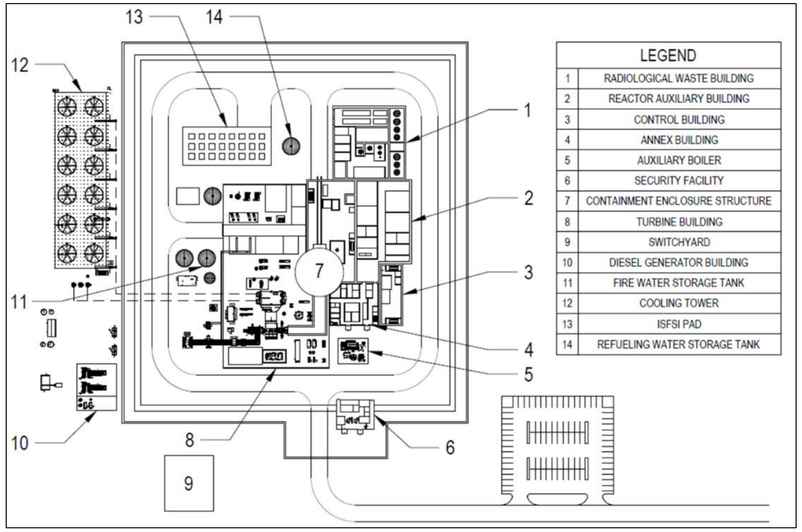
First 72 hours, passive cooling from PCCS and Passive Containment Heat Removal (PCHR)

~3 months, cooling via PCHR with water vapor leaving the reservoir

Indefinite cooling via PCHR with only air

Oyster Creek as Potential SMR-160 Site

- **Holtec is Site Owner and 10CFR50 License Holder through subsidiary companies with responsibility for decommissioning**
- **Decommissioning is ongoing**
  - ✔ Steam Separator and Dryer Segmentation in record duration
  - ✔ Spent Fuel Pool Defueled in record time from shutdown (32 months)
  - ✔ Building demolition, etc.
- **Evaluation and planning for construction of SMR-160 at the site**
  - ✔ Adaptation of Existing Environmental Report
  - ✔ Adaptation of Site Programs and Procedures (e.g., emergency plan, safeguards, etc.)
- **Licensing Plan**
  - ✔ Following the 10CFR50 Two-Part Process (more flexible than Part 52)
  - ✔ Complete PSAR for Standard Design by Dec 2023
  - ✔ Submittal of Construction Permit Application (2024)
  - ✔ Submittal of Operating License Application (2028)
  - ✔ Grid Connection (2029/2030)
- **Other US sites are also under sincere evaluation**



SMR-160 Layout

Oyster Creek Located on New Jersey's Barnegat Bay

Summary of Licensing Activities

- **Formal Pre-application Engagement with USNRC Ongoing (Docket No. 99902049)**
  - Holtec is designing and licensing the SMR-160 based on 10CFR50 Design Criteria, NUREG-0800, and other US Regulatory Guides & Codes and Standards
  - Provision are being incorporated from international standards (IAEA, WANO, etc.)
  - Ongoing pre-engagement meetings and white papers exchanged with USNRC to Prepare for Licensing Submittal (Meeting Log: https://www.nrc.gov/pmns/mtg)
- **Canadian CNSC Vendor Design Review Phase 1 (VDR1) Completed in 2020**
  - "Notwithstanding the above, these issues are foreseen to be resolvable and will be followed up on in future phases of the VDR."
  - Nearly all off the items identified have been closed in last 2+ years of work (excluding compliance with Canadian standards since business approach is not focused on Canada at present time)
  - Link: https://nuclearsafety.gc.ca/eng/reactors/power-plants/pre-licensing-vendor-design-review/holtec-international-executive-summary.cfm
- **Holtec applied for the UK General Design Certification (GDA) in January 2023**
- **Holtec has had numerous informal discussions with other regulators around the world and intends to embark on deeper engagements in specific countries of interest.**

Holtec's SMR-160

Simple **M**odular **A**dvanced **R**eactor **T**echnology

A Safe and Secure Source of Carbon-Free Energy Positioned to Fulfill the World's Energy Needs

- Safe and Secure
- Reliable and Efficient
- Environmentally Friendly
- Low Operation and Maintenance Costs

Thank you!