



**Introduction to X-energy Advanced Reactor  
Technology**  
X-energy Canada

October 2023

## 2009

XE, LLC founded, US  
XE Canada founded  
in 2020

## 3 Products

Xe-100  
Xe-Mobile  
TRISO-X

## 500+

Employees in US, UK,  
and Canada

## 5 Offices

Rockville, MD (2)  
Oak Ridge, TN  
Toronto, ON  
Warrington, UK

## US\$1.2B

Department of Energy  
ARDP Award; First  
AR Demo build by  
2029

## TX1

First nuclear fuel  
facility licence  
application in USA in  
50 years

### X-energy's next generation nuclear technology:



#### Xe-100

80 MWe Small Modular Reactor ("SMR") that can be scaled into a 'four-pack' 320 MWe power plant



#### Xe-Mobile

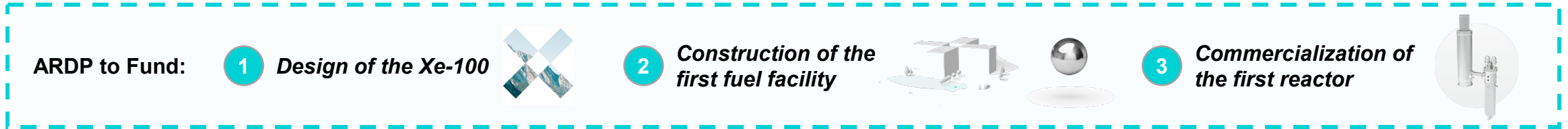
Up to 5 MWe mobile microreactor for small power production in remote needs, off-grid locations, and critical infrastructure applications. Minimal need for construction or site preparation.



#### TRISO-X

Proprietary fuel designed as cue ball-sized pebble with microscopic kernels of uranium wrapped in indestructible layers of carbon

X-energy's selection for the DOE's Advanced Reactor Demonstration Program represents a critical advantage over other competitors



## What ARDP Selection Means to X-energy

*In December 2020, X-energy was selected to receive \$1.2bn in funding to deliver a first-of-a-kind commercial advanced nuclear plant and TRISO-X fuel fabrication facility*

- ✓ Recognition from the DOE as an advanced reactor technology of choice (one of two demonstration awards out of many applicants)
- ✓ Funds all remaining design, licensing, commercialization and construction of the first-of-a-kind reactor as a 50% DOE cost share<sup>(2)</sup>
- ✓ Secures first customer deployment
- ✓ Strengthens DOE's support of the advancement of TRISO fuel

*In May 2020, the DOE announced the ARDP to accelerate the development of advanced nuclear reactors through cost-share partnerships, believing that advanced nuclear energy systems hold enormous potential to lower emissions, create new jobs and build a stronger economy*

## Dow

- On March 1, Dow and X-energy announced the signing of a Joint Development Agreement<sup>(1)</sup> (JDA) to demonstrate the first commercial use of an advanced reactor for an industrial application.
- Dow and X-energy are targeting deployment of a 4-pack Xe-100 plant at **Dow's Seadrift site** to support the provision of industrial steam and electricity.
- Dow added by U.S. DOE as a subawardee under X-energy's ARDP cooperative agreement.
- The JDA includes \$50 million in engineering work, of which 50% is applicable to be funded by the DOE through the ARDP program and the other half by Dow, including the preparation and submission of a Construction Permit Application to the U.S. Nuclear Regulatory Commission.



Note: Commercialization assumes regulatory permitting approvals have been obtained to permit construction of a facility as projected. The regulatory permitting process, including necessary NRC approvals and licensing, is a lengthy, complex process and projected timelines could vary materially from the actual time necessary to obtain all the required approvals. While there is some possibility of an expedited approval process for SMR technology, there is presently no clear path for expedited permitting

1) <https://x-energy.com/media/news-releases/dow-and-x-energy-advance-efforts-to-deploy-first-advanced-small-modular-nuclear-reactor-at-industrial-site-under-does-advanced-reactor-demonstration-program>

# ARDP



- ✓ X-energy selected by U.S. DOE to deliver a *commercial plant and fuel fabrication facility*
- ✓ ARDP provides 50% cost share for a total **funding of \$1.2B USD**
- ✓ X-energy and Dow Chemical announce collaboration using the Xe-100 to provide **process heat and power**
- ✓ Dow selected the Seadrift site for deployment with a target date for the first unit online in 2029



- ✓ July 2023, Energy Northwest announced the selection of Xe-100 for up to 12 units generating 960 MWe for the grid. Target operational date – 2030

# TRISO

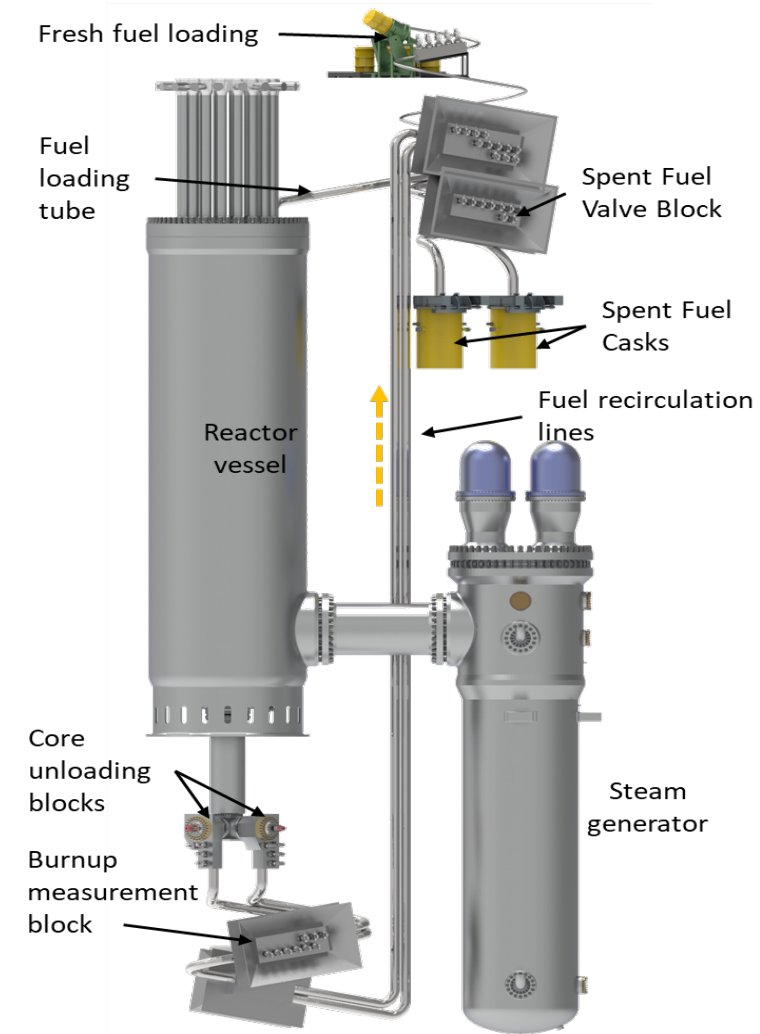
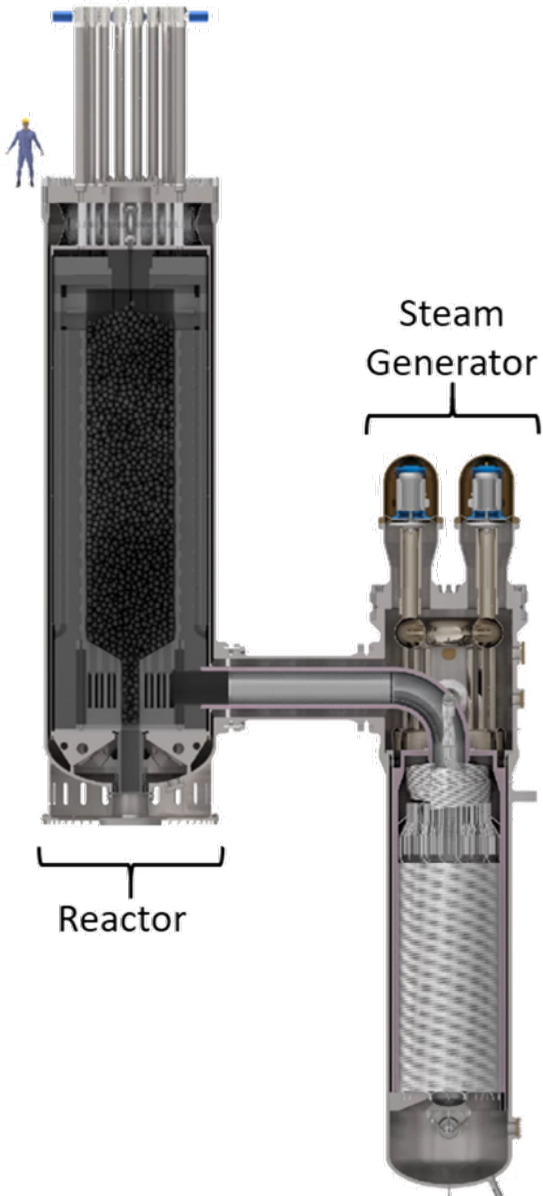


- ✓ X-energy broke ground in October 2022 on **North America's first commercial-scale advanced nuclear fuel fabrication facility (TF3)**

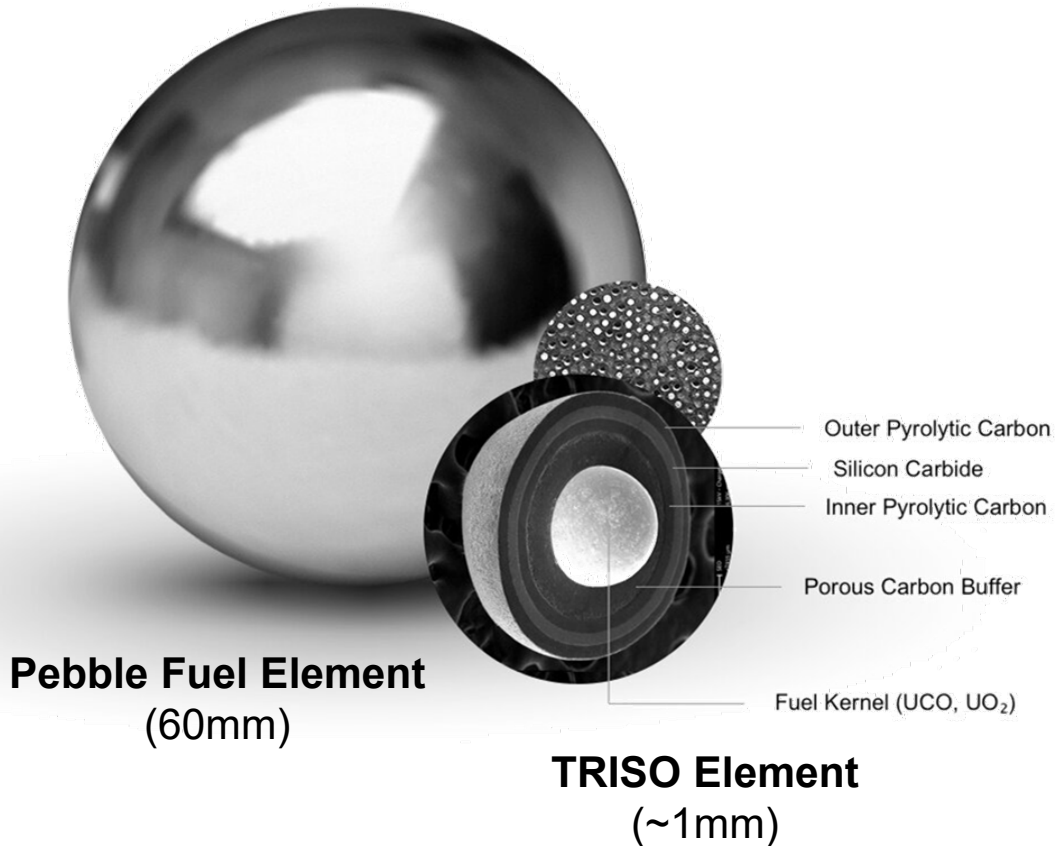
# Simple Design

## Key Technical Specifications

- High Temperature Gas-Cooled Reactor (HTGR)
- 200 MWt Pebble Bed Reactor
- 80 MWe reactor (320 MWe 4-pack)
- 15.5% enriched HALEU
- 60-year design life
- Helical Coil Steam Generator
- Super-heated Steam at 565°C/16.5 MPa
- Multi pass fuel cycle (average 6 passes, 3.5 yrs)
- Continuous online re-fueling
- Burnup up to ~ 170 000 MWd/t
- Ramp rate of 5% per minute, up or down, between 40% - 100% power



Physics, not mechanical systems, ensures 100% safety



**“The most robust nuclear fuel on Earth”**  
- U.S. Department of Energy

- We manufacture our own proprietary TRistructural ISOtropic encapsulated fuel (TRISO-X) to ensure supply and quality control.
- Leveraging more than US\$300M of DOE investment and research.
- 40+ years of prototype and full-scale demonstration reactors.

### Why is this important?

- Inherent safety
  - ✓ The fuel cannot melt
  - ✓ Proliferation-resistant
  - ✓ Zero releases during waste storage

# The X-energy Spent Fuel Strategy (Canada)

Spent Fuel Pebble



Lower heat loads than LWR or CANDU fuel

No reprocessing required

Spent Fuel Canister



Passive air cooling

No water or active cooling systems

On-site Spent Fuel Storage Option



60 Year Fuel Storage

25 m x 31 m → ½ hockey rink per unit

Off-site Spent Fuel Final Disposal



Inherent safety → TRISO-X fuel pebbles retain excess energy over geological timeframes

**Fuel remotely loaded directly from reactor into canister**

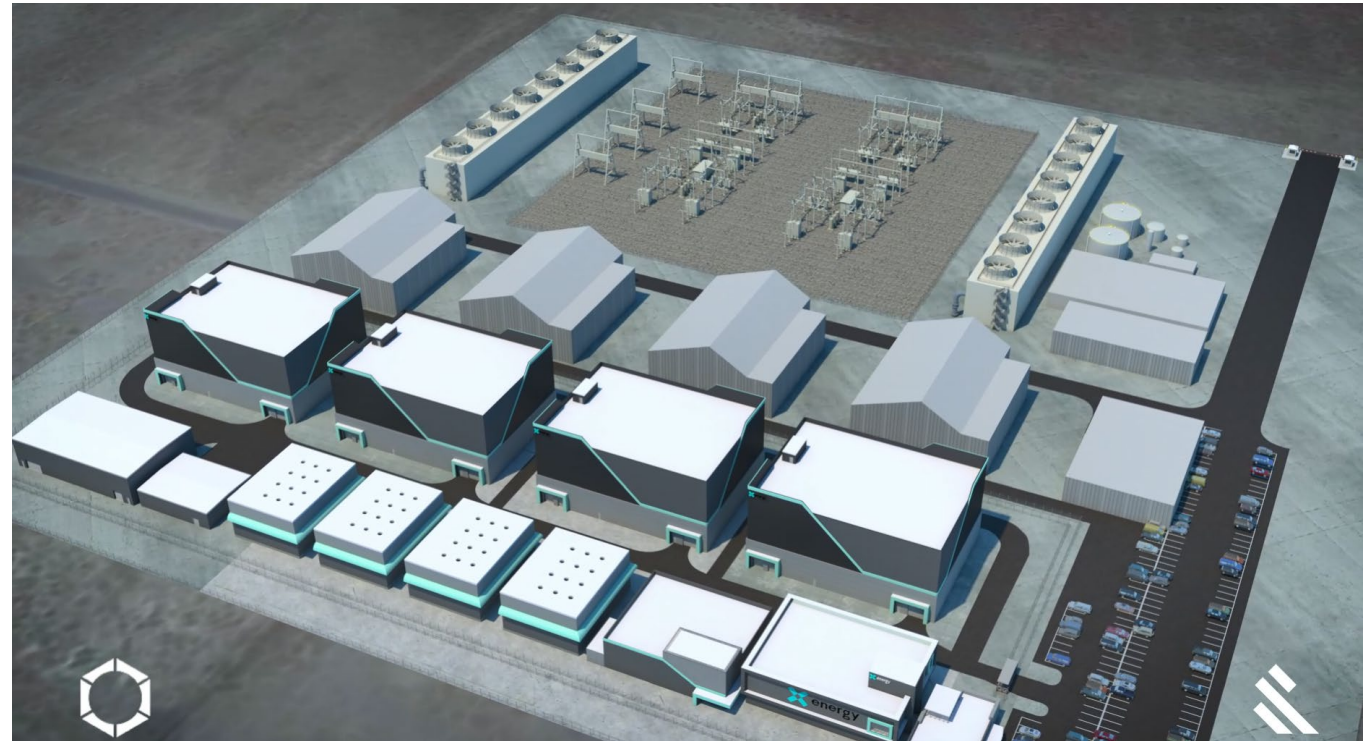
**Air cooled, natural convection, no need for active cooling system**

**Early engagement with NWMO for long term solution in Canada**

*Note: Images not to scale*

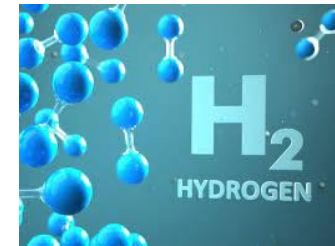
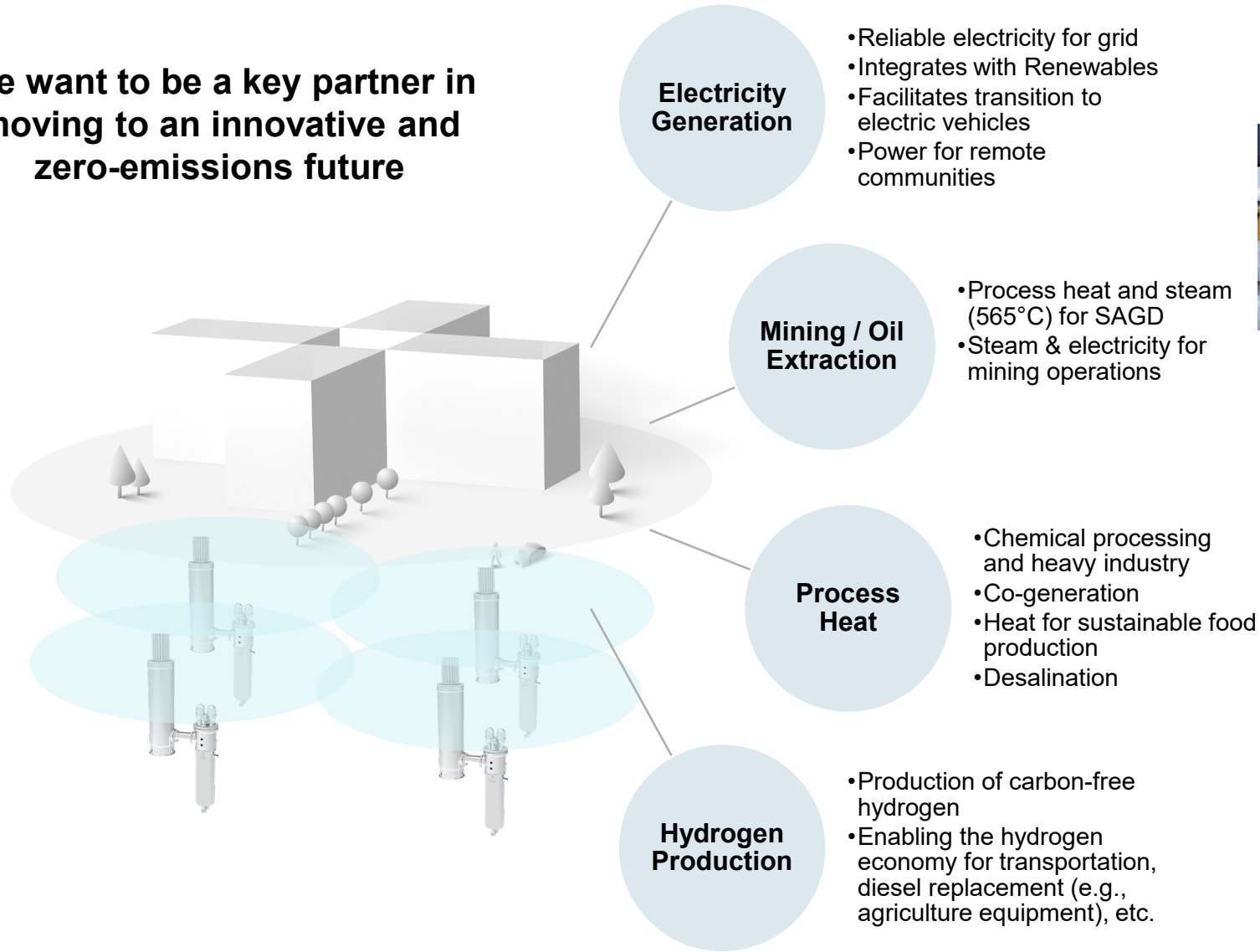
## Standard 4 reactor layout:

- ✓ Economical footprint (~34 acres)
- ✓ Includes all auxiliaries and support buildings
- ✓ Waste storage sized for 60 years
- ✓ Low water requirement option with dry cooling (secondary side) ~60,000 m<sup>3</sup>/yr (about 2 swimming pools per month)
- ✓ Small emergency planning zone (~400 m)






**We want to be a key partner in moving to an innovative and zero-emissions future**



## Our High Temperature Gas Reactor Supports 24/7 Industrial Operations:



**100% reliability** – modular design → (4) x 80MW Units = 320 MWe Plant Output



**Load following** – sustaining base and variable loads



**Low operating costs** – 3 control room operators → 4 to 12 units



**Inherent safety** – zero active safety systems, drastically reduced exclusion zone



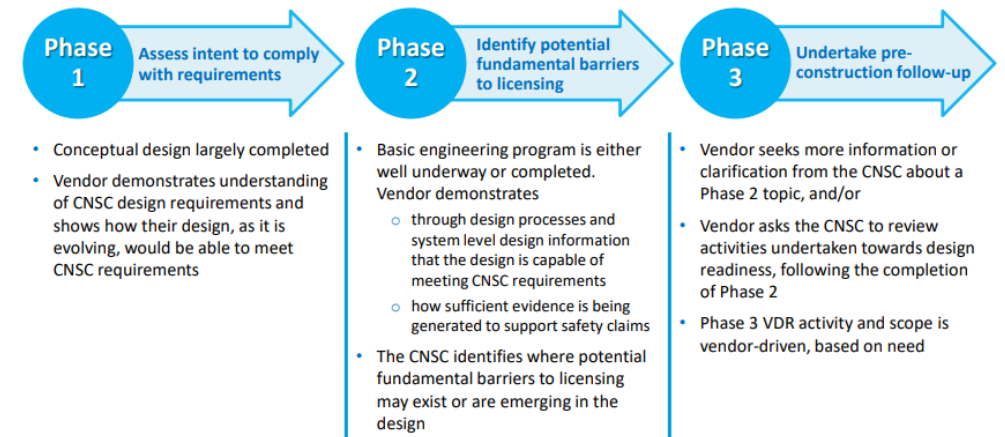
**Reduced nuclear footprint** – independent Nuclear Island and simplified spent fuel handling



**High-temperature steam** – electricity production and make-up steam simultaneously

- X-energy commenced combined CNSC Phase 1 & 2 Vendor Design Review (VDR) for Xe-100 in 2020. Phase 3 Xe-100 VDR to begin in Q3 2023.
- All Phase 1/2 VDR submissions for all 19 Focus Areas complete.
  - Single or multiple submissions provided to CNSC per Focus Area.
  - ~200 documents submitted in total in support of submissions.
- All Requests for Additional Information (RFI) responses complete.
  - No additional RFIs expected from the CNSC as part of Phase 1/2 VDR.
- CNSC final report to be issued ~ Fall 2023:
  - No fundamental licensing barriers have been identified to date, nor are any expected based on weekly status update meetings with the CNSC.

## VDR ASSESSMENT PHASES



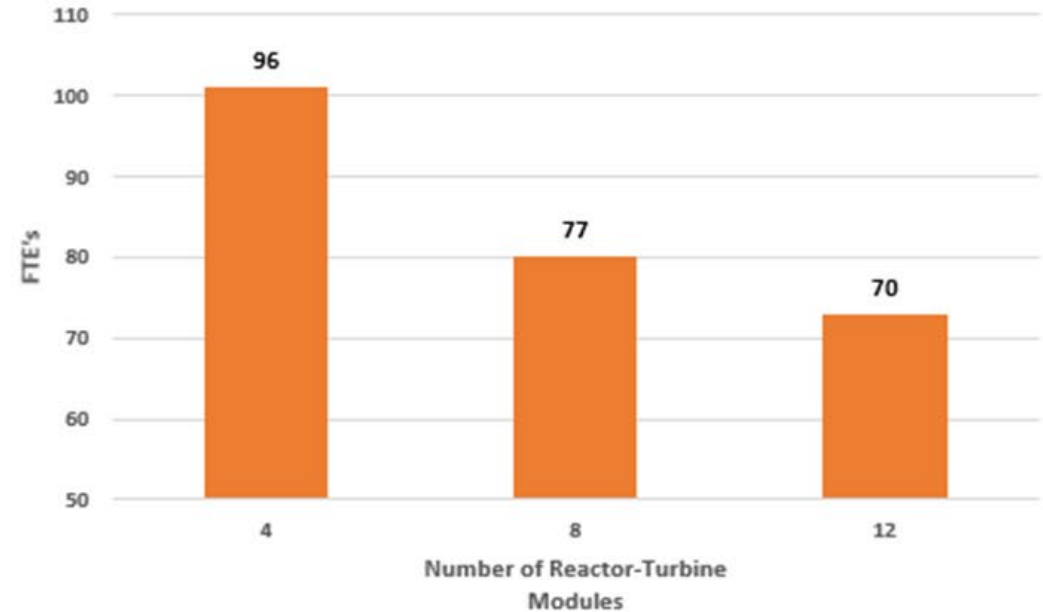
- Identification of all long lead items and the associated risk profile
- Strategic planning around high-risk items engage more than a single vendor in the preliminary phases
- A strategic sourcing process to identify a minimized set of key vendor partners with whom to engage early in the design
- Close collaboration with the identified vendor partners to establish potential contracting models amongst them
- Outreach work to understand the vendor base capabilities beyond the traditional Tier 1 partners, including information sessions and supplier days, with specific attention given to manners in which to engage Indigenous companies
- Optimized manner of integrating Xe-100 projects in Canada and the US with respect to common suppliers
- Identify at least 2 suppliers for each Xe-100 Structures/Systems/Components
- Include suppliers in the design phase to reduce risk
- Xe-100 have a high TRL level – implement as much as possible commercial off the shelf (COTS) systems

# of Reactors	On-Site Staff	Centralized Staff	Total Staff	Average Staff/4 units	% Change
4	58	38	96	96	
8	116		154	77	-20%
12	174		212	70	-27%

- Add 58 staff per 4-pack with no increase in centralized staff

## Divisions:

1. Plant Management
2. Operations
3. Security
4. Centralized Maintenance
5. Centralized Engineering
6. Centralized Licensing & Regulatory Division
7. Centralized Supply Chain Division
8. Centralized Administration





**Xe-100 Mock-Up Control Room**





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