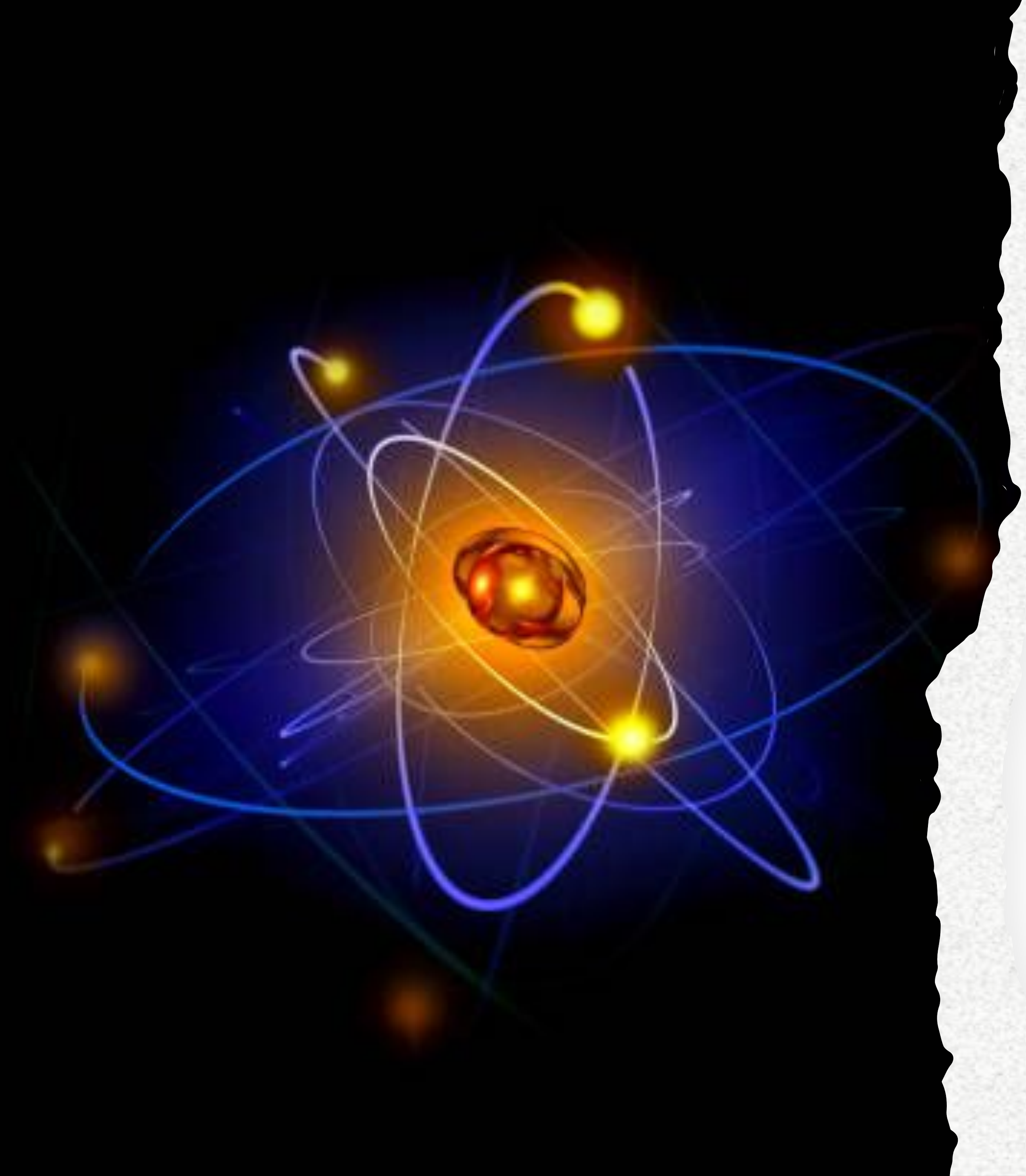


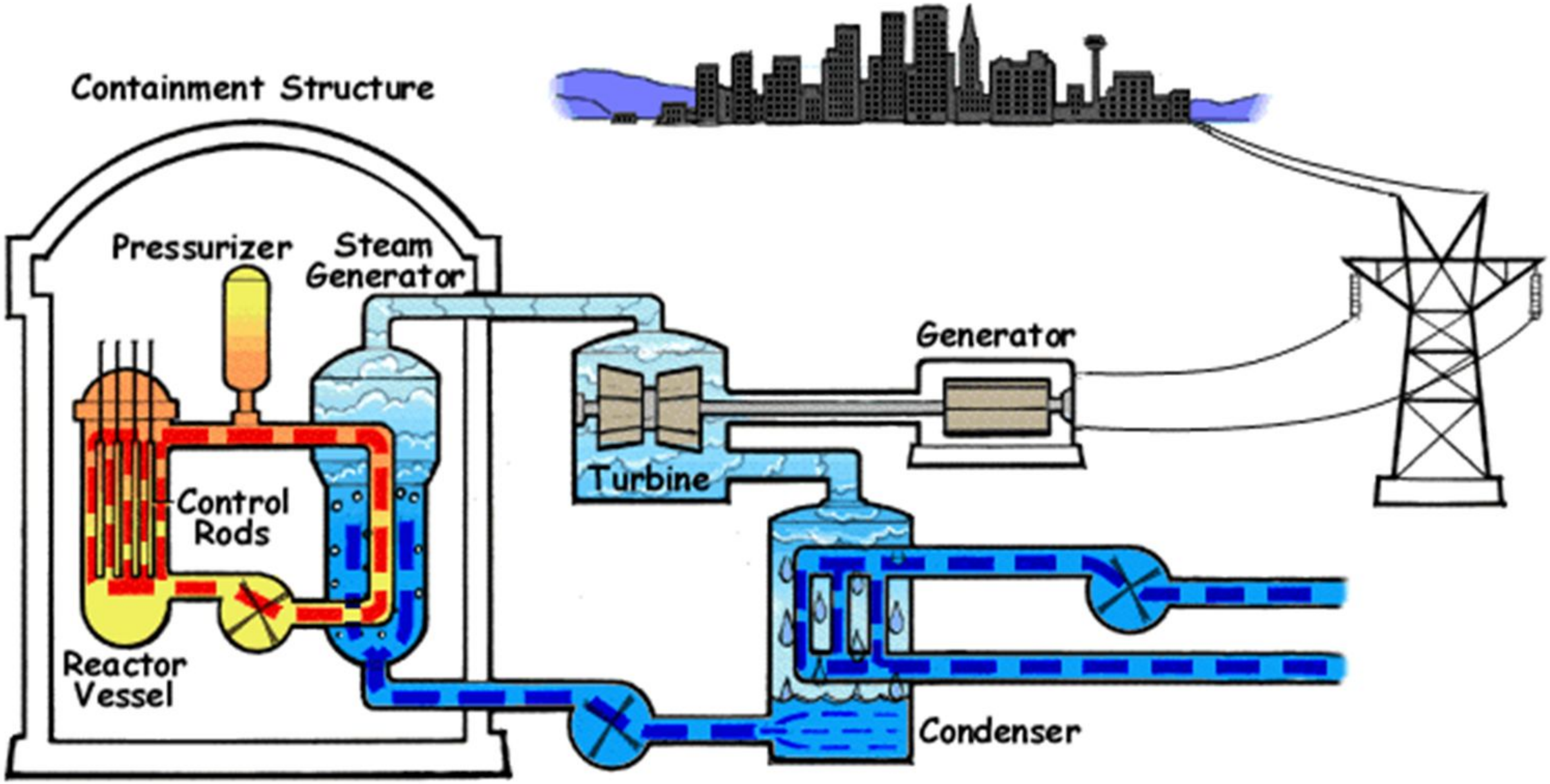
Topics

- How a nuclear reactor works / reactor types/history in Canada
- SMRs – Roadmap / technologies / Canadian projects
- Potential applications in Western Canada

Break

- Regulatory aspects
- Fuel cycle / Waste disposal
- Other applications – medical isotopes / desalination
- Social acceptance – public / indigenous engagement
- Conclusions

How a Reactor Works



Isotopes

- Each element is distinguished by the number of protons, neutrons and electrons. The atoms of each chemical element have the same number of protons and electrons, but not neutrons, whose numbers can vary.
- Atoms with the same number of protons but different numbers of neutrons are called isotopes.
- Some isotopes are unstable and emit radiation and are called radionuclides
- Radionuclides have different half lives – explains different amounts found in nature

Fissile and Fertile Isotopes

- Fissile isotopes can undergo fission from thermal neutrons
- Fertile isotopes are those can not undergo fission directly but can become fissile when they absorb a neutron
- Naturally occurring Uranium is made up of
- U-238 99.27% (fertile) - can become Pu-239….
- U-235 0.71% (fissile)

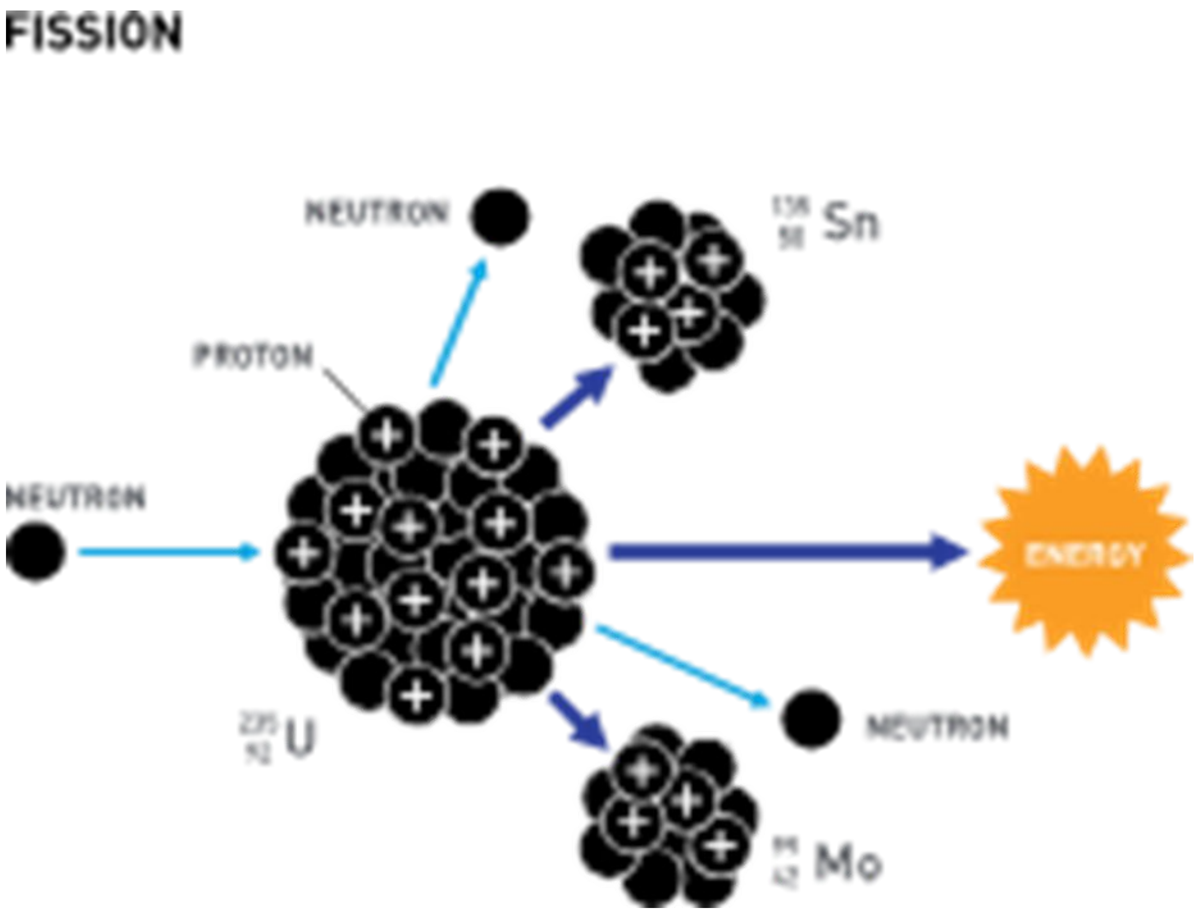
Fun Fact

Half the power generated by the CANDU reactor derives from U235 and rest from U238 via fission of plutonium

Nuclear Fission

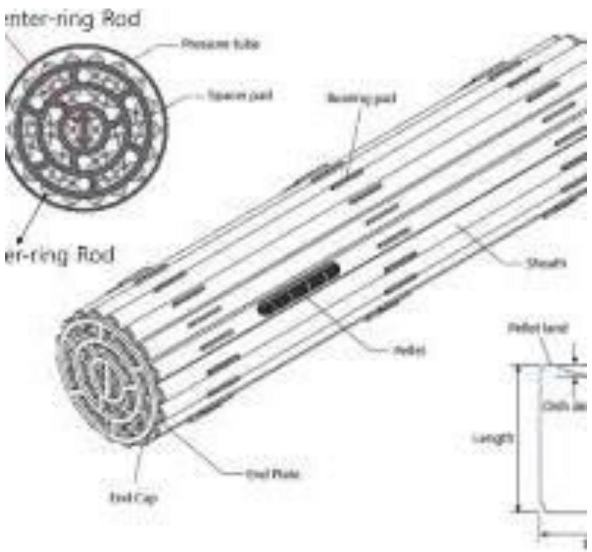
- Splitting the nucleus
- Neutron interactions
- Moderation
- Sustained chain reaction
- Radioactive decay

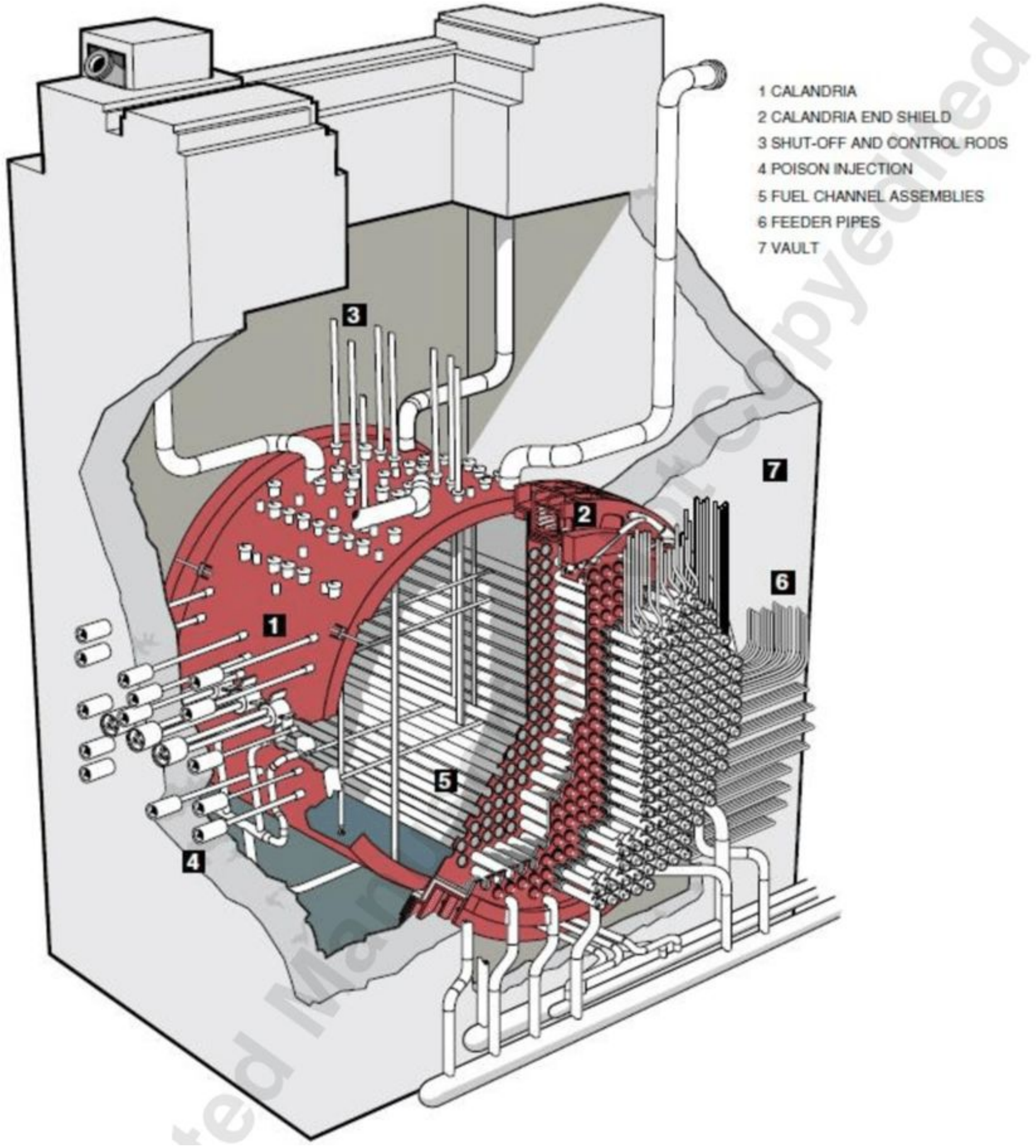
- Different than fusion



Reactor core (engine)

- Fuel bundle
- Lattice
- Core
- Control rods





Different types of reactors

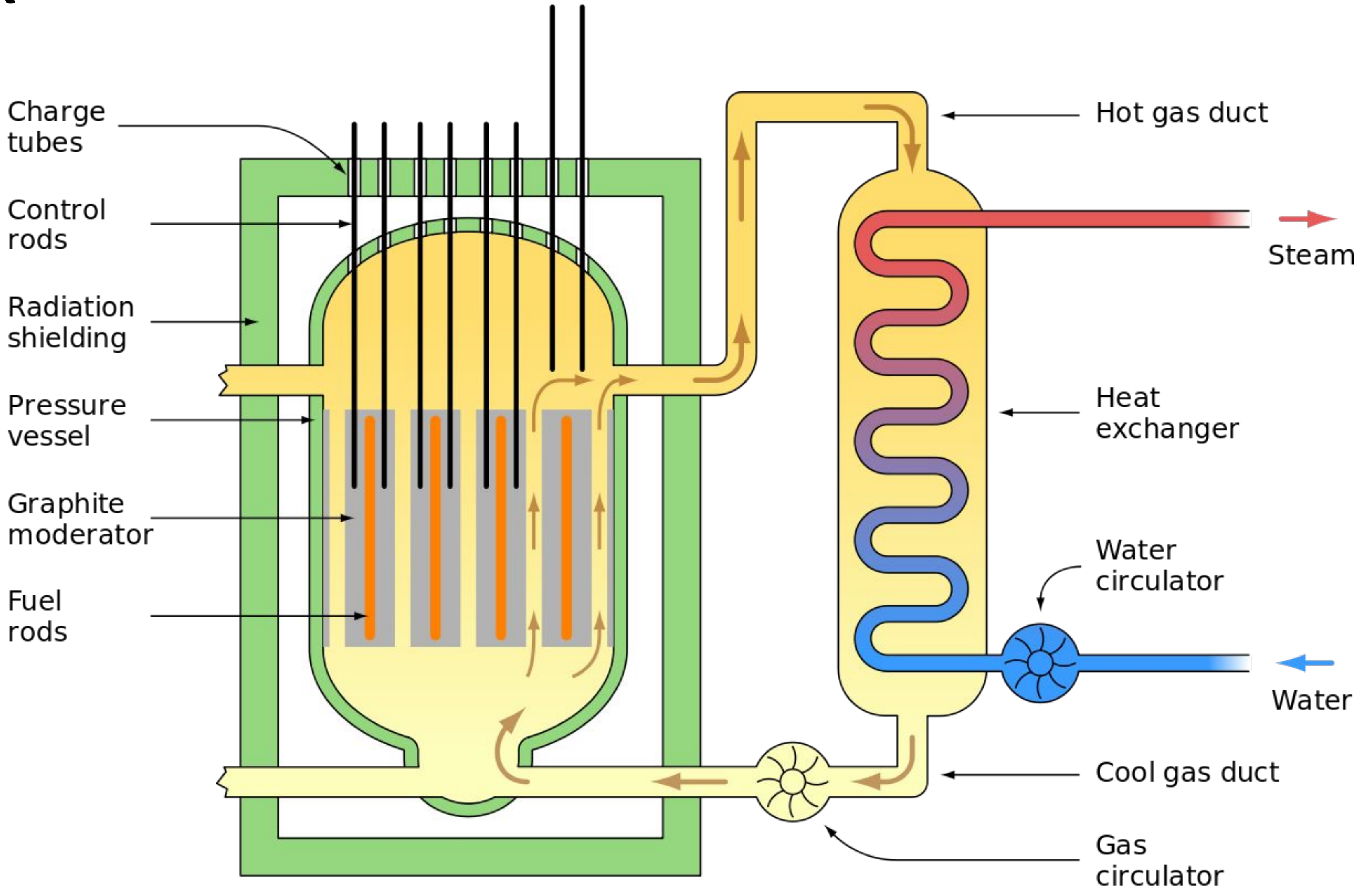
Thermal spectrum (moderated reactors)

Reactor	Fuel	Coolant	Moderator	
Magnox	Nat U	CO_2	C	
CANDU	Nat U	D_2O	D_2O	
PWR	LEU	H_2O	H_2O	(LEU - Low Enriched U)
BWR	LEU	H_2O	H_2O	
AGR	MOX	CO_2	C	(Mox is recycled fuel)

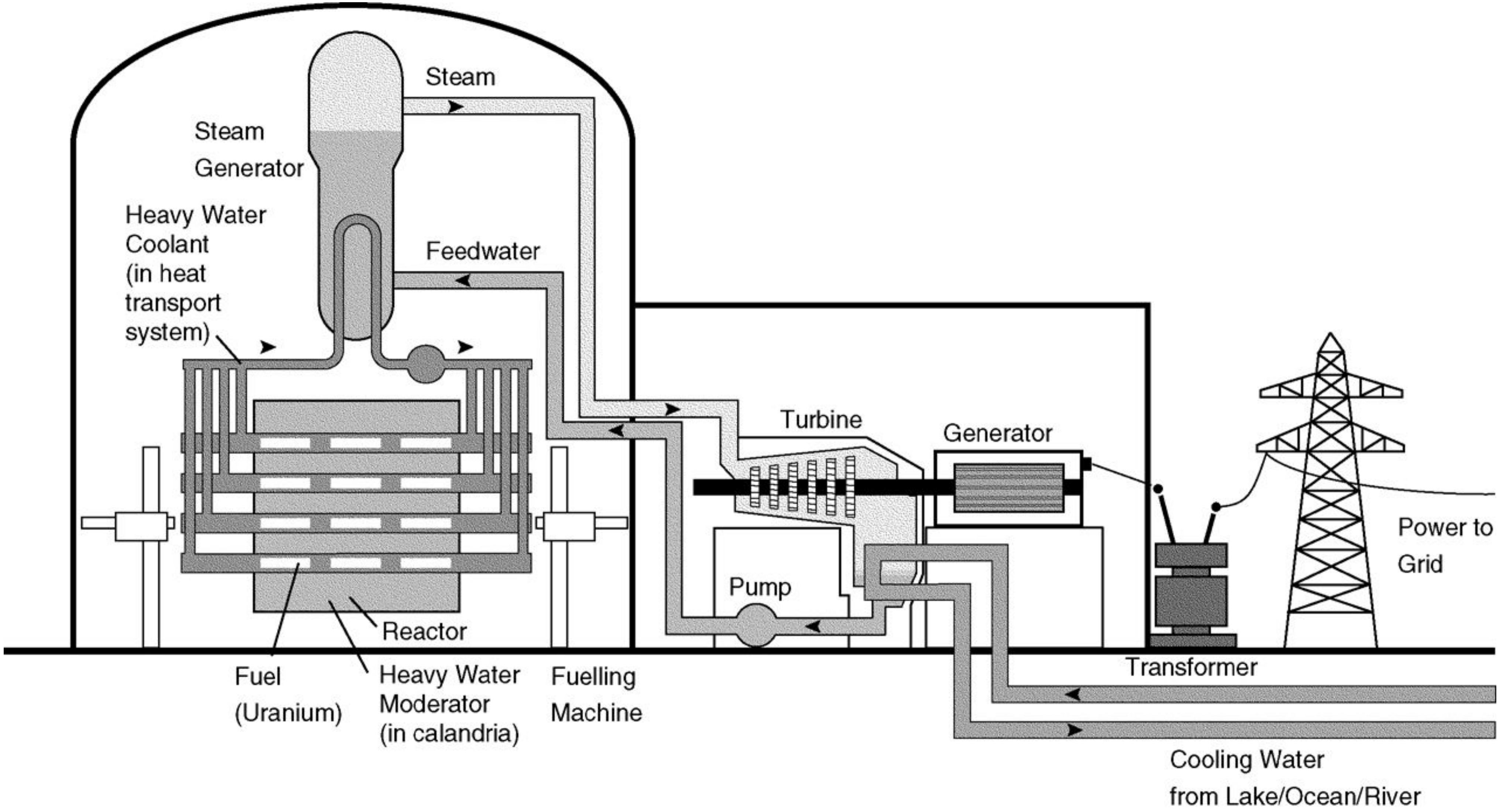
Fast spectrum (no moderator)

BN600	MOX	Na	none	Pool type non-pressurized

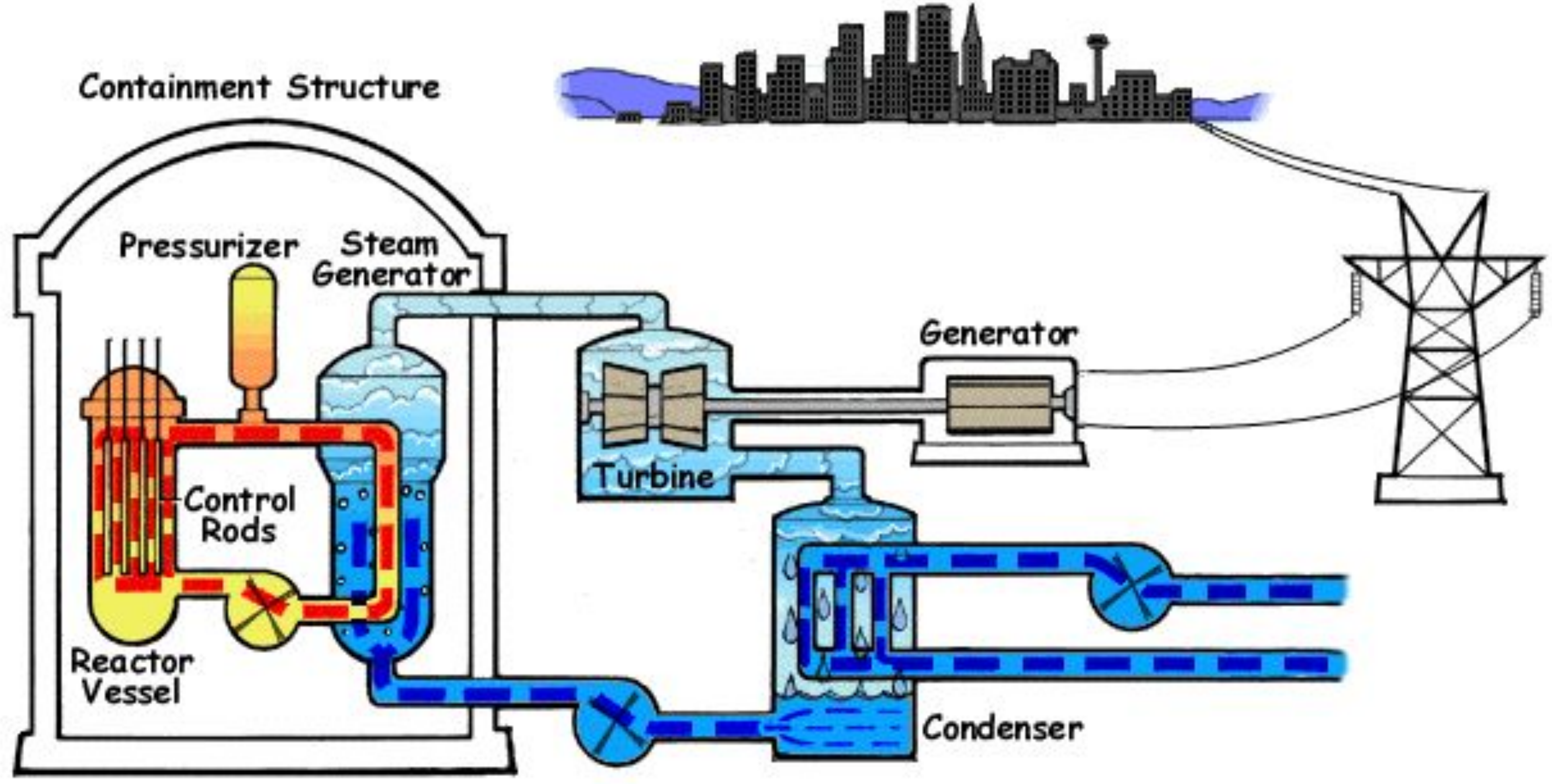
Magnox


Charge tubes
Control rods
Radiation shielding
Pressure vessel
Graphite moderator
Fuel rods
Hot gas duct
Steam
Heat exchanger
Water circulator
Water
Cool gas duct
Gas circulator

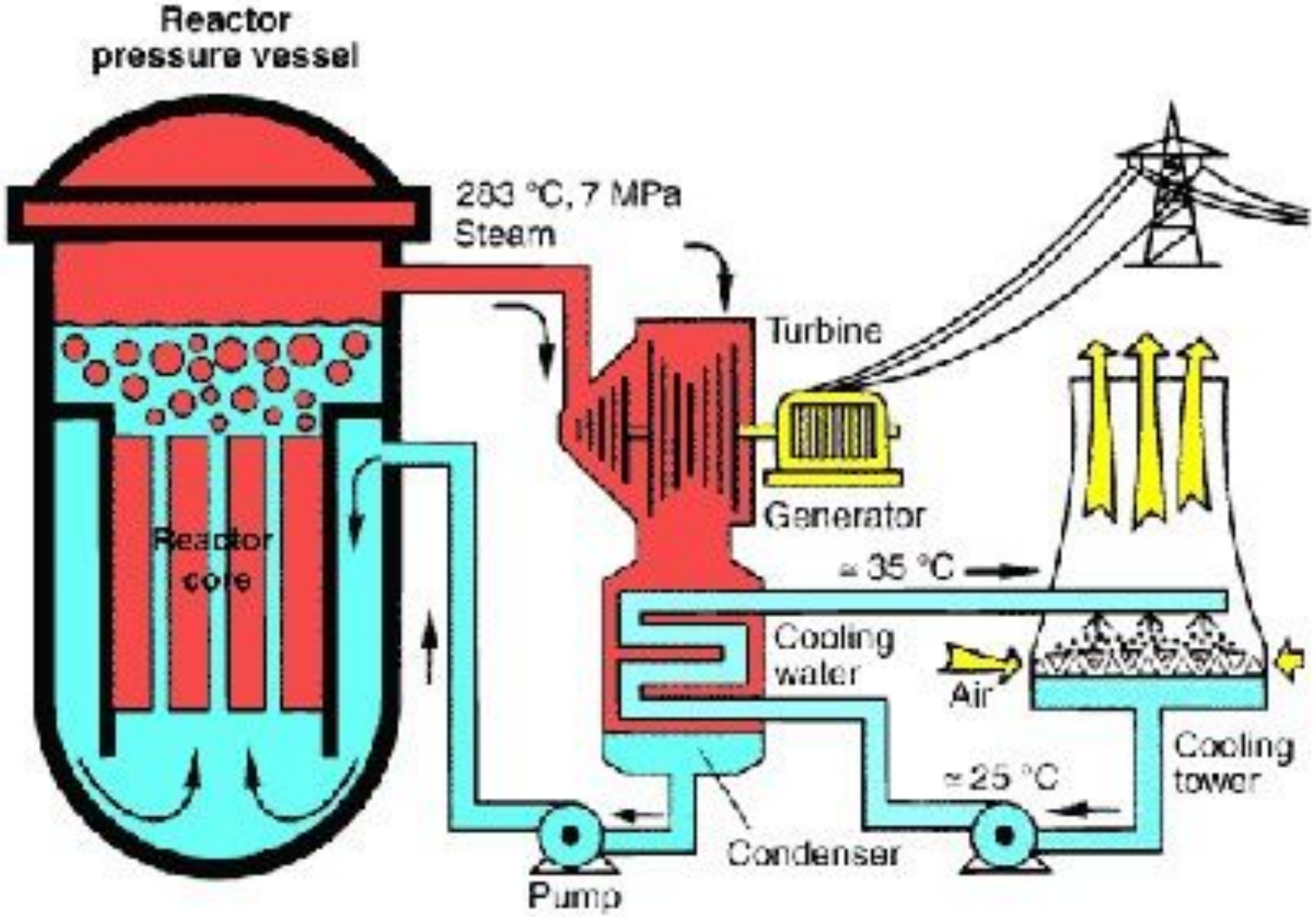
CANDU


Steam
Steam Generator
Heavy Water Coolant (in heat transport system)
Feedwater
Turbine
Generator
Power to Grid
Pump
Reactor
Fuel (Uranium)
Heavy Water Moderator (in calandria)
Fuelling Machine
Transformer
Cooling Water from Lake/Ocean/River

Pressurized Water Reactor (PWR)



Boiling Water Reactor (BWR)



Early Nuclear Development

- Different types of fuels / coolants / moderators
- US developed enrichment
- First power application was Submarines decided on light water – Nautilus versus Seawolf
- US power reactor industry grew out of the submarine program adopting light water coolant and moderator but using LEU
- Majority of reactors around the world are light water reactors
- UK and Canada used natural uranium

Nuclear in Canada starts in the early 40’s

- Montreal lab – English scientists
- Chalk River laboratory – ZEEP / NRX / NRU research reactors
- AECL
- AECB / CNSC
- Slowpoke research reactors – various Universities
- NPD & CANDU power reactors
- Uranium mining – Ontario / Saskatchewan
- Uranium refining & fuel manufacturing
- Nuclear supply chain
- Production of medical isotopes

- Reading - https://unene.ca/essentialcandu/pdf/2%20-%20Genealogy%20of%20CANDU%20Reactors.pdf

Nuclear Canada Cont’d

- NPD
- Douglas Point
- Pickering A 1– 4
- Bruce A1 -4
- G1 and G2
- Point Lepreau
- Pickering B 1-4
- Bruce B U 1-4
- Darlington A 1-4

CANDU reactors world-wide

CANDU 6 units

- Romania -2
- Korea – 4
- China – 2
- Argentina – 1

Early smaller units (Douglas Pt.)

India – 2 (spawned many domestic units)

Pakistan -1

CANDU Life Extension

- Pt Lepreau Nuclear Station refurbished in 2012
  - Life of station extended until about 2042+
- Darlington Nuclear Station is currently undergoing a $10b refurbishment of its four units to extended the life of the units until the 2060s.
  - First two units completed on budget and ahead of schedule.
  - Third unit underway
  - Target date for completion – 2026
- Bruce Power is currently undergoing a $12b major component replacement to extend the life of six units until the 2060's.
  - Bruce Units 1 & 2 were previously refurbished
  - Bruce Unit 3 completed on time and on budget
  - Target date for completion – 2033
- Ontario government recently announced plans to refurbish Pickering nuclear station
  - OPG beginning planning process building on lessons learned in Darlington refurbishment

Canadian Nuclear Supply Chain

- Well-established nuclear supply chain across the entire life-cycle from uranium mining to waste storage and decommissioning.
- Uranium mining and milling based in Saskatchewan
- Fuel fabrication based in Ontario
- Major components largely based in Ontario
- Current supply chain primarily based on CANDU reactors although some work is applicable to non-CANDU reactors (i.e. BWXT pressure vessels).
- Supply chain is fully operational due to refurbishments of the Bruce Power and Darlington sites. Likely to be significantly occupied with Ontario’s plans to build new large reactors.
- SMRs provide an opportunity for other provinces to develop a nuclear supply chain
    - New Brunswick is building on its existing supply chain with ARC and Moltex SMRs
    - Opportunity for fuel fabrication for SMRs in Saskatchewan
    - Opportunity for Alberta to develop nuclear supply chain given the potential deployment of significant number of units

New Large Nuclear Plants

- The government of Ontario announced plans to build new large nuclear plants
  - It is estimated that up to 18GW of new nuclear will be needed if Ontario is to make its net zero target
  - Some new build will be SMRs but the bulk will be large nuclear units
- OPG and Bruce Power have been asked to review potential sites and provide the government with a possible path forward by the end of 2024
- Ontario and Bruce Power recently announced plans to build up to 4800mw on the Bruce Power site (in addition to the existing 7000mw)
  - Federal government recently committed $50m for pre-development plans (i.e. IAA/Licensing)
  - Bruce Power is beginning to review technologies with an RFP expected in the near future
  - CANDU Monarch, Westinghouse AP1000, French, South Korean and GE-Hatachi all expected to bid.
- Refurbishment and new nuclear is likely to occupy most of the Ontario supply chain

What are Small Modular Reactors

Small – units are much smaller than traditional reactors ranging from 1mw up to 300MW. There are approximately 70 designs internationally although far fewer will achieve commercialization.

Modular – **factory constructed**, **portable** and **scalable.** Micro reactors are designed to be factory constructed while larger units will have some on-site construction. Units can be "stacked" to fit needs.

Reactors – using nuclear fission to produce **energy**: energy for electricity, hybrid energy systems, district heating and high-quality steam for heavy industry applications.

SMR Path Forward in Canada

- Canada began looking at SMRs in earnest in 2016 resulting in the release of Canada's SMR roadmap in November 2018. The report was prepared by a Steering Committee comprised of the government of Canada, provincial governments, territorial governments, and power utilities interested in the potential for development, demonstration, and deployment of SMRs in Canada. https://smrroadmap.ca
- In December 2019, the Premiers of Saskatchewan, Ontario and New Brunswick signed an MOU to advance the development and deployment of SMRs. Alberta joined the Mou in April 2021. The MOU encourages co-operation among provinces and industry.
- In 2022, the four provinces released "A Strategic Plan for the Deployment of Small Modular Reactors"
- In addition, the CANDU Owners Group and CNA have been co-ordinating an utility led working group that focuses on the steps necessary to deploy SMRs.
  - Focus areas include:
    - Regulatory framework
    - Fuel
    - Waste Management
    - Security and safeguards

SMRs On Grid

- Wide-spread consensus that one of the keys to meeting our climate change goals is greater electrification. That of course only works if the electricity is net zero. All options will be needed including new nuclear.
- SMRs by virtue of their smaller size are well suited for smaller grids and can be built on existing fossil fuel sites to take advantage of existing infrastructure.
- OPG has selected GE-Hitachi for it's first of a kind on-grid reactor to be deployed at the Darlington site in Ontario targeting first power in 2028.
- Sask. Power worked with OPG on the Darlington technology selection process and also selected GE Hitachi for it's first reactor with a target for first power in the early 2030s.
- Westinghouse is developing an AP300 SMR for on-grid generation.
- GE-H and Westinghouse reactors are scaled down versions of existing light-water reactors
- Advanced or Generation 4 reactors can be deployed for on grid generation as well. These reactors are generally smaller, rely on passive safety systems and often use different fuels and moderators

Advanced Reactors

- 4th generation, advanced small modular reactor designs include innovative and enhanced systems including passive safety systems.
- Some of these reactors are capable of producing high temperature heat and steam that can be used for industrial purposes including the oil sands as well as electricity. – co-generation.
- Advanced reactors can be “stacked” to meet demand levels. For example, X-energy can deploy up to 12 reactors (960mgw) with one control room.
- Prominent 4th generation advanced SMRs included ARC, Terrestrial, Terra Power and X-energy.
- Some designs such as Moltex which is being developed in New Brunswick are designed to burn existing spent fuel.
- NB Power has applied for a license to prepare site from the CNSC and is going through an EIA for the ARC commercial demonstration project at Point Lepreau New Brunswick
- X-energy’s FOAK reactor is being built in Texas for DOW – first reactor deployment for industrial heat, site electricity and electricity to the grid

Micro reactors for mines, industry and remote communities

- Micro reactors are typically 2 – 10 Mw and designed for off-grid applications.
- Reactors are mobile and designed to be assembled operated and then removed
- Advanced/Generation 4 reactors which can produce both heat and electricity and are capable of being “stacked” to meet local demand
- Cost competitive with diesel but not with grid generated electricity
- Prominent designs include
  - Westinghouse’s eVinci which is being developed for Saskatchewan Research Council. About the size of half a hockey rink (ice surface) and produces 5Mw (e) or 13Mw (t)
  - Ultra Safe Nuclear Corporation (USNC) is developing a micro reactor at the Canadian Nuclear Laboratories’ Chalk River site in Ontario
  - X-energy and BWXT are also developing micro reactors

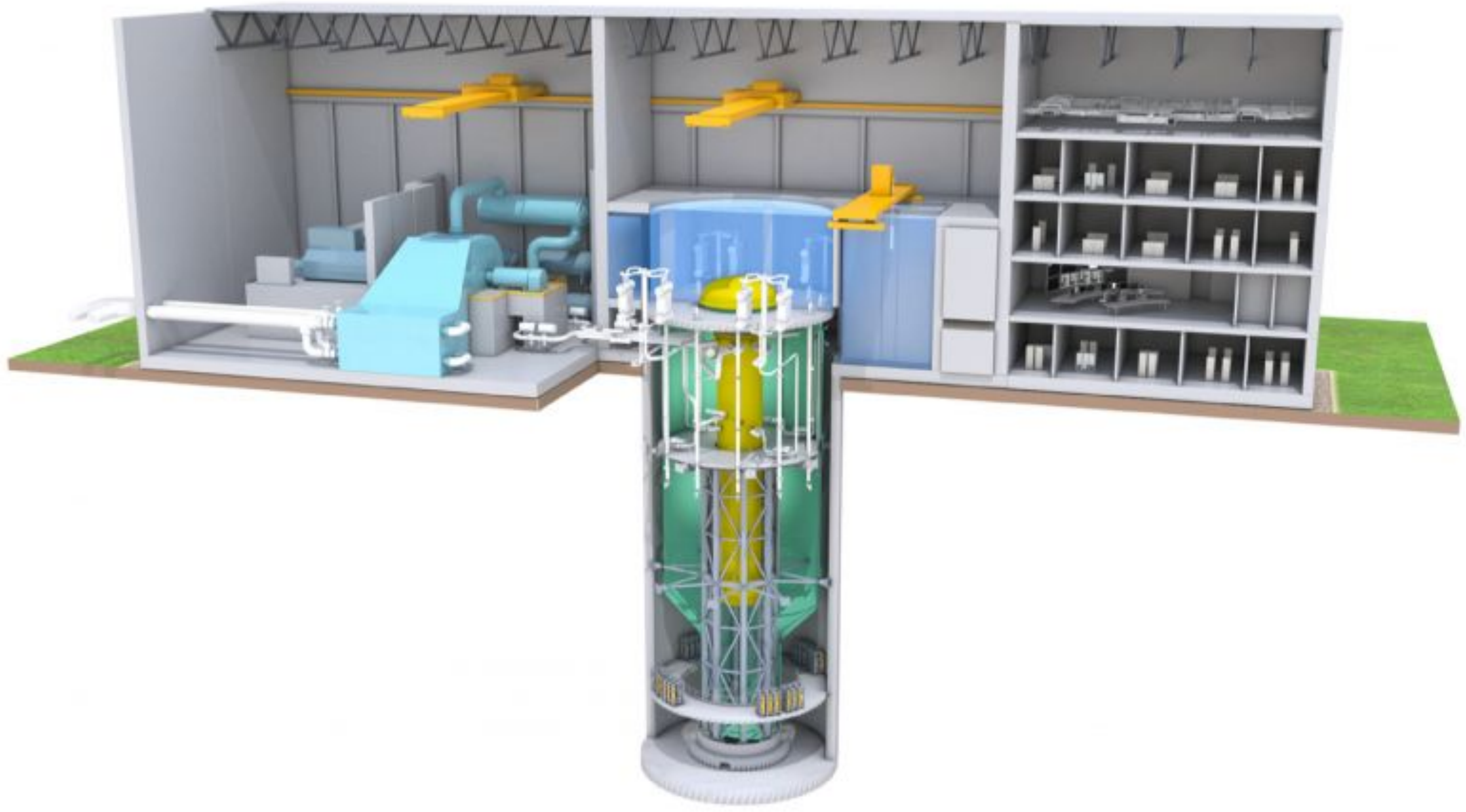
Technology types

- Water cooled
- High temperature gas cooled
- Liquid sodium cooled fast reactors
- Liquid lead cooled fast reactors
- Molten salt thermal reactors
- Moltex salt fast reactors
- Heat pipe reactors

Ref: https://smrroadmap.ca/wp-content/uploads/2018/12/Technology-WG.pdf?x93402

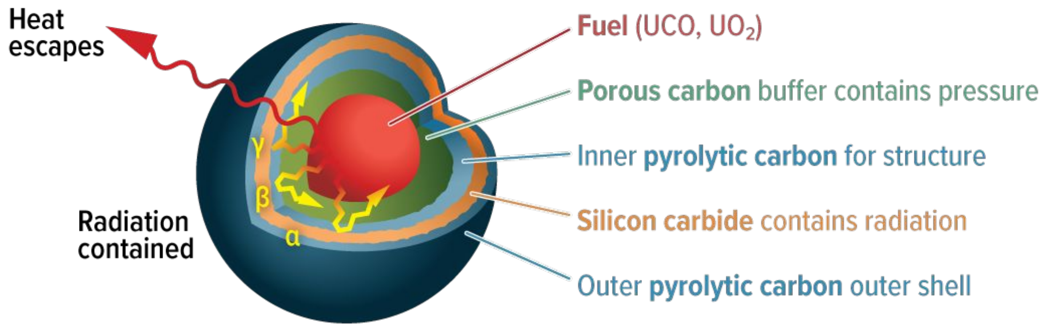
Water cooled (PWRs & BWRs)

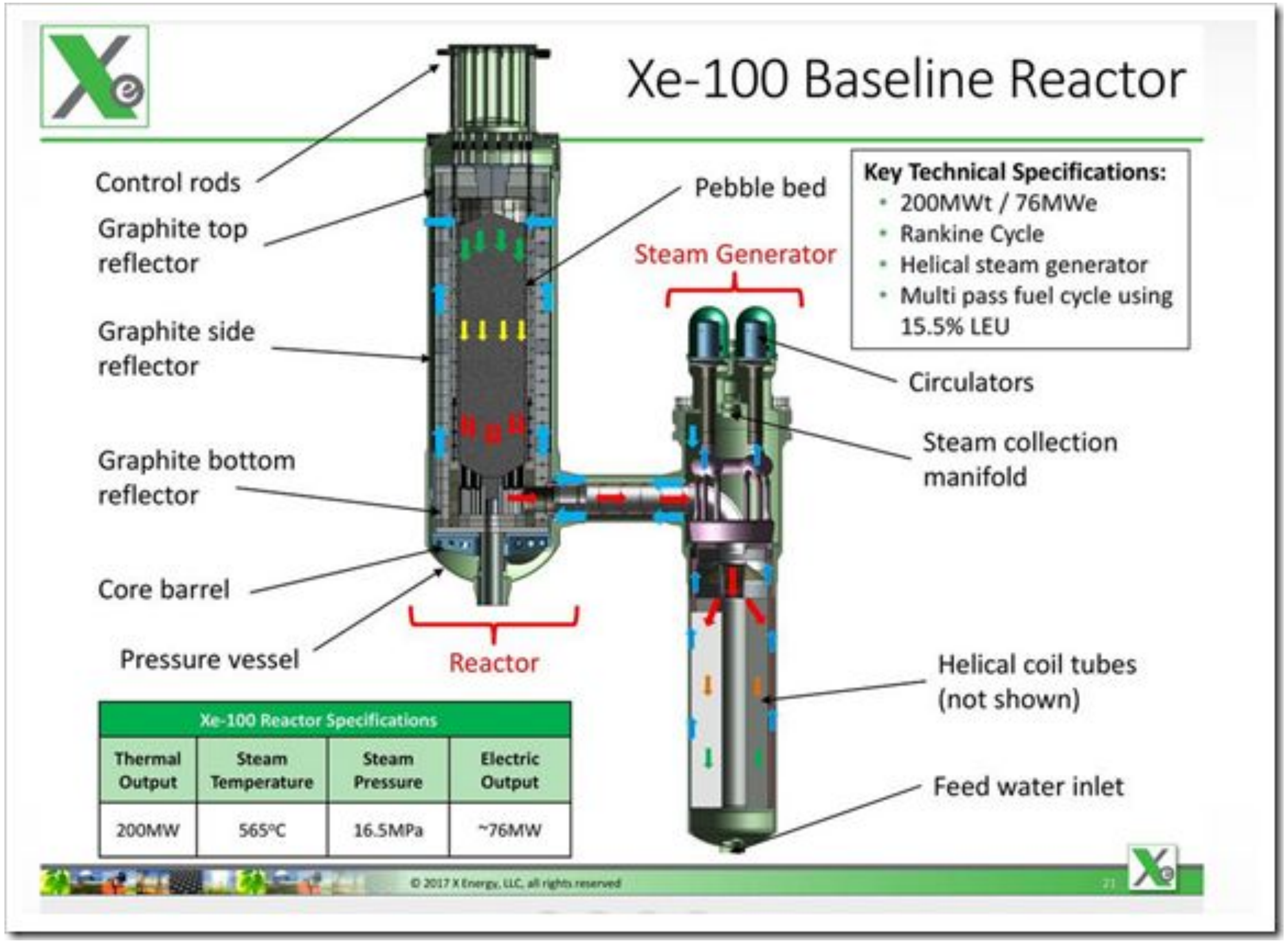
- Light water cooled
- 5% LEU fuel



High Temperature Gas

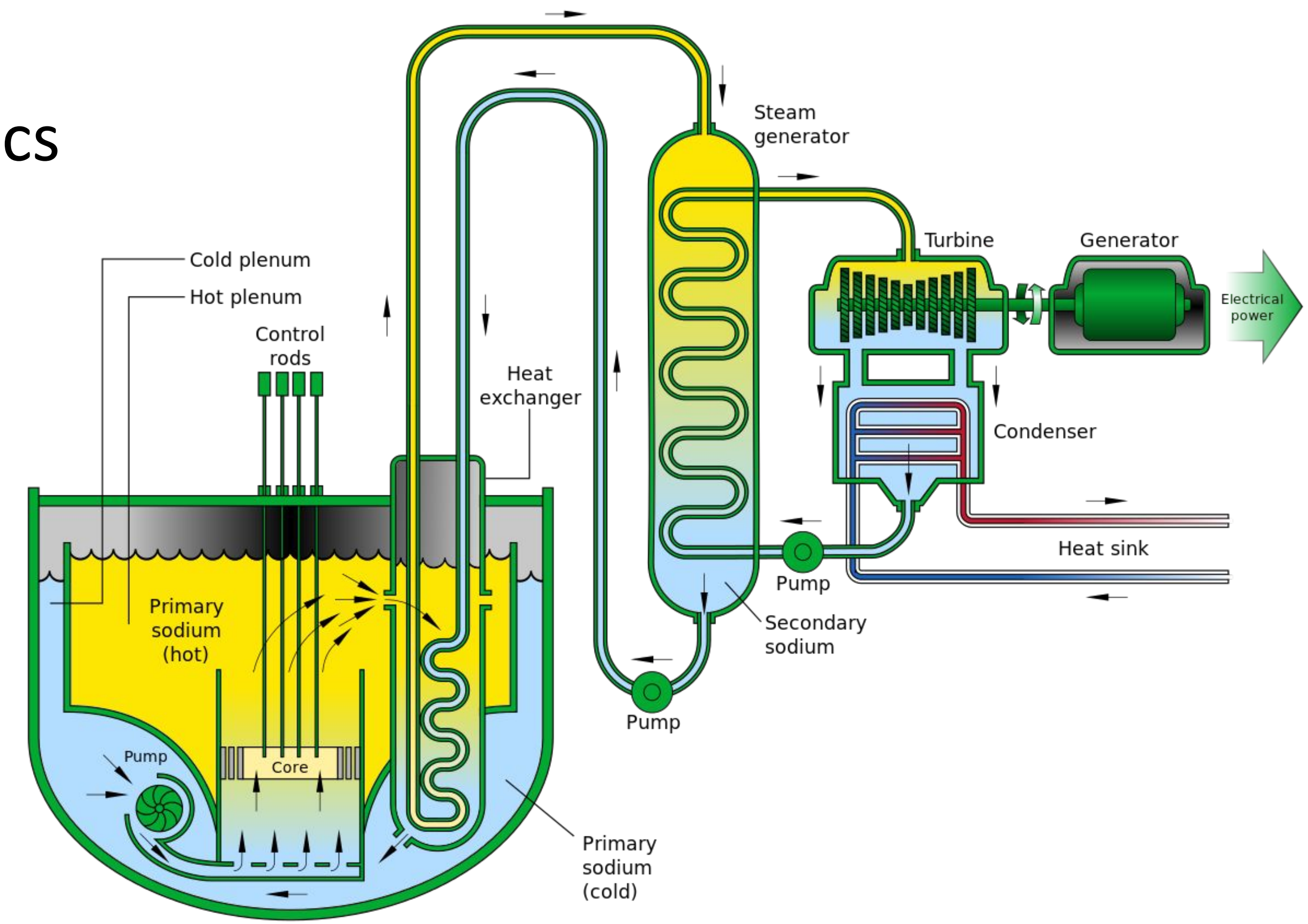
- Thermal spectrum
- He gas cooled
- Superheated steam
- Triso HALEU fuel





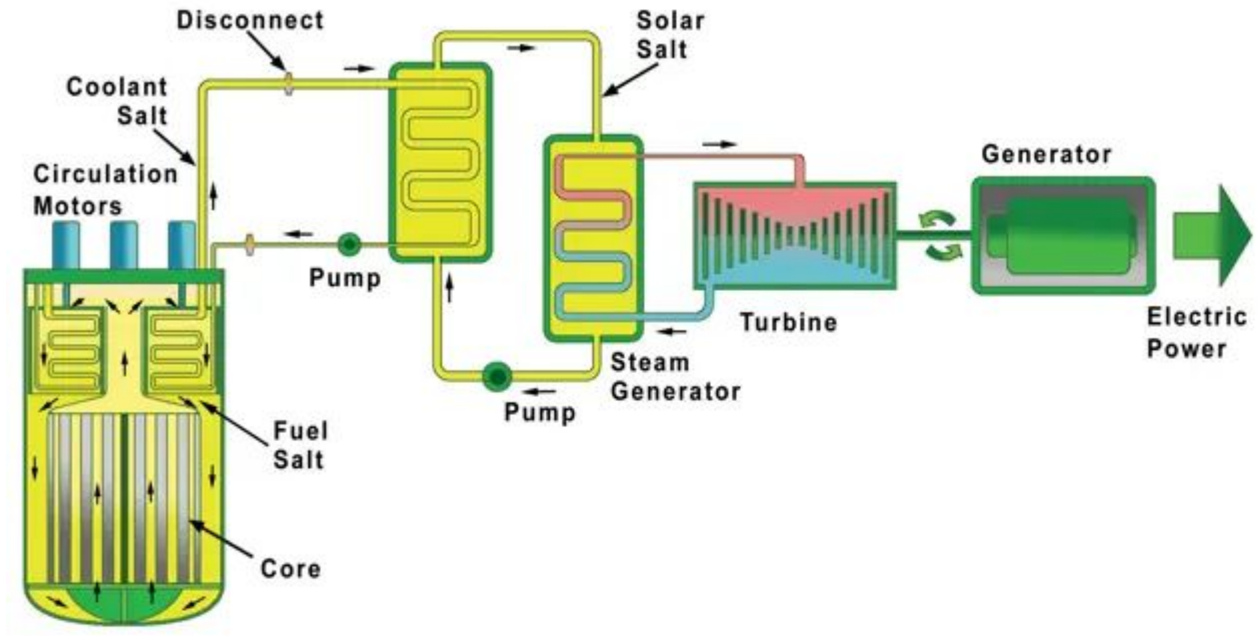
Liquid Sodium Fast Reactors

- Non pressurized pool
- Inherent safety characteristics
- Metallic fuel
- Superheated steam



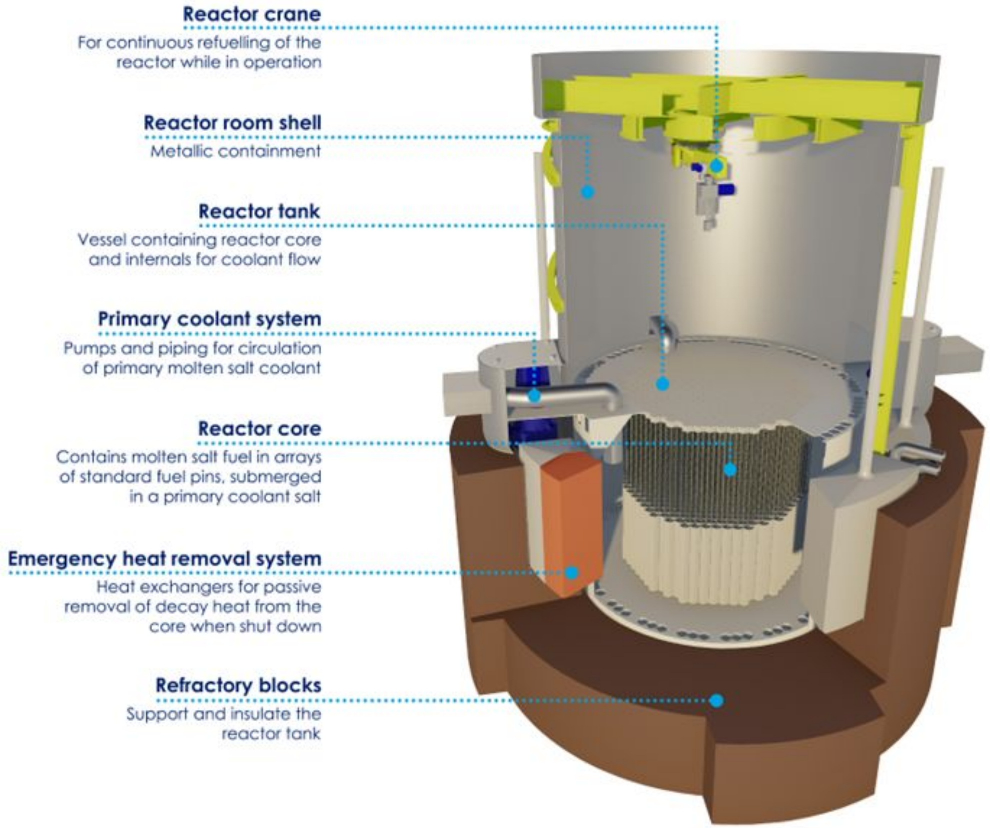
Molten Salt thermal Reactors

- Non pressurized pool
- Fuel is pumped through core
- Inherent safety characteristics
- Superheated steam



Moltex Salt Fast Reactors

- Non pressurized pool
- Recycles used fuel
- Inherent safety Characteristics
- Superheated steam



Heat pipe micro reactors

- Liquid metal coolant is located within heat pipes
- Heat is transferred from the fuel into the heat pipes
- Triso HALEU fuel

SMR projects undergoing licensing in Canada

- OPG Darlington New Nuclear – 4 BWRX-300 SMRs
  - Preparing site, has applied for construction license

- Global First Power MNR high temperature gas micro reactor at CNL
  - Applied for License to prepare site, undergoing EA

- NB Power ARC-100 at Point Lepreau New Brunswick
  - Applied for License to prepare site, undergoing Provincial EIA

Pre-licensing projects

- SaskPower BWRX-300
  - Undergoing site selection & other pre-project activities

- Saskatchewan Research Council – eVinci micro reactor
- NB Power working with Moltex Energy on SSRW-300 and WATSS fuel processing facility for Point Lepreau site
- OPG working with Xenergy on XE-100 for co-gen applications
- NB Power working with ARC on co-gen applications
- Terrestial Energy developing IMSR thermal molten salt reactor

SMR applications across Western Canada

1. **On-grid** – used to replace fossil fuel units in jurisdictions facing significant load needs
2. **Mining** – electricity and heat for remote but rich mining sites
3. **Process heat** – e.g. melting bitumen from the oilsands
4. **Industrial Applications –** ability to produce electricity, heat and hydrogen
5. **Remote communities** – electricity and heat for isolated communities that currently depend on diesel

SMR opportunities and applications in Western Canada

- Job creation and economic diversification
- Development of a Western Canadian nuclear supply chain
- Emissions reductions in the energy sector
- Electricity production for on-grid and remote communities
- Development of Hydrogen Fuel

Energy sector applications

- Reducing emissions in the energy sector is a technical challenge but also an economic opportunity.
- SMRs can play a critical role in decarbonizing extraction and processing in the oil and gas industry.
- SMR technologies have the potential to produce high temperature steam (not just electricity), which allows them to have cogeneration capability for use with industrial applications.
- SMRs can function as an emissions-free CCUS enabling power source.

On-grid and remote communities' applications

- Western Canada will continue to decarbonize its electricity system. There is no silver bullet available to achieve this objective. Simply on-boarding more wind and solar power to the grid will not be enough.
- Higher output SMRs can provide baseload non-emitting electricity to not only reduce emissions from existing generation but meet the rapid increase in demand resulting from broad electrification across sectors.
- SMRs have superior load following abilities and may support integrated energy systems with wind or solar technology.
- SMRs are scalable to suit local needs and can supply non-emitting, low-cost energy for on-grid application and for remote communities – particularly northern and Indigenous ones.

Regulation – The Canadian Nuclear Safety Commission (CNSC)

Regulates the use of nuclear energy and materials to protect:

- health,
- safety,
- Security,
- environment;

implement Canada's international commitments on the peaceful use of nuclear energy

disseminate objective scientific, technical and regulatory information to the public.

Span of control

- Regulate the development, production and use of nuclear energy in Canada
- Regulate the production, possession, use and transport of nuclear substances, and the production, possession and use of prescribed equipment and information
- implement measures respecting international control of the development, production, transport and use of nuclear energy and substances, including measures respecting the non-proliferation of nuclear weapons and nuclear explosive devices

Nuclear Safety & Control Act - Enabling legislation for the CNSC's mission

Regulations

- General Nuclear Safety & Control Regulations
- Administrative monetary penalties
- Radiation Protection
- Class I Nuclear Facilities
- Class II Nuclear Facilities and prescribed equipmen
- Uranium mines and mills
- Nuclear substance and radiation devices
- Packaging and transport of nuclear substances
- Nuclear Security
- Nuclear non-proliferation import and export contr
- CNSC cost recovery fees

- Detailed requirements are found in Regulatory Documents

CNSC Commission

Is an independent, quasi-judicial administrative tribunal and court of record.

President and about 5 members

They hold public hearings to hear information from proponents and interveners as well as question licensees on events

They are authorized to:

- issue, renewal or revoke licenses
- Issue orders
- Administer monetary penalties, etc.

They hold public meetings to receive updates and information

CNSC staff are highly technical and report up to the commission

Nuclear Power Plants are Federally regulated

CNSC is a life cycle regulator

- License to prepare site (requires and approved IA or EA)
- License to construct
- License to operate (requires periodic renewal) – frequent reporting
- License to decommission

Financial guarantees are required to cover decommissioning and disposal of all levels of radioactive waste

CNSC has MOUs with provincial agencies – conventional health & safety, pressure vessel certification/inspection, some aspects of environment, etc.

Readiness for SMRs

- Existing regulatory framework supports SMRs and advanced reactors
- Does require the application of a graded approach and alternate approaches. This takes time for the first application including recognizing the extent of substantiation required.
- Larger issue for micro-SMRs than grid sized SMRs
- CNSC is advancing work with NRC and other regulators on working towards harmonization
- Industry is also working with CNSC on how to benefit from a fleet approach
- CNSC has a program to prepare for SMR licensing both issues and staffing

Impact Assessment Act

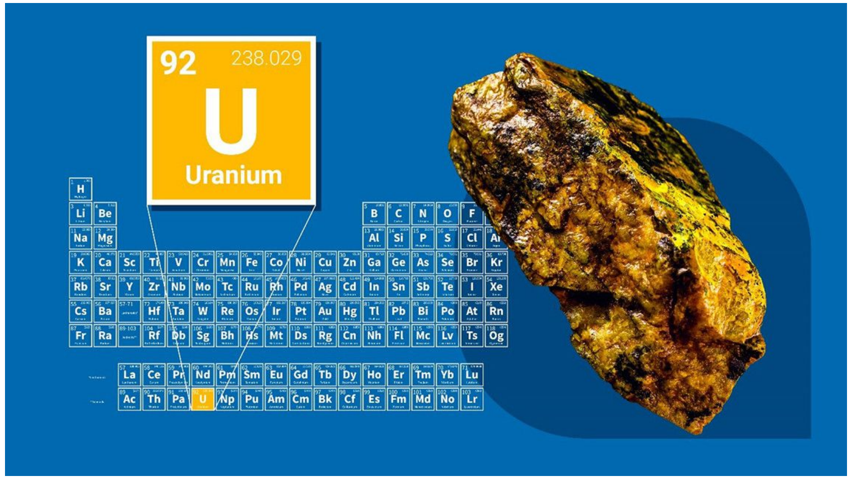
- The IAA broadens the scope of assessments based on sustainability, positive and negative environment, economic, social and health impacts, and mandate greater gender-based analysis and Indigenous engagement.
- Construction of a new nuclear plant requires an approved impact assessment conducted by the Impact Assessment Agency (if on project list) as well as a series of licenses from the CNSC. The IAA requires nuclear projects to undergo an automatic panel review which means that the regulatory process for a first of a kind SMR approval could take 6-8 years (before construction).
- IAA excludes greenfield nuclear projects below the 200MW(t) threshold from the Project List as well as projects below 900 MW(t) on existing nuclear sites on the basis of low safety and environmental risk (a risk informed approach), plus their positive contribution to low carbon energy production. However, the Minister has the right to refer any project to a panel review.
- Last fall, the Supreme Court of Canada ruled that parts of the IAA were unconstitutional largely due to the federal government overstepping the division of powers in the constitution. However nuclear energy falls within federal jurisdiction

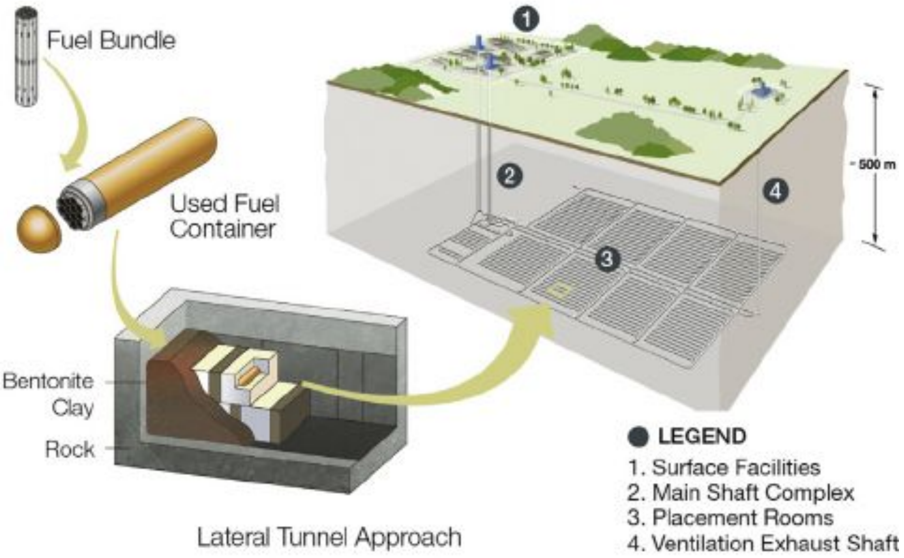
Impact Assessment Act (2)

- After the SCC decision, the IAA began a series of consultations with the nuclear industry focusing on changes to the legislation, project list and process.
- The nuclear industry's primary request was to have nuclear projects removed from the Project List and the Assessment conducted by either the CNSC or through a provincial process.
- The federal government rejected industry's request, but Natural Resources Minister Wilkinson indicated that the federal government was prepared look at changes to processes for SMRs.
- It is not yet clear what the federal government means but industry has made several suggestions:
    - Apply a different approach to "greenfield" sites than "brownfield" sites given the existing baseline data, monitoring programs, management systems, extensive regulatory oversite and past approvals that exist on "brownfield" site
    - Applying a risk-based approach to SMRs recognizing the small risk and acknowledging the safety benefits of new fuels and passive safety systems
    - Focus the scope of Impact Assessment to factors of federal interest and the most important elements of the project
    - Use data from other recognized nuclear regulators (i.e. NRC)
- There appears to be some willingness on the part of the federal government to streamline the regulatory process for second and third of a kind projects provide there are no design changes
- Nuclear projects are subject to other federal regulations including the Fisheries Act, Navigable Waters Act, Species at Risk and CEPA.

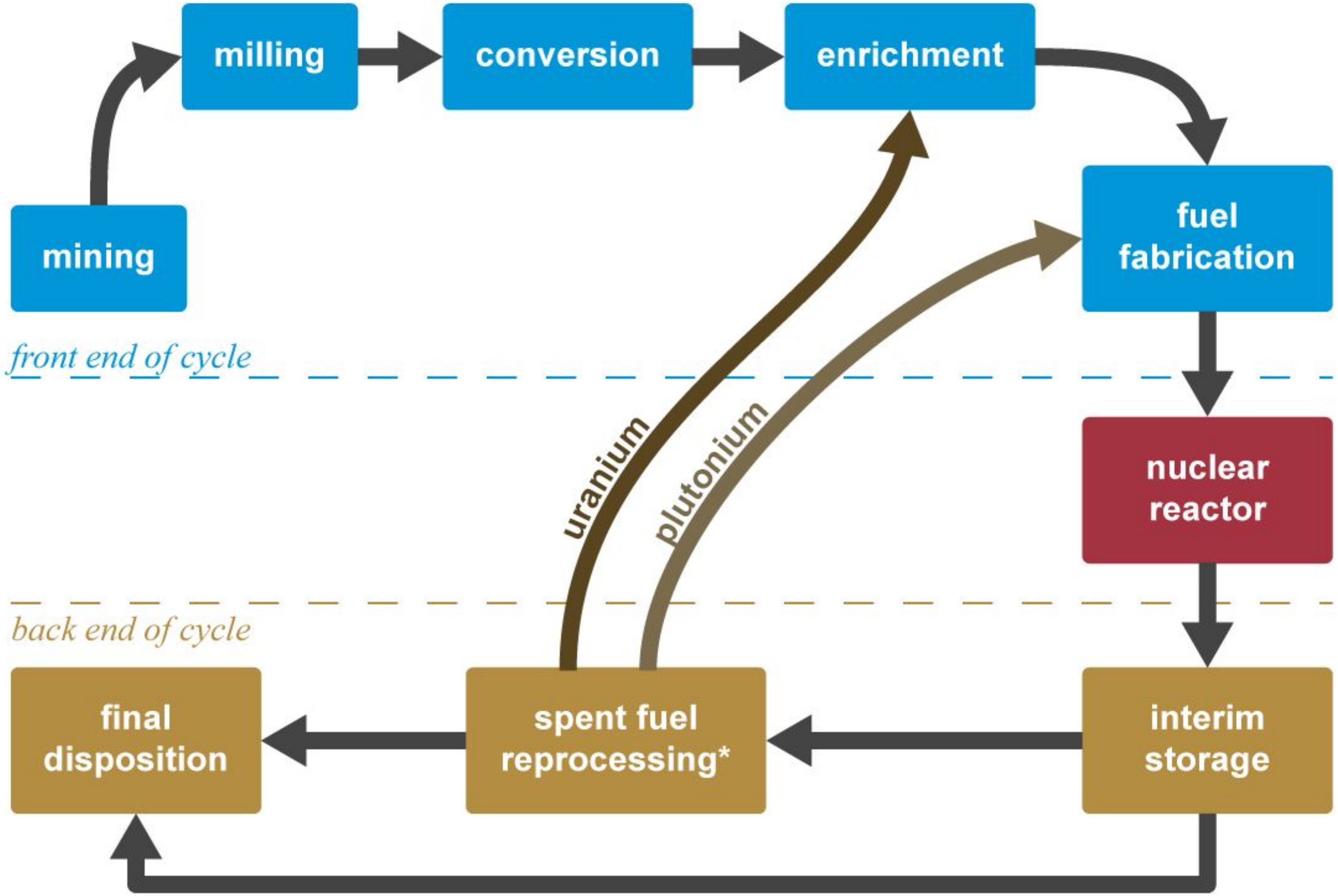
SMR Regulatory Landscape: Alberta

- **Relevant Acts & Regulations**
  - **Alberta Energy**
    - Electric Utilities Act
    - Electricity Statutes Amendment Act
  - **Environment and Parks**
    - Environmental Protection and Enhancement Act (EPEA)
    - Activities Designation Regulation
  - **Regulators**
    - Alberta Utilities Commission
    - Alberta Electric System Operator
- While nuclear power is a federal responsibility, electricity is a provincial responsibility thus requiring the involvement of both jurisdictions. Environmental protection is also a shared jurisdiction.
- The federal and provincial governments need to consider how to harmonize their regulatory policies as much as possible.



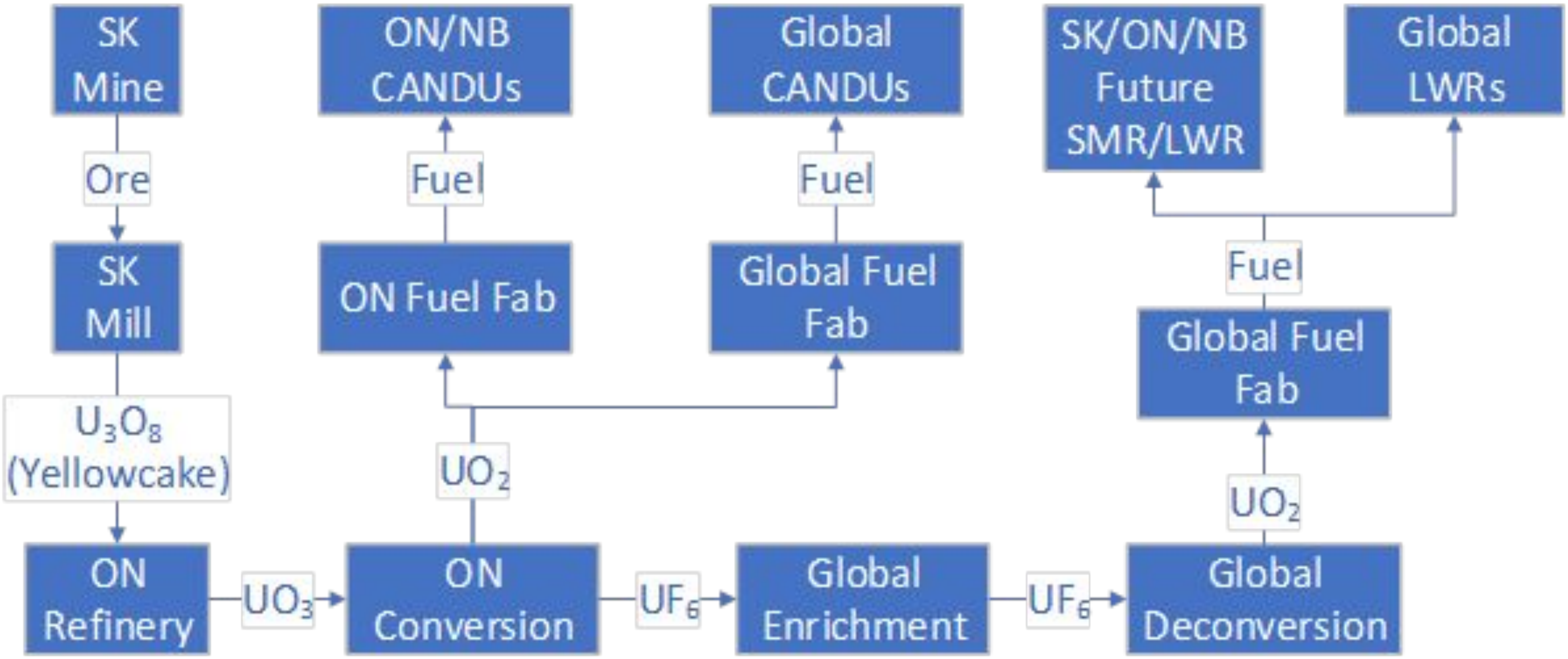


Nuclear fuel cycle



**Spent fuel reprocessing* is omitted from the cycle in most countries, including the United States.

Enrichment and Fabrication



Uranium Mining and Milling

- Canada is the second largest uranium producer in the world. Most Canadian uranium is mined and milled in northern Saskatchewan in the Athabasca Basin region.
- Uranium mining is one of the leading industrial employers of Indigenous people in Canada.
- Canada exports 85% of the uranium it mines adding more than **$1B** to the Canadian economy annually.
- Uranium is very **energy-dense** and a nuclear reactor requires far less fuel than other forms of generation. One 20g uranium pellet produces as much electricity as 400kg of coal, 410L of oil or 350m3 of natural gas.
- Uranium ore is extracted through open-pit mining, underground mining and in-situ recovery. **Saskatchewan has the world's highest-grade uranium deposits with grades more than 100 times higher than the global average.**
- The ore is then crushed in a mill and ground to a fine slurry. The slurry is leached in acid to separate the uranium from the minerals, which is then purified to produce uranium oxide powder.
- The uranium oxide is then sent to Blind River, Ontario (home of Canada's only and the world's largest uranium refining facility). Here a series of chemical processes separate uranium oxide from impurities, producing high-purity uranium trioxide.
- From Blind River, the uranium trioxide is sent to Port Hope where it is converted into uranium dioxide.

Fuel Fabrication - Canada

- Fuel pellets
- Fuel bundle
- Cameco & BWXT

Radioactive Waste – Governance in Canada

- Radioactive Waste and Decommissioning Policy (updated in 2023)
- Nuclear Fuel Waste Act
- CSA standard N292 series of documents
- CNSC regulatory document - Regdoc 2.11 series & 3.3.3

Waste Owner/Generators Responsibilities

- Plan for and set aside necessary funds for decommissioning and management of radioactive waste
- Minimize the generation of radioactive waste,
- Characterize radioactive waste,
- Segregate radioactive waste,
- Classify radioactive waste.
- Handle, volume reduce and temporarily store radioactive waste
- Arrange for safe transport to disposal facility, and ensure waste is appropriately packaged in a certified transport container.

3 Levels of Radioactive Waste

- Low Level
  - requires isolation for only a few hundred years (limited long lived radio-nculides)
  - Examples…. mop heads, rags, etc.
- Intermediate Level
  - Contains long-lived radionuclides in concentrations that require isolation and containment for periods greater than several hundred years
  - Needs no provision, or only limited provision, for heat dissipation
  - Examples … filters, activated components, etc. (most generated during decommissioning)
- High Level
  - generates significant heat via radioactive decay and contains significant quantities of long-lived radionuclides necessitating long-term isolation
  - Example … Used nuclear fuel

Low & Intermediate Level Radioactive Waste

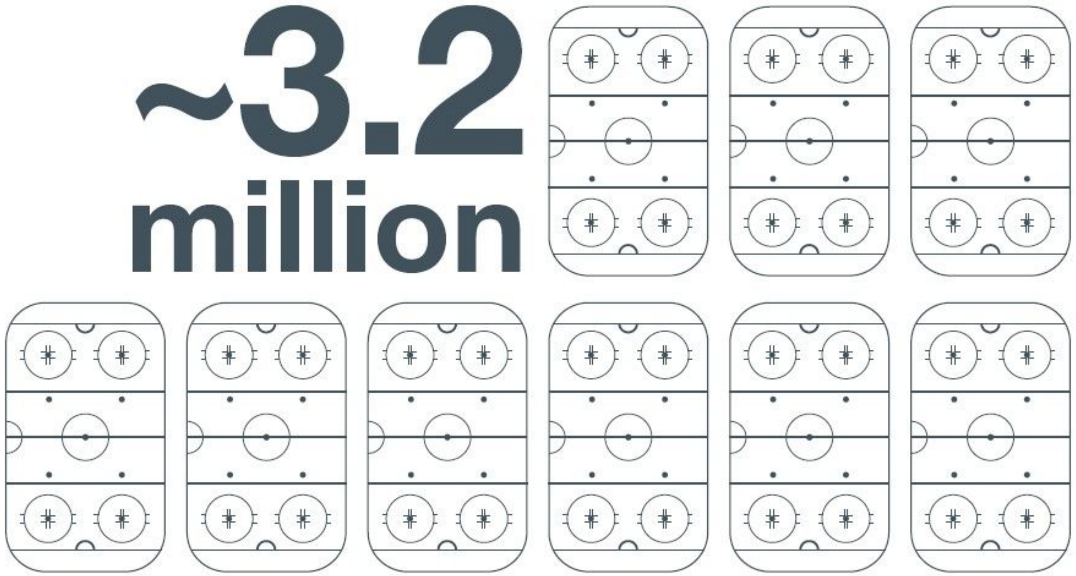
99.5 % of radioactive waste generated in Canada is low and intermediate

- Low
  - Stored in concrete vaults or shielded containers
  - Can be shipped for incineration to reduce volume
  - Long term disposal requires a near surface facility – is the responsibility of Waste owners/generators
- Intermediate
  - Stored in concrete vaults or shielded containers
  - Variety of processing/conditioning processes available to reduce volumes
  - Long term disposal requires a Deep Geological Repository – will be overseen by the Nuclear Waste Management Organization (NWMO)

Radioactive Decay

- The radioactivity of nuclear waste naturally decays and has a finite radiotoxic lifetime; most nuclear waste produced is hazardous for less than fifty years and is routinely disposed of in near-surface facilities, unlike other industrial wastes (e.g., heavy metals), which remain hazardous indefinitely

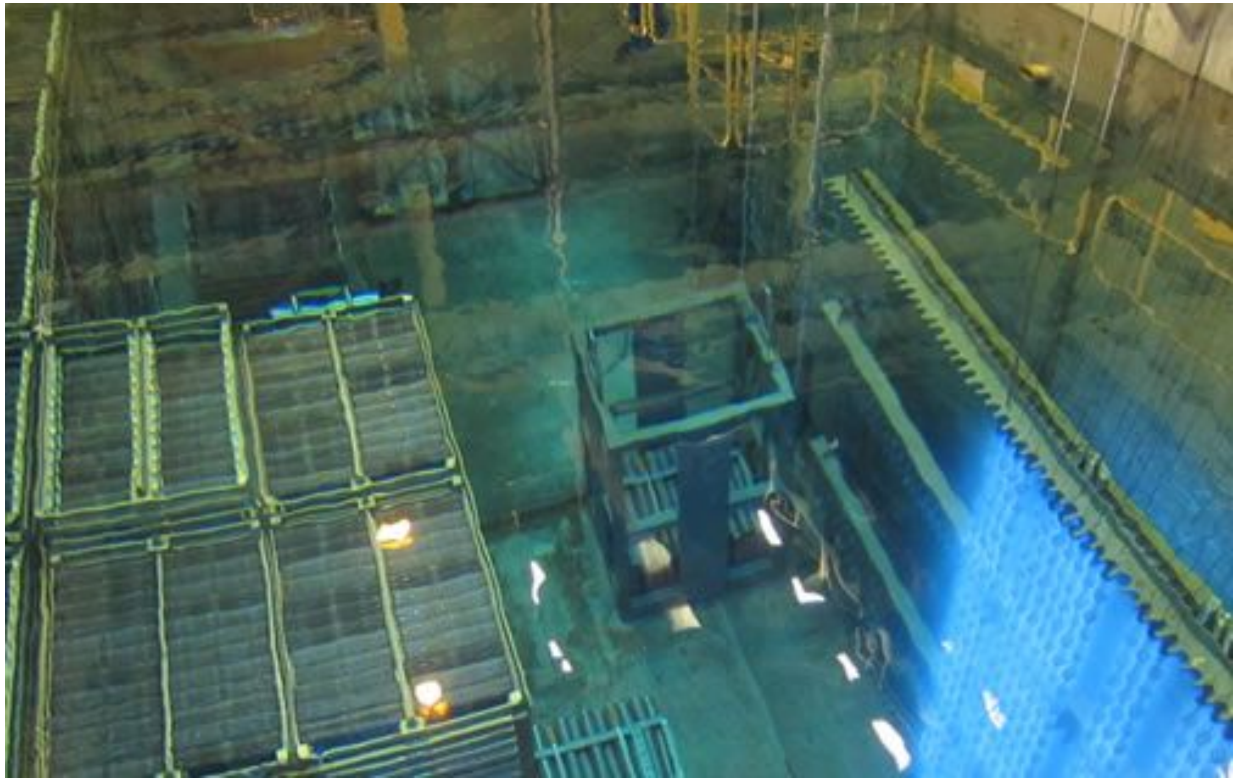
Used Nuclear Fuel



- As of 2022, Canada's inventory was about 3.2 million used nuclear fuel bundles
- If stacked like cord wood would fill 9 hockey rinks up to top of boards
- Currently predict a total of about 5.5 million used fuel bundles

CANDU used Fuel storage – initial cooling

- Bundles resides in core between 6 months and 2 years
- Removed by fuelling machine and stored in cooling bay for 7-10 years
- allows for short term radioactive Decay
- Water serves to cool and provide shielding



CANDU used Fuel storage – dry storage

- Moved to dry storage on-site
- Used fuel will be shipped to the Deep Geological Repository as part of station decommissioning

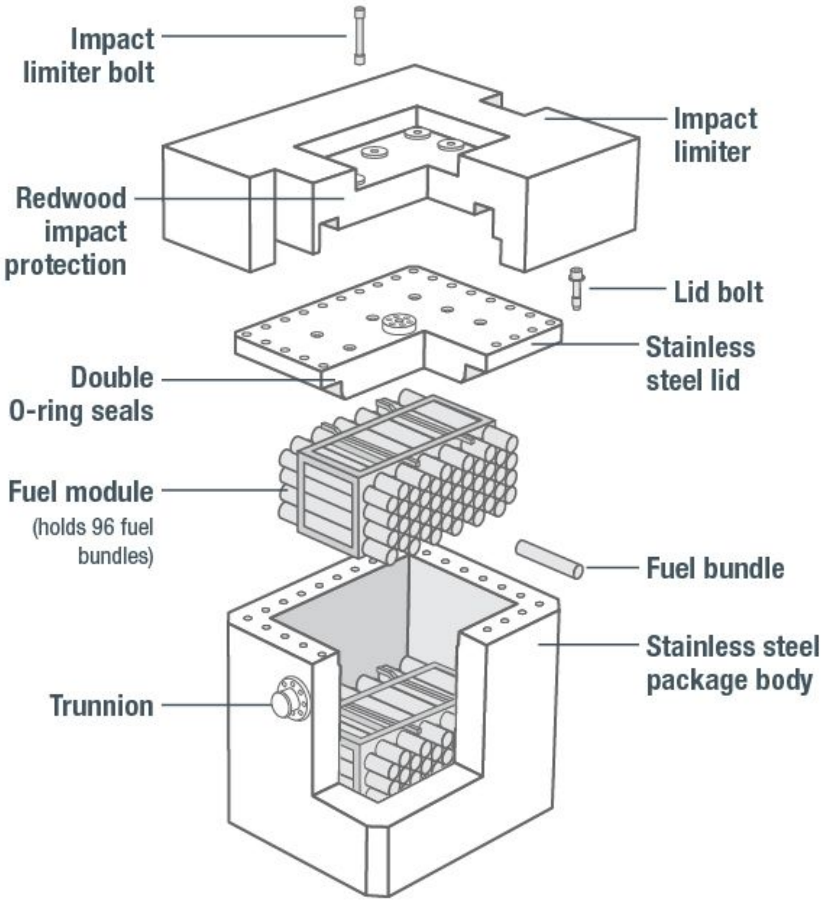
Transportation

Controlled transport process

Transport of dangerous good Act

- A robust, tested and certified transportation package - Extensive testing (drop, puncture, thermal, immersion)
- Licensed qualified shipper
- A Transportation Security Plan
- An Emergency Response Plan

Used Fuel Transport Package - OPG



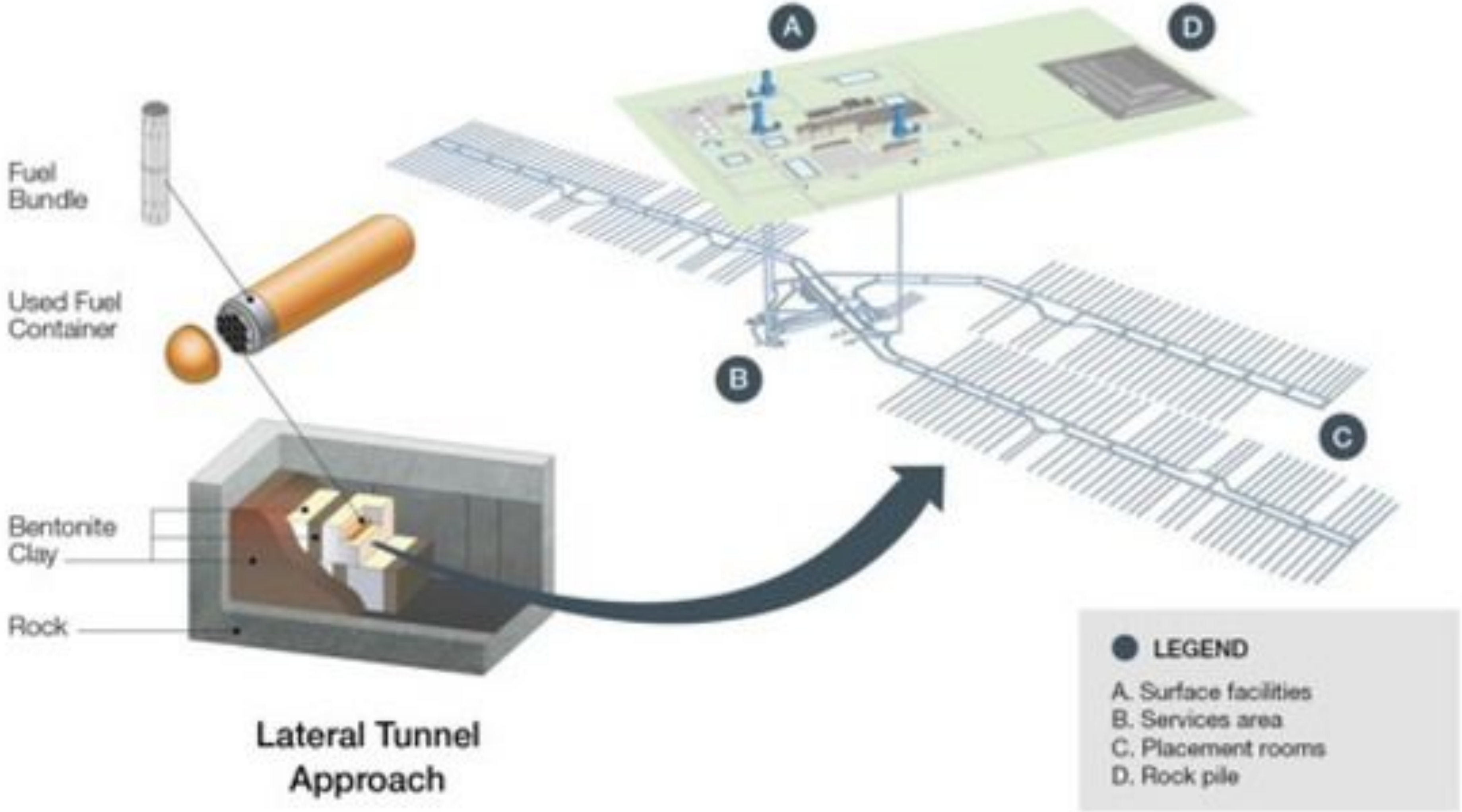
SMR used fuel

- NWMO is responsible for the safe, long- term management of all Canada’s used nuclear fuel, including that created using new or emerging technologies such as SMRs
- Utilities/technology developers will need to work with the NWMO (at their cost) regarding the characteristics of the fuel type to determine the most appropriate disposal method in the DGR
- Used fuel may require conditioning prior to disposal
- Industrial sites interested in SMRs to provide energy may prefer for the proponent to have a regional interim used fuel storage facility located off-site

CANDU used fuel - Disposal

- NWMO responsible for implementing Canada’s plan
- Deep Geologic Repository (DGR) is a scientifically sound solution that is recommended by the IAEA, and safely deployed in other countries.
- Site selection process based on informed and willing host
- In 2010, there were 22 locations that indicated interested locations
- This has been narrowed down to 2 sites in Ontario which are undergoing more extensive evaluations

DGR

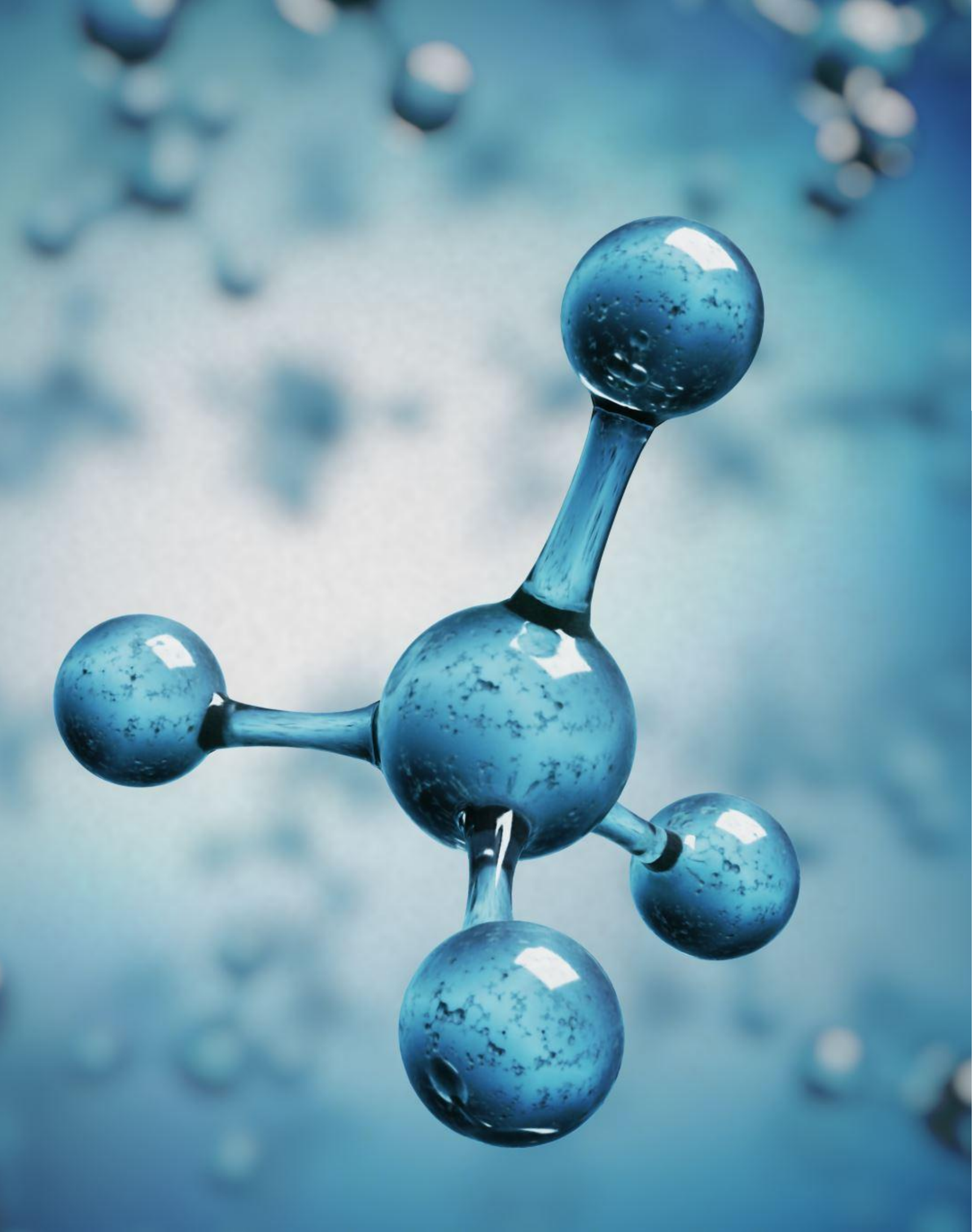

Fuel Bundle
Used Fuel Container
Bentonite Clay
Rock
Lateral Tunnel Approach
A
B
C
D
LEGEND
A. Surface facilities
B. Services area
C. Placement rooms
D. Rock pile

•**Nuclear Medicine**

- Canada is a world leader in nuclear medicine. Bruce Power and OPG are major sources of isotopes which are refined by a well establish nuclear medicine chain.
- Over 10,000 hospitals worldwide use radioisotopes mostly for diagnosis but also for treatment.
- Over 40 million nuclear medicine procedures are performed each year and demand for radioisotopes is increasing by about 5% annually.
- Radiation therapy can be performed either, externally by irradiation or internally by radioisotope.
- The treatments work by delivering radiation to specific areas of the body to destroy cancer cells.

- **Sterilization**

  - The medical industry also uses radioisotopes such as cobalt-60 to sterilize medical equipment such as gloves, gowns, masks, syringes and implants.
  - Over 70% of the world's supply of cobalt-60 is produced at Canadian nuclear reactors.
  - Sterilization by radiation is less expensive than traditional heat sterilization, doesn't cause heat damage and safer because it can be done after the items have been packaged.
  - There was a significant world- wide increase in demand during COVID and the Canadian nuclear industry worked hard to increase its productivity.

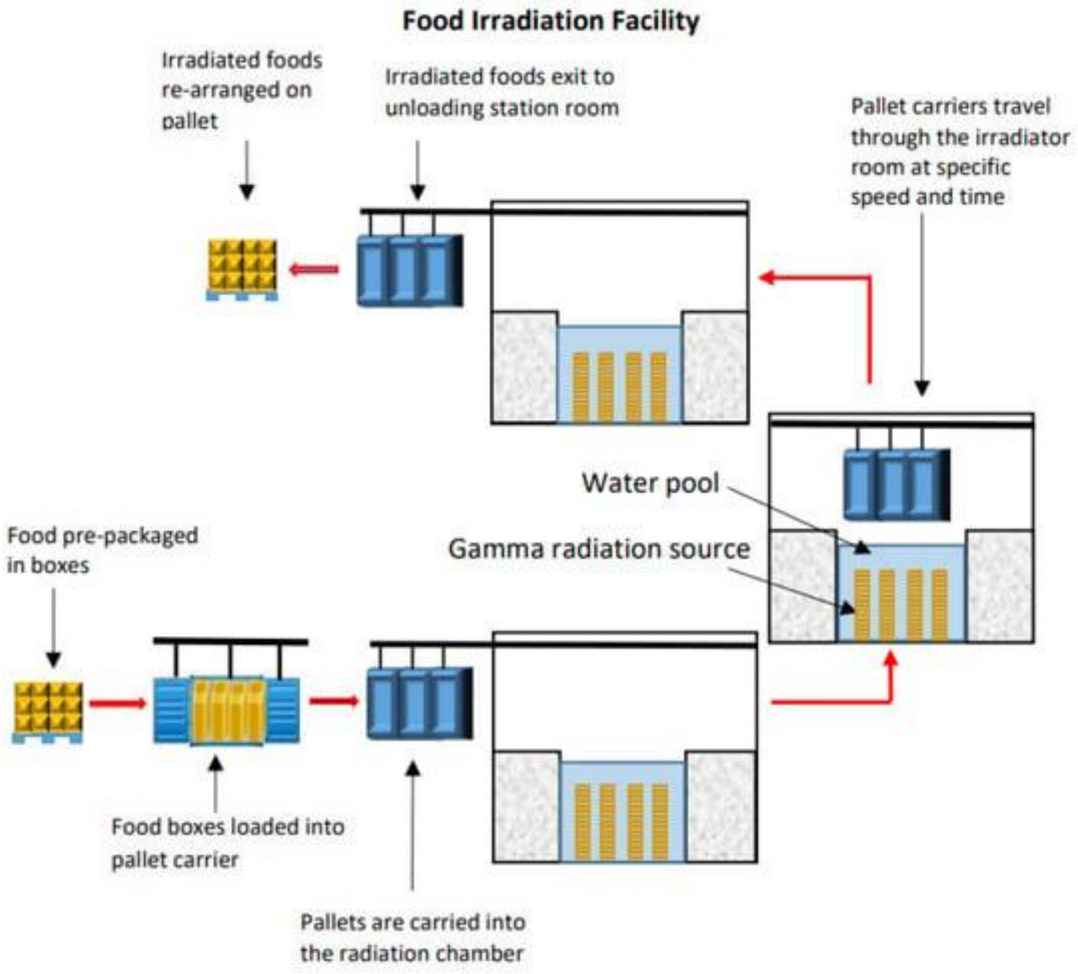


•Hydrogen

- Demand for hydrogen will increase significantly over the next 30 years as the transition to net-zero continues.
- Currently main method of producing hydrogen is by using natural gas but hydrogen can also be produced by electrolyzing water molecules which is less carbon intensive.
- Hydrogen can also be produced by methane pyrolysis which uses heat to strip hydrogen atoms from methane. This method needs high temperature heat which can be produced by advanced reactors.

Food Irradiation

- Food irradiation is the process of using radiation to kill bacteria, insects and parasites that can cause food-borne diseases.
- Food irradiation also extends the shelf-life of food by destroying the mico-organisms that cause spoilage and by slowing the ripening process.
- Like sterilization, the radiation passes through the food and does not cause it to become radioactive.
- More than 55 countries including Canada, irradiate food products such as meat, fruit, vegetables, grains and spices.



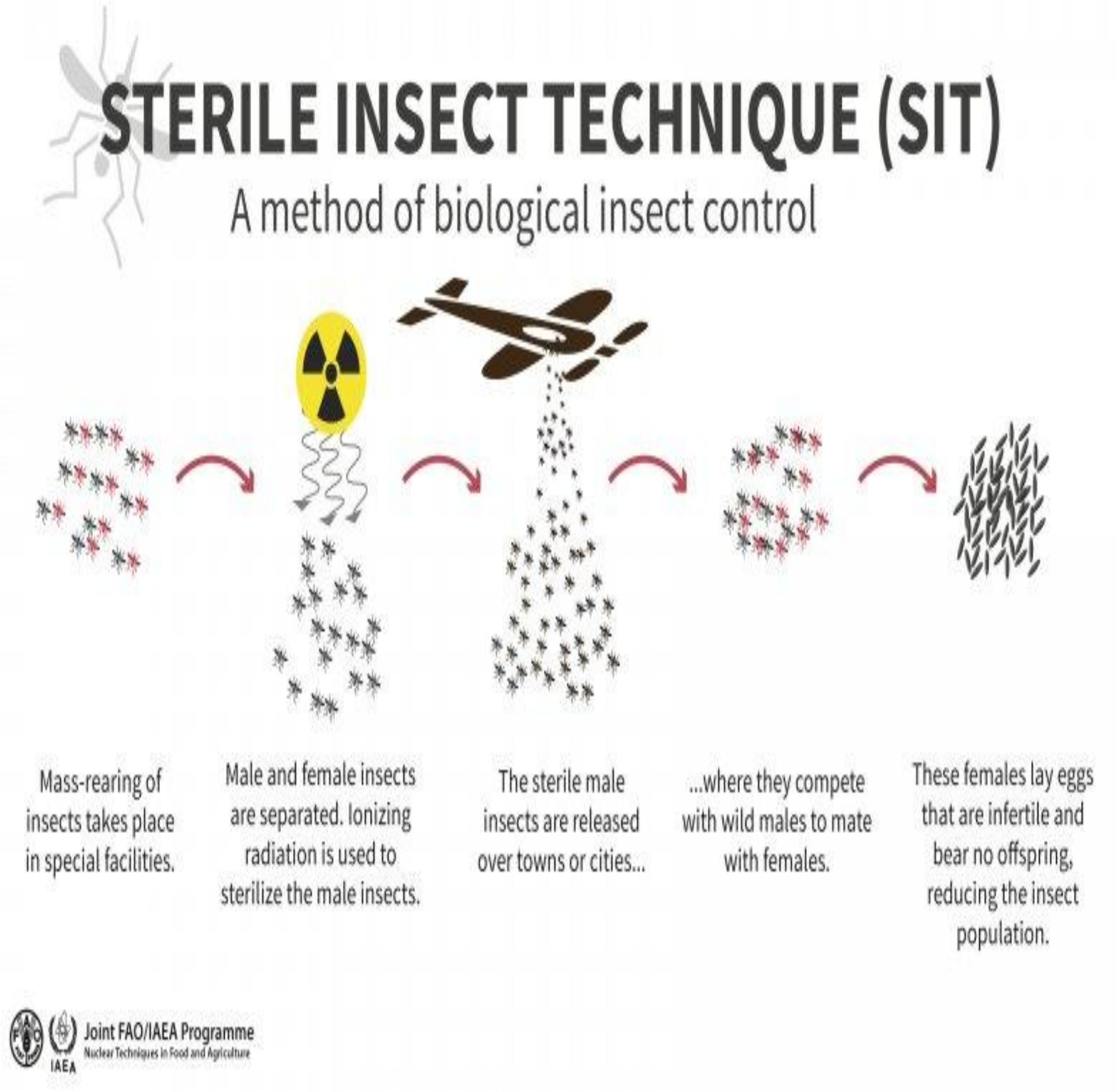
•Agriculture

- Radiation is used to help farmers increase crop production and control pests and diseases.

- Radiation technology allows the creation of new seed varieties that have higher yields, are more nutritional, more adaptable to harsh climates and more resistant to pests.

- Radiation is also used to control insect populations via Sterile insect Technique where male insects are reared and sterilized and then released into the wild where they produce no offspring. This is an environmentally friendly alternative to pesticides.

- One of the most successful SIT programs is the codling moth program in the Okanagan Valley.



Desalination

- Canada is fortunate to have ready access to fresh water but much of the world does not.

- As of 2020. 17,000 desalination plants were operating world-wide, most powered by fossil fuels.

- Nuclear desalinization plants use the heat from SMRs to evaporate water. Leaving the salt and debris behind.

- Only nuclear reactors can deliver the vast amount of energy required for large scale desalinization that will be needed in the future while not emitting greenhouse gases.

Industrial Inspections

- Radioactive materials are used to examine the molecular and macroscopic structure of materials without damaging or changing them. Like x-rays, gamma rays pass through objects and create an image revealing flaws.

- Applications of nuclear images include:
  - Studying aircraft components such as rotors, wings and landing gear.
  - Structure of automotive engines
  - Improving surface structure of medical implants like pacemakers.
  - Analyzing pipes and other oil and gas components to decrease defects.
  - Developing better delivery systems for pharmaceuticals.

Industrial Gauges

- A nuclear gauge uses a radioactive source to quickly detect characteristics of an item like thickness, density or chemical makeup.
- Two types of gauges – fixed and portable
- Fixed gauges are typically used in production facilities to control and monitor product quality.
- Portable gauges are used at work sites to:
  - Analyze walls of holes to identify mineral deposits
  - Search for underground formations that could make a site unstable.
  - Determine density of asphalt in paving to optimize road life.
- Radioisotopes are also used as tracers to study the mixing and flow rates of various liquids and to detect leaks.

Social Acceptance

- Support of First Nations, the local community, and the general public is extremely important
- Essential to earn trust and support based on a commitment to:
    - Ongoing close relationships based on respect
    - Information sharing & open dialogue
    - Active listening, internalizing feedback and acting on feedback
    - Knowing what issues are important to a community
    - Being present and supporting the community
- Trust takes a long time to build and can be lost quickly

- CNSC Regdoc 3.2.1 Public Information & Disclosure
- CNSC Regdoc 3.2.2 Indigenous Engagement

Indigenous Engagement and Inclusion

- Is done above and beyond the legal Duty to Consult
- Key Ingredients
  - Cultural appreciation and understanding
  - Respecting treaties and agreements
  - Building trust (refer to previous slide)
  - Recognizing indigenous peoples longstanding stewardship of the environment
  - Seeking out traditional knowledge
  - Seeking ways to advance on recommendations from Truth & Reconciliation Report
  - Critical to start early in development before things are cast in concrete
  - Actively look for training, employment and partnership opportunities

Engagement can lead to inclusion which can lead to partnerships

Public Engagement

- Community Liaison Committee
- Presentations to organizations & special interest groups
- Open houses
- Webinars
- Information on web site
- Participate/support community events

Public Opinion

- CNA has been conducting polling for several decades. Support ebbs and flows depending on events (i.e. up after 2003 blackout / down after Fukushima) but has been increasing in recent years.
- Data shows the more people know about nuclear energy, the more they support it. Strongest support in communities around nuclear facilities.
- CNA's most recent poll: Environics Nov 17-Dec 4, 2023 (2726 people)
  - Overall support for nuclear energy: (national number weighted)

Region	Participants	Support	Oppose	Not Sure
National	2726	47	40	13
Saskatchewan	411	58	29	13
Ontario	599	57	30	13
New Brunswick	151	50	33	17
Alberta	402	49	40	11
British Columbia	375	45	40	15
Nova Scotia	129	45	39	16
Manitoba	153	41	40	19
PEI/NFLD	54	33	41	26
Quebec	452	31	57	12

- Highest recall of new nuclear projects – Saskatchewan, Ontario, New Brunswick

Public Opinion – (National – weighted)

- Support for new nuclear plants
  - Strong 19% } 50
  - Somewhat 31% }
  - Somewhat oppose 19% \
  - Oppose 17% \ 36
  - Unsure 13%
- Support for SMRs
  - Strong 18% } 55
  - Somewhat 37% }
  - Somewhat oppose 10% \
  - Oppose 6% \ 16
  - Unsure 29%
- Role for nuclear in achieving net zero
  - Major role 35%
  - Minor role 31%
  - No role 18%
  - Unsure 16%
- Leading Concern

Leading Concern	Extremely	Definitely	Somewhat	Not Concerned
Possible Accident	41%	23%	20%	17%
Storage of waste	39%	27%	24%	11%
Environmental impact	29%	26%	26%	19%
Cost	28%	30%	28%	14%
Time to Build	18%	28%	34%	21%

Questions

Conclusion

- Nuclear Power Plants are:
  - Provides reliable, cost-effective, low GHG emitting, baseload electricity (energy)
  - Excellent safety record
  - Strong commitment to Indigenous and public relationships
  - Highly regulated by a well-respected world class regulator
  - Financial guarantees established to cover decommissioning and waste management/disposal
  - Safe and responsible management of wastes
  - High standards for design, materials, construction, commissioning, operation & maintenance and decommissioning
  - Design based on defense in depth using redundancy, diversity and separation
  - Designed to withstand a wide variety of accidents both internal and external
  - Analysis backed up by extensive R&D

Limitations

- This was a very high-level overview and could only scratch the surface of those topics presented
- Due to time limitations, we were not able to cover topics such as:
  - Nuclear Safety
  - Security
  - Safeguards
  - Emergency Planning

Thank you

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