Gmail

Susan O'Donnell <susanodo.ca@gmail.com>

A-2022-00098 / NB - CNSC Access to Information Request - Response

1 message

Dubuc, Philip <Philip.Dubuc@cnsc-ccsn.gc.ca> 30 August 2023 at 12:11
To:
Cc: "Belanger, Nancy" <nancy.belanger@cnsc-ccsn.gc.ca>

Dear Susan O'Donnell,

This is in response to your request under the Access to Information Act for:

> ***"Please provide all communications received by the President, any of the Vice-Presidents, the Executive Advisor, the Commission Secretary, and the Office of Audit, Evaluation and Ethics with respect to the "recycling" or "reprocessing" of nuclear fuel waste (irradiated nuclear fuel, spent fuel, CANDU fuel) including as may be undertaken in conjunction with nuclear research or small modular reactors generated between May 31, 2000 and December 31, 2022. Please include those communications generated within the CNSC and those received from federal departments, regulatory bodies and contracted entities, including but not limited to Natural Resources Canada, Atomic Energy Canada Limited and Canadian Nuclear Laboratories, and any private sector entity or agent including but not limited to the Canadian Nuclear Society, Canadian Nuclear Association, CANDU Owners Group or others.*** "

Please find all the accessible records you requested attached. The exemption provisions s.13(1), 19(1), 21(1)(a), 21(1)(b), 69(1)(e), and 69(1)(g) of the Act have been applied to the package (outlined below):

13(1)	information obtained in confidence
19(1)	personal information
21(1)(a)	advice or recommendations
21(1)(b)	consultations or deliberations
69(1)(e)	briefings to Ministers on Council matters, or discussions referred to in (d)
69(1)(g)	any records making a reference to (a) to (f)

Please refer to the following website to view these provisions: https://laws-lois.justice.gc.ca/eng/acts/a-1/

You have the right to file a complaint with the Information Commissioner of Canada about this aspect of the processing of your request for a period of 60 days following the receipt of this notice. The address is:

30 Victoria Street
Gatineau, Québec
K1A 1H3

Or online at: https://www.oic-ci.gc.ca/en/submitting-complaint

Should you have any questions regarding this request, please contact Nancy Belanger at nancy.belanger@cnsc-ccsn.gc.ca.

Sincerely,

Philip Dubuc

ATIP Coordinator/ Coordinateur AIPRP

Access to Information and Privacy /

Accès à l'information et protection d'information personnel

Canadian Nuclear Safety Commission /

Commission canadienne de sûreté nucléaire

CANDU Advantages in Recycling the Recovered Uranium from Spent LWR Fuels

Briefing on Processing and Reprocessing Facilities
Directorate of Assessment and Analysis
November 25, 2014
eDoc: 4581797

nuclearsafety.gc.ca

Objective

- The President asked :
  - on 2014/11/10: I would like to have a technical briefing session on why is CANDU such a good reactor for recycling fuel and all other reactor are not, after learning the news on “Candu Energy sees promising future to develop reactors that burn recycled uranium”.

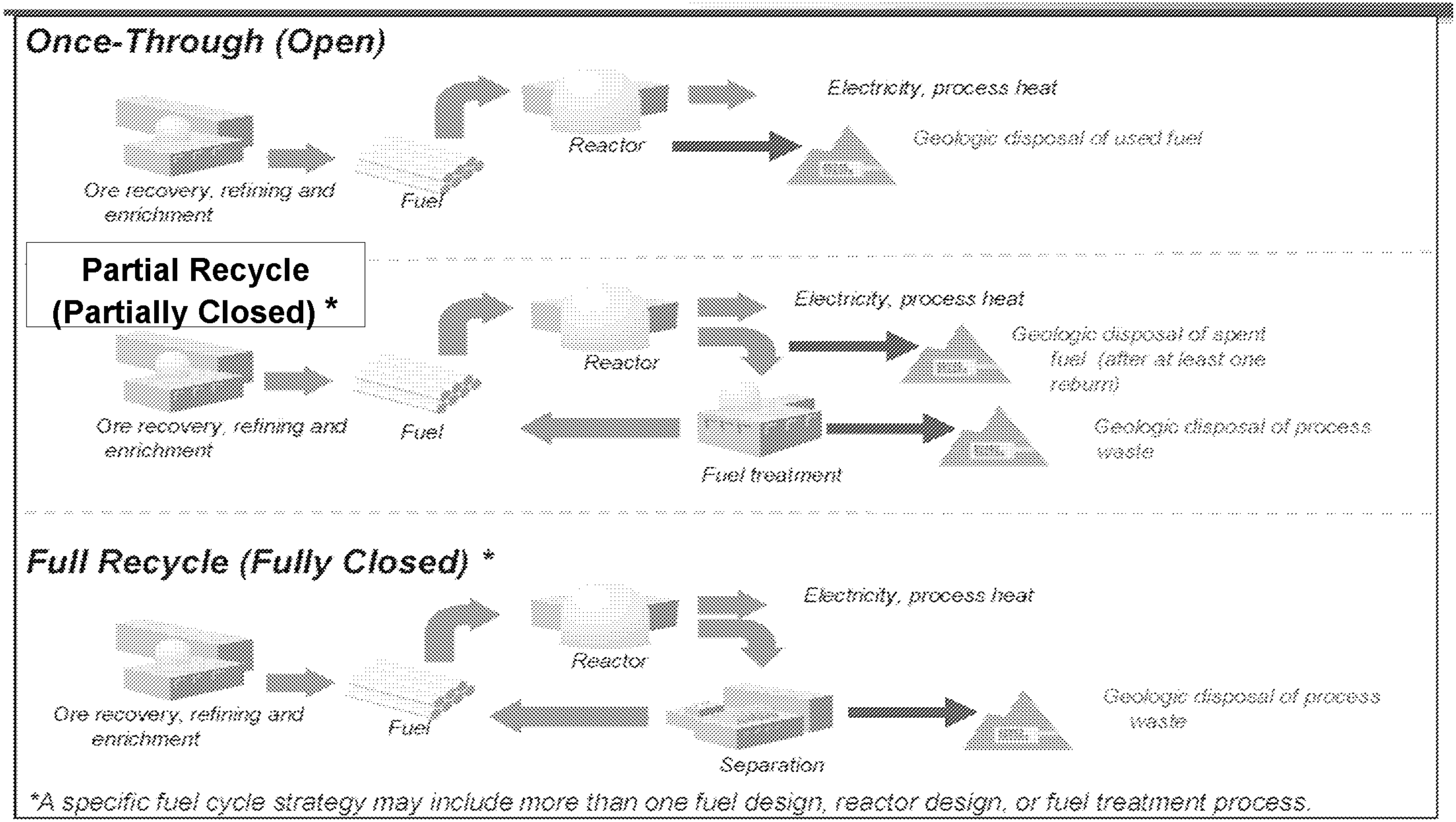
Acronym

- SNF: Spent Nuclear Fuel
- HLW: High-Level Waste
- FP: Fission Products
- MA: Minor Actinides (Np, Am, Cm, etc.)
- TRU: TRansUranic (Pu + MA)
- NU: Natural Uranium
- LEU: Lightly Enriched Uranium
- MOX: (U/Pu) Mixed OXides
- RU: Recovered Uranium (or Recycled Uranium)
- DU: Depleted Uranium
- NUE: Natural Uranium Equivalent
- DRU: Direct use of Recovered (Recycled) Uranium
- AFCR: Advanced Fuel CANDU Reactor

Outline

- Nuclear fuel cycle options and corresponding SNF management strategies
- CANDU fuel cycle advantages and various fuel options
- NUE and AFCR Project - CANDU's role on China's partially closed fuel cycle option
- Why Canada currently uses open fuel cycle without reprocessing?
- Technical Annex
  - Overview of Nuclear Fuel Cycle
  - Reprocessing of SNF for partial recycle
  - Transmutation of SNF for full recycle
  - Overview of NUE and AFCR

Nuclear Fuel Cycle Options

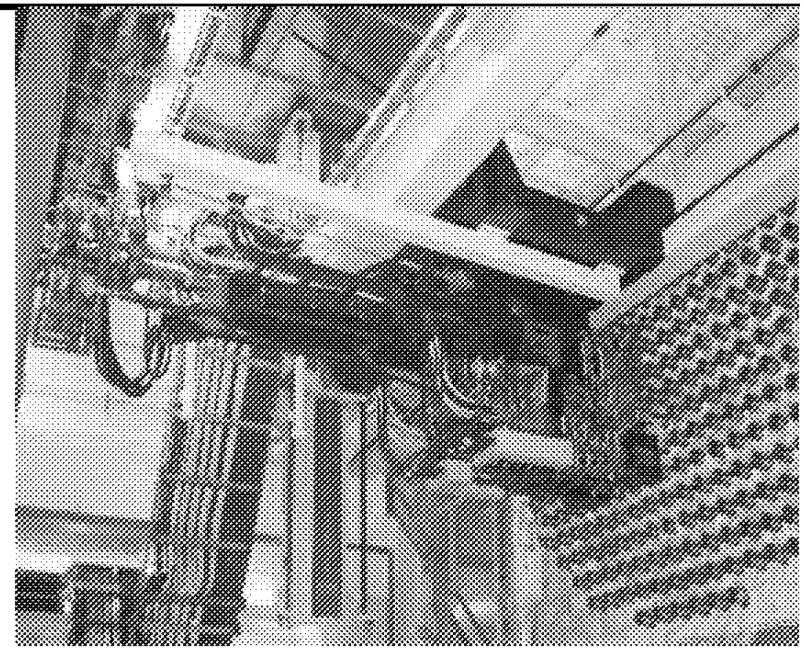


Corresponding SNF Management Strategies

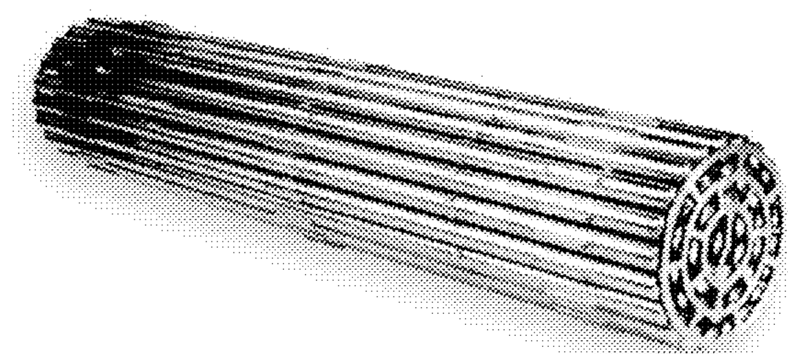
- <u>Open (once-through) fuel cycle - w/o Reprocessing of SNF</u>
  - Interim storage of SNF (Wet & Dry storages) to allow for heat reduction, then
  - Direct disposal of SNF as a waste: permanent deep geological repository
  - SNF management simply refers to radioactive waste management
- <u>Partially closed (partial recycle) fuel cycle - Reprocessing of SNF</u>
  - SNF is reprocessed, some fraction of the actinide materials (U & Pu) are recovered for recycling
  - The reprocessing waste (FPs, MAs, etc.) is typically vitrified
  - **Example:** LWR, CANDU or FR to recycle recovered U/Pu
- <u>Fully closed (full recycle) fuel cycle - Transmutation of SNF</u>
  - SNF is reprocessed and separated into re-useable and waste materials
  - All actinides are recycled multiple times in transmutation-dedicated reactors, and residual waste will go to a geological repository
  - **Example:** LWR or CANDU to recycle recovered U/Pu, FR to transmute TRU
- The need for a repository is never eliminated with Reprocessing or Transmutation.

CANDU Inherent Fuel Cycle Advantages

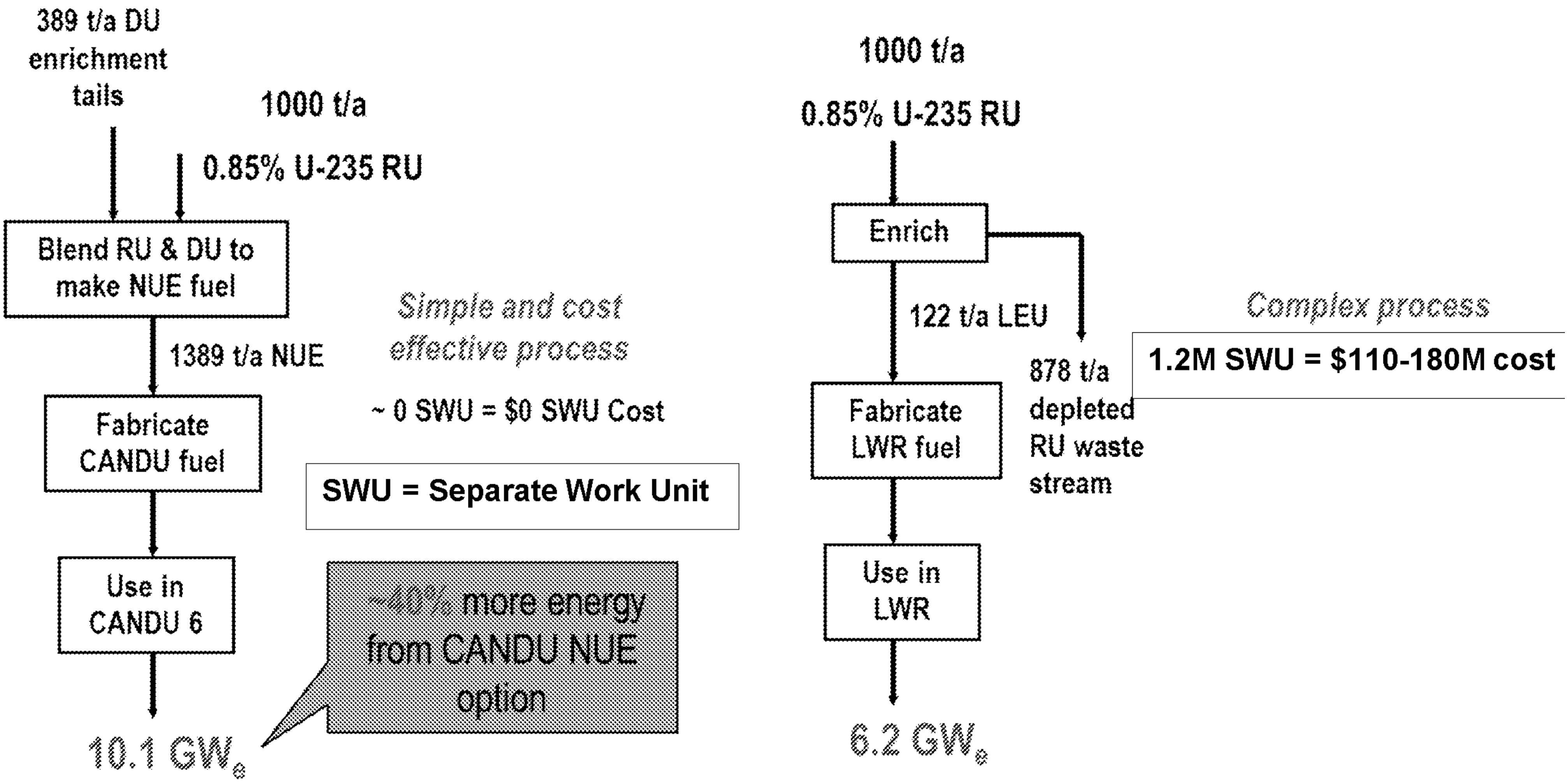
- Heavy-water moderator
  - The lowest uranium consumption and high neutron economy
  - Enable use of low-fissile materials as well as other fuel options (see next slide)
- Fuel channel design with on-power fuelling
  - Ability to position different fuels in different regions
  - Minimal excess reactivity via refuelling scheme
  - Minimal parasitic materials
  - Smoother transition from one type of fuel to another
  - Minimal changes in reactor design
- Simple and small fuel bundle design
  - Ease of fabrication, transportation, and fuelling
  - Flux detectors ensure local power distribution



On-line fuelling



What Can Utilities Do With 1,000 t/a of (RU)?



CANDU option is cheaper & more energy efficient

CANDU Fuel Options

- CANDU design is very flexible and allows use of:
  - Uranium fuel cycle
    - Use of NU: 0.7% U235 and 99.3% U238 - Current CANDUs
    - Use of LEU: 2-5% U235 – ACR design
    - Use of reprocessed fuel (from used LWR fuel) without enrichment
      - NUE : mixture of RU and DU – NUE Project for China
      - RU: U235 (~0.9%), U238, and other impurities U232, U234, U236 – AFCR with DRU for China
      - MOX : Pu + uranium – CANMOX Project for UK
      - DUPIC: no chemical separation of used fuel
      - Other (such as actinide burning)
  - Thorium fuel cycle
    - Use of LEU/Th: Th232 +neutron ⟹ U233 (fissile) – AFCR with LEU/Th for China
    - Use of Pu/Th

CANDU and PWR Synergism

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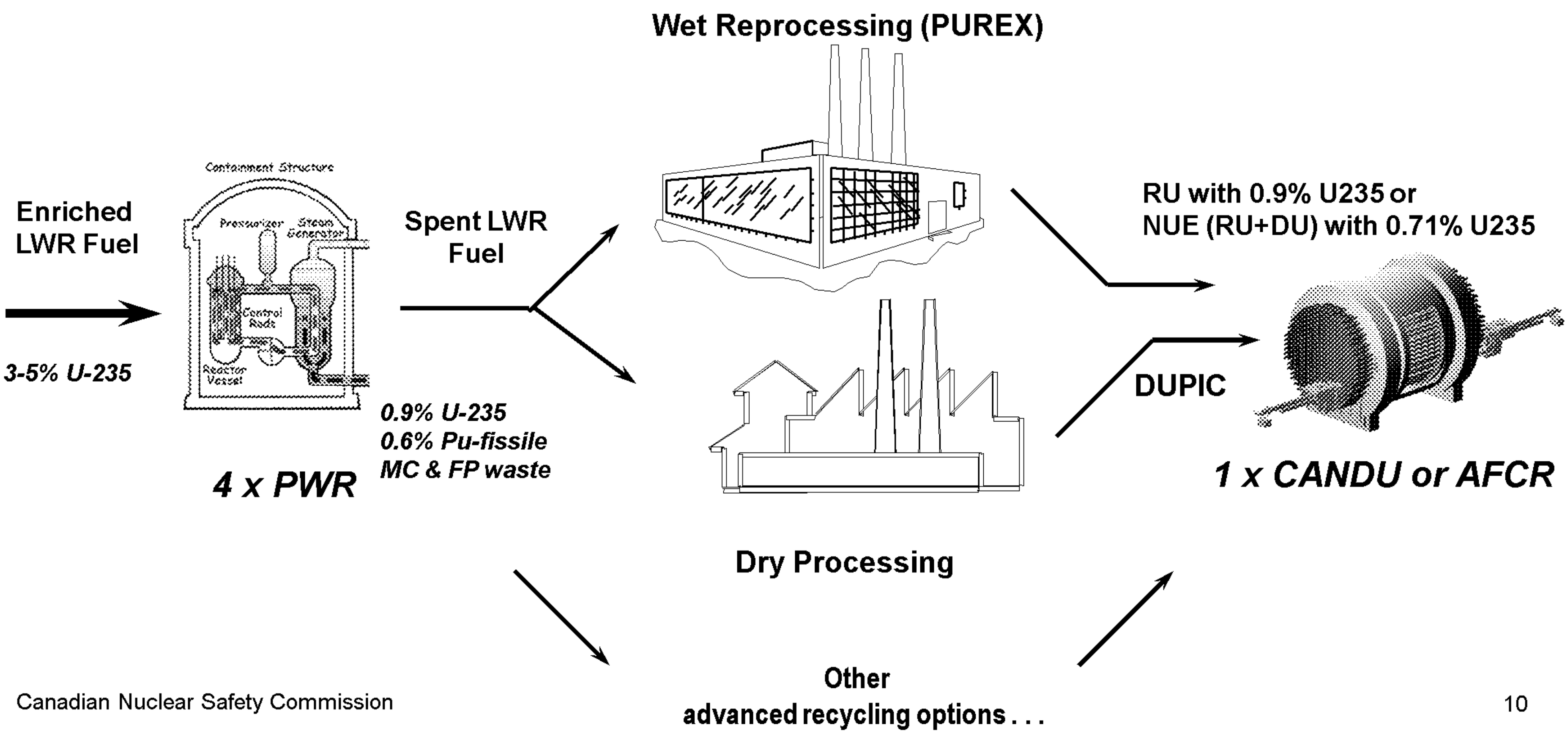
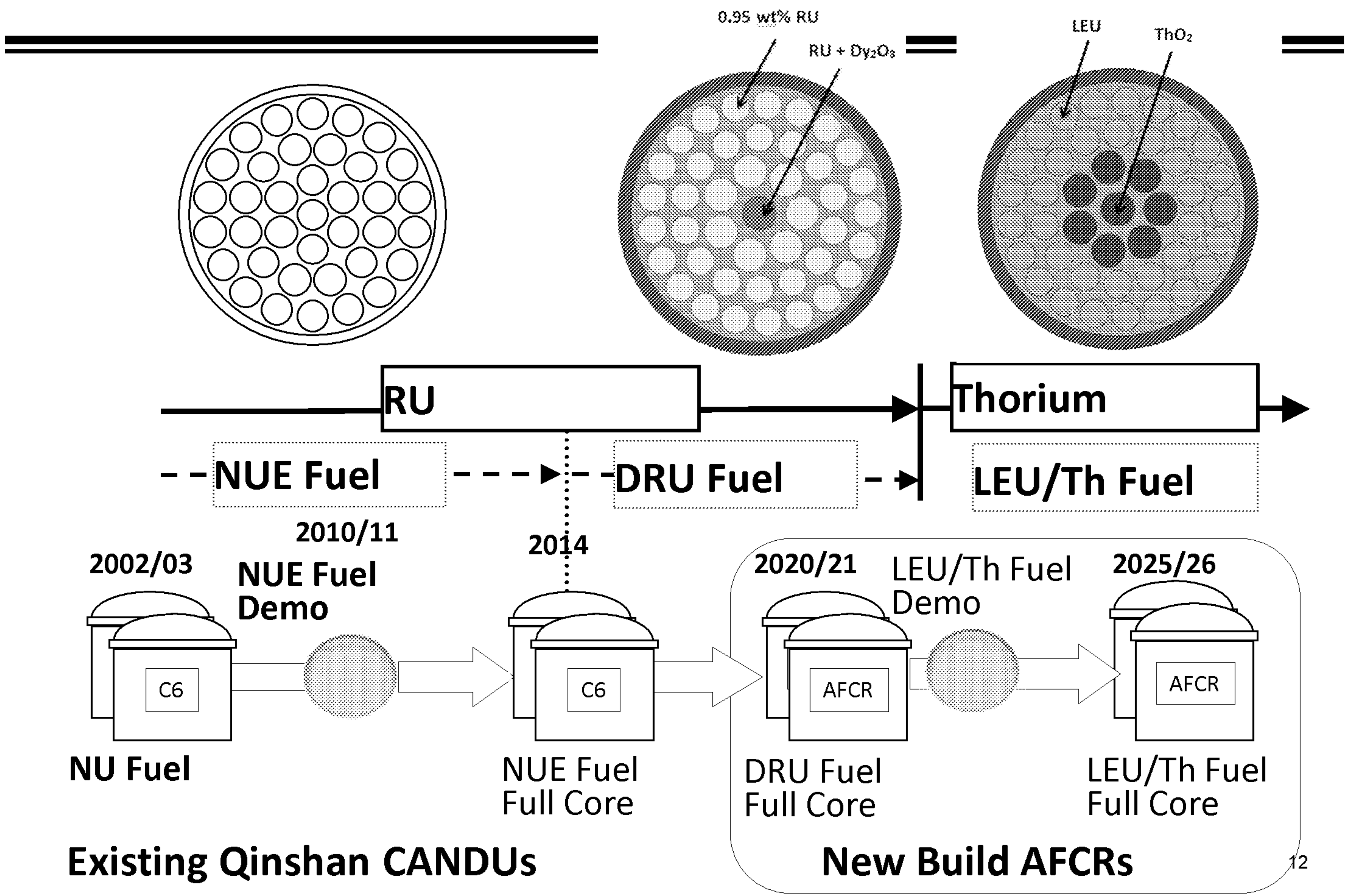
- CANDU design is very flexible and offers many options for exploiting the CANDU and PLWR synergism.
- These can be introduced into CANDU with few or no hardware changes, when the option becomes attractive.



AFCR

- Gen III design based on proven C6 and EC6 design with fuel and fuel-related changes plus further safety enhancements
  1. AFCR forms synergy with China's PWR, FR, and reprocessing plant program
     - Designed with minor changes to use DRU in the beginning and to use LEU/Th later on as per customer timelines (see next slide)
     - Uses the 43-element CANFLEX fuel bundle
     - Increased fuel burnup: 10 GWd/tHE (DRU); 20 GWd/tHE (LEU/Th)
     - Fuel 1 AFCR with RU from 4 typical PWRs
     - Reserve plutonium for use in FR
  2. AFCR provides a development platform to utilize thorium-based fuels
     - Utilize China's thorium for environmental protection and new resource development
     - Save natural uranium resources
  3. AFCR continues to produce Cobalt and other isotopes as by-products

Roadmap of NUE and AFCR Project



Technical Considerations of NUE and AFCR

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- NUE
  - Technical considerations for NU CANDU
  - Fuel/Core Performance due to the fuel heterogeneity and Impurities
  - Radiation Protection due to the daughter products of ^{232}U
    - Fuel Manufacturing
    - Station Fuel Handling & Impact on Reactor Systems
  - Safety Evaluation (e.g., Loss of Reactivity Control)
- AFCR with DRU
  - Technical considerations for NUE
  - Fuel performance with the Dyprosium poison in the center element
  - CANFLEX fuel carrier
  - Enrichment
  - Fuel performance with higher burnup
- AFCR with LEU/Th
  - Technical considerations for NUE
  - see technical annex

Thorium Fuel Cycles - Challenges

- No fissile isotope in natural thorium, need enriched uranium or MOX fuel to serve as a driver fuel to "breeder" Th232 to U233.
- Cost of reprocessing and re-fabrication is higher
- Limited database and know-how experience.
- Lack of qualified physics, fuel, and thermal-hydraulic codes.
- Fuel and fuel fabrication
  - Lack of experience in fabricating fuel bundle in industrial scale
  - Fabrication becomes difficult due to the hard gamma ray
- Safety aspect
  - less shutdown margin, higher decay heat, and
  - faster reactivity transient due to smaller delayed neutron fraction
- Back end issues and challenges
  - Criticality safety, transportation safety, and
  - Radiation protection

NUE and AFCR Accomplishments to Date

- The NUE/AFCR concept design started about 2005
- NUE
  - 2010: The NUE Full Core Implementation project approved.
  - 2011 March: 24 NUE bundles discharged from the Qinshan unit after 1-year irradiation demonstration test.
  - 2012/10 – 2013/10: RU secured, purchased and delivered.
  - 2013/10: started to modify the fuel production line.
- AFCR
  - 2009 Nov. 5-6: Expert Panel Meeting on engineering feasibility & practicality of Thorium-fuelled CANDU reactor in China.
  - 2014 August: 26-month CNNC & CE joint Project on AFCR completed.
  - 2014 Nov. 5: The AFCR Expert Panel review meeting in China.
  - 2014 Nov. 8: Witnessed by Canadian and Chinese Prime Ministers, CNNC and CE signed a framework agreement for establishing a joint venture for the development and deployment of AFCR.

CANDU's Role on China's Partially Closed Fuel Cycle Option

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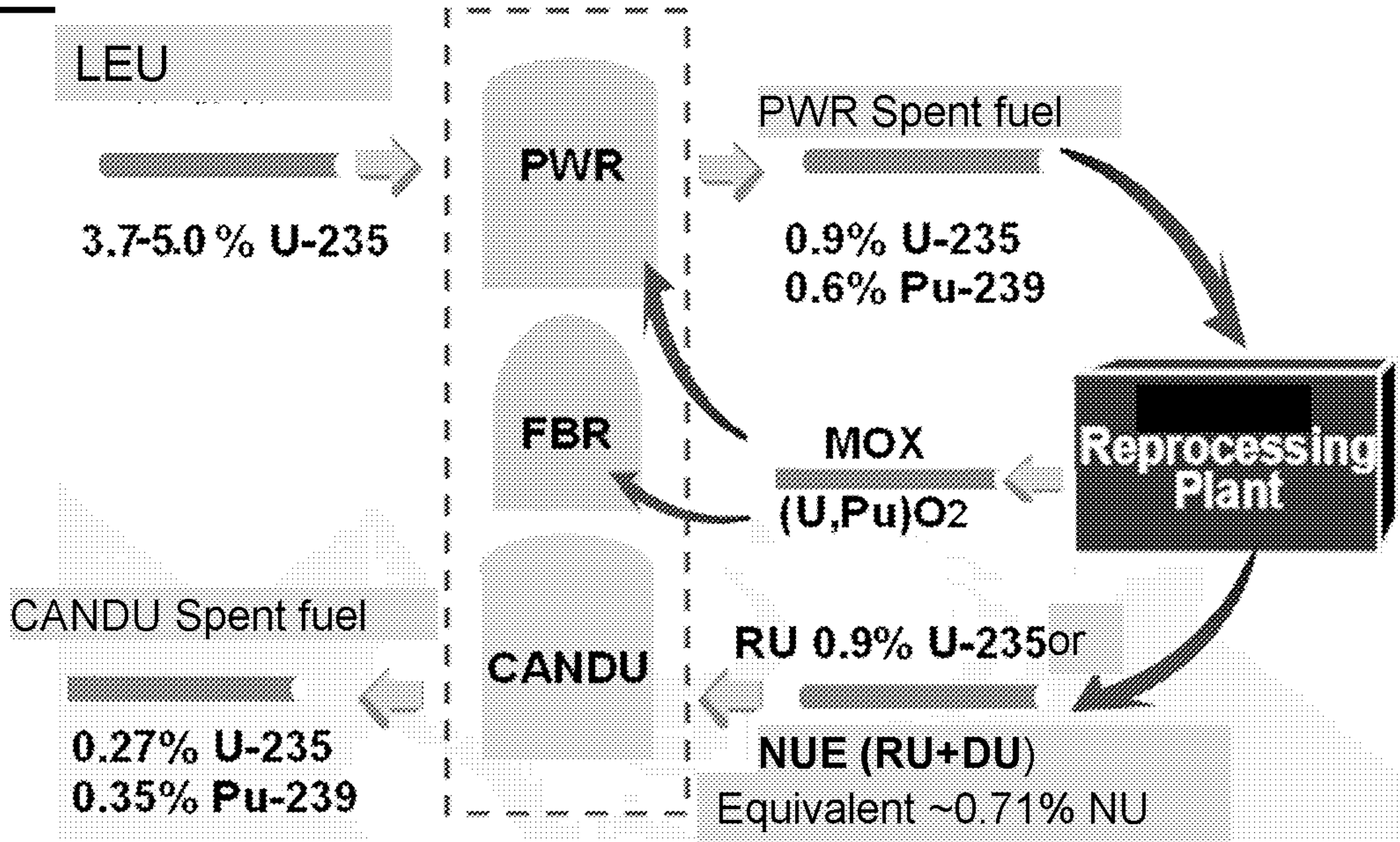

- CANDU/AFCR is unique in bringing the RU from PWR back into the fuel cycle in an economic and efficient manner without enrichment.
- CANDU/AFCR offers a development platform to utilize thorium fuels and to save natural uranium resources.

Why Canada Currently Uses Open Fuel Cycle without Reprocessing?

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- Uranium is plentiful in Canada
- Geological repository space is not limited in Canada
- Canadian Policy regarding non-proliferation assumes no enrichment or reprocessing in Canada
- Technology and Facility are lacking
  - No commercial SNF reprocessing facility, enrichment facility, or MOX fuel fabrication facility; No other type of commercial reactors
- High cost of reprocessing
  - Reprocessing is expensive.
  - Little fissile materials left over in the spent CANDU fuel:
    - 0.2-0.3% U-235 and 0.3-0.4% Pu-239 in spent CANDU fuel
    - 0.9% U-235 and 0.6% Pu-239 in spent LWR fuel
  - No economic reason to recover U-235 from spent CANDU fuel
    - million tons of enrichment tailings with 0.2-0.3% U-235
  - In the future;some countries may consider reprocessing to allow: Recovery of fissile Pu239, deduction of HLW, conversion of fertile U238 to fissile Pu239 with FRs

Thank you