Fusion Energy Council of Canada

Conseil canadien de l'énergie de fusion

Fusion Energy for Canada: Issues Beyond the Science Core

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Outline

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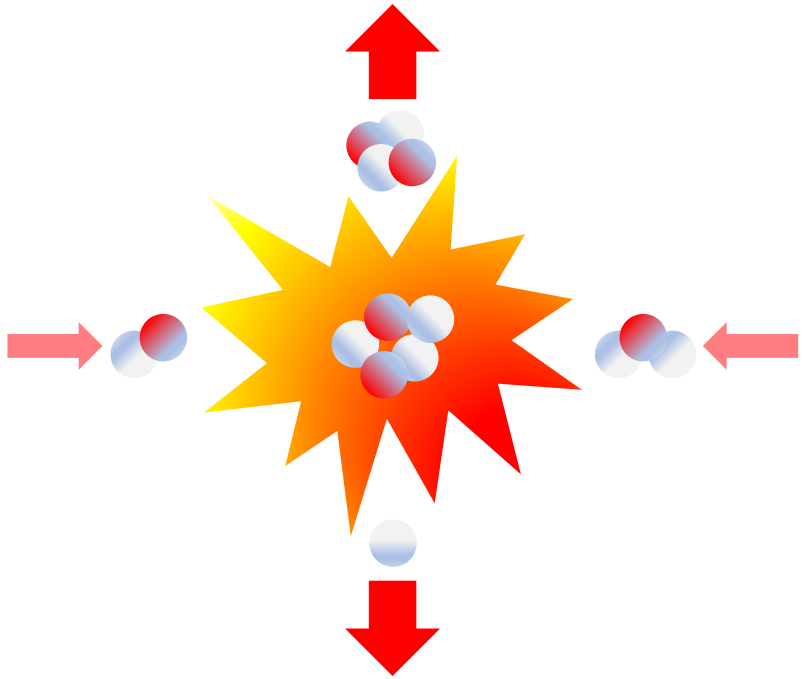
2. Fusion Reactor Feed Materials
   - Deuterium, Tritium, Lithium
3. Fusion Plant
   - Reagent Recovery and Recycling
   - Tritium Breeding
4. Fusion Electricity Uses
5. Engagements
6. Actions



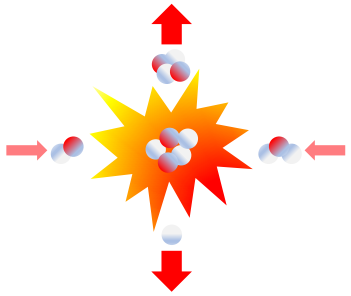
1. Goals for Nuclear Fusion Energy Production

- ***Aspirational*** **Economic Goals**
  - **Levelized Cost of Electricity: 1 to 5 ¢/kW h (10 to 50 $/MW h)**
  - **Capital Cost: 1 $ billion for 1 GW_e plants**

- **Sustainability Goals**
  - **Low Life Cycle GHG emissions**
  - **Minimal wastes, including radioactive by-products & wastes**

- **Regulatory and Community Acceptance Goals**

1. Background



Fusion	^{2}H	+	^{3}H	→	^{4}He	+	^{1}n	17.5 MeV
Breeding	^{1}n	+	^{6}Li	→	^{4}He	+	^{3}H	4.8 MeV
Overall	^{2}H	+	^{6}Li	→	2 ^{4}He			22.3 MeV

Feedstock requirements (kg/year) for a 1 GW fusion plant

	Theoretical (Thermal)	Practical (Electricity)
Deuterium, ^{2}H	30	90
Lithium, ^{6}Li	90	270
Tritium, ^{3}H	?	?

2. Fusion Reactor Feed Materials: Deuterium (^2H)

International Trade (2019) in Deuterium Oxide (tonnes)

	Export	Import
USA	184	93
Canada	123	-
European Union	21	15
Switzerland	-	12

Heavy water (deuterium oxide) exports by country |2019 (worldbank.org)

Source: Fresh or Seawater

Technologies: Proven

Tiverton, ON

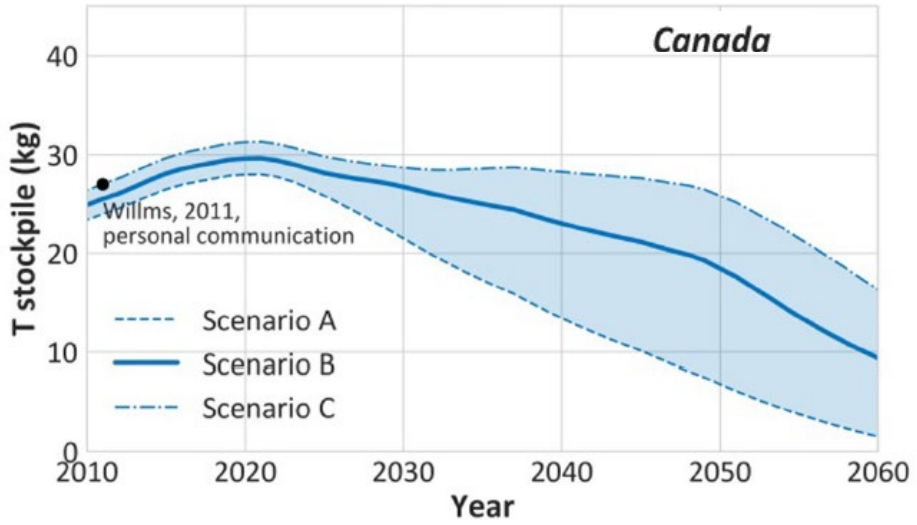
Arroyito, Argentina

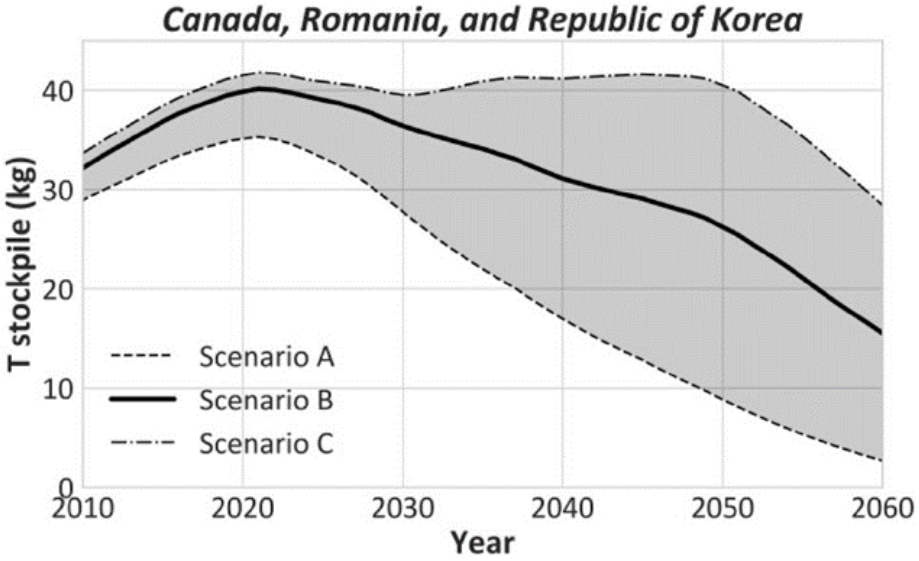
2. Fusion Reactor Feed Materials: Start-up Tritium (^{3}H)

Tritium: OPG Darlington, ON, Canada

Source: CANDU Reactors

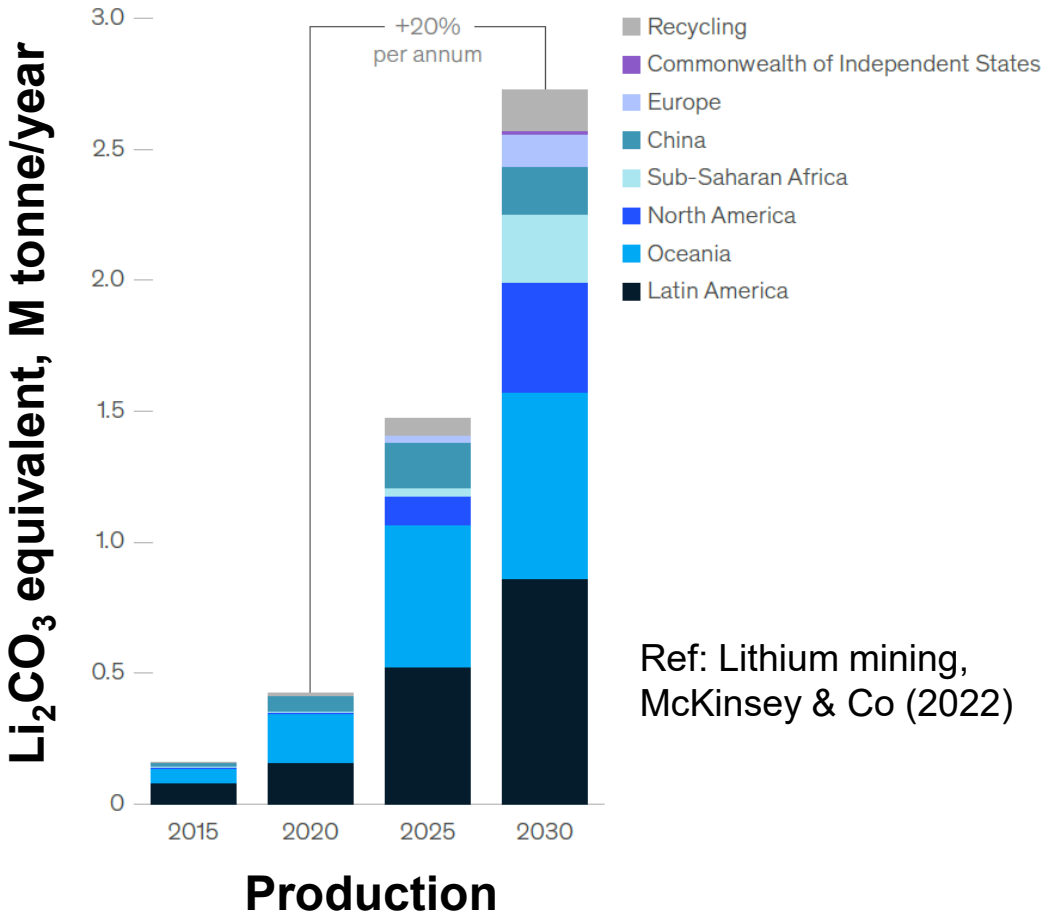
Technologies: Proven





Tritium resources available for fusion reactors, Kovari et al., Nucl. Fusion, 58 (2018)

2. Fusion Reactor Feed Materials: Lithium (^{6}Li)



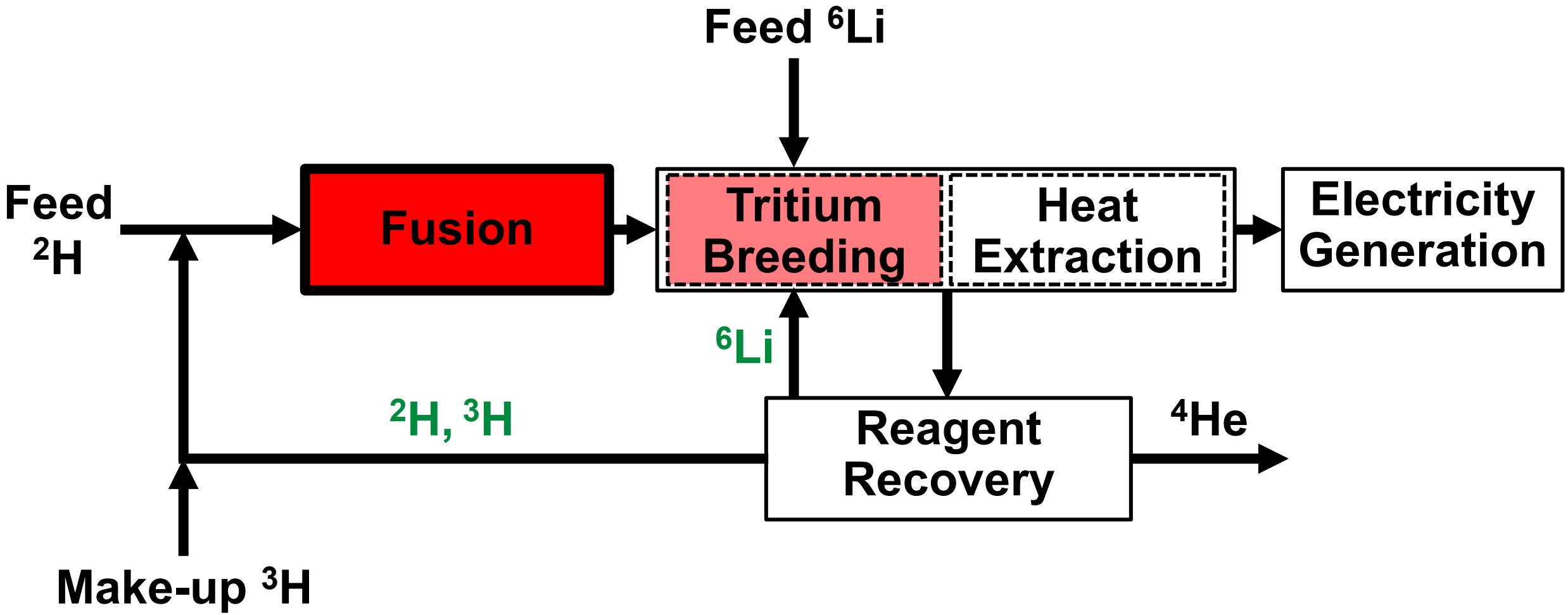
Ref: Lithium mining, McKinsey & Co (2022)

Occurrence: ^{6}Li 7.5% , ^{7}Li 92.5%

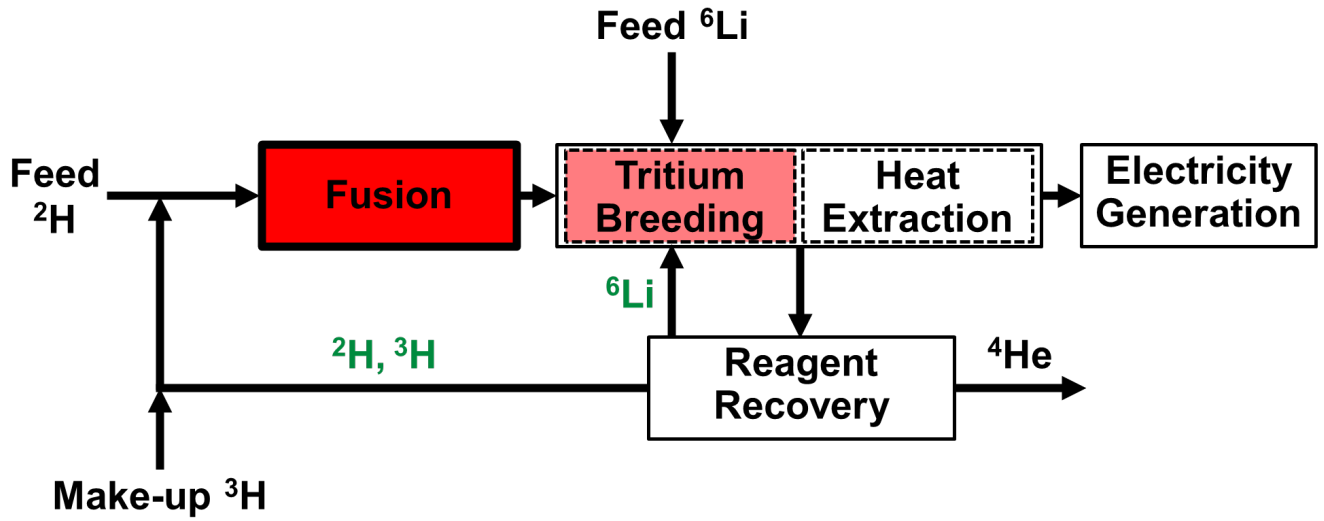
Technologies: Metal: Electrolysis (Proven)

^{6}Li Separation: Emerging

3. Fusion Plant: Overall Process



3. Fusion Plant: Reagent Recovery and Recycling



At issue:
^{6}Li; ^{2}H, ^{3}H, ^{4}He; Other

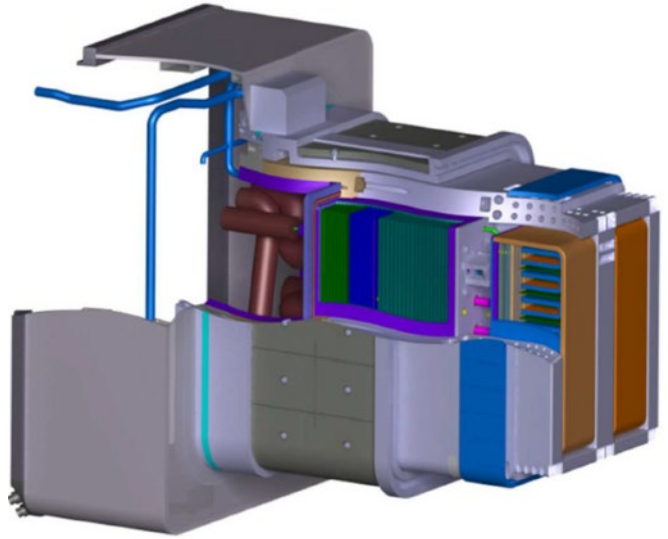
			Technologies
^{4}He	:	Separation	Oxidation and condensation
^{2}H / ^{3}H	:	Ratio adjustment	Oxidation, electrolysis, cryogenic distillation
^{6}Li	:	Separation	Condensation

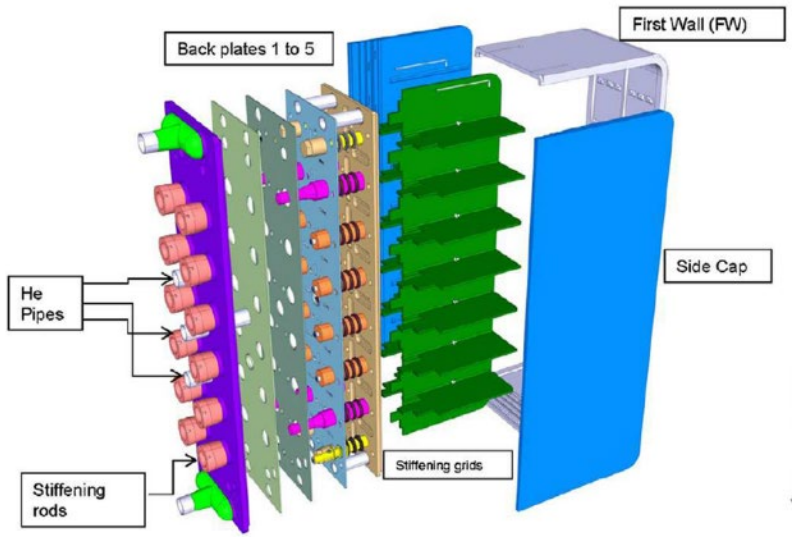
3. Fusion Plant: Tritium Breeding

Key blanket functions:

- **Harvest energy from fusion reactions**
- **Regenerate tritium from $^{6}Li + n$ reaction**
- **Protect vacuum vessel**

Emerging technologies

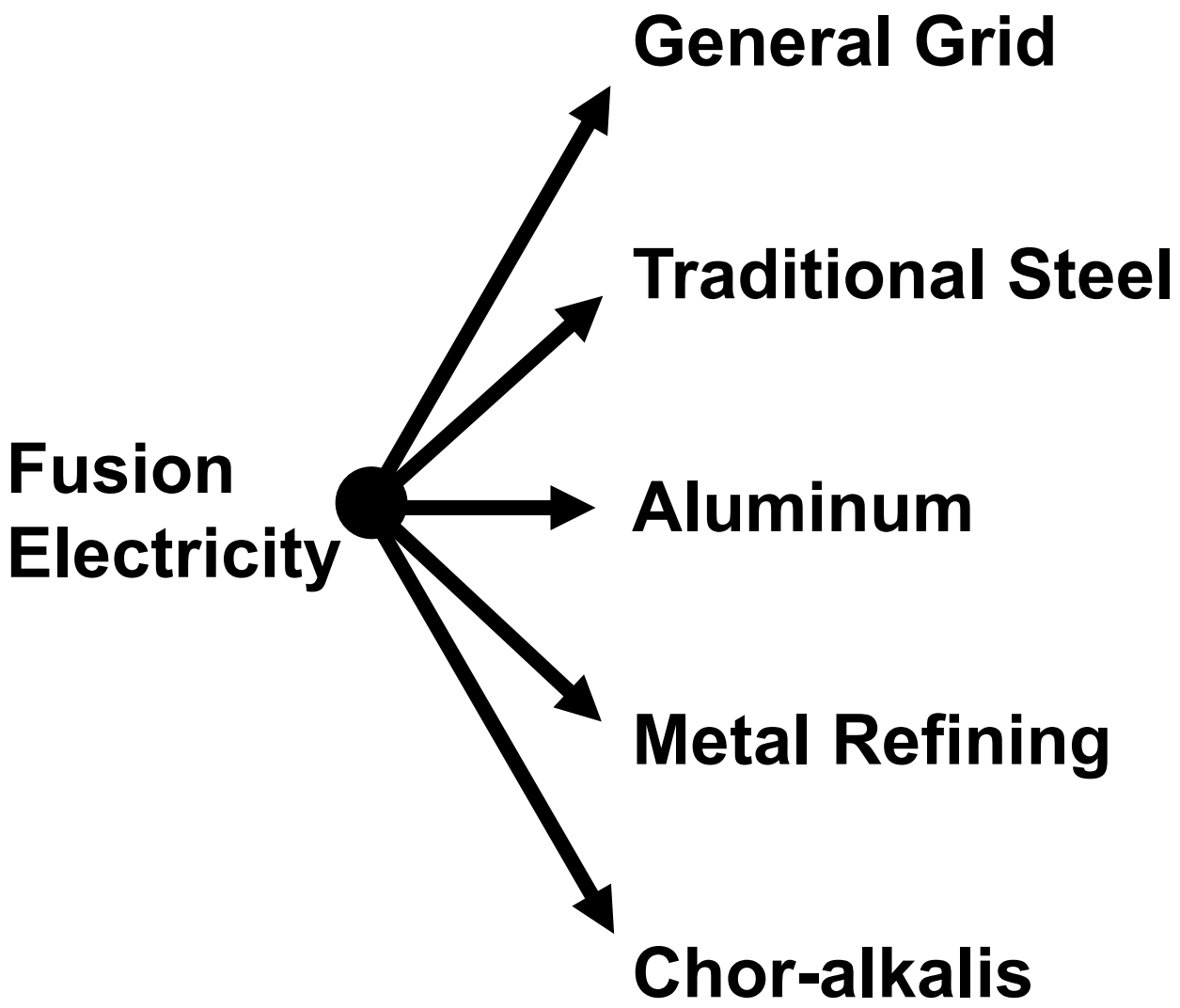




Helium-Cooled Lithium-Lead Blanket Module

G. Aiello et al., DOI:10.1088/1741-4326/aa5f65

4. Fusion Electricity Uses



5. Engagements: ITER

ITER Members

ITER Participants

Cooperation Agreements

AGREEMENT

BETWEEN

THE ITER INTERNATIONAL

FUSION ENERGY ORGANIZATION

AND

THE GOVERNMENT OF CANADA

FOR COOPERATION IN THE PEACEFUL USES

OF FUSION ENERGY

https://www.treaty-accord.gc.ca/text-texte.aspx?lcid=1033&id=105606&t=637860215781313681

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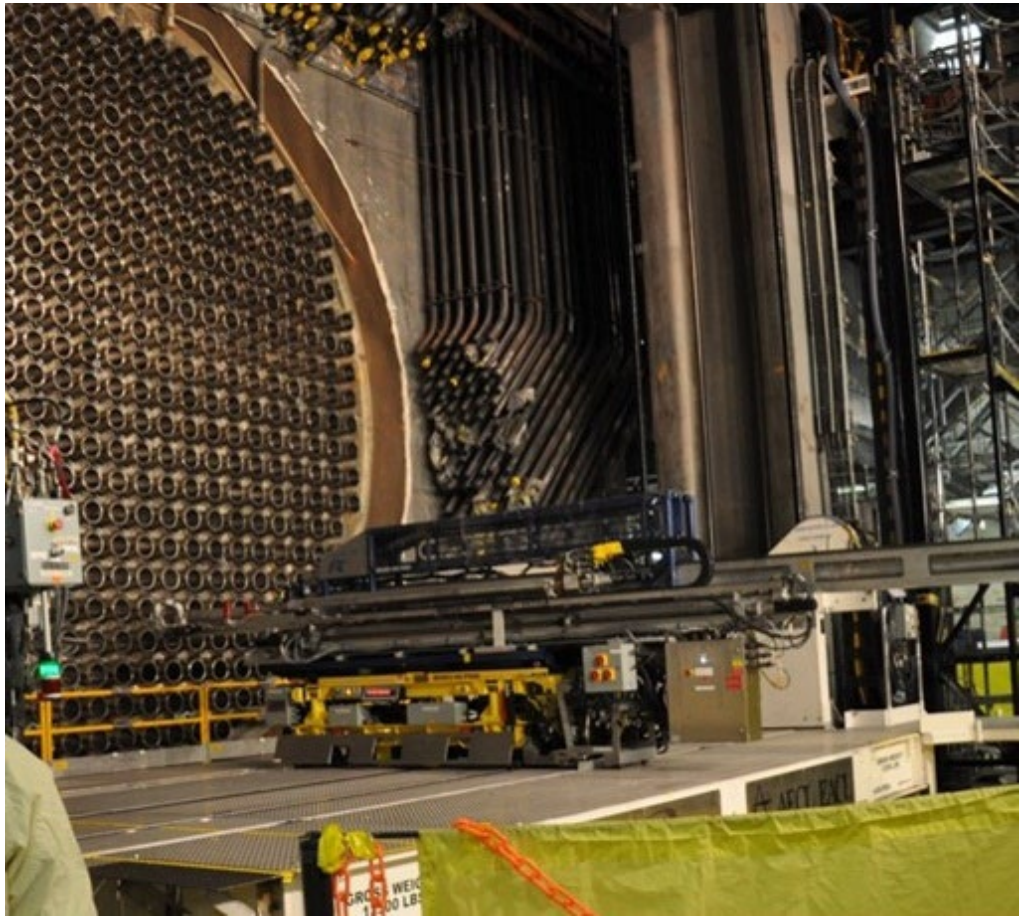
5. Engagements: Canada's Industrial Strengths

Tritium



Remote Handling

5. Engagements: National

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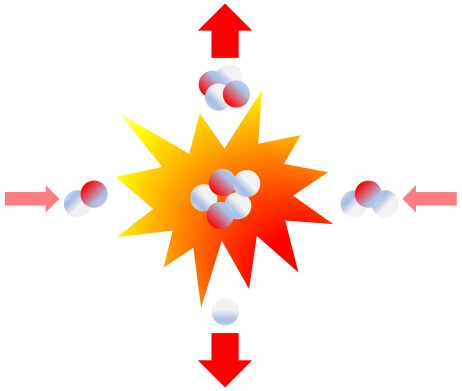
Natural Resources Canada | Ressources naturelles Canada

Canada

Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens

6. Actions



I. Develop fusion technologies beyond reactors, (esp. reagent recycling and tritium breeding)

II. Supply deuterium and tritium for global fusion operations

III. Harness fusion energy benefits for Canada

IV. Advance national and international fusion collaborations (esp. Government, FECC, OCNI, UNENE, industry, ITER)