



Small Modular Reactors: Energy Opportunities



Neil Alexander



Medicine.
Materials.
Energy.
Environment.

Global warming: 2015 and 2016 will be hottest years ever as climate change grips Earth



By *Callum Paton*

September 14, 2015 08:53 BST



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30 July 2015: An Iraqi man shows off a thermometer indicating a temperature of more than 50 degrees Celsius in Baghdad (Ahmad el-Rubayyi/AFP)

2015 and 2016 could be the hottest years on record according to the Met office, as changes to climate systems, particularly in the Pacific and the Atlantic, increase the effects of global warming. The Earth's surface temperature already looks set to **break records for 2015** and is running well over the global average for 1981-2010. The predictions are in keeping with the Met office's forecast in 2014, the hottest on record, of temperatures looking set to increase.

The rising temperatures are being fuelled in part by an **El Nino in the Pacific**, a dramatic warming of sea surface temperatures which occurs every few years. Changes in the flow of the Atlantic have also taken effect.

The two phenomenon together have already led to a weak Indian monsoon and relatively inactive Atlantic hurricane season this year. They will affect regional temperature and rainfall worldwide in coming years.

Head of the Met Office Hadley Centre, Professor Stephen Belcher said: "We know natural patterns contribute to global temperature in any given year, but the very warm temperatures so far this year indicate the continued impact of increasing greenhouse gases. With the potential that next year could be similarly warm, it's clear that our climate continues to change."

According to Reuters, a 2013 UN report observed that temperatures had increased at a slower rate in the years since 1998 than the preceding 50 years. Professor Adam Scaife, who led the Met Office analysis, said these changes are consistent with a return of rapid warming in the near term: "Although we can't say for sure that the slowdown in global warming is over, global temperatures are now rising again... Decadal warming rates are likely to reach late 20th century levels within two years."

More about the weather:

- **Japan floods:** Houses swept away as wall of water from Kinugawa River hits town of Joso
- **Notting Hill Carnival weather:** Rain won't dampen spirits at London street party [Photos]
- **August bank holiday weather:** Rain forecast for Reading and Leeds festivals during grim weekend
- **Global warming:** July 2015 was the hottest month ever recorded



A dog suns itself in central London (Getty)

WWF: Oceans turned into watery deserts as half of marine life wiped out in 40 years



By *Sean Martin*

September 16, 2015 12:14 BST

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Climate change, pollution and over-fishing has devastated ocean life (André Kunzelmann/UFZ)

Climate change and human interference has taken its devastating toll on ocean life as 49% of marine populations have been wiped out in the past 42 years, according to a new report. The World Wildlife Fund (WWF) and Zoological Society of London study revealed that as global warming worsens and "over-exploiting fisheries" continues, the situation will only be exacerbated.

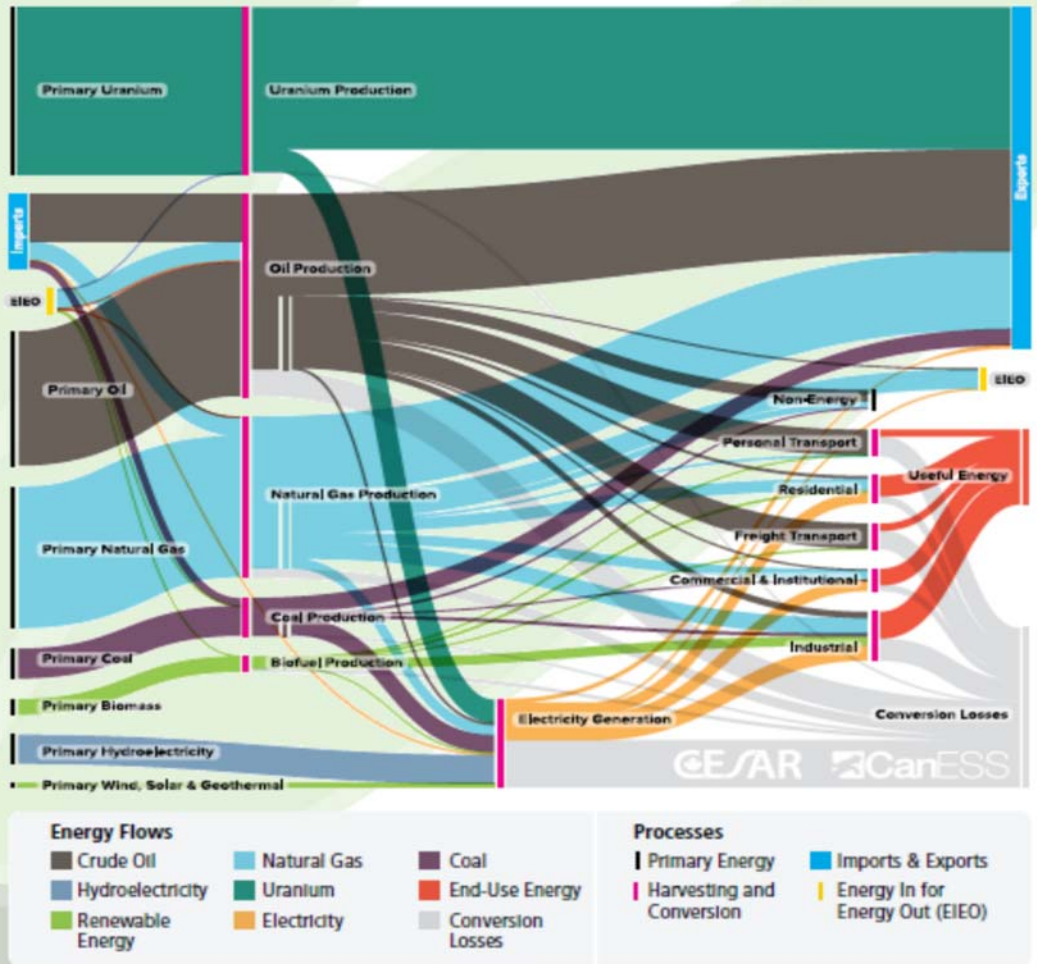
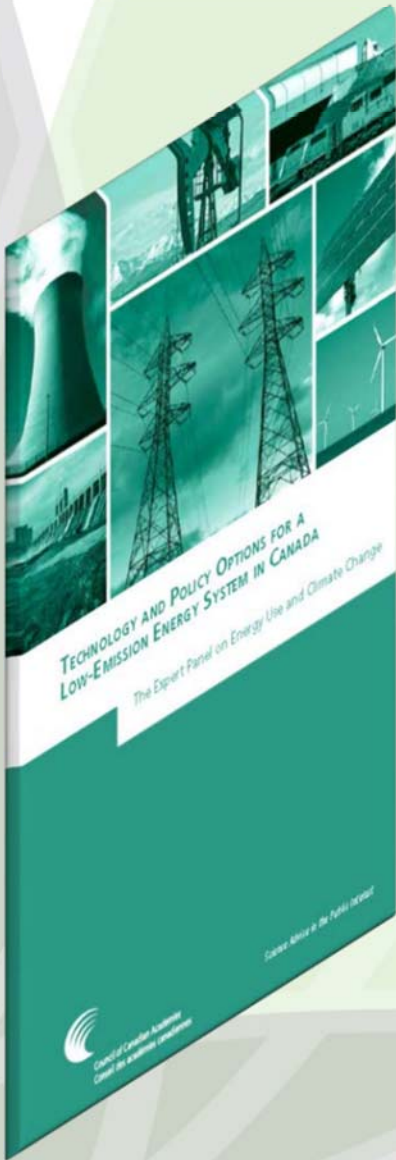
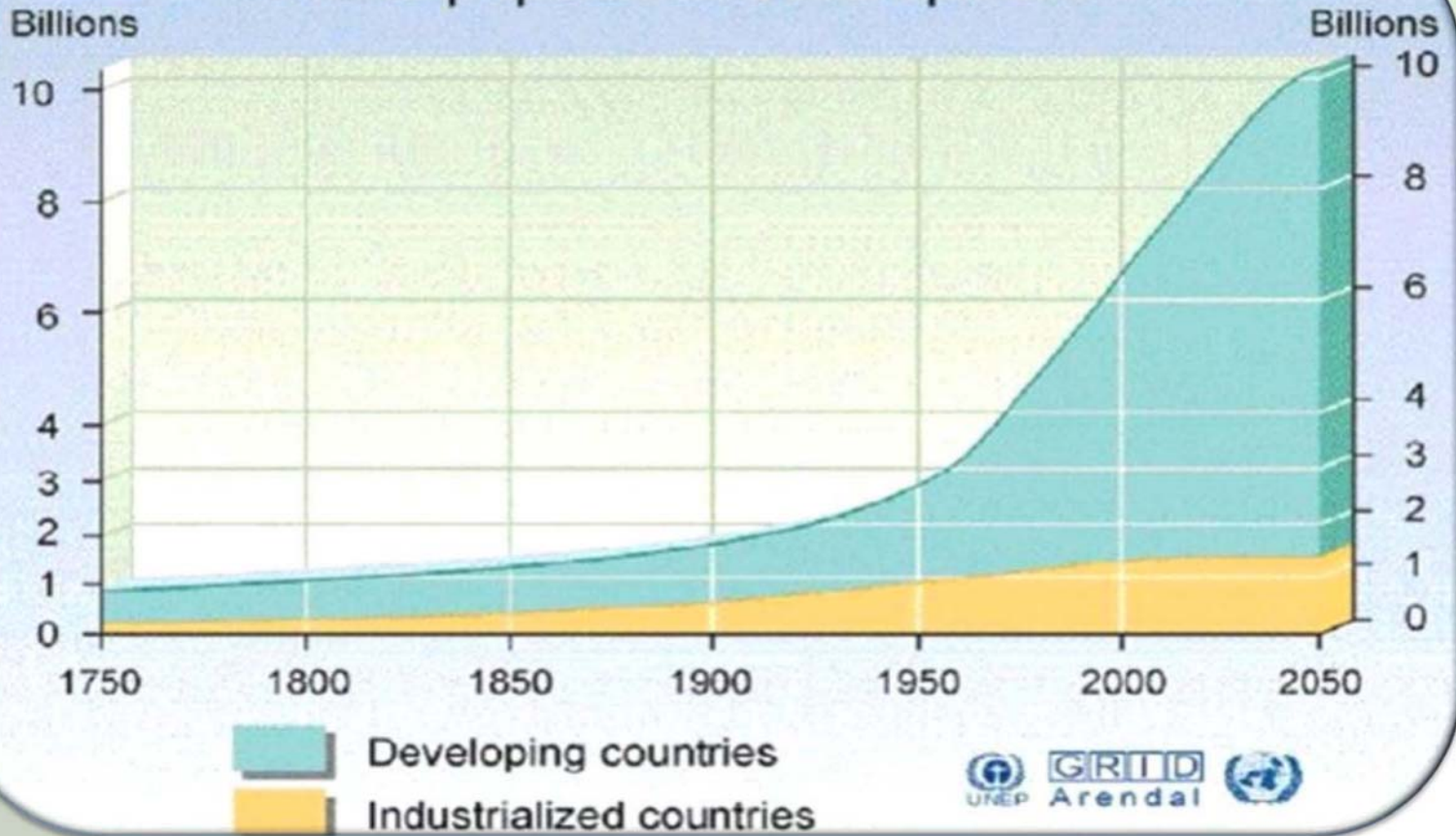


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World population development



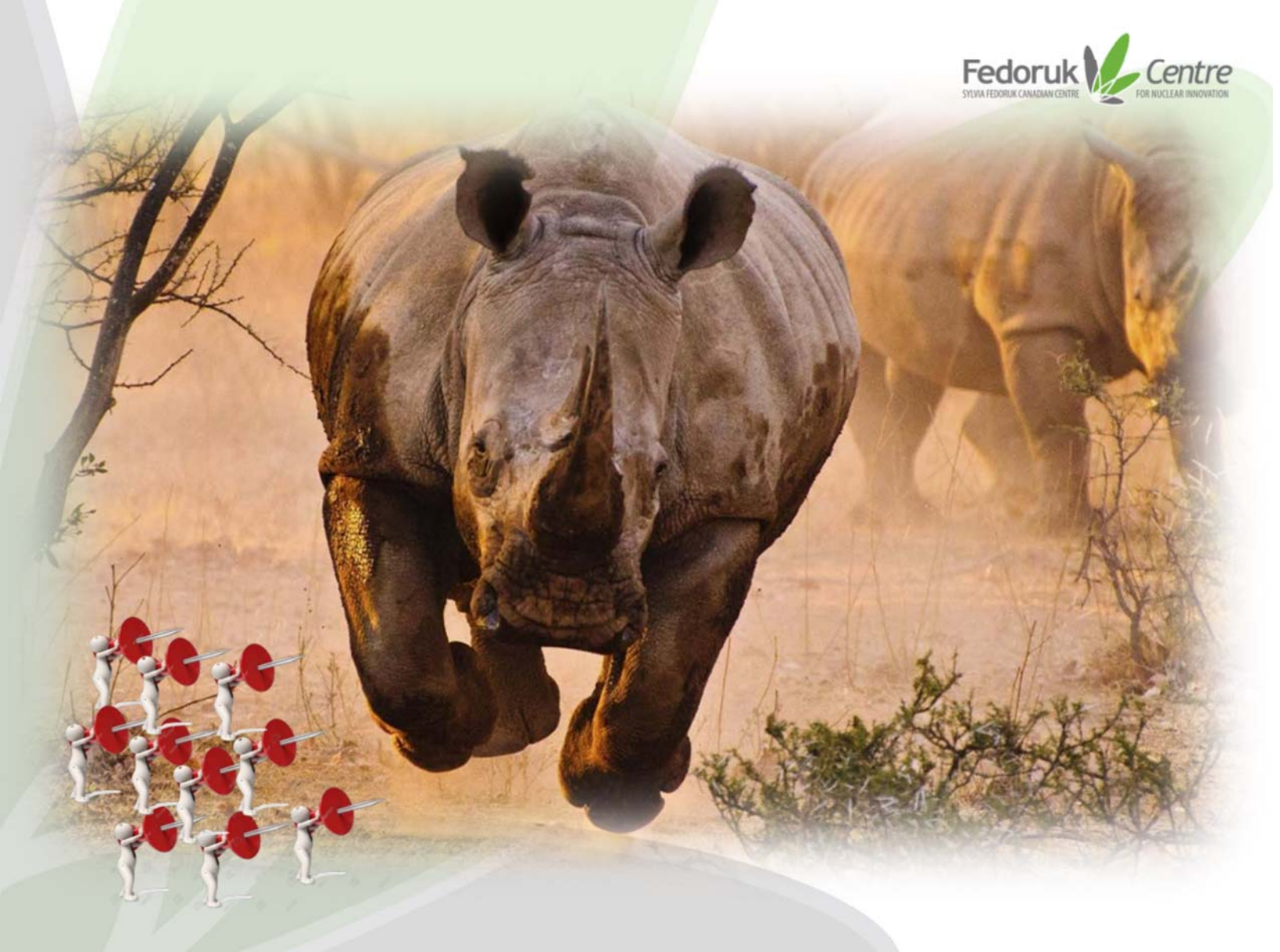
Drivers of Change



Electrification and Development

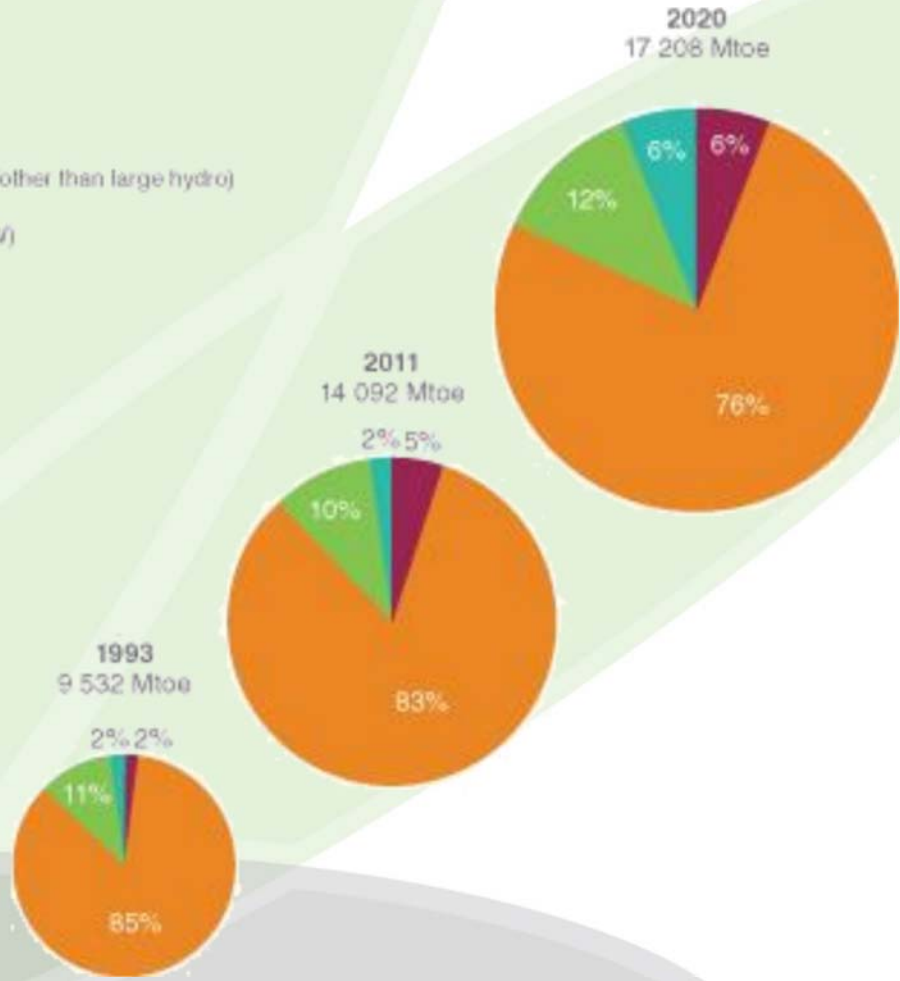
Population Growth & Urbanisation





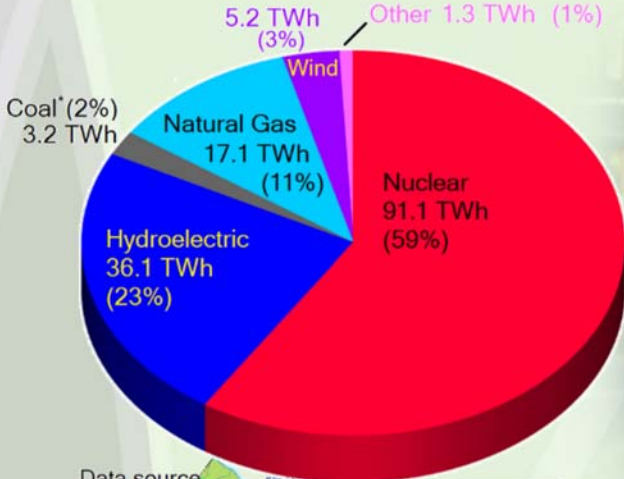
Energy by source history and projected.

- Nuclear
- Fossil
- Renewables (other than large hydro)
- Hydro (>10MW)



What does renewable mean?





Data source
<http://www.ieso.ca/Pages/Power-Data/Supply.aspx>

*Use of coal discontinued in 2013



Stages of Development

Reactors being built today

Chernobyl

Three Mile Island
Fukushima

Generation I
Early Prototypes



- Shippingport
- Dresden
- Magnox

Generation II
Commercial Power



- PWRs
- BWRs
- CANDU

Generation III
Advanced LWRs



- CANDU 6
- System 80+
- AP600

Generation III+
Evolutionary Designs

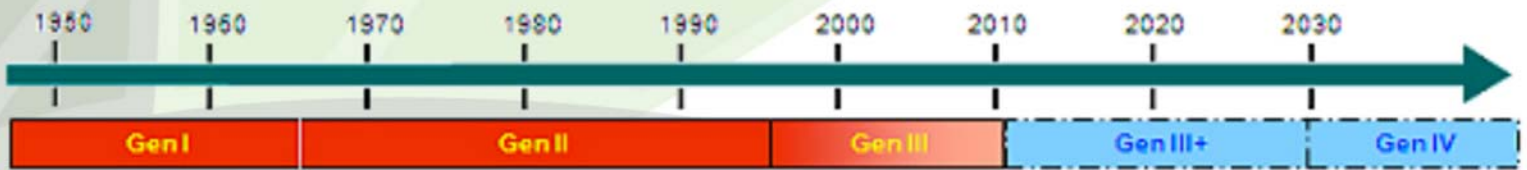


- ABWR
- ACR1000
- AP1000
- APWR
- EPR
- ESBWR

Generation IV
Revolutionary Designs



- Safer
- Sustainable
- Economical
- More Proliferation Resistant and Physically Secure



Electricity Generating Plants

93% Less than
500MWe

56% have
Capacities
below 50 Mwe

20% Less than
1 MWe



Possibilities

Remote and Island Communities

- 170 island communities in the world over 100,000 in population
- Many remote communities in the Arctic, India, Malaysia, the Middle East, etc.
- Drivers: Cost, Access, and Reliability



Mining and Oil & Gas Production

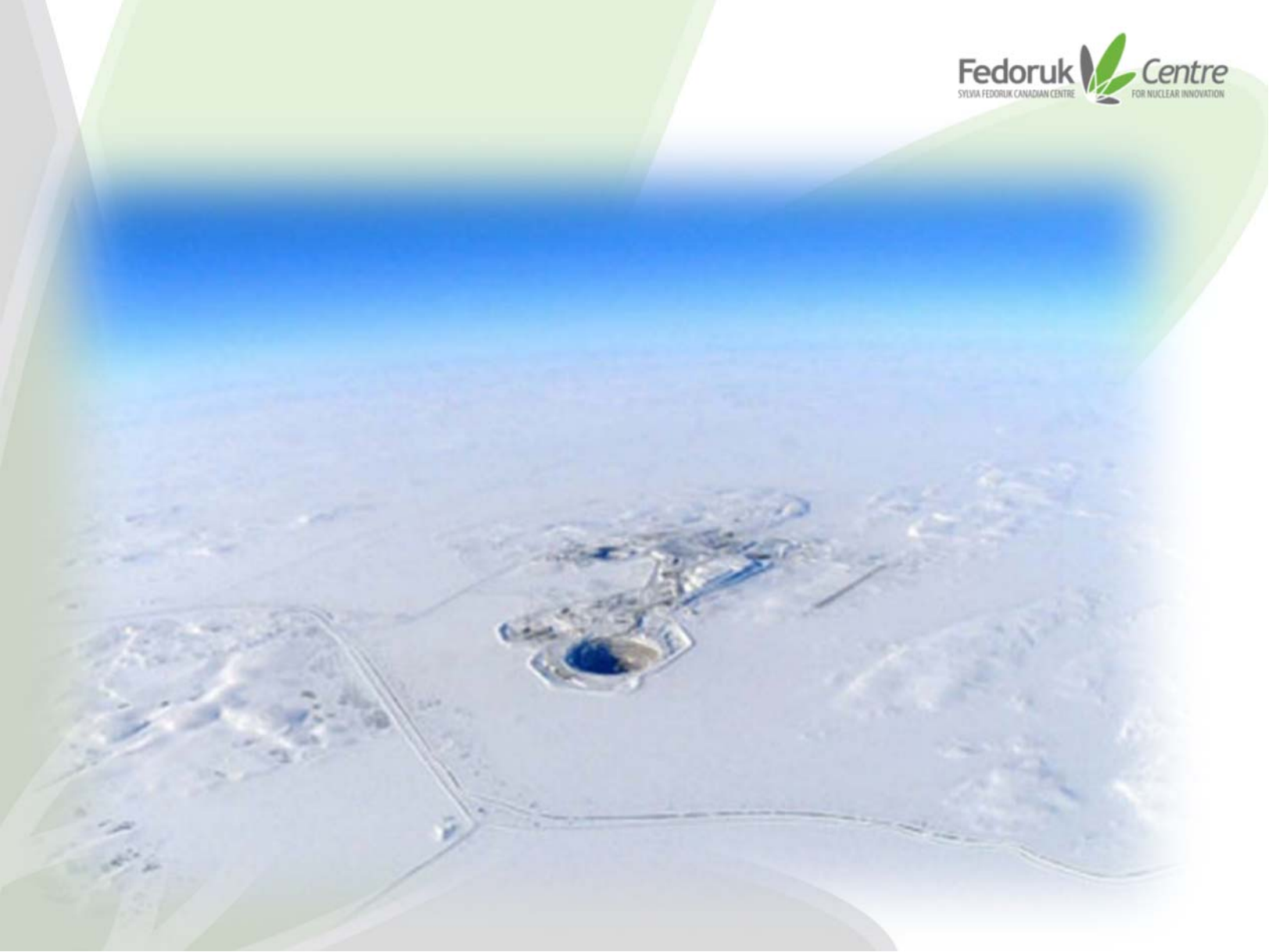
- Many remote sites, highly energy intensive
- Drivers: Cost, Supply chain disruptions, GHG intensity



Government Facilities

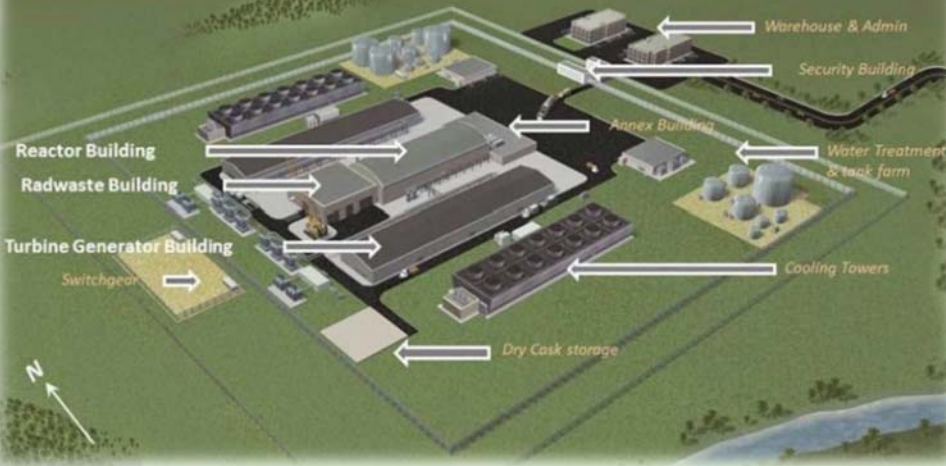
- Over 100 U.S. Govt. facilities where a 25MWe unit would be appropriate
- Drivers: Security, GHG Reduction







• ~ 44 acres (17.8 Hectares) inside exterior security fence



Thermal capacity – 160 MWt

Electrical capacity – > 50MWe (gross)

Capacity factor – >95 percent

Dimensions – 80' x 15' cylindrical

Weight – ~ 650 tons

Transportation – Barge, truck or train

Cost – <\$5,000/KW

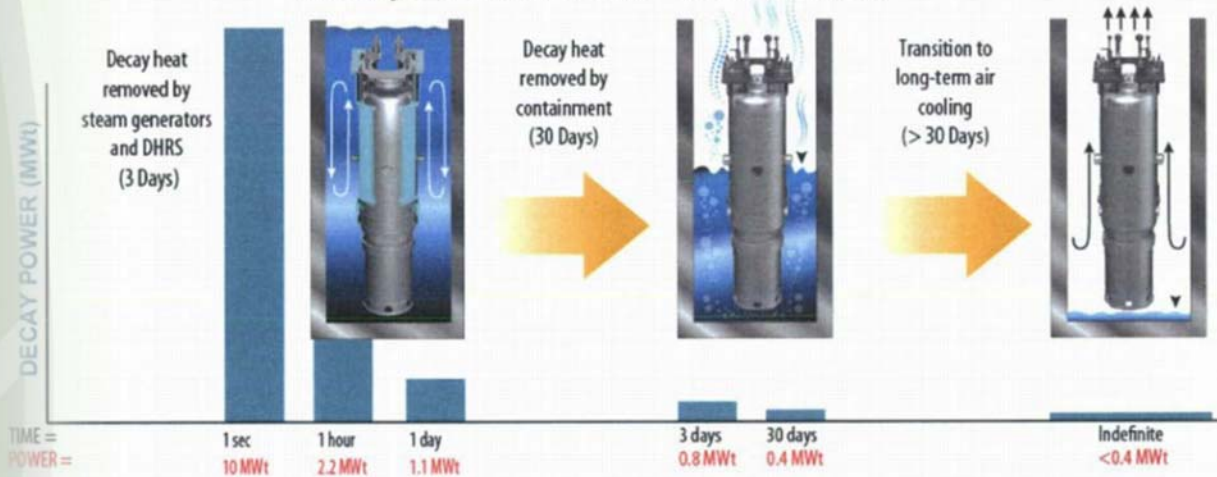
Fuel – Standard LWR fuel

Stable Long-Term Cooling Under All Conditions

Reactor and nuclear fuel cooled indefinitely without pumps or power

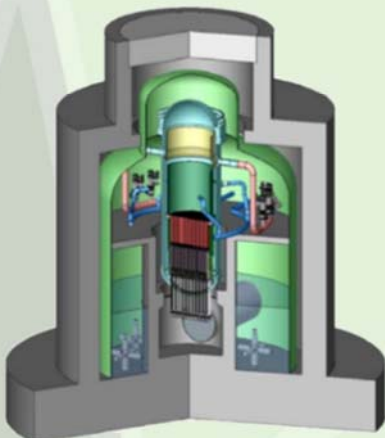


No Pumps • No External Power • No External Water



Based on conservative calculations assuming all 12 modules in simultaneous upset conditions and reduced pool water inventory

HITACHI



 The Japan Atomic Power Company

DMS (Double MS, Modular Simplified Medium Small)

Jointly developed with Japan Atomic Power Company

430MWe Natural Circulation BWR

Package Reactor



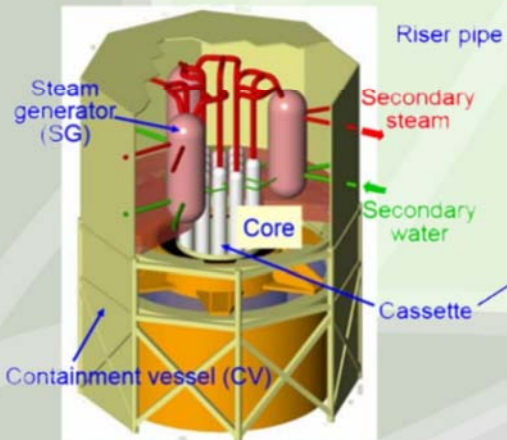
Our Technologies. Your Tomorrow

Jointly developed with Mitsubishi Heavy Industries

10-100MWt Natural Circulation BWR

No active components within Pressure Boundary

10m tall, 5.5m diameter



STARCORE

N U C L E A R

- Montreal registered
- Triso fuelled High Temperature Gas (helium) Cooled Reactor
- 10MWe per unit
- Fuel remains intact at highest temperature if all coolant lost

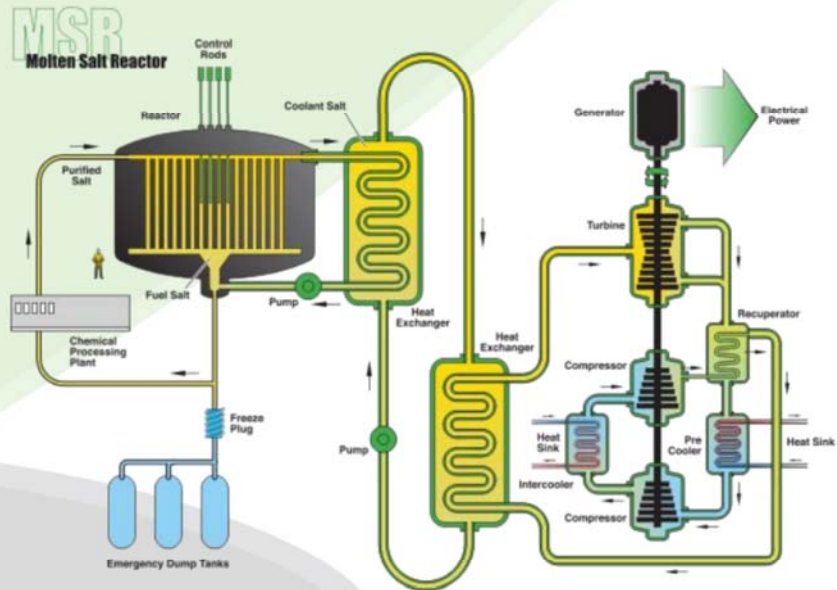
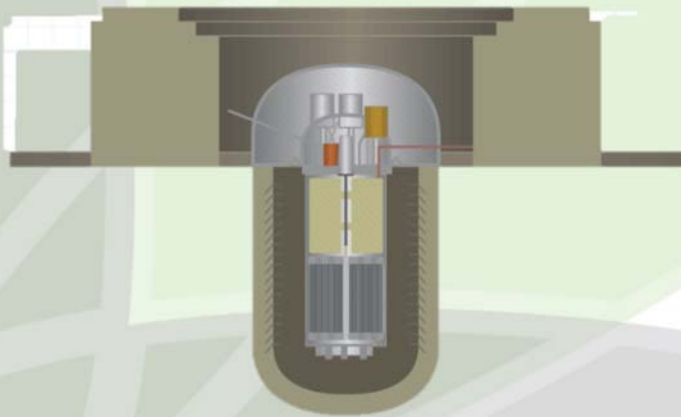


TERRESTRIAL ENERGY

- Mississauga HQ
- Integrated Molten Salt Reactor
- Scaleable 80-600MWth
- Atmospheric Pressure
- 7 year core life

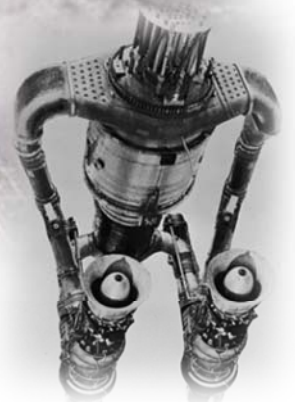


Aircraft Reactor Experiment ORNL





NB 36 H made 47 flights with a reactor on board



HTRE3 reactor powered jet engine

generalfusion

-  Based in Vancouver 
-  Magnetized target fusion
-  Plasma physically compressed to required density



































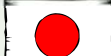






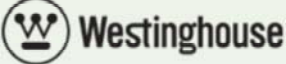




COMPRESSION
SYSTEM



generalfusion



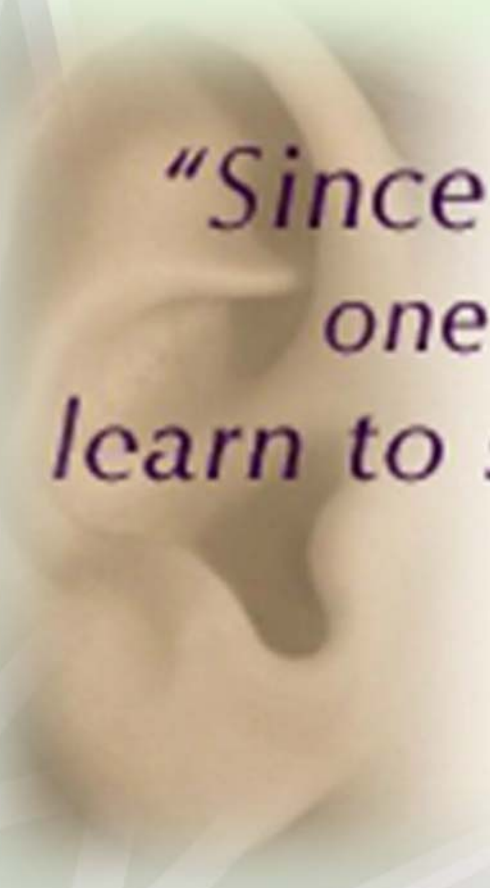
Potential SMR developers with interests in Canada

| Developer | Current Base | Move to Canada | Move fabrication/ supply chain to Canada |
|--|---|--|---|
|  |  Mississauga, Ontario |  |  |
|  |  Vancouver, BC |  |  |
|  |  Registered in Montreal, Quebec. Offices virtual  |  In the right circumstances |  In the right circumstances |
|  |  Cambridge, Ontario |  |  |
|  |  Main base in Stockholm, registered in Alberta with office in Ontario  |  In the right circumstances |   |
|  |  Denver, Colorado |  In the right circumstances |  In the right circumstances |
|  |  Corealis, Oregon |  Base too firmly established. |  In the right circumstances |
|    |  Hitachi City, Japan |  Base too firmly established. |  In the right circumstances |
|  |  Lynchburg, VA |  Base too firmly established. |  Expected to be fabricated at B&W Canada in Cambridge |
|  |  Cranberry Twp, PA |  Base too firmly established. |   Some opportunity for component supply |

Policy Innovation: The Canadian Institute of Science and Innovation Policy (CISIP)



- Understand how you have a successful discussion about a technically complex issue
- Understand what information people need in order to have an informed discussion
- Understand how to convey that information to those people in a constructive way



*“Since in order to speak,
one must first listen,
learn to speak by listening.”*

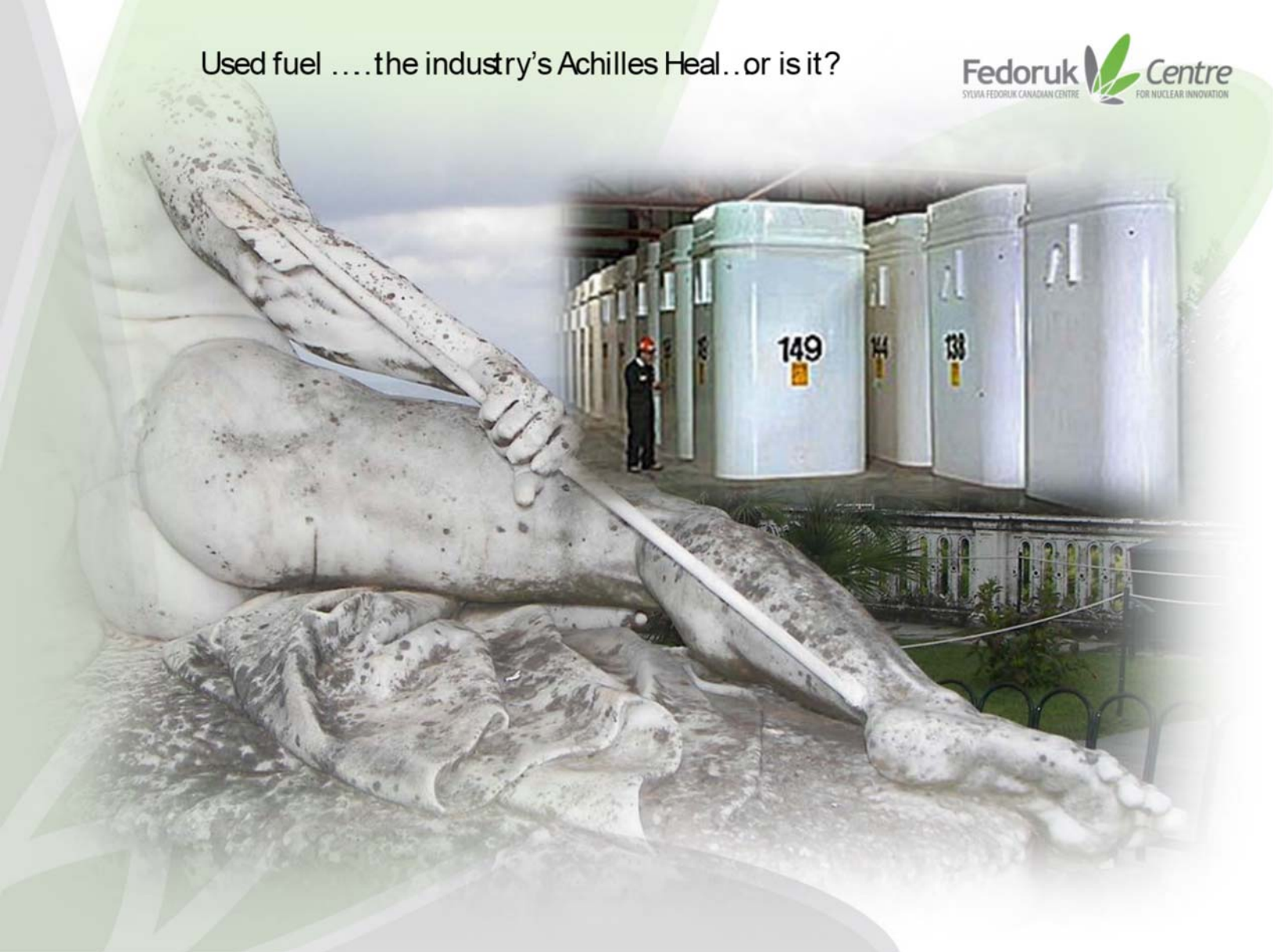
- Mevlana Rumi

Overall Impression of Nuclear Power in Saskatchewan

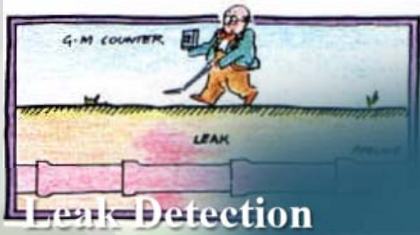
Percentage of those expressing an opinion



Used fuelthe industry's Achilles Heal...or is it?



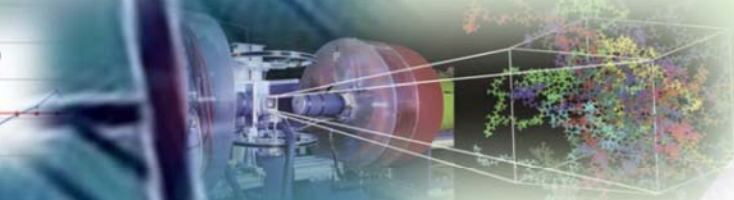
Every day in every way Nuclear Technology is making us safer, healthier and happier



Leak Detection



Compact Fluorescents



Materials Research



Preserving Foods

DNA Sequencing



Nuclear Medicine & Imaging



Detecting stowaways



Sterilizing Medical Equipment

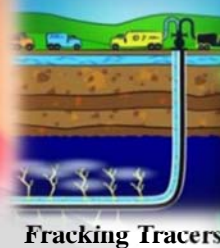
Quality and Safety Inspections



Emergency Lighting



Smoke detectors



Fracking Tracers

Glow in the dark toys



Tritium, Krypton, Promethium

Thank you



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Medicine.
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Environment.