



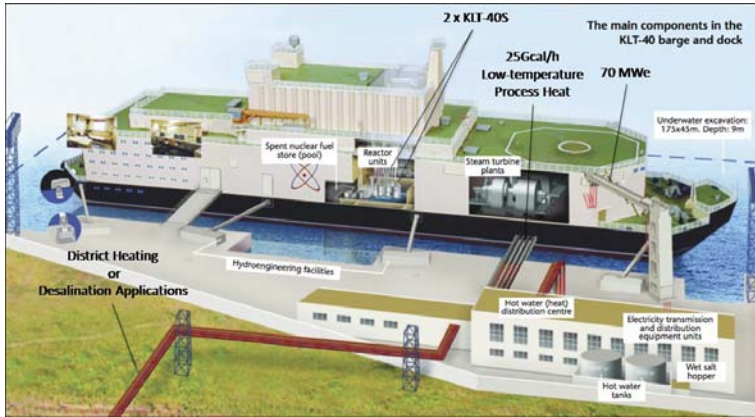
# Floating Nuclear Power Plants for Mining in the North

*A Safe, Clean, Low Cost Energy Solution for the Mining  
Industry*

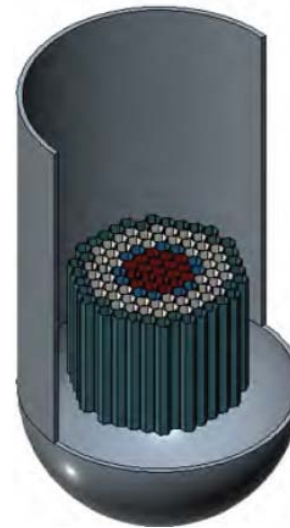
Peter Lang  
President



**Dunedin**  
Energy Systems Limited.



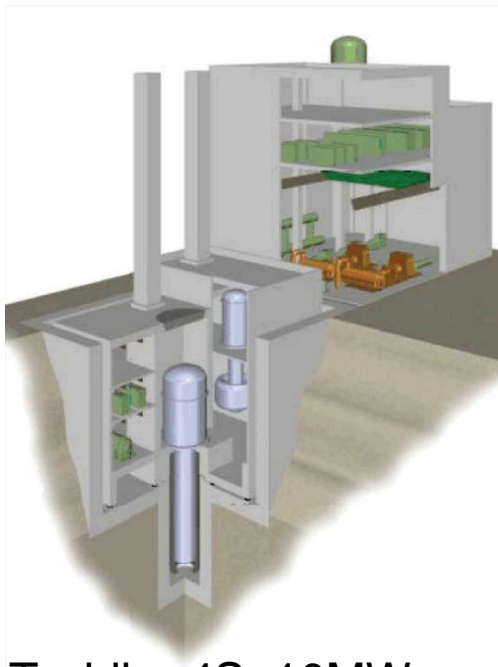
KLT-40 2x35MWe



SEALER 3MWe



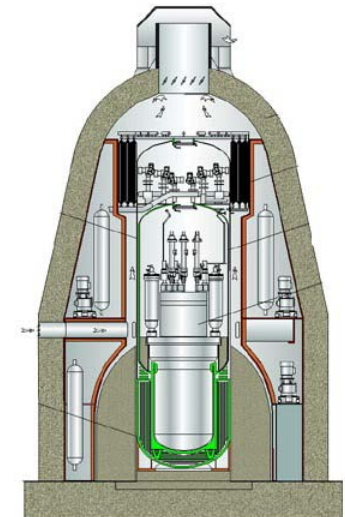
Gen4Energy 25MWe



Toshiba 4S 10MWe



StarCore 10MWe



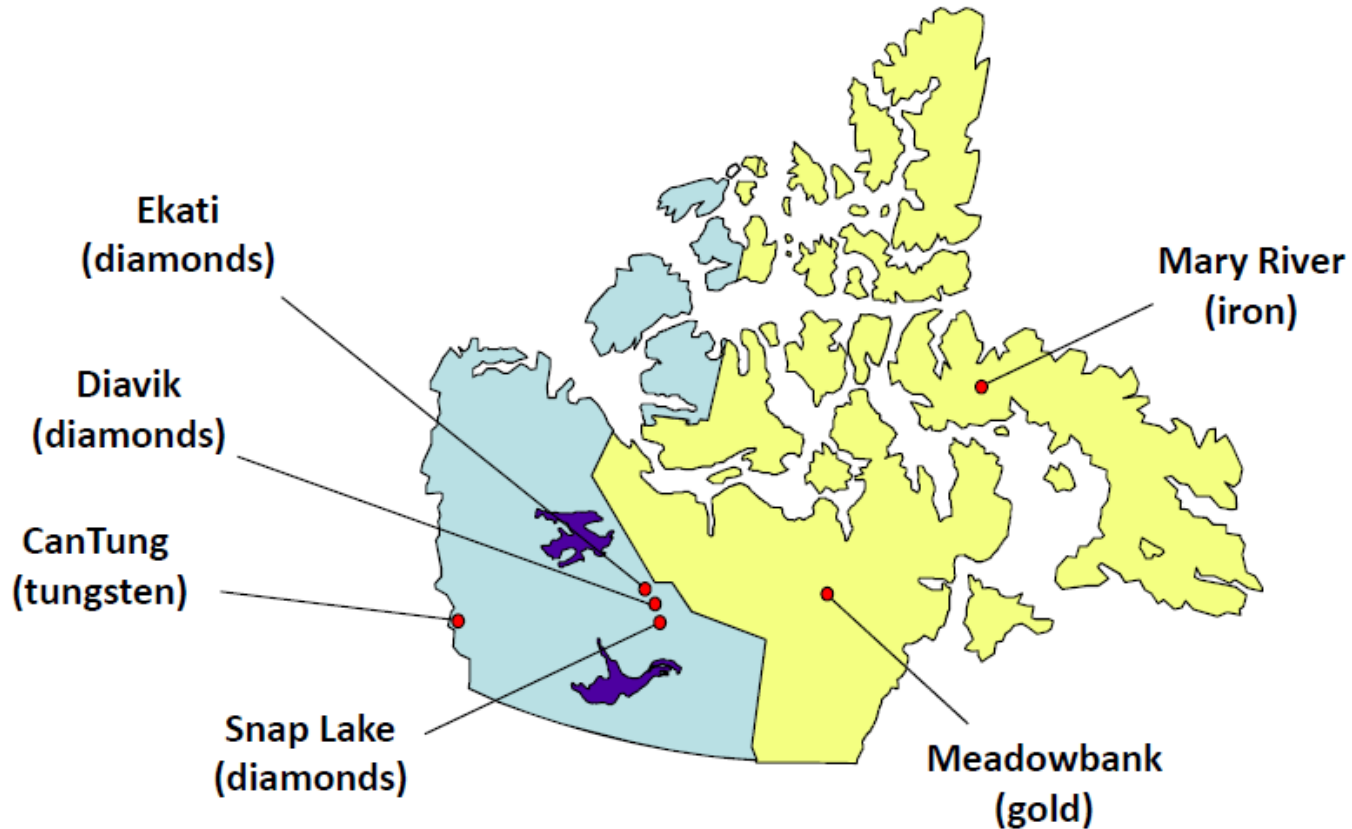
SMART 6MWe



Russia, Nuclear Lighter Aboard Ship Sevmorput  
(Lazer\_one)

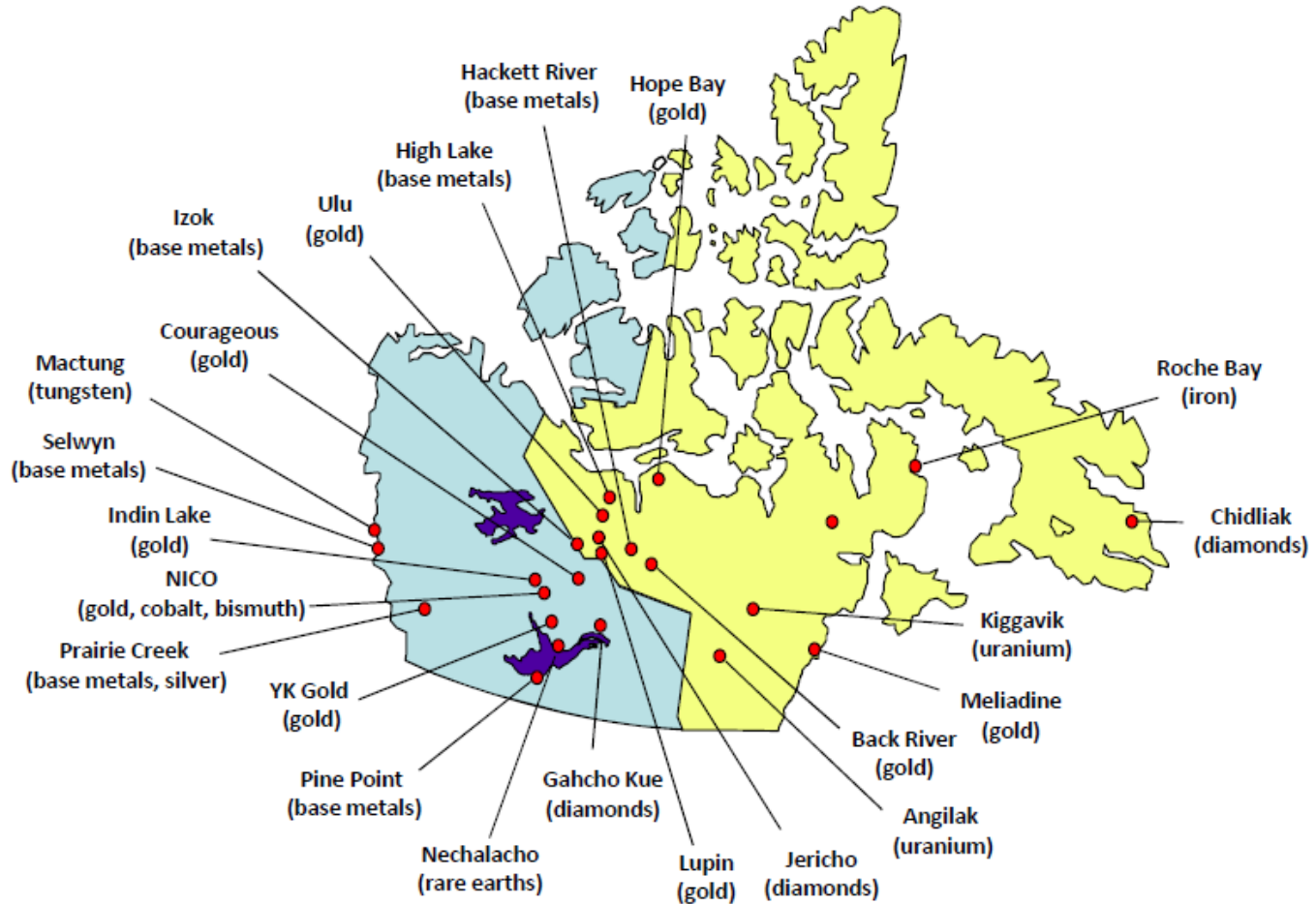


## Mineral production today is from 6 mines





# Potential mines provide diversified opportunities





# Why Diesel?

- ✓ Mature
- ✓ Reliable
- ✓ Scalable
- ✓ Portable
- ✓ Low capital cost



## Why NOT Diesel?

- High fuel cost
- Unpredictable fuel cost
- Expensive & difficult logistics
- Environmental hazard



# Diesel Fuel



**86% Carbon by mass**

**Each litre of diesel fuel burned produces  
2.7 kg of CO<sub>2</sub>**



The Inuit Circumpolar Council wants to see reductions in the amount of black carbon that enters the Arctic—those tiny black particles produced by the exhaust of airplanes, ships, generators and fires, which act as magnets for heat. (FILE PHOTO)

# NUNATSIAQ ONLINE



■ NEWS: Climate Change December 05, 2012 - 2:00 pm

## Inuit want “immediate action” on climate change: ICC

The Inuit Circumpolar Council wants to see reductions in the amount of black carbon that enters the Arctic – those tiny black particles produced by the exhaust of airplanes, ships, generators and fires, which act as magnets for heat.

# NUNATSIAQ ONLINE



■ **NEWS: Climate Change** May 09, 2011 - 11:10 pm

**“It could make a difference”**

**JANE GEORGE**

Fires, diesel-burning power generators, trucks and ships: they’ve all got something in common.

That’s their ability to generate soot in the Arctic, which accounts for as much as 30 per cent of the warming in the region.

“It’s an Arctic problem,” said Andreas Stohl from the Norwegian Institute for Air Research at last week’s Arctic climate change and pollution conference in Copenhagen.



The haze which you see sometimes in the spring may be the result of agricultural fires in Canada’s western provinces, which also contribute to Arctic warming. (PHOTO BY JANE GEORGE)

**FRED** 

— Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma





**FRED** 

— Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma



# Tibbit to Contwoyto Ice Road

**Cost - \$12M to \$15M**

**Serviceable – 8 to 10 weeks / yr**



# Tibbit to Contwoyto Ice Road

**Cost - \$12M to \$15M**

**Serviceable – 8 to 10 weeks / yr**

May 29, 2011

## Global warming jeopardizing ice highways, study says

By Nathan VanderKlippe  
From Monday's Globe and Mail

*Canada will lose winter-road access to nearly 400,000 square kilometers of land by mid-century, UCLA researchers predict*



# Photo: The Coast Guard breaks the ice

NUNATSIAQ NEWS



[REDACTED] of Frobisher Bay towards Iqaluit, where it arrived on the night of July 11-12. [REDACTED] of at least one cargo vessel at Iqaluit. Meanwhile, the CCGS Terry Fox is also on the scene, where three other vessels are waiting to get into Iqaluit. The CCGS Des Groseilliers is on its way. "Navigation has been a challenge with rain, drizzle and fog cutting down on visibility. But this is nothing new for the Coast Guard, which operates in some of the harshest weather conditions in the world," Coast Guard spokesperson Carol Launderville said in an email. (PHOTO COURTESY OF ENVIRONMENT CANADA)



## Fuel logistics are expensive, complex and not without risk



9.5 million litres grounded near Gjoa Haven



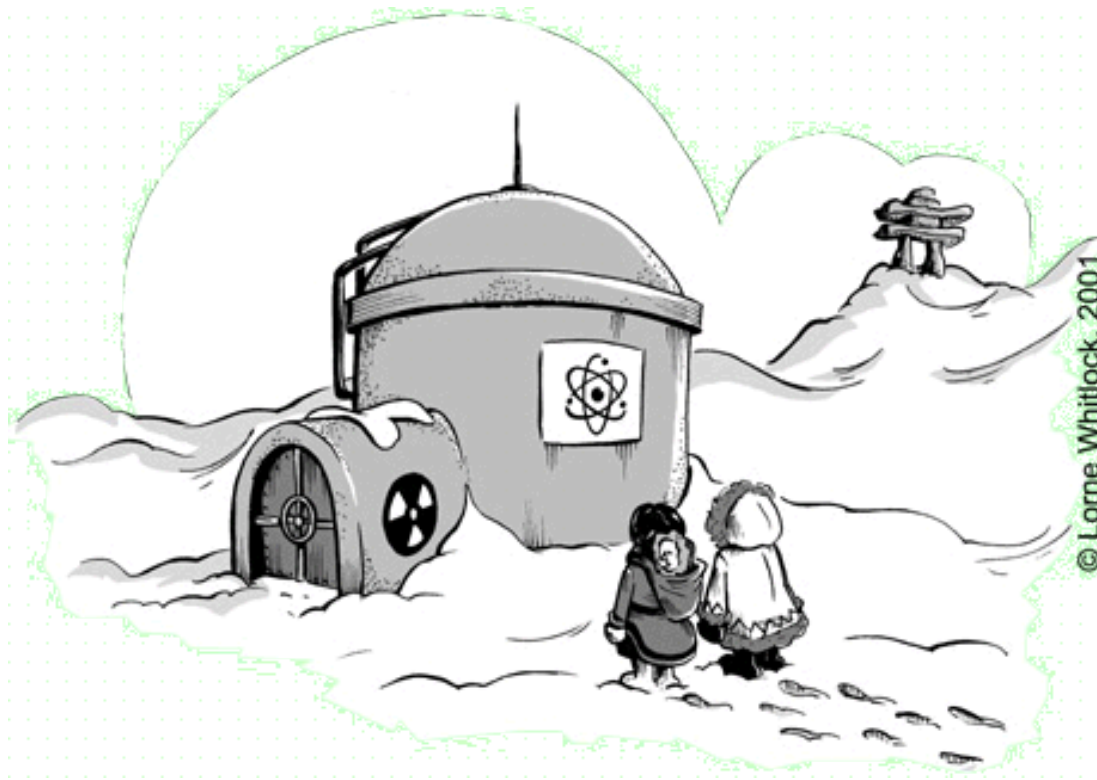
Tanker grounding near Pangnirtung

***“There has been a significant number of fossil-fuel spills in Nunavut and these appear to be increasing with time”***

Ikummatit - Government of Nunavut energy strategy document

Is there a nuclear solution?

**YES**



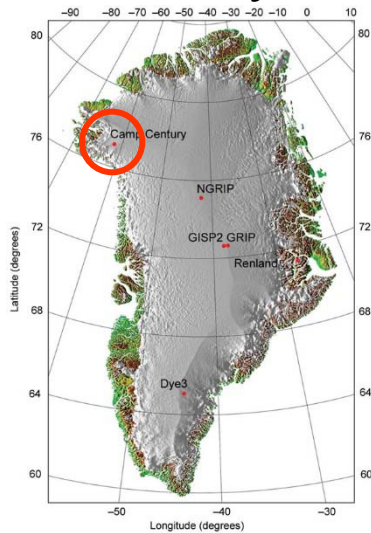


Most people think that nuclear only comes in one size - **GIGANTIC** -

## Ft. Greely

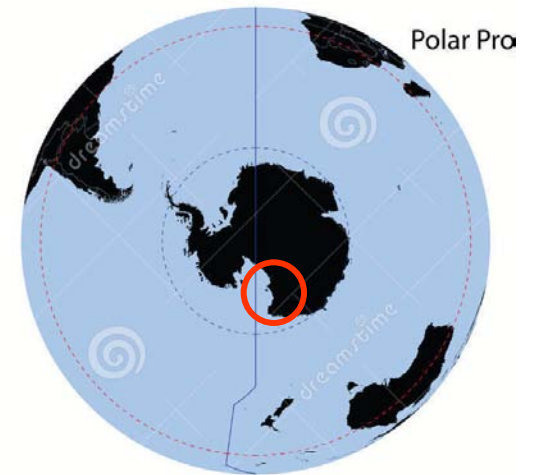


## Camp Century



Approximately 1.6 MWe  
+ space heating

## McMurdo Station









**USS Nautilus 1954**





# United States Navy





# United States Navy

## 103 reactors

- 10 Aircraft Carriers
- 73 Submarines
- 4 Training reactors

Nuclear powered ships have safely steamed more than 128 million miles, equivalent to over 5,000 trips around the world without a reactor accident.\*

Since the first nuclear-powered vessel (USS *Nautilus*), the United States Navy has logged over 6,200 “reactor years” with no radiological accidents.\*

\* ADMIRAL F. L. "SKIP" BOWMAN, U.S. NAVY DIRECTOR, NAVAL NUCLEAR PROPULSION PROGRAM BEFORE THE HOUSE COMMITTEE ON SCIENCE  
29 OCTOBER 2003

**World wide there are over 140 ships 180 reactors, 12,000 reactor years of operation**

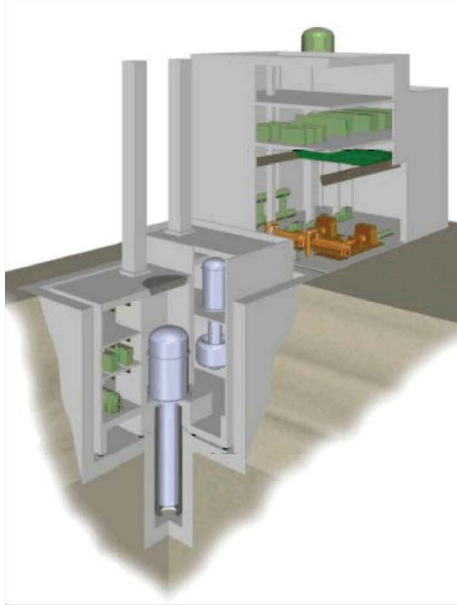


# USNS Sturgis



10 MWe Panama Canal Zone 1968 -1976





Toshiba 4S 10MWe



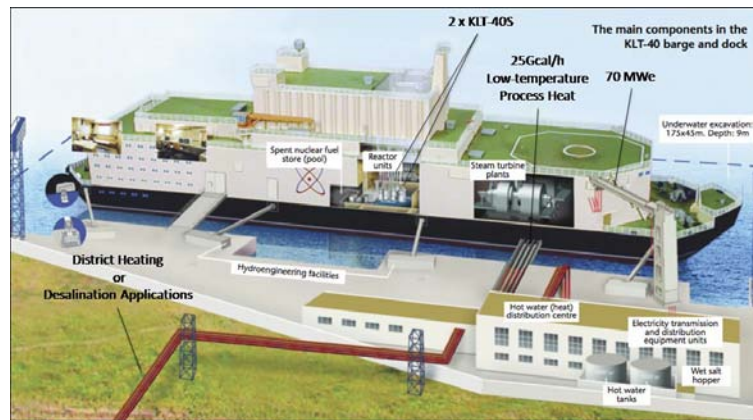
SEALER 3MWe



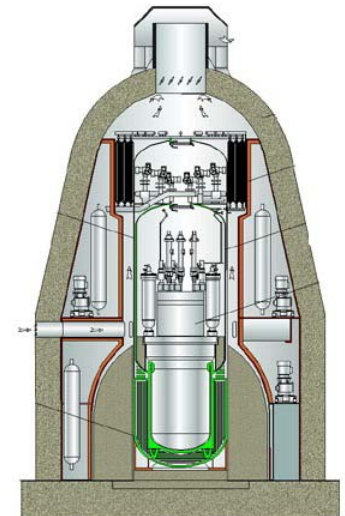
Gen4Energy 25MWe



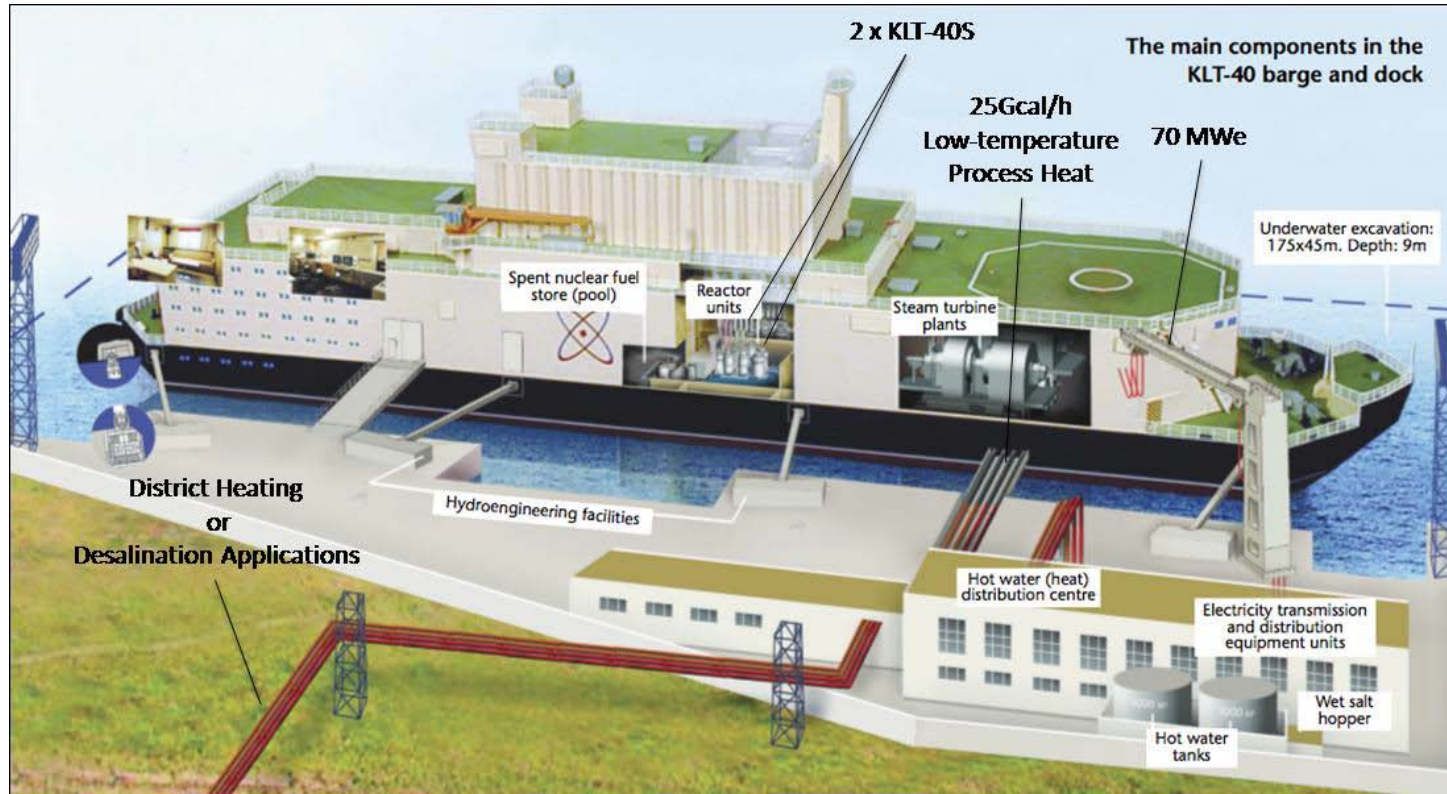
StarCore 10MWe KLT-40



KLT-40 2x35MWe



SMART 6MWe







**Floating 70 MWe Nuclear Power Plant**



*The first steam generating unit - comprising the reactor, steam generators and pressurizer - is lowered into the vessel's reactor compartment (Image: Rosenergoatom)*



Taymyr class icebreaker powered by two KLT-40 nuclear reactors





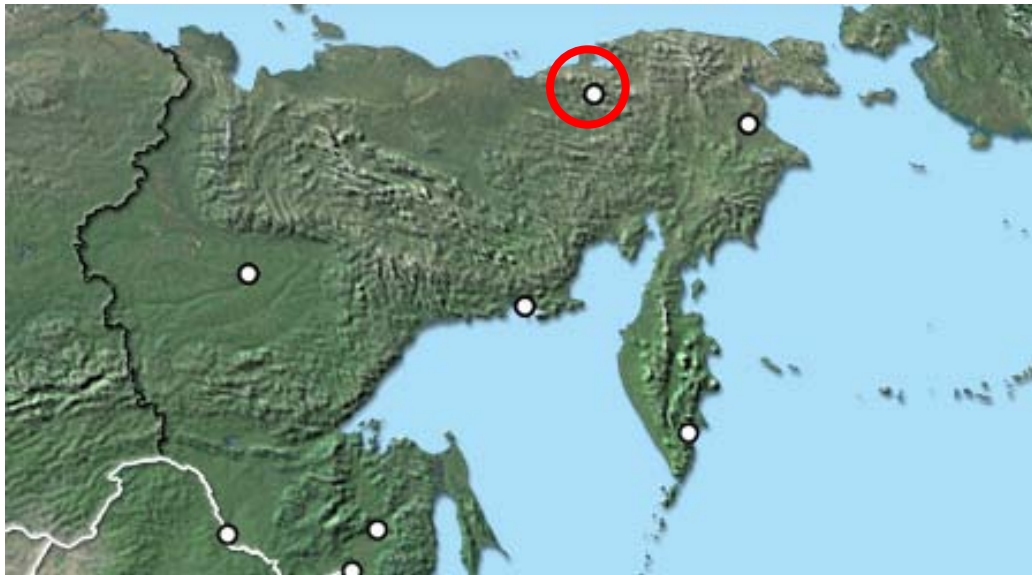


# Arctic Nuclear Proof of Concept

**Bilibino – Siberia – Russia - 68<sup>o</sup> north**

***Powered by four 12 MWe nuclear reactors***

In commercial operation since 1974





## Bilibino, Pop. 5,500



### Gold Mine



### Nuclear Heated Green House

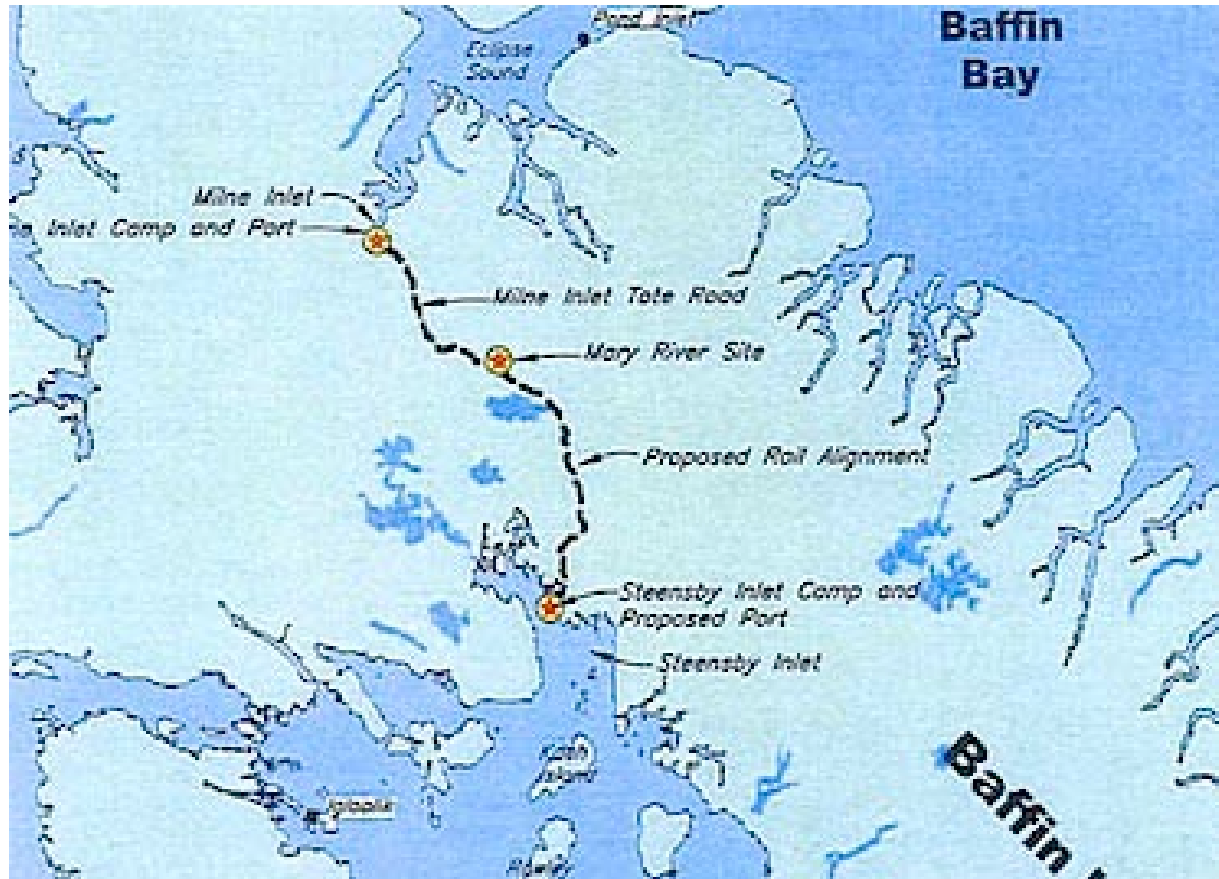






The estimated power demands for the mine and port are summarised below.

<b>Item</b>	<b>Mary River</b>	<b>Port</b>
Connected load	19 400 kW	25 400 kW
Demand load	15 800 kW	21 500 kW
Running load	9 800 kW	11 000 kW



149 km haul railway to Steensby Inlet



## 13 diesel locomotives

NUNATSIAQ [ONLINE](#)

Nunavut May 03, 2012



8.8 MWe  
heavy haul  
freight  
locomotive



**SIEMENS**

E40AC

4 MWe

13 Ordered by BHP to haul coal



# China ready to construct floating nuclear power plant

Staff Reporter | 2014-09-28 | 11:16 (GMT+8)

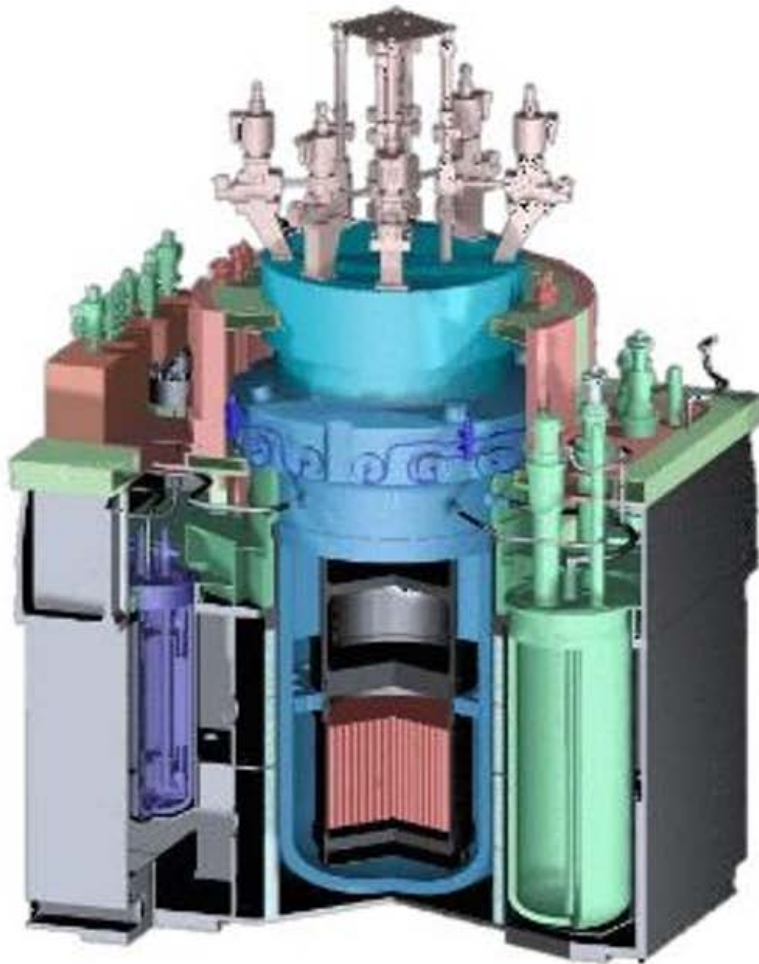


Concept art for China's nuclear power plant. (Internet photo)

The 719th Research Institute of the China Shipbuilding Industry Corporation was appointed to establish China's first R&D center for floating nuclear power plants in central China's Hubei province, reports our Chinese-language sister newspaper Want Daily.



# ABV-6M



Reactor type: Pressurized light water reactor

Coolant/moderator: Light water

System pressure: 15.7 MPa

System temperature: 330°C

Thermal capacity: 38 MW(th)

Electrical capacity: 100 MWe

Design life: 60 years

Fuel material:  $\text{UO}_2$

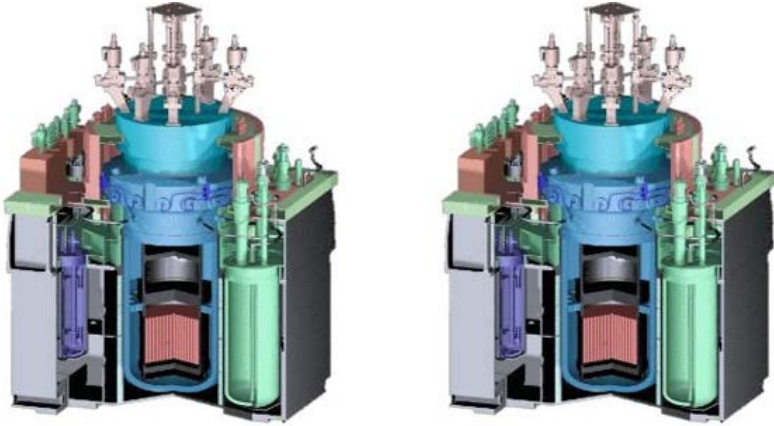
Fuel enrichment: 19.7%

Reactor core life: 10 years

Design status: Detailed design

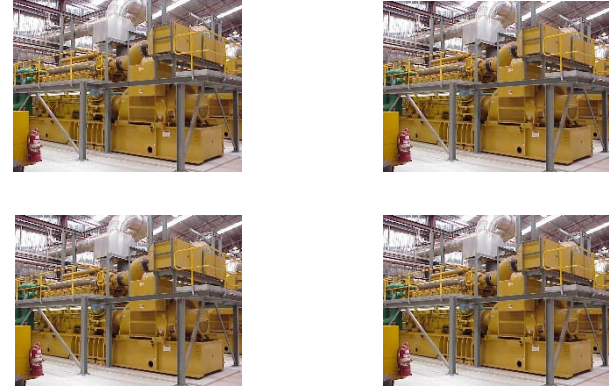
Distinguishing features: Natural circulation in the primary circuit for land based and floating nuclear power plants

## 16MWe **ABV-6M** Plant



Annual power production 126,000 MWh

## 16 MWe Diesel Plant



Annual power production 126,000 MWh

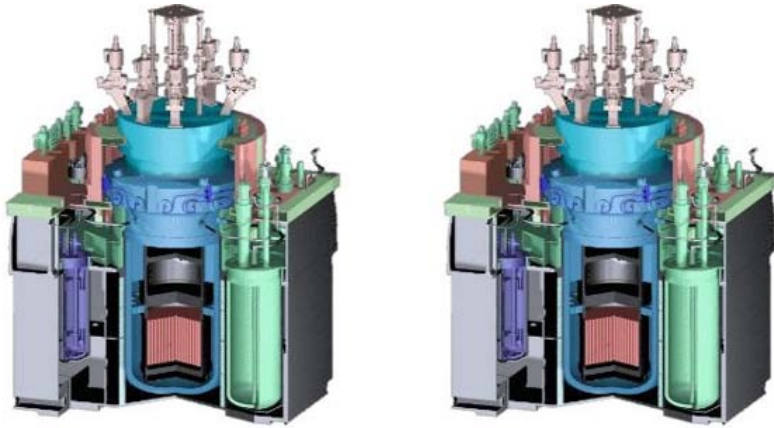
Annual fuel logistics 31,500,000 L



**630+ Super B loads**

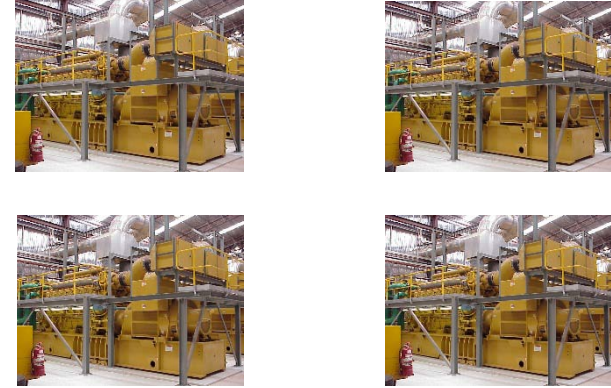


### 16MWe **ABV-6M** Plant



Annual power production	126,000 MWh
Annual fuel logistics	<b>0</b>

### 16 MWe Diesel Plant



Annual power production	126,000 MWh
Annual fuel logistics	31,500,000 L
Annual GHG production	85,000 t



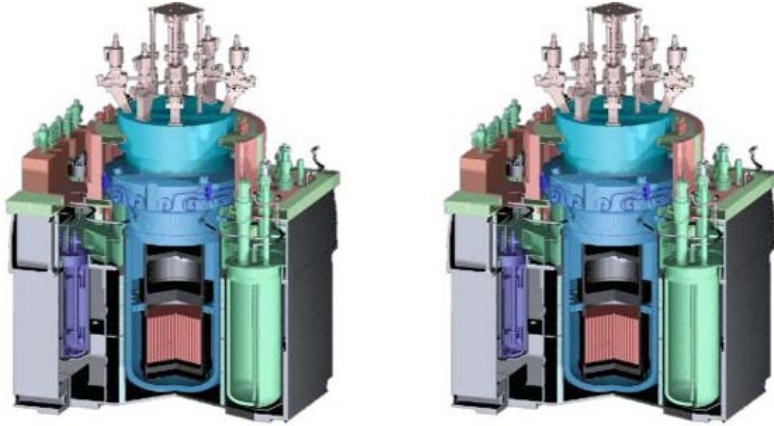


*Whoa !... How much CO<sub>2</sub> did you say??*

**16 MWe diesel electric = 85,000 tonnes CO<sub>2</sub> annually**

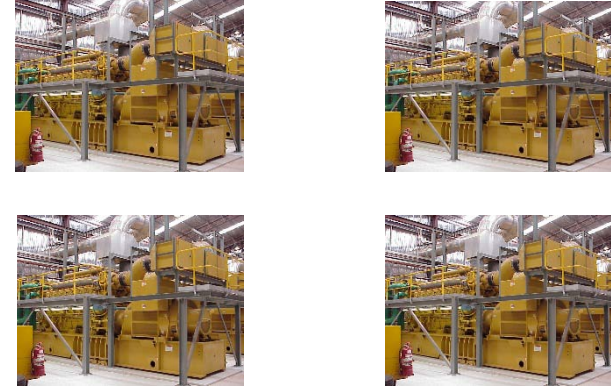


### 16MWe **ABV-6M** Plant



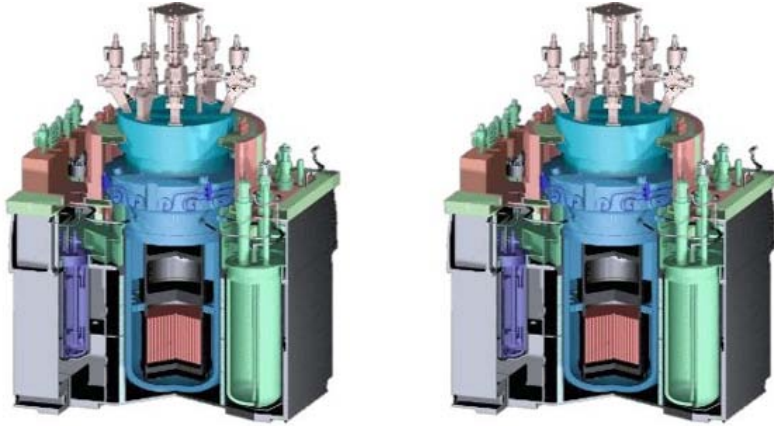
Annual power production	126,000 MWh
Annual fuel logistics	<b>0</b>
Annual GHG production	<b>0</b>

### 16 MWe Diesel Plant



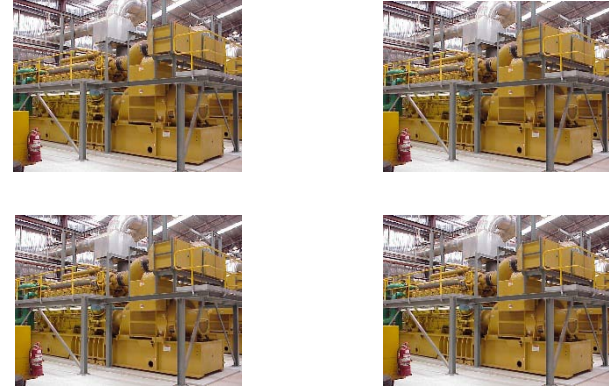
Annual power production	126,000 MWh
Annual fuel logistics	31,500,000 L
Annual GHG production	85,000 t
SOx, NOx, VOC, Soot	YES

### 16MWe **ABV-6M** Plant



Annual power production	126,000 MWh
Annual fuel logistics	<b>0</b>
Annual GHG production	<b>0</b>
Annual SOx, NOx, VOC, Soot	<b>0</b>

### 16 MWe Diesel Plant



Annual power production	126,000 MWh
Annual fuel logistics	31,500,000 L
Annual GHG production	85,000 t
SOx, NOx, VOC, Soot	YES
Annual Carbon <b>Tax</b> \$	?



## THE GLOBE AND MAIL

**KEITH NEUMAN**

### Canadians are ready for a carbon tax. Is anyone listening?

**KEITH NEUMAN**

The Globe and Mail

Published Monday, Mar. 11 2013, 8:46 AM EDT

Last updated Monday, Mar. 11 2013, 2:36 PM EDT

### The changing climate and a much-needed carbon tax

**MICHAEL VAUGHAN**

Special to The Globe and Mail

Published Tuesday, Sep. 11 2012, 3:36 PM EDT

Last updated Tuesday, Sep. 11 2012, 3:43 PM EDT



**BREAKINGVIEWS**

### Carbon tax would beat green energy credits

**DANIEL INDIVIGLIO AND CHRISTOPHER SWANN**

Reuters Breakingviews

Published Thursday, Jan. 17 2013, 5:23 PM EST

Last updated Thursday, Jan. 17 2013, 5:23 PM EST

### Scientists call for dramatic steps to curb emissions

**NATHAN VANDERKLIPPE AND SHAWN MCCARTHY**

The Globe and Mail

Published Monday, Feb. 25 2013, 6:00 AM EST



### Carbon tax the best route: academic

**RICHARD BLACKWELL**

From Friday's Globe and Mail

Published Friday, Jan. 15 2010, 12:00 AM EST

Last updated Thursday, Aug. 23 2012, 1:45 PM EDT

Carbon Tax = \$15 per tonne

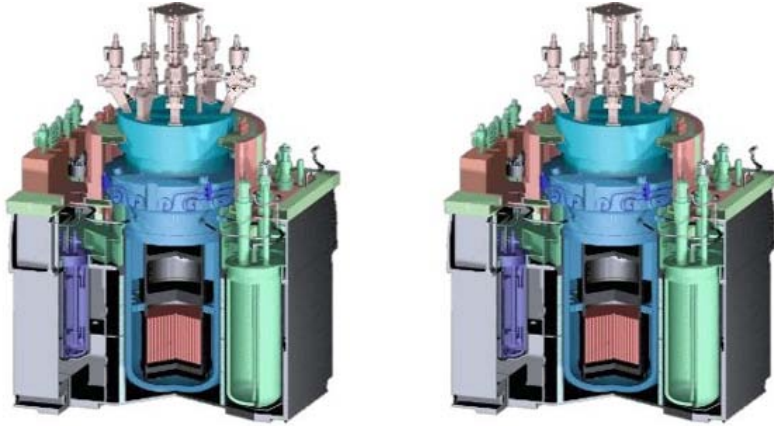
16 MWe Diesel Plant = 85,000t = Carbon **Tax** \$1,275,000

# Carbon Tax = \$15 per tonne

16 MWe Diesel Plant = 85,000t = Carbon **Tax** \$1,275,000

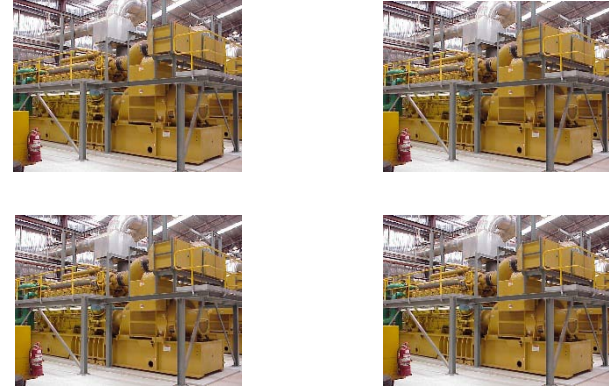
16 MWe **ABV-6M** Plant = **0**t = Carbon **Credit** \$1,275,000

### 16MWe **ABV-6M** Plant



Annual power production	126,000 MWh
Annual fuel logistics	<b>0</b>
Annual GHG production	<b>0</b>
Annual SOx, NOx, VOC, Soot	<b>0</b>
Annual Carbon <b>Credit</b> \$	?

### 16 MWe Diesel Plant



Annual power production	126,000 MWh
Annual fuel logistics	31,500,000 L
Annual GHG production	85,000 t
SOx, NOx, VOC, Soot	YES
Annual Carbon <b>Tax</b> \$	?



**Is nuclear energy safe?**

**Is nuclear energy safe?**

**YES**

## Who regulates nuclear energy in Canada?



Canadian Nuclear  
Safety Commission

Commission canadienne  
de sûreté nucléaire

Canada

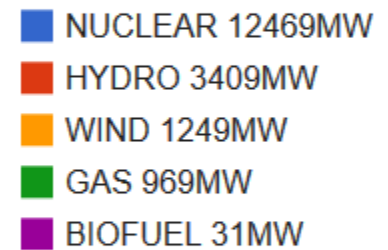
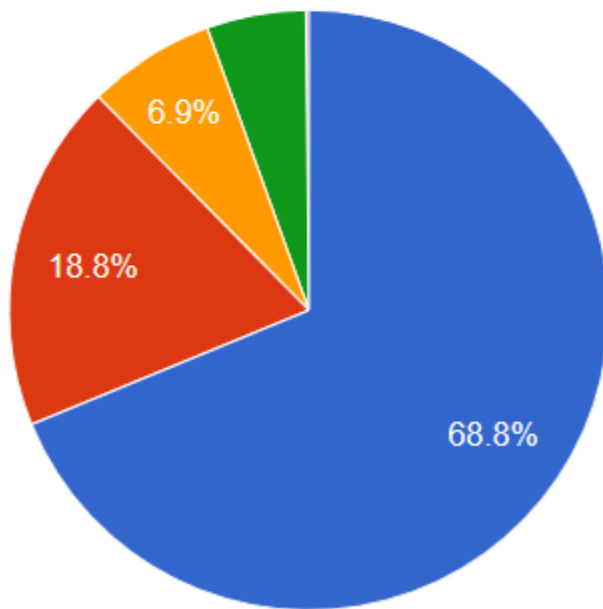
<http://www.cnscccsn.gc.ca/eng/>

*“The Canadian Nuclear Safety Commission (CNSC) protects the health, safety and security of Canadians as well as the environment, and respects Canada's international commitments on the peaceful use of nuclear energy.”* opening paragraph of CNSC website

## Electricity Generated in Ontario

Mar 27 2015 07:45

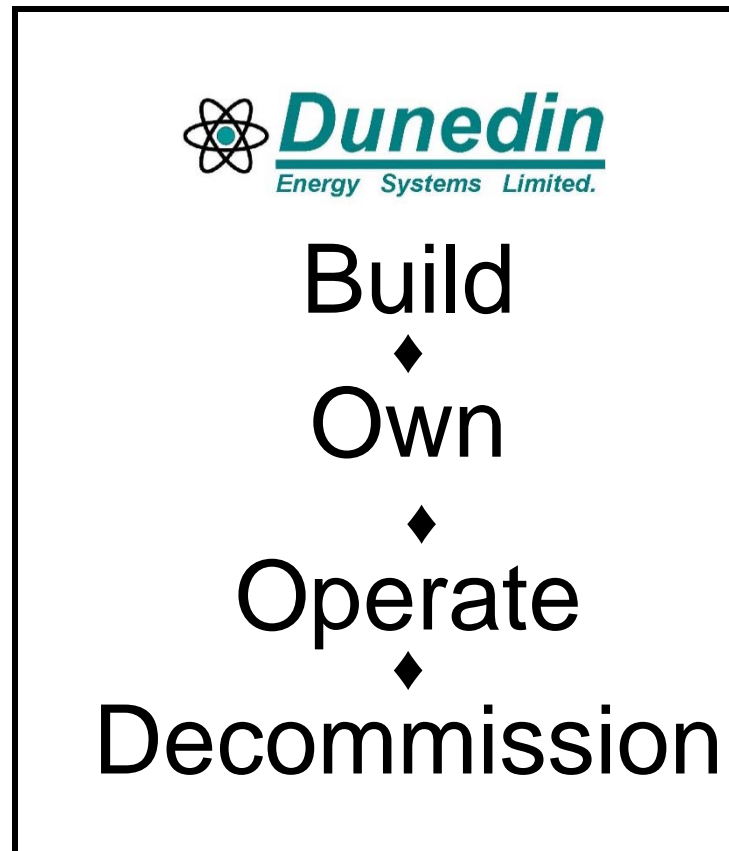
### Generation Totals





**How much does it cost?**

# How much does it cost?



What happens when the  
power plant is no longer  
needed?

# Site decommissioning and remediation



## Site decommissioning and remediation

- Decommissioning funds are held in escrow

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- Decommissioning funds are held in escrow
- Funding requirements subject to review during periodic license renewal

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- Entire power plant will be completely removed, site returned to original state

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- Decommissioning funds are held in escrow
- Funding requirements subject to periodic review
- Entire power plant will be completely removed, site returned to original state
- No residual radioactivity



# SUMMARY

- Clean, safe, affordable energy is key to mine profitability and resource development
- Current diesel energy model is not sustainable
- Small floating nuclear power plants can be an important part of the solution in the future energy mix

QUESTIONS?



ABOUT NREL

ENERGY ANALYSIS

SCIENCE & TECHNOLOGY

TECHNOLOGY TRANSFER

TECHNOLOGY DEPLOYMENT

## Energy Analysis



*“nuclear power is similar to other renewables and much lower than fossil fuel in total life-cycle GHG emissions.”*

# Renewable Energy Sources and Climate Change Mitigation

## Special Report of the Intergovernmental Panel on Climate Change

