Total energy supply for remote Human Habitations

(Or “Nuclear North of 60”)

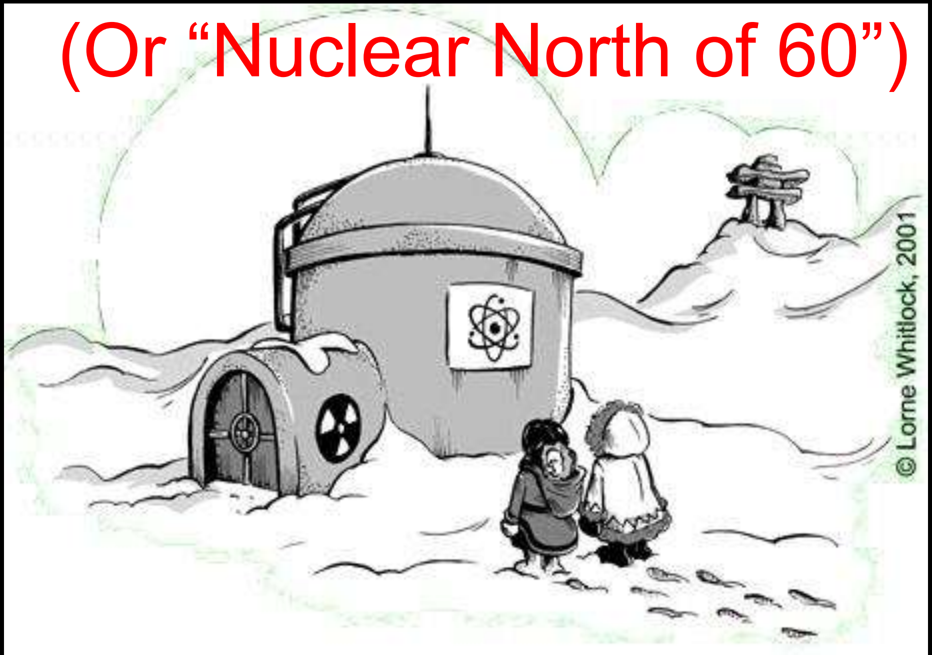


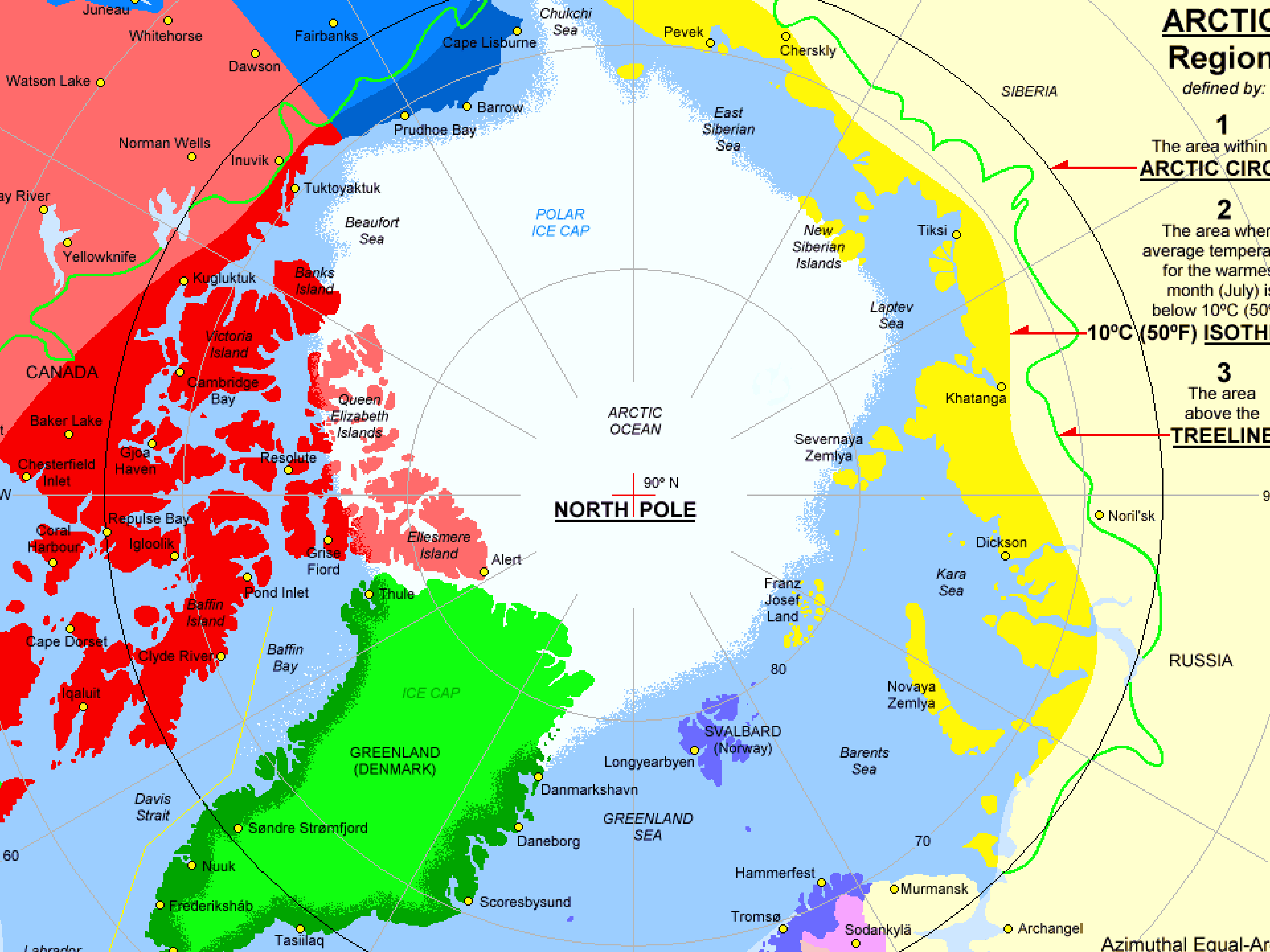
Image courtesy of *www.porkcoffee.com*

Prepared by: Jay Harris
Port Elgin, Ontario, Canada
Band member of Cowesses First Nation

Jay.k.harris@gmail.com

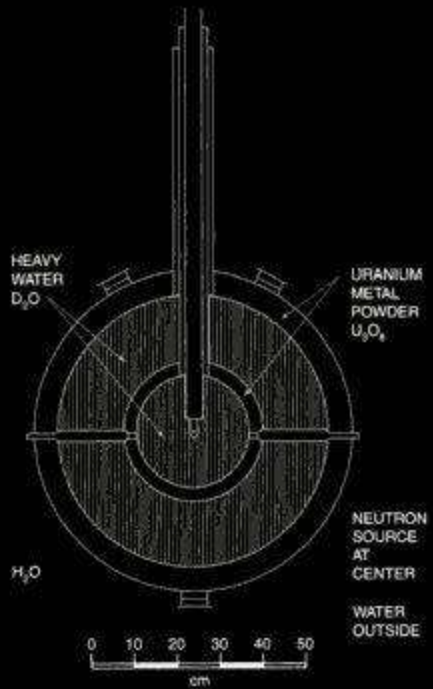
CNS Saskatoon Version


POLICE
RCMP
GRC



ARCTIC
Region
defined by:
1
The area within
ARCTIC CIRC
2
The area wher
average tempera
for the warmes
month (July) is
below 10ºC (50
10ºC (50ºF) ISOTH
3
The area
above the
TREELINE
Azimuthal Equal-Ar
Juneau
Whitehorse
Fairbanks
Chukchi Sea
Cape Lisburne
Pevek
Cherskly
Dawson
Watson Lake
SIBERIA
Barrow
Prudhoe Bay
Norman Wells
Inuvik
East Siberian Sea
Tuktoyaktuk
ay River
Beaufort Sea
POLAR ICE CAP
New Siberian Islands
Tiksi
Yellowknife
Kugluktuk
Banks Island
Laptev Sea
Victoria Island
CANADA
Cambridge Bay
Queen Elizabeth Islands
Khatanga
ARCTIC OCEAN
Baker Lake
Severnaya Zemlya
Gjoa Haven
Resolute
Chesterfield Inlet
90º N
NORTH POLE
Noril'sk
Repulse Bay
Coral Harbour
Igloolik
Grise Fiord
Ellesmere Island
Alert
Dickson
Pond Inlet
Thule
Franz Josef Land
Kara Sea
Baffin Island
Cape Dorset
Clyde River
Baffin Bay
RUSSIA
80
Iqaluit
ICE CAP
Novaya Zemlya
SVALBARD (Norway)
GREENLAND (DENMARK)
Barents Sea
Longyearbyen
Danmarkshavn
Davis Strait
GREENLAND SEA
Søndre Strømfjord
Daneborg
70
60
Nuuk
Hammerfest
Murmansk
Frederikshåb
Scoresbysund
Tromsø
Sodankylä
Archangel
Tasiilaq
Labrador

A short history on Small Nuclear Reactors

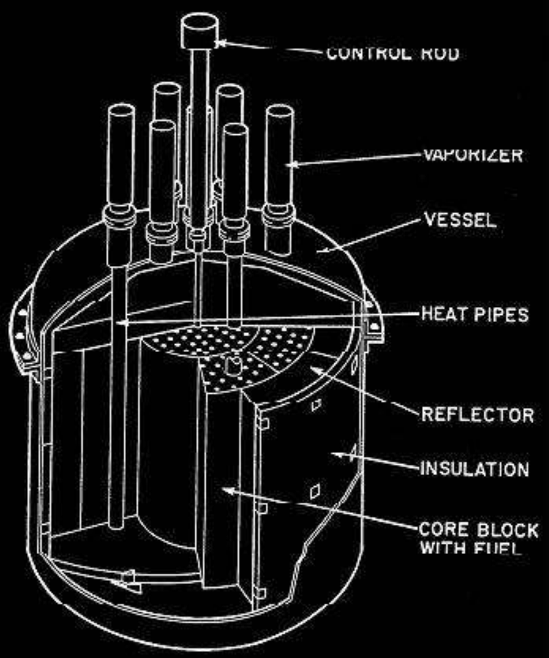


Heisenberg's Leipzig L-IV; 1942

(Sub-critical pile; also the world's first reactor accident)

USS Nautilus; 1955

(World's first nuclear submarine)

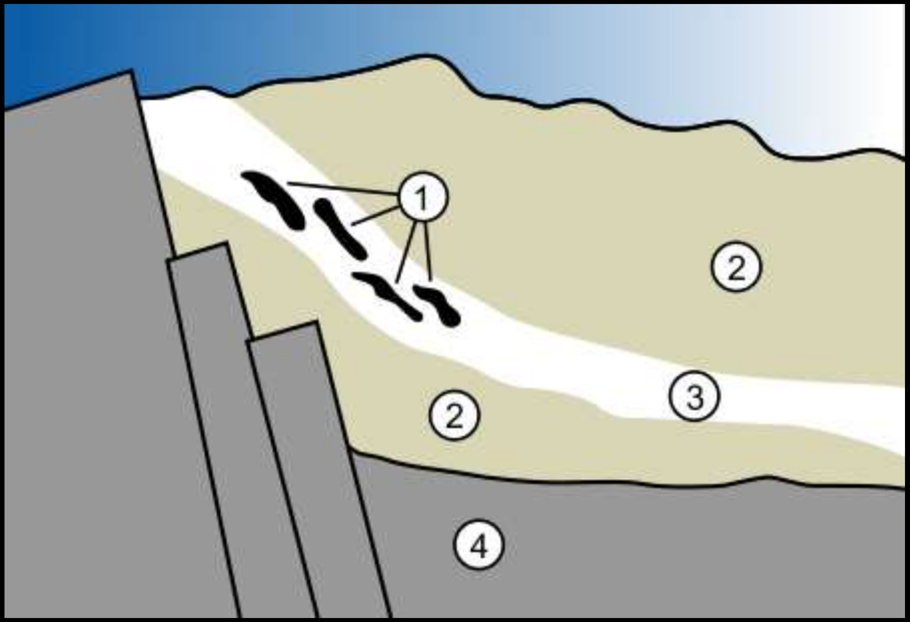


AECL Nuclear Battery proposal; 1988

(600 KWe AECL proposal)

or; "Planes, Trains, Automobiles...*and lots of Boats*"

2 Billion years ago; Oklo, Gabon



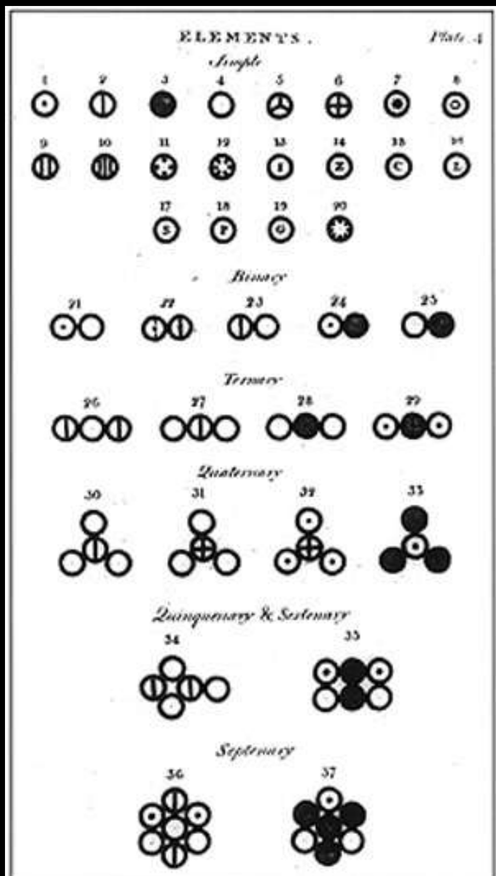
Geological situation in Gabon leading to natural nuclear fission reactors

1. High Uranium concentrations
2. Porous Sandstone
3. Uranium ore layer
4. Granite

2 Billion years ago natural uranium contained ~3% U-235 by isotopic content. The naturally occurring content of U235 was even greater at the creation of the universe, and is slowly decaying. At the present time it exists at 0.7% in Natural Uranium.

In the Oklo natural reactors water percolated through the bedrock, and collected in the Uranium deposits. The light (Natural) water provided a moderating effect, and the portions of the ore deposit with high concentrations of uranium became critical. The ore deposits effectively became naturally occurring, light water reactors.

Early research into Nuclear Fission



Various atoms and molecules as depicted in John Dalton's *A New System of Chemical Philosophy* (1808).

1805 John Dalton proposes the theory of the atom, and publishes his list of atomic weights.

1898 Pierre and Marie Curie discover Radium

1899 Ernest Rutherford classifies Apha, and Beta radiation.

1900 Gamma rays discovered by Paul Villard.

1902 Gilbert Lewis proposes ‘cubic model’ of the atom.

1904 Hantaro Nagaoka proposes ‘Saturnian Model’ of the atom.

1904 J.J. Thompson proposes plum pudding model of the atom.

1911 Ernest Rutherford develops, ‘Planetary atomic model’

1913 Neils Bohr develops the modern quantum atomic model

1914 Ernest Rutherford discovers Protons

1920 Rutherford ‘predicts’ existence of the Neutron

1929 Ernest Lawrence invents the Cyclotron

1932 James Chadwick discovers the Neutron

1934 Leo Szilard files a patent for an ‘Atomic Explosive’

1938 **Lise Meitner**, and **Otto Hahn** discover Nuclear Fission

1939 A busy Year

Hahn

Meitner

Strassman

January 1939: Hahn and Strassman publish their findings on fission. Meitner is not mentioned, however is considered by many to be the ‘Mother of Fission’ having interpreted the results of the experiment.

Straus

January 1939: Leo Szilard writes to Lewis Strauss, informing of the development of fission. Including it’s applications both as an energy source, and as an explosive device.

Szilard

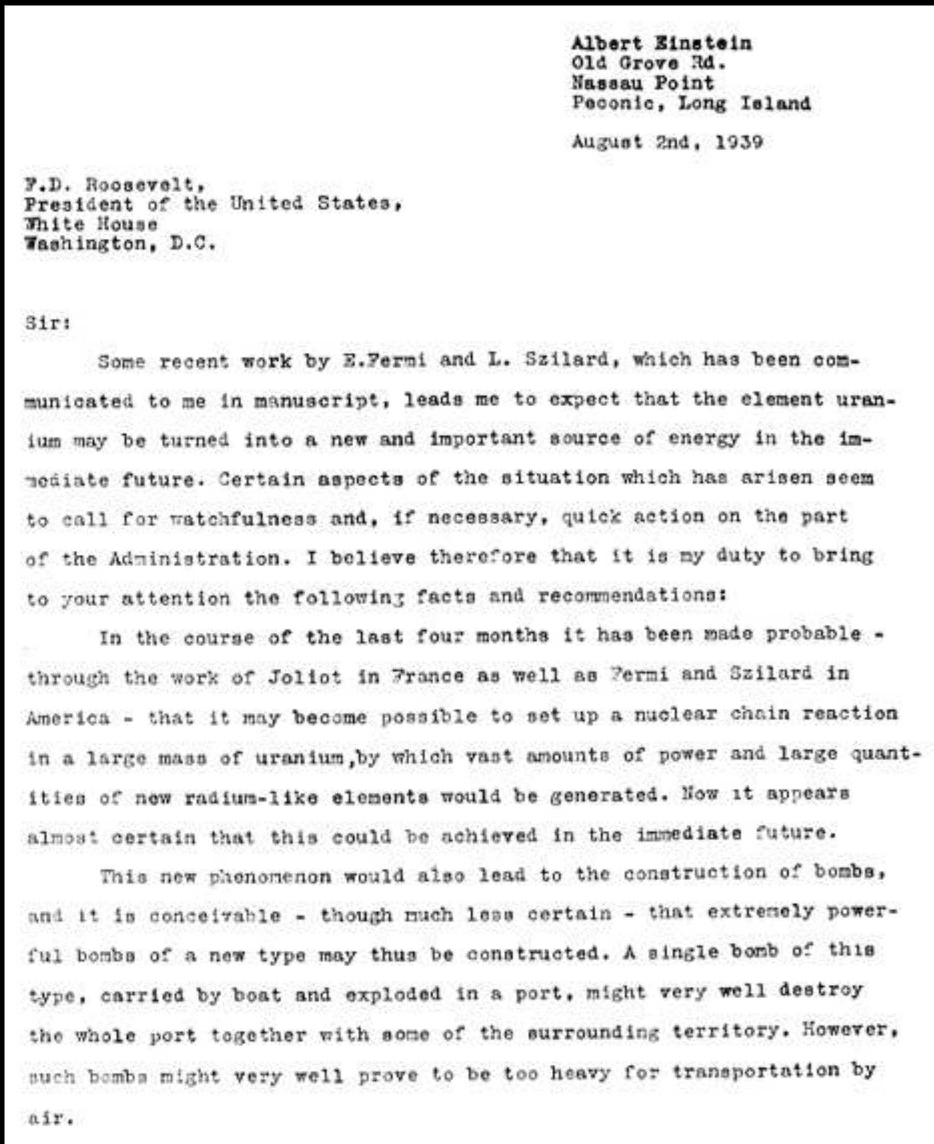
By the 26th of January 1939: Frisch in Copenhagen; Joliot in France; Dunning, Slack, and Booth at Columbia University all experimentally confirm the Hahn, Meitner, Strassman findings.

8th of March, 1939: Halban, Joliot, and Kawarski discover further neutrons are emitted in fission.

15th of March, 1939: At Columbia, Fermi, Anderson and Hanstein, and Szilard and Zinn, complete experiments which parallel the French work. Also on this date German troops seize the free remnant of Czechoslovakia.

April, 1939: The Paris team, and the Columbia group independently find that 2 or 3 Neutrons are emitted during fission. Enough to make a chain reaction possible.

1939 Gets busier still…



Albert Einstein
Old Grove Rd.
Nassau Point
Peconic, Long Island

August 2nd, 1939

F.D. Roosevelt,
President of the United States,
White House
Washington, D.C.

Sir:

Some recent work by E.Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendations:

In the course of the last four months it has been made probable - through the work of Joliot in France as well as Fermi and Szilard in America - that it may become possible to set up a nuclear chain reaction in a large mass of uranium,by which vast amounts of power and large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable - though much less certain - that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.

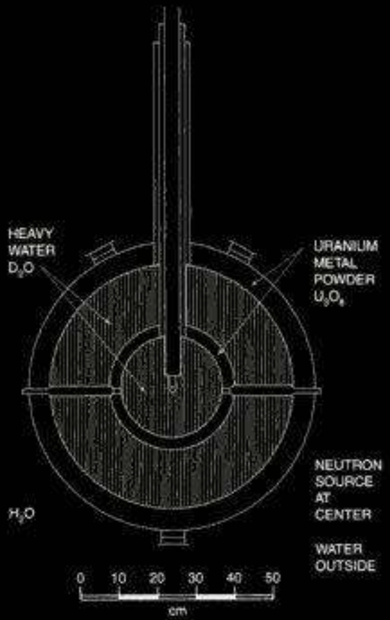
April 1939: American, British, French, German, and Russian scientists all approach their respective governments to seek support for fission research and a watch on uranium supplies.

September 1st, 1939: Germany invades Poland, World War II begins in Europe.

Bohr and Wheeler publish theory of fission; they show that only the isotope U-235 will fission more easily than U-238, and is more likely to occur with slow neutrons building on the research of Fermi in the U.S. ***This is one of the last openly published papers on fission research.***

August 2nd, 1939: Szilard drafts, then Einstein signs and delivers a letter to President Roosevelt. In it he indicates the military implications of fission, and uranium. Roosevelt sets up an advisory committee on Uranium.

From <u>1939 to 1945;</u> a great deal happened. Including the Manhattan Project, and the bombings of Nagasaki, and Hiroshima. We will only deal with issues relating to small, modular, and deployable reactor technology. Some mention of other milestones will be included for reference.



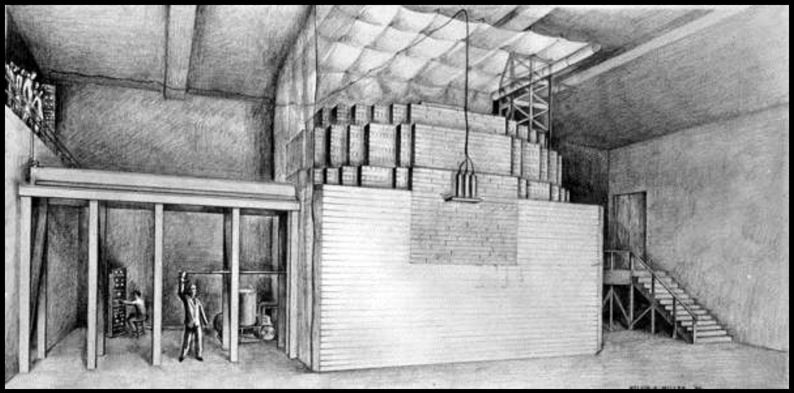
The Leipzig L-IV

April 1942; (Germany) Werner Heisenberg achieves 13% neutron multiplication in the Leipzig L-IV pile (reactor). The L-IV is driven by a neutron source, and is not a self sustaining fission reaction. As such it is not considered to be the first “Critical” reactor.

June 23rd, 1942; The Leipzig L-IV is destroyed in a fire. The powdered Uranium fuel of the L-IV is contaminated by water leaking into the fuel jacket. A pyrophoric reaction occurs, and Heisenberg’s Leipzig lab is destroyed in a fire. The Leipzig experiments are abandoned in favor of other reactor designs.

December 2nd, 1942; Enrico Fermi achieves criticality in the Chicago Pile, as part of the Manhattan Project.

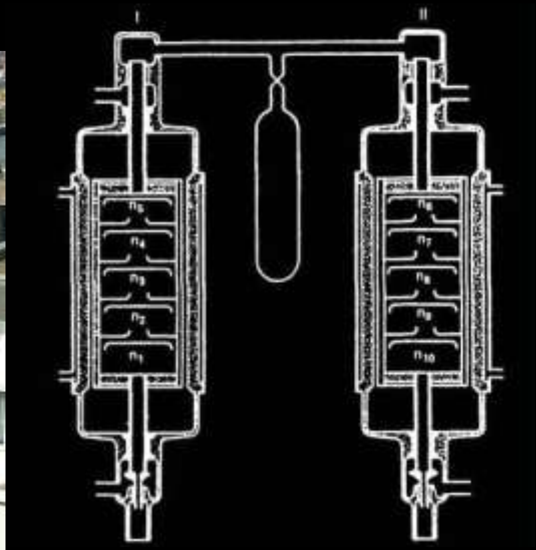
The Chicago Pile CP-1



Also in 1942; Paul Harteck (Germany) perfects the gaseous centrifuge for Uranium enrichment, building on the earlier work of Eric Bagge (Germany). This remains the most prevalent method of Uranium enrichment today.

July 1943; The Kriegsmarine (German Navy) moves the U-boat nuclear propulsion project from Hamburg following American aerial bombardment. Admirals Otto Rhein, and Karl Witzell oversee the project. Physicist Dr. Otto Haxel takes over scientific leadership of the "Oberkommando der Marine" (OKM) nuclear project.

Type XXI Uboat, proposed platform for Kriegsmarine Nuclear Propulsion Program



Harteck's double rocking gas centrifuges

Dr. Paul Harteck

In April 1944 Paul Harteck (Germany) gains funding for industrial scale enrichment of uranium. Orders were placed with BMAG Meguin for production of gaseous uranium centrifuges.

May 7^{th}, 1945 Germany Surrenders.

August 15^{th}, 1945 Japan Surrenders. World War II is officially over.

May 28^{th}, 1946; US Army Airforce undertakes the “Nuclear Energy for the Propulsion of Aircraft” Project.

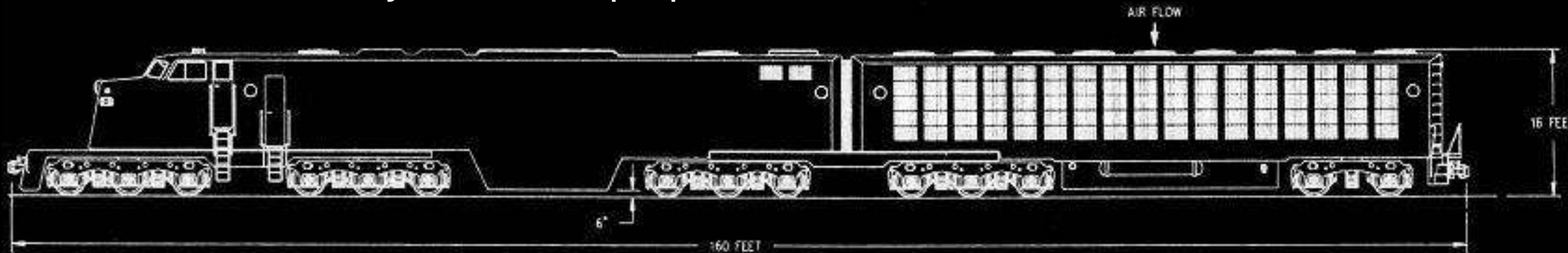
1953; Under the leadership of Admiral Rickover the first U.S. naval reactor achieves criticality.

1954; The US ARMY Nuclear Power Program (ANPP) begins.

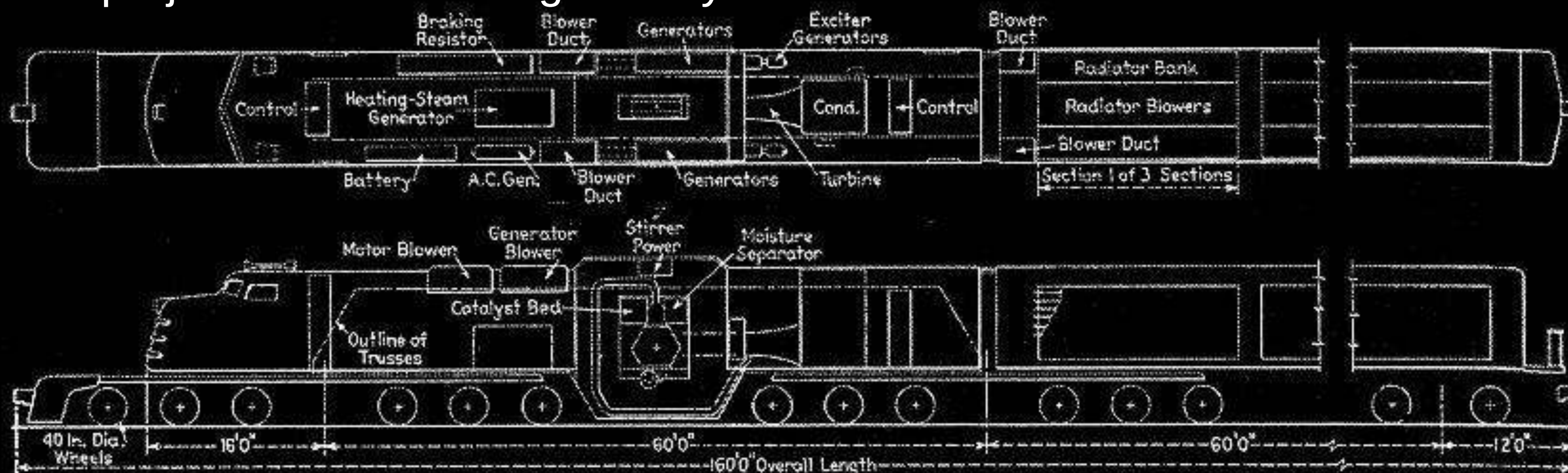
June 27^{th}, 1954; (Soviet Union) The AM-1 the world’s first Civil Nuclear Power Plant is commissioned at Obninsk, Russia (6 MWe). After 48 years of accident-free operation the plant was shut down on the 29^{th}, of April, 2002.

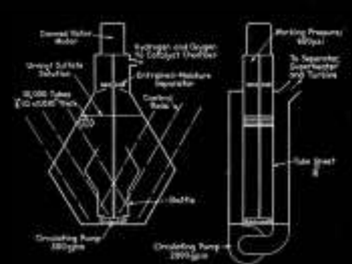
Undated photos of the Obninsk Power plant. Located 102 km’s southwest of Moscow.

June, 1954; Dr. Lyle B. Borst proposes an atomic locomotive. The X-12.

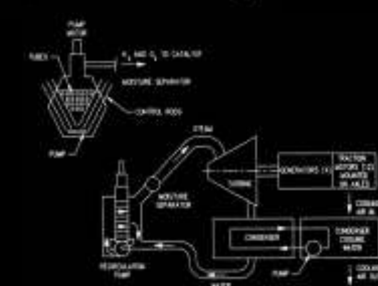


The X-12 was to feature a Uranyl Sulfate liquid fuel reactor. The locomotive was to include ‘on power’, and ‘on board’ ***reprocessing*** equipment. Refuelling intervals were projected to be as long as 10 years.





The X-12 was to compete economically with diesel locomotives of the day when amortization of the long fuel cycle was considered. It was never constructed.



Circa 1950's another Atomic locomotive proposal from West Germany.

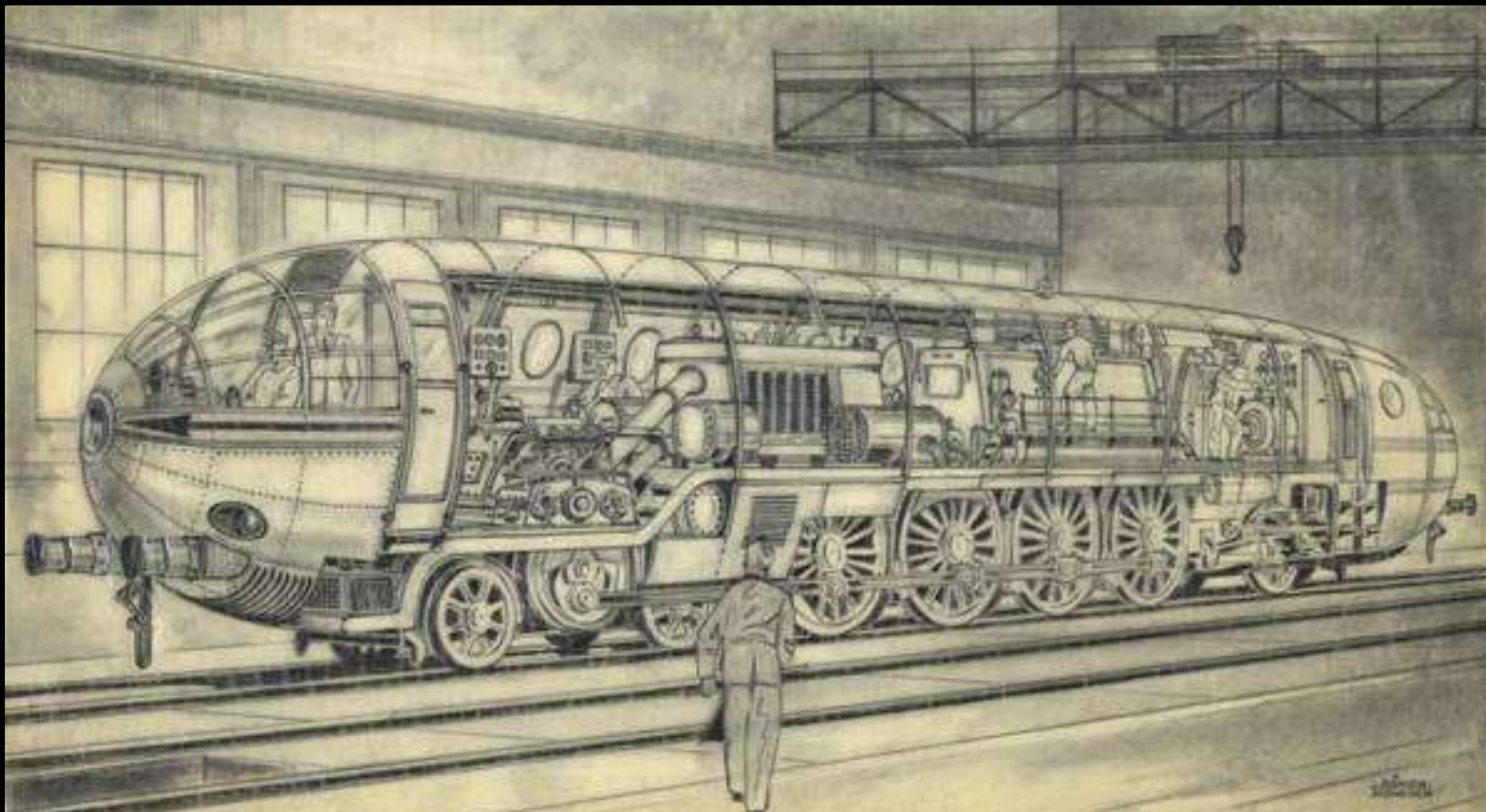
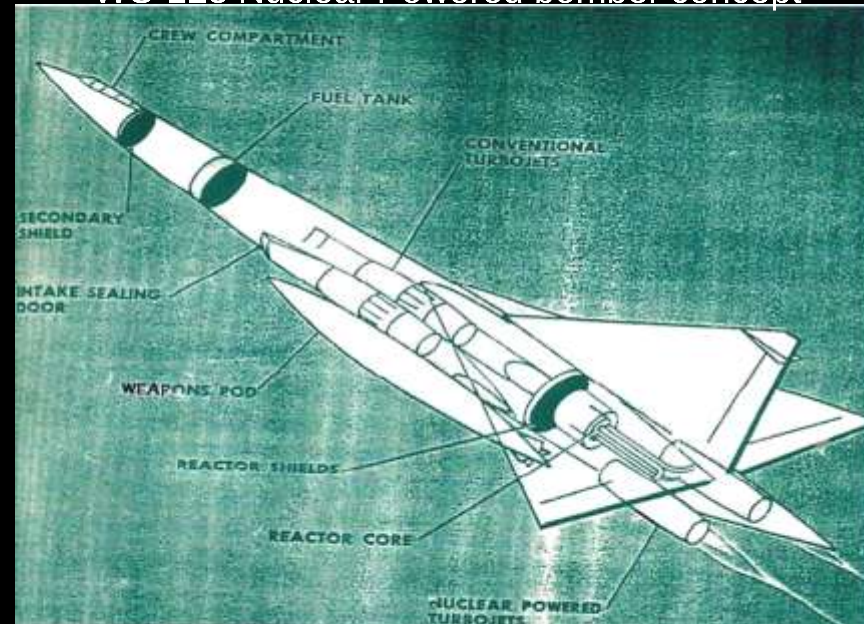


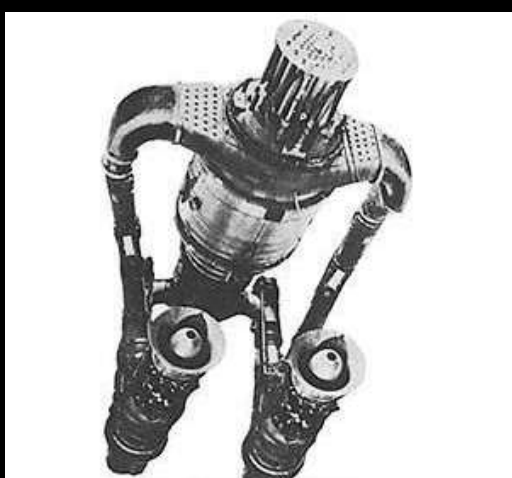
Image courtesy of the "Deutsches Museum" www.deutschesmuseum.de

July 1955; First flight of the Convair X-6 with a 3 MW thermal air cooled reactor. The reactor is not propulsive, but only for airborne shielding tests.

Convair X-6 Flying reactor test bed

WS-125 Nuclear Powered bomber concept





The HTRE-3 without supporting structure.

Left: The HTRE-3 reactor showing the relation of the turbines to the reactor.

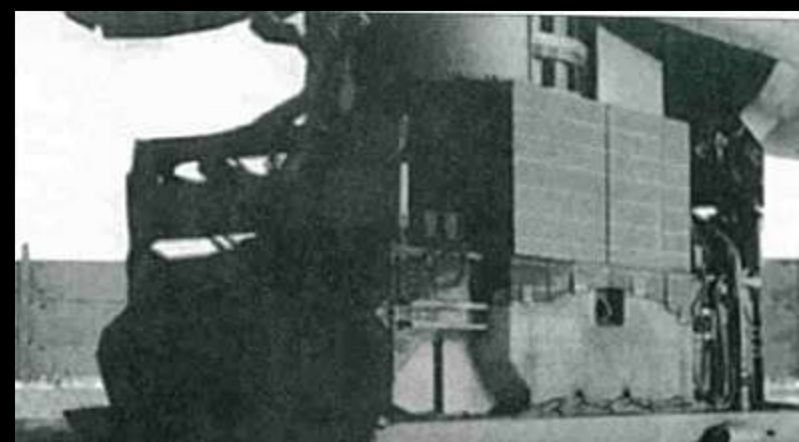
Right: The HTRE-3 reactor – turbine test stand. *(Yes it worked!)*

HTRE-3

August 12th, 1955; The Council of Ministers (Soviet) issues a mandate for the development of a Nuclear Powered Bomber.

Tupolev TU-95 LaL Flying reactor test bed

An early impression of the Myasichev M-60 Nuclear powered bomber.



Bomb bay mounted flight test reactor TU-95

Early 1961; Soviet Leadership calls for the cancellation of all Nuclear Aircraft Propulsion projects.

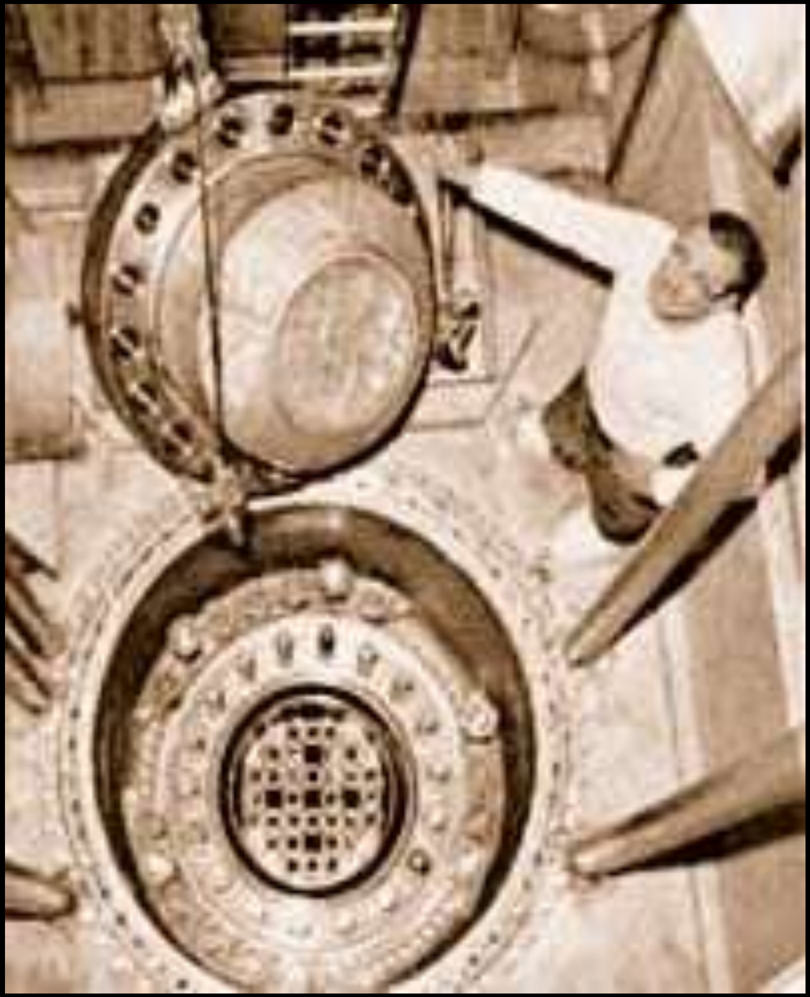
1955; The USS Nautilus, becomes the world's first nuclear powered submarine.

The USS Nautilus; circa 1964

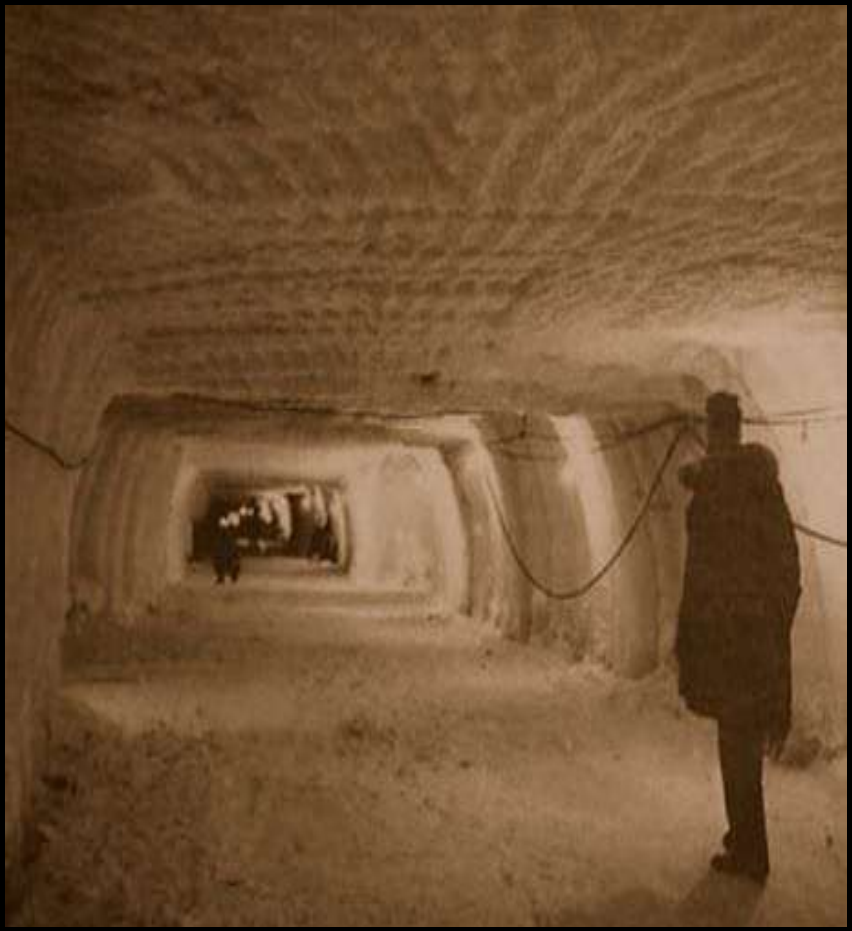
July, 1958; The Soviet Union puts it's first nuclear submarine into service. The K3 'Leninsky Komosoll', the first November class remained in service until 1988.

Left: A 'November' on patrol. (Undated photo)

October 1960; The PM2A, 2 MWe, (plus district heating) Achieves criticality, at Camp Century, Greenland. The first "portable" nuclear power reactor. Brought to Greenland in parts, assembled, operated, disassembled, and shipped back.



Far Left: The PM2A core.



Remaining photos are images of the ‘under the ice’ nature of Camp Century.

1959; (Soviet Union) The NS Lenin a Nuclear Powered Icebreaker enters service as the world's first Nuclear Icebreaker, and the first Nuclear Civilian vessel.

A postcard, and postage stamp featuring the NS Lenin. The Stamp is dated 1978.

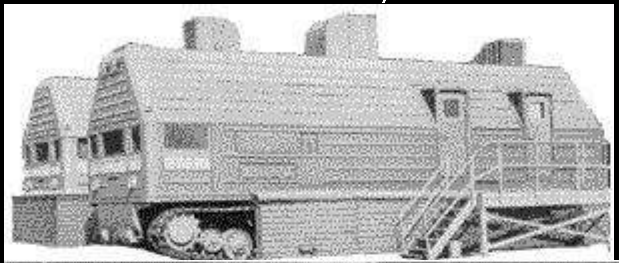
January 3rd, 1961; ANPP reactor, SL-1 is destroyed in a suspected suicide by an operator. This reactor was intended for use at Distant Early Warning (DEW) line radar stations in Canada. Due to the incident, and Canadian sensitivities this reactor was never deployed.

SL-1 Reactor Building prior to January 3, 1961. U.S. National Reactor Testing Station near Idaho Falls, Idaho, United States.

1962; The NS Savannah (United States) enters service. The second civilian nuclear vessel, but the first civil nuclear cargo vessel.

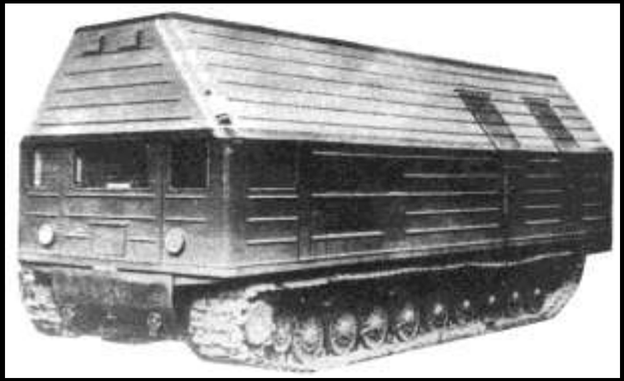
The NS Savannah

Sometime in 1961; The TES-3 concept is commissioned at Obninsk, Russia.

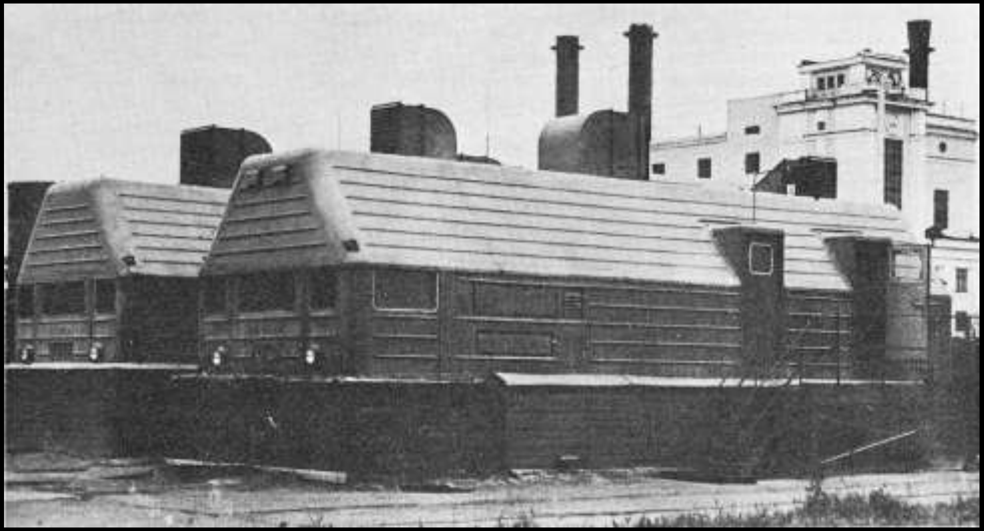


Left: TES-3 Mobile Reactor mounted on four crawler transporters.

Below: TES-3 In deployed, and mobile mode.

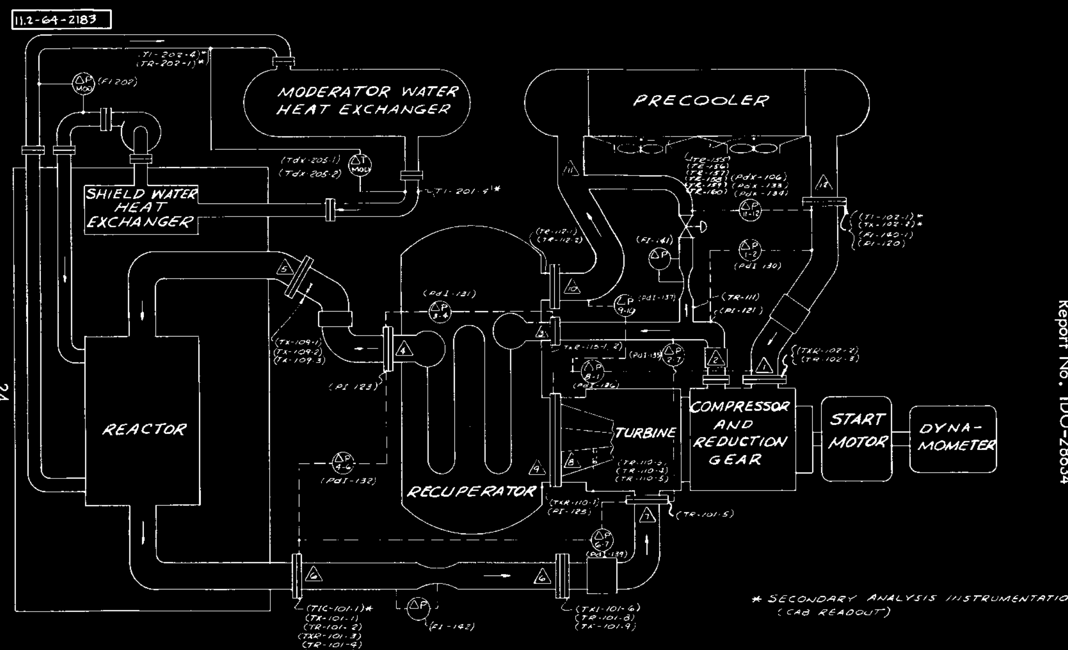


The TES-3 was a 2 MWe, and 8.8 MWt reactor. The unit was intended for remote air defence bases. This reactor was light water cooled, and used Highly Enriched Uranium fuel. The unit was intended to be shielded with earthworks at the establishing site. There is no indication this design went into production, or deployment beyond prototype testing.



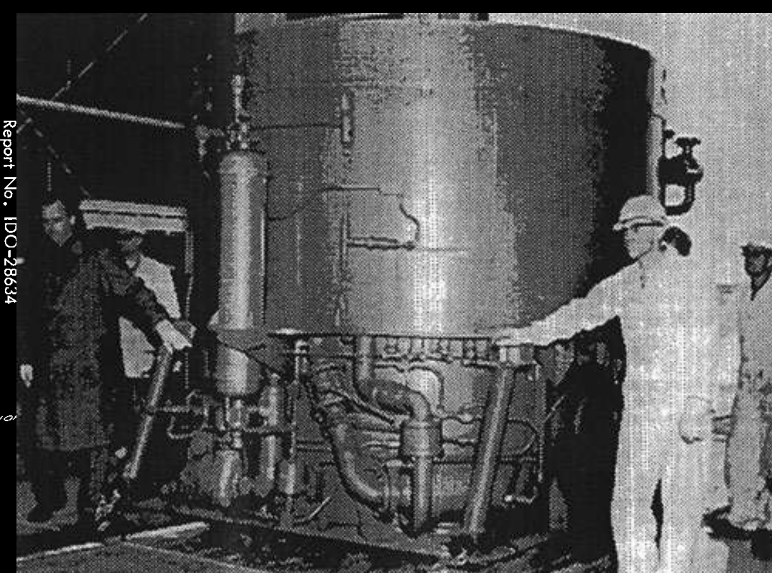
March 30th, 1961. The ML-1 (U.S. ANPP) reactor goes critical. The reactor could fit into a single box, however the complete system required 6 shipping containers. The ML-1 is described as "the first nitrogen cooled, water moderated reactor with a nitrogen turbine energy conversion system."

The ML-1 was intended to be delivered by truck, air, rail, or barge.



NOTE: NUMBERS IN PARENTHESIS ARE EXPLAINED IN APPENDIX B.
NUMBERS IN TRIANGLES ARE STATE POINTS.

FIGURE 9. ANALYSIS INSTRUMENTATION SENSOR LOCATIONS ML-1



1962; ANPP reactor PM1 is commissioned at Sundance, Wyoming, and operated by the U.S.Airforce. The Unit powers a radar station providing 1.25 MWe, plus district heating until decommissioning in 1969.

March 1962; The PM3A ANPP (Navy operated) reactor is deployed to McMurdo Station, Antarctica. This reactor continues to operate until 1972 when it is taken out of service due to a leak. The reactor provided 1.75 MW of Electricity, seawater desalination, and district heating. The reactor, facilities, and 7700 cubic meters of contaminated dirt were removed to California on decommissioning in 1972

McMurdo Station, Antarctica

March 1962; The SM1A ANPP is deployed to Fort Greely, Alaska. Providing 2 MW Electrical plus district heating. This reactor was decommissioned in 1969. The site suffered several mechanical incidents, including a frozen cooling pipe resulting in large environment discharge of activated water to the environment. The reactor has since been disassembled, and removed from the site.

Fort Greely Reactor building

Image courtesy of Mark Farmer

Fort Greely, Alaska

1967; The MH-1A (ANPP) goes critical. As a ‘barge’ mounted reactor, it was positioned in Panama in 1968, providing 10 MW of electricity, and desalination to the adjacent base. The unit was removed in 1976 with cessation of U.S. zone ownership. This unit was built on the hull of a ‘Liberty ship’ (SS Charles H Cugle), and became the first floating nuclear power plant, renamed “The Sturgis”.

The MH-1A installed in “The Sturgis”

Containment vessel of the MH-1A reactor

March 28th, 1979; The generating Station at Three Mile Island suffers a partial core meltdown. There is a release of contaminated water from the plant due to operator error, and equipment malfunction, however the containment of the Reactor Vault remains intact.

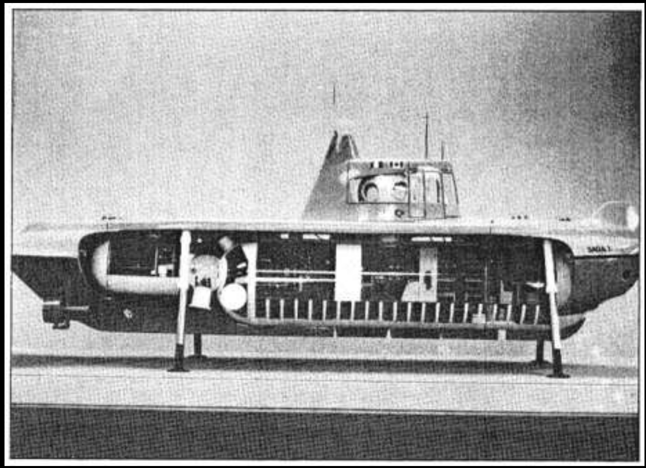
1979 (approx.); The U.S. Army Nuclear Power Program (ANPP) ends.

1981 (Approx.); The Soviet Union begins work on the Pamir concept. This is a reactor plant built on two off road trucks originally designed to carry mobile ICBM's. The reactor was designed to produce 650KWe, and use no water. It was cooled with Dinitrogen Tetroxide. During the development 60 emergency shutdowns occurred, resulting in releases of N_20_4, and radioactive particles.

The Pamir Project was cancelled in 1986.

Early 1980’s; The Royal Military College of Canada, works on a proposal to develop an Autonomous Marine Power Source (AMPS). This module was based on Slowpoke (unpressurized) reactor technology, driving an organic Rankine cycle (Freon turbine), to constantly recharge the submarine’s batteries. This module was supplementary to the vessel, it was never meant to replace the diesels of the sub.

1984; **International Submarine Transportation Systems Ltd** is formed in Canada; a consortium of four companies. The French Institute for Exploration and Exploitation of the Seas (Ifremer) 25%, COMEX SA a French underwater salvage company 25%, International Submarine Engineering Ltd owning 45%, ECS Energy Conversion Systems Inc owning 5%. ISTS proceeds to jointly develop a civil submarine powered by the AMPS concept. This project is built on the hull of an existing submersible. The craft is named the “SAGA-N”.



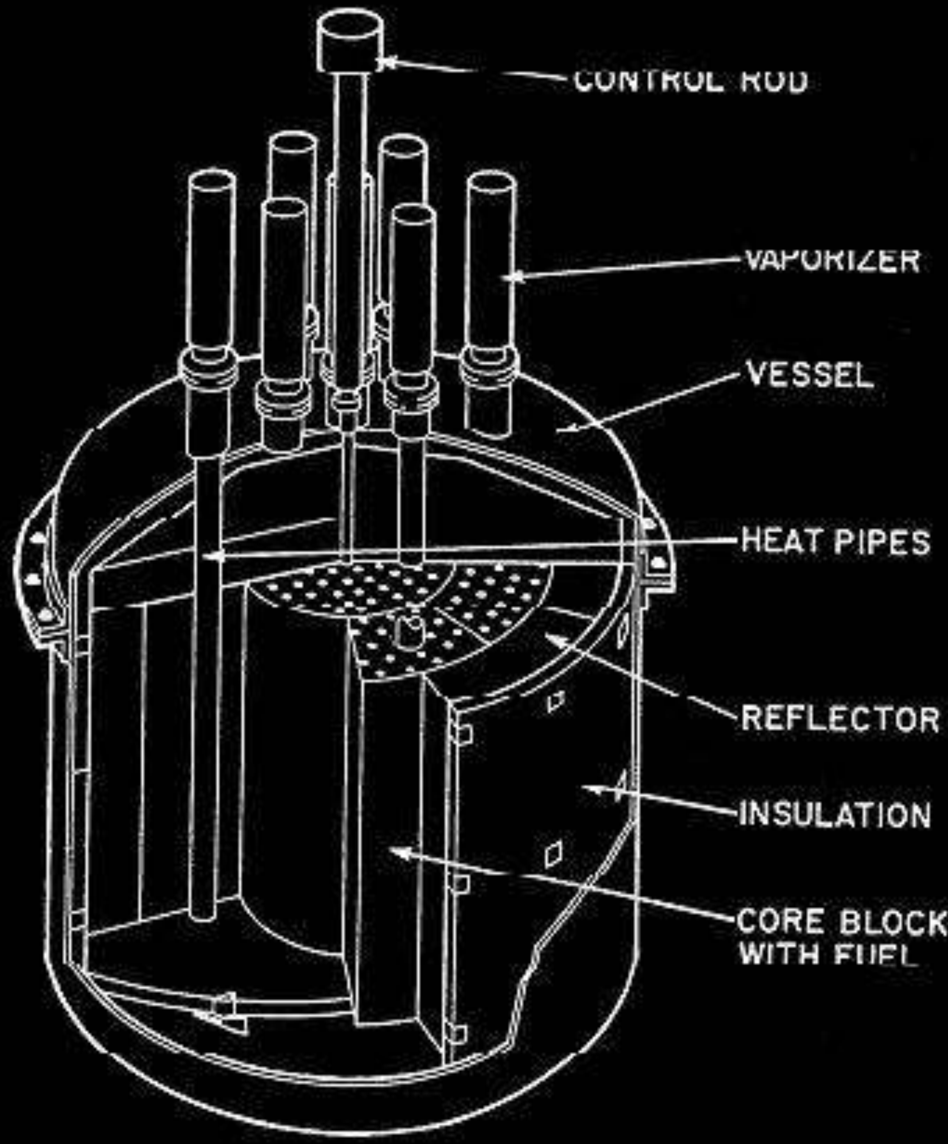
Images of the SAGA-N courtesy of the Canadian Nuclear Society.

In 1987; The project was cancelled due to a tax dispute over a research grant.

26th, of April 1986; The Chernobyl disaster occurs, near the Ukrainian town of Pripyat. During a test of emergency equipment the cooling pump's power supply is turned off, subsequently nearly all the control rods are removed from the reactor by an operator. The reactor power reaches 12,000%, a steam explosion occurs destroying the reactor vessel and most of the plant.

The fuel melts, and partially homogenises with the reactor's graphite moderator. The melted fuel/graphite mass melts through the remaining reactor vessel, and into the basement of the plant. The reactor building is partially destroyed by the steam explosion, the ensuing fire then spews radioactive particles, and steam out of the building and into the environment. Radiation detectors throughout the northern hemisphere detect fallout from the reactor catastrophe.

1988; Atomic Energy Canada Limited proposes and partially develops the AECL Nuclear Battery.



The AECL nuclear battery was to use low enriched uranium, and was graphite moderated. It was designed to be inherently safe (Hands off). It was passively cooled with heat pipes, and with it's low power density would not have enough energy to raise the core temperature high enough to allow any damage to the core or fuel assemblies. Further enhancing safety the design featured 'doppler broadening' which reduces the likelihood of fission as the core temperature rises. Thus if the core temperature exceeded engineered limits, the rate of fission would slow and lower heat output of the reactor.

This reactor was expected to operate for 15 full power years as a sealed unit, producing 630 KW of electricity.

In the mid 2000’s the price oil rose above $80US a barrel.

In 2005; Al Gore released his “An inconvenient truth” documentary.

In July of 2008; Oil peaked at $147US a barrel.

In 2007, the Territory of Nunavut spent $237 Million (CAD) on fuel, and fuel subsidies. -Source Canadian Press 15 July, 2008

In 2006 the population of Nunavut was 29,474.

This was before the oil spike in July of 2008.

The town of Resolute Bay from a hill overlooking the bay
Photo: G. Osinski, Canadian Space Agency

What sort of new capabilities would an operator have to add to service this area?

Heavy Airlift, and Rapid Airlift

What if…?

Terrorists tried to steal nuclear materials from one of these sites? What if they got in and blocked the runway? How would your security response work?





All of the prospective vendors have developed ‘hardened’ access, and designed their reactors to make it difficult to remove materials at the site. In some cases the reactors are actually buried great distances underground, and feature sealed vessels. This is without considering the deadly fields coming off of the materials themselves which would require special, and extensive handling facilities to remove from the site. It would also be important to remember that an initial response need only prevent these parties from leaving the site with the materials.

All of the sites would require monitoring in real time, security patrols, and inspections at regular intervals.

What if…?

There was an emergency?

In nearly every small reactor product, the core contains a relative low energy density. Further nearly all of the designs that could compete in this market feature inherent passive safety. In layman’s terms this is known as ‘hands off’ safety.

This means that even if you did nothing during a unexpected event, no failure would occur. In some cases the products cannot be made to fail even under malicious attempts. A number of the new generation small reactors rely on something called Doppler Broadening to reduce their reactivity as the temperature goes up.

Chinergy, a developer of a pebble fuel reactor in China, recently removed all the control rods, and turned off all the cooling in one of their prototype reactors. They let it sit in this state for days. The temperature of the core never exceeded design limits.

-Source ‘Wired Magazine’; “Let a thousand reactors bloom” September 2004.

Additionally new fuel technology (Triso for example), has raised the failure temperature of fuel assemblies to very high temperatures. These new encapsulated particle fuel designs do not permit anything to escape from the fuel, and are very resistant to damage, and deformation.

Emergency and Security Preparedness

The final word…

A fleet operator will have to provide security, and emergency response to support a given fleet of small reactors. Environmental monitoring, and emergent response would also be required.

This could only be accomplished over the great distances, and in these isolated locations with centrally coordinated air mobility, and remote monitoring.

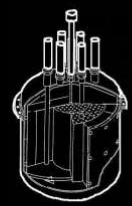
Pre-deployment kits, for security, environmental, and emergency situations would need to be assembled, and inventoried for immediate deployment by aircraft. The pre-deployment kits would be similar in nature to the Canadian Forces Major Air Disaster Kit. The 'Majaid' kit is stored in air deployable containers, and can be air dropped. It contains a nearly complete field hospital, in addition to other materiel useful during a major air disaster.

This permits extremely large, and forceful responses in a wide geographical area, even if suitable airports were not accessible, or serviceable.

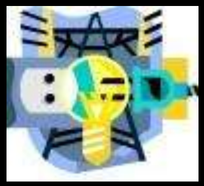
A Hercules aircraft drops the major air disaster (MAJAID) kit at the simulated crash site near Comox during Artic SAREX 07.

Total Energy Cycle…

What does it mean? How do we do it?



A fuelled micro reactor is delivered to site and commissioned.

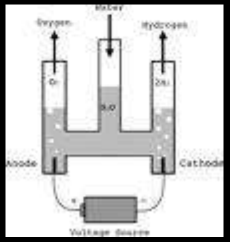


Electricity is generated and distributed at the site.

Waste heat is collected, distributed, and heat pumped at the consumer.

Excess heat and power is used in greenhouses, to produce foodstuffs, and Jatropha biodiesel.

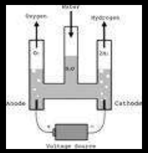
Electricity and heat is used in the Biodiesel production process. Additionally Glycerine, and fertilizer is produced as a byproduct.



Electricity is used to produce Hydrogen (H2), with Oxygen (O2) as a byproduct

The Hydrogen is used to capture and Process atmospheric CO2 into synthetic petroleum fuels. (Gasoline, Diesel, jet fuel, Ammonia)

At the end of it's fuel cycle the reactor is returned to the operator for refuelling. A new reactor is delivered.



This sort of local energy cycle could provide some value added economic benefits through the export of excess foodstuffs, Biodiesel, Hydrogen, Synthetic petroleums, and radioisotopes from the spent reactor.

Secondary applications

Rapid one off prototyping, production and 3D printing, prototyping, and construction for consumer goods, and shelter.

(Laser sintering, boutique chemical production, micro ore processing, micro chemical processing)

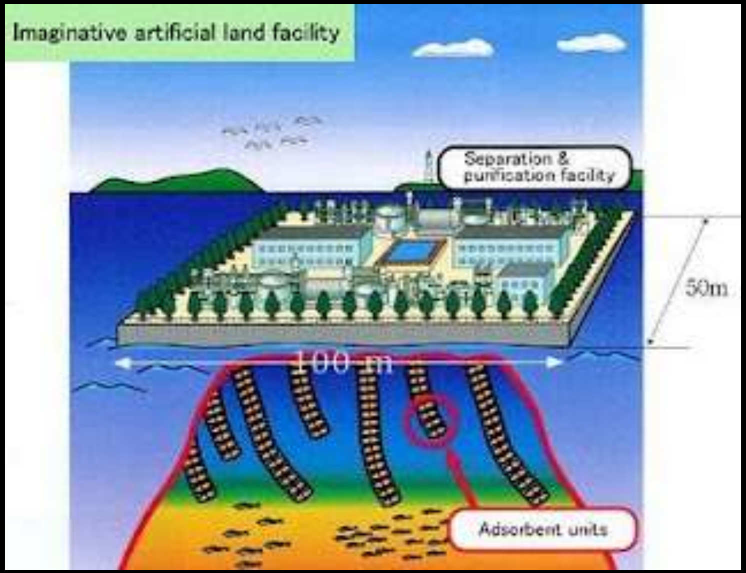
The additional use of off demand power base for the production of valuable minerals, and chemical stocks through auqueous mining for export from the community.

Secondary applications

3D printing of unique or one off products.

Boutique manufacturing of consumer goods.

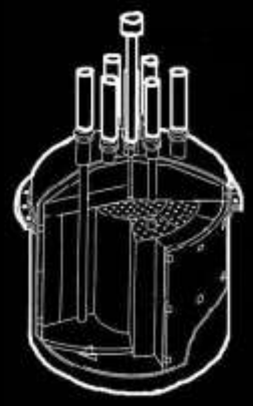
The development of seawater mining technology as a suitable loadsink, and exportable industry.



Total Energy Cycle…

What does it mean? How do we do it?

Electrical Production and distribution



=

Carried out in the conventional manner (Mostly).

(We will not examine it here)

Total Energy Cycle…

What does it mean? How do we do it?

“KalteFermewarmen” or Cold District Heating

The waste heatsink fluid is heat pumped at the customer.

Core cooling, Condenser cooling, all sub 100c waste heat.

Beznau NPP Switzerland

Refuna District heat network

Beznau, and *Refuna* are a conventional steam based district heating system. They are included here as examples of existing Nuclear power based district heating.

Total Energy Cycle…

What does it mean? How do we do it?

Greenhouse Production

Foodstuffs, and Biodiesel

NUNATSIAQ NEWS

August 3, 2007

Greenhouse gives Iqaluit fresh produce

"This is what romaine lettuce should taste like."

JOHN THOMPSON

Iqaluit may be experiencing a mostly cold and dreary summer, but there's one spot in town where it's sensible to wear shorts and a t-shirt: the newly-opened community greenhouse.

Peter Workman waters tomatoes inside Iqaluit's community greenhouse on Sunday, July 29. (PHOTO BY JOHN THOMPSON)

Total Energy Cycle…

What does it mean? How do we do it?

World’s-First Biofuel Test Flight

The world's first commercial aviation test flight powered by a sustainable second-generation biofuel took place on Tuesday 30 December, 2008 by Air New Zealand.

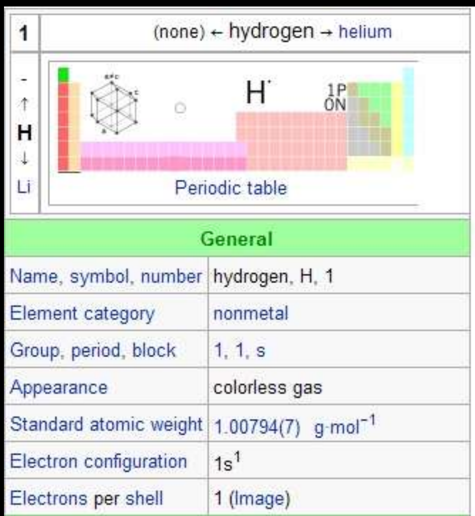
Why is this important?

In the far North, Air Mobility is Vital and forms a portion of the pricing of nearly <u>everything.</u>

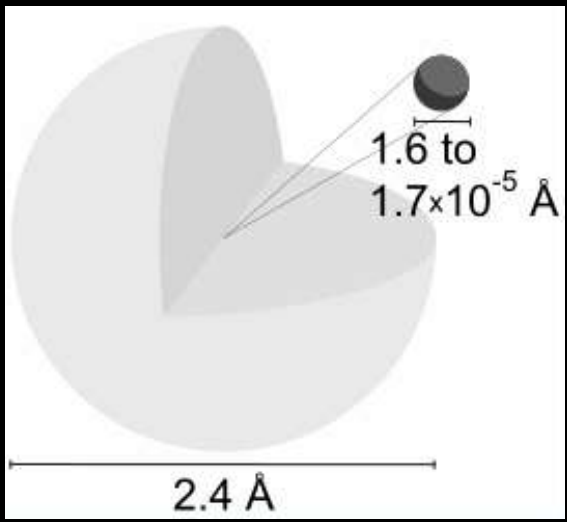
Total Energy Cycle…

What does it mean? How do we do it?

Hydrogen



1	(none) ← hydrogen → helium
- ↑ H ↓ Li	Periodic table
General	
Name, symbol, number	hydrogen, H, 1
Element category	nonmetal
Group, period, block	1, 1, s
Appearance	colorless gas
Standard atomic weight	1.00794(7) $g \cdot mol^{-1}$
Electron configuration	$1s^1$
Electrons per shell	1 (Image)



Hydrogen is of itself an energy carrier, but the energy density is low and new fuel handling, and distribution systems would need to be built for use. Further there are few motive sources which can use Hydrogen as a direct fuel source.

Hydrogen is an energy carrier, it is not a source of energy!!!

Hydrogen economy? Hey we still need the carbon!

Recently a new CO2 capture technology has been developed at the University of Calgary. This technology is expected to capture 10 tons of high purity CO2, with one Megawatt hour of Electricity.

Nothing else we have looked at is this efficient.

Dr. Keith has overseen the startup of his company Carbon Engineering with a commercial interest in Atmospheric CO2 capture.

Dr. David Keith with his ground breaking CO2 from atmosphere capture technology. c2008

(With permission per D.Keith)

Total Energy Cycle…

What does it mean? How do we do it?

Synthetic fuels from atmospheric CO2

(The opposite of Global Warming…*sort of*)

The Majority of the remainder of the presentation will be based on

United States Patent 4,568,522

[54] **SYNFUEL PRODUCTION SHIP**

[75] Inventor: **Marshall J. Corbett, East Northport, N.Y.**

[73] Assignee: **Grumman Aerospace Corporation,** Bethpage, N.Y.

[21] Appl. No.: **417,309**

[22] Filed: **Sep. 13, 1982**

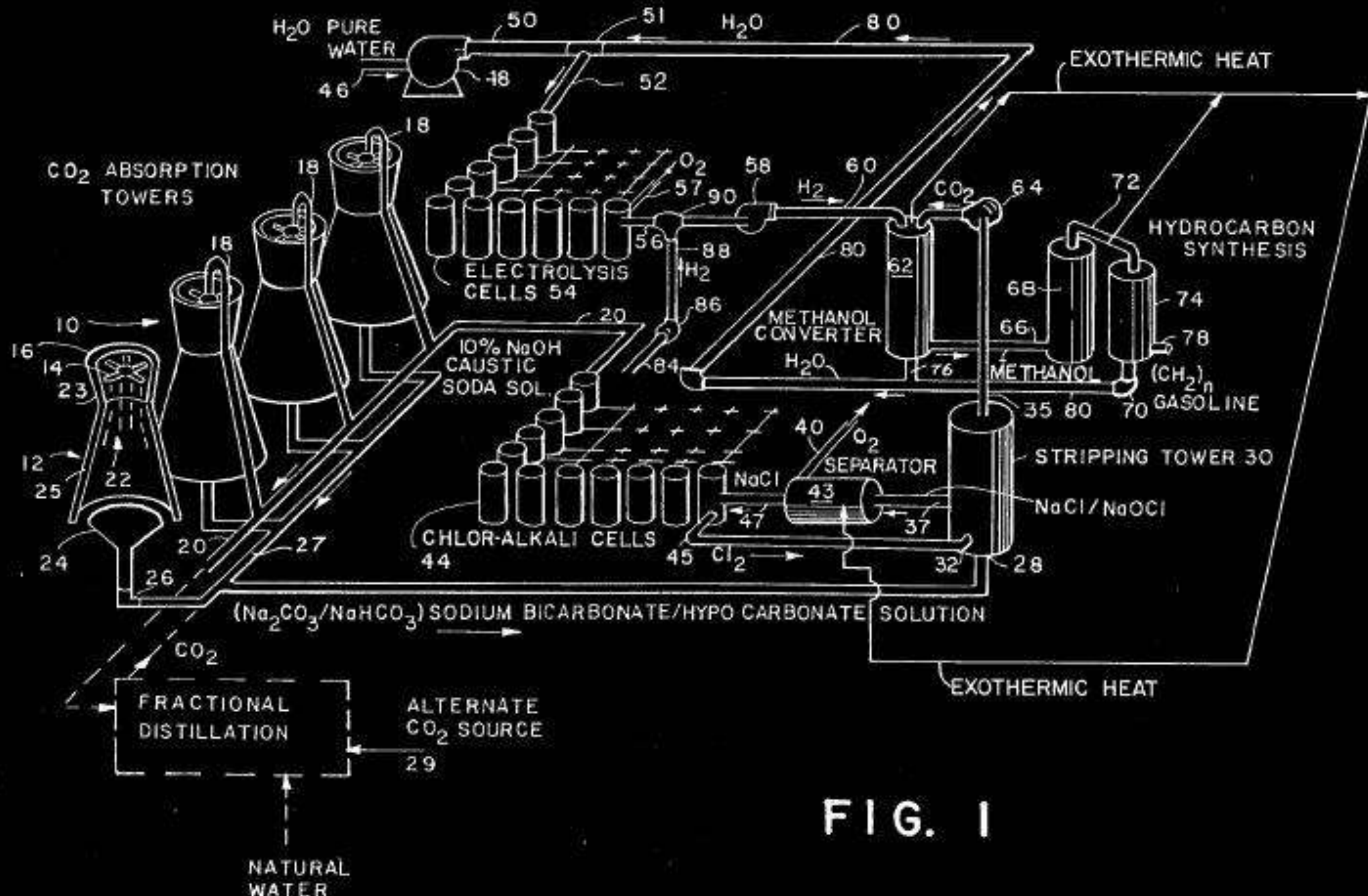

H_2O PURE WATER
50
51
H_2O
80
EXOTHERMIC HEAT
46
48
52
18
CO_2 ABSORPTION TOWERS
18
O_2
58
60
H_2
CO_2
64
72
57
90
56
88
80
HYDROCARBON SYNTHESIS
18
ELECTROLYSIS CELLS 54
H_2
62
68
74
10
20
86
METHANOL CONVERTER
66
78
16
14
23
10% NaOH CAUSTIC SODA SOL.
84
H_2O
76
METHANOL
$(CH_2)_n$ GASOLINE
35
80
70
40
O_2
SEPARATOR
STRIPPING TOWER 30
12
25
22
NaCl
43
NaCl/NaOCl
47
37
CHLOR-ALKALI CELLS
44
45
Cl_2
32
28
24
20
27
26
$(Na_2CO_3/NaHCO_3)$ SODIUM BICARBONATE/HYPO CARBONATE SOLUTION
CO_2
EXOTHERMIC HEAT
FRACTIONAL DISTILLATION
ALTERNATE CO_2 SOURCE
29
NATURAL WATER

FIG. 1

Total Energy Cycle…

What does it mean? How do we do it?

Synthetic fuels from atmospheric CO2

SYN. GAS COMPONENT	PROCESS & EQUATION	EQUIPMENT
(a) HYDROGEN	ELECTROLYSIS OF WATER $2H_2O \xrightarrow{e} 2H_2 + O_2$	ELECTROLYTIC CELLS
(b) CARBON DIOXIDE — SODIUM HYPOCARBONATE & SODIUM BICARBONATE	CO_2 ABSORPTION $2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$ $CO_2 + Na_2CO_3 + H_2O \rightarrow 2NaHCO_3$	SPRAY ABSORPTION TOWERS
(c) — CARBON DIOXIDE	CO_2 STRIPPING $Na_2CO_3 + Cl_2 \rightarrow NaCl + NaOCl + CO_2$ $2NaHCO_3 + Cl_2 \rightarrow NaCl + NaOCl + 2CO_2 + H_2O$	STRIPPING TOWER
(d) — SODIUM CHLORIDE	OXYGEN SEPARATOR $2NaOCl \xrightarrow{\Delta} 2NaCl + O_2$	BOILER
(e) — CAUSTIC/CHLORINE	CHLOR-ALKALI ELECTROLYSIS $2H_2O + 2NaCl \xrightarrow{e} 2NaOH + Cl_2 + H_2$	ELECTROLYTIC CELLS
(f) METHANOL	$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$	METHANOL SYN.
(g) GASOLINE	$n\,CH_3OH \rightarrow (CH_2)_n + nH_2O$	HYDROCARBON SYN.

FIG. 2

Total Energy Cycle…

What does it mean? How do we do it?

Synthetic fuels from atmospheric CO2

The Grumman patent estimated that it would produce 600,000 gallons of Gasoline per day from two 860MWe Reactors.

(This is very similar in size to a pair of Bruce/Darlington style CANDUs).

On a simple linear scale, one would assume

3488 Gallons (13184 liters) per day of Gasoline from a 10 Megawatt installation.

The Grumman Patent is an old process (1982). There are newer, better, more efficient ways to accomplish this today. This example was used as it is one of the easiest to explain.

Total Energy Cycle…

What does it mean? How do we do it?

There are other easier, less energy intensive synthetic fuels we can also produce.

-Methane (Natural Gas) CH4; CNG and LNG

-Dimethyl Either (DME)

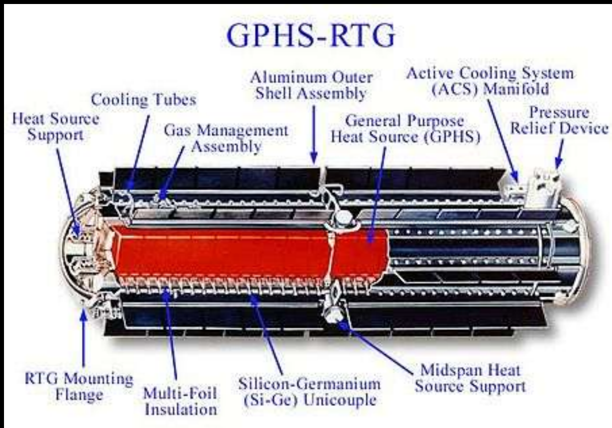
-Alcohol family related fuels, (Methanol)

-Ethanes, Acetones, synthetic

However cars, trucks, ships, and generators do not run on these fuels without modifications.

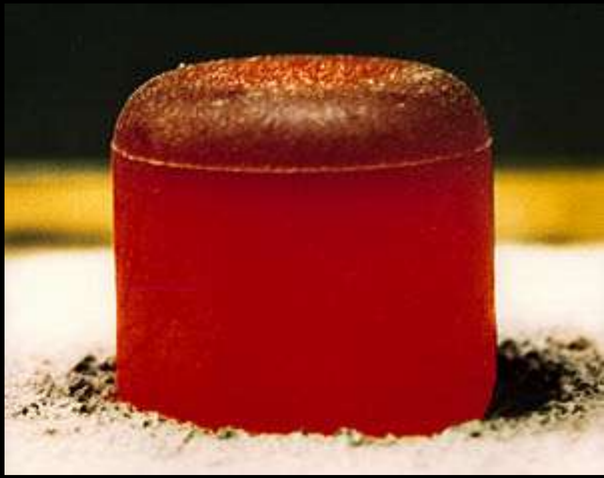
Hey but what are these RTG things you mentioned?

An RTG is a Radioisotopic thermal generator.



It is (Generally) an object made of a specific element, or chemical makeup. Which is irradiated in a reactor (bred up), to form new elements, usually unstable ones.

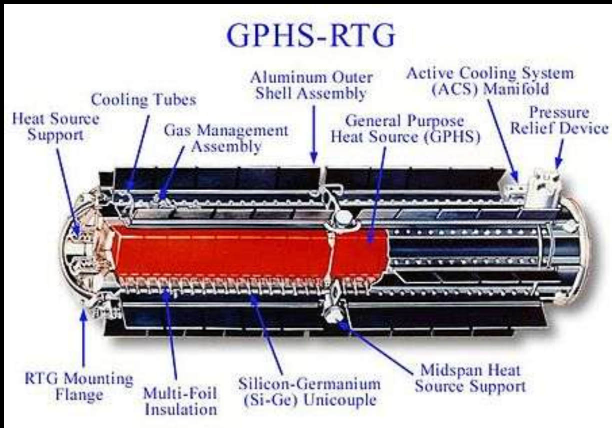
These unstable elements want to become stable. We refer to this as decay. The Radioisotopes decay by different processes to give off sub atomic particles and energies such as **heat** to become stable elements. This process can take years.



As such these are often referred to as heat batteries, or nuclear batteries. They usually require a nuclear reactor or powerful neutron source to breed them up.

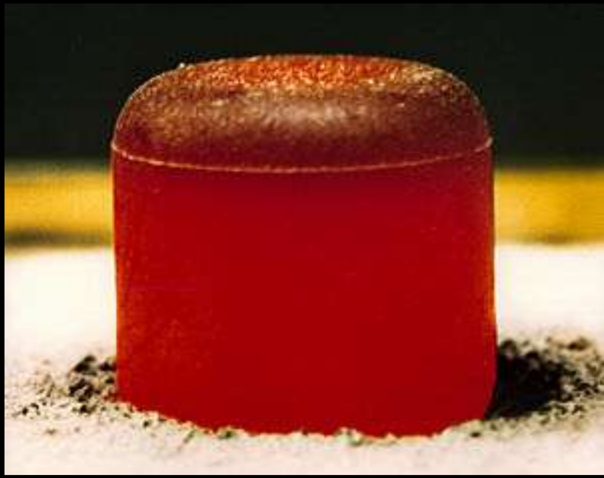
Hey but what are these RTG things you mentioned?

Why aren't they used all the time?



Strong radiation fields depending on the element used.

Radiolytic reactions causing the production of unwanted Hydrogen and Oxygen. (Or other unwanted products depending on the thermomechcanical cyle).



Poor thermoelectric performance due to the use of Thermocouples (solid state generator) for electricity production.

Size. These generators are typically small. Being only a few kilowatts thermally.

Hey but what are these RTG things you mentioned?

Well isn't there some use for them here on earth?

The Soviet union deployed many of these RTG units in automated lighthouse projects. However with the collapse of the Soviet Union many of these lighthouses were no longer serviced and the radioactive sources were lost.

Hey but what are these RTG things you mentioned?

Yes, but we're not in the Soviet Union…

We actually have many uses for heat, hydrogen and Oxygen here on earth.

The University of New Brunswick was previously working on a new modernized land based Terrestrial RTG.

Also many of the aforementioned isolated communities in the north have energy demands far too low to be serviced by even the smallest SMR.

Oil sands, marine operators, Northern ports, de-icing, coal to fuel operations, Heavy oil upgrading….

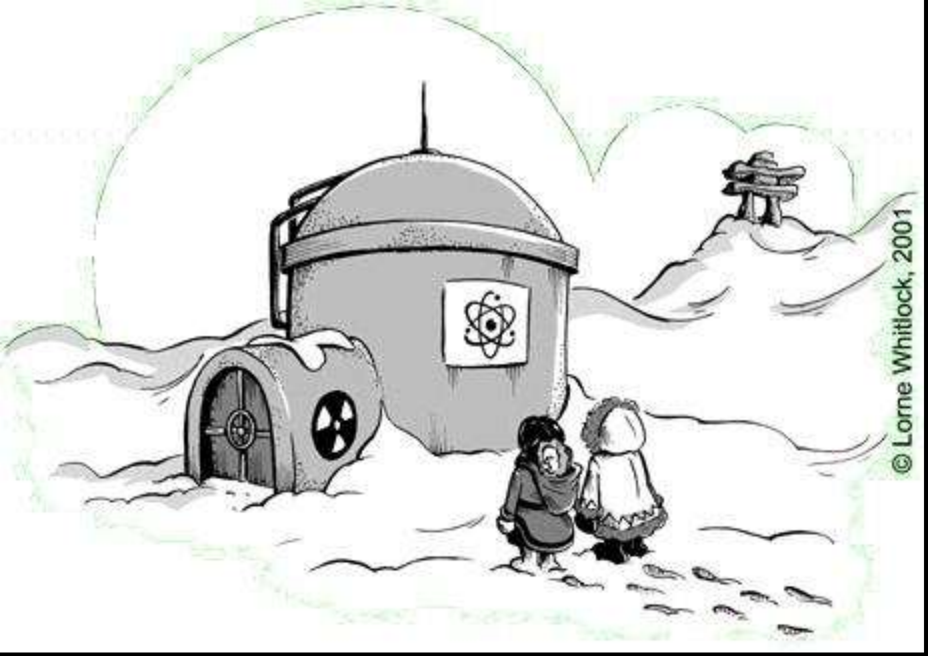
All require heat, and/or hydrogen, and Oxygen.

So what does all this mean to residents of the North?

Lower cost electricity, heating, food, fuels, shipping, and **Air Transport**.

Value added services moved to the community, and **possibly some export of those value added goods.**

Local Employment, new incomes, improved self sufficiency and, increased standards of living.



Total energy supply for remote Human Habitations

(Or “Nuclear North of 60”)

With thanks to: Peter Lang (Small reactor Zealot); Duane Pendergast (CNS Alberta Chair; Energy Solutions International (Cold process Jatropha data*, and My wife, and kids!*

Prepared by: Jay Harris
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Band member of Cowesses First Nation