Why We Should Support Nuclear Power

Chuck Edwards

Microsoft PowerPoint

Warning:

Side effects include drowsiness, nausea, light-headedness, and, in rare instances, a diminished will to live.

Nuclear power is

- Safe
- Clean
- Cost competitive (and stable)
- Sustainable
- A proven base load option


NORTHWEST TERRITORIES
NUNAVUT
©GraphicMaps.com
Uranium City
Lake Athabasca
300 mi
300 km
MANITOBA
Prince Albert Nat. Park
La Ronge
N
Edmonton
Prince Albert
Cedar Lake
Lake Winnipeg
Saskatoon
ALBERTA
SASKATCHEWAN
Moose Jaw
Regina
Lk. Manitoba
Montana
North Dakota
MN

Tonnes CO_2 per person (2005)

• Quebec	12
• Yukon	13
• BC	15
• Ontario	16
• PEI	17
• Manitoba	17
• Nfld. & Lab.	20
• NWT & Nunavut	21
• Nova Scotia	24
• New Brunswick	28
• Alberta	71
• Saskatchewan	72

SaskPower Generation

• 3 X coal	1664 MW
• 4 x natural gas	327 MW
• 7 x hydro	853 MW
• 3 x wind	172 MW

Alternative Energy

- Alternative energy = cleaner energy
- Cleaner = lower CO_2 emissions

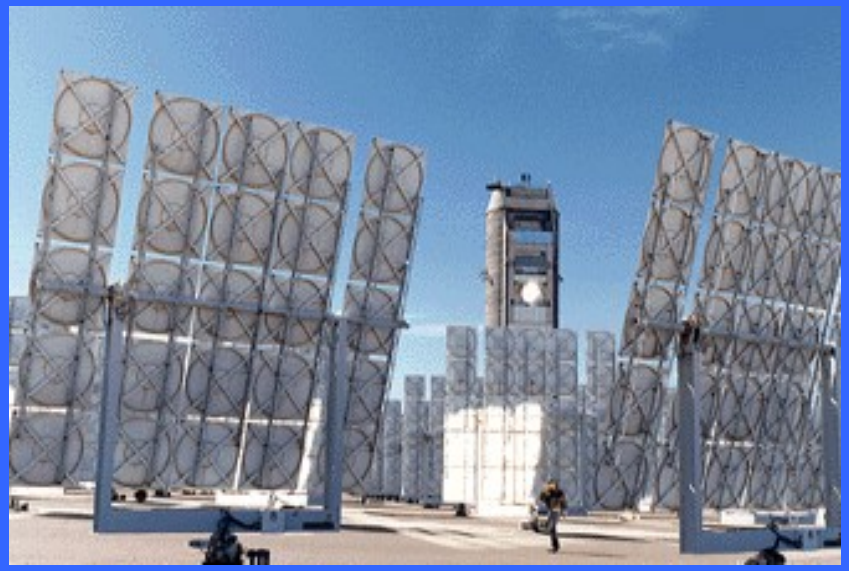

RAESIDE
HAH! WE DON'T NEED BIG, SMELLY POWER PLANTS. WE CAN MAKE DO WITH ALTERNATIVE, GREEN POWER!
POWER PLANT BLOCKED.
HONEY, COULD YOU PICK UP THE PACE A BIT? I'D LIKE TO USE THE TOASTER OVEN.
POWER PLANT BLOCKED

Prudent & Judicious

- Solar
- Wind
- Biomass
- Hydro
- Nuclear

Solar Power

- Clouds?
- Night?
- Site area?
- Expensive
  - Utility
  - Home



?

Solar Power

- Clouds?
- Night?
- Site area?
- Expensive
  - Utility
  - Home


ENERGY MANAGEMENT
it's in your hands
Government of Canada
Gouvernement du Canada

Wind Power

- Discontinuous
- NIMBY
- Site area?

Biomass

- Land usage?

Biomass

NPP

(Net Primary Production)


1 9 9 7


400 YEARS

?

10 Terawatts

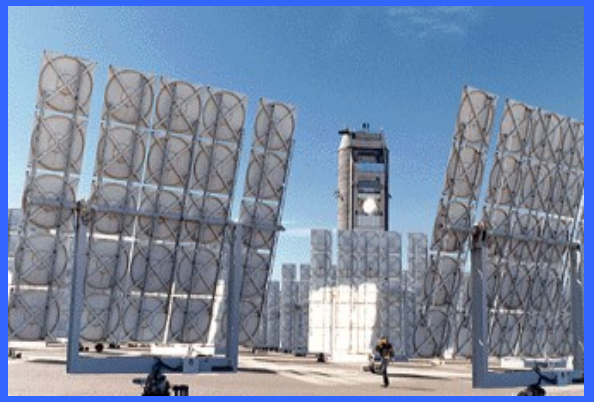
10 Terawatts =

100% of agricultural land

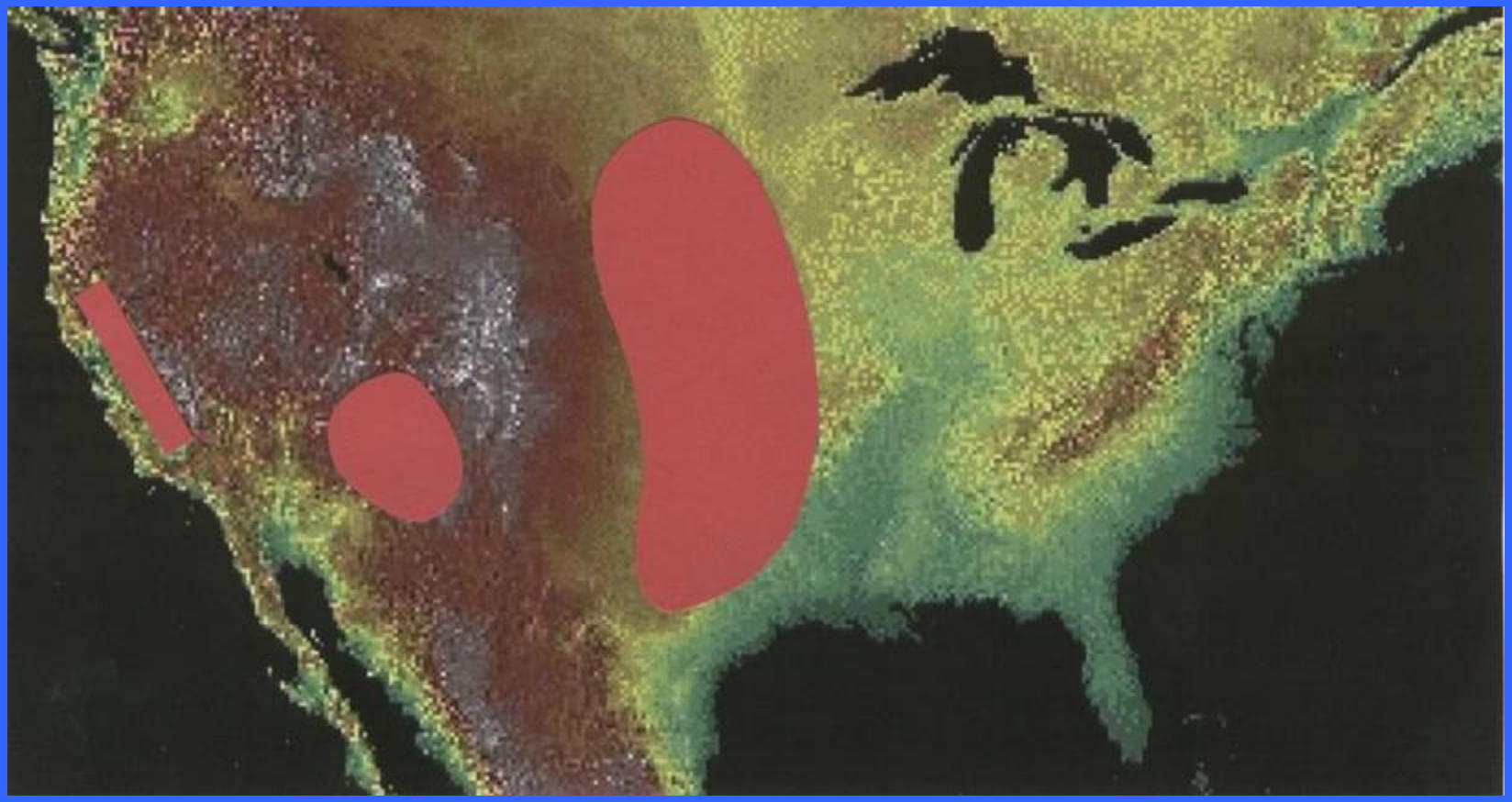
Hydro

- Weather
- NIMBY

Role of “Renewables” in the United States



Role of “Renewables” in the United States



Role of “Renewables” COST?

- Solar
- Wind
- Biomass

Role of “Renewables” COST?

Role of “Renewables” COST?

Role of “Renewables” COST?

Role of “Renewables” COST?

Role of “Renewables” COST?

Role of “Renewables”
COST?

Royal Academy of Engineering
Electricity Generating Costs (pence/kWh)

Nuclear	2.3
Onshore wind farm	3.7
Offshore wind farm	5.5
Wave and marine	6.6

Royal Academy of Engineering
Electricity Generating Costs (pence/kWh)

Nuclear	2.3
Onshore wind farm - With stand by capacity	3.7 5.4
Offshore wind farm - With standby capacity	5.5 7.2
Wave and marine	6.6

Role of “Renewables”

- Solar
- Wind
- Biomass

Prudent & Judicious

- Nuclear

Life Cycle CO_2 Emissions (gram CO_2 per kWh)

- Coal thermal 975

- Oil thermal 742
- LNG thermal 608
- Photovoltaic 53

- Wind 29
- Hydro 11
- Nuclear 9

Range of Life Cycle CO_2 Emissions (gram CO_2 per kWh)

• Lignite	1311 - 836
• Coal	1309 - 755
• Oil	902 - 546
• Natural Gas	689 - 385
• Photovoltaic	280 - 30
• Hydro	237 - 4
• Biomass	61 - 31
• Wind	48 - 9

Range of Life Cycle CO_2 Emissions (gram CO_2 per kWh)

• Coal	1182 - 790
• Photovoltaic	731 - 13
• Natural Gas	511 - 389
• Wind	124 - 7
• Biomass	101 - 15
• Nuclear	59 - 2
• Hydro	48 - 2

Relative CO_2 Emissions
(Life Cycle of Fuels)

- IC, “clean” gasoline 100
- Electrical/IC, “clean” gasoline 35
- Fuel cell, “clean” gasoline 35
- Fuel cell, methanol from NG 35
- Fuel cell, H_2 from NG 24
- Fuel cell, H_2 from biomass 12
- Fuel cell, H_2 from nuclear 0

Nuclear power is

- Safe
- Clean
- Cost competitive (and stable)
- Sustainable
- A proven base load option

US Electricity Production in 2002
Fuel Cost (¢/kWh)

Natural Gas	3.44
Nuclear	0.45

Royal Academy of Engineering
Electricity Generating Costs (pence/kWh)

Nuclear	2.3
Gas-fired CCGT	2.2
Coal-fired pulverized-fuel	2.5
Coal-fired circulating fluid bed	2.6

Royal Academy of Engineering
Electricity Generating Costs (pence/kWh)

Nuclear	2.3
Gas-fired CCGT	2.2
(with carbon tax)	3.4
Coal-fired pulverized-fuel	2.5
(with carbon tax)	5.0
Coal-fired circulating fluid bed	2.6
(with carbon tax)	5.1

University of Chicago Study
Cost of Electricity, ¢/kWh

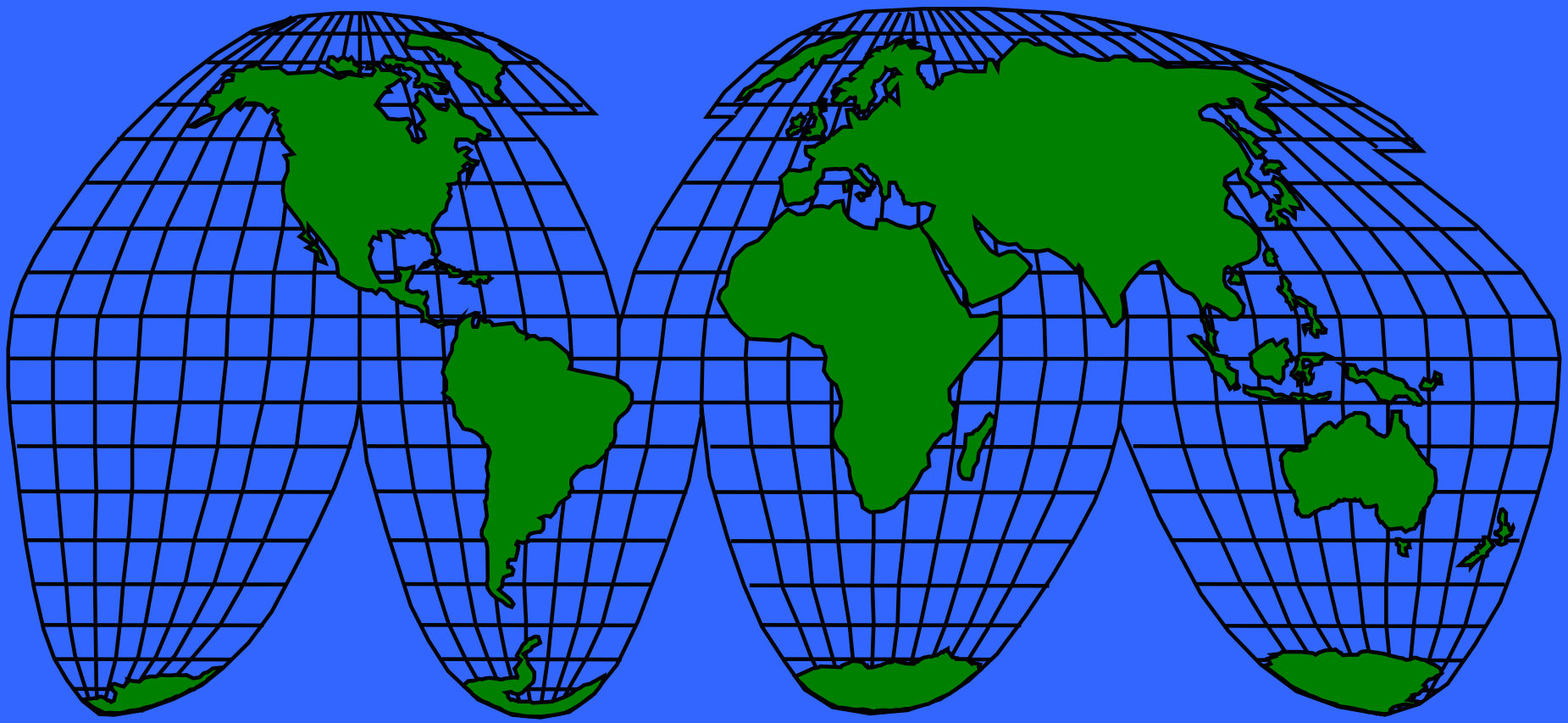
Coal-fired (no carbon tax)	3.3 to 4.1
Gas-fired (no carbon tax)	3.5 to 4.5
Nuclear (first-of-kind engineering)	4.7 to 7.1

University of Chicago Study
Cost of Electricity, ¢/kWh

Coal-fired (greenhouse gas or carbon tax)	up to 9.1
Gas-fired (greenhouse gas or carbon tax)	up to 6.8
Nuclear (series engineering)	3.1 to 4.6

Nuclear power is

- Safe
- Clean
- Cost competitive (and stable)
- Sustainable
- A proven base load option



Nuclear power is

- Safe
- Clean
- Cost competitive (and stable)
- Sustainable
- A proven base load option

Replace Fossil Fuels in Base Load Supply?

Wind	no
Solar	no
Biomass	no
“Clean” coal	no

Range of Life Cycle CO_2 Emissions (gram CO_2 per kWh)

• Coal	350 - 210
• Natural Gas	220 - 110
• CCS	70 - 75
• Solar	20 - 30
• Hydro	5 - 15
• Wind	7 - 15
• Nuclear	2 - 10

Nuclear power is

- Safe
- Clean
- Cost competitive (and stable)
- Sustainable
- A proven base load option

Nuclear Power Reactor Safety

- 10,000 reactor-years
- 32 countries
- 2 significant accidents

Nuclear Power Reactor Accidents

Chernobyl

- 25 April 1986
- Flawed reactor design
- Inadequate training
- Procedure violation
- Steam explosion
- Graphite fire
- 5% of core released
- 31 immediate deaths
- ~10 deaths since

Nuclear Power Reactor Accidents

Three Mile Island

- 28 March 1979
- Equipment failure
- Inadequate instruments
- Operator confusion
- Cooling water leak
- Heat build up in core
- Fuel assemblies melted
- Small radiation release
- No deaths
- No injuries
- No health effects

Accident Statistics in Primary Electricity Production

Fuel	Immediate Fatalities (1970-92)	Who?
Coal	6400	Workers
Natural Gas	1200	Workers & Public
Hydro	4000	Public
Nuclear	31	Workers

Comparative Radiation Doses and Their Effects

Comparative Dose	Source/Effect
1 mSv/year	cosmic rays/none
2 mSv/year	natural background/none
3 mSv/year	inhaled radon/none
9 mSv/year	polar route/slight to none
100 mSv/year	total/cancer risk increase
1,000 mSv single dose	total/radiation sickness (but not death)

Comparative Radiation Doses and Their Effects

Comparative Dose	Source/Effect
1 mSv/year 0.5 mSv	cosmic rays/none
2 mSv/year	natural background/none
3 mSv/year	inhaled radon/none
9 mSv/year	polar route/slight to none
100 mSv/year	total/cancer risk increase
1,000 mSv single dose	total/radiation sickness (but not death)

Comparative Radiation Doses and Their Effects

Comparative Dose	Source/Effect
1 mSv/year 1.4 mSv	cosmic rays/none
2 mSv/year	natural background/none
3 mSv/year	inhaled radon/none
9 mSv/year	polar route/slight to none
100 mSv/year	total/cancer risk increase
1,000 mSv single dose	total/radiation sickness (but not death)

Comparative Radiation Doses and Their Effects

Comparative Dose	Source/Effect
1 mSv/year	cosmic rays/none
2 mSv/year	natural background/none
3 mSv/year 3.1 mSv	inhaled radon/none
9 mSv/year	polar route/slight to none
100 mSv/year	total/cancer risk increase
1,000 mSv single dose	total/radiation sickness (but not death)

Comparative Radiation Doses and Their Effects

Comparative Dose	Source/Effect
1 mSv/year	cosmic rays/none
2 mSv/year	natural background/none
3 mSv/year	inhaled radon/none
9 mSv/year 9.3 mSv	polar route/slight to none
100 mSv/year	total/cancer risk increase
1,000 mSv single dose	total/radiation sickness (but not death)

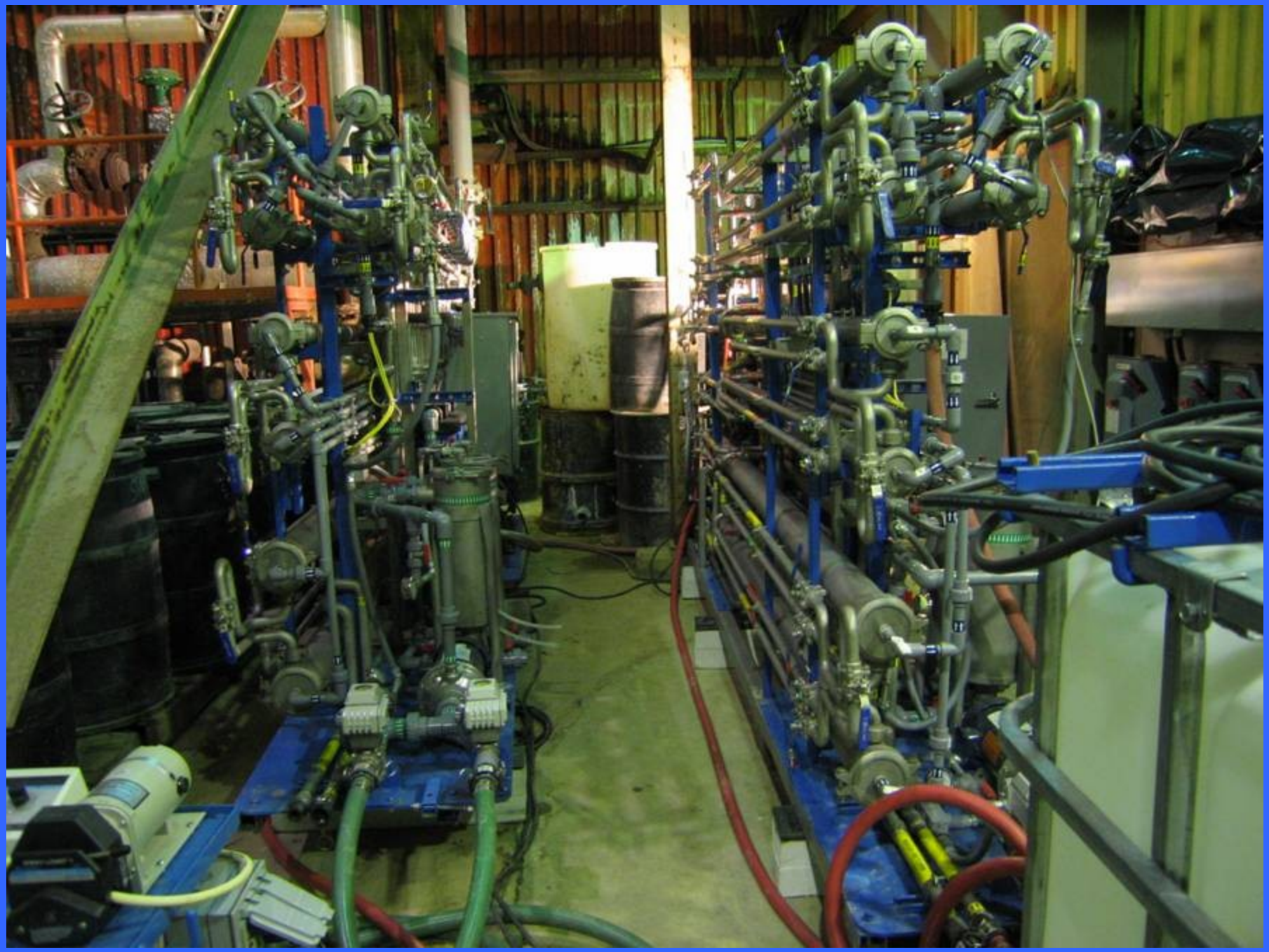

McArthur River


Key Lake

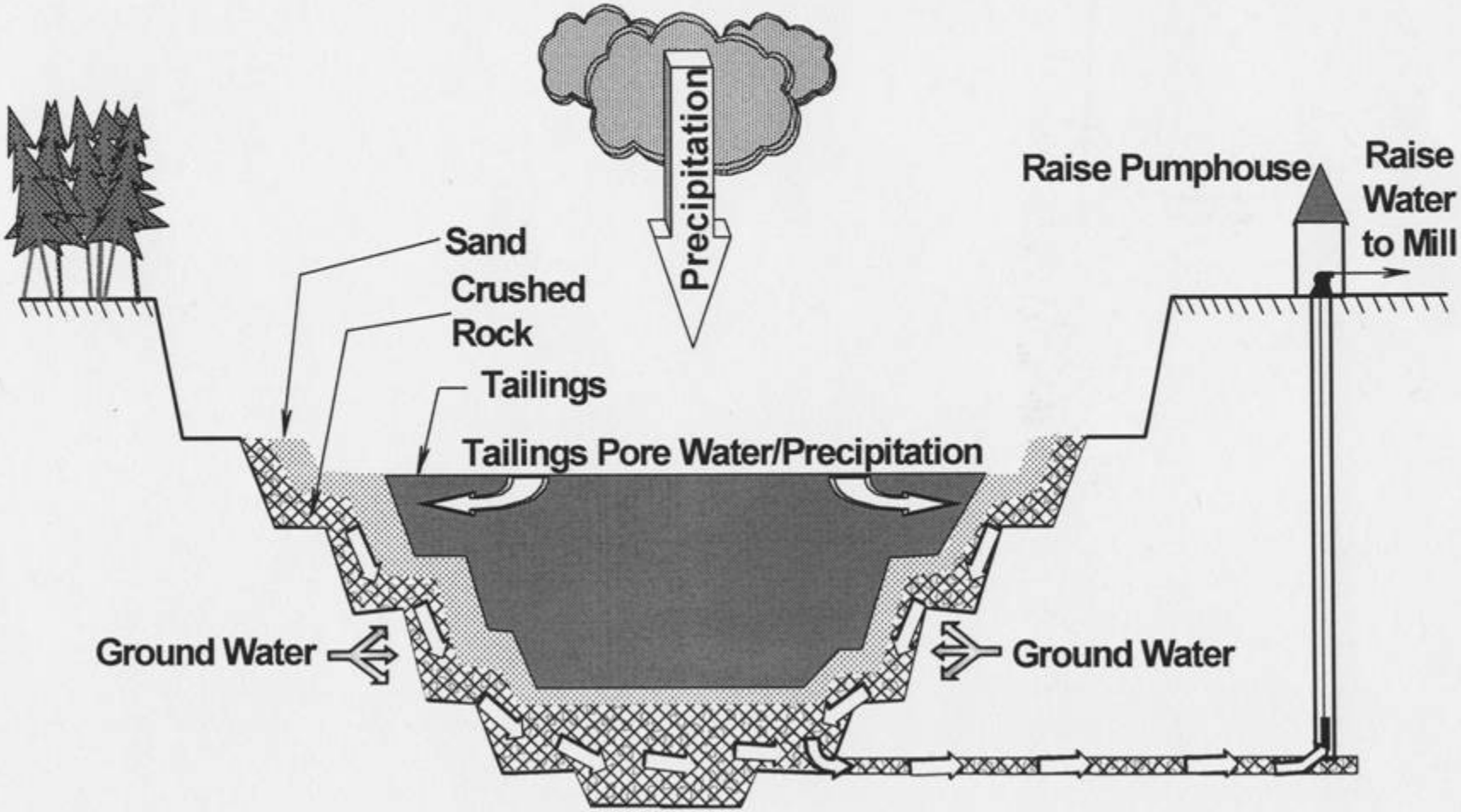

Rabbit Lake


McClean Lake

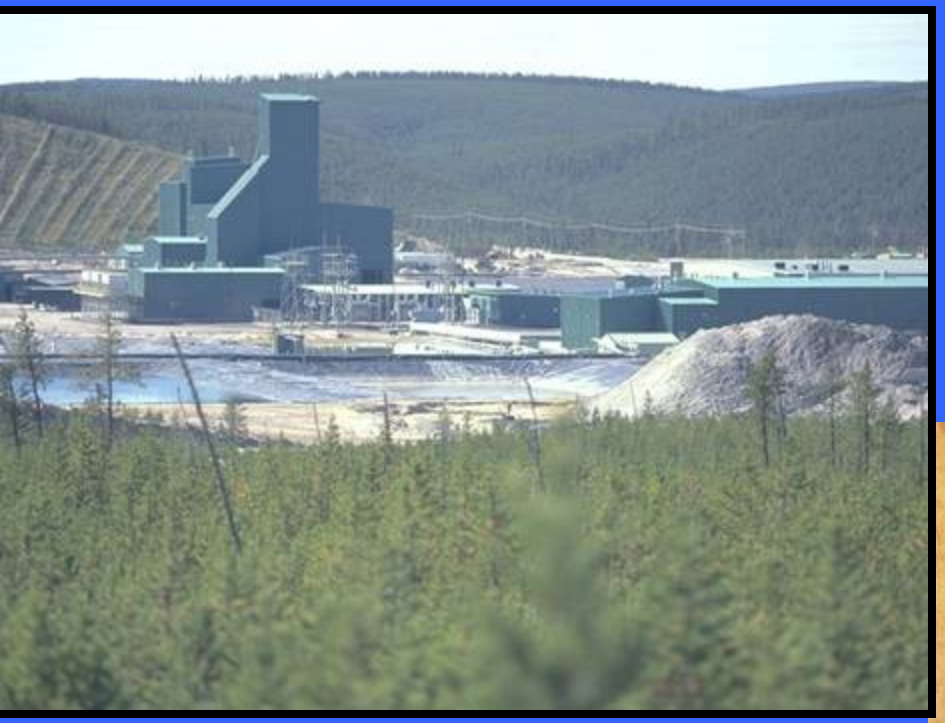

NOV 21 2006

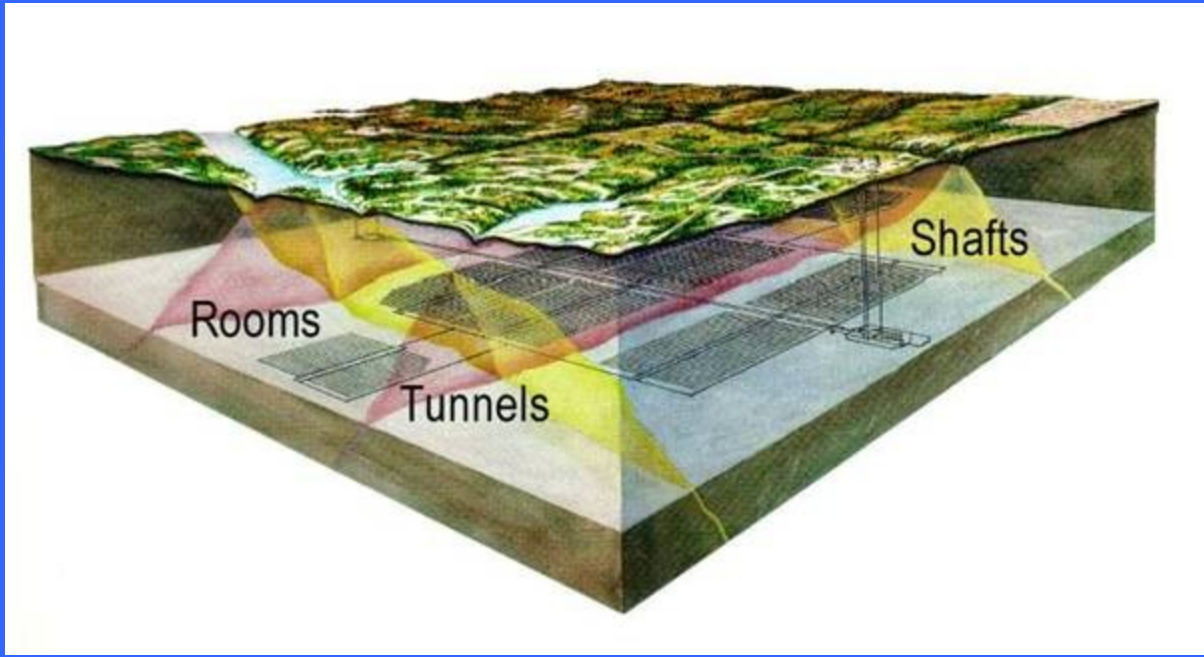


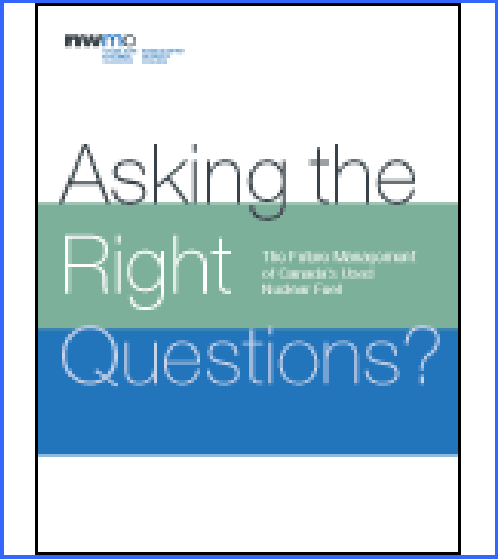
Pervious Surround Concept

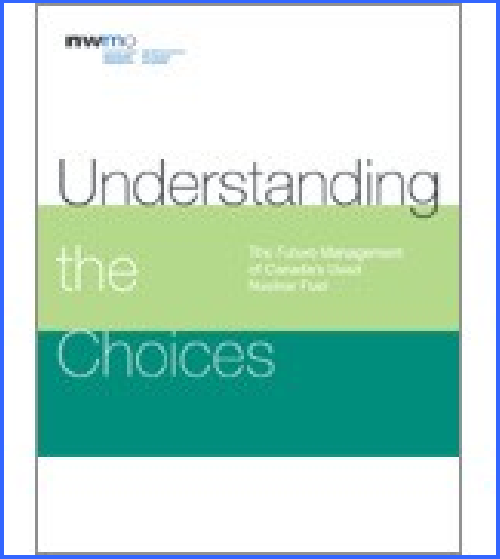


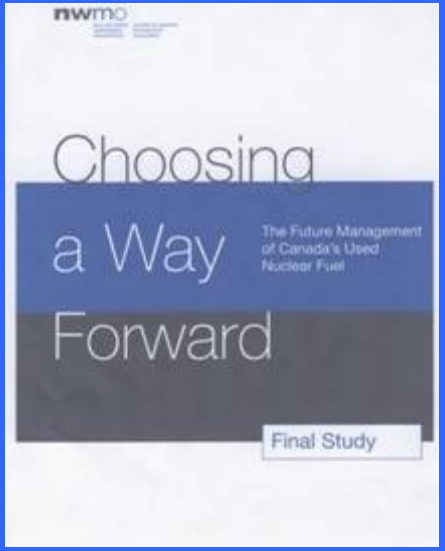
Public Exposure to Radon




Shafts
Rooms
Tunnels


nwmo
Asking the Right Questions?


nwmo
Understanding the Choices


nwmo
Choosing a Way Forward
The Future Management of Canada's Used Nuclear Fuel
Final Study

Natural Uranium

U-238	99.275%
U-235	0.720%
U-234	0.005%

Uses for Depleted Uranium

- aircraft counter weights
- yacht keels
- radiation shielding

Uses for Depleted Uranium

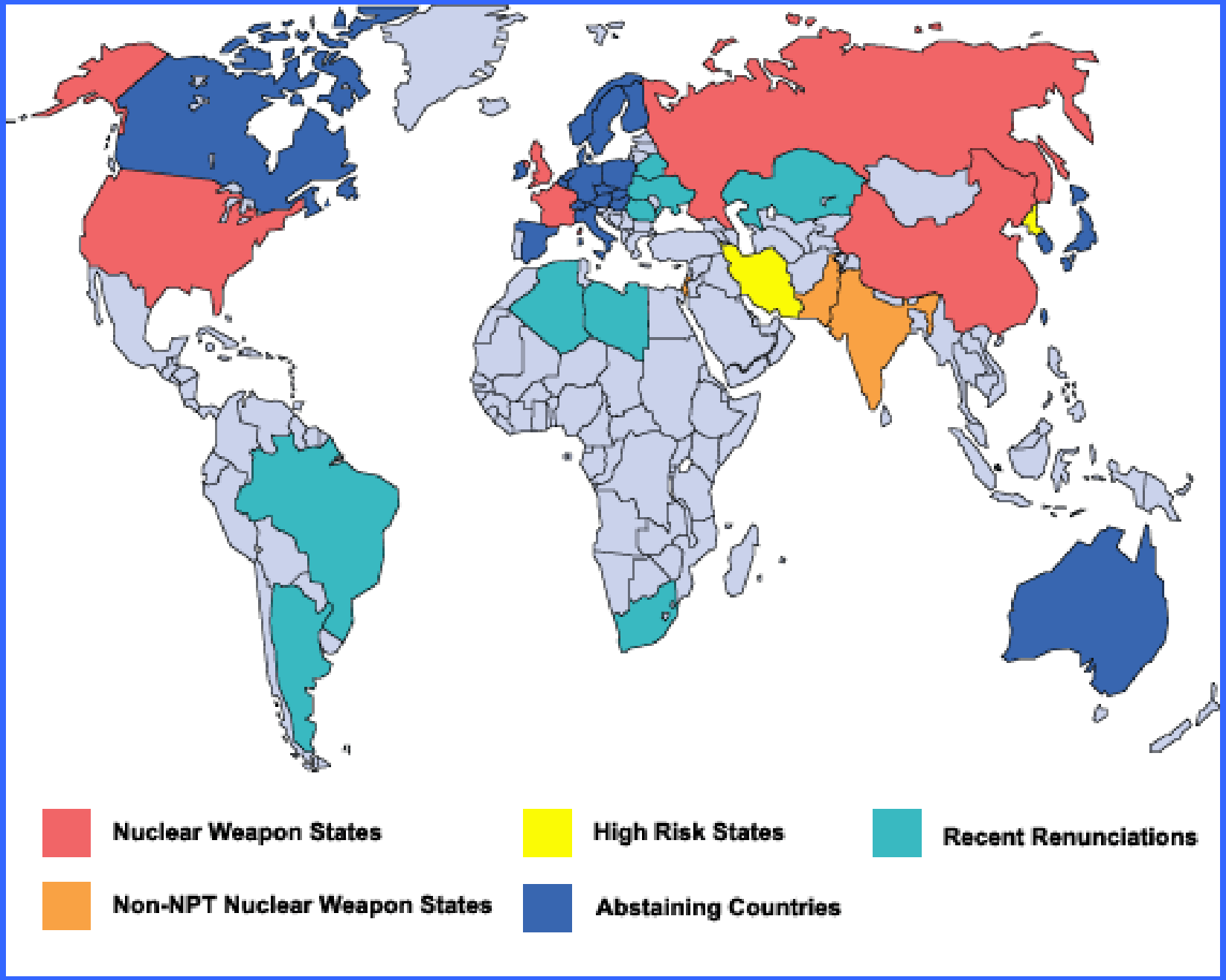
- aircraft counter weights
- yacht keels
- radiation shielding
- armour-piercing shells

Depleted Uranium Projectiles

- Gulf War
- Kosovo

Exposure to Depleted Uranium

- External
- Ingestion
- Inhalation


Nuclear Weapon States
High Risk States
Recent Renunciations
Non-NPT Nuclear Weapon States
Abstaining Countries

Nuclear Materials

Uranium

- power reactor fuel = 3% to 4% U-235
- weapons grade = >90% U-235

Nuclear Materials

Plutonium

- weapons grade = >93% Pu-239
- spent power reactor fuel = ~60% Pu-239

~40% Pu-240


Kim Jong Il

Uranium Perspective

1 nuclear weapon = 5 t

Annual electricity production = 66,000 t

HEU Agreement

HEU Agreement

- Between Russia and the United States
- Russia blends HEU down to LEU
- Cameco purchases LEU
- Cameco sells LEU as reactor fuel

8000 decommissioned

Nuclear power is

- Safe
- Clean
- Cost competitive (and stable)
- Sustainable
- A proven base load option

We should support nuclear power because it is

- Safe
- Clean
- Cost competitive (and stable)
- Sustainable
- A proven base load option

EMTF END

Chuck Edwards