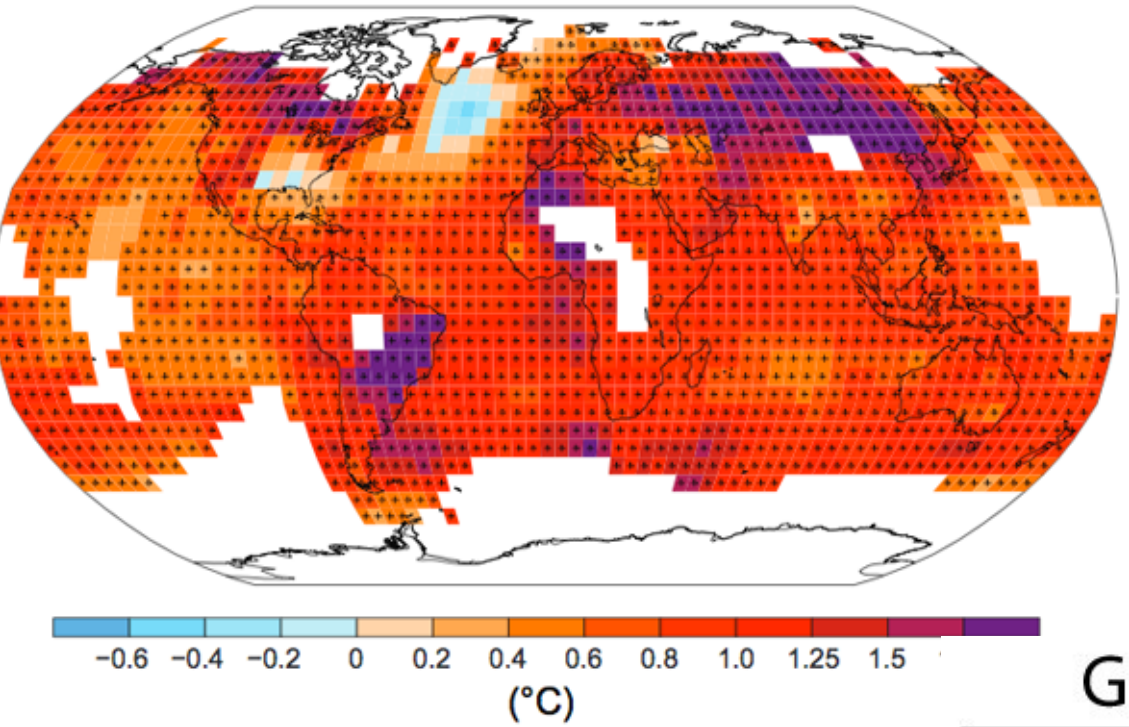
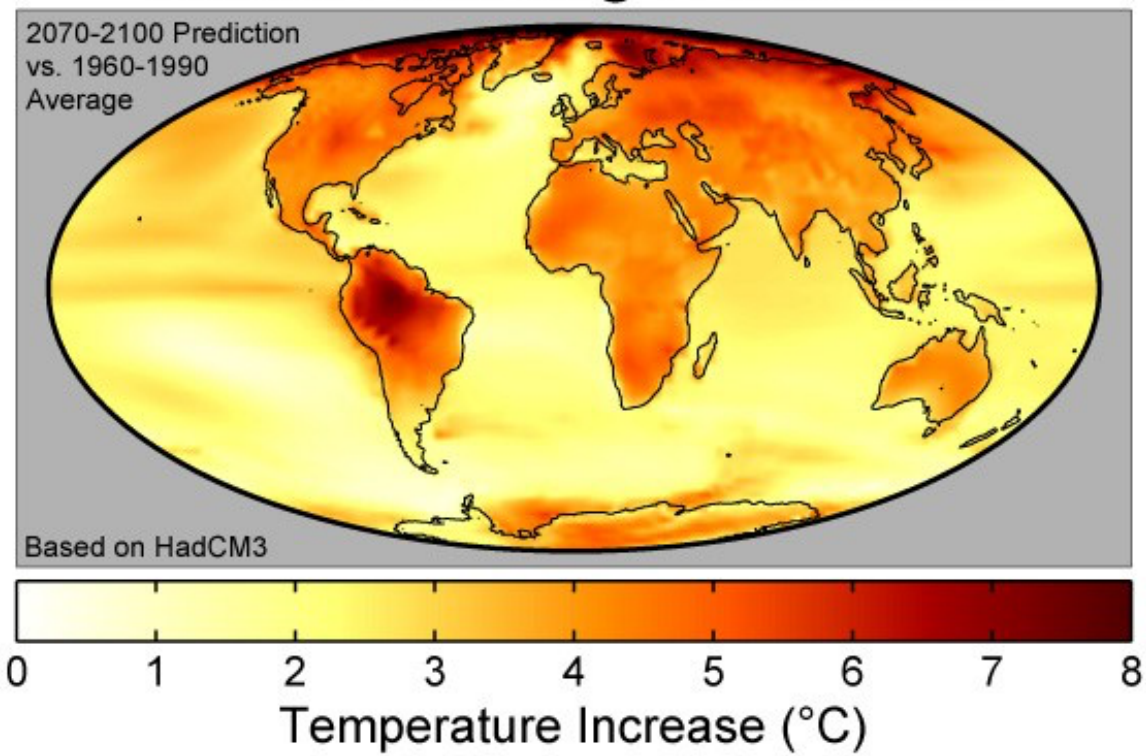
Observed change in surface temperature 1901–2012



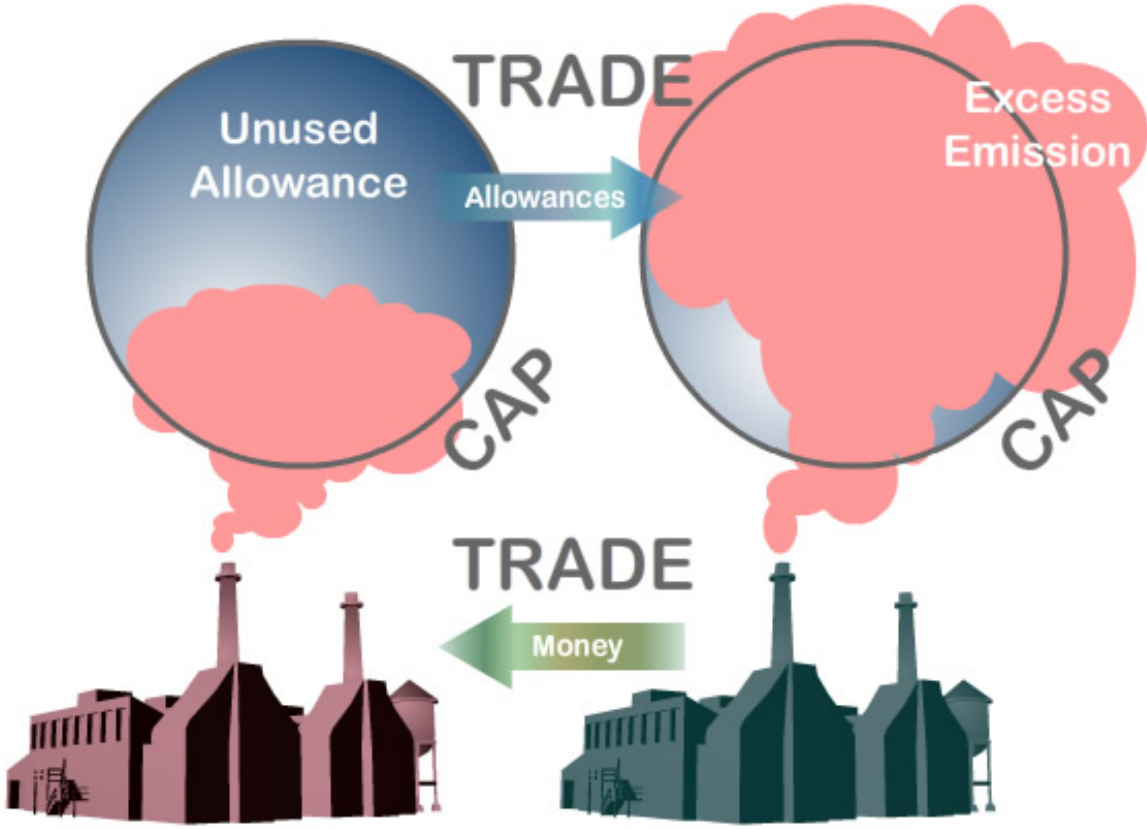
Global Warming Predictions



How to reduce CO_2 emission in a market-driven economy?

Carbon tax

Cap & Trade



Québec-California-Ontario Carbon Market: A Strong Example of North American Collaboration

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Feb 28, 2018, 17:23 E

Ford government 'gutted' climate change programs that were working: report

PCs poised to kill Green Energy Act

Liberal legislation aimed to grow Ontario's solar and wind energy supply

The Canadian Press · Posted: Sep 20, 2018 3:19 PM ET | Last Updated: September 20

Greenpeace suing Ontario government over cancellation of cap-and-trade program

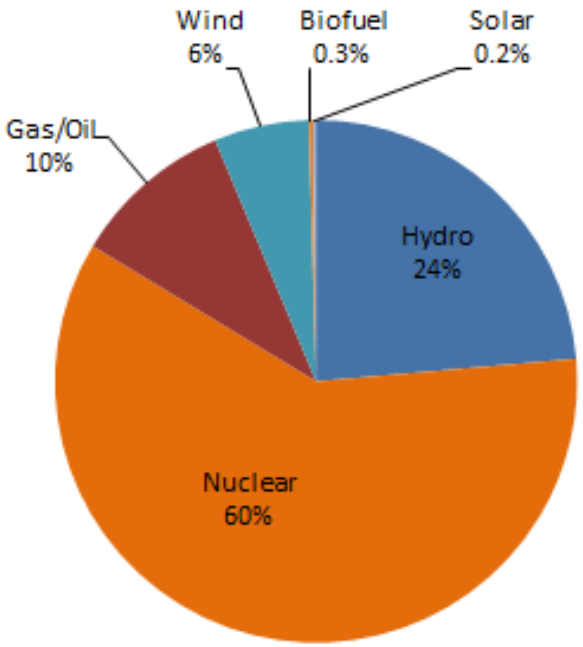
Lawyers for Ecojustice, in conjunction with uOttawa-Ecojustice Environmental Law Clinic, filed the suit

CBC News · Posted: Sep 11, 2018 3:33 PM ET | Last Updated: September 11

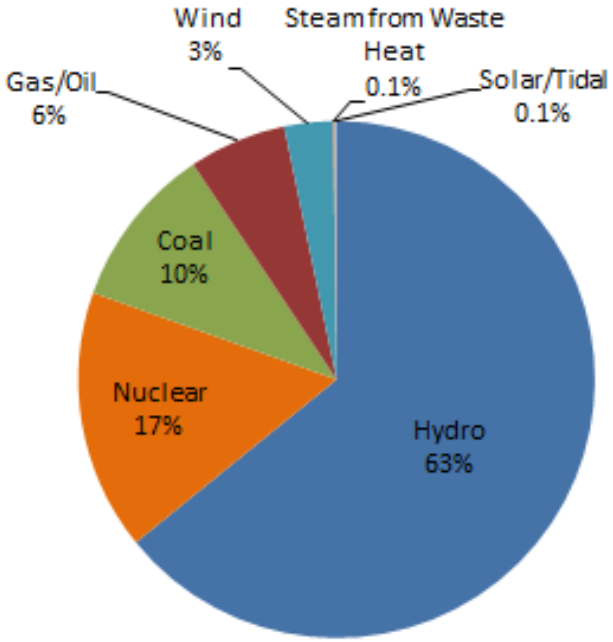
End of cap-and-trade will see Ontario natural gas bills go down

BY THE CANADIAN PRESS
POSTED SEP 27, 2018 5:59 PM EDT

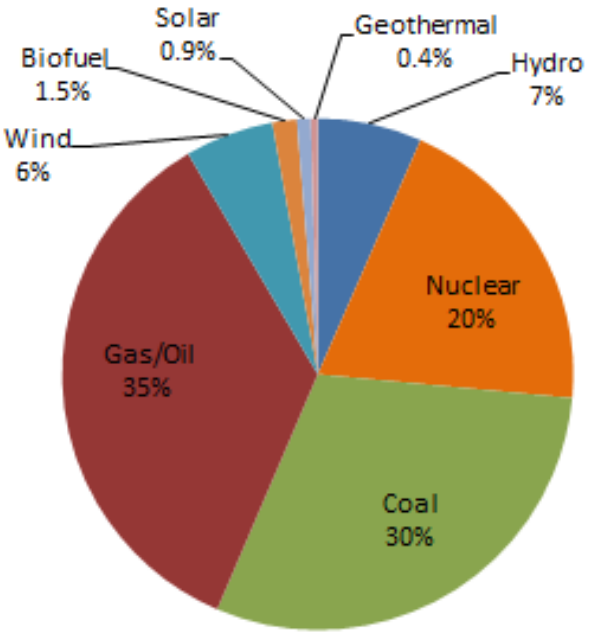
Electricity generation: Ontario electricity is relatively “clean”.



Electricity Generation in Ontario per 2015 TWh



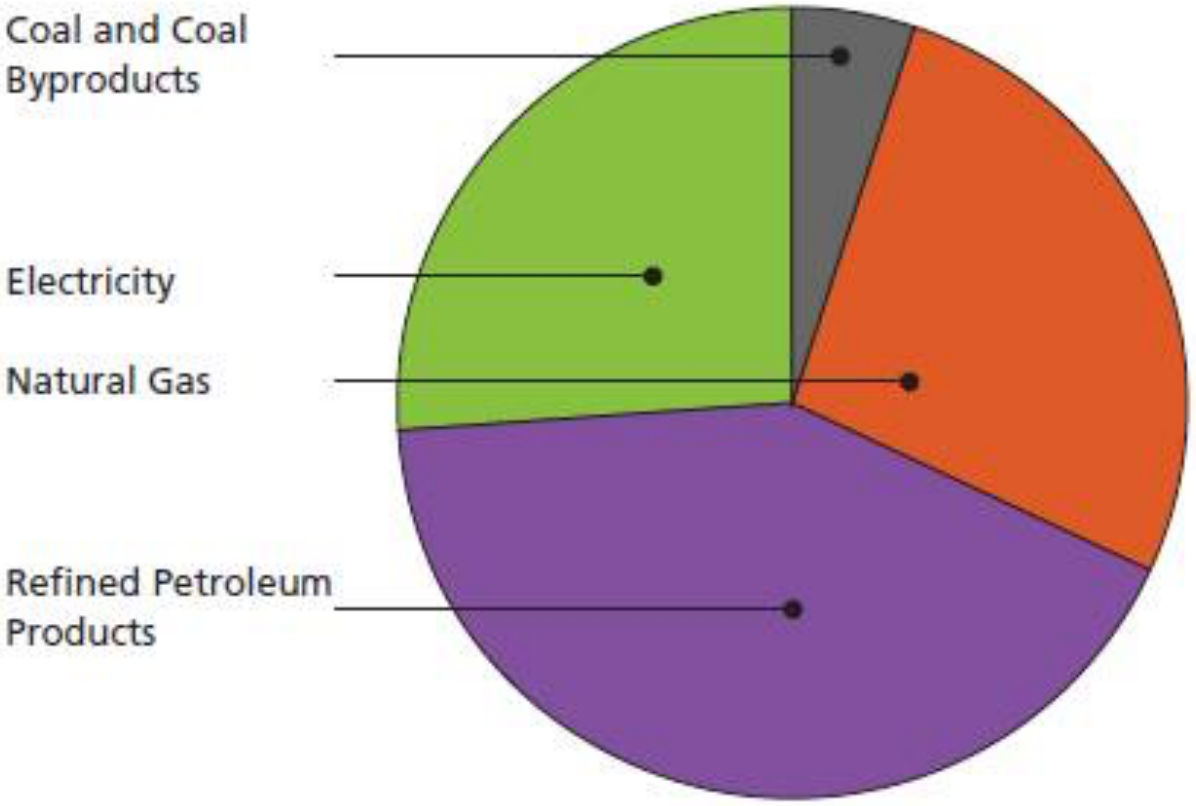
Electricity Generation in Canada per 2015 TWh



Electricity Generation in USA per 2016 TWh

But we use energy in forms other than electricity.

Figure 1: Total 2011 Ontario Energy Use By Fuel Type



Source	Share
Coal and Coal Byproducts	5%
Electricity	26%
Natural Gas	27%
Refined Petroleum Products	42%
TOTAL	**100%**

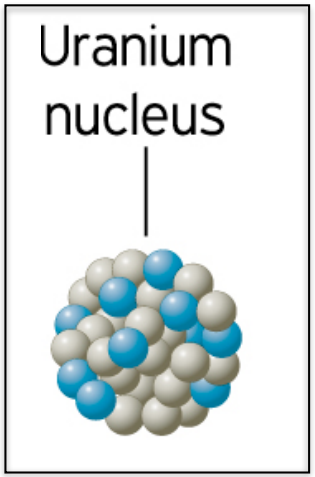
Source: Statistics Canada, CANSIM Tables 128-0016 and 127-0004

Canadian uses in average 100x 1500 kCal/day

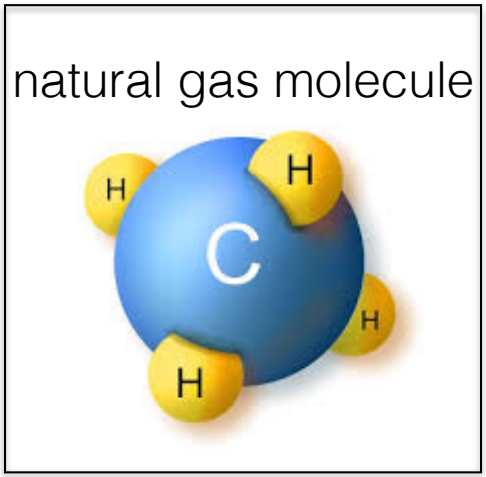
Energy yield of nuclear vs. fossil fuels:

nuclear: $\Delta E = \Delta m\, c^2$

where $\Delta m \sim 0.1\%\ m$



fossil fuel: per chemical bond $\Delta E \sim e^2/r$,
where r ~ angstrom



per gram of fuel, the ratio of energy yield is ~ 10^6

= 10,000 barrels

~ 1000 tons of CO^2

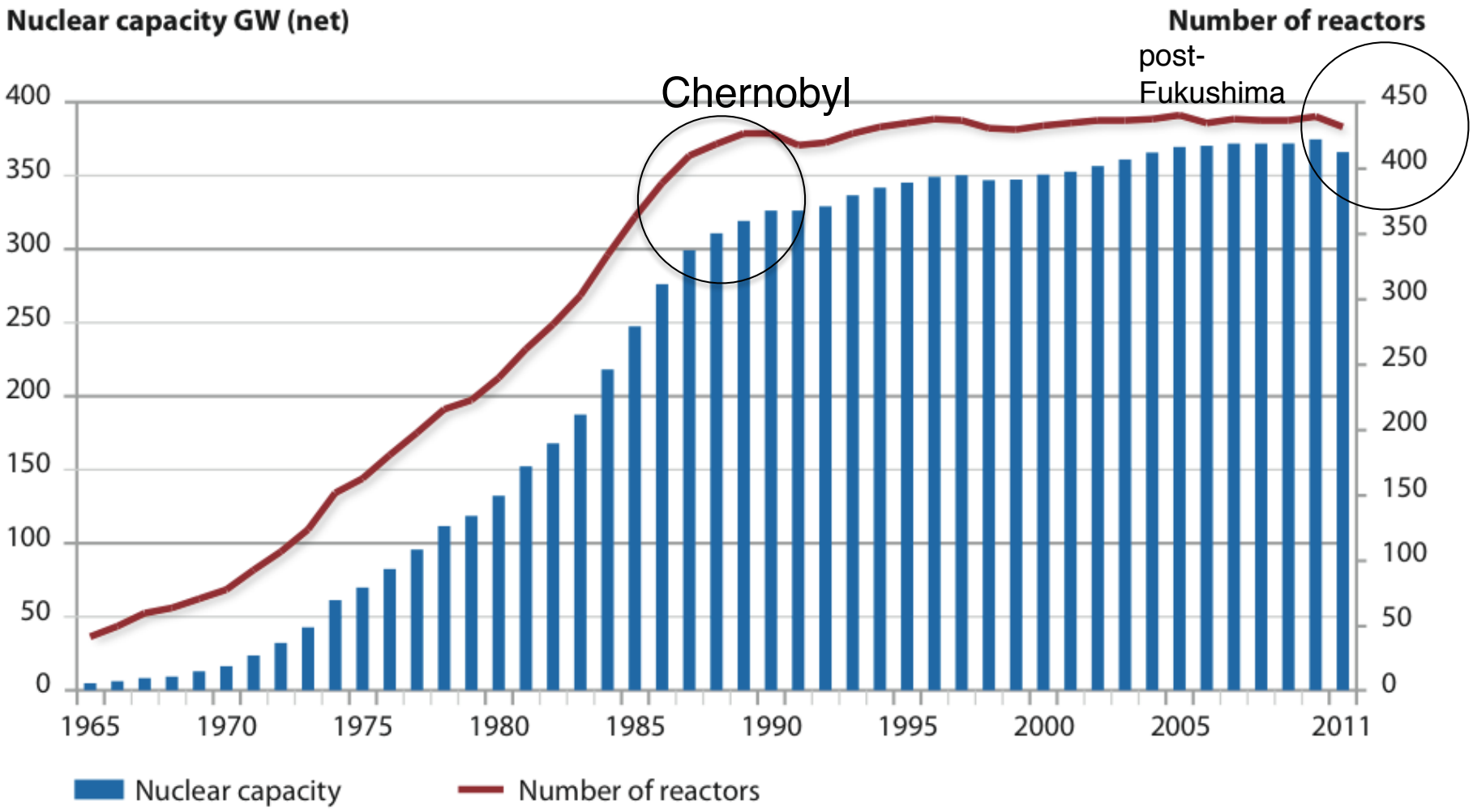
1 gram of Uranium can power a typical household (1kW) for two years.

fuel type	coal	nuclear
energy content (kWH/kg)	6	10 million
fuel efficiency	30%	30%
cost of electricity ($/kWH)	$0.03	$0.007 (fuel only) $0.02 (**overall)**
CO_2 emission (kg/kWH of electricity)	1	**0**

~ 10 B/reactor; insurance; spent fuel…

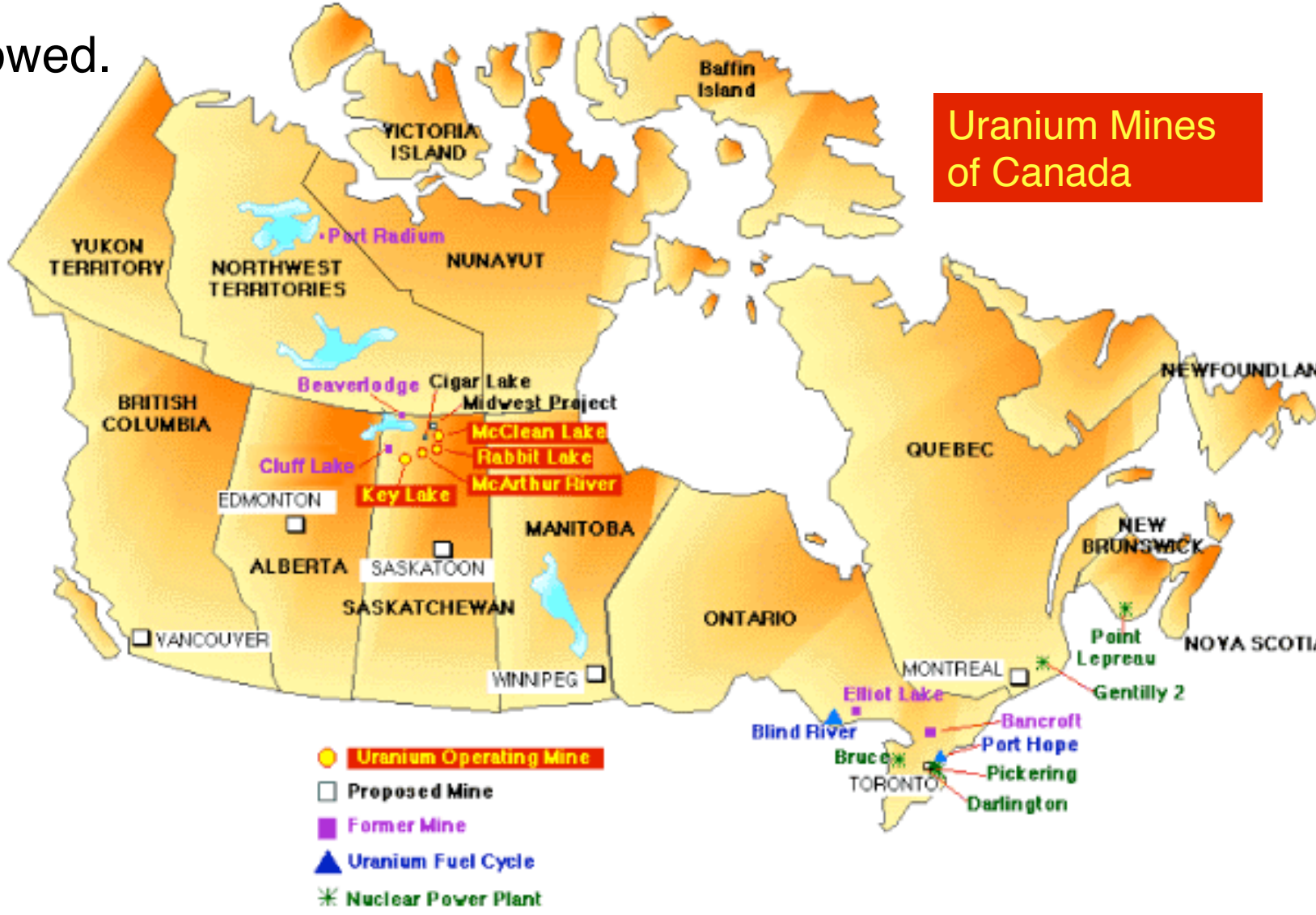
Nuclear power is not happening!

Figure 1.1: **Worldwide nuclear generating capacity and number of operating reactors (1965-2011)**



Source: IAEA Power Reactor Information System (PRIS).

Canada is endowed.



Canada's uranium production is ~20% of total world output (after Kazakhstan)

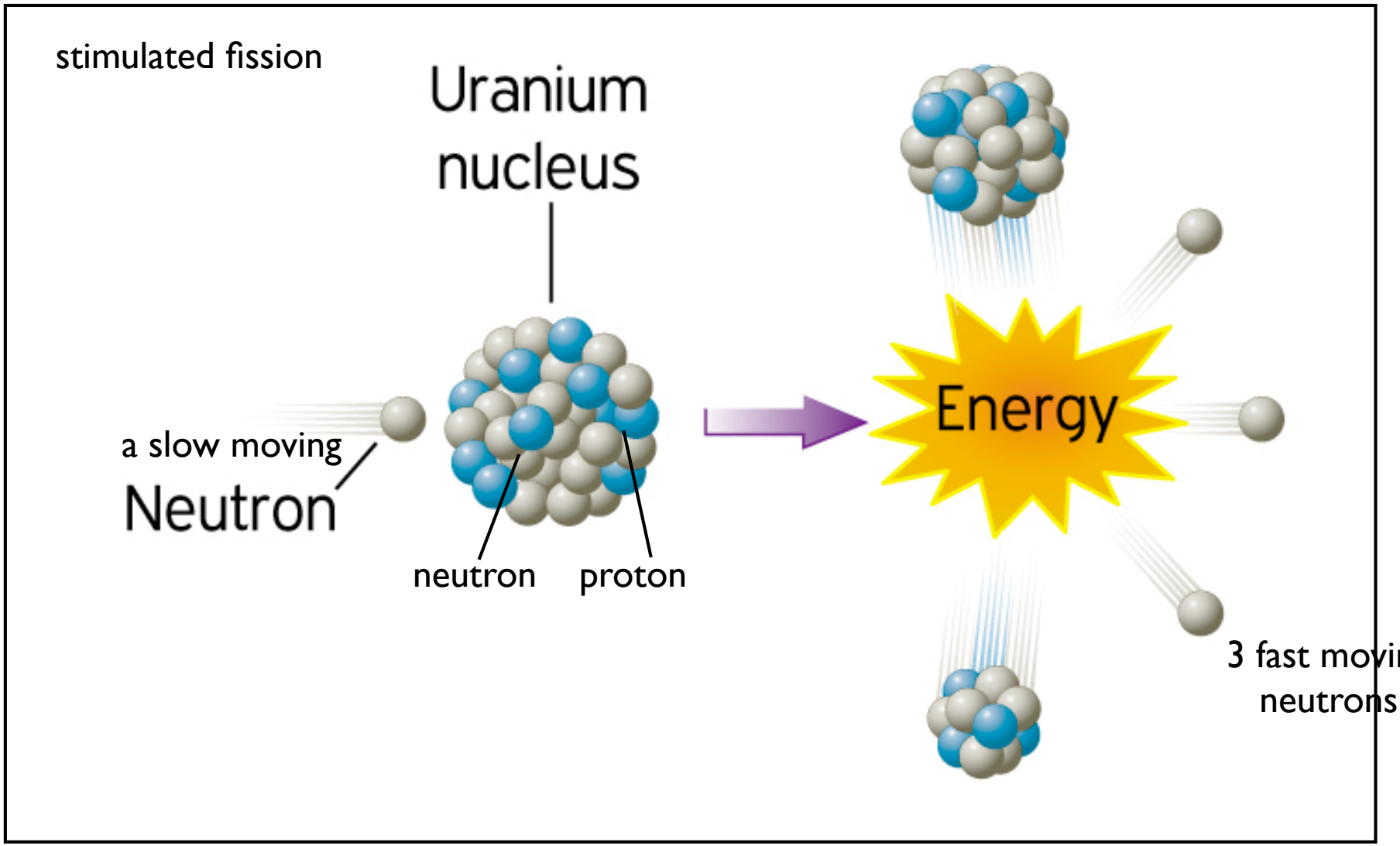
together with exporting CANDU technology, nuclear industry is an important economics sector.

MCARTHUR RIVER OPERATION

McArthur River miner Ken Pederson uses a remote controller to run the scoop tram, keeping himself at distance from the high grade uranium ore being moved from the extraction chamber to the underground grinding circuit.

www.cameco.com

Uranium spontaneous decay half life: ^{238}U 4.5 Gyrs; ^{235}U: 0.7 Gyrs;
As well, ^{235}U can undergo stimulated (induced) fission. Instant.



making it useful for nuclear reactors and….

Nuclear reactor & Waste: Nature does it fine

Oklo, Gabon, Africa: Ancient Nuclear Reactor

(~1.7 Byrs ago)

The uranium isotopes found at Oklo strongly resemble those in the spent nuclear fuel generated by today's nuclear power plants.

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INTERNATIONAL

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  - Stop climate change
  - Defending Our Oceans
  - Protect ancient forests
  - Demand Peace and Disarmament
  - Say no to genetic engineering
  - Eliminate toxic chemicals
  - End the nuclear age
  - Encourage sustainable trade

Welcome to Greenpeace International

Greenpeace exists because this fragile Earth deserves a voice. It needs solutions. It needs change. It needs action.

Greenpeace website, 2014

"Nuclear power plants are, next to nuclear warheads themselves, the most dangerous devices that man has ever created. Their construction and proliferation is the most irresponsible, in fact the most criminal, act ever to have taken place on this planet."
Patrick Moore (co-founder of Greenpeace), *Assault on Future Generations*, 1976

The reality of nuclear power is no different now than it was in the 20th Century - it is inherently dangerous. -- Greenpeace website

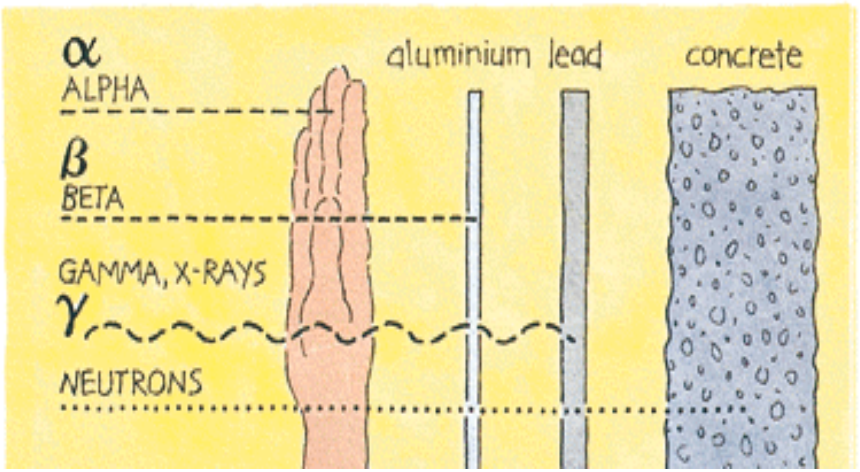
Syncrude Aurora Tar Sands Mine, north of Fort McMurray in Alberta, Canada.

Which of the following is more radio-active?

A) your cellphone

B) the air in your basement

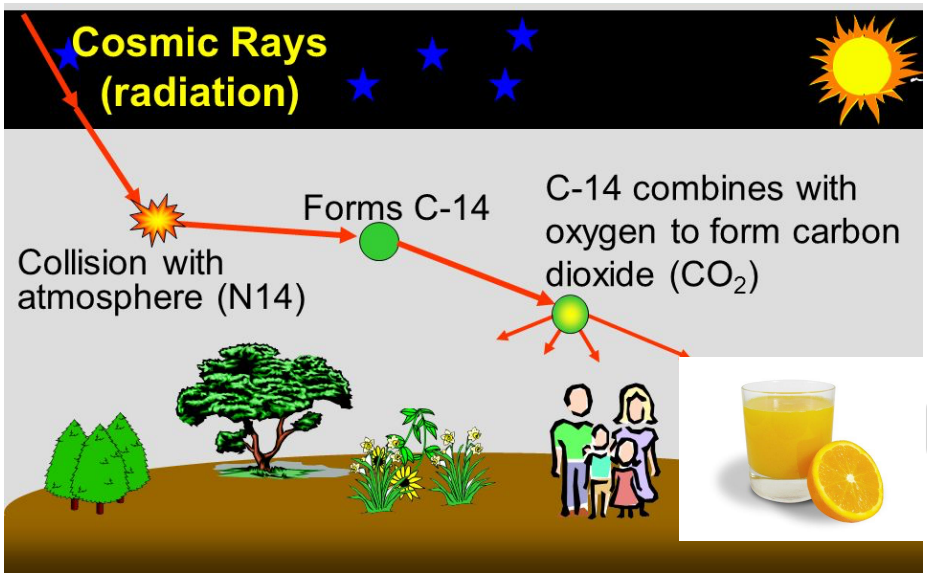
Spontaneous Decay: half-life



Which of the following is more radio-active?

A) a litre of gasoline

B) a glass of orange juice

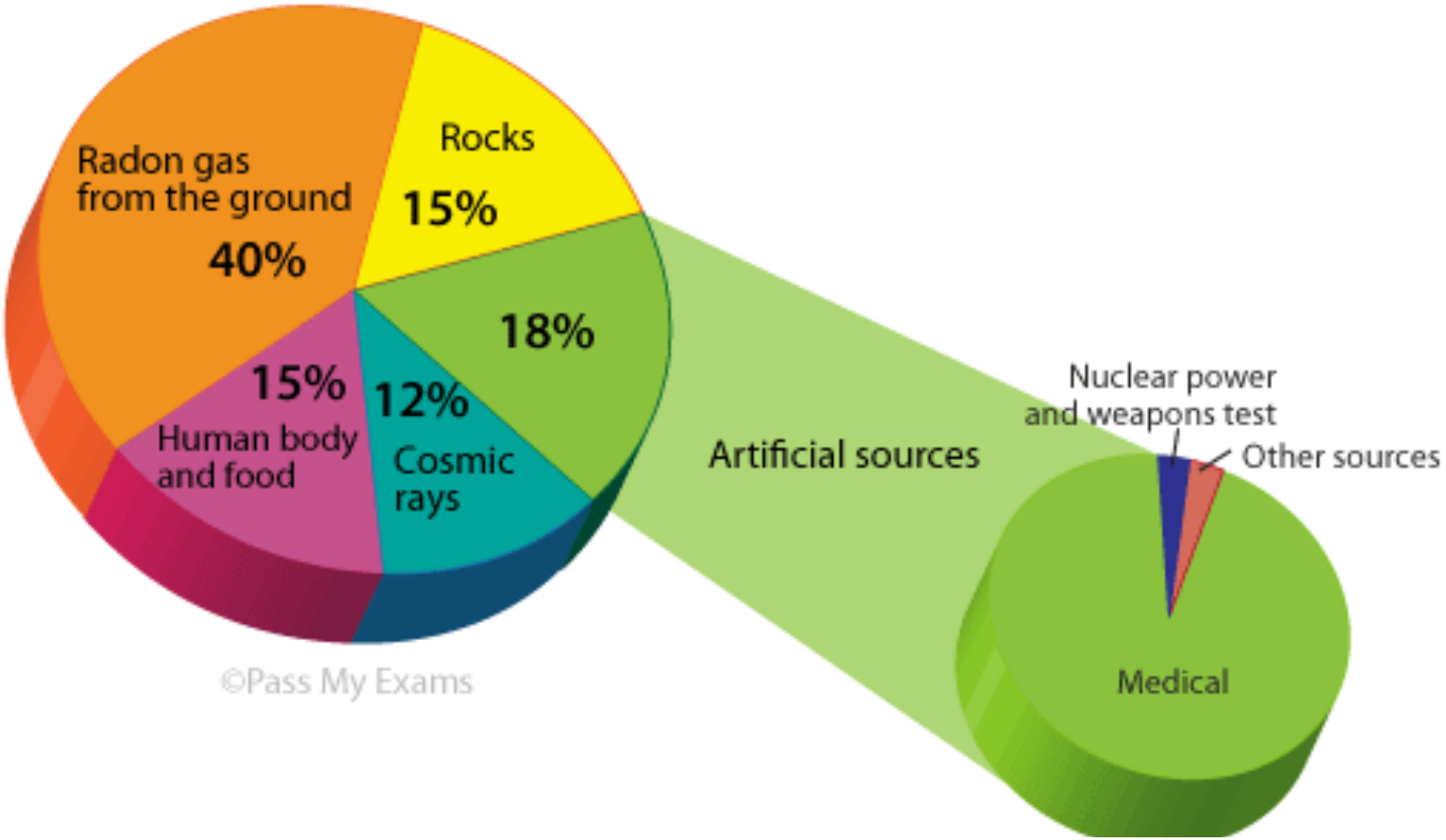


Background radiation for an average person

1) cosmic-ray producing ^{14}C
2) ^{238}U decay product (Radon)

Life has evolved in this background.
Radiation good/bad?

Background Radiation

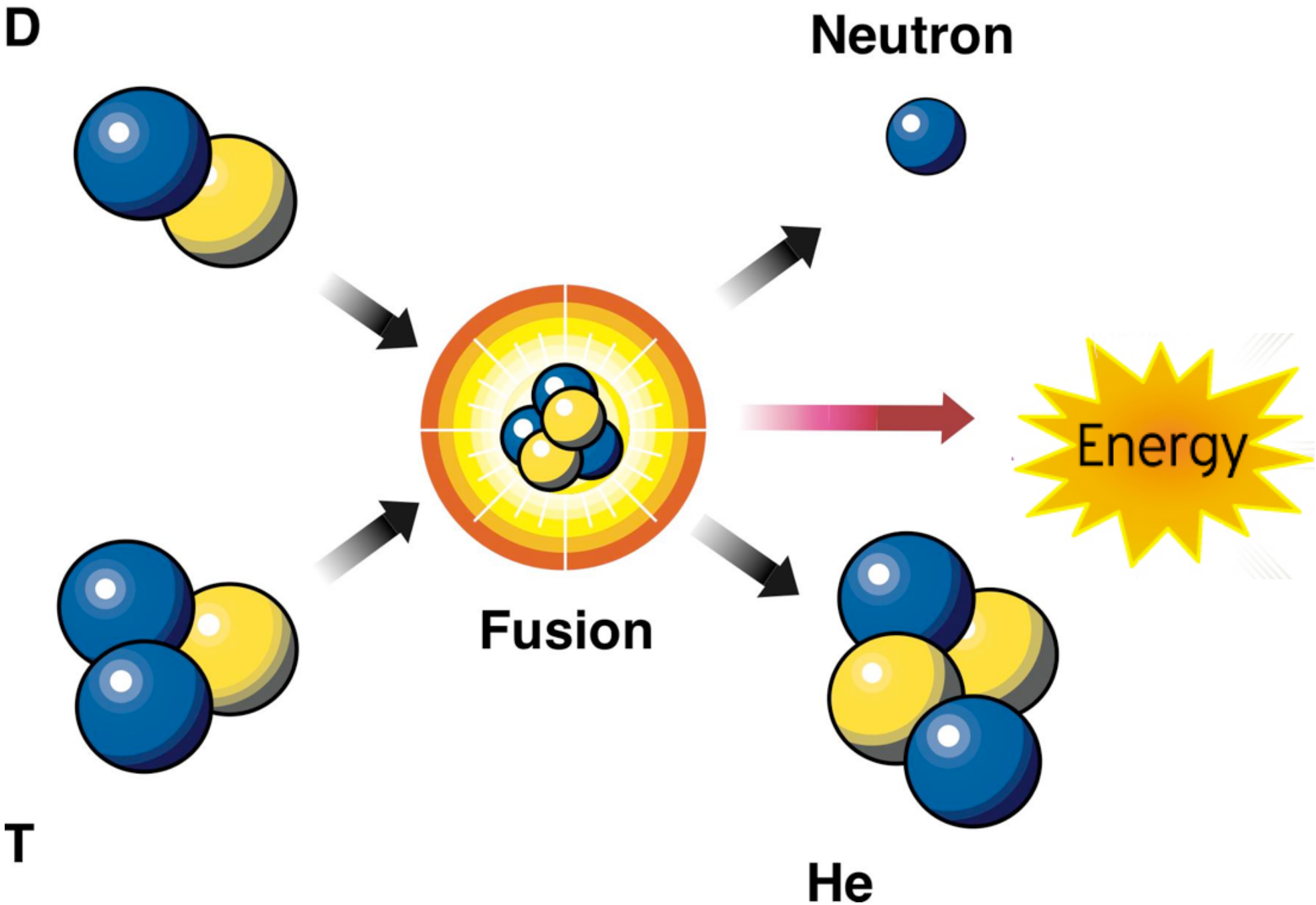


- **Going Nuclear**

  A Green Makes the Case
  By Patrick Moore
  Sunday, April 16, 2006, Washington Post

  .... Thirty years on, my views have changed, and the rest of the environmental movement needs to update its views, too, because nuclear energy may just be the energy source that can save our planet from another possible disaster: catastrophic climate change....

Fusion: the technology everyone will be happy with



How to set the nuclear fire?

or, why haven't we had fusion on Earth yet?

nearly inexhaustible energy
first hydrogen bomb 1952

. quantum tunnelling allows nuclear fusion at T ~10^7 K (λ~100fm)
— tunnelling exponentially less likely at lower T, "ignition temperature"
— reaction rate rises with density of material

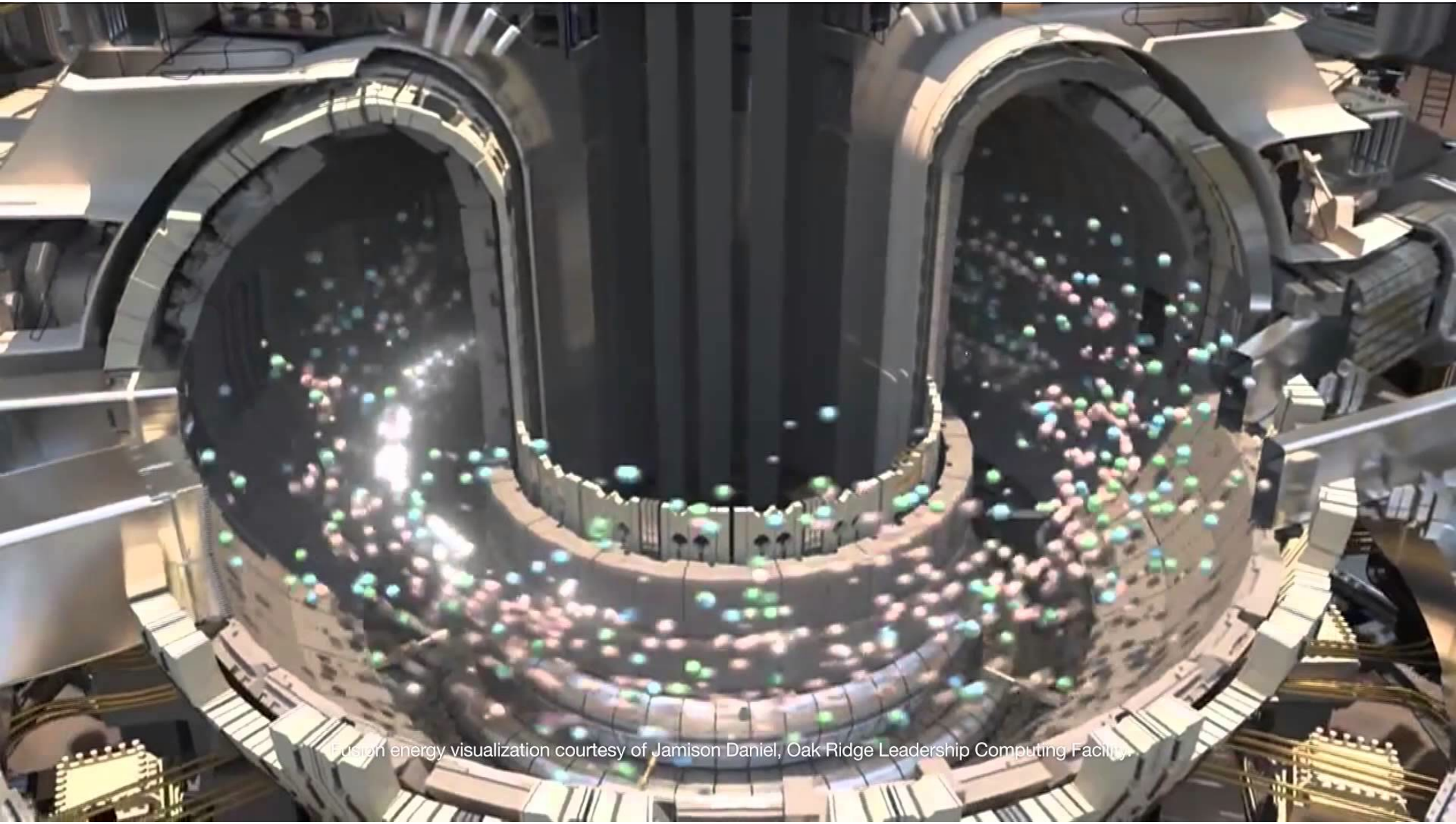
"confinement": $P = \rho k_B T/\mu m_{H;}$

"Cold fusion": Pons & Fleischmann, Univ. of Utah,1989

international thermonuclear experimental reactor

iter

china eu india japan korea russia usa



No one has reached the Mark: 10^8 K for 1,000 seconds

China overtakes Germany to make nuclear fusion breakthrough: Reactor creates conditions THREE times hotter than the sun

- **Test was conducted on a magnetic fusion reactor known as EAST**
- **Chinese team were able to maintain 50 million°C for 102 seconds**
- **The breakthrough that could someday make fusion power a reality**
- **Last week Germany used 2 megawatts of microwave radiation to heat hydrogen gas to 80 million°C for a quarter of a second**

By ELLIE ZOLFAGHARIFARD FOR DAILYMAIL.COM

PUBLISHED: 21:41 GMT, 5 February 2016 | **UPDATED:** 13:20 GMT, 6 February 2016

Fusion may happen in another 20 years, meanwhile…