

Fossil Fuels and Energy Risks

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Energy - Risk - Cost...

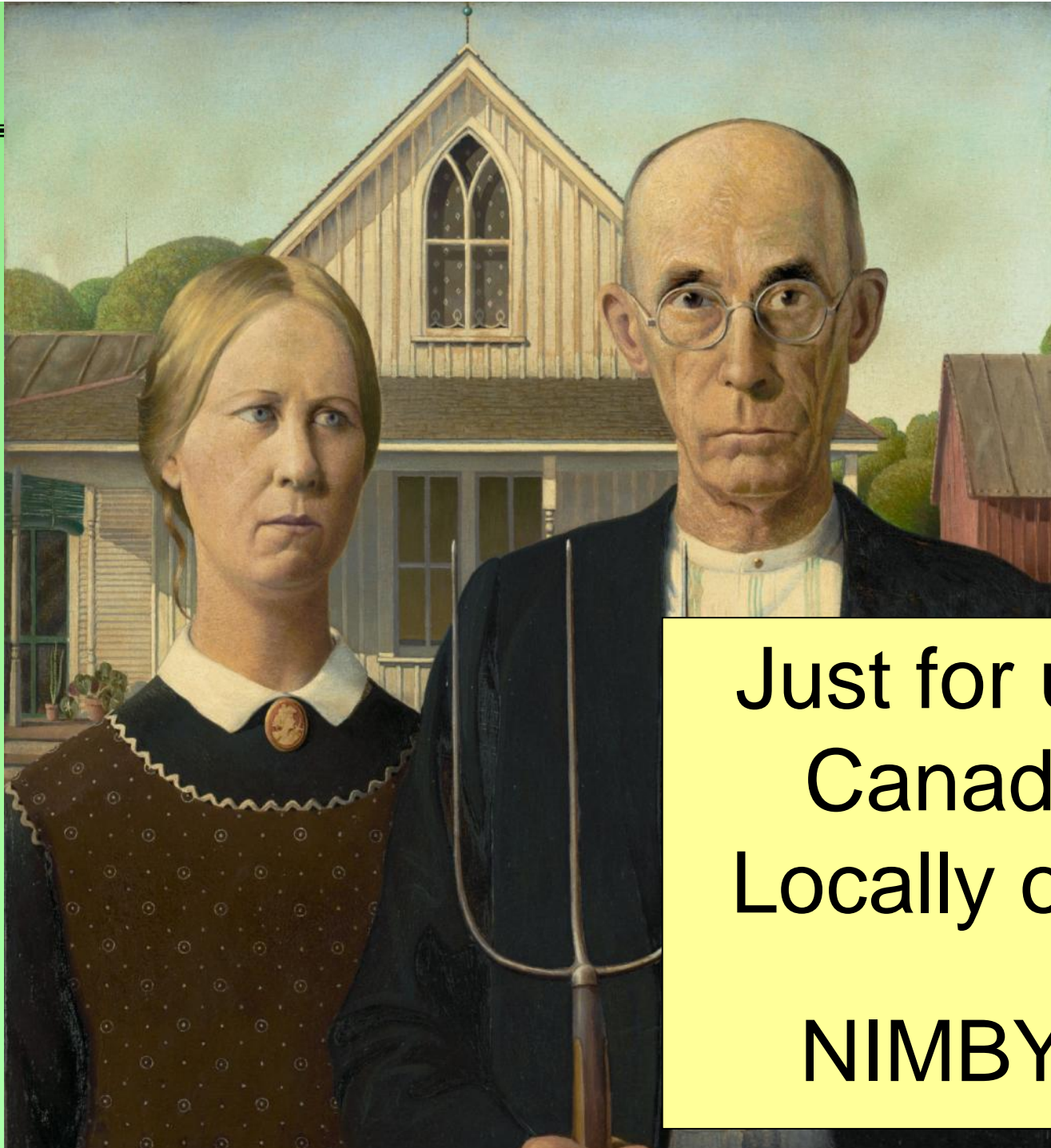


Is conservation of energy the lowest risk alternative? For everyone?

Are renewables risk-free?

Cost must be considered: is part of risk!

Should we calculate energy risk globally?

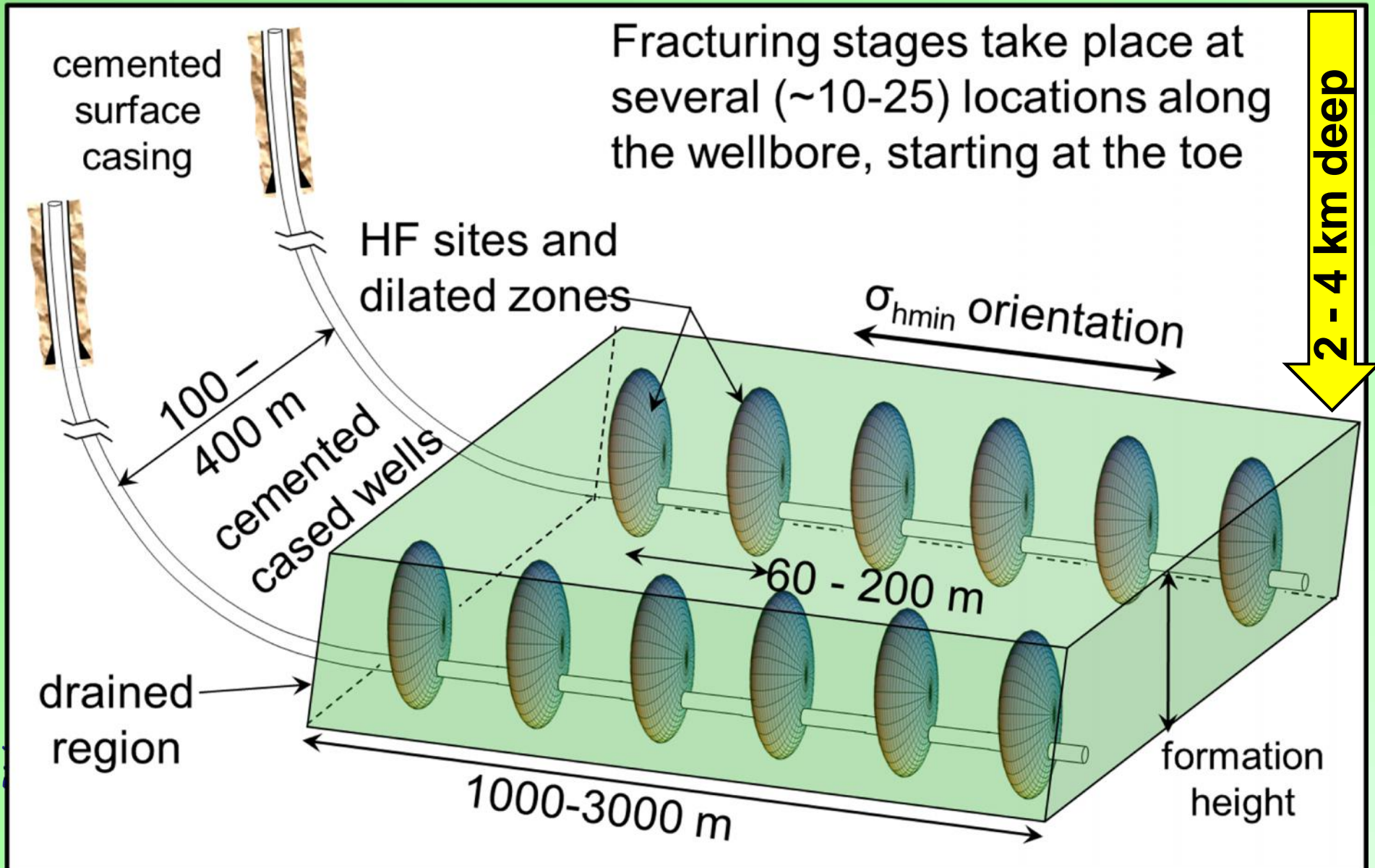


Just for us in
Canada?
Locally only?
NIMBY?

Example: Shale Gas Energy

- ◆ Vast amounts of CH_4 in shale strata can now be developed: an ENERGY source...
- ◆ ...using multi-stage hydraulic fracturing in long horizontal wells...
- ◆ Resources in many countries: Argentina, Canada, Australia, US, China, even UK...
- ◆ What are the real risks of developing or not developing this source of energy?

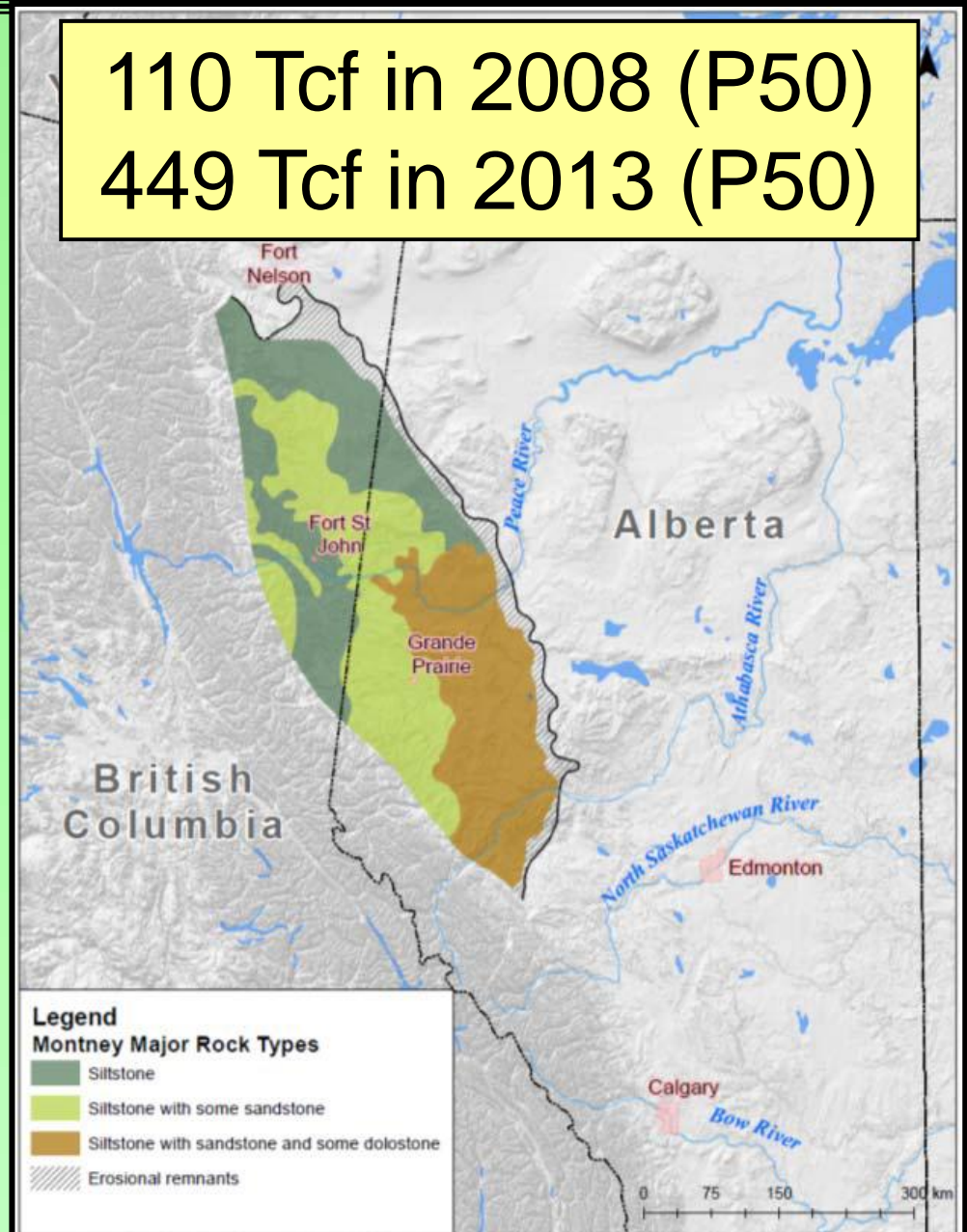
The Technology...



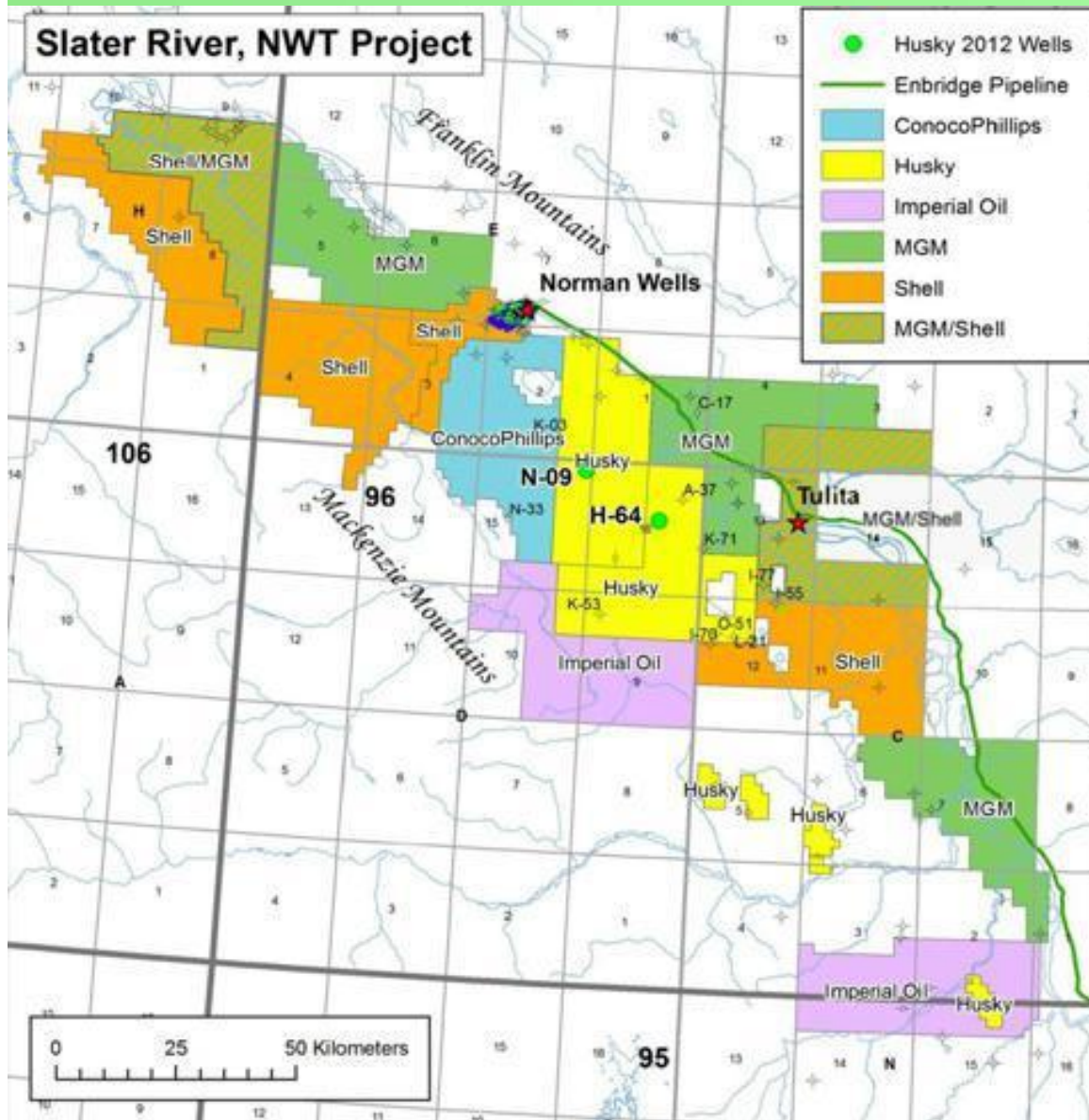
Example: The Montney Shale...

- ◆ A huge "find"...
- ◆ Thick, rich, etc.
- ◆ >100,000 km²
- ◆ 100-300 m thick
- ◆ 449 Tcf CH₄
- ◆ 15 Bb NGL
- ◆ 1.1 Bb NGL
- ◆ Number of wells?
~500,000 wells

110 Tcf in 2008 (P50)
449 Tcf in 2013 (P50)



Canol River...?



Is the Canol River Shale Oil the next big play in North America?

What are the development risks? ...and the risks of no development?

...and, there will be other shale oil and shale gas plays in the far north...

- **P ~ 0.50 of...**
- **270 Bb OOIP**
- **270 Tcf gas**
- **38 Bb NGL**

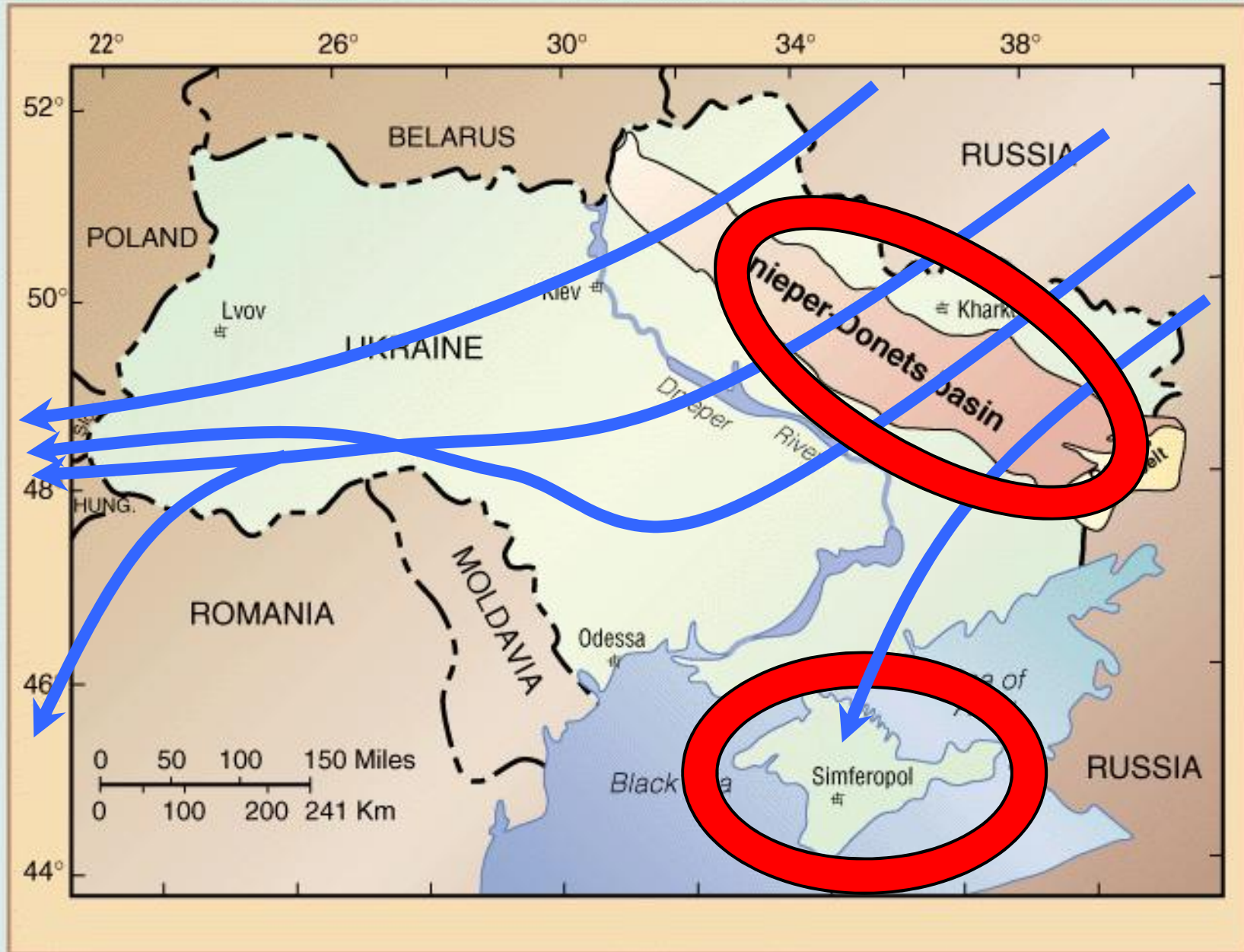
Geopolitical/Economic Risk..



Russia - Ukraine - Energy - Risk

1991	Break-up of USSR
1994 March	Russia cuts gas supplies by 65%
2001 January	Gas producer Itera stops deliveries (65 million debt)
2006 January	Gazprom cuts supplies, gas shortages all across Europe for a few days
2007 October	Gazprom threatens cut-off, agreement reached
2008 March	Gazprom cuts gas by 25% - Russia claims 1.5 billion debt unpaid
2009 January	Russia/Gazprom cuts all gas to Ukraine for 12 days, and also to Europe
2010 April	Agreement for gas at 30% discount in return for long-term Russian lease of naval port in Crimea
2014 March	Agreement unilaterally canceled by Russia
2014 March	Crimea re-occupied by Russia
2014 April	Donetsk, eastern Ukraine issues (Donetsk Basin!)

DNIEPER-DONETS BASIN AND DONBAS FOLDBELT



Mar 11... Polish
PM declares new
concessions for
rapid shale gas
development.
Why?
...Russia...

Donald Tusk



Canada's export gain is OPEC's loss

DAVID PARKINSON

It only makes sense that as the United States becomes increasingly self-sufficient for its own oil supply needs, someone who exports oil to the U.S. market has to pay the price. But, it appears, that someone isn't Canada. It's OPEC that's taking the United States' shale oil boom on the chin.

In a research note Monday, National Bank chief economist Stéphane Marion noted that according to U.S. government data, Canada's exports of crude oil and products hit a record 3.4 million barrels a day in the first quarter of this year - even as surging U.S. domestic oil production reached its highest level in 25 years. While U.S. oil production has surged almost 50 per cent since the middle of 2011, Canada's shipments into the U.S. have risen by more than 30 per cent.

But the same can't be said for the Organization of the Petroleum Exporting Countries; the oil cartel is losing its once-powerful grip on the U.S. energy market. In the past six years, OPEC's exports to the U.S. have declined by nearly 50 per cent; more than half of that has occurred since the U.S. shale-oil production boom took hold in earnest in mid-2011.

Indeed, as Mr. Marion noted, Canada has surpassed OPEC as the biggest exporter of crude oil and petroleum products to the United States. At crude, OPEC's exports have fallen by more than 50 per cent since mid-2011. This means that the U.S. has become a net importer of oil products from Canada.



While U.S. oil production has surged almost 50 per cent since 2011, Canada's oil exports to the U.S. have not suffered. EDDE SEAL/BLOOMBERG NEWS

ical forces on both sides of the Canada-U.S. border who have long talked about reducing U.S. reliance on OPEC as an energy supplier, citing concerns about the reliability, political stability

But more to the immediate point, as the Bank of Canada noted in its quarterly Monetary Policy Report last week, the shale-oil boom hasn't much hurt U.S. refineries' appetite for crude from Canada's oil sands, nor

Alberta oil sands heavy crude has filled the void (which, in case we've lost it in all the political rhetoric, was the logic behind the Keystone XL pipeline project in the first place). The result has been that as U.S. energy demand

ment, put forth by CIBC chief economist Avery Shenfeld, that Statistics Canada's export data have been understating the strength of Canadian oil exports to the United States. In short, the energy sector may be more of a

Today's Globe and Mail

ecov-
with
to ac-
ect this
of Can-
recov-

Newfoundland Declares Moratorium on Shale Gas Fracking

Reviews, public consultations needed before policy developed, minister says

Natural Resources Minister Derrick Dalley has declared a moratorium on fracking in the province.



Nov
04
2013

Economically and politically, Canada
is a low-risk energy supplier

There are complex risks associated with
NOT developing energy sources

Resource Export Issues...

- ◆ Canada: <0.5% of the world's population
 - 13-14% of the world's petroleum
 - 6-7% of the world's natural gas
 - Important primary resources sector
- ◆ Companies and provinces want to export LNG, but the US doesn't want our gas now; perhaps Asia and Europe!
- ◆ Royalties and employment are key issues in the provinces...
 - NWT & Yukon ... health, education...

World's Leading Oil Producers

Rank	Country	March Oil Output, Barrels per day (M)
1	Russia	9.99
2	Saudi Arabia	9.10
3	United States	7.12
4	China	4.16
5	<i>Canada</i>	3.49
6	Iran	3.20
7	Iraq	3.07
8	United Arab Em.	2.82
9	Kuwait	2.65

...as Scientists...

...our responsibility is to collect, analyze and present the facts as they are; citizens' elected representatives make decisions after being informed by voters, scientists, economists... Scientists should clarify issues, quantify risks, and outline the choices in energy risk management.

...Energy and all industrial activity carry some level of risk, and decision-making has to weigh many non-technical issues.

SGD in Well-Populated Areas



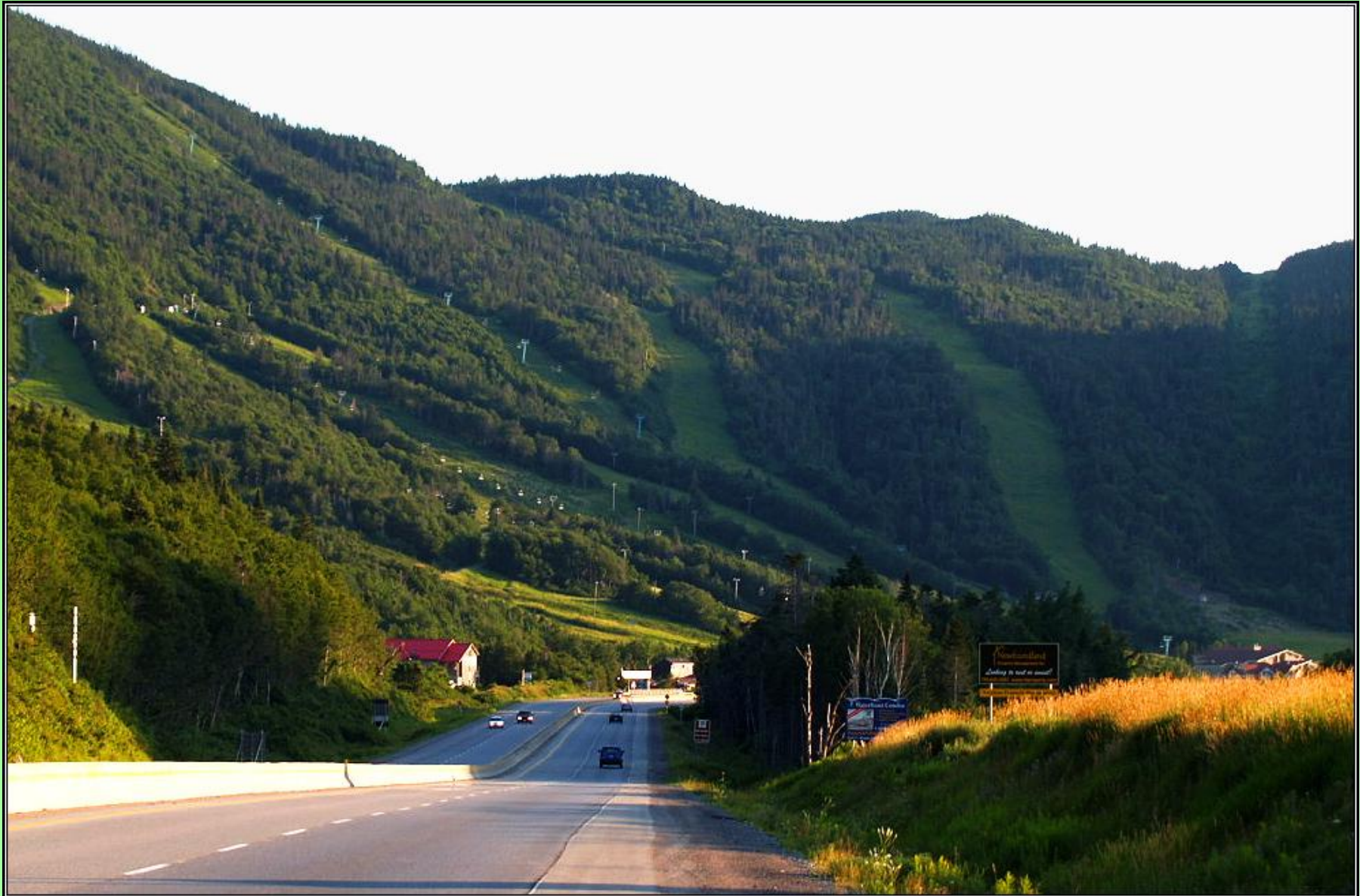
...and Remoter Areas (no farmers)

- ◆ Horn River (BC) multiwell pad drilling



SW Newfoundland...

Energy Risks



Gros Morne National Park



Key Points

Canada remains #3 in the world in gas production, after USA and Russia

Farmland area development – Pennsylvania
What are the development Consequences?

Average population density - 0.05 persons/km²
What are the development Consequences?

Beautiful, unspoiled, but very few jobs...
What are the development Consequences?

Don't worry. Gros Morne National Park Not on the development table...

Sticking to the Energy Facts...

- ◆ What are the facts about shale gas?
- ◆ Impacts on the earth's surface and groundwater?
- ◆ ...surface water and the air we breath?
- ◆ Are there seismic risks?
- ◆ How do we reduce risks?
- ◆ How do we regulate the O&G industry?
- ◆ Are there opportunity risks in not developing shale gas?
- ◆ ...and so on...

Accidents will happen...

We know how to reduce these types of risks.

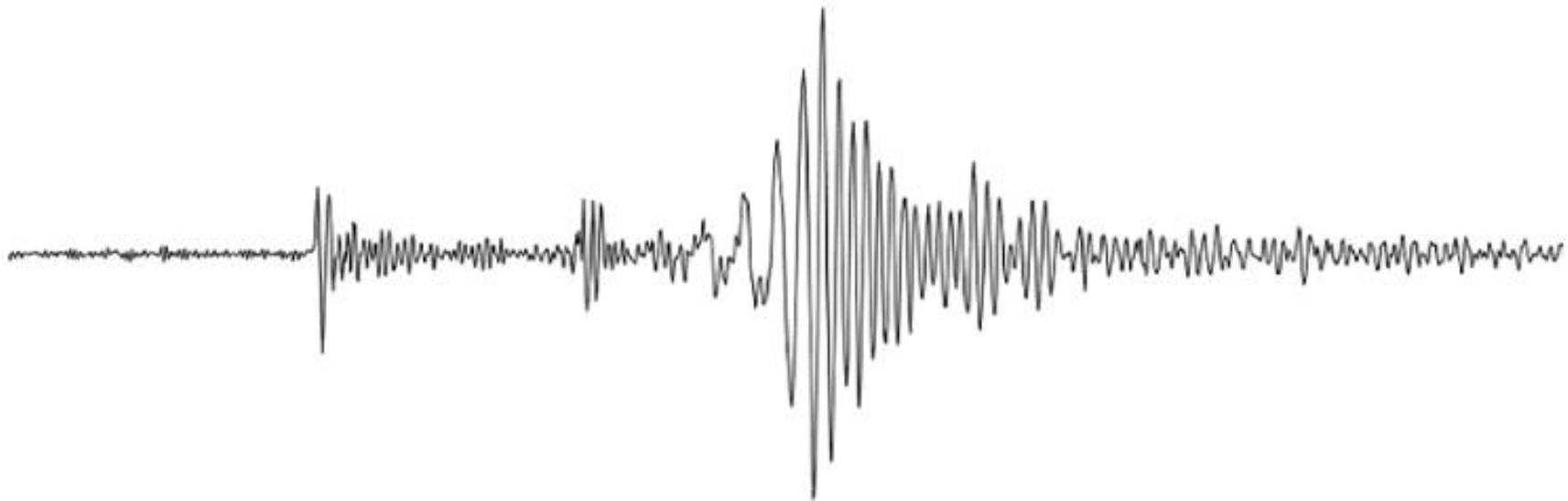


Marcellus Shale Gas Drilling , USA



Induced Seismicity...

- ◆ Risks from HF - extremely low
- ◆ From large-scale waste water injection?
Not so low; must be managed properly...
- ◆ This is a seismic record from an injection well



- ◆ Traffic accidents are always a risk, everywhere.
- ◆ We know how to quantify and reduce seis-mic risks from HF and deep well injection

Where Will the Water Come From?



Using high quality groundwater? Not an option!



**Williston Basin Shale Oil
Development, North Dakota**

Water impacts are directly related to:

Zone thickness

Fracture stimulation strategy

Water availability

Population density

Land use

...

Where Are the Fracture Fluids?





11 06 2007

Canada vs. US

- ◆ What happens in Canada (picture) is **NOT THE SAME** as the USA!
- ◆ ...but, leaky wells exist...

What Science Tells Us...

- ◆ Compared to other energy sources, shale gas is not particularly risky
- ◆ Realistically? Road accidents, spills, fugitive gas emissions...
- ◆ Methane emissions risks can be greatly reduced (a technical issue)
- ◆ Well integrity can be improved
- ◆ Natural methane in groundwater occurs naturally in many areas
- ◆ ...and so on...

Our Carbon Future...

Carbon
Heavy

- Oil and coal mainly
- Energy source of past decades

Carbon
Light

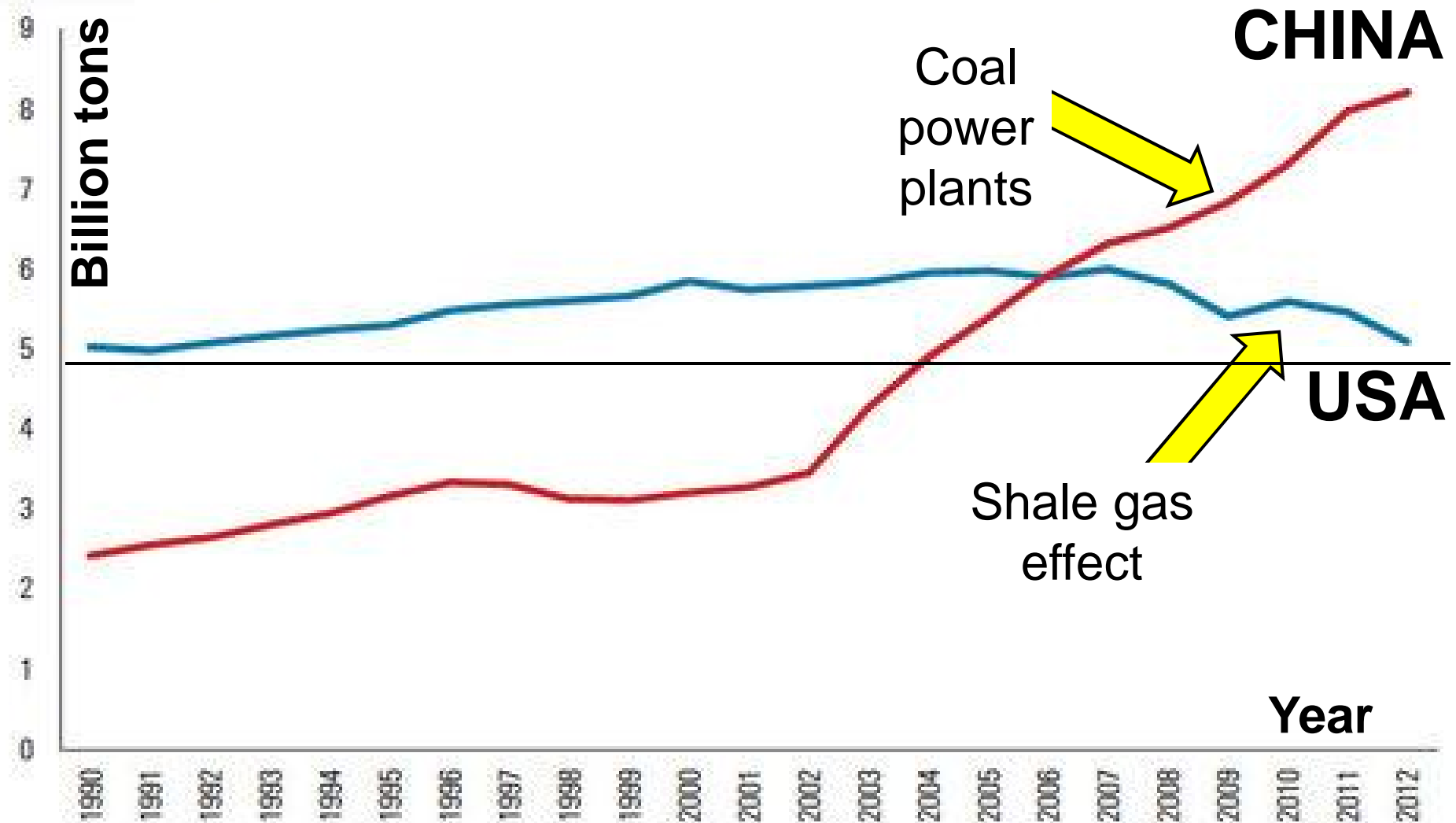
- Natural gas & Nuclear power
- Energy source of the near future?

Carbon
Free

- Geothermal, solar, wind, etc.
- Energy sources of the future?

China - USA - CO₂

ENERGY RELATED CO₂ EMISSIONS...



Future

- ◆ Gas is a transitional fuel allowing energy integration and more renewables
- ◆ Helping China convert to gas would greatly reduce CO₂ emissions

Combatting Pollution, CO₂...

Harbin, China

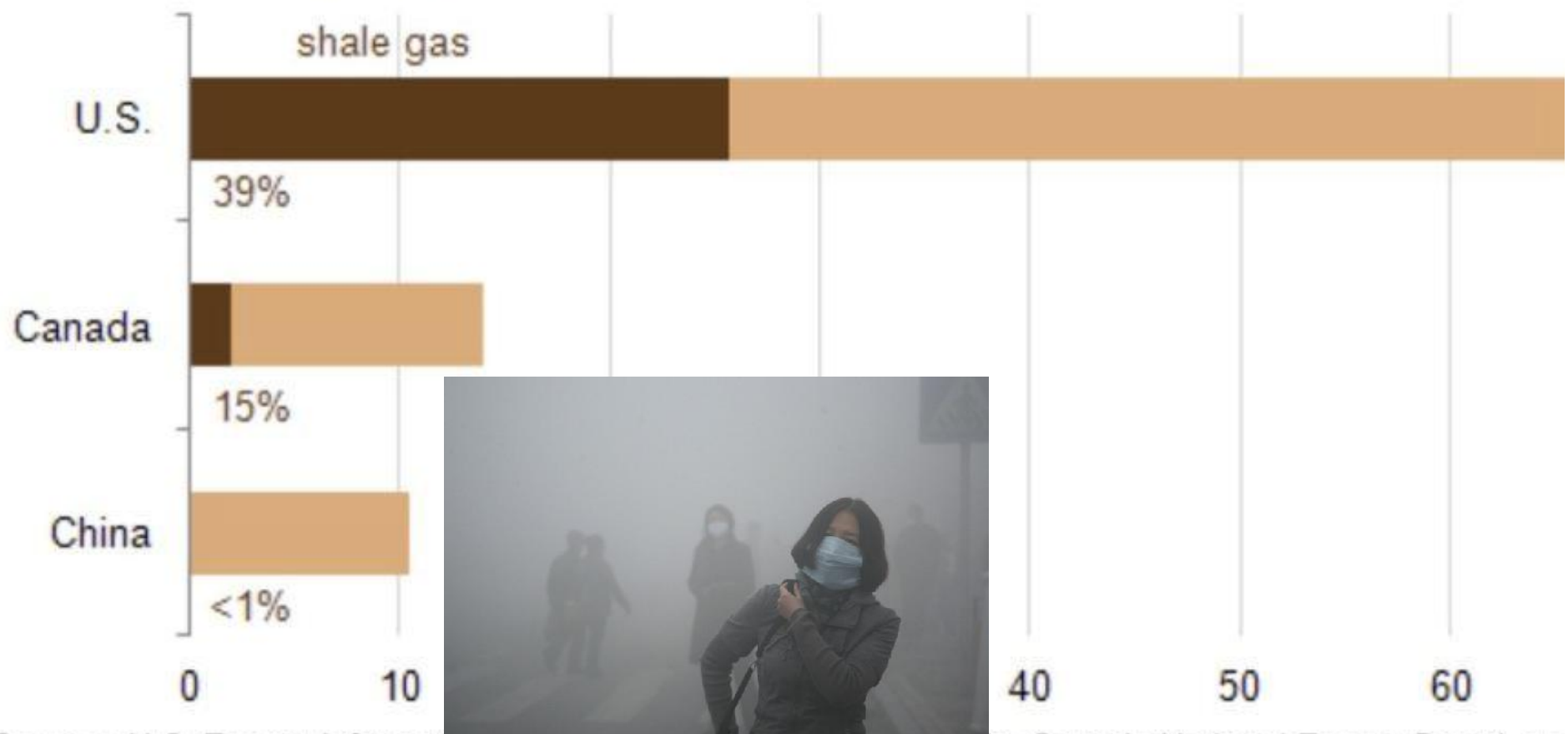
Oct 23 2013
Coal-fired
electricity



Shale Gas Development...

◆ China's current position...

Shale gas as share of total dry natural gas production in 2012
billion cubic feet per day



Source: U.S. Energy Information Administration, LCI Energy Insight, Canada National Energy Board, an Energy

CH₄ - The Transition Fuel

- ◆ Coal & electrical energy (28% in US and dropping, over 90% in China and India...)
- ◆ China has been the world's largest emitter of CO₂ for a number of years
- ◆ USA CO₂ emissions dropped for 5 years...
 - Natural gas from shale is replacing coal...
 - No new coal-fired power plants...
- ◆ Reduced Risks!
 - Far lower health risks of all kinds
 - No solid wastes, SO_x, fly ash, coal dust...
 - Half the CO₂ of coal per kWhr

China

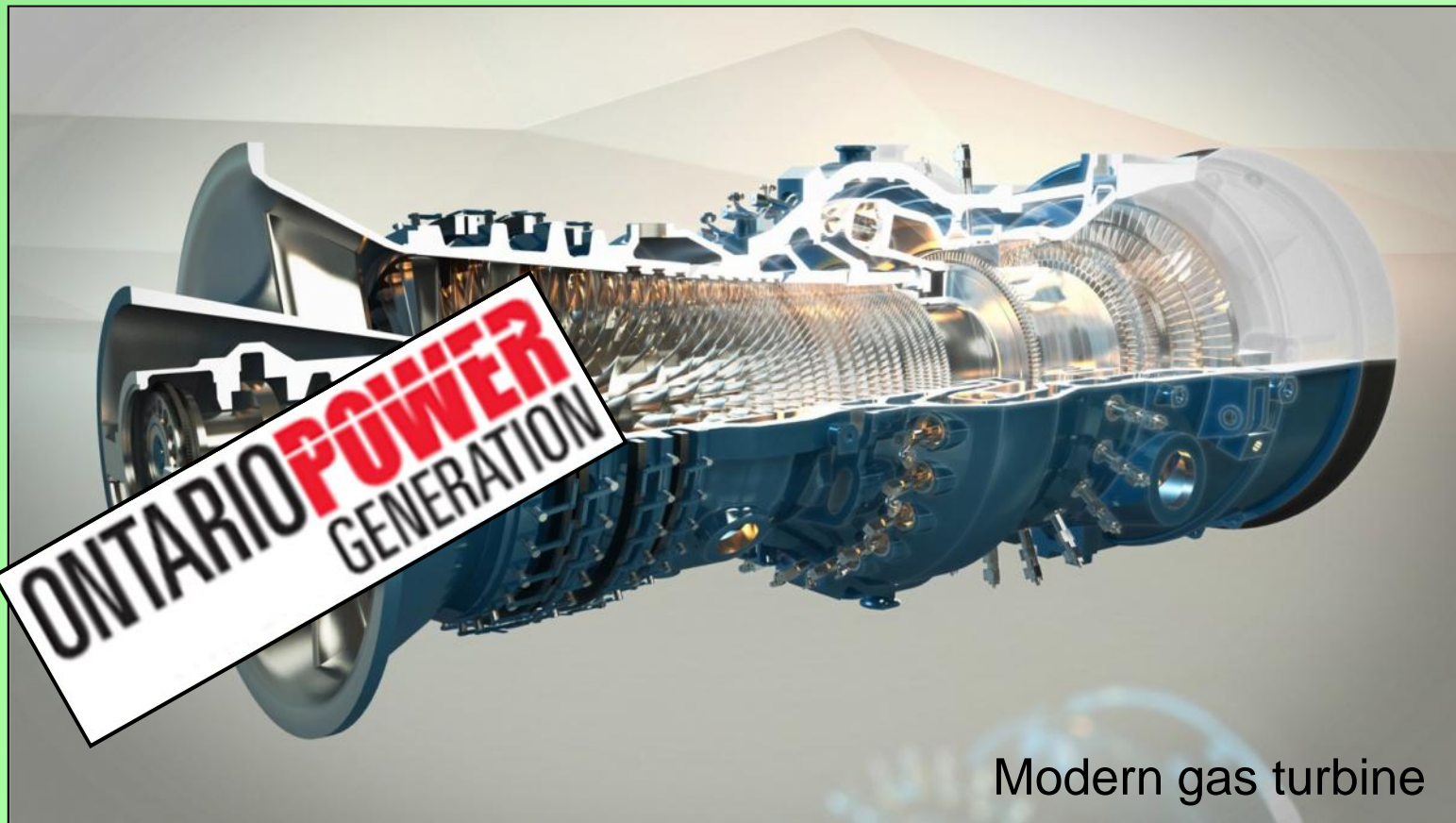
...if we were serious about
CO₂, we would help China
convert to CH₄

Shale Gas Basins of China



Gas Turbines are Scalable!

- ◆ Local power generation capability in the future will affect monopolistic utilities.



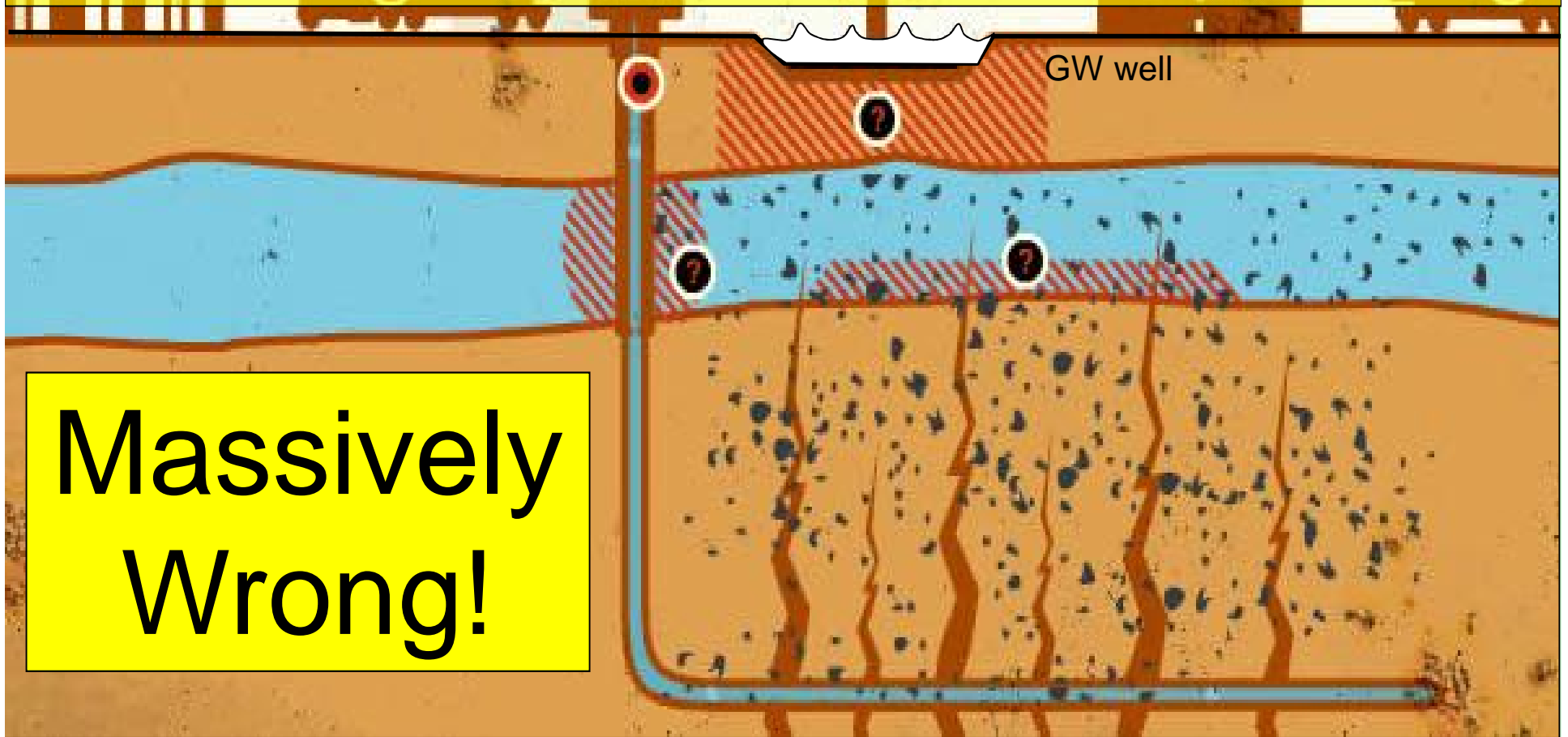
Misinformation is Rampant...



Is OPG market at risk?

Is misinformation a risk?

Is this inaccurate figure a deliberate attempt to scare people?



Science Society Risk



Opinions

- ◆ You are entitled to an opinion...
- ◆ But do an honest assessment!

What About YOUR Energy?

- ◆ No energy source is without risk...
- ◆ Energy brings vast benefits as well...
- ◆ How will you react to "Energy Change"?
- ◆ Will you weigh the scientific facts?
- ◆ Will you weigh the plusses and minuses?
- ◆ For other communities as well as yours?
- ◆ ...for China as well as for Canada?
- ◆ And... ..things change; they always do...
 - ➔ Energy technologies...
 - ➔ Risk understanding and mitigation...