Shale Gas:
Macro-level Benefits and Risks

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Whitehorse

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Professional Background

1987-present – Professor, Resource & Environmental Mgmt., SFU

1987 - PhD in energy economics and policy, University of Grenoble

1992-97 - Chair and CEO BC Utilities Commission

1993-96, 2009-12 - IPCC assessments / reports

1994-2001, 2008-09 – China Council for International Cooperation on Environment & Development

2007-12 – Global Energy Assessment

1987-present – Advising jurisdictions in Canada & abroad, including the Yukon in 1991, 1997, 1998 & 2011

Overview

1. Is today's shale energy "revolution" a surprise?
2. Are the local risks of fracking acceptable?
3. What is the net greenhouse gas effect of shale gas?
4. What are the risks for shale gas investors?
5. What are government's risk management options?

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1. Is today's shale energy revolution a surprise?

Energy economists have long predicted humans would keep innovating ways to exploit the earth's enormous, diverse fossil fuel resources.

They explained why long-term scarcity (peak oil, gas, coal) is unlikely given (1) vast fossil fuel resources in different forms, and (2) human ability to innovate, especially in response to short-term scarcity.

Shale energy revolution is yet another demonstration of predictions by

Peter Odell with oil in the 70s.

Morrie Adelman with oil, coal and gas in the 80s.

World Energy Assessment 2000.

Global Energy Assessment 2012.

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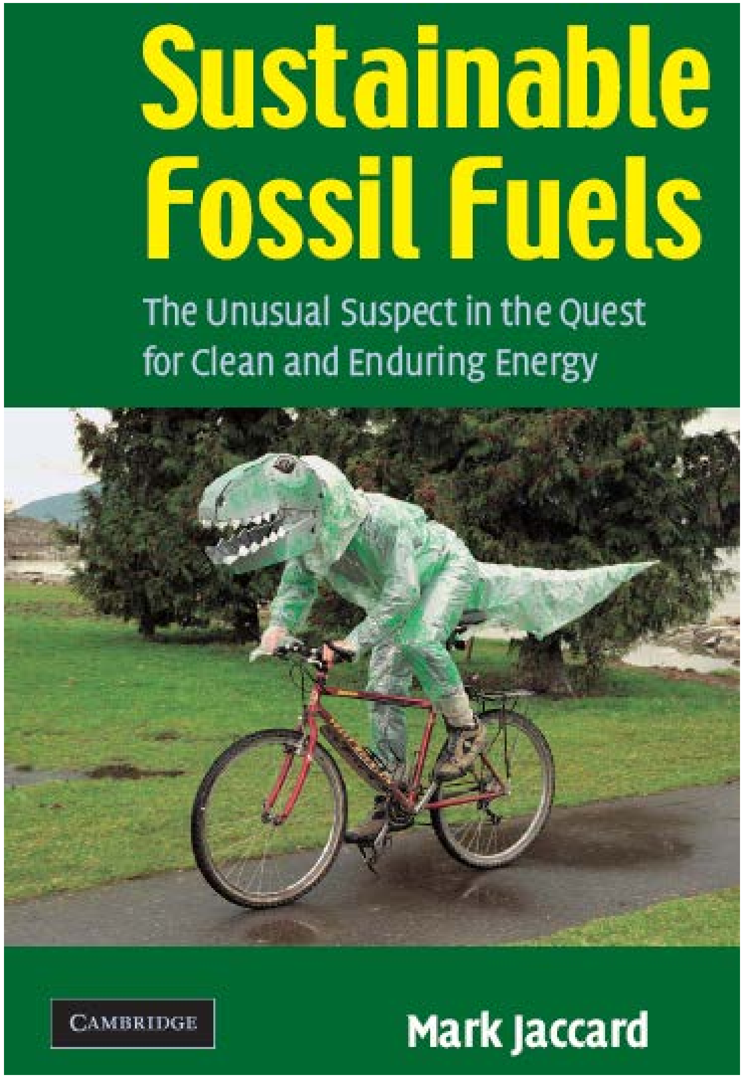
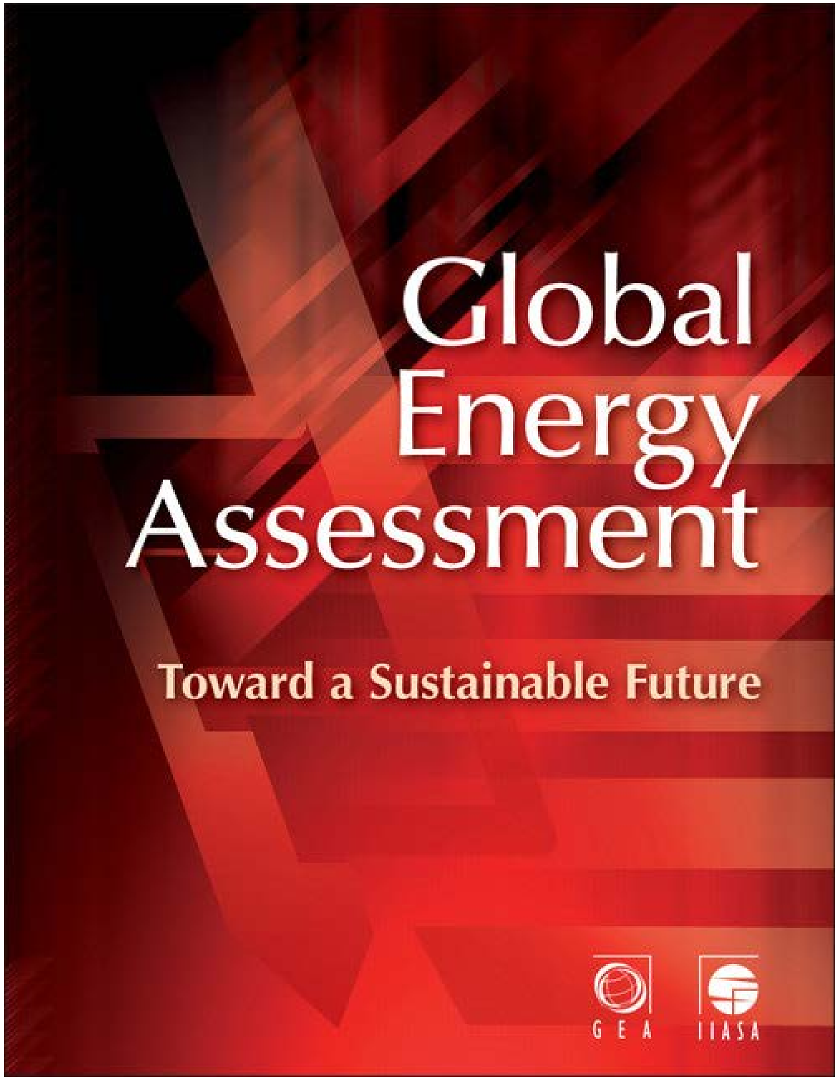
Individual and multi-author assessments





Global Energy Assessment (2012)

	Historical production through 2009	Production 2009	Reserves	Resources	Additional occurrences
	[EJ]	[EJ]	[EJ]	[EJ]	[EJ]
Conventional oil	6 647	166.7	4 900 – 7 610	4 170 – 6 150	n.a.
Unconventional oil	607	23.1	3 750 – 5 600	11 280 – 14 800	> 40 000
Conventional gas	3 467	112.7	5 000 – 7 100	7 200 – 8 900	n.a.
Unconventional gas	158	12.0	20 100 – 67 100	40 200 – 121 900	> 1 000 000
Coal	7 269	152.7	17 300 – 21 000	291 000 – 435 000	n.a.
Conventional uranium[b]	1 333	25.6	2 339	7 420	n.a.
Unconventional uranium	n.a.			4 100	2 600 000

2.Are local risks of fracking acceptable?

You have had many witnesses on local technical risk issues, and I have little to add to their evidence.

As a former regulator, my general sense of the evidence is that effective regulation should be able to reduce most local technical risks of shale fracking to acceptable levels.

But, in your shoes, I would not put much weight on my view. I was an economic regulator!

3.What is the net GHG effect of shale gas?

Advocates emphasize single-use comparisons

Natural gas combustion produces 50% less CO_2 than coal (in electricity plants) and 25% less than gasoline (in vehicles).

But GHG emissions over full fuel cycle more complicated.

- Estimate methane and CO_2 emissions in fuel production.
- Add estimated methane and CO_2 emissions in fuel transport.
- Add estimated methane leaks in local gas distribution.
- Then add estimated CO_2 and other fuel combustion emissions.

Must broaden analysis to include all key energy uses and all energy supply options

Comparison is complicated by including all energy uses and all of the energy forms and supply chains that might satisfy each use.

Electricity generation: NG vs coal, nuclear, diesel, wind, biomass, solar, large hydro, small hydro, geothermal

Transport: NG vs gasoline, diesel, ethanol, biodiesel, hydrogen, electricity.

Space heating: NG vs grid-electricity, biomass, solar.

Industry: NG vs refined petroleum products, electricity, biomass, biofuels, possibly coal.

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Must further broaden analysis to reflect region-differences and global market effects

Each region has different costs for energy options, which also change with global markets. Only global energy-economy models can assess net energy – and net GHG - effects.

Example China. Net effect of more shale gas at lower cost:

- Replace some future coal with gas for electricity = GHG ↘
- Replace some future renewables & nuclear with gas = GHG ↗
- Lower electricity prices which increases use = GHG ↗
- Replace diesel with natural gas in heavy transport = GHG ↘
- Global effect to lower oil prices for transport = GHG ↗
- Higher emissions in producing shale energy = GHG ↗

Shale gas: climate bridge or detour?

Global modelers simulate energy system transformation to prevent temperature increase greater than 2 C by 2100.

In all scenarios, emissions from electricity generation must fall dramatically – 50-80% - and transport by 40-60% by 2050.

Some scenarios accept increased gas production for a few decades, but not much more.

Some show that expanded gas infrastructure (pipelines, LNG terminals) increases 2 C cost by delaying innovation in efficiency, renewables, nuclear, and carbon capture and storage.

Combination of plentiful fossil fuels, human ingenuity, free-access to atmosphere, ineffective global governance, and human ability to rationalize potentially harmful acts – and the odds are not good.

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4.What are the risks for shale gas investors?

1990s innovations in horizontal drilling and fracking in Barnett shale in Texas triggered US revolution in extracting oil and gas from shale and tight rock formations.

Rapid increase in US oil and gas production, with production cost of shale gas now at $4/mcf and shale and tight oil at $45-55/b.

US gas price has fallen from $10-13/mcf in 2008 to $3-$4 today, and total gas production has increased 25% since 2010.

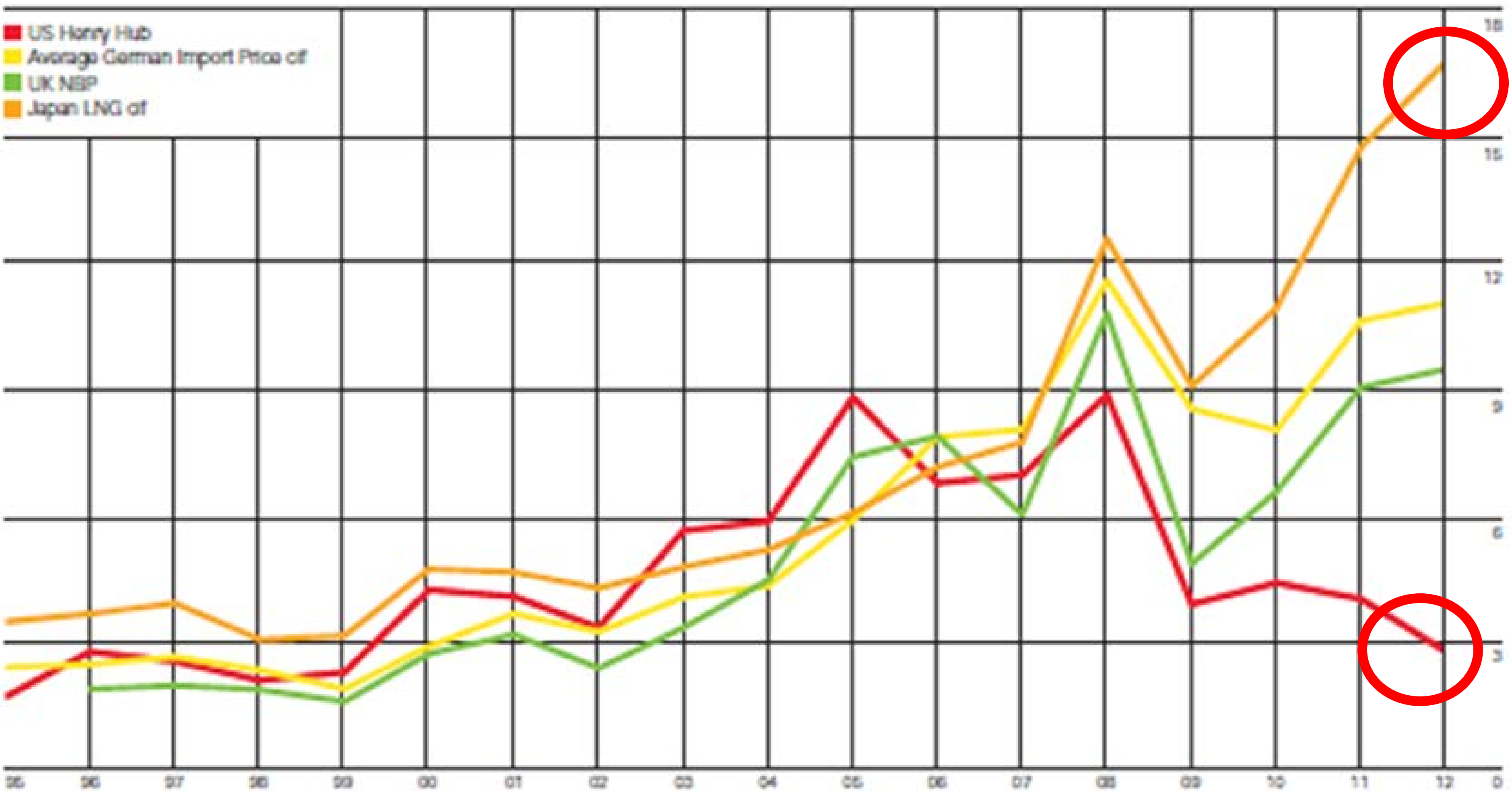
Total US oil has grown 60% in last 5 yrs, up from 5 mbd to 8 mbd. Downward effect on world oil price? Possibly $10 - $20/b.

Potential to expand production from US and Canada alone is huge.

Shale and tight oil potential in NA

Source: U.S. Energy Information Administration based on data from various published studies. Canada and Mexico plays from ARI.
Updated: May 9, 2011

Result? Global gas prices now in extreme disequilibrium ($/mcf)



Global energy market drivers

Shale energy revolution in US reduces power of major oil and gas exporters (OPEC, Russia) as US poised to become oil self-sufficient and an LNG exporter to Europe and east Asia.

China has huge shale resources, but there is uncertainty about its ability to quickly ramp up production.

Europe has shale resources, but faces public resistance in many countries over local environmental impacts.

Gas price disequilibrium has triggered a race among US, Canada, Australia, Russia, and others to supply gas to east Asia and Europe.

Specific risks for shale gas investors in western Canada

Some uncertainties can be controlled in advance, others cannot.

Uncertainties with some potential to control in advance

- Require governments to set tax and royalty rates
- Try to lock-in long-term fixed prices and quantities with customers
- Try to lock-in by contract construction costs

Difficult to control uncertainties

- Inflation can lead to much higher costs for drilling, pipeline construction, LNG construction and operation.
- Lack of social license can raise costs (legal conflicts, delays) and block access to key lower-cost plays.
- Natural gas price and demand in east Asia is highly uncertain.

Huge shale resources in China

Rank	Country	Shale gas (trillion cubic feet)	
1	China	1,115	
2	Argentina	802	
3	Algeria	707	
4	U.S.[1]	665	(1,161)
5	Canada	573	
6	Mexico	545	
7	Australia	437	
8	South Africa	390	
9	Russia	285	
10	Brazil	245	
	World Total	**7,299**	**(7,795)**

[1] EIA estimates used for ranking order. ARI estimates in parentheses.

Limited knowledge of shale resources

Figure 1. Map of basins with assessed shale oil and shale gas formations, as of May 2013

Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies.

Future of the east Asian gas price - I

Gas demand in China should rise strongly, for domestic reasons (air quality compared to coal), offset slightly if Japan returns to nuclear.

East Asian gas price has been $13-15 /mcf, but in future China's gas options will include:

1. pipeline gas from Russia,
2. developing its huge shale gas resources,
3. pipeline gas from other central Asian suppliers
4. multiple LNG suppliers (US, Australia, Canada, Qatar, etc.)

Future of the east Asian gas price - II

BC LNG to Asia may cost $8.50 - $10 /mcf including production at $3.25-$4.75 and transport at $5.25 (includes LNG).

May 22, 2014 - China-Russia 30-year gas supply agreement (38 bcm). Independent source estimates price at $10.50 /mcf.

Some other prospective LNG suppliers likely to have lower production costs than estimated for western Canada.

China moving to bring in co-investors to develop its shale gas resources. Will take time, but eventual costs to be well below $10.

In current climate, China, Japan and Korea exploring options to form a buyers negotiating group.

5.What are government's risk management options?

Establish top environmental regulations from the start. Better that industry not get started rather than make a mess.

Assume with considerable confidence that the east Asia - North America gas price gap will diminish over the next 5 to 15 years and assume periods of cut-throat competition as prices are renegotiated.

Be prepared for "few-or-no-LNG-plants" scenario. Thus, avoid major public infrastructure investments. Let industry do it.

Be prepared for "LNG-boom-and-bust" scenario. Thus, tax and royalty revenue could sometimes fall to zero (as they should when industry is on its knees).

Beware specious rationales for local production or distribution of LNG. If it is cheapest option for trucks, electricity back-up, etc, have an open bidding process that includes environmental / GHG goals.