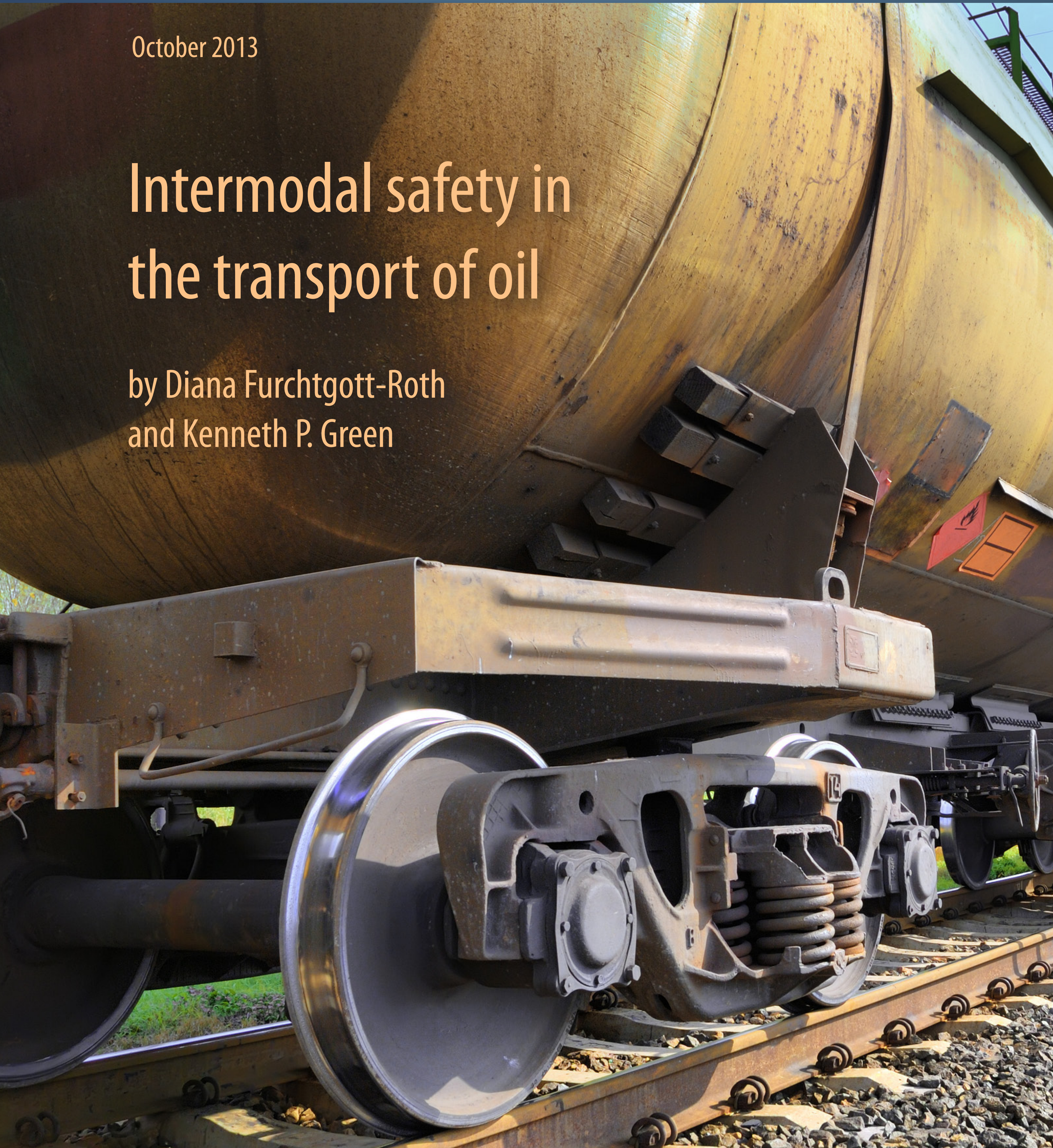
STUDIES IN
ENERGY TRANSPORTATION

FRASER INSTITUTE

October 2013

Intermodal safety in the transport of oil

by Diana Furchtgott-Roth
and Kenneth P. Green



Contents

Executive summary

Rising oil and natural gas production in North America is outpacing the transportation capacity of our pipeline infrastructure. As one of us (Green) discussed in a previous study in this series, *The Canadian Oil Transport Conundrum*, Canada is poised to dramatically increase production of bitumen from oil sand deposits in Western Canada (2013). In the face of expanding production and pipeline bottlenecks, more oil is moving by rail in both Canada and the United States, but transport of oil by rail (or other non-pipeline transportation modes) carries its own set of risks. While pipelines may leak, trains and trucks can crash, hurting individuals, as we saw in Lac-Mégantic in July 2013, and barges can sink. There is no perfectly risk-free way to transport oil, or anything else for that matter.

Although North America is home to 825,000 kilometres of pipeline in Canada and 4.2 million kilometres in the US, US government authorities still insist on blocking additional pipeline construction.

Data to compare the safety of transportation of oil and gas by pipeline, road, and rail in the US is publicly available from the Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA). Operators report any incident that crosses a certain safety threshold, as well as injuries and fatalities, to PHMSA.

US data on incident, injury, and fatality rates for pipelines, road, and rail for the 2005 to 2009 period (the latest data available) show that road and rail have higher rates of serious incidents, injuries, and fatalities than pipelines, even though more road and rail incidents go unreported. Americans are 75 percent more likely to get killed by lightning than to be killed in a pipeline accident (Furchtgott-Roth, 2013).

After reviewing available data on the safety of different oil-transport modes, we conclude that the evidence is clear: transporting oil by pipeline is safe and environmentally friendly. Furthermore, pipeline transportation is safer than transportation by road, rail, or barge, as measured by incidents, injuries, and fatalities.

For North America to realize the massive economic benefits from the development of those oil sands, the transport conundrum must be solved. At present, resistance to pipeline transport is sending oil to market by modes of transport that pose higher risks of spills and personal injuries such as rail and road transport.

Introduction

The Obama administration's decision to delay approval for the construction of TransCanada Inc.'s proposed Keystone XL pipeline was based, in part, on concerns over the safety and reliability of oil pipelines. The Keystone XL pipeline is intended to transport oil from Canada to US refiners on the Gulf of Mexico. In announcing his decision, President Barack Obama called for a full assessment of "the pipeline's impact, especially the health and safety of the American people." (White House, 2012). Additional proposed pipelines in Canada are also being challenged on the grounds of environmental safety. Most recently, the government of British Columbia rejected the proposed Northern Gateway pipeline on environmental grounds (*CBC News,* 2013, May 31). Proposals to double the existing Trans Mountain pipeline (which transports oil from Alberta west to British Columbia) and to reverse the flow of Enbridge's "Line 9" pipeline (which runs between Sarnia and West Northover, Ontario) to also face environmental challenges (Vanderklippe, 2012, Sept. 18).

In June the National Academy of Sciences released a study entitled *Effects of Diluted Bitumen on Crude Oil Transmission Pipelines* that was required as part of the Pipeline Safety, Regulatory Certainty and Jobs Creation Act of 2011. The report found no evidence that diluted bitumen, the type of crude oil that would flow through the proposed Keystone XL pipeline, would contribute to pipeline failures or corrosion (National Research Council, 2013).

At the end of June, Obama put forward another requirement with regard to allowing the Keystone XL pipeline to advance, in a speech on climate policy given at Georgetown University on June 25, 2013. Obama said

Allowing the Keystone pipeline to be built requires a finding that doing so would be in our nation's interest. And our national interest will be served only if this project does not significantly exacerbate the problem of carbon pollution. The net effects of the pipeline's impact on our climate will be absolutely critical to determining whether this project is allowed to go forward. (White House, 2013)

Pipelines for oil and gas

Pipelines have been used to transport Canadian natural gas and oil, both across Canada and into the United States, for over a century. Canada's first pipeline began in 1853, with the development of a 25 kilometre cast-iron pipeline that moved natural gas to Trois-Rivières, QC, for street lights (Natural Resources Canada, 2013). Canada is home to an estimated 825,000 kilometres of transmission, gathering, and distribution pipelines. The National Energy Board, which has regulated inter-provincial and international pipelines since 1959, is currently responsible for 71,000 kilometres of oil and natural gas pipelines (Natural Resources Canada, 2013). Our neighbor to the south, not surprisingly, has a much larger pipeline network—4.2 million kilometres of interstate pipeline crisscross America, carrying crude oil, petroleum products, and natural gas. In the United States these pipelines are primarily regulated by the Department of Transportation.

Based on the experience of both Canada and the United States, we can examine the question of whether pipeline transport of oil is safe.

Rail transportation of oil

As the major alternative means of fuel shipment, transport of crude oil by rail has been increasing as limitations on pipeline capacity both in Canada and the United States have become manifest.

Canada

The Canadian Association of Pipeline Producers (CAPP) reports that transportation of crude oil production by rail in Canada is still quite modest, at 20,000 barrels per day (bbl/d) in 2011 (CAPP, n.d.).

United States

RBC Capital Markets estimates that currently 115,000 barrels of oil per day are shipped by rail to the United States, with a trend toward 300,000 barrels per day by 2015. RBC observes that there is no official tracking data available for crude oil shipments by rail (RBC, 2013). For perspective, the Keystone XL pipeline, if approved, would carry 830,000 barrels per day.

The Association of American Railroads reports that between 2008 and 2011 the total share of oil and gas rail shipments grew dramatically, from 2% of all carloads to 11% (Parrish, 2011). In 2011 alone, rail capacity in the Bakken area—stretching from southern Alberta to the northern US Great Plains—tripled to almost 300,000 barrels per day (Efstathiuo, 2012, Jan. 23). Crude oil shipments via rail have continued to expand at an accelerating rate; US Class I railroads delivered 234,000 carloads of crude in 2012, compared to just 66,000 in 2011 and 9,500 in 2008 (Association of American Railroads, 2013).

United States and Canada

RBC suggests that the future growth of oil by rail depends heavily on whether or not large pipelines are built:

> Continued growth in crude oil shipments by rail will absorb some of the planned growth envisioned by select companies in Canada's oil sands sector, but we expect some large projects are likely candidates to be deferred with overall industry growth being constrained if the 830,000 bbl/d Keystone XL pipeline is not approved. In the event that Keystone XL is declined by President Obama, our analysis suggests that approximately 450,000 bbl/d, or one-third, of Canada's oil sands growth could be temporarily deferred in the 2015–16 timeframe, with production remaining nearly 300,000 bbl/d (6%) lower than our base outlook by 2020. As a base case, we expect crude oil shipments by rail from Canada to peak at just above 300,000 bbl/d by 2015 (approximately 8% of estimated Western Canadian production at that time). However, in the event that Keystone XL is declined, we would expect crude oil shipments by rail from Canada to increase to 425,000 bbl/d by 2017 (approximately 16% of estimated Western Canadian production at that time. (RBC, 2013)

The question of how to transport oil safely and reliably is not a transitory one linked only to Keystone XL or other pipeline controversies of the day. Petroleum production in North America is now nearly 18 million barrels a day, and could climb to 27 million barrels a day by 2020 (US Energy Information Administration, 2013). This oil will have to travel to where it is needed. Whether it is produced in Canada, Alaska, North Dakota, or the Gulf of Mexico, it will be used all over the continent.

The primacy of pipelines

Pipelines are the primary mode of transportation for crude oil, petroleum products, and natural gas in both Canada and the United States. In Canada, 97% of natural gas and petroleum products are transported via pipelines (Canadian Energy Pipeline Association, n.d.). In the United States, approximately 70% of crude oil and petroleum products are shipped by pipeline on a ton-mile basis. US tanker and barge traffic accounts for 23% of oil shipments. Trucking accounts for 4% of shipments, and rail for the remaining 3%.

Pipeline safety

If safety and environmental damages in the transportation of oil and gas were proportionate to the volume of shipments, one would expect the vast majority of damages to occur on pipelines. But as we will discuss, a review of statistics from both Canada's National Energy Board as well as the US Department of Transportation clearly shows that, in addition to enjoying a substantial cost advantage, pipelines result in fewer spillage incidents and personal injuries than road and rail. North Americans are more likely to be killed by a lightning strike than in a pipeline accident.

The distinctive nature of pipeline transportation

The superior safety and environmental performance of pipelines is hardly surprising: the genius of this technology is that the "shipping container" is static while the commodity it is transporting moves. Moreover, that container is typically buried, with about a metre of earth over the top of it. By contrast, in every other means of oil transportation, both the container and the commodity are moving over the surface, often in close proximity to other large containers moving in the opposite direction, and the empty container has then to return to its point of origin to load another consignment.

Table 1: Liquid spill incidents by year and volume

Year	Liquid spill incidents by year & volume		
	Liquid release <8m³	Liquid release >8m³	Liquid release >100m³
2008	8	3	1
2009	4	0	2
2010	2	5	1
2011	4	1	1
2012	1	2	0
Jan-April 2013	5	0	0
Total	24	11	5
5 year average	3.8	2.4	0.8

Source: National Energy Board (2013).

Spill and safety data, Canada

Data on pipeline safety in Canada are available from the National Energy Board. In Canada, any pipeline failure (rupture or leak) that results in a release of more than 1.5 cubic metres of liquid, or that results in a significant effect on the environment, must be reported to the National Energy Board (National Energy Board, 2011). Table 1 shows the reported liquid pipeline releases from 2008 to 2012. As the table shows, while

Table 2: Pipeline operational leaks, 2000-2009

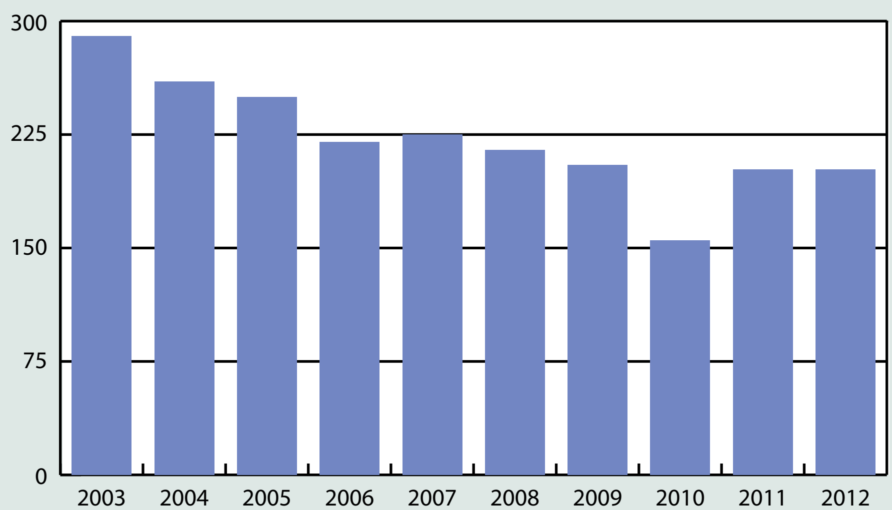
Year	Number of leaks ≤1.5m³	Number of leaks ≥1.5m³	Total number of leaks	Total leak volume (m³)
2000	42	2	44	102
2001	15	4	19	279
2002	38	9	47	1,184
2003	43	1	44	13
2004	57	5	62	34
2005	48	3	51	1,269
2006	25	7	32	322
2007	26	4	30	129
2008	25	6	31	186
2009	47	4	51	226

Source: National Energy Board (2013).

spills do occur periodically, they are infrequent, and the majority release very small quantities of oil to the environment.

In addition to leaks from the body of the pipelines, spills also happen in operational facilities when other pipeline components such as flanges, valves, and pumps malfunction. Table 2 shows pipeline operational leaks from 2000 to 2009. As the National Energy Board points out, these leaks are distinguished from pipe body leaks in that they are "often contained within fenced pipeline facilities which may have a secondary containment mechanism." And these leaks are small, most less than 1.5 cubic metres in volume (National Energy Board, 2011). When one considers that Canada produces (and transports) 3.2 million barrels of oil per day (509,000 cubic metres), the

Figure 1: Rail incidents in Canada, 2003-2013



Source: Transportation Safety Board of Canada (2012) spill volumes are remarkably small. The 10-year average for the frequency of liquid leaks, according to the National Energy Board is approximately three leaks per 1,000 km of pipeline (Canadian Association of Petroleum Producers, 2013).

Fatality rates for pipeline workers averaged 0.2 per year from 2000 to 2009. Injuries to workers, contractors, and other employees averaged 3.8 per 200,000 work-hours over the same time span (National Energy Board, 2011).

How does this compare with goods moved by trucks and trains? In the summer 2012 newsletter, Transport Canada sums up the record for accidents involving trucks carrying dangerous materials (Williams et al., 2012). There were 345 reportable accidents in Canada involving trucks hauling dangerous goods. Twenty-seven percent of the spills involved crude oil; 12.7% involved diesel fuel, fuel oil, gas oil, or heating oil; 7.8% involved methanol; 5.8% involved hydrochloric acid; and the remaining 4.9% involved liquefied petroleum gases. The majority of these accidents occurred in Alberta (63%). Most occurred during handling operations (62%) and most were considered minor (94.5%).

According to the Transportation Safety Board of Canada (TSB), in 2012 (Transportation Safety Board of Canada, 2013):

A total of 1,023 rail accidents under federal jurisdiction were reported to the TSB in 2011, a 5% decrease from the 2010 total of 1,076 and a 15% decrease from the 2006-2010 average of 1,198.

Rail-related fatalities totaled 71 in 2011, compared to 81 in 2010 and to the five-year average of 81.

In 2011, a total of 204 rail incidents were reported under the TSB mandatory reporting requirements, up from 160 in 2010 but comparable to the five-year average of 205.

"Dangerous goods leakers" are rail incidents that result in the leakage of dangerous goods. There were 63 dangerous goods leakers in 2012, a 24% increase from the previous year, but a 2% decrease from the five-year average of 64. In 2012, dangerous goods leaker incidents accounted for 31% of reported rail incidents.

Spill and safety data, United States

Extensive data on pipeline safety in the United States is available from the US Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) Office of Pipeline Safety (PHMSA, 2013a). Operators report to PHMSA any incident that crosses a certain safety threshold. These reports enable the public to compare the safety of pipelines to that of road and rail.

A pipeline incident must be reported to PHMSA if any of the following occur: (1) Explosion or fire not intentionally set by the operator; (2) Release of five gallons or more of a hazardous liquid (any petroleum or petroleum product) or carbon dioxide; (3) Fatality; (4) Personal injury necessitating hospitalization; or (5) Property damage, including cleanup costs, the value of lost product, and the damage to the property of the operator or others, or both, estimated to exceed $50,000 (Pipeline and Hazardous Materials Safety Administration, 2011). Table 3 shows how crude oil and petroleum are transported in the United States.

One way to look at the safety record of petroleum, petroleum products, and natural gas pipeline operators is to examine PHMSA's aggregated data from individual reports. Table 4 shows a summary of all reported incidents and damage between 1992 and 2011. Property damage costs are reported by PHMSA in 2011, with lost product accounted for at benchmark prices at the time of the incident.

Table 3: Crude oil and petroleum products transported in the United States by mode (billions of ton-miles)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Share[c]
Crude oil, total	**376**	**376.6**	**384**	**380.4**	**374.1**	**376**	**366**	**335.5**	**372**	**336**	
Pipelines[a]	283.4	277	286.6	284.5	283.7	294	300.5	266.6	306.3	268.2	80
Water carriers	91	98.1	95.7	94.1	88.7	81.1	63.8	66.9	63.2	65.1	19
Motor carriers[b]	1.2	1.1	1.2	1.3	1.2	1.4	1.4	1.6	1.7	1.7	1
Railroads	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.7	1	0
Refined peroleum products, total	**497.3**	**493.2**	**480.6**	**502.9**	**528.4**	**530**	**489.4**	**499.9**	**485.9**	**474.1**	
Pipelines[a]	293.9	299.1	299.6	305.7	315.9	314	280.9	291.1	299.4	300.2	63
Water carriers	153.4	145.9	131.9	146	158.2	159	149.3	149.1	130.8	121.7	26
Motor carriers[b]	30.1	29.7	29.4	31.9	33.2	33.4	33.8	33.5	33.4	32.2	7
Railroads	19.9	18.5	19.7	19.3	21.1	22.8	25.4	26.2	22.3	19.9	4
Combined crude and petroleum products, total	**873.3**	**869.8**	**864.6**	**883.3**	**902.5**	**906**	**855.4**	**835.4**	**857.9**	**810**	
Pipelines[a]	577.3	576.1	586.2	590.2	599.6	608	581.3	557.7	605.7	568.4	70
Water carriers	244.4	244	227.6	240.1	246.9	241	213.1	216	194	186.8	23
Motor carriers[b]	31.3	30.8	30.6	33.2	34.4	34.8	35.2	35.2	35.1	33.9	4
Railroads	20.3	18.9	20.2	19.8	21.6	23.2	25.8	26.6	23	20.9	3

a Beginning with 2006, pipeline data were taken from PHMSA F 7000-1-1. Previously, data were extracted from FERC Form No. 6, which included data for federally-regulated pipelines. For 2005, data for federally regulated pipelines were estimated to include about 90 percent of the total national ton-miles, so the pipeline statistics for that year were adjusted to include an additional 10 percent of ton-miles. From 1990 through 2004, the federally regulated estimate was 84 percent with a 16 percent addition for other pipeline ton-miles.

b The amount carried by motor carriers is estimated.

c Share shipped by mode in 2009 (percent)

Details may not add to totals due to rounding in the source publication.

Source: Association of Oil Pipe Lines, Shifts in Petroleum Transportation, 1990-2009: (Washington, DC: Annual Issues), tables 1, 2, and 3, <http://www.aopl.org/publications/?fa=reports as of Apr. 5, 2012>.

Table 4: Pipeline incidents and related injuries and fatalities (1992-2011)

Year	Number	Property damage as reported (in millions)	Net barrels of liquids lost	Injuries	Fatalities
1992	389	$70.50	68,810	118	15
1993	445	$67.30	57,559	111	17
1994	467	$160.60	114,002	120	22
1995	349	$53.40	53,113	64	21
1996	381	$114.50	100,949	127	53
1997	346	$79.60	103,129	77	10
1998	389	$126.90	60,791	81	21
1999	339	$130.10	104,487	108	22
2000	380	$191.80	56,953	81	38
2001	341	$63.10	77,456	61	7
2002	644	$102.10	77,953	49	12
2003	673	$139.10	50,889	71	12
2004	673	$271.90	69,003	60	23
2005	721	$1,246.70	46,246	48	14
2006	641	$151.10	53,905	36	21
2007	616	$154.90	68,941	53	15
2008	664	$555.80	69,815	59	9
2009	627	$178.00	32,258	66	13
2010	586	$1,336.40	123,419	109	22
2011	599	$336.30	108,663	65	17
Totals	10,270	$5,530.0	1,498,341	1,564	384

Source: United States Department of Transportation Pipeline and Hazardous Materials Safety Administration Office of Pipeline Safety, <http://primis.phmsa.dot.gov/comm/reports/safety/Allpsi.html?nocache=8953>.

To the untutored eye, it can appear that pipelines are prone to significant accidents. For instance, there were 721 incidents in 2005, and 53 fatalities in 1996, many caused by a propane explosion in San Juan. However, as the tables make clear, safety-related incidents, as measured by volume, are actually minor. More important, it is crucial to keep in mind that there is no way, in an advanced industrial economy, to avoid shipment of fuels to provide power.

Table 4 shows that the number of incidents is relatively low. It has ranged from 339 in 1999 to 721 in 2005. Property damage has ranged from $53 million in 1995 to $1.3 billion in 2010. Lost barrels of liquids spanned a low of 32,258 barrels in 2009 to a high of 123,419 the following year. Injuries ranged from 36 in 2006 to 127 in 1996, and fatalities ranged from 7 in 2001 to 53 in 1996.

A major criterion for determining if an incident had to be reported to PHMSA was significantly revised in 2002. Between 1992 and 2002 a spill only had to be reported if it was greater than 50 barrels of liquids or CO2 (after 1991). However, beginning in 2002, the limit was dropped to five gallons, with an exception for maintenance-related spills of five barrels or less confined to company sites (PHMSA, 2011). Hence, minor spills that were not reported prior to 2002 were reported afterwards. From 1992 through 2001 an annual average of 383 incident reports were filed with PHMSA. Then, from 2002 through 2011, companies filed an annual average of 644 incident reports.

Gross barrels spilled do not take into account the number of barrels that were recovered during cleanup. The volume of liquids spilled that is ultimately recovered varies widely from year to year, and is likely heavily influenced by the nature of the spill. Between 1992 and 2011 about 40% of spilled liquids were recovered (Table 5). Over the entire 20-year period a total of less than

1.5 million net barrels were spilled.

Volumes that are spilled are miniscule when compared to the volumes of petroleum that are used in the United States. To provide some perspective, US refineries produce over 7 million barrels of gasoline every single day (US Energy Information Administration, 2013, May 20). Considering the vast network—175,000 miles of petroleum pipeline and over 2 million miles of natural gas pipelines (about 321,000 of transmission and gathering lines, over 2 million of local distribution main and service lines)—incidents are exceedingly rare (Pipeline and Hazardous Materials Safety Administration, n.d.).

Table 5: Percent of liquids recovered from pipeline incidents, all reported incidents (1992-2011)

Year	Gross barrels spilled	Net barrels spilled	Percentage recovered
1992	137,065	68,810	50
1993	116,802	57,559	51
1994	164,387	114,002	31
1995	110,237	53,113	52
1996	160,316	100,949	37
1997	195,549	103,129	47
1998	149,500	60,791	59
1999	167,230	104,487	38
2000	108,652	56,953	48
2001	98,348	77,456	21
2002	97,255	77,953	20
2003	81,308	50,889	37
2004	89,311	69,003	23
2005	138,094	46,246	67
2006	137,693	53,905	61
2007	94,981	68,941	27
2008	102,076	69,815	32
2009	54,964	32,258	41
2010	174,921	123,419	29
2011	137,932	108,663	21
Totals	2,516,625	1,498,341	40 (Avg.)

Source: United States Department of Transportation Pipeline and Hazardous Materials Safety Administration Office of Pipeline Safety, <http://primis.phmsa.dot.gov/comm/reports/safety/Allpsi.html?nocache=8953>, and Manhattan Institute calculations.

To draw another comparison, according to the National Weather Service, lightning caused an average of 35 reported deaths annually from 2003 to 2012 (Office of Climate, Water, and Weather Services, 2012). From 1992 to 2011 fatalities related to pipeline incidents were about 20 per year. An individual had a 75% greater chance of getting killed by lightning as being killed in a pipeline incident.

Data are also provided by PHMSA that make it possible to determine in what type of pipeline system a particular incident occurred. There are four basic categories of pipeline systems, namely hazardous liquids, natural gas gathering, natural gas transmission, and natural gas distribution. Natural gas gathering pipelines bring raw natural gas from the wellhead to the gas processing plant. The natural gas transmission system is made up of pipelines that bring processed (dry) gas from the plants and carry it across the country

Table 6: Percentage of incidents, fatalities, injuries, and property damage by pipeline systems (1992-2011)

	Incidents	Fatalities	Injuries	Property damage
Natural gas gathering	2	0	1	7
Natural gas transmission	18	12	14	28
Natural gas distribution	26	78	75	17
Hazardous liquid	54	11	11	49

Note: Not all columns sum to 100 due to rounding.

Source: United States Department of Transportation Pipeline and Hazardous Materials Safety Administration Office of Pipeline Safety, <http://primis/phmsa.dot.gov/comm/reports/safety/Allpsi.html?nocache=8953>, and Manhattan Institute calculations.

to city gates or to large customers (e.g., heavy industry or electrical power plants). The natural gas distribution system is operated by local distribution companies that transport gas from the city gate to local households and local businesses. Table 6 displays what percentage of incidents, fatalities, injuries, and property damage from 1992 through 2011 occurred in each pipeline system.

Although fatalities and injuries are relatively low, the majority of those that do occur have been associated with pipelines that are part of a natural gas distribution system. The US natural gas distribution pipeline network spans over 2 million miles, and the federal government does not regulate intrastate pipelines (local distribution and production gathering lines), except for gathering lines that are located on federal lands. Local distribution companies, where both the vast majority of pipeline miles exist and accidents occur, are regulated by states and municipalities.

Table 7: Incidents, fatalities, injuries, and property damage by pipeline system (1992-2011)

	Incidents	Fatalities	Injuries	Property damage as reported
Natural gas gathering	212	0	12	$357,080,128
Natural gas transmission	1845	45	216	$1,534,724,575
Natural gas distribution	2644	298	1,165	$942,404,551
Hazardous liquid	5569	41	171	$2,695,828,774

Source: United States Department of Transportation Pipeline and Hazardous Materials Safety Administration Office of Pipeline Safety, <http://primis.phmsa.dot.gov/comm/reports/safety/Allpsi.html?nocache=3087#_all>, and Manhattan Institute calculations.

The proportion of property damage from incidents originating at hazardous liquids pipelines is largely the result of the inclusion of lost product as part of the damage, and the high cost of cleaning up of oil spills. From an operational standpoint, incidents associated with natural gas transmission and hazardous liquid systems (large diameter interstate pipelines) have resulted in 86 deaths and 387 injuries from 1992 through 2011, as shown in Table 7.

How does this compare with road and rail? We have analyzed US Department of Transportation data and produced incident and injury rates for oil and gas pipelines, road, and rail for petroleum products in the period 2005 through 2009 (PHMSA, 2010). Because reporting of pipeline incidents is only required for events involving injury or release over 5 gallons, we eliminated road and rail incidents not meeting those criteria from consideration.

Table 8: Comparative statistics for petroleum incident rates-onshore transmission pipelines vs. road and railway (2005-2009)

Mode	Avg. billions ton-miles shipment per year	Avg. incidents Per Year	Incidents per billion ton-miles
Road*	34.8	695.2	19.95
Railway*	23.9	49.6	2.08
Hazardous liquid pipeline	584.1	339.6	0.58
Natural gas pipeline	338.5	299.2	0.89

*Only incidents involving and ton-mileage carrying those products carried by pipeline (petroleum products, liquid natural gas, etc.) are counted for road and railway.

Sources: Ton-Mileage values are based on Tables 1-50 (for Natural Gas Pipeline) and 1-61 (all others) of the Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics National Transportation Statistics, <http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/index.html>. Incident and release volume data for Road and Railway were extracted from the Office of Hazardous Materials Safety Incident Reports Database Search, <https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/>, HL Pipeline release volumes were extracted from the Pipeline and Hazardous Material Safety Administration Hazardous Liquid Accident Data - 2002 to 2009 file, <http://phmsa.dot.gov/portal/site/PHMSA/menuitem.ebdc7a8a7e39f2e55cf2031050248a0c/?vgnextoid=fdd2dfa122a1d110VgnVCM1000009ed07898RCRD&vgnextchannel=3430fb649a2dc110VgnVCM1000009ed07898RCRD&vgnextfmt=print>.

Even after this narrowing of scope, road and rail have higher rates of serious incidents and injuries than pipelines, even though more road and rail incidents go unreported.

Table 8 compares incident rates for road, rail, oil and petroleum products pipelines, and natural gas transmission. Road had the highest rate of incidents, with 19.95 per billion ton miles. This was followed by rail, with 2.08 per billion ton miles. Natural gas transmission came next, with 0.89 per

Table 9: Comparison of hazmat fatality statistics, operator personnel and general public for road, rail, and pipeline (2005-2009)

	2005	2006	2007	2008	2009	Total	Average per year
Road	24	6	10	8	3	51	10.2
Railway	10	0	0	1	1	12	2.4
Hazardous onshore only	2	0	4	2	4	12	2.4
Gas transmission onshore only	0	3	2	0	0	5	1.0

Source: Reproduced from US Department of Transportation, Pipeline, and Hazardous Materials Safety Administration, Office of Pipeline Safety, Building Safe Communities and its Application to Local Development Decisions, October, 2010, Table 3: 26, <http://www.pstrust.org/library/docs/PIPA-PipelineRiskReport-Final-20101021.pdf>.

Table 10: Injuries resulting from petroleum incidents-pipelines vs. road and railway

		2005	2006	2007	2008	2009	Total	Average per year
Road	Hospitalization	9	10	10	6	9	44	0.2526
	Total	38	37	38	17	41	171	0.9816
Railway	Hospitalization	20	2	1	0	0	23	0.1925
	Total	24	2	4	0	1	31	0.2594
Hazardous liquid pipeline	Hospitalization	2	2	10	2	4	20	0.0068
Natural gas pipeline	Hospitalization	45	32	37	53	58	225	0.133

Sources: Road and Railway injuries were counted in the data extracted for Table 6. Pipeline injuries are reproduced from <http://primis.phmsa.dot.gov/comm/reports/safety/SerPSI.html?nocache=5757#_all.>

billion ton miles. Oil pipelines were the safest, with 0.58 serious incidents per billion ton miles.

With respect to pipeline systems, natural gas transmission lines had the lowest average fatality rate for operator personnel and the general public between 2005 and 2009, with a rate of one person killed per year. This was followed by oil and rail, each with an average of 2.4 people per year. The rail figure is skewed by a chlorine incident on January 6, 2005 in Graniteville, South Carolina. Since chlorine is not transported by pipeline, some question the validity of drawing such a comparison, even though chlorine is a hazardous material. The highest fatality rate is for transport via road, with an average of 10.2 people killed each year in the US. This is not because members of the public are killed due to road accidents with oil trucks. Only 1.4 members of the public, on average, were killed annually, but an average of 8.8 operators died per year.

As shown in Table 10, rates of injury requiring hospitalization and of injury in general show a similar pattern. On average, annual injuries for 2005 through 2009 were lowest for hazardous liquid pipeline, at 4 people with injuries requiring hospitalization per year. The rate was higher for rail, at 4.6 of such injuries per year, although for rail this number was heavily biased by the 2005 observation. Road accidents hospitalized 8.8 people per year, and natural gas pipelines hospitalized 45 people each year.

The rates of injury per ton-mile in Table 10 are most pertinent, however. On this measure, oil pipeline outperforms rail and road by a wide margin, causing just 0.00687 injuries requiring hospitalization per billion ton-miles. Rail causes nearly 40 times that many injuries requiring hospitalization on a per-ton-mile basis. Rail is also outperformed by natural gas pipelines on this measure, causing almost twice as many serious injuries per ton-mile. Road is the worst performer on this measure, averaging one serious injury per billion ton-miles. This is 145 times the oil pipeline rate.

Conclusion

The evidence is clear: transporting oil by pipeline is safe and environmentally friendly. Furthermore, pipeline transportation is safer than transportation by road, rail, or barge, as measured by incidents, injuries, and fatalities—even though more road and rail incidents go unreported (Committee on Transportation and Infrastructure, 2009, Sept. 9). (Reliable data on water borne spills, which fall under the jurisdiction of the Coast Guard, are not readily available and so will not be included in this essay.)

Despite their safety, pipelines release more oil per spill than rail—but less than road. As Table 11 shows, typical release volumes on rail, particularly

Table 11: Comparative statistics for petroleum product release rates: onshore transmission pipelines vs. road and railway (2005-2009)

Mode	Avg. product release per year (gallons)	Release per incident (gallons)	Release per billion ton-miles (gallons)
Road*	477,558	687	13,707
Railway*	83,745	1,688	3,504
Hazardous liquid pipeline	6,592,366	19,412	11,286
Natural gas pipeline**	—	—	—

*Only incidents involving and ton-mileage carrying those products carried by pipeline (petroleum products, liquid natural gas, etc.) are counted for road and railway.
**No release volume data are available for gas pipeline in the PHMSA incident database.

Sources: Department of Transportation, Research, and Innovative Technology Administration, Bureau of Transportation <http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/index.html>, Office of Hazardous Materials Safety, <https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/>, Pipeline and Hazardous Material Safety Administration <http://phmsa.dot.gov/portal/site/PHMSA/menuitem.ebdc7a8a7e39f2e55cf2031050248a0c/?vgnextoid=fdd2dfa122a1d110VgnVCM1000009ed07898RCRD&vgnextchannel=3430fb649a2dc110VgnVCM1000009ed07898RCRD&vgnextfmt=print>.

of petroleum products, are relatively low at 3,504 gallons per billion ton-miles. While it outperforms road in terms of product release per ton-mile, pipeline transport of petroleum products still experienced product release of 11,286 gallons per billion ton-miles. This figure does decrease by approximately one-third if the high product-recovery rate for pipelines is considered, however.

Some claim that pipelines carrying Canadian oil sands crude, known as diluted bitumen, have more internal corrosion, and are subject to more incidents (Skinner and Sweeney, 2012). However, PHMSA data show that oil releases from corrosion are no more common in pipelines carrying Canadian diluted bitumen than in other lines (National Academy of Sciences, 2012).[1] Oil sands crude has been transported in American pipelines for the past decade.

Rising oil and natural gas production in both the US and Canada is outpacing the transportation capacity of our pipeline infrastructure. As one of us (Green) discussed in a previous study, Canada is poised to dramatically increase production of bitumen from oil sand deposits in Western Canada (Angevine and Green, 2013). For Canada to realize the massive economic benefits from the development of those oil sands, the transport conundrum must be solved. At present, resistance to pipeline transport is sending oil to market by modes of transport that pose higher risks of spills and personal injuries such as rail and road transport.

1 Data is from form PHMSA F 7000-1, slides 51-52.

References

Angevine, Gerry and Kenneth P. Green (2013). *Canada as an Emerging Energy Superproducer*. Fraser Institute. <http://www.fraserinstitute.org/research-news/display.aspx?id=19462>, as of September 8, 2013

Association of American Railroads (2013). *Moving Crude Petroleum by Rail*. Association of American Railroads. <https://www.aar.org/keyissues/Documents/Background-Papers/Moving%20Crude%20Petroleum%20by%20Rail%202012-12-10.pdf>, as of September 8, 2013.

Association of Oil Pipe Lines (2012). *Shifts in Petroleum Transportation, 1990-2009*. Association of Oil Pipe Lines <http://www.aopl.org/publications/?fa=reports>, as of April 5, 2012.

Canadian Association of Petroleum Producers [CAPP] (2013). *Crude Oil Forecast, Markets & Transportation*. Canadian Association of Petroleum Producers. <http://www.capp.ca/forecast/Pages/default.aspx>, as of September 8, 2013.

Canadian Energy Pipeline Association (no date). *Facts*. Canadian Energy Pipeline Association. <http://www.cepa.com/library/factoid>, as of September 8, 2013.

CBC News (2013, May 31). B.C. Officially Opposes Enbridge Northern Gateway Pipeline. *CBC News*. <http://www.cbc.ca/news/canada/british-columbia/story/2013/05/31/bc-northern-gateway-rejected.html>, as of September 8, 2013.

Committee on Transportation and Infrastructure (2009). *Hearings on Concerns with Hazardous Materials Safety in the US: Is PHMSA Performing Its Mission? (written report submitted by Majority Staff to the Members of the Committee)*. US House of Representatives.

Efstathiuo Jr., Jim (2012, January 23). Buffet's Burlington Northern Among Pipeline Winners. *Bloomberg*. <http://www.bloomberg.com/news/2012-01-23/buffett-s-burlington-northern-among-winners-in-obama-rejection-of-pipeline.html>, as of September 8, 2013.

National Academy of Sciences (2012). *Transportation Research Board Study of Pipeline Transportation of Diluted Bitumen*. Pipeline and Hazardous Materials Safety Administration, US Department of Transportation. <http://onlinepubs.trb.org/onlinepubs/dilbit/Daughertyetal072312.pdf>, as of September 8, 2013.

National Energy Board (2011). *Focus on Safety and Environment –A Comparative Analysis of Pipeline Performance–2000-2009*. Canada, National Energy Board. <http://www.neb-one.gc.ca/clf-nsi/rsftyndthnvrnmnt/sfty/sftyprfrmncndctr/fcsnsfty/2011/fcsnsfty2000_2009-eng.html>, as of September 8, 2013.

National Energy Board (2013). *Pipeline Incidents: Spills of Hydrocarbon Liquids*. National Energy Board. <http://www.neb-one.gc.ca/clf-nsi/rsftyndthnvrnmnt/sfty/pplnncdntgrprtng/pplnncdntshydrcrbnsplls/pplnncdntshydrcrbnsplls-eng.html>, as of September 8, 2013.

National Research Council (2013). TRB Special Report 311: Effects of Diluted Bitumen on Crude Oil Transmission Pipelines. *National Academies Press*. <http://www.nap.edu/catalog.php?record_id=18381>, as of September 8, 2013.

Natural Resources Canada (2013). *Frequently Asked Questions Concerning Federally-Regulated Petroleum Pipelines in Canada*. Natural Resources Canada. <http://www.nrcan.gc.ca/energy/sources/natural-gas/pipeline-faq/2248>, as of September 8, 2013.

Office of Climate, Water, and Weather Services (2012). *Weather Fatalities*. National Weather Service. <http://www.nws.noaa.gov/om/hazstats.shtml>, as of July 1, 2013.

Office of Pipeline Safety, Pipeline and Hazardous Materials Safety Administration (2010). *Building Safe Communities: Pipeline Risk and its Application to Local Development Decisions*. US Department of Transportation. <http://primis.phmsa.dot.gov/comm/publications/PIPA/PIPA-PipelineRiskReport-Final-20101021.pdf>, as of September 8, 2013.

Parrish, Ray C. (2011). *EIA: Rail Delivery of Crude Oil and Petroleum Products Rising. Blog (November 16)*. Crude Oil Trader. <http://crudeoiltrader.blogspot.com/2011/11/eia-rail-delivery-of-crude-oil-and.html>, as of September 8, 2013.

Pipeline and Hazardous Materials Safety Administration [PHMSA] (no date). *Community Toolbox: Pipeline Safety Connects Us All*. US Department of Transportation. <http://primis.phmsa.dot.gov/comm/>, as of September 8, 2013.

Pipeline and Hazardous Materials Safety Administration [PHMSA] (2010a). *Distribution, Transmission, and Liquid Accident and Incident Data*. US Department of Transportation. <http://phmsa.dot.gov/portal/site/PHMSA/menuitem.ebdc7a8a7e39f2e55cf2031050248a0c/?vgnextoid=fdd2dfa122a1d110VgnVCM1000009ed07898RCRD&vgnextchannel=3430fb649a2dc110VgnVCM1000009ed07898RCRD&vgnextfmt=print>, as of April 2013.

Pipeline and Hazardous Materials Safety Administration [PHMSA] (2010b). *Building Safe Communities and its Application to Local Development Decisions*. US Department of Transportation. <http://www.pstrust.org/library/docs/PIPA-PipelineRiskReport-Final-20101021.pdf>, as of April 2013.

Pipeline and Hazardous Materials Safety Administration [PHMSA] (2011). *Reporting Criteria Changes: 1990-Current*. US Department of Transportation. <http://primis.phmsa.dot.gov/comm/reports/safety/docs/IncidentReportingCriteriaHistory1990-2011.pdf>, as of September 8, 2013.

Pipeline and Hazardous Materials Safety Administration [PHMSA] (2012). *All Reported Pipeline Incidents*. US Department of Transportation. <http://primis.phmsa.dot.gov/comm/reports/safety/Allpsi.html?nocache=8953>, as of April 24, 2012.

Pipeline and Hazardous Materials Safety Administration [PHMSA] (2013, April). *Office of Hazardous Materials Safety Incident Reports Database Search*. PHMSA. <https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/>, as of April 2013.

Pipeline and Hazardous Materials Safety Administration [PHMSA] (2013a). *Pipeline Basics*. US Department of Transportation. <http://primis.phmsa.dot.gov/comm/PipelineBasics.htm>, as of September 8, 2013.

Pipeline and Hazardous Materials Safety Administration [PHMSA] (2013b). *Serious Pipeline Incidents*. US Department of Transportation. <http://primis.phmsa.dot.gov/comm/reports/safety/SerPSI.html?nocache=5757#_all> as of September 8, 2013.

Royal Bank of Canada Capital Markets (2013). *Rail: The Invisible Hand. Energy Insights*. Royal Bank of Canada.

Skinner, Lara and Sean Sweeney (2012). *The Impact of Tar Sands Pipeline Spills on Employment and the Economy*. Cornell University Global Labor Institute. <http://www.ilr.cornell.edu/globallaborinstitute/research/upload/GLI_Impact-of-Tar-Sands-Pipeline-Spills.pdf>, as of September 8, 2013.

Transportation Safety Board of Canada (2013). *2011 Rail Annual Statistics –Highlights*. Government of Canada. <http://www.tsb.gc.ca/eng/stats/rail/prelim-2011/>, as of September 8, 2013.

US Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics (2013). *National Transportation Statistics*. US Department of Transportation. <http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/index.html>, as of April 2013.

US Energy Information Administration (2013). *Petroleum Production Table*. US Department of Energy. <http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=53&aid=1>, as of September 8, 2013.

US Energy Information Administration (2013, May 20). *This Week in Petroleum*. US Department of Energy. <http://www.eia.gov/oog/info/twip/twip_crude.html#production>, as of May 20, 2013.

Vanderklippe, Nathan (2012, September 18). Opposition to Trans Mountain Pipeline Nearing Northern Gateway Levels. *Globe and Mail*. <http://www.theglobeandmail.com/news/british-columbia/opposition-to-trans-mountain-pipeline-nearing-northern-gateway-levels/article4551051/>, as of September 8, 2013.

Williams, Susan, Lindsay Jones, and Jonathan Rose (2012). *Reportable Accidents across Canada in 2011. Transport Dangerous Goods Newsletter, Summer*. Transport Canada. <http://www.tc.gc.ca/eng/tdg/newsletter-summer-2012-1148.htm#article3>, as of September 8, 2013.

White House (2013). *Remarks by the President on Climate Change*. Speech, given at [Georgetown University, Washington, DC], [June 25, 2013]. <http://www.whitehouse.gov/the-press-office/2013/06/25/remarks-president-climate-change>, as of September 8, 2013.

White House (2012). *Statement of the President on the Keystone XL Pipeline*. White House. <http://www.whitehouse.gov/the-press-office/2012/01/18/statement-president-keystone-xl-pipeline>, as of October 3, 2013.

About the author

Diana Furchtgott-Roth
Diana Furchtgott-Roth is a Senior Fellow with the Manhattan Institute.

Kenneth P. Green
Kenneth P. Green is Senior Director, Natural Resource Policy Studies at the Fraser Institute.

Acknowledgments

Research assistance for this report was provided by Andrew Gray, Claire Rogers, and Joshua Sheppard. The authors thank the anonymous referees who made a number of valuable comments and suggestions. Of course, these reviewers are not responsible for any of the errors or omissions that still remain in the manuscript. The views expressed in this study do not necessarily reflect the views of the supporters, trustees, or staff of the Fraser Institute.

Publishing information

Distribution

These publications are available from <http://www.fraserinstitute.org> in Portable Document Format (PDF) and can be read with Adobe Acrobat® 7 or Adobe Reader®, versions 7 or later. Adobe Reader® XI, the most recent version, is available free of charge from Adobe Systems Inc. at <http://get.adobe.com/reader/>. Readers who have trouble viewing or printing our PDF files using applications from other manufacturers (e.g., Apple's Preview) should use Reader® or Acrobat®.

Ordering publications

For information about ordering the printed publications of the Fraser Institute, please contact the publications coordinator:

- e-mail: sales@fraserinstitute.org
- telephone: 604.688.0221 ext. 580 or, toll free, 1.800.665.3558 ext. 580
- fax: 604.688.8539.

Media

For media enquiries, please contact our Communications Department:

- 604.714.4582
- e-mail: communications@fraserinstitute.org.

Copyright

Date of issue

October 2013

ISSN

ISSN 1918-8323 (online version)

Citation

Furchtgott-Roth, Diana, and Kenneth P. Green (2013). *Intermodal Safety in the Transport of Oil.* Studies in Energy Transportation. Fraser Institute. <http://www.fraserinstitute.org>.

Cover design

Bill Ray

Cover images

©soleg_1974, Bigstock (Oil Transportation in Tanks by Rail)

Supporting the Fraser Institute

To learn how to support the Fraser Institute, please contact

- Development Department, Fraser Institute
  Fourth Floor, 1770 Burrard Street
  Vancouver, British Columbia, V6J 3G7 Canada

- telephone, toll-free: 1.800.665.3558 ext. 586

- e-mail: development@fraserinstitute.org

Lifetime patrons

For their long-standing and valuable support contributing to the success of the Fraser Institute, the following people have been recognized and inducted as Lifetime Patrons of the Fraser Institute.

Sonja Bata	Serge Darkazanli	Fred Mannix
Charles Barlow	John Dobson	Jack Pirie
Ev Berg	Raymond Heung	Con Riley
Art Grunder	Bill Korol	Catherine Windels
Jim Chaplin	Bill Mackness	

Purpose, funding, & independence

The Fraser Institute provides a useful public service. We report objective information about the economic and social effects of current public policies, and we offer evidence-based research and education about policy options that can improve the quality of life.

The Institute is a non-profit organization. Our activities are funded by charitable donations, unrestricted grants, ticket sales, and sponsorships from events, the licensing of products for public distribution, and the sale of publications.

All research is subject to rigorous review by external experts, and is conducted and published separately from the Institute's Board of Trustees and its donors.

The opinions expressed by the authors are those of the individuals themselves, and do not necessarily reflect those of the Institute, its Board of Trustees, its donors and supporters, or its staff. This publication in no way implies that the Fraser Institute, its trustees, or staff are in favour of, or oppose the passage of, any bill; or that they support or oppose any particular political party or candidate.

As a healthy part of public discussion among fellow citizens who desire to improve the lives of people through better public policy, the Institute welcomes evidence-focused scrutiny of the research we publish, including verification of data sources, replication of analytical methods, and intelligent debate about the practical effects of policy recommendations.

About the Fraser Institute

Our vision is a free and prosperous world where individuals benefit from greater choice, competitive markets, and personal responsibility. Our mission is to measure, study, and communicate the impact of competitive markets and government interventions on the welfare of individuals.

Founded in 1974, we are an independent Canadian research and educational organization with locations throughout North America and international partners in over 85 countries. Our work is financed by tax-deductible contributions from thousands of individuals, organizations, and foundations. In order to protect its independence, the Institute does not accept grants from government or contracts for research.

Nous envisageons un monde libre et prospère, où chaque personne bénéficie d'un plus grand choix, de marchés concurrentiels et de responsabilités individuelles. Notre mission consiste à mesurer, à étudier et à communiquer l'effet des marchés concurrentiels et des interventions gouvernementales sur le bien-être des individus.

Peer review—validating the accuracy of our research

The Fraser Institute maintains a rigorous peer review process for its research. New research, major research projects, and substantively modified research conducted by the Fraser Institute are reviewed by experts with a recognized expertise in the topic area being addressed. Whenever possible, external review is a blind process. Updates to previously reviewed research or new editions of previously reviewed research are not reviewed unless the update includes substantive or material changes in the methodology.

The review process is overseen by the directors of the Institute's research departments who are responsible for ensuring all research published by the Institute passes through the appropriate peer review. If a dispute about the recommendations of the reviewers should arise during the Institute's peer review process, the Institute has an Editorial Advisory Board, a panel of scholars from Canada, the United States, and Europe to whom it can turn for help in resolving the dispute.

Editorial Advisory Board