McCullough Research

Robert F. McCullough, Jr.
Principal

Date: June 5, 2019

To: McCullough Research Clients

From: Robert McCullough
Michael Weisdorf
Eric Shierman

Subject: The Questionable Economics of Jordan Cove LNG Terminal

A decade ago, one member of Oregon's congressional delegation asked us for a review of the Jordan Cove LNG import terminal proposed for Coos Bay.[1,2] The analysis was not difficult. The price of LNG exported to Japan from Alaska is reported in both Japan and Alaska. These prices were higher than the increasing amounts of natural gas appearing on the market from Alberta and Wyoming. Clearly, Jordan Cove was not a competitive solution for the import of LNG.

Jordan Cove's owners gradually realized that the new technologies of oil and natural gas made the import proposal uneconomic and changed the direction of LNG to a proposed export terminal in 2012.[3]

However, there are a number of good reasons to question whether this is a good location and a good project design. First, the supplies for Jordan Cove are taken from the Malin hub in southern Oregon. This puts the terminal at a six-hundred-mile disadvantage in transportation costs. Second, the announced costs of the terminal are high by market standards – significantly higher than its competitors. Third, the technology of Jordan Cove – using natural gas as opposed to electricity for compression – makes it less efficient than its competitors in British Columbia or the Gulf Coast.

Our analysis indicates that Jordan Cove will have a significant cost disadvantage compared to its competitors – approximately 25%. We also calculate the chance of Jordan Cove reaching operation is only one third.

---

[1] McCullough Research. *Memo on LNG Pricing.* April 8, 2008.
[2] LNG refers to Liquified Natural Gas. LNG is a liquid when maintained at 260 degrees (F) below zero.
[3] Jonathan Thompson. "A pipeline built years ago may start to export Rocky Mountain gas to Asia." *High Country News*, April 14, 2014. https://www.hcn.org/blogs/goat/how-a-little-noticed-pipeline-might-make-natural-gas-exports-possible

Jordan Cove is currently at the pre-FID stage in its development. FID is an industry term standing for "Final Investment Decision". The FID is a critical decision that initiates actual financing and construction. The justification for proceeding to FID usually depends on two different analyses:

1. Is the location and facility likely to succeed given the past history of feed gas and ultimate markets?
2. How competitive is this specific facility compared to its peers?

The price differential between feed gas at the production site and delivered LNG at the destination market forms the economic basis for the decision to invest in LNG export projects. The chart in Figure 1 below shows the price history for Platts JKM (Japan/Korea Marker) price index, the global market with the highest price premium, as well as the price of Canadian feed gas at the AECO hub, which in recent years has traded at the lowest prices in North America.[4]

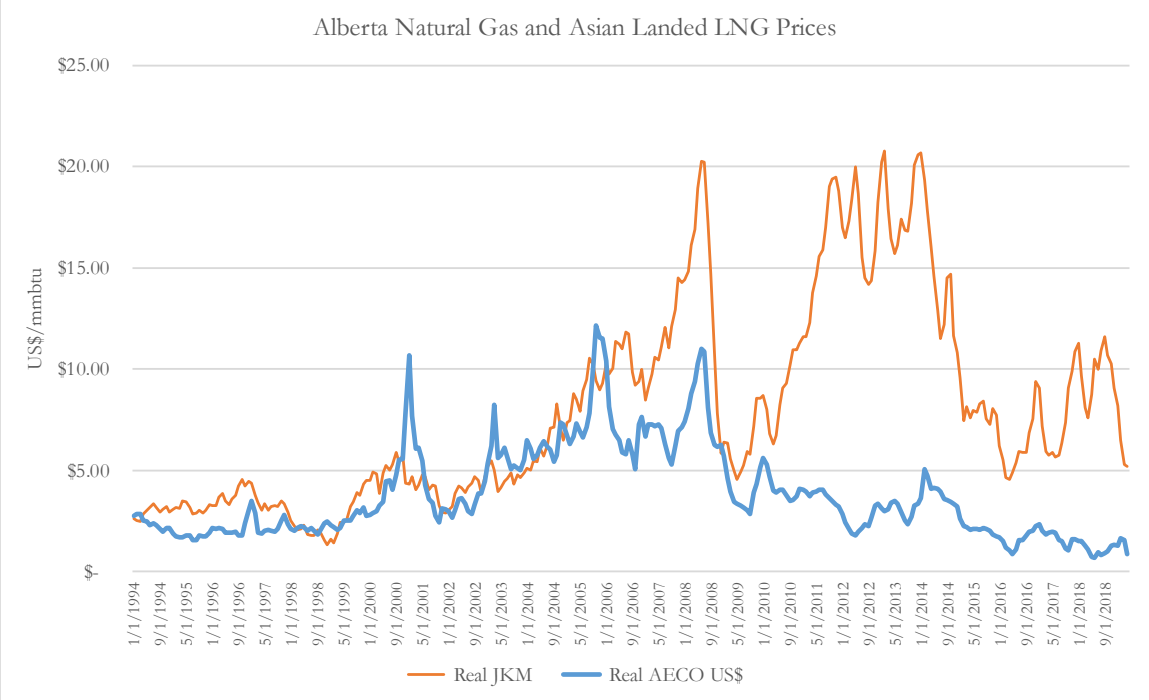

Figure 1: Natural Gas Prices in Canadian and Japanese Markets

[4] "Platts JKM™ is the Liquefied Natural Gas (LNG) benchmark price assessment for spot physical cargoes. It is referenced in spot deals, tenders and short-, medium- and long-term contracts both in Northeast Asia and globally." https://www.spglobal.com/platts/en/our-methodology/price-assessments/natural-gas/jkmt-japan-korea-marker-gas-price-assessments

A number of LNG export projects were proposed, planned, invested in, and built in the years following the 2011 Tohoku earthquake and resultant nuclear accidents at Fukushima Daiichi. During this period, all of Japan's nuclear reactors were taken offline, and large quantities of LNG were imported to replace the lost megawatts of electric power, causing the large increase seen in the JKM price marker. As nuclear plants begin to come back online in Japan, and the global LNG supply has expanded, the premium prices at JKM have begun to fall back in line with other natural gas markets around the world. Although Japan, with little to no gas supplies of its own, will continue to import gas from other markets, it seems unlikely that the large price premium observed from 2011-2016 will be a permanent feature of this market, which currently trades below $6/MMBtu.

The price of LNG in Japan has dropped markedly in the last six months, and even more dramatically in the last 3 years.[5] The following chart in Figure 2 shows the spread between JKM LNG and the Henry Hub index price of North American natural gas.

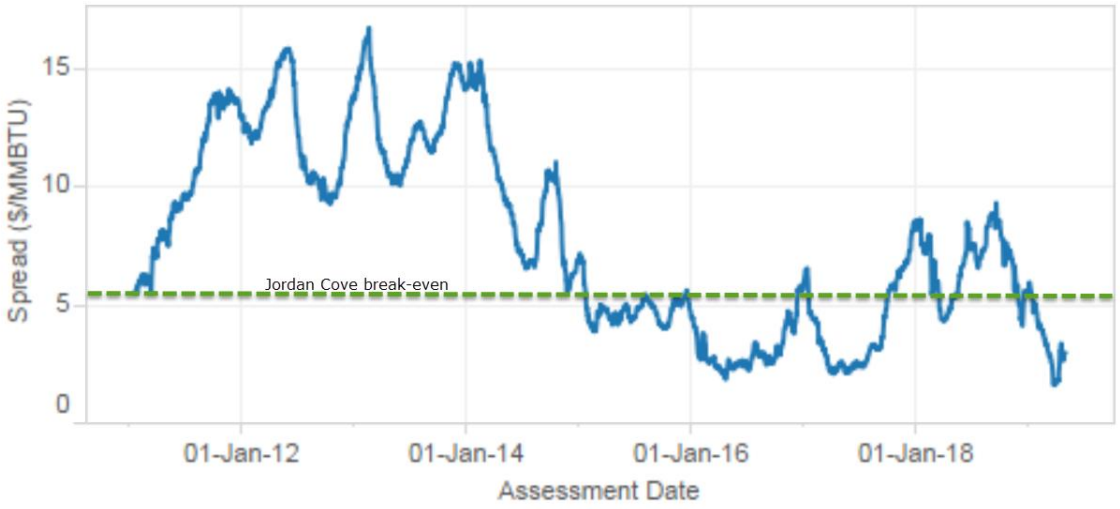

Figure 2: Recent JKM Price Changes

Beyond just the costs of feed gas itself, the costs of building, maintaining and operating an LNG export terminal must be recovered from the sale of LNG in the export market. The Jordan Cove Energy Project proposes to operate as a tolling model, providing liquefaction,

[5] *LNG Daily*, S&P Global Platts. https://www.spglobal.com/platts/en/products-services/lng/lng-daily

storage, and transport services to buyers of natural gas, who will pay a tolling fee per unit (MMBTU) based on the costs involved.[6]

Reviewing the materials submitted to FERC by the applicant allows us to calculate the tolling fee that would be needed to fully recover the costs of the project. Similar data is available for the British Columbia LNG terminal that received its FID last year. LNG Canada, sited at Kitimat, British Columbia, is larger than Jordan Cove, closer to inexpensive Alberta natural gas, and has better technology.[7]

The industry leader in North America is Cheniere Energy.[8] They have massive projects already in operation and plan an additional 30 MTPA to come into operation in the near future. Their data is contained in many sources and is generally subject to SEC rules on reporting.

The following table compares the three projects:

	Jordan Cove	LNG Canada	Cheniere
Output (MTPA)	7.8	14	31.5
Pipeline Cost (Billion $)	$ 2.46	$ 4.77	
LNG Project Cost (Billion $)	$ 7.30	$ 10.77	$ 30.00
Required Profit Margin for FID (Billion $)	$ 0.98	$ 1.55	$ 3.00
Total (Billion $)	$ 12.05	$ 19.18	$ 33.00
Per MTPA	$ 1.54	$ 1.37	$ 1.05
Annualized/MTPA @ 10% Real RoR	$0.16	$0.15	$0.11
Annualized/MMBTU	$3.33	$2.95	$2.26
O&M	$ 0.05	$ 0.04	$ 0.02
O&M/MMBTU	$0.94	$0.83	$0.32
Natural Gas Basis Differential ($/MMBTU)	($0.07)	($0.64)	$0.00
Required Margin @ FID	$4.27	$3.78	$2.58
Transportation to Asia ($/MMBTU)	$0.87	$0.87	$1.50
Required Margin at Asian Market	**$5.07**	**$4.01**	**$4.08**

Table 1: Comparison of Jordan Cove, LNG Canada, and Cheniere

[6] "Tolling" is an industry term that indicates that natural gas suppliers can bring natural gas to the LNG facility and have it compressed into liquified natural gas and delivered to the final market. The facility operator does not own the product at any point.

[7] Compression of natural gas into a liquid can be done by electricity or natural gas. Electricity is less expensive and more reliable. Jordan Cove's competitors are using electricity. Jordan Cove is using natural gas.

[8] Cheniere Energy, once an importer of LNG to its Sabine Pass, LA terminal, became the first Gulf Coast LNG exporter in early 2016. https://www.cheniere.com/terminals/lng/

The calculation of the minimum tolling fee that an LNG project can charge and make an acceptable project starts with the proposed output in millions of metric tons per annum. The pipeline cost from existing natural gas hubs to the project is added in the second line.

The cost per MMBTU (Millions of British Thermal Units) is derived by dividing the cost per MTPA by the BTU content of a metric ton of LNG.

Annual O&M costs are assumed to be 3% of the total project cost. Cheniere has a lower O&M cost available from its financial reports and financial presentations.

The basis differential for natural gas supplies is discussed below. Put simply, natural gas costs less at the well head – Alberta or Texas/Louisiana – than it does at the end of the pipeline.

The required profit margin is assumed to be 10% of the total investment. This is a standard industry assumption reflecting the risks of investing in the volatile LNG industry.

Transportation to Asia is taken from Cheniere's financial reports and estimates for West Coast projects. The West Coast is closer to Asia and has a significant transportation advantage.

The final line, in bold, sums the costs and arrives at the amount that the projects require as a fee for natural gas suppliers to take their feed gas to Asia.

The next chart (Figure 3) shows the price of Canadian natural gas in Alberta, the cheapest possible feedstock for the project plus the Jordan Cove tolling fee, as compared to the JKM price marker. The convergence of these two series seen in recent years suggests that the economics of this project are questionable at best.

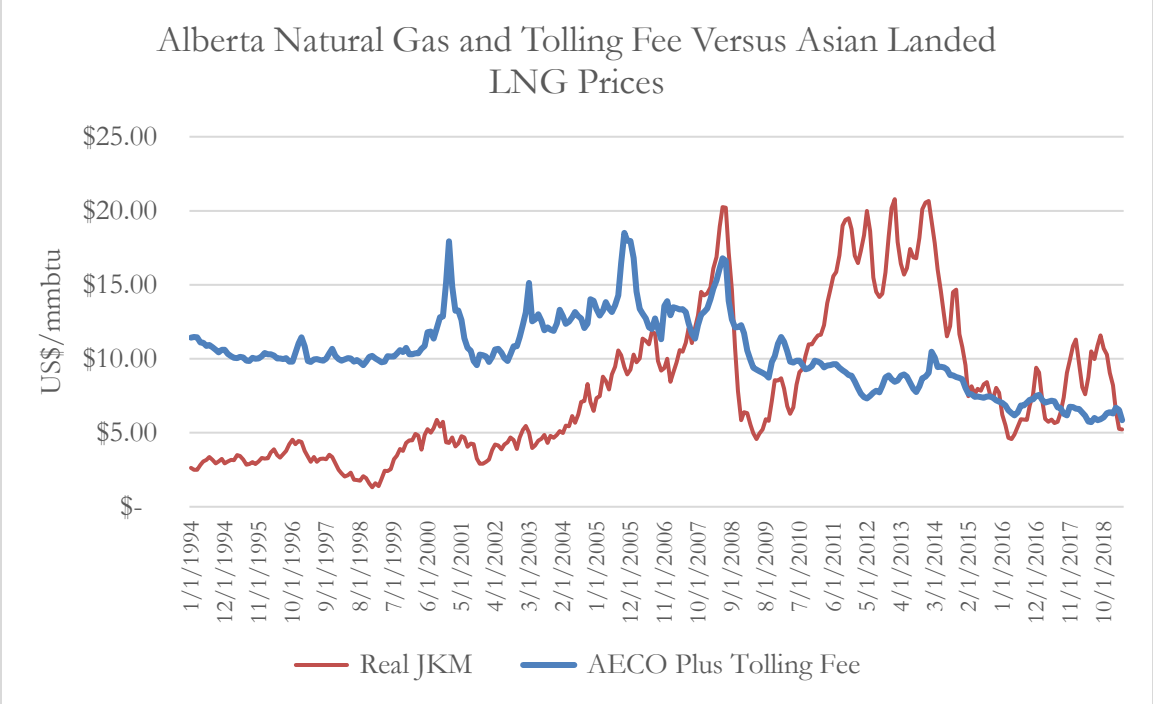

Figure 3: Delivered Cost and Asian Prices

In addition to our retrospective analysis, McCullough Research has developed a Monte Carlo model designed to predict the probability of success for West Coast LNG export terminals.

The Monte Carlo method was invented by Stanislaw Ulam during the Second World War at Los Alamos National Laboratory where models were used to help design the first thermonuclear weapons. One of the challenges Dr. Ulam and his colleagues faced in developing atomic fission was the sheer complexity of the possible reactions. Calculating over all possible interactions was impossible given the limited computers of his era (who generally were staff doing computations on mechanical calculators). The Monte Carlo method relies on large volumes of random samples. Each pick of variables is called a "game" and the results, when averaged, closely approximate what a very extensive analysis might develop. Today, Monte Carlo models are frequently used in economics, finance, engineering, and science.

Our model compares all the possible combinations of feed gas and Asian landed gas prices observed over the past decade, to generate a total of 92,416 games. Even with the unusually high post-earthquake prices of 2011-16 included in the study period, this analysis indicates that the probability of Jordan Cove successfully reaching FID is no more than 34%, as shown in Figure 4 below.

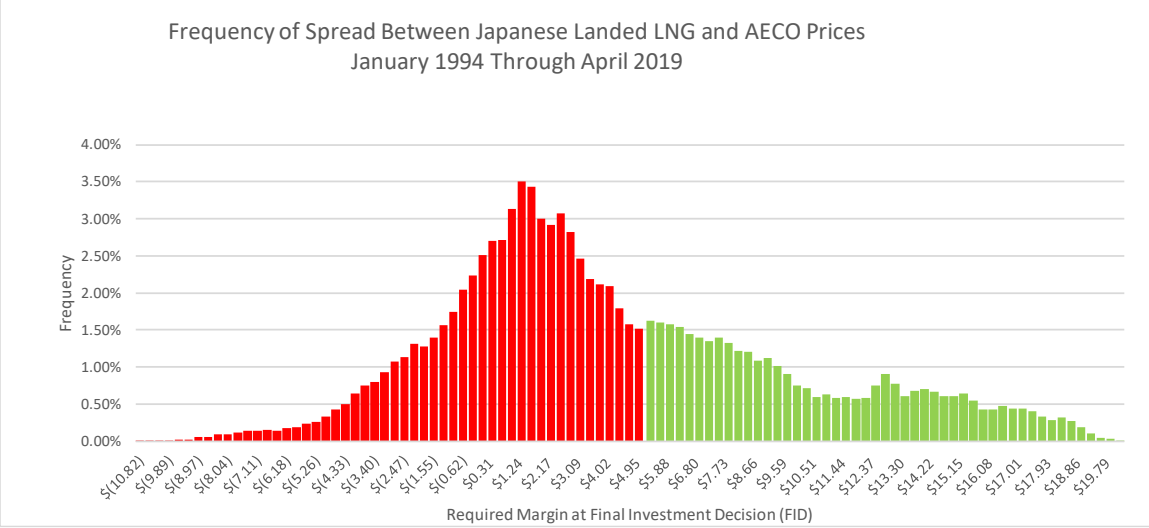

Figure 4: Monte Carlo Results

The modeling suggests strongly that more often than not, the spread between these prices is substantially less than what would be required to cover the costs of Jordan Cove, let alone earn any profits.

A critical issue in the future of Jordan Cove is the supply of natural gas and, very importantly, its price. The West Coast's major market for natural gas is in California. Pipelines extend into California from the north (Alberta and Colorado) and the east (the Gulf States).

Not surprisingly, prices are lower at the wells and increase with distance. Since California enjoys competition between different sources, the price for natural gas tends to increase or decrease with the major trading hub at Henry Hub, Louisiana. When prices fall at Henry Hub, competitors elsewhere in the U.S. and Canada must lower their prices to compete.

The locations where multiple suppliers and customers meet to negotiate transactions are known as a "hub". The term is meant to remind us of a wheel where spokes (pipelines) fan out from a central location.

On the West Coast there are ten major hubs as shown in the map in Figure 5:

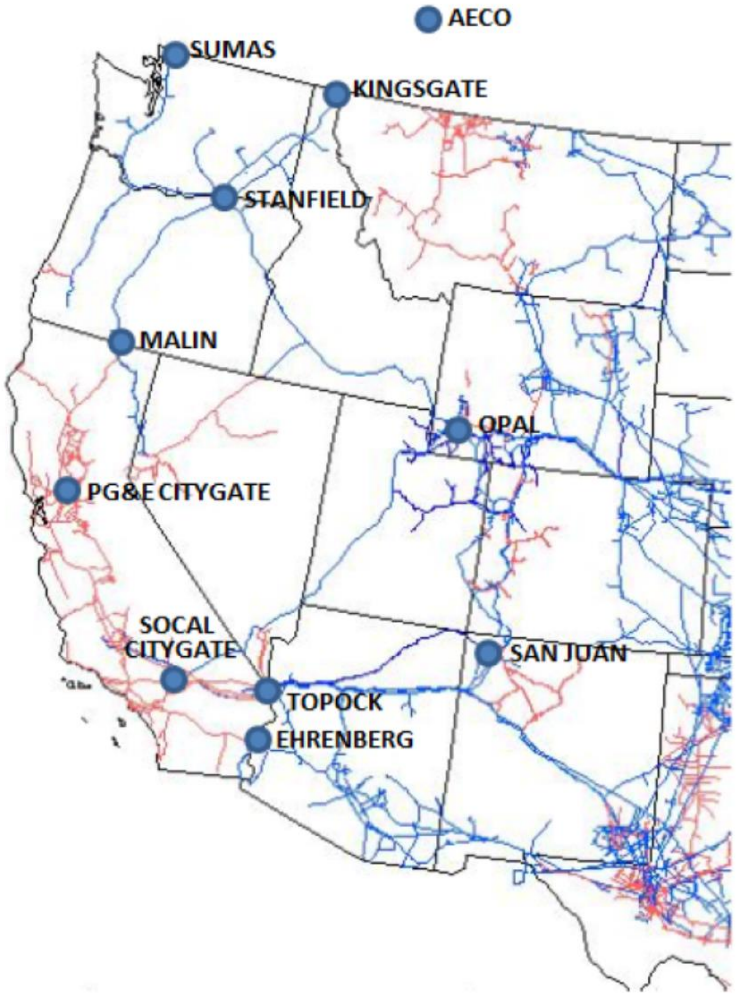

Figure 5: West Coast Natural Gas Hubs and Pipelines[9]

The trader's term for the difference in prices between hubs is *basis differential*. This value represents the expected difference between lower priced areas like Alberta and high-priced areas like Southern California. Traders watch these differentials and seize upon moments when they can profit by moving natural gas between hubs.

Financial markets like the Chicago Mercantile Exchange (which now includes the New York Mercantile Exchange – NYMEX) and the Intercontinental Exchange (ICE) document prices at the various hubs and facilitate long term commodity contracts.

[9] Bonneville Power Administration. Power Market Price Study and Documentation, BP-18-E-BPA-04. Page 40. https://www.bpa.gov/secure/Ratecase/Documents.aspx

An LNG export project like Jordan Cove requires a firm supply of feed gas delivered to its location, which is the purpose of the Pacific Connector pipeline connecting the proposed export terminal to the natural gas trading hub at Malin, Oregon near the California border.

The commercial success of the project thus very much depends on future movements in the price of gas at Malin. Commodities futures contracts, used to hedge against the risk of adverse price movements, are typically executed with respect to a basis differential, which specifies a discount or premium above or below an index price. Gas futures are priced with respect to the spot price at the Henry Hub in Louisiana, which is the delivery location specified by NYMEX for natural gas futures contracts and thus serves as the index price of US natural gas.[10]

As shown in Table 2 below, most Pacific Northwest gas hubs trade at a discount to Henry Hub, while California markets trade at a premium. The basis differential from Henry Hub at Malin is an estimate of the cost of long-term gas supply to the Jordan Cove project, while the competing LNG Canada project will be able to source its feed gas at a much lower price, due to the much wider basis discount seen at the AECO hub in Alberta.[11]

[10] "Henry Hub refers to the central delivery location (or, hub) located near the Louisiana's Gulf Coast, connecting several intrastate and interstate pipelines. Henry Hub has been used as a pricing reference for the futures since April 1990." https://www.cmegroup.com/trading/why-futures/welcome-to-nymex-henry-hub-natural-gas-futures.html

[11] "The AECO-C price is derived from the U.S. Henry Hub market price, taking into account transportation differentials, regional demand, and the U.S./Canadian dollar exchange rate. Similarly, the Alberta Reference Price (ARP) is derived from the AECO-C price, taking into account Alberta pipeline transportation costs." https://www.aer.ca/providing-information/data-and-reports/statistical-reports/commodity-prices-methodology

BPA Rate Cases: Power Risk and Market Price Studies						
FY	2014	2015	2016	2017	2018	2019
Henry Hub	$4.08	$4.35	$3.86	$4.05	3.24	3.25
AECO	-0.37	-0.39	-0.4	-0.42	-0.61	-0.64
Kingsgate	-0.19	-0.19	-0.16	-0.16	-0.2	-0.21
Malin	-0.09	-0.08	-0.03	-0.04	-0.07	-0.07
Opal	-0.12	-0.13	-0.13	-0.15	-0.13	-0.13
PG&E	0.25	0.27	0.31	0.32	0.34	0.36
SoCal City	0.05	0.05	0.24	0.26	0.22	0.22
Ehrenberg	0.05	0.05	0.12	0.13	0.04	0.04
Topock	0.05	0.05	0.12	0.13	0.04	0.04
San Juan	-0.12	-0.1	-0.16	-0.17	-0.13	-0.13
Stanfield	-0.15	-0.14	-0.1	-0.11	-0.14	-0.14
Sumas	-0.03	-0.06	-0.09	-0.1		

Table 2: BPA Rate Case Basis Differentials

Table 2 shows estimates for basis differentials developed by the Bonneville Power Administration.[12] Their estimate for 2019 is that Alberta's natural gas prices are $.64/MMBTU less than the hub at Henry Hub, Louisiana. By the time natural gas has travelled to the Oregon/California border, the price advantage has fallen to $.07/MMBTU. One of the reasons why LNG Canada has received its Final Investment Decision is that its natural gas supply is directly from the oil and natural gas fields priced at the AECO hub.

In conclusion, Jordan Cove faces a number of insurmountable challenges:

1. Jordan Cove's costs are higher – roughly $1 / MMBTU more – than its competitors.
2. With the rapid decline in Asian landed LNG prices, it is unlikely that it will reach a Final Investment Decision.
3. Its technology is likely to be less reliable and more costly than the electric compression methods used elsewhere.

As with a number of other LNG export projects proposed for the Pacific Northwest, the chances of its successful completion seem quite low.

[12] Bonneville Power Administration. Power Market Price Study and Documentation for BPA Rate Case in 2014, 2016, 2018, 2020. (e.g. BP-20-E-BPA-04) https://www.bpa.gov/secure/Ratecase/Documents.aspx