MEMORANDUM

TO: Planning and Sustainability Commissioners, PSC Staff
FROM: Gary Oxman
DATE: April 6, 2015
SUBJECT: Displacement of other fuels by propane in Asia

Fellow Commissioners

Throughout our deliberations on Pembina's proposal to site a propane export terminal at Terminal 6, the potential for propane to displace other more harmful fuels has been cited as a benefit. The March 13 report by Bentek makes two arguments in this regard:

1. Propane will have a beneficial impact on CO2 emissions because it produces less CO2 per unit of heat produced, and
2. Propane will help reduce the human health impacts of indoor air pollution because it is a cleaner-burning fuel.

As a public health professional, I have been intrigued by the possible benefits of expanded use of propane in Asia. To better understand the potential benefits, I have taken a closer look at the data in the Bentek report and want to share my observations with you. I believe that the methods of my analysis are reasonable, but would welcome your criticism and comments.

In summary, I found no evidence from the Bentek report data that expanded use of propane as a fuel has either substantially displaced other more harmful fuels or reduced CO2 emissions.

Page 27 of the Bentek report presents data on Chinese residential/commercial sector fuel use to support the idea of displacement. The report cites:

1. A downward trend in demand for biofuels and waste (wood, charcoal, grass, and dung). This is expressed in terms of demand percentages for various fuels.
2. Upward trends in demand for natural gas and "refined products (including propane)". These are expressed in terms of millions of metric tonnes of crude oil equivalent (MMtoe).

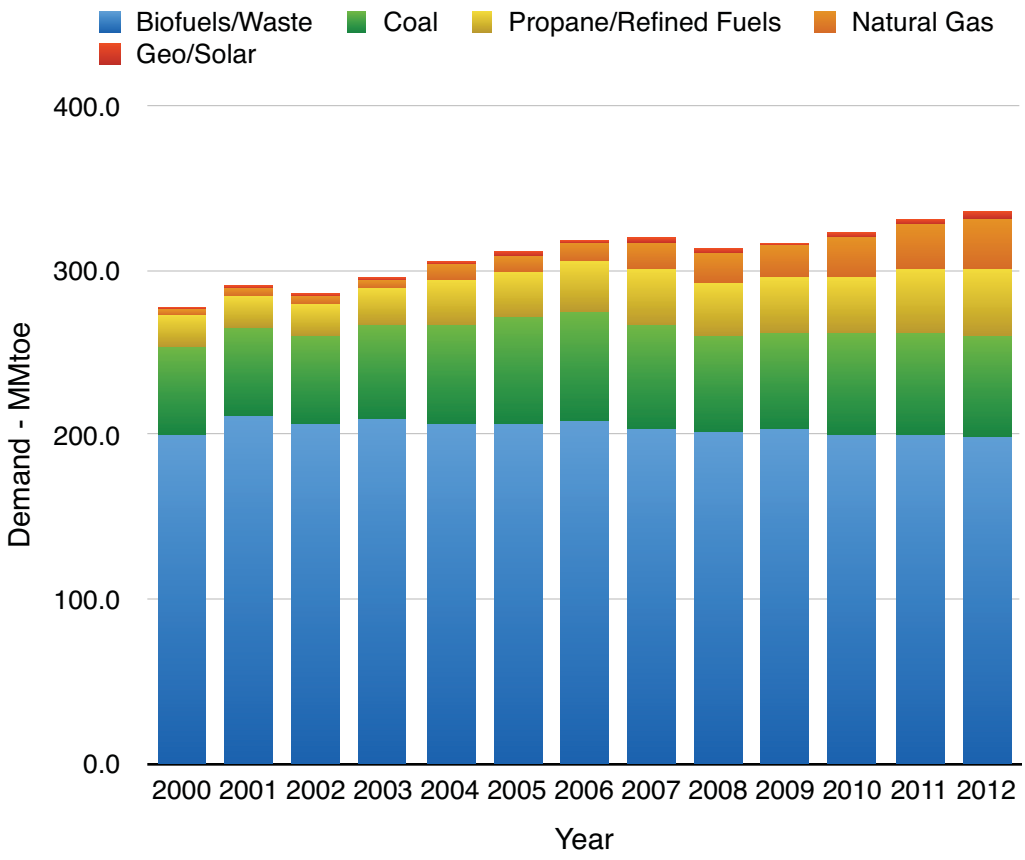
I limited my analysis to the Chinese residential/commercial sector because the Bentek report did not include detailed data on other countries or sectors. To better understand the trend data, I looked at actual demand amounts expressed as MMtoe as well as demand percentages. This involved converting the percentage data on Biofuels and Waste into estimated MMtoe (see Appendix 1: Methods Notes for details).

Figure 1 below presents the data.

To summarize:

- While the *percentage* of total demand met by Biofuels and Waste decreased from 73% in 2000 to 59% in 2012, *actual demand* for Biofuels and Waste was essentially unchanged (199 MMtoe in 2000 vs. 197 MMtoe in 2012). This apparent discrepancy is the result of an overall increase in demand for energy.
- Between 2000 and 2012, there were major increases in demand for "Refined Products (including propane)" (+22 MMtoe or +111%), and natural gas (+28 MMtoe or +869%).
- Coal use increased modestly (+8 MMtoe or +16%) over the same period.

Figure 1: 2000-2012 Trends in Fuel Demand - China Residential/Commercial Sector
(Demand data estimated from percentage data - see Method Notes)



The picture that emerges is primarily one of an expanding demand for energy in the Chinese residential/commercial sector - an increase in demand of ~58 MMtoe or 21% from 2000 to 2012. It appears that increasing amounts of cleaner energy types (natural gas, propane, and to a very small degree geothermal and solar) were layered on top of large existing demands for coal and biofuels/waste.

After adjusting for population growth between 2000 and 2012, there was small decrease (-7%) in the *rate* of demand for biofuels/waste per billion population. Between 2000 and 2012, the population of China increased from 1.263B to 1.351B (7%). So it is reasonable to expect some increase in overall fuel use as a result of population growth. If fuel use followed the year 2000 pattern, an increase demand of 17 MMtoe would have been expected from population growth. However actual fuel use increased 58 MMtoe. This implies that roughly 41 MMtoe of the observed increase (i.e., 70% of the total increase) was the result of increased rate of fuel use in general. Population adjusted data are presented in Appendix 2.

A similar picture emerges with regard to changes in CO2 emissions related to the Chinese residential/commercial sector. There was an essentially flat trend in actual demand for Biofuels and Waste between 2000 and 2012. Over that time period, there was a very small decrease (-3 million tonnes or -0.9%) in CO2 emissions from biofuels and waste. In contrast, increasing demand for other fuels is reflected in increased CO2 emissions (+22 million tonnes or +111% for refined fuels/propane) and (+25 million tonnes or +869% for natural gas). These data take into account the superior CO2 emissions profiles of the latter fuels. Overall, CO2 emissions in the residential/commercial sector increased +58 million tonnes or +13%. Full emissions data are shown in Appendix 3.

The only hopeful signals in the data were: a) a small decrease in the population *rate* of use of biofuels/waste, and b) a flat trend in CO2 emissions from biofuels and waste despite an increase in population. It is important to view these signals in context:

- On a population level, the human health impacts of dirty fuels depend on the number of people exposed. There is no evidence that fewer people were exposed. A sensible interpretation is that there was a large and stable class of people that continued to use coal and biofuels/waste, while other classes increased use of cleaner fuels.
- The greenhouse gas impact of CO2 emissions arises from the amount of CO2 emitted into the air. Since the flat trend in biofuels/waste-related emissions was overwhelmed by increased emissions from other fuels, environment burden of CO2 actually increased over time.

In conclusion:

- The data presented in the Bentek report fails to provide evidence for significant displacement of dirtier fuels (coal and biofuels/waste)
- The data also fail to provide evidence for beneficial impacts of increasing propane use on either human health or climate change.

Appendix 1: Method Notes

1. Estimated numeric percentages of use of all fuels (biofuels/waste, coal, natural gas, refined fuels including propane, and geothermal/solar)
    a) Used left-hand graph on p. 27 of Bentek report.
    b) Measured heights of graph bars and scale lines in mm
    c) Entered data into a spreadsheet
    d) Calculated numeric percentage for each fuel (by year) by multiplying graph bar height by a scale factor (i.e., 10% per 11.3 mm)
    e) Checked numeric results against graph to see if numeric results were consistent with the graph

2. Estimated numeric amounts of selected fuels with data shown (coal, natural gas, refined fuels including propane, and geothermal/solar)
    a) Used right-hand graph on p. 27 of Bentek report.
    b) Measured heights of graph bars and scale lines in mm
    c) Entered data into a spreadsheet
    d) Calculated numeric amount in MMtoe for each fuel (by year) by multiplying graph bar height by a measured scale factor (10 MMtoe per 11.3 mm)
    e) Checked numeric results against graph to see if results were consistent with the graph

3. Calculated estimated numeric amounts biofuel/waste for each year (in MMtoe)
    a) Used numeric percentage data derived above to determine percentages of
        - Biofuels/waste
        - The other four fuels combined ("4 fuels")
    b) Using formula in spreadsheet, calculated amount of biofuels/waste demand each year (in MMtoe):

$$\text{Biofuels/waste (MMtoe)} = \text{Amount of 4 fuels (MMtoe)} \times \frac{\%\text{ of biofuels/waste}}{\%\text{ of 4 fuels}}$$

Notes:

- Measuring graphs induces some small degree of measure error - probably less than 1% overall, but higher for graph bars representing small numbers (e.g., geothermal/solar)
- Formula-calculated figures vary from hand calculation due to rounding errors (spot-checking suggests this error is less than 0.6%)
- % biofuels/waste calculated as 100% - % 4 fuels

Appendix 2: Population Adjusted Data

Fuel	Actual Demand in 2000 (MMtoe)	Actual Demand in 2000 (MMtoe per Billion Population)	Actual Demand in 2012 (MMtoe)	Actual Demand in 2012 (MMtoe per Billion Population)	Change in Actual Demand 2000 to 2012 (MMToe)	% Change in Actual Demand 2000 to 2012	Change in Actual Demand 2000 to 2012 per Billion Population (MMToe)	% Change in Demand 2000 to 2012 per Billion Population	Predicted 2012 Demand Using Year 2000 Pattern
Natural Gas	3.2	2.5	31.0	22.9	27.8	872%	20.4	809%	3.4
Biofuels and Waste	199.1	157.6	197.4	146.1	-1.7	-1%	-11.5	-7%	213.0
Coal (hard)	54.0	42.7	62.4	46.2	8.4	16%	3.4	8%	57.7
Refined Fuels (LPG)	19.5	15.4	41.2	30.5	21.7	111%	15.0	98%	20.8
Geotherma l/Solar	1.3	1.1	3.5	2.6	2.2	167%	1.6	149%	1.4
TOTAL	277.1	219.4	335.5	248.3	58.4	21%	28.9	13%	296.4

Appendix 3: CO2 Emissions Data

Fuel	Demand in 2000 (MMToe)	Demand in 2012 (MMToe)	Change in Demand 2000 to 2012 (MMToe)	% Change in Demand 2000 to 2012	CO2 Emissions 2000 (Million Tonnes)	CO2 Emissions 2012 (Million Tonnes)	Change in CO2 Emissions 2000 to 2012 (Million Tonnes)	% Change in CO2 Emissions 2000 to 2012	Population-Adjusted CO2 in 2000 (Million Tonnes CO2 per Billion Population)	Population-Adjusted CO2 in 2012 (Million Tonnes CO2 per Billion Population)	Change in Population-Adjusted CO2 in 2012 (Million Tonnes CO2 per Billion Population)	% Change in Population-Adjusted CO2 2000 to 2012
Biofuels and Waste (Calculated as wood)	199.1	197.4	-1.7	-0.9%	347.3	344.4	-3.0	-0.9%	275.0	254.9	-20.1	-7.3%
Natural Gas	3.2	31.0	27.8	868.8%	2.9	27.8	24.9	868.8%	2.3	20.5	18.3	805.6%
Coal (hard)	54.0	62.4	8.4	15.6%	82.3	95.1	12.8	15.6%	65.1	70.4	5.2	8.0%
Refined Fuels (LPG)	19.5	41.2	21.7	111.3%	20.0	42.2	22.2	111.3%	15.8	31.2	15.4	97.5%
Geothermal/ Solar	1.3	3.5	2.2	169.2%	0.2	0.6	0.4	0.0%	0.2	0.5	0.3	151.7%
TOTAL	277.1	335.5	58.4	21.1%	452.7	510.0	57.3	12.7%	358.4	377.5	19.1	5.3%