Before the Public Utilities Board of Manitoba

Manitoba Hydro General Rate Application

2017/18 and 2018/19

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Introduction

EDUCATION

- Economics and Mathematics, B.A. University of Toronto
- Economics M.A. University of Toronto
- Economics Ph.D. Harvard University

FACULTY POSITIONS

- Faculty member University of Toronto, Department of Economics (since 1980)
- Various visiting appointments including
  - University of Chicago
  - Trinity College, Cambridge University
  - Australian National University

Introduction

RESEARCH

- Econometrics – theoretical and applied
- Energy economics and related areas

TEACHING

- Ph.D. courses in econometrics
- Undergraduate and graduate courses in energy and regulation
- Courses on energy for non-economists at the School of Environment
  - What are the Big Ideas in Energy that everyone needs to know?

Introduction

EDITORIAL EXPERIENCE

- Served in various editorial capacities at *The Energy Journal* since 1995.
- Editor-in-Chief of *The Energy Journal* since 2006.

PROFESSONAL EXPERIENCE

- Advised public and private sector companies on energy, regulatory and other matters for over 30 years and have provided analysis and testimony in numerous regulatory and litigation proceedings.

Scope of Work

- Manitoba Hydro has advised the Board that it needs rate increases of 7.9% for each of the upcoming six fiscal years followed by an increase of 4.54% in the seventh year. The cumulative effect would be to increase electricity rates by close to 50% in real terms over the coming decade.

- In broad terms, the purpose of this testimony is to assess the likely impacts on, and responses of various customer groups to rate increases of this magnitude, as well as the implications for the Manitoba economy as a whole.

Background

Economic Setting

- Manitoba is endowed with
  - excellent fresh water and hydraulic resources,
  - very productive agricultural lands,
  - a variety of deposits of metals and minerals.

- Its economy is **well diversified**.
  - There is considerable variation in energy and electricity intensity across sub-sectors; some firms more vulnerable to electricity price increases, while others more resilient to such price changes.

Economic Setting

Figure 1: Manitoba GDP Shares 2016

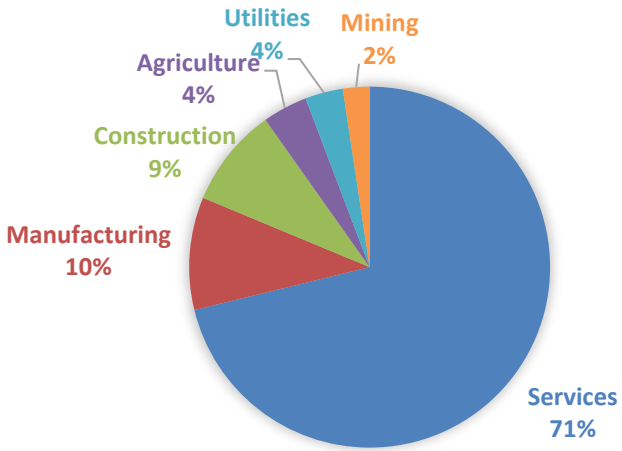
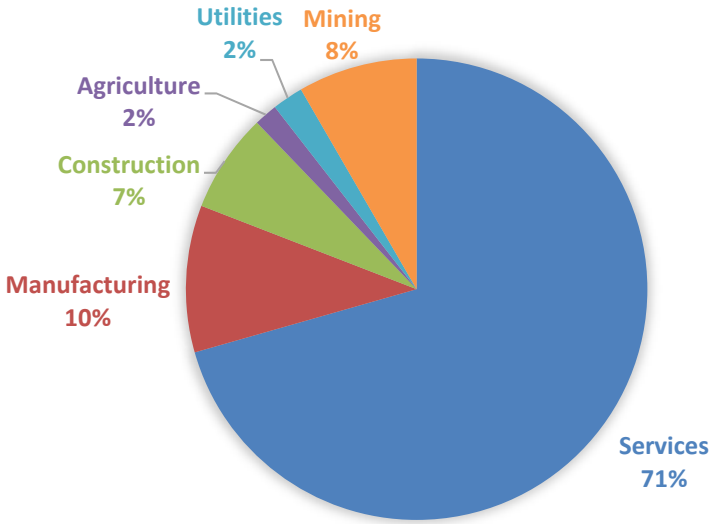
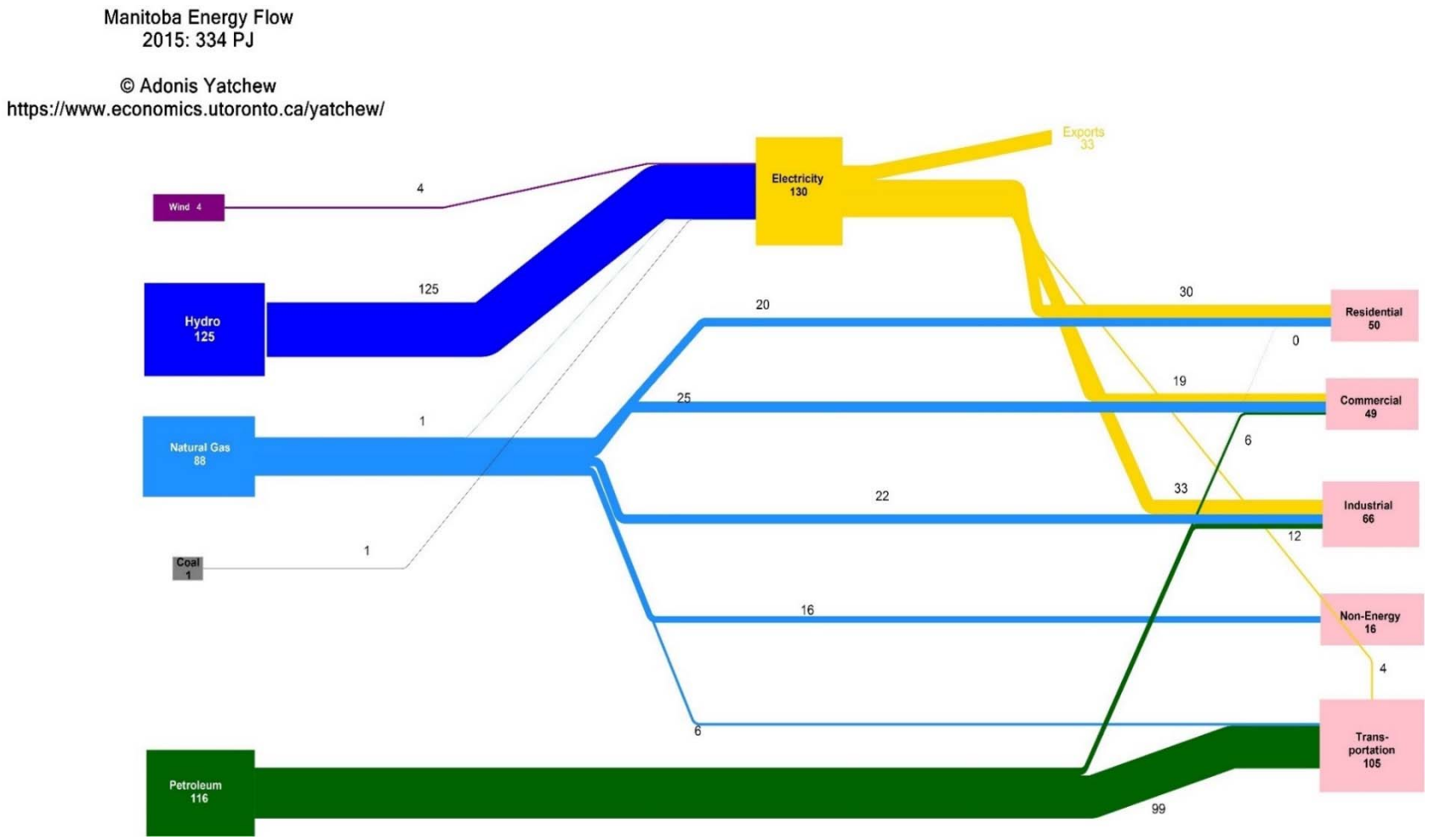


Figure 2: Canada GDP Shares 2016



Manitoba's Energy Sector

Figure 3: Manitoba Energy Flow (Sankey Diagram)



Manitoba's Energy Sector

Figure 3: Manitoba Energy Flow (Sankey Diagram)

- A particularly informative visual representation of energy sources and uses is provided by 'Energy Flow' diagrams, also known as Sankey diagrams.

- Figure 3 depicts this type of diagram for the Province of Manitoba. 'Pipe' diameters reflect the magnitudes of flows.

- The multi-colored boxes on the left depict the primary sources of energy: hydro, petroleum, natural gas, coal and wind.
  - But these are normally measured in different units: petroleum in barrels, natural gas in cubic meters, hydraulic energy in kWh's.
  - How are all these combined in one chart? By converting the various units into a common unit: in this case Joules (actually peta-joules PJ's).
  - At the top left is the total Manitoba energy flow – 334 peta-joules.

Manitoba's Energy Sector

Figure 3: Manitoba Energy Flow (Sankey Diagram)

- The pink boxes on the right depict the uses of these sources of energy (the demand side): Residential, Commercial, Industrial and Transportation.
  - There is an additional pink box entitled "Non-Energy". Think of this as the petrochemical industry.

- The 'pink boxes' plus 'Electricity Exports' (33 PJs) add up to 319 PJs which is less than the 334 PJs at the top left.
  - The difference reflects transmission/distribution losses in the electricity sector.

Manitoba's Energy Sector

Figure 3: Manitoba Energy Flow (Sankey Diagram)

- Manitoba's successful development of cheap and accessible hydraulic electricity is reflected in its share of total energy, and its shares within each end-use sector.
  - About 60% (30 PJ of 50 PJ) of energy used in the residential sector is electricity.
  - For the industrial sector the share is 50% (33 PJ of 66 PJ).
  - For the commercial sector the share is 39% (19 PJ of 49 PJ).

Manitoba's Energy Sector

Figure 3: Manitoba Energy Flow (Sankey Diagram)

- The Sankey diagram also provides a departure point for considering the impacts of changes in the price of electricity. Where natural gas is available, substantial increases in electricity prices could lead to substitution to gas in the residential, commercial and industrial sectors, particularly given the relatively low shares of natural gas there.

- The diagram is also useful for informing decarbonization discussions. Manitoba is very well positioned with such a large share of hydraulic source energy. Its use of coal is minimal and the remainder of non-transportation energy comes from natural gas, the hydrocarbon with the lowest carbon footprint (roughly half that of coal). The dominant share of energy-related carbon generated in Manitoba is in the transportation sector, which is the most difficult to decarbonize.

Manitoba's Energy Sector

Figure 3: Manitoba Energy Flow (Sankey Diagram)

- Sankey diagrams can be extended to track energy that produces energy services, and energy that is 'rejected' or lost in the form of heat.

- Sibling diagrams which track 'Carbon Flows' can also be constructed, to inform discussions of decarbonization.

- See https://www.economics.utoronto.ca/yatchew/ for Canada-wide energy and carbon flow diagrams and https://flowcharts.llnl.gov/ for U.S. diagrams.

Key Trends Affecting Manitoba and Manitoba Hydro

Oil and Natural Gas Markets

Why is it important to understand oil and natural gas markets in considering electricity issues in Manitoba?

- First, natural gas competes with electricity in certain industrial, commercial and residential applications, particularly if the end-use is space heating or process heat. A large increase in electricity prices could lead to loss of electricity load to natural gas.

- Second, low-priced natural gas is the 'go-to' fuel for electricity generation in many parts of North America, including states neighboring Manitoba, and the MISO transmission system to which Manitoba belongs. This in turn affects Manitoba Hydro export markets.

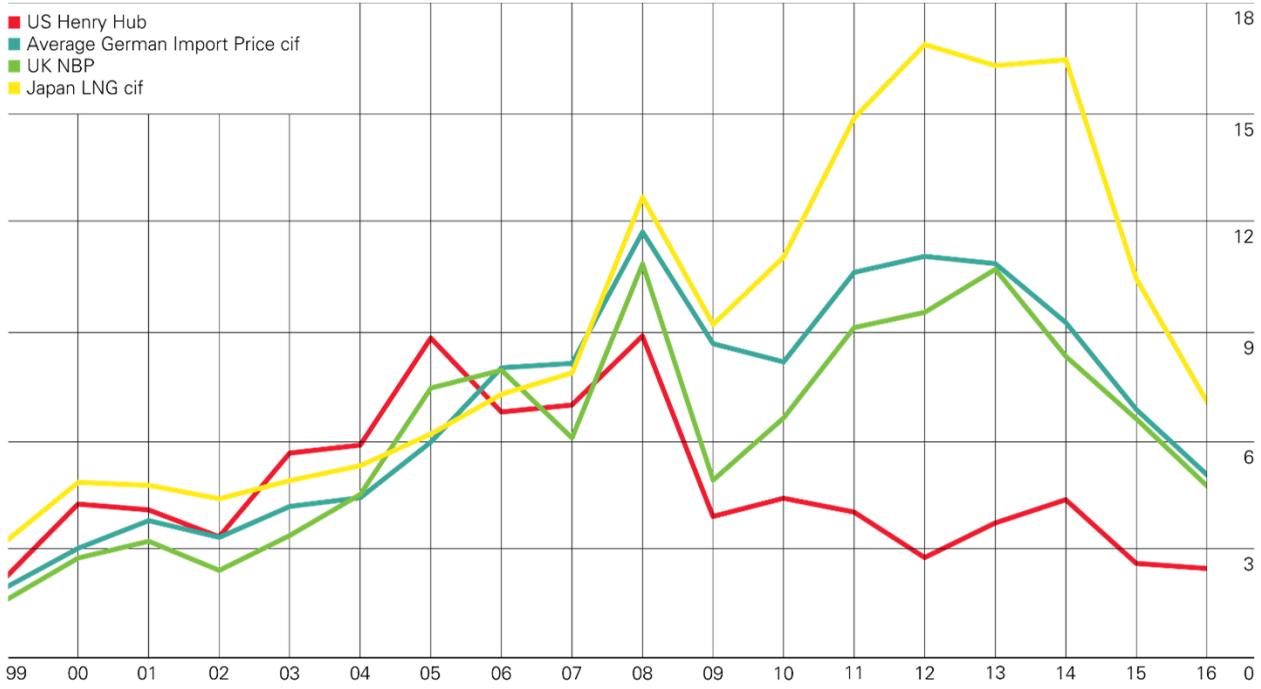
- Third, oil prices have an important impact on Canadian export revenues and on exchange rates. The precipitous decline in oil prices which began in mid-2014 has had a dramatic impact on the economy of Alberta and to a lesser degree on Saskatchewan and Manitoba. Canada has vast reserves of oil, mainly in the form of bitumen. But these reserves are among the highest priced in the world.

A Quiet Revolution

- Hydraulic fracturing (fracking) of shale has *fundamentally* revolutionized hydrocarbon markets.
  - Vast new supplies of natural gas in North America have led to a sustained drop in prices and gradual globalization of natural gas markets through LNG exports.
  - *Scalable* supplies of shale oil have impaired the market power of OPEC and as a result, altered strategic behaviour of OPEC.

Natural Gas Prices

BP Statistical Review of World Energy 2017 © BP p.l.c. 2017



Oil Prices and Exchange Rates

2003-2017

Figure 12: Oil Prices (blue) vs CAD/US Exchange Rate (orange)

Exchange Rates

- Canada's exchange rate has historically been closely linked to world oil prices.
  - Exchange rates have an important effect on Manitoba's economy as they influence demand for, and revenues from exports, including those in the electricity sector.
  - *Expectations* about future oil prices inform forecasts of Canada/U.S. exchange rates.

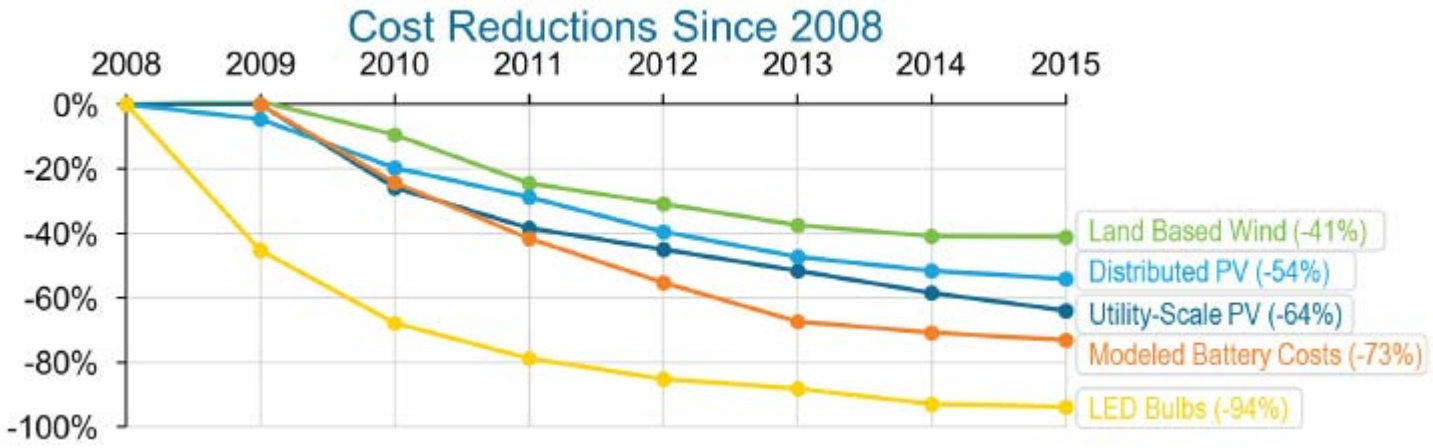
New Energy Technologies

- The costs of new key energy technologies have been declining rapidly. Since 2008,
  - costs of wind generation have dropped by 41%;
  - photovoltaic costs have dropped more than 50%;
  - battery costs by 73%;
  - LED bulbs by a stunning 94%.

- Continuation of these trends could have an important impact on Manitoba Hydro domestic and export markets.

New Energy Technologies

Figure 5



Source: "Revolution … Now, The Future Arrives for Five Clean Energy Technologies – 2016 Update", U.S. Department of Energy, September 2016.
Available at https://www.energy.gov/eere/downloads/revolutionnow-2016-update.

Decentralization of Electricity Systems

- Electricity systems are facing powerful decentralizing forces, in part as a result of the *scalability* of new generation and storage technologies, and the enabling effects of information technologies.
- Manitoba Hydro, because of its vast hydroelectric resources, continues to operate with a highly centralized model, relying on massive investments in generation and transmission.
- These large investments have long life-times, and face financial risks in a world of rapid technological innovation.

Demand Modeling and Elasticities

Types of Energy Models

- **Time-series models** use data for a single geographic area over a period of time (e.g., monthly observations over a series of years for Manitoba).

- **Cross-section models** use data for a single period across multiple geographic areas (e.g., observations for 2016 for all Provinces, or all American states).

- **Panel data models** use data over multiple geographic areas over a period of time (e.g., monthly observations for all Provinces).

Types of Energy Models

- Data may be disaggregated by sector -- residential, commercial, industrial.
- Time-series models do not benefit from experience in other jurisdictions.
- Cross-section models do not benefit from changes and trends that occur over time.

Demand Elasticities

- The ‘price elasticity’ estimates the responsiveness of electricity demand to changes in the price of electricity.

- The income or ‘GDP’ elasticity estimates the responsiveness of electricity demand to changes in economic activity.

Recommended Demand Elasticities

- **a short-term price elasticity of -0.1 across all sectors**; that is, an electricity price increase of 10% leads to a 1% decline in electricity demand in the short-term;

- **a long-term overall price elasticity of -0.4;** that is, an electricity price increase of 10% leads to a 4% decline in electricity demand in the long-term;

- **long-term price elasticities of -0.35 for the residential and commercial sectors, and -0.5 for the industrial sector;**

- **a GDP elasticity of 0.8;** that is, an increase in GDP of 10% eventually leads to an increase in electricity consumption of 8%.

Demand Elasticity Calculations

- Given the projected price increases, basic load (unadjusted for certain demand management activities) is likely to be stagnant over the coming decade.
  - Suppose that cumulative increases in electricity prices are about 50% and that the economy grows at 2% per year, so that GDP is 22% larger ten years hence.
  - Then the price increase reduces electricity demand by about 20% (-0.4 x 50%) and GDP growth increases demand by about 18% (.8 x 22%).

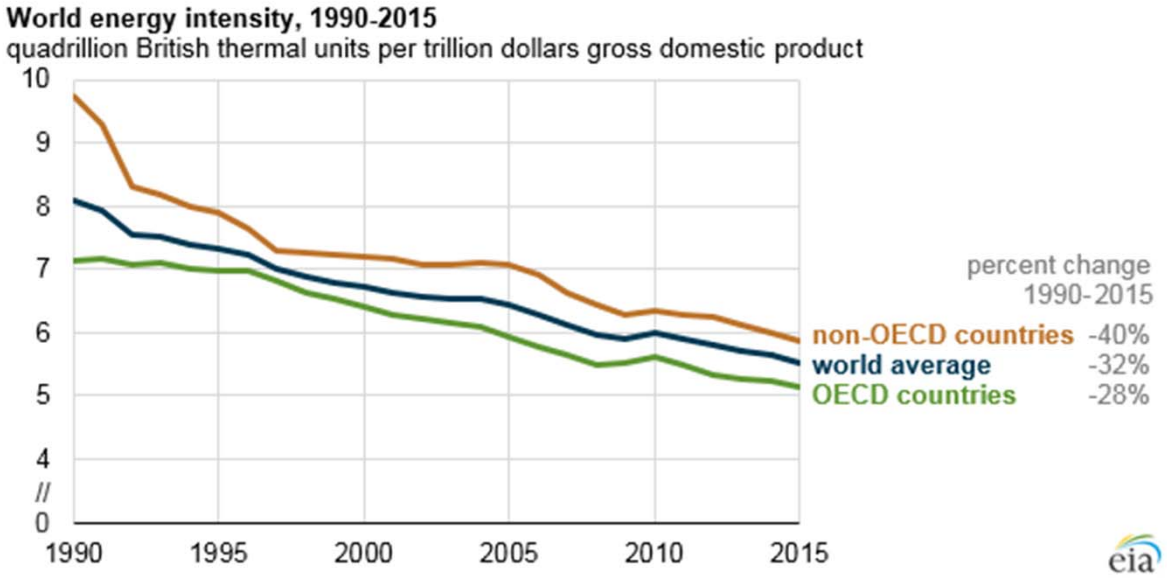
Energy Intensity Trends

- Over the last 25 years, energy intensity, that is the amount of energy used per dollar of GDP, has been falling by more than 1% per year in Canada, a figure comparable to the average for OECD countries.

- Manitoba energy intensity has been dropping more rapidly, at a rate closer to 2% per year.

Energy Intensity Trends (World)

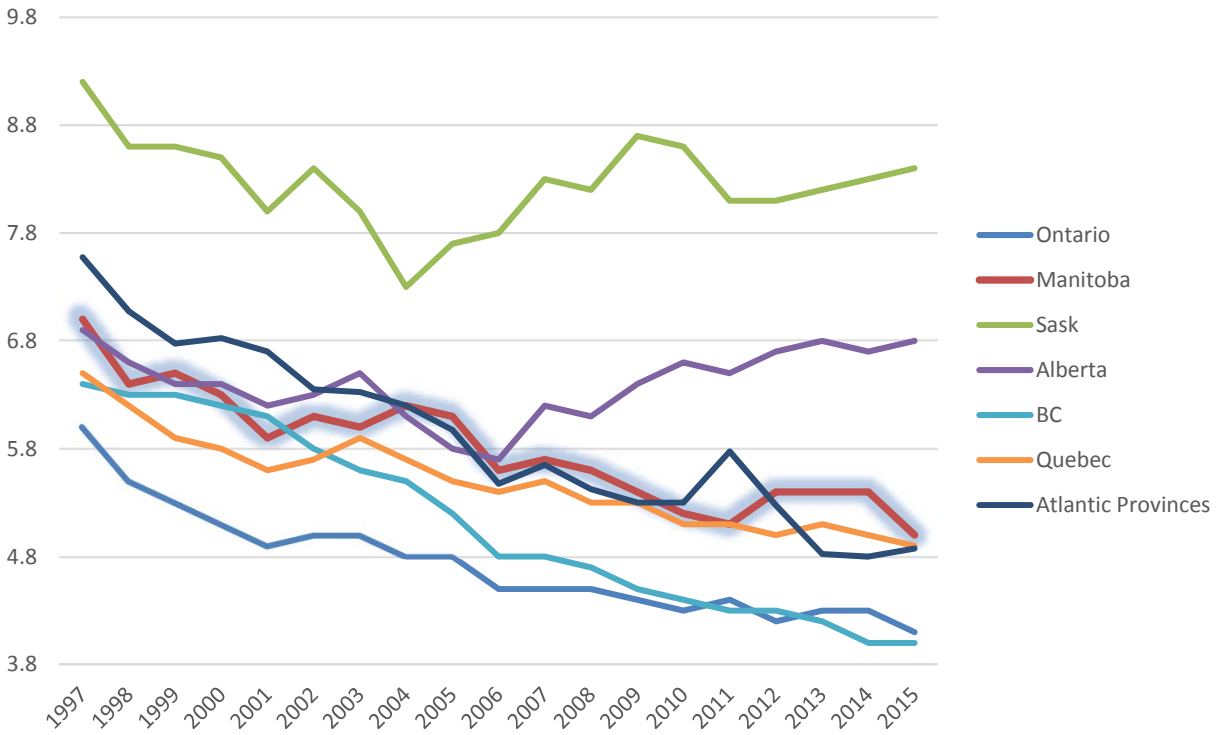
Figure 6 – World Energy Intensity Trends



Source: EIA, International Energy Outlook 2016, International Energy Statistics, and Oxford Economics
Note: OECD is the Organization for Economic Cooperation and Development. GDP calculated in purchasing power parity terms. Available at https://www.eia.gov/todayinenergy/detail.php?id=27032.

Energy Intensity Trends (Canadian Provinces)

Figure 7 – Provincial Energy Intensity Trends



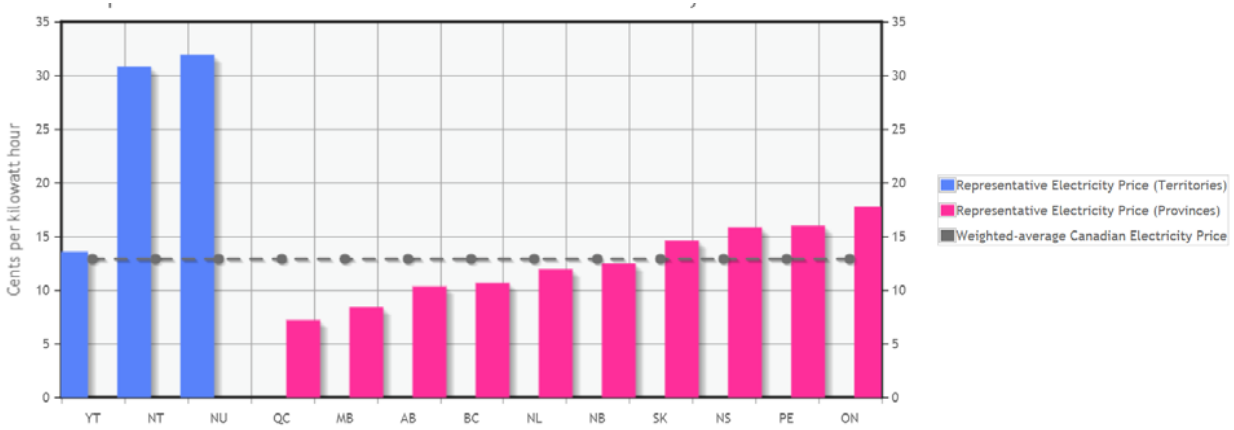
Electricity Intensity Trends

- Patterns of electricity intensity in Manitoba have been mixed.
  - In the service sector, which is by far the largest, intensity dropped by about 25% between 2005 and 2012, but by 2015 it had recovered to 2005 levels.
  - Intensity in the manufacturing sector peaked in 2005, and has been displaying a fairly steady decline since that time.
  - Agricultural sector intensity remained high until 2005, but subsequently dropped significantly

ENERGY POVERTY

Energy Prices

Figure 8 – Representative Electricity Prices 2016



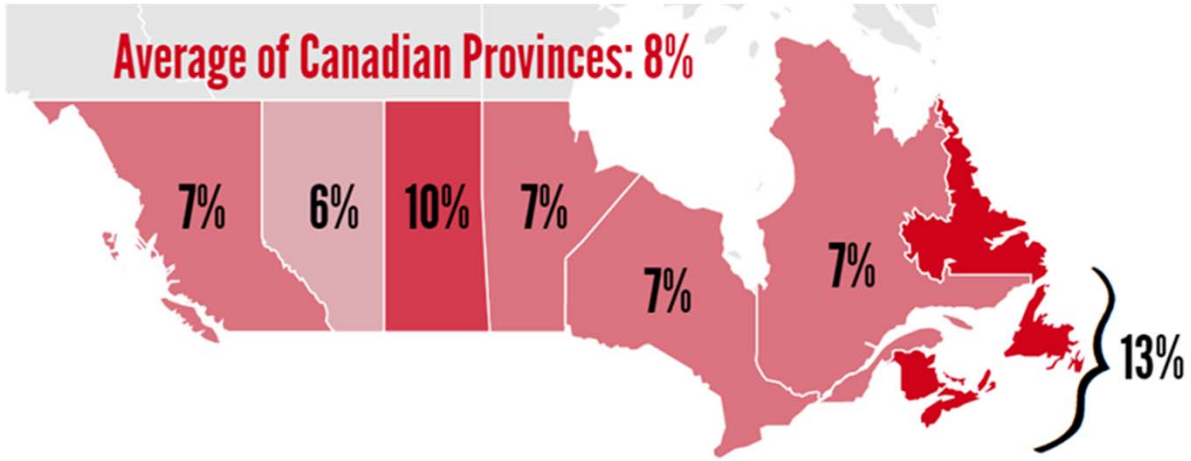
"Explaining the high cost of power in northern Canada", National Energy Board, February 16, 2017, available at https://www.neb-one.gc.ca/nrg/ntgrtd/mrkt/snpsht/2017/02-03hghcstpwr-eng.html

Energy Poverty

- Manitoba has a relatively low rate of energy poverty in comparison to some other provinces:
  - about 7% of households spend 10% or more of their income on energy;
  - the incidence of energy poverty varies significantly across the Province and is particularly high in remote communities where prices of many goods, among them energy, are high;
  - the projected growth in electricity prices will increase rates of energy poverty.

Energy Poverty

Figure 9: Household Fuel Poverty Rates in Canadian Provinces in 2015



Source: "Market Snapshot: Fuel poverty across Canada – lower energy efficiency in lower income households", National Energy Board, https://www.neb-one.gc.ca/nrg/ntgrtd/mrkt/snpsht/2017/08-05flpvrt-eng.html .

First Nations

- The impact on energy poverty in First Nations communities of the proposed price increases:
  - likely to be especially acute given the limited possibilities for energy substitution;
  - low incomes will hamper substitution of capital goods, such as improved insulation, and efficient windows and doors;
  - commercial and industrial establishments will also be adversely affected, particularly in the absence of energy substitutes such as natural gas.

MACROECONOMIC ISSUES

Energy Price Shocks

- Market economies have experienced major energy price shocks.
- Past experiences are helpful in bounding the likely effects of significant electricity price increases in Manitoba.
- The dramatic oil price shocks of the 1970s which were largely unanticipated, led to economic contractions of half a per cent or less.
- The cumulative impact on U.S. GDP of the oil price shock in the late 1970s is estimated to be about 3%.

Risks Associated With Exchange Rates and Commodity Prices

- Certain sectors of the Manitoba economy are subject to large, difficult-to-predict variations in key variables.

- Exporters are subject to exchange rate variations:
  - over the last decade, the Canadian dollar has varied from below 70 cents/USD to well above parity;
  - wheat prices, which reached a post-recession high of $9 US/bushel in 2012, have since declined to $4 - $5 in 2017;
  - nickel, copper, zinc and gold prices have also exhibited large swings.

Vulnerable Economic Sectors

- Electricity prices affect all households, firms, institutions and agencies. The extent of response depends on the electricity intensity and alternatives available.
  - In the manufacturing sector, the most vulnerable industries appear to be 'basic chemicals' and 'pulp and paper' where electricity comprises high shares of costs. Iron and steel mills, foundries and non-ferrous metal production also have significant electricity cost shares.
  - In the agricultural sector, 'greenhouses' and 'animal production' have significant electricity cost shares.
  - In the mining sector, 'support activities for oil and gas production' and extraction of metals also have significant electricity cost shares.
  - See Appendix 4, p. 77 of the Report.
- Where natural gas is available, some of these industries may engage in fuel substitution. **Others are likely to carefully consider, or reconsider future investment plans.**

Macroeconomic Impacts of Large Electricity Price Increases

- In the event that large electricity price increases are approved over the coming years, the Manitoba economy will adapt.
  - The *net* effect on GDP may eventually be modest, but in the interim, there are likely to be significant adjustment costs.
  - In some locations, particularly those which are heavily dependent on an industry that is sensitive to electricity prices, there could be large local impacts on employment, incomes and output.
  - The projected rate increases are not of the same magnitude as the energy price shocks of the 1970s. However, given that in the short-term, demand for electricity is highly price-inelastic, the steepness of the projected rate increases will impose a significant burden, particularly on households, businesses and institutions that do not have access to substitutes, such as natural gas.
- Ontario has experienced electricity price increases in excess of 50% since 2009. Notwithstanding these increases, and the fluctuations in exchange rates, the Ontario economy continued to grow and the manufacturing share remained steady at about 13% of Provincial GDP.

The Current U.S. Administration

- In any discussion of Canada's economic circumstances, consideration of the effects of the current U.S. administration cannot be ignored.
  - The North American Free Trade Agreement is being re-negotiated at the initiative of the U.S.
  - At a minimum, this injects considerable uncertainty into trade relations with our largest trading partner.
  - The U.S. administration has also altered direction on its decarbonization policies, disengaging from the Paris Agreement and making efforts to revive the coal industry.
  - Together, these factors are likely to have a dampening effect on investment.

CONCLUDING OBSERVATIONS

Regulatory Signaling

- The regulatory decision made in this proceeding, which ostensibly deals with rate increases over a two-year test period, will have an important impact on decision-making by industry because it will signal the likely future path of rate increases.

- Approval of increases that are close to the proposed 7.9% will suggest the acceptance of Manitoba Hydro arguments, and its focus on the time profile of future financial ratios.

Excess Capacity

- Large increases will induce a price response.

- In a period of excess capacity this may be sub-optimal as it will erode revenues at a time when marginal costs of production are low.

Cost Reductions

- Manitoba Hydro operates under a 'cost-of-service' regulatory regime.
  - Many other jurisdictions have moved to a mode of incentive regulation in order to improve incentives for cost minimization.
  - Manitoba Hydro is implementing a "Workforce Reduction Plan" which would eliminate 900 positions (15% of the workforce) over the course of two to three years.

Intergenerational Fairness

- Are the projected rate increases equitable from an intergenerational standpoint?
  - Expansion of hydroelectric systems, such as that in Manitoba, involves lumpy investments in generation (to exploit scale economies) and transmission (as supply sources are distant from loads). They do not enjoy the beneficial scalability features of solar, wind and natural gas generation.
  - This leads to long-term cyclical pressures on rates. Current customers have benefited from past investments, particularly those that have been largely depreciated, but remain functional. Future customers will need to pay for current projects. The calculus of intergenerational fairness is therefore, at a minimum, complex, and may not lead to unequivocal answers.

Intergenerational Fairness

- Rate-smoothing is a useful tool for promoting inter-generational equity. The projected profile is more in the nature of a step function over six years, followed by a rapid decline to increases close to the rate of inflation.

- A ramped sequence of increases, perhaps linked to a clear demonstration of efficiencies achieved by Manitoba Hydro, may provide a useful framework for promoting internal efficiencies, allowing time to adjust to electricity rates, and distributing costs more equitably over each generation of customers.

Mitigation of Rate Increases

- The effects of the large projected increases, should they be approved, could in theory, be mitigated.
  - Special industrial rates could be offered to those firms with large electricity cost shares. But this would be viewed as inequitable by other customers.
  - Alternatively, the Government might implement incentives to retain major industrial customers.

Mitigation of Rate Increases

- There would be a substantial increase in the number of households facing energy poverty, however it is measured.

- To alleviate this effect will require funds either from other Manitoba Hydro customers, or from Government coffers.

Environmental Considerations

- From the standpoint of carbon emissions, Manitoba's energy sector is very well positioned:
  - 37% of all energy (including the transportation sector) comes from hydraulic sources, and 1% comes from wind generation (recall the Sankey diagram in Figure 3);
  - natural gas provides 26% of total energy, coal a miniscule 0.3%, and the remaining 35% consists of transportation fuels;
  - other jurisdictions are focusing on decarbonizing the electricity sector, but Manitoba has already accomplished this;
  - in total, about 60% of Manitoba energy is from hydrocarbons. Compare this to Canada-wide numbers where about 80% of domestic energy comes from hydrocarbons.

Environmental Considerations

- Increasing energy prices, whether in the electricity sector (for fiscal reasons) or in the natural gas sector (via a carbon tax), may be counter-productive from an environmental perspective.
  - If Manitoba's energy intensive industries decamp to other jurisdictions, the net effect on global emissions is likely to be unfavourable.
  - To put it simply, how many industry-friendly jurisdictions are there with an energy mix as clean as that of Manitoba?
  - Reductions in carbon emissions may make Manitobans feel that they are doing 'their share' with respect to global warming, but it may not be rational unless the 'carbon leakage' problem is solved.

Thank You

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