

**EVALUATING THE DEMAND FOR SITE C and  
THE POTENTIAL FOR MEETING  
FUTURE INCREASES IN DEMAND  
BY CONSERVATION / DEMAND SIDE MANAGEMENT  
INITIATIVES**

Submission to the British Columbia Utilities Commission's  
Inquiry into BC Hydro's Site C Dam Project

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## **1. Introduction**

Over my lifetime, I have undertaken two home projects with an objective of significantly reducing our energy consumption and latterly reducing our CO<sub>2</sub> emissions.

In the first, we built a new home in Winnipeg that was almost three times the size of my previous very modest little home (625 sq. ft.) and reduced our energy consumption by over half and the cost by about two-thirds.

The most recent project is included in this brief as the 9<sup>th</sup> Chapter. Our energy efficiency upgrades to our home have dramatically cut electrical consumption despite moving from oil heat to a high-efficiency electric heat pump, our total electrical use is only 32% of what it once was and our electrical bill has hardly changed, despite a near 50% increase in rates since 2001.

As a young Budget Analyst in Manitoba's Department of Finance, I witnessed the exaggerated demand growth estimates presented by Manitoba Hydro in their annual capital budget submission. Being young at the time and one of the few willing to challenge their estimates, I did not have any success.

At the time, Manitoba was forging ahead with massive power dams with no long-term sales for the new power generated. The dams were as much about economic development as they were to provide needed power. Jobs, jobs, jobs.

The utility became as much a political liability as an asset, with the implementing government going down to defeat with Hydro's financial status being one of the main issues. The added debt obligations without matching or greater sales meant that Manitoba Hydro had several years of financial stresses. The subsequent government considered selling part of a dam to an aluminum producer as a way to reduce financial pressures and create a new heavily subsidized industry for Manitoba.

A few years later, as an MLA, I pressed as hard as I could to ensure that firm long-term export sales were in place before my government proceeded with the 1,100 MW Limestone Generating Station. The delays involved in this process turned out to be doubly beneficial as when Manitoba put the project out to bid, there was a dearth of mega projects worldwide and the bids came in dramatically lower than had been estimated some 4 or five years previously. It was a good reminder that costs don't always go up.

## 2. Executive Summary

Intelligent demand management via effective province-wide home energy efficiency upgrades can free up or “supply” as much electricity as Site C will generate.

BC’s domestic demand growth does not warrant such a gamble as Site C. BC Hydro has continuously over-estimated demand and is not creditable.

American electricity demand has been stagnant for a decade. BC Hydro’s traditional export markets in the Pacific NW does not exist, especially at the price Site C’s power will cost to generate.

Site C’s cost to complete the project is very unpredictable and in any case, even the current “official” estimate, is too high to be economically viable. BC Hydro’s experience with cost overruns does not add faith to their estimates. No other Canadian utility has been able to deliver massive dam projects at a cost that even come close to projections for a decade or more.

Pursuing an active program to replace inefficient space heating in homes in BC will have no net costs to BC Hydro and free up as much electricity as Site C will generate, and more reliably as no shutdown or maintenance time is required by BC Hydro. And no new transmission lines are required.

This initiative would not put any participants out-of-pocket, as the value of energy savings will pay off the homeowners energy efficiency upgrade loans.

As many if not many more jobs will be created with this energy efficiency initiative than with Site C. These are quality jobs and would last for a decade or more as the program continues. What’s more, they would be where our population lives, in our communities not in a remote work camp.

BC Hydro’s debt obligations would be less (estimated cost of \$6 billion if 80% of BC’s estimated 370,00 single family detached homes heated with electricity participated at \$20,000 per home) relatively short term (15-25 years).

BC Hydro would not have to assume the risks associated with extremely long-term debt obligations and the renewal provisions that are inevitably part of such long-term (70 year) debt obligations.

Site C will jeopardize the financial viability of and already debt stressed BC Hydro. It is not worth the risk.

### 3. Energy Demand in BC – Current trends and future demands

Demand for electricity in BC has been stagnant for some time. In fact, 2016's demand (49,421 GWh) essentially equals the demand (49,450 GWh) in 2005.

Since 2005, we've had 6 years with slight growth in demand and 5 years with declines in demand. Three of the most recent four years have produced declines in production for net decline of 1%.

And this has been achieved with Hydro only giving lip service to energy conservation as Power Smart has been de-emphasized. If BC Hydro proactively promoted and facilitated major energy conservation measures like replacing baseboard heaters with high efficiency heat pumps, the declines in demand would have been substantial.

While BC Hydro jumps at the chance to show electrical demand is growing when there is a short spike<sup>1</sup>, they ignore the fact that demand is actually falling year on year on average and do not prominently display historic demand (at least not that I have been able to find on their web site in areas that one would expect to find the data<sup>2</sup>.)

The trend in electrical consumption is down, not up. Every time we replace a light bulb, we save some 90% of the energy the old one consumed. Replace an old appliance with a new one and saving can be 30% to 80%. Today's laptops use a small fraction of energy needed to power desktops, especially older ones.

Industry is making similar gains. Forbes magazine<sup>3</sup> ran an article earlier this year showing how energy consumption and GDP are decoupling and have been for some 30 years in countries like Japan. To be competitive, smart commercial and industrial firms are putting energy efficiency near the top of their strategies to reduce operating costs and reduce GHG emissions. New equipment and processes in various mills is much more energy efficient than those they are replacing. Aluminium producers know that aluminium is essentially canned electricity so reducing energy demand increases their competitiveness. Big data firms and Internet companies with thousands of servers are demanding more efficient computers and building renewable electricity sources into their energy supply lines, including massive roofs lined with solar panels.

There is no need for new construction, be it residential or commercial to have significant electrical demands for heating and air-conditioning or lighting. Net Zero or near net zero homes are not only within current design and construction parameters, but will pay for themselves in relatively short periods of time. Same goes for commercial buildings. Our passive solar home we built in 1986 only cost about

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<sup>1</sup> <https://www.youtube.com/watch?v=0nLzGp5fe0s>

<sup>2</sup> [https://www.bchydro.com/energy-in-bc/our\\_system.html](https://www.bchydro.com/energy-in-bc/our_system.html)

<sup>3</sup> <https://www.forbes.com/sites/williampentland/2016/03/29/the-radical-implications-of-declining-u-s-electricity-consumption/#2eb6676d18d4>

4% more than standard construction, which paid for itself in just a few years. Our current homes heat pump retrofit will pay for itself in 7- 10 years.

To reduce future electricity demand, the province and municipalities can use their regulatory authority to demand new construction meet the now practical and much higher energy efficiency standards. For example, baseboard heaters and electric furnaces should be banned, just like water guzzling toilets were a decade or so ago. It should require solar panels to be included in the construction of new commercial, industrial and residential buildings. Elon Musk's Tesla Solar Roofs are now in production<sup>4</sup> and have the benefit of an extremely long life, many times a conventional roof's life expectancy (they have a house-lifetime guarantee, not your lifetime!), and a roof that will generate electricity and cash for its owner throughout the home's existence.

Taking this kind of bold action would have substantial benefits to other aspects of BC's economy. With regulatory requirements like this in place, combined with the initiative I propose in Chapter 6, BC would be an attractive place for manufactures of high efficiency products like heat pumps and solar cells and roofs to build facilities in BC which would be a welcome boost to the manufacturing sector of BC's economy.

Years ago, my contract with Winnipeg Hydro stipulated that at peak-demand hours, Hydro could cut the electrical supply to my hot water tank if system demand pressured the supply capacity. They did that via a signal sent through the power lines. I never ran out of hot water, because my morning supply was heated during the low demand hours at night and in off-peak hours during the day. Re-implementing old technology like that would eliminate fears over peak demand.

In Chapter 8, I will demonstrate how a relatively straightforward initiative by BC Hydro and the province could save some 5,550 GWh of electricity used to heat homes in BC, more than Site C will generate.

Some proponents of Site C claim it will be needed if we move to electric cars in the future. This is not justified. Here are some calculations that show how 60% of BC's cars and light trucks could be fuelled by the energy freed up in converting homes with electric baseboard heaters and electric furnaces to high efficiency heat pumps. Attaining that ratio of electric cars in 15-20 years would be a real challenge without new legislation and regulations.

Average Energy demand for electric car = 19 kWh/100 km or 0.19kWh/km

Average distance driven per year in Canada = 15,336 km. (BC likely drives less)

kWh to drive 15,336 km. = 2,914 kWh

Number of cars & light trucks in BC in 2016 = 2,901,758 , 66% = 1,914,320

GWh of electricity to power 1,914,320 cars 15,336 km. each = 5.578 GWh

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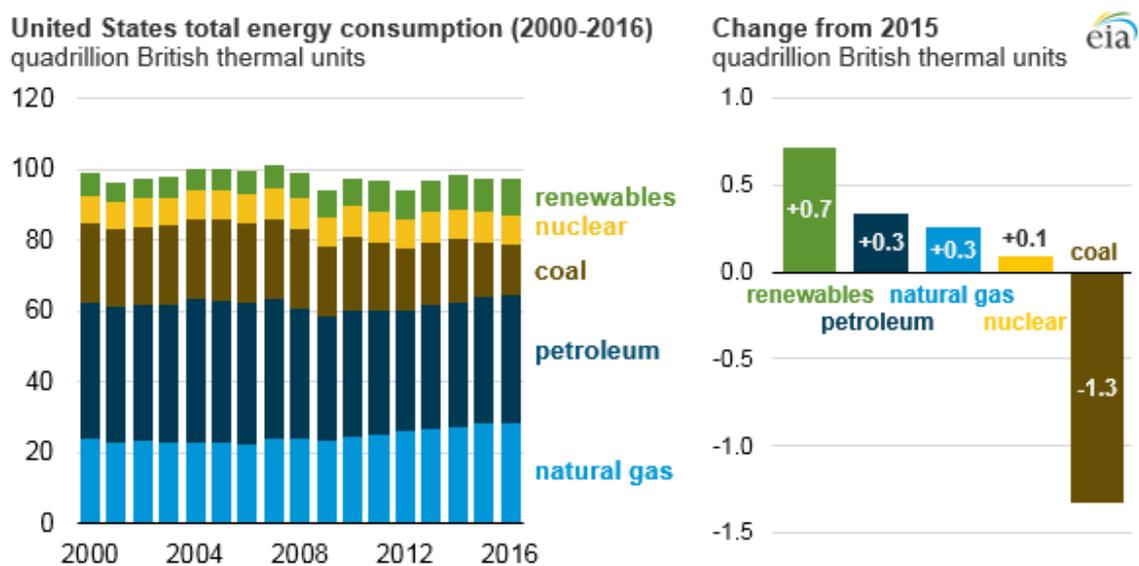
<sup>4</sup> [https://www.tesla.com/en\\_CA/solarroof](https://www.tesla.com/en_CA/solarroof)

This is essentially the same amount of electricity that would be saved by converting baseboard heaters and electric furnaces in single detached and duplexes to high efficiency heat pumps.

In addition, it is not unusual for owners of electric vehicles to install their own solar panels. This may not appear to make a lot of sense economically in terms of electricity usage at first, but when you consider the cost savings in vehicle fuel, the panels will pay for themselves in a few years and then give the owner essentially free transportation energy.

#### 4. Energy Demand in BC Hydro's markets in the USA

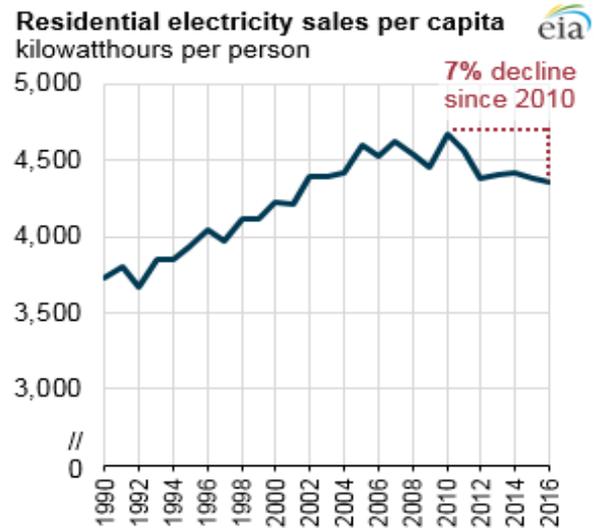
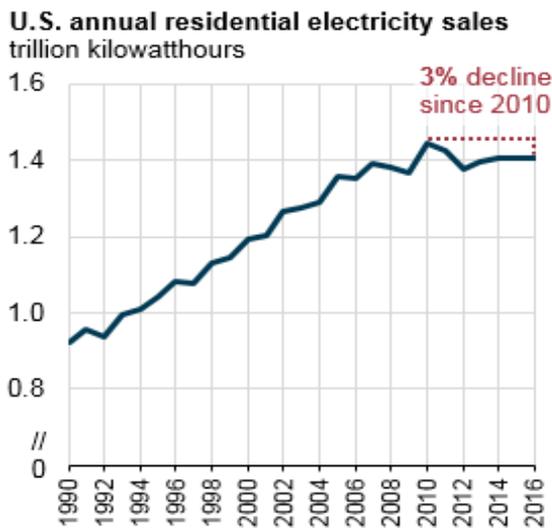
Like BC, American electricity consumption has been falling most years since 2007<sup>5</sup>.



The US Energy Information Administration further reported on July 27, 2017 that the residential demand in the USA is falling both in absolute (-3%) terms and per capita (-7%) consumption<sup>6</sup>.

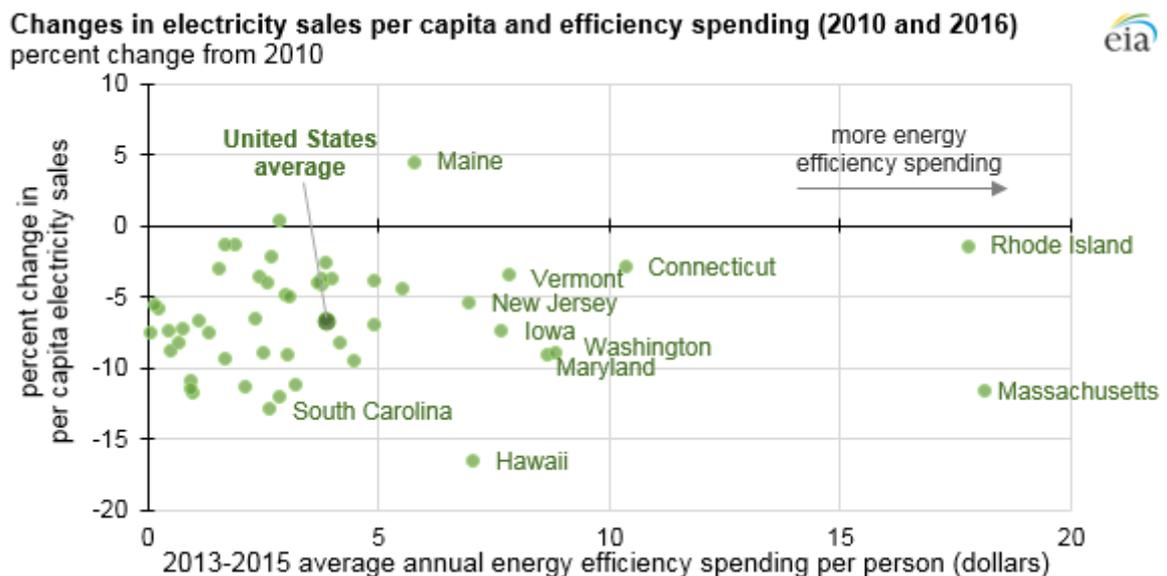
<sup>5</sup> <https://www.eia.gov/todayinenergy/images/2017.04.05/main.png>

<sup>6</sup> <https://www.eia.gov/todayinenergy/detail.php?id=32212>



They note that these declines are due to two factors, lowered Heating Degree Days with as much as 10% fewer HDD's in some states (due to Global Warming) and more efficient electrical appliances and lighting.

Of particular interest is how electrical demand has fallen in states that have invested more in energy efficiency measures.<sup>7</sup>



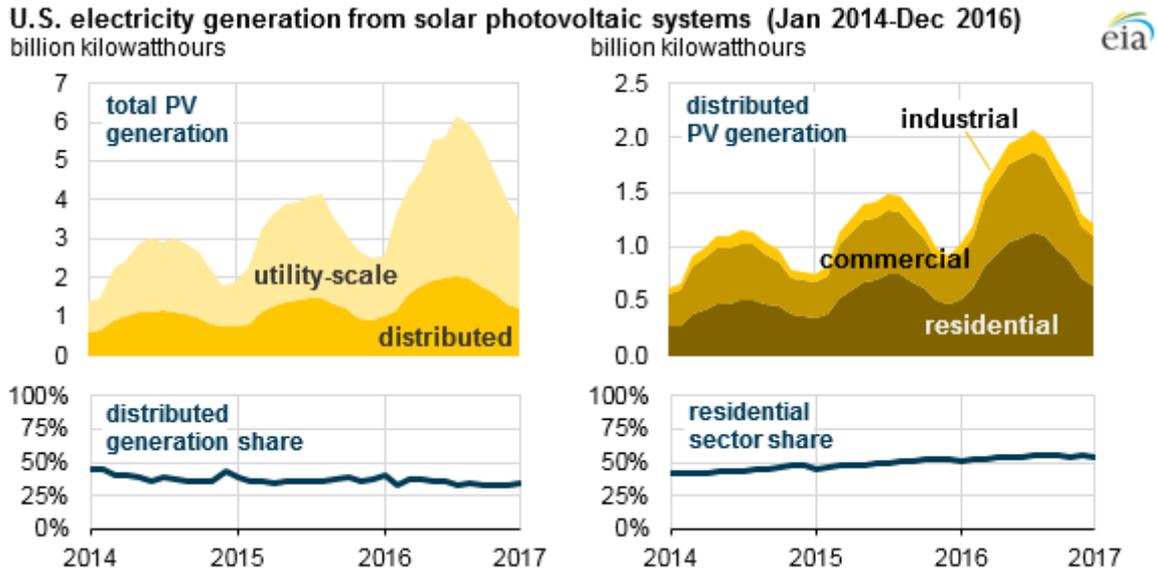
Looking at BC's export market, the USA NW, both Washington and Oregon States are net exporters of electricity and are expected to continue to be so.

California's electrical demand has been stagnant for several years and it is the state with the fastest growth in renewables, especially Solar PV. It is possible that this increase in home-generated electricity will lessen future grid demand and may well alter the mix of sales as California's significant hydro resources are increasingly used as batteries storing water to generating power when the sun is not shining and to complement gas powered facilities to meet peak demand hours.

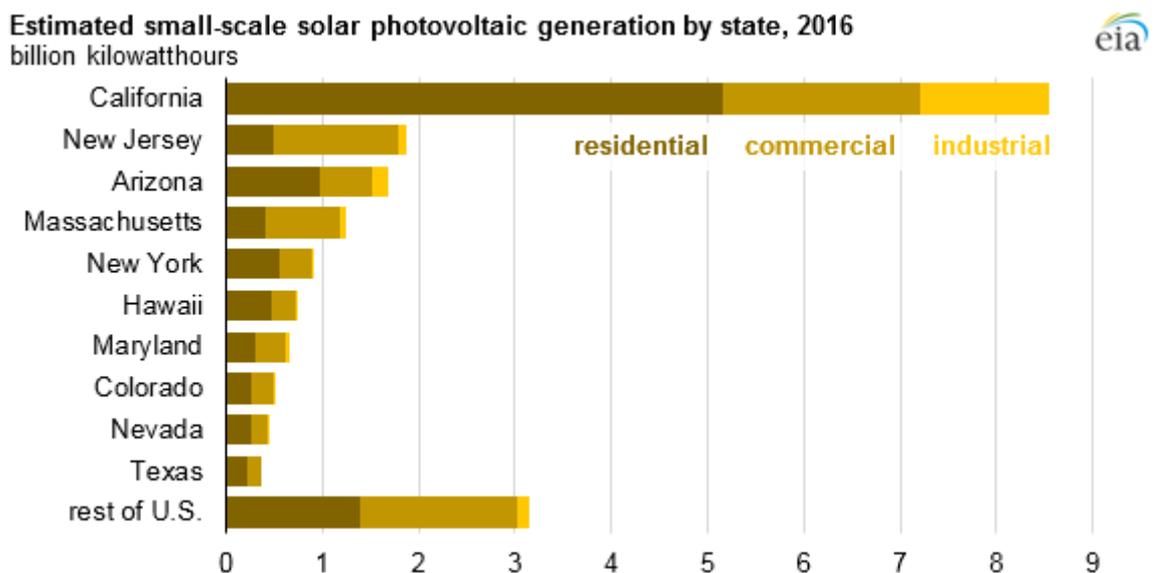
<sup>7</sup> *ibid.*

Their Peak ISO demand has fluctuated slightly since 2007 and 2016's 46,232 MW was similar to 2007's 48,615 MW and well below the 2005 peak of 50,270 MW.<sup>8</sup>

Small scale PV, primarily household roofs, now comprises over half of the solar PV generation in California.<sup>9</sup>



California leads the USA in small scale Solar PV generation and it seems to be growing exponentially<sup>10</sup>.



<sup>8</sup> <https://www.eia.gov/todayinenergy/detail.php?id=31452>

<sup>9</sup> <https://www.eia.gov/todayinenergy/detail.php?id=31452>

<sup>10</sup> <https://www.eia.gov/todayinenergy/detail.php?id=31452>

The May 2017 retail price of electricity in BC's US market was as follows:

Washington State	\$.0968/kWh
Oregon State	\$.1086/kWh
California	\$.1829/kWh

Site C's 2014 projected cost to generate electricity based on a construction cost of \$8.335 billion was about \$8.3/kWh not including sunk costs. Today, with Hydro's cost estimates up over \$9 billion and with independent experts predictions of costs as high as \$12 billion based on difficulties with the current construction contract (feuding partners), geologic uncertainties and the massive cost overruns in other Canadian hydro mega projects plus transmission infrastructure costs, it is not beyond reason to estimate the eventual cost in the range of \$.12/kWh.

Who's going to pay \$.12/kWh wholesale or that power? That is the current retail residential rate for Step 2 in BC, way over BC's Hydro's Large Service General rate of \$.055/kWh.

It is above the retail rates in Washington and Oregon. It appears competitive to California wholesale rates, but California's slow demand growth rate and rapid expansion of solar and wind power could mean there is not the market there either.

How much will BC Hydro lose on each kWh generated from Site C?

And, for how long?

## **5. Cost of Site C**

A cost estimate produced during the 2007 feasibility study placed the financial cost at a maximum of C\$6.6 billion based on the 1981 design, safety, and engineering standards. An updated cost projection was released in May 2011 placing the estimated cost at \$7.9 billion, which was revised to \$8.3 billion in 2014. This does not include the cost of a high voltage transmission lines to major population centres, estimated to be in the range of \$743 million additional, bringing the total estimated cost to approximately \$9 billion. Some experts have stated that the costs may reach as high as \$11 to 12 billion<sup>11</sup>.

Currently the prime contractors are suing one another for not meeting the terms of their partnership agreement. From what I can understand, the contractors have never undertaken such a large project in the past, and in particular a massive hydro project. This does not build confidence.

The BCUC must reappraise the cost estimates of the project with a critical eye to give the public any confidence that the project we are collectively financing is viable. Will it be Hydro's future or its millstone?

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<sup>11</sup> [https://en.wikipedia.org/wiki/Site\\_C\\_dam](https://en.wikipedia.org/wiki/Site_C_dam)

## **6. Cost-Free Supply Equivalent to Site C via Energy Efficiency Initiatives**

Using the energy savings we have achieved in our home and extrapolating the savings possible in converting existing homes with electric baseboard heaters and electric furnaces, I have shown that it is possible for free up as much electricity demand as Site C will produce (see Section 8).

A high efficiency heat pump (and only high efficiency units should qualify as they consume much less electricity) will only consume about 25-35% of the electricity of a resistance heater (baseboard or electrical furnace) in coastal BC and the lower-mainland where the vast majority of our homes are. In the Southern Interior, the efficiency will not be much less.

It is in BC Hydro's and the public's interest for BC Hydro to manage a program to replace baseboard heaters and electric furnaces with high-efficiency heat pumps.

BC Hydro would borrow the money and lend it to homeowners to do prescribed energy efficiency upgrades and install high efficiency heat pumps at rates high enough for Hydro to cover its financing and administration costs.

Homeowners would continue to pay their pre-renovation energy costs until the loan is paid off. The difference between their pre-energy efficiency upgrades and their actual post renovation demand costs would pay off the loan over time. I estimate that most loans would be about 10-12 years duration with some as much as 20 years.

Homeowners could choose to finance it themselves like we did, and get instant savings. Those who choose to use the program should be able to make lump-sum payments to their outstanding energy efficiency loans with no penalty to speed up the loan repayment and thus realize the lower energy costs sooner.

Consideration should be given to requiring the outstanding loans to be repaid on the sale of the subject home, as this would significantly reduce Hydro's debt repayment schedule both in terms of money and time as homes turnover at a fair pace.

The financing program should be incorporated into BC Hydro's billing system so that consumption savings can be illustrated and the customer can see both their energy savings and the amount of their loan that is outstanding and what their payments would be once the renovation loan is paid-off.

Stats Canada identifies 847,120 single detached homes in BC<sup>12</sup>. In terms of GJ of energy, it is estimated that 44% (370,000) of homes in BC are heated by electricity, the vast majority of them with baseboard heaters and electric furnaces. With an optimistic 80% participation rate, this would mean some 296,000 single detached homes. At \$20,000 of renovations per house, this would mean a total financing requirement of \$5.9 billion. This would not be up-front requirements, but spread over time, likely a decade or more. Hopefully it would be faster and with some federal and provincial initiatives for low-income households, it could be quicker.

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<sup>12</sup> <http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/famil55c-eng.htm>

This should not cost BC Hydro a dime in net costs and would create more jobs than Site C, and those jobs will be in existing communities, not some far off temporary construction camp that is a magnet for drug pushers. Using our home as an example, we had two to three HVAC techs for 2 days, 2 electricians for a total of about one day, a sheet metal worker for a day at the house and a day or more in the shop. Converting that to person years, it creates .044 person-years of work and with 296,000 homes, this produces some 13,000 person-years of employment.

This will be much healthier for the economies of communities across the province as the money invested will be in each of those communities. The electrical, sheet metal, HVAC, and home renovation trades will have a huge boost. In fact, it would be difficult finding all the trades people necessitating a significant expansion in training in these and related fields.

For Hydro, it would mean an average homeowner loan of perhaps \$20,000 with 12-15 years of financing. I would expect it to take 10 years or so to achieve 80% compliance, which would stretch Hydro's loan requirement of 20 to 25 years compared to 70 years of much higher borrowing requirements with Site C. This would dramatically reduce Hydro's long-term debt risk.

## 7. BC Hydro's Rising Debt and Financial Risk

Governments of all stripes have used BC Hydro as a cash cow since its inception. WAC Bennett transferred much of BC's debt to the new utility when established, infamously burning BC's debt papers on a barge in on Lake Okanagan. It could be said that he set a bad precedent.

Over time, BC Hydro has been used to reduce provincial deficits and even produce so called surpluses by forcing BC Hydro to declare huge "dividends" to the province. From what I understand, BC Hydro has had to borrow money to pay those dividends.

By 2014, BC Hydro had paid \$5.2 billion in "dividends" to the Government of BC since 1992, 60% of which was borrowed<sup>13</sup>. And the pace of dividends has not lessened:<sup>14</sup>

2014/15	\$588 million in dividends	
2015/16	\$653 million	"
2016/17	\$693 million	"
2017/18	\$707 million	"

BC Hydro's Debt has risen steadily.

When one includes the BC Liberals recently created (fanciful accounting) deferral accounts and the massive future obligations for IPP contracts, analysts have surmised

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<sup>13</sup>

<http://www.vancouversun.com/news/Hydro+paid+most+dividends+using+borrowed+cash/10723965/story.html>

<sup>14</sup> [http://bcbudget.gov.bc.ca/2015/bfp/2015\\_budget\\_and\\_fiscal\\_plan.pdf](http://bcbudget.gov.bc.ca/2015/bfp/2015_budget_and_fiscal_plan.pdf)

that the BC Liberals increased Hydro's debt obligations by 1337% since 2005. The breakdown is as follows:

BC Hydro Long Term Debt (shown on Financial Statements)	\$18 Billion
Deferred Accounts	\$ 5.9 Billion
Long Term IPP Contracts	<u>\$56.3</u> Billion
Total	\$80.2 Billion

Site C and ongoing projects will push the Long Term Debt to some \$30 billion in another 6 or 7 years.

Will BC Hydro still be viable with Site C?

Today's (Aug. 30<sup>th</sup>) Globe & Mail reports on economist and Newfoundland's former head of Newfoundland & Labrador's public utilities regulator David Vardy warning BC not to repeat the Muskrat Falls fiasco, where costs have doubled and the project is simply not viable and threatens the financial stability of the province.<sup>15</sup>

To multiply BC Hydro's problems, there are the massive IPP contracts noted above.

The BCUC must examine the IPP contracts to see if they were entered into in good faith on behalf of the province, where there was any fraud or abuse of public trust and to identify the legal consequences of cancelling the contracts and perhaps legislative options to get Hydro and the Province of BC out of most of these contracts.

## **8. Copy of Home Energy Study**

To illustrate the potential of energy conservation as a source of supply, I am finishing with a copy of my recently completed study of the impact of various energy upgrades on our home. Rather than adding it as an attachment, I have included it as Chapter 8. It is self-explanatory.

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<sup>15</sup> <https://beta.theglobeandmail.com/news/british-columbia/muskrat-falls-experience-a-warning-for-site-c-dam-project-expert-says/article36123404/?ref=http://www.theglobeandmail.com&>

# **Energy Enhancements and Switching from Oil Furnace to High Efficiency Heat Pump Cuts CO<sub>2</sub> Emissions by 90%(-5,015 kg) Saving BC Home Over \$1,500 Annually**

## ***Executive Summary***<sup>16</sup>

Energy related improvements we have undertaken have cut our home's annual carbon emissions by at least 90%. Our annual costs have tumbled 64%, despite the price of electricity increasing by about 50% since 2000.

Individual families can make dramatic reductions in their home's carbon emissions and easily save significant amounts of money now and into the future. This is not rocket science, but it does require addressing easily identified factors and solving them in a co-ordinated way.

Energy consumption is affected by a number of factors. The primary factors that contributed to our reduction of energy and CO<sub>2</sub> emissions were:

- Replacing our oil furnace with a high efficiency heat pump
- Reducing heat loss by replacing single pane windows with good quality double-pane windows, increasing our insulation levels in the basement and replacing 2 of our 3 wooden doors with insulated doors with much improved seals which, with the new windows, reduced air leakage.
- Gradually replacing our old electrical appliances and incandescent lights with much more efficient appliances and LED lighting.
- The number and age of people living in the house
- The length and depth of the cold seasons in Heating Degree Days (HDD's)

Together, these factors dramatically reduced our annual carbon emissions by at least 90%.

The heat pump's financial payback, depending upon price assumptions and replacement options, ranges from 5.7 years to 11 years. This implies a return on investment of between 6.5% and 13%, much better than one can get on most investments, and this return is virtually guaranteed.

By counting carbon as carefully as we count dollars, citizens make sounder investments, save lots of money, dramatically reduce our homes' carbon emissions and reduce electricity demand on BC Hydro. If enough of us do this, the measures we take will contribute to significantly reducing electricity demand by more than Site C's capacity, and freeing up enough electricity to electrify two thirds of BC's cars. More critically, we will reduce our own greenhouse gas (GHG) emissions that are forcing global temperatures rapidly upwards and presenting near impossible challenges for our children and future generations.

### ***Background***

While attending a forum on global warming and energy in 2012 hosted by the Pacific Institute for Climate Solutions (PICS)<sup>17</sup>, I commented on the significant reduction energy consumption and CO<sub>2</sub> emissions we experienced at our home following the installation of a high-efficiency heat pump. Hearing this, then PICS Director Dr. Thomas Pedersen asked me

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<sup>16</sup> For Public Policy Recommendations, see page 7

<sup>17</sup> <http://pics.uvic.ca>

to produce a short paper on our experience. This paper<sup>18</sup> is the result. The scope has been expanded to include operating costs, lifecycle CO<sub>2</sub> emissions and a section making public policy recommendations including a Hydro facilitated program to encourage more homeowners to replace oil and natural gas furnaces and electric baseboard heaters and furnaces with high efficiency heat pumps. Federal energy use researchers at NRCan have noted that it is rare to have this degree of actual household experience both prior to and after the installation of various energy related home improvements. I hope you find the study useful.

Our 1967 built home was heated with a forced-air oil furnace until 2010. We do not have a natural gas line to the house. Virtually all other energy consumed<sup>19</sup> is electricity, including our domestic hot water, which is heated in a 170-litre tank and is our second largest electricity consumer. On December 16, 2010, we replaced the oil furnace with the highest efficiency electric powered heat pump we could find that was compatible with the existing air ducts system used to distribute heated air throughout the house.

We looked at various systems by both North American and foreign manufacturers. Choosing a comparable wholly North American manufacturer would have cost more, meant a less efficient unit and required \$3500 to upgrade our 100 AMP electrical panel to a 200 AMP panel. However, with low ampere demand of the Mitsubishi Zuba Central heat pump (Mr. SLIM) and its internal air handler<sup>20</sup>, both 220-volt units with highly efficient variable speed DC fan motors, our existing 100 AMP panel was sufficient with the addition of new 220 lines to both units at a cost of \$1200.

The Zuba Central's advanced technology allows it to work down to -30°C (COP<sup>21</sup> = 1.2). Therefore it is still very efficient at coastal British Columbia's winter temperatures (COP = 3.4 @ +5° C, COP = 2.6 @ 0° C, COP = 2.1 @ -5°C, & COP = 1.8 @ -15° C), whereas most NA manufacturers' heat pumps don't function efficiently below 0° C, requiring a cold weather supplement (resistance coils [COP = 1.0] or gas/oil furnace [COP = .80 to .95] when outside temperatures dip below freezing. The one NA manufacturer's premier unit with DC motors would have cost about \$1,000 more. I asked a couple of third party commercial technicians with extensive experience installing many brands of heat pumps to compare them. They told me there was no comparison. They said the Mitsubishi is way more efficient, much quieter, had superior reliability, less maintenance and worked at much lower temperatures. Only Mitsubishi approved trained technicians are allowed to install them.

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<sup>18</sup> This paper updates the original and subsequent editions to Dec 31, 2016 and includes 17 years of data, 2000-2016. The author may be contacted at [donaldscott@telus.net](mailto:donaldscott@telus.net)

<sup>19</sup> For complete disclosure, we have two fireplaces, one with an occasionally used high efficiency wood-insert stove, which was installed in Feb. 2007 for emergency use after a two-day winter power outage in 2006. The other fireplace is strictly decorative and blocked with insulation as it loses more inside warm air up the chimney than it produces in heat when used. We also use our propane BBQ occasionally, generally less than a tank (20 lbs.) per year.

<sup>20</sup> Heat pump made in Japan. Air Handler made in Grenada, Mississippi by Advanced Distributor Products. At 7 years, the only maintenance on our Zuba Central has been bi-annual inspections and air filter replacements.

<sup>21</sup> Coefficient Of Performance – Ratio of heat output per unit of energy input. A COP of 3.5 provides 3.5 units of heat for each unit of energy consumed (i.e. 1 kWh consumed would provide 3.5 kWh equivalent heat output). For reference, a baseboard heater or electric furnace's COP is 1.0.

We anticipated that converting to the heat pump would significantly increase our electricity consumption, probably in the vicinity of 3,000 – 4,000 kWh annually, which at 2010 Tier 2 electricity rates of \$.0878/kWh, would cost between \$265 and \$350 annually. That would still yield an annual savings of \$900 to \$1,250 compared to heating with oil at 2010 prices.

### ***Energy Consumption Over Time***

With energy consumption records kept since moving into our 1967-built split-level 1900 square foot (2400 ft<sup>2</sup> incl. heated basement, 2x4 walls with R7 insulation) home in 1994, one can observe changes to our fuel oil and electricity consumption over time. This allows us to measure the impact of upgrades such as replacing the oil furnace with our heat pump and upgrading windows, doors, basement insulation, appliances and lighting. From this energy consumption data, we can also calculate our CO<sub>2</sub> emissions annually and measure the impact the changes have had on reducing our carbon footprint.

Chart 1 depicts our home's energy consumption in megajoules (MJ)<sup>22</sup>. Using megajoules allows one to illustrate the energy consumed in both fuel oil and electricity in a common unit of measure. The vertical red columns represent the energy in the fuel oil consumed and the vertical blue columns represent the electrical energy consumed. The columns are stacked to illustrate total energy consumed each year. The MJ's consumed are depicted in the left hand scale.

The horizontal black line shows the dramatic reduction in CO<sub>2</sub> emissions due to the drop in energy usage with the scale on the right measuring the CO<sub>2</sub> emissions in kilograms.

Chart 1

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<sup>22</sup> The **joule** (symbol: J) is a **derived unit** of **energy** in the **International System of Units**.<sup>[1]</sup> It is equal to the energy transferred to (or **work** done on) an object when a **force** of one **newton** acts on that object in the direction of its motion through a distance of one **metre** (1 newton metre or N · m). It is also the energy dissipated as heat when an electric **current** of one **ampere** passes through a **resistance** of one **ohm** for one second. A Mega Joule is 1,000,000 joules. For comparison, 1 GJ = 30 litres of gasoline or 2 standard BBQ propane tanks.

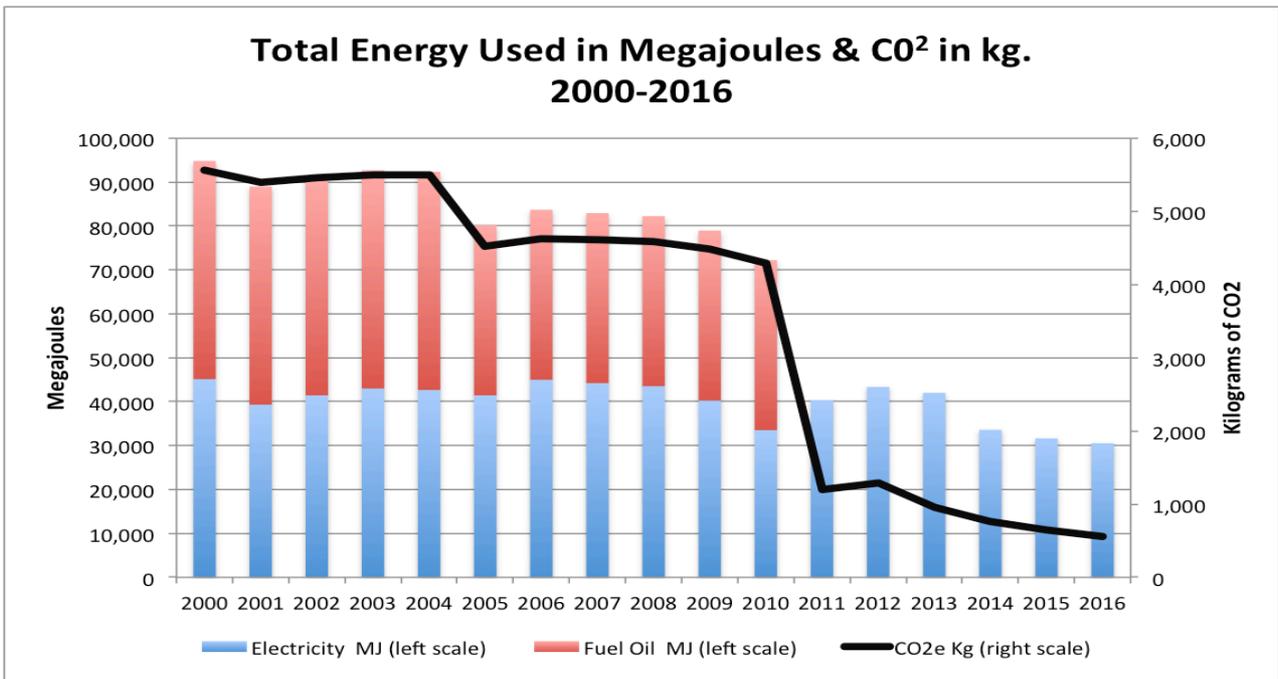


Chart 2 depicts our home’s energy consumption & emissions in more familiar terms: fuel oil (red) in liters, electricity (blue) in kWh, CO<sub>2</sub> emissions in kg, with Heating Degree Days (green) in HDD<sup>23</sup> added to give year-to-year comparisons of the severity of each year’s heating season.

The left hand scale measures quantities of electricity (in kWh), fuel oil (in litres) and CO<sub>2</sub> (in kg.)

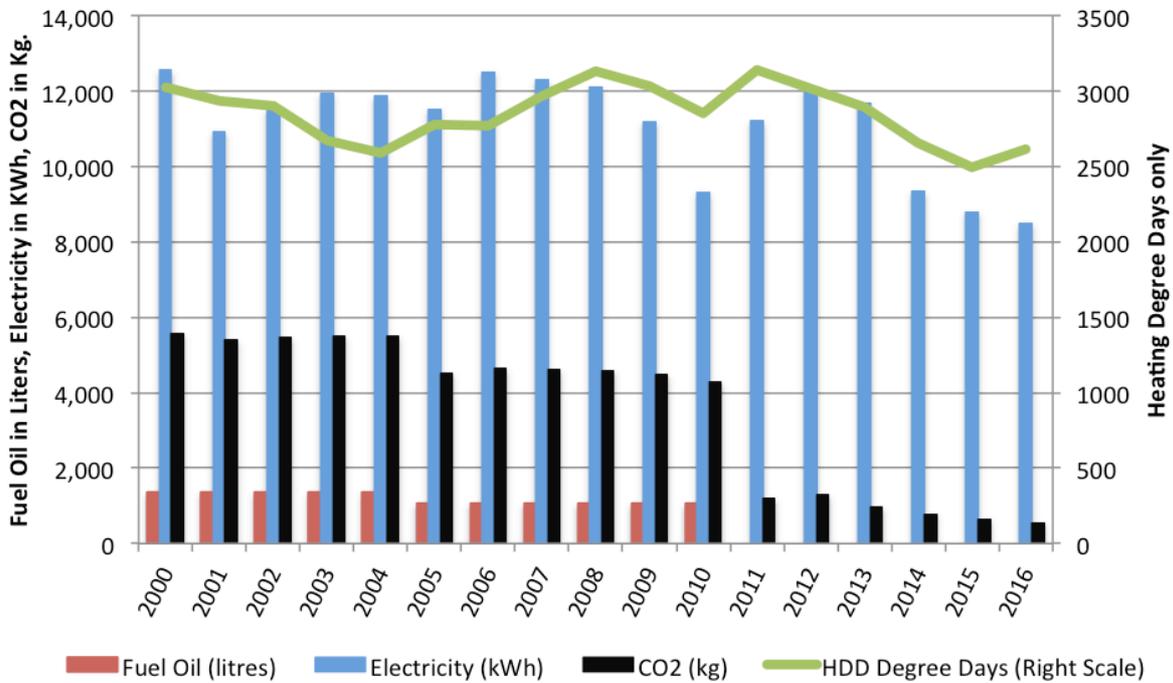
The right hand scale applies only the Heating Degree Days horizontal green zigzaging line.

Chart 2

<sup>23</sup> Heating Degree Days - a measure of heating demand. I have set calculator for 18° C outside air temperature as below that requires home heating. E.g. a day at 10° C would be an 8 degree-day, a temp. of 0° C would be an 18 degree-day.)

[http://www.weatherdatadepot.com/?pi\\_ad\\_id=8426228665&gclid=CKfX9uOg-7QCFQ\\_hQgodG1MAdw](http://www.weatherdatadepot.com/?pi_ad_id=8426228665&gclid=CKfX9uOg-7QCFQ_hQgodG1MAdw)

## Home Consumption of Electricity in kWh, Fuel Oil in litres & CO2 generated in kg. with Heating Degrees Days in HDD 2000-2016



Average annual fuel oil consumption<sup>24</sup> dropped 23% after we replaced all our aluminum framed single-pane windows with high quality dual pane vinyl windows in February 2005<sup>25</sup>. From 2005 to December 2010 average annual fuel oil consumption fell 300 litres from (1,353 to 1,054 litres) which reduced CO<sub>2</sub> emissions by an average of 963 kg. per year. At the 2008 price of \$1.24/litre, replacing the windows saved us approximately \$375 annually in fuel oil costs. Besides cost savings, the home became quieter, less draughty and much more comfortable. As with kitchen upgrades, cost recovery is not always one's sole consideration.

In 2011, our first full year with the heat pump, we consumed 11,207 kWh of electricity (see Table 1 on page 12), approximately 1,900 kWh more than in 2010 (when heating with oil). This was much less of an increase than the 3,000 – 4,000 kWh we anticipated with the heat pump. 2010<sup>26</sup> was a mild year with only 2,848 HDD compared to 3,036 HDD in 2009 and 3,136 HDD in 2011 which should have increased kWh usage more.

<sup>24</sup> Because the fuel oil tank was not filled in the same month each year, and not at all in 2010, I have averaged fuel consumption for the two periods 2000-2004 (actually average of 1995-2004) and 2005-2010.

<sup>25</sup> Windows made locally by The Vinyl Window Company of Saanichton, BC and installed by them. Vinyl windows on the local market differ substantially in quality.

<sup>26</sup> In 2010, electrical consumption slid 1,876 kWh below 2009 due primarily to the reduction of 188 HDD, a long bare basement wall insulated to R22 in 2009 and our 3 daughters being away from home for half the year.

In March 2011 we raised the insulation level in the basement to R-26 from R-12 on two walls (one was insulated to R22 in 2009 - the fourth wall is not insulated as it abuts the on-slab two-story part of the house so is not an exterior wall). In 2011 we also replaced two of three exterior wood doors with insulated steel doors and new doorframes with much better seals to reduce heat loss.

In 2012, electricity consumption increased by 841 kWh to 12,048 kWh which was similar to 2008. The HDD of 3,018 was back at 2008 and 2009 levels and we had at least 2 college age daughters at home all year.

Since 2012, despite heating the home with electricity alone, we're using much less electricity than we did before installing the heat pump. In 2013 we became mostly empty nesters, but as we are now both retired, we keep the house warmer during the day than when we were away at work. 2014's electrical consumption matched the 2010 low with only 9,333 kWh hours. HDD was down near 2010 levels and we only had one daughter at home for 8 months and two for 3 months.

Our energy consumption continues to fall, with both 2015 and 2016 well below 9,000 kWh. In 2016 our electricity consumption hit a record low of 8,486 kWh. This is 4,015 kWh (-32%) less than 2006's 12,501 kWh – despite heating with electricity instead of oil!

Other factors that have contributed to reducing energy consumption have been replacing appliances [fridge (2004 & 2009), freezer (2004 and 2012), dishwasher (1999), top-load washer and dryer with front-load units (2002)] and our household lights with LED or florescent lights. Each of these appliances/lights consumes dramatically less energy than the units they replaced. Given our reduction in kWh, could it be possible that the heat pump is not using any more electricity than the oil burner motor and AC fan on the old oil furnace?

### ***CO<sub>2</sub> Emissions Since 2000***

Looking at CO<sub>2</sub> emissions for the past 15 years, our 2016 CO<sub>2</sub> emissions (514 kg.) are some 4930 kg. (-90%) below our 2000-2004 annual average (5,485 kg.) and 3,968 kg (-80%) less than the 2005-2010 average (4522 kg.) prior to installation of the heat pump but after upgrading windows. The biggest factor was replacing the oil furnace with the Mitsubishi Zuba Central heat pump.

The CO<sub>2</sub> calculations are based on our past fuel oil consumption and on the lifecycle carbon content of power supplied by BC Hydro<sup>27</sup>. The latter is very difficult to ascertain. BC Hydro has three natural gas fired generating stations<sup>28</sup>. Together they represented about 8% of Hydro's generation capacity till 2012 with the Burrard Gas Plant at 950 MW 89% of Hydro's fossil fuel generating capacity. Burrard has been phased-out of operation since 2012 and mothballed in 2016. But Hydro also buys power from Independent Power Producers in BC (some from fossil fuels) and from Alberta and Washington State. Hydro imports cheap night-time surplus fossil fuel fired electricity generated in Alberta (coal and gas) and from the USA

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<sup>27</sup> CO<sub>2</sub> calculations are based on fuel oil at 3.128 kg/litre consumed, Fossil fuel generated electricity at 850 g/kWh and water generated electricity at 24 g/kWh. All are "lifecycle" based emissions.

<sup>28</sup> [https://www.bchydro.com/energy-in-bc/our\\_system/generation/thermal\\_generation.html](https://www.bchydro.com/energy-in-bc/our_system/generation/thermal_generation.html) Burrard is now mothballed.

(primarily hydro and nuclear) to store more water in its reservoirs that is used to generate electricity sold back to Alberta and the USA during the day and summer at higher prices. Hydro states that 92% of its generation is water based<sup>29</sup>, which is true, but generation is not quite the same as sales due to intermittent supply from various sources. To include the changing nature of BC Hydro's supply, I have calculated that 9% of BC Hydro's sold electricity was fossil fuel based until 2012, 7% in 2013 and 2014, 6% in 2015 and 5% in 2106. If one credits BC Hydro for the power exported reducing CO<sub>2</sub> emissions in Alberta and the NW USA, one could argue that Hydro's net CO<sub>2</sub> emissions are lower.

Water generated electricity is also not carbon free because carbon is released in the construction of the dams and the building of transmission lines. Manufacturing one tonne of Portland cement releases one tonne of CO<sub>2</sub><sup>30</sup>. Mining and transporting the gravel used in the making concrete also produces CO<sub>2</sub>. Reinforcing steel produces CO<sub>2</sub> emissions in their manufacturing and transportation to the site and in construction. Earthen dams, common in some BC Hydro reservoirs for power generation stations involve a lot of heavy-duty equipment that emit greenhouse gases. These emissions must also be factored in and are amortized over the life of the plant in calculating CO<sub>2</sub> emissions. Reservoirs release methane from any vegetation and soils that are submerged so that must be considered. This is not an easy aspect to calculate so I have reviewed a IPCC<sup>31</sup> study that notes the range is generally 4-14 g/kWh but some reservoir outliers were as high as 150 g/kWh. I have also spoken with an expert in hydro generation facilities and he notes that for BC, 24 g/Kwh was a reasonable estimate; I have used 24 g/kWh in my calculations. Emissions during operations and maintenance of hydro plants are minimal.

### ***Our Cost of Energy since 2000***

Previous editions of this home energy study have focused on energy use (litres of oil and kWh of electricity) and CO<sub>2</sub> emissions. This was intended to have people focus on counting CO<sub>2</sub> emissions as carefully as we count dollars. However, readers have frequently asked about costs and how much we are paying for energy over time. So I have added Table 2<sup>32</sup> and from that derived Chart 3 illustrating annual costs since 2000 in this update.

Cost is determined by quantity of energy used and the cost per unit of that energy. Both fuel oil and electricity have fluctuated over time: fuel oil was a low of \$.57/litre in 2001 to \$1.29/litre in 2008. The current price in August 2017 is \$1.35.

Hydro prices have been going in one direction, up. Back in 2001 electricity cost \$0.06/kWh but in 2008 BC Hydro introduced graduated rates to promote conservation and increase revenues. When introduced, the Step 1 rate of \$0.591/kWh applied to monthly residential consumption under 710 kWh and the Step 2 rate was \$0.0827/kWh on consumption beyond 710 kWh. Over the years, both rates have risen while Step 2's threshold has lowered. In 2016, Step 1 applied to the first 644 kWh/month and costs \$0.0829 /kWh. Beyond 644kWh, Step 2's rate of \$0.1243/kWh applies. So BC Hydro's base rates have increased 38% since 2000 and Step 2 rates have increased 107% over the single base rate in 2000. With BC

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<sup>29</sup> [www.bchydro.com/energy-in-bc/our\\_system/generation/our\\_facilities.html](http://www.bchydro.com/energy-in-bc/our_system/generation/our_facilities.html)

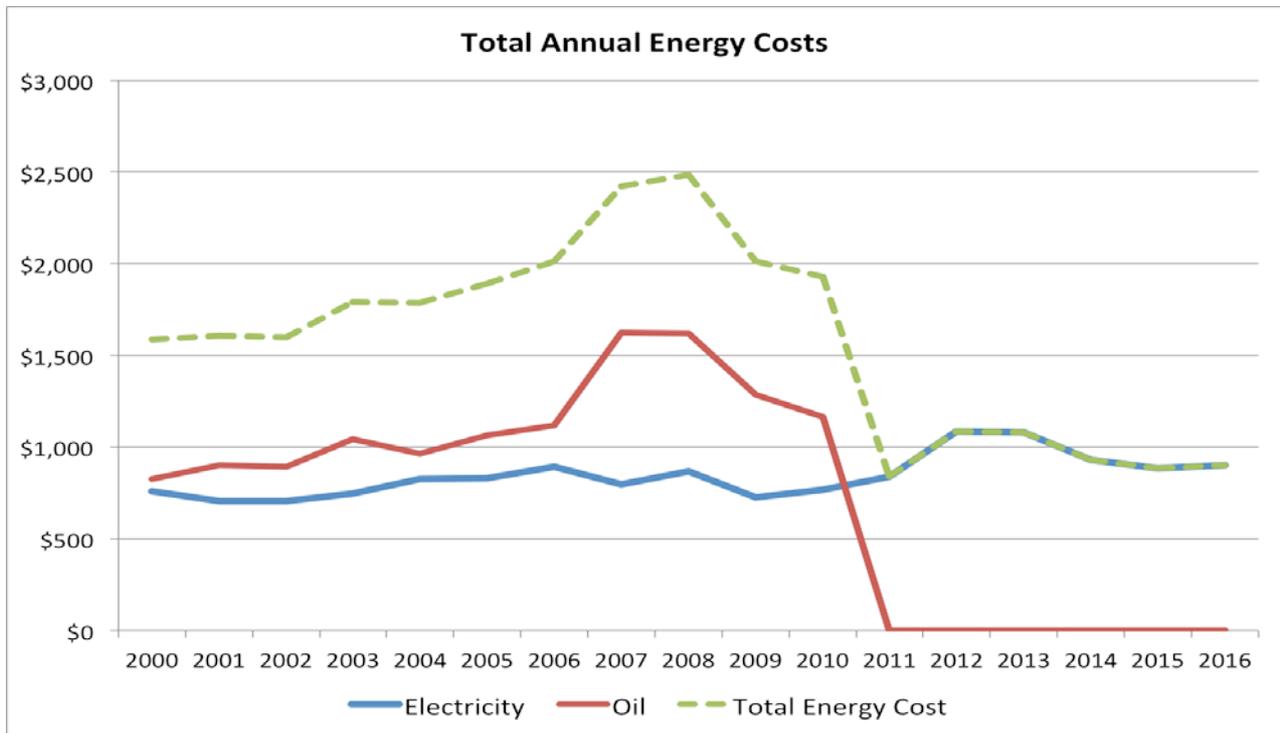
<sup>30</sup> <http://blogs.ei.columbia.edu/2012/05/09/emissions-from-the-cement-industry/>

<sup>31</sup> [http://www.ipcc-wg3.de/report/IPCC\\_SRREN\\_Ch05.pdf](http://www.ipcc-wg3.de/report/IPCC_SRREN_Ch05.pdf)

<sup>32</sup> See Table 2 on page 12

Hydro's escalating debt due to Hydro paying massive dividends to the province and Site C's \$9 billion cost, both rates are scheduled to continue rising.

Chart3



Yet, as Chart 3 and Table 2 illustrate, despite significantly increased Hydro rates, our total energy costs have fallen dramatically. Our total energy costs were \$1,588 in 2000, peaked at \$2,486 in 2008 and are currently only \$901, down 64% from the peak.

### ***Public Policy Recommendations & Conclusions***

Introduce an energy efficiency home improvement program at low interest rates with possible provincial assistance for low-income households. It makes sense for BC Hydro to handle the financing and manage the program, as BC Hydro is a major benefactor of the program and has the base energy data, the collection capacity via its billing system and can borrow at extremely low interest rates.

Participants would repay the loan by continuing to pay their current total energy costs (electricity plus oil and/or natural gas used to heat the house) with the value of energy savings going to pay off their loan. Households would not be out of pocket. Once the loan is paid-off, the full savings accrue to the homeowner in dramatically lower monthly energy charges and payments. If homeowners choose, they could opt to pay up front or if they use the Energy Upgrade Financing, they could make lump-sum payments lowering their principal thus speeding up the loan repayment, without penalty, so they could realize their lower monthly energy charges sooner. Outstanding loans could be recovered on the sale of the subject house. An added benefit for homeowners is that heat pumps can reverse operations during summer months and provide air conditioning, which has been a welcome benefit in the summer of 2017.

The program must include heat loss reduction measures. It makes little sense to put an efficient heat pump in a leaky, poorly insulated home. That's not in Hydro's nor the homeowner's interest.

To achieve projected results, target improvements to reduce energy consumption by at least 60% (and CO<sub>2</sub> emissions by 85% for currently oil and gas heated homes). Include energy audits. Start by reducing heat leakage by replacing leaky windows and doors with EnerGuide approved double or triple-pane windows, insulated doors and hatches with good seals. Insulate attics to R50 and insulate basements and crawl spaces to at least R20. Ceilings are easy and inexpensive to insulate. Upgrade exterior walls where it is cost effective or to increase comfort levels. Target homes to achieve an EnerGuide Rating of 80. With this is achieved, address the heating units.

#### Oil furnace replacement segment

BC's Oil to Heat Pump program (\$1,700 subsidy) is scheduled to expire in 2019 and has had a very low take up due to very little publicity and minimal promotion by the government and none by BC Hydro. Replacing oil furnaces with high efficiency heat pumps that meet the Heating Seasonal Performance Factor (HSPF) 9.0 or higher and function with a COP of at least 1.5 at minus 15 deg. C. SEER should be 15 to minimize air conditioning load.

Enerficiency's<sup>33</sup> study on home heating in BC estimated 4.4% of the energy used to heat homes in BC is fuel oil, consuming some 7.5 million GJ of energy. Replacing oil furnaces with high efficiency heat pumps could eliminate an estimated 210 million liters of fuel oil burned and 650,000 tonnes of CO<sub>2</sub> emissions in BC<sup>34</sup>.

#### Replacing baseboard heaters and electric furnaces

Replacing baseboard heaters and electric furnaces with high efficiency heat pumps will reduce home heating related electrical consumption by 60% to 75%<sup>35</sup>, a reduction in of over 5,500 GWh.

#### Natural Gas heated homes

Enerficiency's 2010 study estimated that natural gas comprises 46% of the energy used to heat BC's homes burning 82 million GJ of natural gas (10 times oil's 7.5 million GJ). At 56 kg/GJ of natural gas this produces 4.5 million tonnes of CO<sub>2</sub> annually. (Note, this is not "lifecycle" emissions, and the US DOE has noted that lifecycle natural gas emissions are dramatically higher due to large fugitive emissions at the wellhead, in processing and transmission. Other independent studies (Purdue<sup>36</sup>) show this to be true and with the new Canadian GHGSat's<sup>37</sup> Claire satellite in operation for the past year, monitoring fugitive emissions is now readily possible.)

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<sup>33</sup> [http://www2.gov.bc.ca/assets/gov/environment/climate-change/stakeholder-support/ceei/resources/residential\\_heat\\_estimates.pdf](http://www2.gov.bc.ca/assets/gov/environment/climate-change/stakeholder-support/ceei/resources/residential_heat_estimates.pdf), page 6

<sup>34</sup> Mike Wilson of Enerficiency (Residential Heating Oil, Propane, and Wood Heat Estimates for BC Communities) estimated 7.5 Million GJ of heating fuel is used for domestic heating. This converts to 210 million liters of fuel oil and 650,000 tonnes of CO<sub>2</sub>

<sup>35</sup> COP = 1 for a baseboard heater or electric furnace. Moving to a high efficiency heat pump increases COP to 2.5 - 3.5 at winter temperatures in Coastal BC, Vancouver Island and the Lower Mainland and for a 55% to 75% saving.

<sup>36</sup> <https://www.desmogblog.com/2017/03/20/natural-gas-power-plants-fracking-methane>

<sup>37</sup> <http://www.ghgsat.com/> [https://www.utias-sfl.net/?page\\_id=1254](https://www.utias-sfl.net/?page_id=1254)

Initially concentrate on older lower efficiency natural gas furnaces (75-80% efficiency), then move on to the higher efficiency units to get emissions down fastest.

Once home heating has been tackled, consider electric domestic hot water heating as air-to-air heat pumps are emerging that may be able to handle that high demand appliance as well. Solar panels can also contribute to hot water heating and reducing system load.

#### Enhancing BC Hydro's capacity by eliminating inefficiency

Energyefficiency's 2010 study<sup>38</sup> estimated that 68 million GJ of electricity is used in residences in BC. Baseboard heaters, electric furnaces and hot water heating (DHW) will consume most of this. BC Hydro's Power Smart Conservation Potential Review – Residential Sector (2007) claimed single family and duplex homes in the Lower Mainland with electric heat used 3,276 kWh for DHW, 9,174 kWh for heating which represented 44% of their total annual usage of 20,970 kWh (note this is over twice our home's kWh consumption.)

At 44% of total electricity consumed being used to heat the house, this equals 30 million GJ across BC. Using an average 67% savings in converting baseboard heaters and electric furnaces to high efficiency heat pumps means a savings of some 20 million GJ of electricity annually. Twenty million GJ converts into 5,550 GWh of electricity<sup>39</sup>.

#### Equivalent to Site C Dam

This is 109% of Site C Dam's projected 5,100 GWh<sup>40</sup> or 70% of the Revelstoke Dam's 7,817 GWh production. Efficiency gains are guaranteed supply, as availability is not dependent upon dam or generator maintenance or low water shutdowns. Once freed up by eliminating inefficient consumption, saved electricity is available forever.

So an aggressive program to convert existing baseboard heaters and electric furnaces starting with single family and duplex residences alone will "free up" more electricity than the controversial, costly and destructive Site C Dam will produce. And this will not cost BC Hydro a dime. Homeowners will pay for it out of their energy cost savings over 7 to 20 years depending on how much energy efficiency upgrading is required. Site C will cost \$9 billion plus the costly burden of very long-term debt.

In terms of jobs, many times more jobs will be generated over the life of this initiative than with Site C and these jobs will be created where most people already live, in their home communities. No expensive remote construction camps are required.

#### Freeing up electricity for electric cars

The 5,550 GWh in energy savings would allow for the replacement of 67% of BC's 2.86 million registered passenger vehicles. An average electric car consumes 19 kWh per 100 km. Canadians, on average drive some 15,336 km per year.

Driving two thirds of BC registered passenger vehicles (1.902 million vehicles) driven the 15,336 km. Canadian average annually at 19 kWh per 100 km would require 2,914 kWh per

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<sup>38</sup> [http://www2.gov.bc.ca/assets/gov/environment/climate-change/stakeholder-support/ceei/resources/residential\\_heat\\_estimates.pdf](http://www2.gov.bc.ca/assets/gov/environment/climate-change/stakeholder-support/ceei/resources/residential_heat_estimates.pdf)

<sup>39</sup> <http://www.translatorscafe.com/unit-converter/en/energy/2-14/#33>

<sup>40</sup> [https://www.bchydro.com/energy-in-bc/projects/site\\_c.html](https://www.bchydro.com/energy-in-bc/projects/site_c.html)

car and 5,578 GWh collectively. This matches the energy savings generated by converting just single-family homes and duplexes with baseboard heaters or electric furnaces in BC to high efficiency heat pumps in the recommended program. Add townhouses, apartments and condos to the program and it might electrify 100% of BC's passenger vehicles.

Dramatically Reducing BC's GHG emissions is not only possible, it is relatively easy

Government estimates that BC emits about 64.5 mega tonnes of CO<sub>2e</sub> annually. Replacing residential oil and natural gas furnaces with high efficiency heat pumps can reduce those emissions by 5.15 MT or 8%. Converting electric furnaces and baseboard heaters with high efficiency heat pumps will free up over 5,500 GJ of electricity, which can be used to heat homes with the oil and natural gas conversions plus allow for the electrification of most of the cars in BC reducing CO<sub>2</sub> emissions by another 4 MT and light trucks by another 5 MT<sup>41</sup>. Combined, this would reduce BC's GHG's by 14.5 MT of CO<sub>2e</sub> or 22% of BC's reported emissions.

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<sup>41</sup> <https://catalogue.data.gov.bc.ca/dataset/british-columbia-greenhouse-gas-emissions/resource/11b1da01-fabc-406c-8b13-91e87f126dec>

## Summary of Operating and Installation costs

### Operating Costs:

Cost of heating with oil (at 2017 price of \$1.25/ litre) 1,055 litres =	\$ 1,320 / year
Cost of heating with Zuba Central Heat Pump (2017)	\$ ~ 200 / yr.
Savings: @ \$1.25/litre of fuel oil	\$ 1,120 / year
Savings: @ \$1.75/litre of fuel oil	\$ 1,450 / year

### Capital cost of heat pump in 2010:

Preliminary Electrical <sup>42</sup> – adding 2x220V lines to 100AMP panel	\$ 1,200
Zuba Central & Installation <sup>43</sup>	\$12,277
Relocating Air handler to increase air flow efficiency	\$ 1,000
HST	\$ 1,593
Government (Canada and BC) Energy efficiency rebates	\$ -1,400
Sale of unused biofuel still in tank	\$ -200
Net Cost with electrical upgrade	\$14,470

### Payback

Straight line: net cost @ \$1.25/ litre: \$14,470/\$1320 =	11.0 years
Straight line net costs @ \$1.75 / litre: \$14,470/\$1845 =	7.8 years
Cost of Zuba over installing a high efficiency gas furnace	\$4,000
Payback over natural gas furnace (\$4000/ est. \$700 ann. saving)	5.7 years

### Subject Home in Victoria BC

Energy Guide Efficiency Ratings – Energy Audits by City Green Solutions

2005	Before new windows = <b>EnerGuide: 61</b>
2005	After windows = <b>EnerGuide 75</b>
2011	Before Zuba, basement insulation and 2 new exterior doors <b>EnerGuide: 67</b> Pre-retrofit Air leakage: 5.46 ACH@50 Pa
2011	After Zuba Central, basement insulation upgrade to R22 & replacing two exterior Wood doors with new insulated steel doors <b>EnerGuide: 82</b> Post-retrofit Air leakage: 4.91 ACH@50 Pa

### Home Energy Efficiency Upgrades – Insulation, Air Tightness & Wood Insert

2005	Replaced all windows with vinyl framed double pane windows <sup>44</sup>	\$10,335
2007	Vermont Castings small Winter Warm wood insert stove <sup>45</sup>	3,200
2009-11	Insulated basement walls to R-22 and 2 new insulated doors <sup>46</sup>	3,962
2011	EnerGuide Testing by City Green / ecoEnergy	<u>168</u>
		\$18,765

<sup>42</sup> Electrical by John & Chris Arnold of CanStar Electric

<sup>43</sup> Installation by Foster Heating & Cooling

<sup>44</sup> Vinyl Window Company

<sup>45</sup> Majestic Mechanical Ltd.

<sup>46</sup> Allegra Mgmt. - Harald Wolf, Roxul rock wool insulation



Subject House



Internal Unit - Zuba Central ADP Air Handler 34,000 BTU



Exterior Zuba Central Unit - Mr Slim 34,000 BTU, HSPF

Table 1 Fuel Oil (l) and Electrical Consumption (kWh), Heating Degree Days and CO<sub>2</sub> emissions 2000-2016

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fuel Oil (litres)	1,353	1,353	1,353	1,353	1,353	1,054	1,054	1,054	1,054	1,054	1,054	0	0	0	0	0	0
Electricity (kWh)	12,540	10,922	11,515	11,945	11,852	11,515	12,501	12,287	12,094	11,186	9,310	11,207	12,048	11,670	9,333	8,791	8,486
HDD Degree Days	3023	2936	2900	2667	2587	2778	2771	2967	3128	3036	2848	3136	3,018	2,889	2655	2494	2614
CO <sub>2</sub> (kg)	5,569	5,397	5,460	5,506	5,496	4,525	4,630	4,607	4,587	4,490	4,290	1,195	1,284	955	764	647	554
HDD source	<a href="http://www.weatherdatadepot.com/?pi_ad_id=8426228665&amp;qclid=CKFX9uOg-7QCFQ_hQqpdG1MAcw">http://www.weatherdatadepot.com/?pi_ad_id=8426228665&amp;qclid=CKFX9uOg-7QCFQ_hQqpdG1MAcw</a>																

All CO<sub>2</sub> calculations use “lifecycle” emissions. Fuel oil produces 3.128 kg. of CO<sub>2</sub> (lifecycle) per litre burned. Coal generated electricity produces 0.909 kg. of CO<sub>2</sub> per kWh generated<sup>47</sup>. Blue Sky’s estimate for Natural Gas CO<sub>2</sub> emissions are 0.465 kg. /kWh, but emerging academic (Purdue U.) and US EPA and DOE estimates of actual GHG’s emitted by fracked Natural Gas production’s fugitive methane leaks and transportation are at least doubling the CO<sub>2</sub> equivalent of Natural Gas so it virtually equals coal. Water generated (hydro) electricity’s lifecycle costs are estimated at 24 g/kWh. Estimates vary depending on the type of dam, climate and the substrate flooded. An IPCC study estimates most hydro at 4 to 14 g/kwh with some as high as 150 g/kWh. E.g. If our electricity consumed is 9% generated by fossil fuels, multiply the total kWh sold by 0.09 and then multiply that result by 850 g (.85 kg, a value recommended between coal and gas) to produce the total CO<sub>2</sub> embedded in the electricity consumed. Adding the CO<sub>2</sub> produced by the fuel oil to the CO<sub>2</sub> embedded in the electricity consumed produces total CO<sub>2</sub> in kilograms.

HDD is determined by setting the calculator at 18 degrees C as we set the thermostat to heat the house when the temperature is 18 deg. C or below.

Table 2	Total Annual Energy Costs																
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Electricity	\$760	\$705	\$706	\$747	\$825	\$828	\$894	\$796	\$868	\$727	\$767	\$840	\$1,085	\$1,082	\$932	\$882.53	\$901.33
Oil	\$828	\$901	\$895	\$1,043	\$963	\$1,064	\$1,119	\$1,625	\$1,618	\$1,287	\$1,162	\$0	\$0	\$0	\$0	\$0	\$0
Total Energy Cost	\$1,588	\$1,606	\$1,601	\$1,790	\$1,788	\$1,892	\$2,013	\$2,421	\$2,486	\$2,014	\$1,929	\$840	\$1,085	\$1,082	\$932	\$883	\$901

<sup>47</sup> <http://blueskymodel.org/kilowatt-hour>