Carmangay Solar Project
Good for Carmangay….Terrible for the Rest of Us

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As reported by Global News on Dec 10 [1], the Village of Carmangay, Alberta has completed "*a solar farm project that will produce nearly 150 kW of power and is expected to save the Village more than $13,000 annually.*" The project, which will produce more than enough electricity for the village (population 261), has been touted as producing "net zero" carbon dioxide emissions. This is a nice project for the people of Carmangay. Unfortunately, Global didn't report the full picture. The rest of the story is that the project is heavily subsidized by the Alberta and federal governments—in other words, by taxpayers and all Alberta electricity consumers ("the Rest of Us"), and that the actual reduction in CO_2 emissions is small and comes at a high cost.

Carmangay's solar energy is much more expensive than electricity from the grid. In a press release on December 8 [2], the Village of Carmangay stated that the total cost of the project was $380,000 and that it will produce 213,765 kilowatt-hours (kWh), or about 214 megawatt-hours (MWh), of direct current electricity per year for an expected project life of 25 years. "Direct Current" or "dc" energy is like the energy you get from a car battery. However, the power grid uses alternating current or "ac" energy like the power in your house. For energy from a solar farm to be compatible with use on the power grid, it must be converted to ac energy. Converting energy to ac energy produces energy losses in the order of 10 percent, so the output of the project is approximately 193 MWh ac. If we make the favourable-to-solar assumptions that there is no performance degradation, no downtime for maintenance, no fixed operating or maintenance costs and no variable operating costs for the life of the project, the total cost of Carmangay's solar energy is equal to the $27,000 annual cost of a 25-year, $380,000 loan at 5%, divided by 193 MWh, or $140/MWh = 14.0 ¢/kWh. By comparison, the average wholesale price in Alberta's competitive electricity market in 2020 was $46.72/MWh = 4.7 ¢/kWh. While this comparison is interesting, it does not tell the full story.

Wind and Solar must be 100% backed up by conventional generation. Alberta's power system must be able to reliably supply customers at all times, and since the annual maximum demand for electricity across the province typically occurs after sunset on cold winter evenings when solar power is not available, we cannot eliminate any of the conventional generation that backstops solar generation. The same reasoning holds true for wind power, as the wind does not always blow during maximum demand periods.

The Carmangay solar project's electricity is seven times more expensive than the gas-fired electricity it is displacing. The fact that wind and solar generation must be 100% backed up by conventional generation means that Carmangay's solar project does not eliminate any of the fixed costs of conventional generation. Moreover, as we retire existing coal plants and add more intermittent and highly variable renewable generation to the grid, the need for flexible and efficient gas-fired generation will only grow. Therefore, the "full story" economic comparison is between the total costs (fixed plus variable) of the solar electricity and the variable costs (only) of the gas-fired electricity that we could be using instead. For example, based on data from the United States Energy Information Administration (EIA) [3], a modern gas-fired combined-cycle power plant (such as the recently completed Shepard plant on the east side of Calgary) burns 6.8 gigajoules (GJ) of natural gas per MWh of electricity produced. At the 2020 average delivered natural gas cost of $2.25/GJ [4], the fuel cost would be $15.30/MWh. Adding the EIA's $3.50/MWh for variable O&M costs, we get a total variable cost of $18.80/MWh or just under 2 ¢/kWh. Thus, solar energy from the Carmangay project at 14 ¢/kWh (see above) is about seven times more expensive than the electricity it is displacing. While proponents of green energy claim that wind and solar are now less expensive than conventional generation, this is simply not true when all costs are considered.

Stated another way, at current pricing, the total cost of power generation from a solar project in Alberta must be considerably less than 2 cents per kWh to be economic.

Wind and solar projects impose other costs on the grid not accounted for here. What about possible savings on transmission or distribution wires costs? No such savings are likely, for three main reasons. First, the cost of the existing wires is essentially fixed, so to the extent the Carmangay project allows the village to avoid wires costs, they must be paid by other Albertans. Renewable generation can sometimes reduce the need for wires, but only in very rare and well-controlled circumstances. Second, additional wires must be built to connect wind and solar projects to the provincial power grid. Third, the variable nature of renewable energy can impose costs on other generators on the grid. More detail on the fact that renewable generators like the Carmangay project will increase the cost of generation, transmission and distribution is a subject for a later post.

Carmangay's solar project is economic for the village because the rest of us are paying most of the cost. The Village's press release states that the solar power system is expected to produce an annual savings of about $13,400 based on 2019 electricity prices, and that grants from a number of federal and provincial sources made the project viable and have reduced the payback period for the Village to between 14 and 15 years. It also states that the payback period will be reduced further when electricity rates climb. But a saving of $13,400 per year for 15 years has a present value of only $139,000 (at a 5% discount rate), which comes nowhere near to covering the original cost of the plant. The remaining $241,000 of capital costs are paid for by the rest of us. Considering Carmangay has a population of 261, this comes to a

subsidy of $920 per person. (A similar subsidy for all Albertans would cost $4 billion.) Regarding the notion that the payback period will be even lower when electricity rates climb, it is notable that the main driver of increased electricity rates in Alberta will be the forced integration of more renewable generation under federal and provincial climate policies.

The cost of the CO_2 emissions reduction far outweighs the environmental benefit. As noted above, the fuel gas saving resulting from the solar project is 6.8 GJ per MWh. The 193 MWh/yr generated by the project will therefore result in a fuel saving of 1,310 GJ per year. The emission rate from natural gas is very close to 0.05 tonnes per GJ [5], so the CO_2 reduction resulting from this solar project amounts to 66 tonnes per year. At an amortized capital cost of $27,000 per year less the variable operating cost saving of the gas turbine ($18.80/MWh x 193 MWh/yr = $3,620 per year), the CO_2 emissions reduction comes at a cost of $350 per tonne (($27,000 - $3,620)/66).

There are several measures of the benefit of reducing CO_2 emissions. The benefit of removing a tonne of CO_2 from the atmosphere is termed the Social Cost of Carbon (SCC). There have been many studies evaluating this benefit with a wide range of outcomes. The average SCC of peer reviewed studies is $39 per tonne [6]. Two other measures for the benefit of removing CO_2 from the atmosphere are the Carbon Tax at $40/tonne (as of April 1, 2021) [7] and the market value of carbon offsets, which are currently trading for $24/tonne [8]. It appears that the cost of the Carmangay Solar Project far outweighs the environmental benefit. The CO_2 emissions and environmental damage resulting from the mining, manufacturing and eventual disposal of the solar panels for this project is significant and must also be considered when evaluating the merits of any solar project.

This is all a very high price to pay so that the Village of Carmangay can boast they are electrically net-zero. They could have made the same claim (and saved the rest of us a lot of money) just buying $24/tonne carbon offsets for a total price of only $1,580/yr, or $22,000 for the 25 year life of the project.

The Carmangay Solar Project makes no sense financially or environmentally. The December 8 press release states that the Village of Carmangay "has taken a major step forward in progressing as an environmentally and financially sustainable municipality." But as we have seen, financially, the solar plant produces electricity that is much more expensive than electricity produced by efficient gas-fired power plants and is only viable because of grants, subsidies, and other forms of taxpayer and ratepayer support. Environmentally, the benefit of Carmangay achieving an electrically net zero status is far outweighed by the cost, and is not in any way sustainable. So, while the project may appear to be environmentally and financially sustainable for the village, it is not sustainable for Albertans collectively.

The Carmangay solar project may be good for the people of Carmangay, but it is terrible for the rest of us. And these facts represent the rest of the story, which was not reported by the media.

SOURCES

[1] Global News Village of Carmangay the latest in Southern Alberta to harness solar power

[2] villageofcarmangay.ca Village of Carmangay Becomes Electrically Net Zero

[3] United States Energy Information Administration: *Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2020,* Table 1. Downloaded from https://www.eia.gov/outlooks/aeo/assumptions/pdf/table_8.2.pdf on January 4, 2021. The table cites a heat rate of 6431 Btu/kWh, which equals 6.8 GJ/MWh, for a single-shaft combined-cycle unit. It also cites US$2.54/MWh, or about C$3.50/MWh, as a variable O&M charge.

[4] GasAlbertaInc. *Intra-Alberta Cost of Natural Gas - Wtd Avg for 2020*. http://gasalberta.com/gas-market/gas-rates-in-alberta The delivered price of natural gas to an individual consumer in Alberta is a contractually negotiated price which will vary from this weighted average.

[5] United States Energy Information Administration: *Cost and Performance Summary Table*, Table 2 from the last column, row 8, 117 lb/mmBtu = 53.07kg/1.0551 GJ = 50.3 kg/GJ = 0.053 t/GJ The number depends on the exact composition of the gas. For pure methane the value is 49.4 kg/GJ https://www.eia.gov/analysis/studies/powerplants/capitalcost/pdf/capital_cost_AEO2020.pdf

[6] *Estimates of the Social Cost of Carbon: A Review Based on Meta-Analysis*. In the Abstract - Main Findings point ii) The estimated SCC ranges from -$13.36 to $2,386$/tCO_2, with a mean value of 30.78$/t$CO_2$ with a PRTP at 3% in peer-reviewed studies. The mean value of $30.78 is in USD which converts to $39/tonne CDN at a conversion rate of 1.27. https://www.sciencedirect.com/science/article/abs/pii/S0959652618334589

[7] The Federal Government plan is to raise CO_2 taxes from the current $30/tonne to $40/tonne as of April 1, 2021 to $170/tonne by 2030. The Alberta Court of Appeal has declared the federal carbon tax unconstitutional and is awaiting a decision from the Supreme Court of Canada. Carbon Taxes and Rebates Explained

[8] A carbon offset is a credit for emissions reductions given to one party that can be sold to another party to compensate for its emissions. Carbon offsets are bought and sold through international brokers, online retailers and trading platforms. Less (https://www.less.ca/en-ca/flights.cfm?auid=ac) is one of these companies that provide CSA Standard-Certified Canadian Offsets for $20.00/tonne, and the Gold Standard-Certified International Offsets for $24.00/tonne (Jan 5, 2021 pricing).