CASE STUDY

Solar panels boost business case for electrifying multi-unit low-rise housing

Solar photovoltaic (PV) systems can improve building resilience, balance electricity demand when well-integrated with the electrical grid, and enable high-performance buildings to reach a net-zero-energy target. Solar PV can also improve the business case for energy retrofits. This case study illustrates how integrating solar PV can improve the business case for retrofitting a low-rise multi-unit residential building (MURB) in B.C.

The analysis concludes that integrating solar PV into the building retrofit could generate a net positive cashflow of $3,100 within the first year of operation and accelerate capital payback of the mechanical systems. For further details, see our solar PV primer and watch our Solar Panels and Deep Retrofits webinar at www.pembina.org/event/solar-panels-deep-retrofits.


Photo: Impact Engineering

About the building

The subject building[1] is a low-rise, wood-frame MURB built in 1982. The envelope retrofit will upgrade its performance to Step 2 of B.C.'s Energy Step Code; new electric heat pumps will supply the domestic hot water and heat previously unheated make-up air. The cost analysis presented in this case study is based on the following building systems:

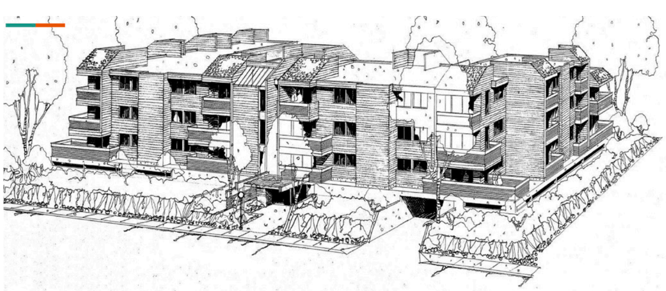
Walls: 2x4 wood-frame with batt insulation and double-glazed vinyl windows, clad with 3" of Roxul and vinyl siding

Roof: modified bitumen built-up roof including 5" of polyisocyanurate insulation

Space heating: existing electric baseboards

Ventilation: three roof-mounted heat pumps (COP 3.5); door undercuts and continuous washroom fans

Domestic hot water: six heat pumps (COP 4) with four 120-gallon storage tanks



The subject building is a low-rise, wood-frame MURB built in 1982. Left: before retrofit; right: after retrofit

Electrifying without solar

Installing electric heat pumps for ventilation and domestic hot water systems will save 1,300 GJ of natural gas and 65 tonnes of CO_2e annually relative to installing equivalent natural gas solutions, but will increase the capital expenditure. Table 1 shows a breakdown of the incremental cost difference between the two options.

Table 1. Comparing retrofit options

	Natural gas solution	Electric solution	Incremental cost between gas and electric options
Ventilation	$228,000	$267,000	$39,000
Domestic hot water	$64,000	$131,000	$67,000
Total mechanical upgrade	$292,000	$398,000	$106,000

The retrofit nets a utility savings of approximately $3,000. In addition, the building owner applies an internal carbon price of $120/t CO_2e saved, which returns approximately $10,000 in annual carbon savings and a simple payback period of about 10 years.[2] The following analysis illustrates how solar further improves this business case.

Electrifying with solar

For this study, the mechanical retrofit designer engaged a solar PV designer to estimate the potential cost benefits of introducing solar to the retrofit solution, which was not originally included in the retrofit scope of work.

Advanced software and lidar were used to create a 3D model of the site, including all shade points (trees, and all equipment on the roof including stacks). A typical weather year was calculated based on 30 years of historic data, and hour-by-hour annual sun path calculations were used to develop an irradiance map for every point on the roof. The designer determined that the large flat roof has excellent solar potential despite having some shading. With the goal of achieving net-zero energy for the common areas, the proposed system layout includes 360 solar PV panels on the roof and a solar awning (which also provides passive cooling), generating 137,000 kWh per year.

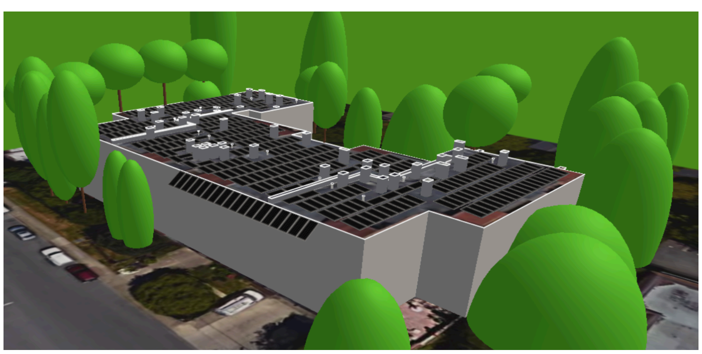
On a site like this one, the cost for solar PV is estimated at $1.85 per watt installed. Based on total cost of ownership and utility savings over a 30-year lifetime, the levelized cost of electricity produced is estimated at 10¢/kWh.[3]

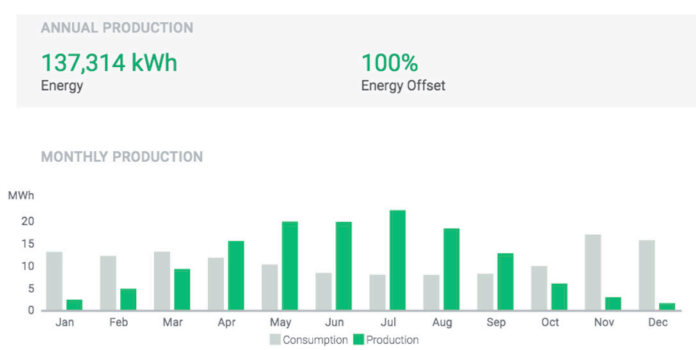
Electrification of the domestic hot water and heating the make-up air supply is projected to double the cost of electricity for the building owner. This increased electricity demand also means that the electricity generated by the panels will displace a larger portion of Tier 2 electricity, making the business case even stronger.

Integrating solar PV into this retrofit at this site would offset 100% of the post-retrofit electricity demand for ventilation and domestic hot water at a cost of $266,400. The solar PV system would be paid back after 12 years and accelerate payback of the mechanical equipment incremental costs by about four years. Alternatively, if the system were financed at today's low interest rates amortized over 25 years, it could generate a net positive cash flow of $3,100 in the first year of operation.[4]

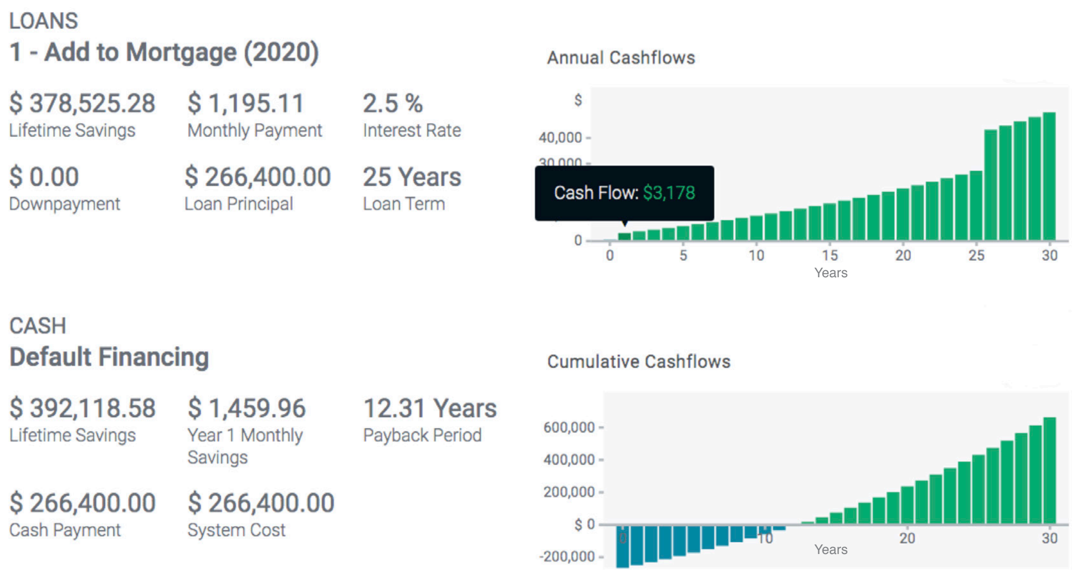
Table 2. Net zero with solar summary

Electricity generated	137,000 kWh/y
Electricity savings	$17,500/y
Without financing	12-year simple payback
Year 1 net cash flow with financing	$3,100 at 2.5% over 25 years





Model of solar installation and year 1 performance projections by Penfolds Roofing & Solar



Source: Penfolds Roofing & Solar

Top:
Cashflow projected if solar installation is financed

Bottom:
Cashflow projected if solar installation is paid up front, in full

Key takeaways

1. Low-rise MURBs can offer a positive business case for solar PV installations, especially when:
   - They have large roofs with few protrusions
   - Site conditions maximize production (e.g. minimum shading)
   - Their existing electrical panel is sufficient to carry the load (as is typically the case for MURBs).
2. A positive business case for solar PV can in turn support a positive business case for electrification of heating systems. Where electrification pushes building energy demand into Tier 2 electricity pricing, solar could help keep rates within Tier 1.
3. Combining energy efficiency upgrades with solar PV can unlock additional financial benefits through synergies such as:
   - Reducing installation costs by integrating solar PV into the installation of a new roof assembly, for either anchored or ballasted systems
   - Minimizing insurance complications by combining roofing and PV system installation services
   - Optimizing system sizes by co-ordinating the mechanical and solar equipment design and layout, which could facilitate reaching net zero.

Endnotes

1. Project details and mechanical retrofit design provided by Impact Engineering. Envelope upgrade details and cost estimates are not included in this analysis.
2. Without the carbon price, the incremental cost of electrification would have a simple payback period of about 34 years.
3. Levelized cost of electricity is calculated by dividing the net present value (NPV) of costs by the NPV of electricity produced over the system lifetime. Modelling of electricity costs takes into account B.C.'s stepped rate — the model estimates a blended rate based on how much electricity is charged at Tier 1 (9.35¢/kWh) and Tier 2 (14.03¢/kWh) rates.
4. Based on annual estimated savings of $17,520, a 4.3% escalation rate (BC Hydro average from 1973 to 2013), a 0.7% degradation rate, and a 2.5% interest rate. NPV (assuming a 2% discount rate and 25-year lifetime) is $378,500. Solar power production estimates by Penfolds Roofing & Solar are considered accurate to 1.8%.

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