CONSUMER GUIDE

BC HOUSING
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Solar Photovoltaic Systems for Multi-Unit Residential Buildings

Solar photovoltaic (PV) system prices have come down considerably now making the savings and benefits affordable for many building owners.

Low and mid-rise multi-unit residential buildings (MURBs) typically have larger roofing areas for the installation of a PV system, and the energy benefits may offset a good portion of the buildings' common electricity consumption. High-rise buildings on the other hand, typically have a smaller roof area, and greater common area electricity use. Although PV systems may still be installed on these buildings, a smaller portion of the electricity can be captured to offset consumption. Greater savings may be identified by updating lighting to Light Emitting Diodes (LED) lamps, mandatory timers on gas fire places and close management and adjustment of heating, ventilation and air conditioning systems.

If you live in a strata property in B.C., there are a number of decisions your community must make before you can proceed. The installation of a PV system is an optional expenditure of funds and the change in use or appearance of the common property, the cost for the installation, and possible alterations for cabling will require your strata community approval. If you live in a Bare Land Strata in B.C., check your bylaws and registered building schemes before you change a strata lot or building.

To get your solar project started, it is important to assess and communicate the costs and benefits of going solar.

This guide, produced by BC Housing, was prepared by Remi Charron Consulting Services in partnership with the Condominium Homeowners Association (CHOA). Special recognition to Central Park condominium complex for providing the background research information.

If you are a solar champion ready to start considering solar for your building, this guide will provide you with comprehensive information for each step of the process.

To help demonstrate the guiding principles outlined in this guide, details from a Case Study are presented as an example.

Ballasted PV system installed on flat roof

Is Your Building Right for Solar?

- Will the roof need to be replaced in the short to medium term?
- Are there large sections of the roof that are unshaded for most of the year?
- Is one of the condo owners or council members championing the project? Having a resident who acts as the primary advocate for the project will ensure that everyone involved understands the value of installing solar. Council support is also necessary for any project to go forward.
- Is the building's roof covered by a warranty? If so, verify how a solar system could be installed without voiding the warranty.
- Are we located in a geographic zone with sufficient annual sun hours?

Solar Equipment

- Do the selected solar modules come with a 25 year product warranty?
- Does the inverter(s) and other project components come with a product warranty?

CASE STUDY

In the spring of 2015, a solar photovoltaic (PV) system was installed on the flat roof at the Central Park condominium building in Victoria. The 14.7 kW system is projected to reduce the common area electricity costs for the strata corporation by one third, or $2,100 per year. The funding of $47,000 for the project was approved from the strata corporation contingency reserve fund (CRF).

Building Suitability

The first step in evaluating the potential for a PV solar system is to assess if your building is a good candidate.

SOLAR ACCESS

Most low to mid-rise buildings in B.C. are located in medium density zoning areas where the roof is unlikely to be shaded by a neighbouring high-rise, and many are tall enough that the roof is not shaded by trees.
The performance of PV systems is significantly impacted when there is shade on the PV modules from adjacent buildings, mountains or trees. Even having a few modules shaded can impact the performance of the whole system. Before deciding to install a PV system on your roof, the first step is to examine if and how much the roof is currently shaded, or whether it is expected to be shaded in the foreseeable future by recently planted trees or future neighbouring developments.

If a large section of the roof is unshaded, continue with your analysis of whether PV solar is right for your building. If most of the roof is shaded throughout the year, it is unlikely that your building is a good candidate for a solar system. In situations where there is some shading, you can proceed with caution, understanding a shading assessment must be completed by a solar design professional to determine the estimated impact of the shading on the output of a PV system.

Contractor Selection

- Does the contractor have experience in working with strata corporations and roofing consultants?
- Can the contractor provide references for previous completed solar projects?
- What is the contractor's knowledge of zoning, electrical requirements and codes?
- Does the contractor provide a warranty for the labour/ installation? What about maintenance service?
- Will the contractor help apply for any potential rebates with the utility?
- Will the contractor provide a comparison showing the estimated electrical cost savings to operate your new PV system and how this compares with the estimated project cost?
- Is the contractor properly licensed, insured for liability and registered with WorkSafe BC?
- How long have they been in business?
- Have you researched the contractor with the Better Business Bureau to be sure you are dealing with a reputable company?
- Does the scope of work include labour, materials, lifts required, permitting and connection costs?

ROOF CONDITION

Given that PV systems may last 25 or more years, it is possible that the roof will need to be replaced during the life of the PV system. In a system with low financial return, the added cost of removing and reinstalling a solar system can mean the difference between a positive and negative return on investment.

If you expect the roof will need to be replaced within the lifetime of the solar PV system, the cost of removing and reinstalling panels should be factored into the economic analysis of the PV system. The most economically beneficial period to install a PV solar system is at the same time a new roof is installed. The construction and warranties can be managed simultaneously with the lowest cost and risk.

ROOF WARRANTY

If the building has a roof that is still under warranty, contact the warranty provider and a qualified roofing consultant to determine the requirements of installation without damaging the roof or voiding your warranty. While a roof-mounted PV system should not increase the rate of wear of a roof (and might actually decrease it because it offers some protection from weather), penetrations through the roof membrane to fasten the system to structural elements may result in leaks.

Installation Approach

Solar PV systems may be installed on a roof using two different methods:

1. a mounting structure that is firmly attached to the building with penetrations through the roof, or
2. a ballasted set-up that does not penetrate the roof (limited to flat roof installations)

The choice of racking (installation method) will depend on a number of factors.

Roof-penetrating racking will anchor the system to the roof using screws or bolts that pass through the roof and attach to internal structures, such as rafters. Ballasted racking systems use weights to secure the PV panels to the roof, meaning few to no roof penetrations will be required. Ballasted racking is only possible on flat roofs.

Each option has advantages in different circumstances, which can be discussed with your solar contractor.

Once a solar system is installed, it can reduce wear and tear on a roof because it protects the roof from the sun, weather and elements. Regardless of the racking, your contractor's structural engineer will likely want to look at structural drawings and schematics of the roof to ensure it can carry the load of a solar system. Having these ready for a contractor will be a big help.

Central Park Victoria used a ballasted system, where the modules were mounted at a lower-than-optimal,

10-degree, slope to limit wind uplift forces. Modelling showed that the system would generate roughly nine percent less electricity than if it was mounted with a 45-degree slope. However, the ballasted system was simpler and cheaper to install, and significantly reduced the risk of future roof leaks. Adding an extra five PV modules would make up for the lower anticipated production from the reduced slope.

System Sizing

There are several factors that help determine the overall size of the PV system:

- Is the installation affordable? What will it cost the property owner?
- How many PV modules will fit on the designated roof area?
- How much electricity should be generated based on electricity consumption and utility rates?
- How will the system be metered?

Grid-Connected Systems

The great majority of PV systems being installed today are grid-connected systems with no battery back-up. These systems will not produce electricity when utility power is not available to your building (i.e. during a power outage). This auto-disconnect feature is to protect the safety of utility line crews that may be working to repair the electrical distribution system. Adding a battery backup system that would allow the PV system to keep operating during a power outage is possible, but it adds complexity and cost. Once the system is operational, retrofitting the system later to add battery storage may be an option.

Location of Inverter

PV systems generate direct current (DC) electricity and require an inverter to generate grid compatible alternating current (AC). Typically inverters are located close to the main electrical panel and utility meter.

Some inverters are designed to be able to be installed outside. At both the proposal and design stages, it is important to consider the proposed location of inverters, in relation to the main electrical panel. If the inverter is to be mounted indoors, as much as 5 to 10% of the generated electricity can be lost as waste heat at the inverter, so ventilation may be required to prevent excessive temperatures.

Alternatively, each PV module may be fitted with its own micro-inverter eliminating the need for one large inverter and minimizing the impacts of shading on the performance of the overall PV array.

PV System Costs

The cost of PV systems continues to decrease every year. Discussions with a number of installers in the Vancouver area indicated the costs for a system in 2017 would be in the range of $3,000 to $4,000 per kW of PV module. Each kW of PV will generate roughly 1,100 kWh of electricity per year depending on climate and design of your system. If the PV system is offsetting your electricity consumption, and you pay $0.12/kWh, each $3,000 to $4,000 invested will save roughly $130/year in electricity costs. At these rates, the systems will pay for themselves over their life, but will not generate a significant return.

The 14.7 kW PV system at Central Park cost $43,350 plus GST, as well as an additional $754 standard fee for the electrical permit and $400 for the structural engineering analysis.

The electricity savings from the project were estimated to be roughly $2,100, or $25 to $39 per year, per unit. Although this is a modest return on investment, the owners were confident that the total cost of the system — under $1,000 per unit — would make each unit worth at least $1,000 more or make them easier to sell. The small cost per unit also encouraged owners who wanted to contribute to GHG reductions.

New York City Multifamily Solar Guide

Research has shown that people are up to 200% more likely to go solar if their neighbors have gone solar. Even if no buildings in your immediate vicinity have solar installed, one of the most effective ways of building support is to talk to residents of other multifamily buildings who have.

Gauge the Interest of Other Owners

As discussed, given that a PV system is not part of the existing infrastructure, and that it is not a required upgrade, the expense must be approved by the owners. In B.C., installing a PV system is an optional expenditure of funds. Before you proceed with a PV project, the first step is to establish whether your community will be willing to support the changes and the cost. A council member or project leader within your community is essential to coordinate communication with the owners to determine their level of support.

Survey whether the owners will support the concept of putting solar on the building. When discussing solar with fellow residents, it is important to clearly lay out the potential benefits of solar:

- An investment that provides savings over time
- A hedge against rising electricity costs
- A way to make the building “greener” and more marketable

If your community is enthusiastic, move on to the next step.

If there is sufficient support for the idea, share it with the strata council. Get PV solar on the meeting agenda to explain the opportunity for solar and the interest of other owners. Obtain approval from council to seek out a solar contractor and roofing consultant to perform a preliminary assessment of your building.

Solar Contractor & Roofing Consultant

A solar contractor is essential to conduct a preliminary assessment of your building’s potential for a PV system. The roofing consultant will assess the condition of your roof, life expectancy, and conditions for installation. When you are conducting routine roofing inspections for maintenance, it is a timely opportunity to have your roofing consultant provide information on future installation of PV solar installations.

The solar contractor will assess technical issues such as shading, roof condition, and permitting. They also estimate the size of the system you may install, the estimated cost, annual electricity generation, and associated utility cost savings.

Although a solar contractor is likely providing free advice to you at this stage, you will be developing a relationship, and your experience will help determine if you want this contractor to ultimately design and install your solar project. Consider the following when you look for this contractor:

- Previous experience in commercial building or multi-unit building installations
- Previous installation experience in your local area
- Knowledge of local codes and bylaws

Having a solar installer who understands the unique circumstances of condominium solar projects will give you support throughout the process and access to the information you need.

Evaluate Legal Issues

Before your strata corporation proceeds, the project will require the approval of the owners at a general meeting. The ¾ vote resolutions for approval must include the following:

- Approval of any significant changes in use or appearance of the common property

- The approval for funding for the installation and,
- The purchase of any assets over $1,000

If there are areas of the roofing intended for a PV system that are allocated within the boundaries of a strata lot or that are designated as Limited Common Property, you may require the consent of the owner(s) before proceeding. It is recommended to have a lawyer review the contracts for the installation and services, any implications to the roofing warranties, and to write the ¾ vote resolutions for the consideration of the owners at a general meeting.

Financing Options

The strata corporation, by ¾ vote at a general meeting, may approve the funding for any of the following options:

- Expense from the contingency reserve fund
- Special Levy of the owners, due and collected before the projected commences
- A loan from a financial institution or private lender; however, the cost savings of the solar PV would be quickly consumed by the loan costs

The Central Park strata paid for the installation (capital cost) from their contingency reserve fund and the owners agreed to increase the contribution to the contingency fund to pay back the cost within 5 years. At $9,400 per year, this worked out to about $10 to $15 per month per unit.

Project Approval Checklist

- ☐ Did you survey the owners and determine the level of support for a Solar PV System?
- ☐ Do you have the support of the strata council to investigate the potential for a solar project?
- ☐ Have the benefits of the project been well communicated to the suite owners?
- ☐ Will a representative from a solar company present information on the preliminary system design and expected performance before the vote?

The strata corporation members were successful in approving the project by ¾ vote resolution at their AGM.

Vote on Project

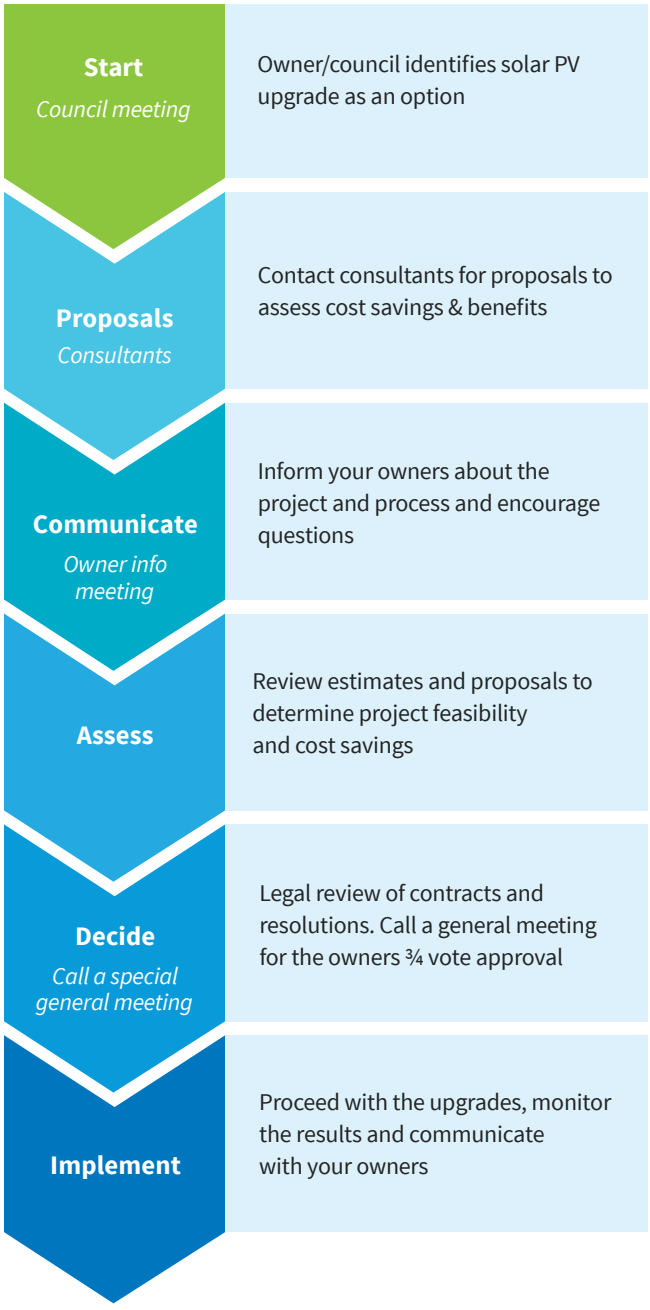
Once the strata council understands the economics of the project and technical questions, schedule a special general meeting or add the item to your annual general meeting agenda to vote on the PV project. An information meeting a week before the voting meeting may be helpful to answer questions from the owners and provide council time to respond to questions.

At Central Park, two information sessions were held for all the residents to learn about the proposed project, ask questions, and give their opinions before putting a motion to a vote. Based on that feedback, the strata council agreed to present the project for a vote by the owners at its Annual General Meeting (AGM).

The strata corporation members were successful in approving the project by ¾ vote resolution at their AGM.

Contractor Selection

If you obtain sufficient votes to proceed with the project, it is now time to get detailed quotes for the design and construction of your PV system. One of the prospective contractors might include the one you worked with earlier during the feasibility phase of the project, additional



proposals by other contractors will also encourage competition and potentially provide other options to installation or products.

When asking for quotes, you should provide prospective bidders with all information gathered to date, but also require the bidders to confirm that this information is correct and that they take responsibility for its accuracy. Providing this level of specification to prospective bidders will help get "apples-to-apples" pricing to compare.

Hiring a Professional Structural Engineer

At Central Park, the strata hired a certified professional structural engineer to assess three key aspects of the structural strength of their roof and proposed PV system:

- Is the roof strong enough to handle the "static load" (the weight of the equipment combined with possible snow, rain, and people)?
- Will the equipment resist "wind uplift" — i.e. will it stay in place during windstorms?
- Will the equipment withstand "seismic acceleration"? In an earthquake, will it slide around and damage other material up there, or will it fall off and hurt someone on the ground?

The engineer's assessment found that the roof and system design met all these structural considerations.

Your roofing/technical consultant may provide you with additional services of detailing the final project specifications.

Prospective contractors should visit the site before preparing quotes in order to verify building details. This site visit should be scheduled as part of the solicitation process. Set a deadline of date and time for all proposals to be received.

Contract Execution

Request the installer/contractor submit a contract to the buyer for execution. This is the time to have your lawyer review the contract terms and conditions.

Expect to execute a single contract with the contractor that will cover both the design and construction phases of the project. The contract should specify what is covered in the design phase and in the construction phase, including deliverables, separate prices for design and for construction, and payment schedule. It should also allow the buyer to opt out of construction at the end of design with payment for the negotiated design price and not for the full project cost, in the event your strata corporation decides not to proceed with the project.

Project Closeout

Once the construction is complete, the contractor should commission the equipment to confirm that all components are operating properly. Commissioning is a key process designed to verify that the owner's requirements have been met and ensures that systems are operational, safe, and performing as expected. As one of the last steps in project implementation, it should allow observation and participation from the multifamily property owners and/or representatives. Commissioning should be outlined in the RFP process and will include required documentation, checklists, testing procedures, and performance testing.

As part of the project closeout process, the contractor should provide copies of technical manuals, equipment specification sheets, as-built design drawings, and warranties to the strata and training to the owner(s) about safety and system operations and maintenance requirements.

Monitoring is a critical component of the training. Before the project closes out, participants will need to learn how to access and understand system monitoring, how frequently to look at it, and how to interpret any deviations from normal output. If the monitoring is web based, participants will need to know website URL's and passwords.

SYSTEM MONITORING AND INTERNET ACCESS

The performance of the PV system may be tracked over the internet by providing an internet connection to the inverter. If this requires a new internet account with associated monthly fees, factor these costs into the financial analysis of the project. Online monitoring access is very useful in tracking the performance of the system and flagging issues as they arise. Some inverters can be programmed to email notices if malfunctions are detected.

Overall solar PV system benefits included:

- Substantial energy cost savings
- Minimal operation and maintenance
- Helping owners meet personal environmental goals
- Marketable benefit when selling units

INSURANCE

Contact your insurance broker and advise the PV system has been installed on the roof. This ensures that in the case of damages to the system or related to the system, an insurance claim can be filed. The broker will confirm whether the system is protected with existing coverage or advise if additional insurance is required.

Service Life and Warranties

Solar PV modules are typically warranted for 25 years, and may last much longer. They typically lose a small percentage of their efficiency (power output) over time (~0.5% per year). Most warranties specify a maximum rate of power loss over time.

Inverters, which convert DC power generated from the PV modules into grid-compatible AC electricity, typically come with a 10 to 15 year warranty. You may want to include an inverter replacement at year 15 when evaluating the overall financial benefit of the project. Some systems make use of micro-inverters where each PV module has its own inverter. Some of these micro-inverters come with warranties of up to 25 years.

Check the product warranties on your other components, and the approximate cost of replacing them such as mounting hardware.

A note of caution on warranties. The solar industry has many new products and companies. Not all of these will

Front sign markets PV system at Central Park in Victoria

endure the test of time. This means that although some of your components may be under warranty, the company might no longer be around to service them.

POST-PROJECT COMMUNICATION

The owners decided to proceed with the project, because they felt they could more than recoup their investment when selling their condos. To advertise the PV system on the roof, "Solar Strata" was added to the building sign and a display monitor was installed in the lobby, which showed how much electricity the PV system was generating. The owners also set up a website that publicly displays the output from their system.

Operation and Maintenance

A PV system has no moving parts. Once it is set up, it requires little maintenance except occasional cleaning of the modules and visual inspection of the inverter and components.

The designer and installer must document all maintenance actions that are required by the equipment manufacturers and ensure any site-specific maintenance actions are included. The intervals between these maintenance actions should also be included in this documentation. Factors that can influence maintenance requirements include:

- Panel tilt angle (low tilt angles may require more frequent cleaning)
- Environmental factors (leaf litter, dust, salt spray, etc.)
- Fauna (birds, squirrels and other animals)

Working at elevated heights requires fall protection, which may include personal fall arrest systems and guardrails around openings and edges of roofs. Confirm the current WorkSafe BC status for all contractors and consultants working on the project, and any safety or fall protection required for maintenance.

Take care that no shading of panels occurs over time due to vegetation growth or future placement of equipment or obstructions on the roof that block the PV modules from direct sunlight.

Snow removal is generally not recommended because it damages the modules, but it is sometimes required to reduce snow weight on a roof or to remove ice dams. Snow removal should be done using powerful fans such as landscape blowers, not shovel or other mechanical means.

The Central Park PV system has been operating well since its installation and the owners are generally happy with their purchase decision. From July 2015 to June 2017, the system generated 34,463 kWh, four percent more than predicted in the initial model. The total electricity bill for two months ending August 16, 2015 was $39.96, compared with $707.46 for the same period in 2014.

Cleaning

Most PV systems rely on rain to keep the array clean; no cleaning regimen is employed. Heavy rains result in a nearly complete cleaning effect, whereas light rains clean much less effectively and can even increase soiling if dust sticks to sparse water droplets. The cleaning effect of rain will also be less for systems that are mounted with a low tilt angle.

Soiling reduces the energy output of the PV array, and can lead to localized hot-spot failures if the soiling is uneven. Efforts should be taken to reduce uneven soiling, for example from bird droppings. Care must be taken with array cleaning to avoid damaging the components. Follow the PV module manufacturer's recommendations with any array cleaning. Clean PV modules with plain demineralized water with mild detergent recommended by the

manufacturer. An economical method is with a bucket of water, strip cleaner and squeegee (often on opposite sides of the same tool). Use overlapping vertical strokes in the same way window glass is cleaned on commercial buildings. Do not use high-pressure water, brushes, or any types of solvents, abrasives, or harsh detergents.

If there are lots of birds around, a number of steps can be taken to reduce their impact on your system:

- Reduce open cracks between panels where birds can build nests
- Use bird netting to seal areas under the panels down to the roof completely around the array
- Install bird spikes along the top edge of the array to prevent roosting
- Use plastic owl or falcon with swivel head to scare off birds
- Schedule rooftop services and removal of nests according to nesting season timing

The strata's electricity bills for summer months are down to under $25 per month compared with $350 before the project.

Broom and bucket used to clean the PV modules

The only work required for the PV system at Central Park is washing the PV modules once a year at the same time as the roof skylights are cleaned. In the first year, one of the owners cleaned the system with water and a bit of dish soap, along with a small, nylon floor broom to scrub and rinse the bottom edges (figure above). It took just over half an hour to clean the entire system.

More Information

Best Practices in PV System Operation and Maintenance, available at www.nrel.gov

A Solar Guide for Condominium Owners and Associations in Massachusetts, available at www.mass.gov

Solar Permitting and Installation Handbook, available at www.cambridgema.gov

New York City Multifamily Solar Guide, available at www.nysolarmap.com

Residential Consumer Guide to Solar Power, available at www.seia.org

Canada's Go Solar Guide and Directory, available at www.cansia.ca

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