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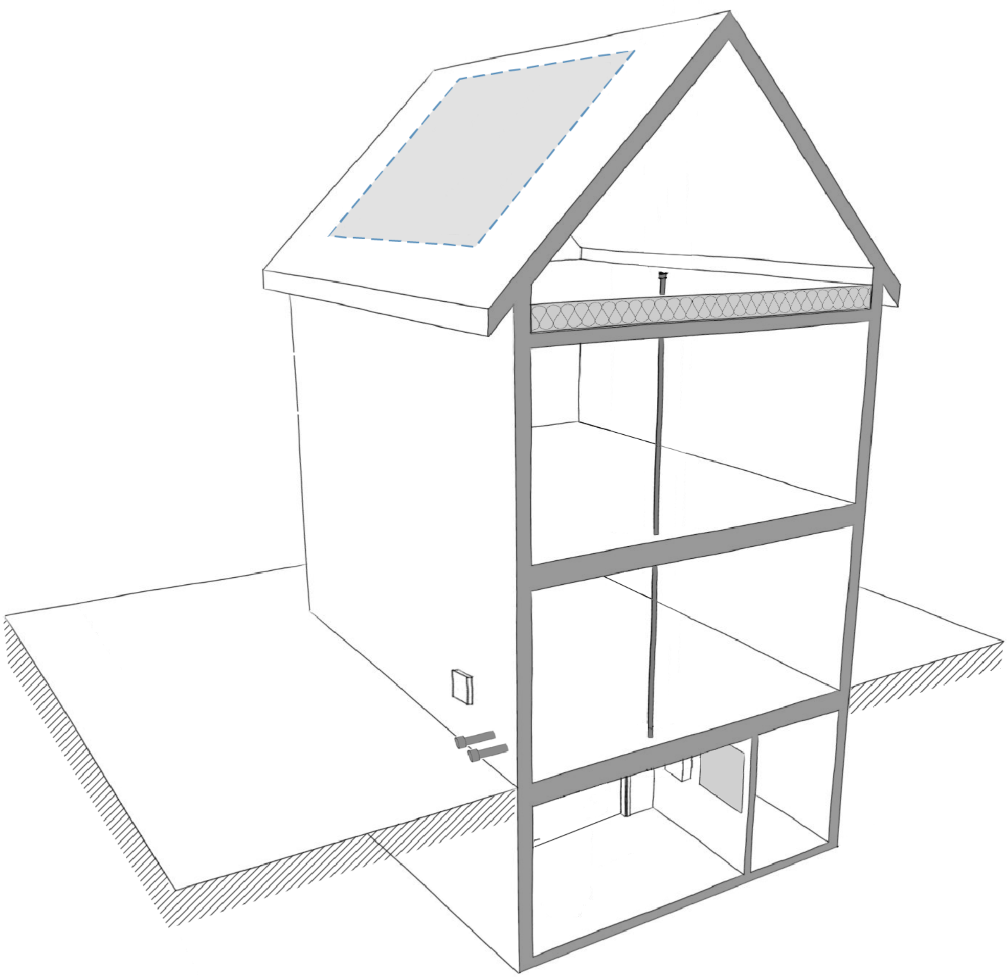
CanmetENERGY
Leadership in ecoInnovation

Photovoltaic Ready

Guidelines

Version 2.0



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I. INTRODUCTION & KEY BENEFITS

The *Photovoltaic (PV) Ready Guidelines* describe design considerations and specify modifications builders can make to new attached and detached homes in preparation for the installation of a future large array photovoltaic system. The design considerations and modifications include the following: elements on the roof, PV and utility connection conduit installation and termination, wall space, electrical panel rating, breaker slot and network communications. Structural loading considerations are discussed in the Guidelines.

These Guidelines are intended to be simple and inexpensive to implement, while enabling significant savings in installation costs should a homeowner choose to install a large array PV system in the future. The *Photovoltaic Ready Guidelines* are specifically targeted towards the installation of PV modules and components as tested and / or certified according to relevant Canadian Standards Association (CSA) test standards; and as installed by qualified installers. For more information on relevant CSA test standards, see Section III, Part 7.

See Section IV for an explanation of the anticipated performance of PV systems for homes built *Photovoltaic Ready*.

This document is intended to help increase builder and consumer awareness of the opportunity that large array roof-mounted photovoltaic systems provide.

PHOTOVOLTAIC READY HOMES BENEFIT:

- Homeowners, by enabling them to save money on the installation of a future photovoltaic system;
- Builders, by offering them the tools to provide an environmentally-conscious, low-cost upgrade to new homes; and
- Manufacturers and installers, by encouraging market uptake of photovoltaic systems.

The *Photovoltaic Ready Guidelines* can be found on NRCan's website nrcan-rncan.gc.ca. Builders should ensure they are working with the most recent version.

INTENDED USE OF THE PV READY GUIDELINES AND SOLAR READY GUIDELINES:

The *PV Ready Guidelines* are intended for large array PV systems (e.g., as would be the case in near net zero or net zero energy home designs). The *Solar Ready Guidelines* are intended for solar thermal and small array PV systems.

***PHOTOVOLTAIC READY* BACKGROUND:** *Natural Resources Canada collaborated with the Canadian Home Builders' Association and the Canadian Solar Industries Association to develop the technical specifications of these* Photovoltaic Ready Guidelines.

II. TECHNICAL SPECIFICATIONS

Each of the following requirements should be completed by the builder. See Section III for additional information.

1 On The Roof

Builders should:

1.1 identify on the house plans a large roof area to allow the installation of a photovoltaic array with a design energy output to offset a significant portion of the annual energy budget of the house;

1.2 ensure the roof area identified in 1.1 is unobstructed (clear of chimneys, roof vents, skylights, gables and other protrusions and is not foreseen to be significantly shaded by building elements, surrounding buildings or mature trees at any time of the year) (see Section III Part 1);

1.3 consider that the optimal orientation for the roof area identified in 1.1 will be south facing (azimuth will generally be 180° from true North);

1.4 consult with the municipality to determine needs for ridge setbacks and / or pathway allowances as may be needed for fire access and / or smoke ventilation (See Section III Note to Builders);

1.5 consider designing the roof to a recommended (not required, see Section III, Part 1) roof pitch of 4/12 to 18/12, corresponding to angles of between 18° and 56° above horizontal (0°); (Note: optimal roof angle will generally be 10° less than the site latitude);

1.6 consider utilizing roofing materials which will provide a minimum 25-year serviceable life to mirror PV system life expectancy.

NOTE: *Structural loading considerations are outside the scope of the* Photovoltaic Ready Guidelines*. Builders should ensure the roof structure as designed not only meets all applicable building code requirements, but will also support additional loads associated with common photovoltaic energy systems. Refer to Section III, Part 1, "Note to Builder - Loading and Attachment" for related commentary. Builders should note the design load rating of the roof truss system and whether it has been built to accommodate additional loads associated with common PV systems on the "*PV Ready *Checklist and Builder's Declaration" form, provided in Section V.*

2 PV Conduit and Utility Connection Conduits

2.1 To prepare for a photovoltaic system, one PV conduit constructed of metallic conduit of at least 2.5cm (1") nominal diameter or non-metallic conduit of at least 5.1 cm (2") nominal diameter should be installed. For attached homes where the ceiling provides the required fire separation between the units, non-combustible conduit should be used.

2.2 To prepare for connection of the system to the outdoor utility meter and back to the indoor electrical panel, two utility connection conduits of at least 3.2 cm (1 1/4") nominal diameter each constructed of rigid PVC conduit should be installed.

NOTE: *Best practice is to use metallic conduit for the PV electrical cable and utility connection cables (this will simplify the installation and inspection process). Rigid PVC conduit can be used as a conduit for the PV electrical cable and utility connection cables, subject to a number of limitations stipulated in the Canadian Electrical Code (CEC), Part 1. For example, rigid PVC conduit cannot be used where enclosed in thermal insulation (see Rule 12-1102). The PV electrical cable used within the rigid PVC conduit will need to have metal armour or a metal sheath (see Rule 64-014(1)(b)). Rule 12-902(2) regarding types of conductors and cables stipulates additional limitations of use.*

3 Installation and Termination of PV Conduit and Utility Connection Conduits

General

3.1 The PV conduit should be installed entirely within the building envelope (except for the roof termination if applicable). The conduit should be continuous from an accessible attic or roof location to the designated wall space for the PV electrical hardware (bends / elbows will be fine).

3.2 The utility connection conduits should provide a continuous pathway (bends are acceptable) from a location adjacent the designated wall space for the PV system hardware to a location adjacent the home's outdoor utility meter.

3.3 In installations with any bends or elbows greater than 45 degrees, a nylon pull-rope (6 mm (¼") diameter or larger) should be installed in the conduit to facilitate installation of conductors at a future date.

Termination of Utility Connection Conduits

3.1U The utility connection conduits must be properly sealed at the home's envelope penetration, and must be capped and sealed at the outdoor and indoor ends to maintain air tightness and fire separation where required.

Attic Termination of PV Conduit (applicable where attics are present)

3.1A The PV conduit must be properly sealed at the attic penetration, and must be capped (or terminate in a sealed junction box) to maintain air tightness and fire separation where required.

3.2A Workspace should be allowed for around the termination of the PV conduit in the attic. The conduit should extend about 15.2 cm (6") above the attic insulation, while allowing about 45.7 cm (18") of vertical distance between the end of the conduit and the underside of the roof decking.

Roof Termination of PV Conduit (applicable to homes with no attic, e.g., cathedral ceilings)

3.1R As with any element that protrudes through a roof, the PV conduit terminating above the roof must be sealed and flashed around the roof penetration using a rubber or corrosion-resistant metal flange / boot with a gasket around the conduit, and capped (or terminate in a sealed junction box) to maintain air and water tightness.

3.2R Workspace should be allowed for around the termination of the PV conduit on the roof. A 5 cm (2") clear vertical space above the end of the conduit and a 15.2 cm (6") clear horizontal space in one direction will be sufficient to allow future installers to access the conduit and route wires within it as needed.

Electrical Room Termination of PV Conduit (applicable to all homes)

3.1E The PV conduit must be properly sealed at the electrical room penetration point and capped (or terminated in a sealed junction box) to maintain air tightness and fire separation where required.

3.2E Workspace should be allowed for around the termination point of the PV conduit in the electrical room. A 5 cm (2") clear vertical space beyond the end of the conduit and a 15.2 cm (6") clear horizontal space in one direction will be sufficient to allow future installers to access the conduit and route wires within it as needed.

NOTE: *Fire protection must be provided between attached houses. At the ceiling level, this may be accomplished by extending the demising wall, which is required to be constructed as a rated fire separation, through the attic or by constructing the ceilings of both units to provide the required separation. In the latter case, penetrations of the ceiling by the PV conduit must not compromise any required fire separation.*

4 Wall Space / Electrical Panel Rating / Breaker Slot / Network Communication

Wall Space

4.1 Wall space should be allocated in the electrical room, adjacent to the main electrical panel for the house, for the future installation of a photovoltaic system inverter and connection hardware. A recommended space of 91.4 cm (36") x 91.4 cm (36") is suitable, with a minimum clearance of 91.4 cm (36") between the bottom of the allocated space and the floor.

Electrical Panel Rating

4.2 Check and verify the electrical distribution panel ampere rating (i.e., “busbar” rating) is high enough to accommodate the connection of a PV system that potentially could be installed on the roof area identified in 1.1 (see Section III, Part 4) according to Rule 64-112(4)(d) of the CEC Part 1. Calculate and record the maximum allowable PV breaker ampere rating in a net metering configuration on the ***Photovoltaic Ready*** **Checklist and Builder’s Declaration** sheet (see Section V).

Open Slot for Double Pole Breaker

4.3 Ensure there is an available slot for a double pole breaker at the bottom of the electrical panel busbar to allow for the future installation of a double pole breaker for the PV system supply feed.

Network Communication

4.4 In houses with wired networks, a wired network connection (ethernet jack) should be installed next to the allocated wall space for future PV inverter connection to the internet.

5 Code Compliance

5.1 Building and electrical work must be completed in compliance with the building and electrical codes and regulations that apply at the building site. Refer to Section III, Part 7 of the *Photovoltaic Ready Guidelines* for a list of useful documents and links.

6 Identification of *Photovoltaic Ready* Components

6.1 A completed copy of the ***Photovoltaic Ready*** **Checklist and Builder’s Declaration** should be provided to the home buyer for their records as well as to the local building permits office as part of the permitting package. It is recommended that a copy of this documentation be attached to the wall space allocated for future PV hardware next to the main electrical panel of the *PV Ready* house.

III. SUPPORTING INFORMATION

1 On the Roof

Roof Space, Orientation and Mounting Angle

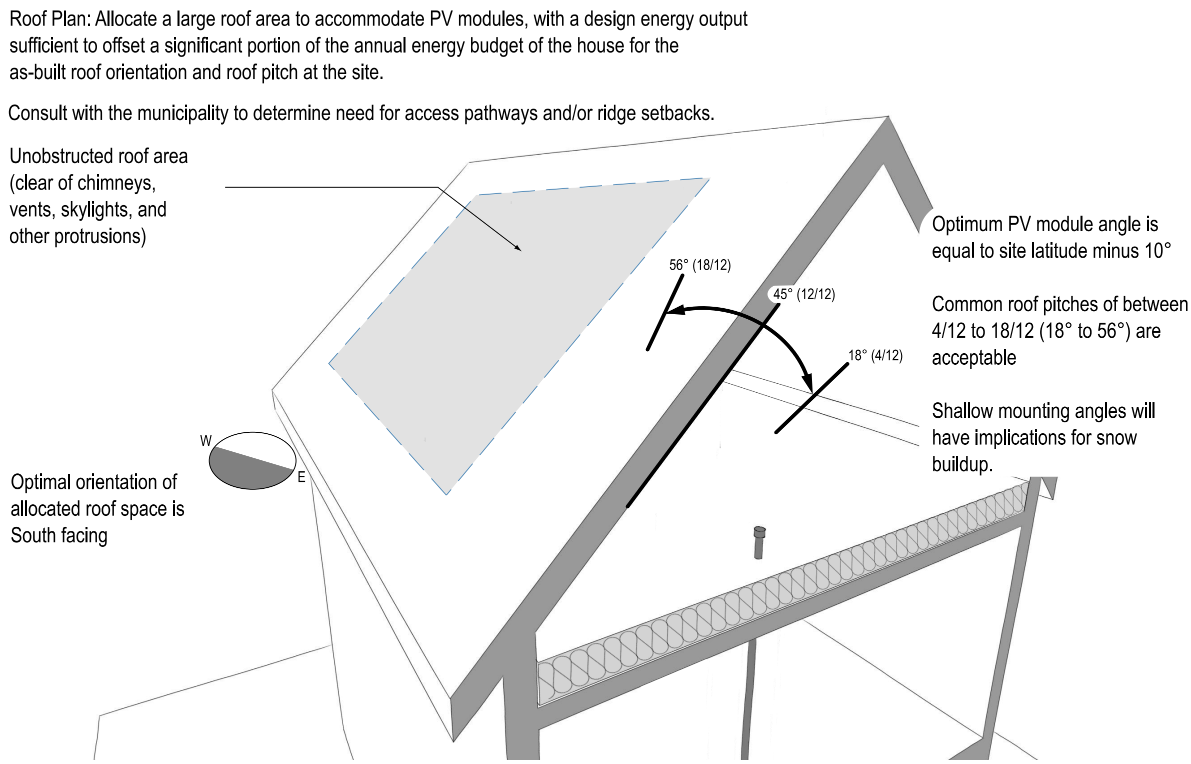

Figure 1: Roof space, orientation and mounting angle of PV modules

ROOF SPACE

In most residential applications, roof-mounted equipment is the most cost effective way to install a solar PV system. Figure 1 describes the recommended roof space, orientation and mounting angle of the solar PV modules. A site inspection of surrounding building structures and consultation with landscaping plans will ensure the allocated area will not be significantly shaded by surrounding buildings / mature trees at any time of the year. *Photovoltaic Ready* shading considerations are described in Figure 2.

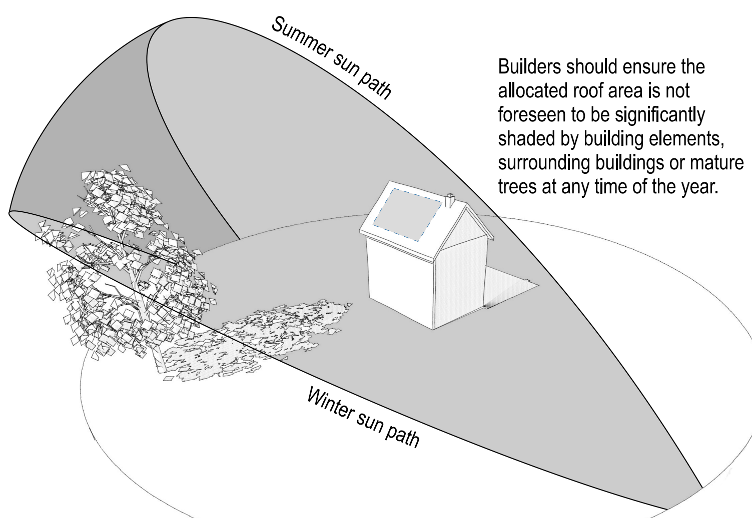

Figure 2: Shading considerations for PV systems

LOCATING ROOF VENTS, PLUMBING STACKS, SKYLIGHTS

It may be beneficial to locate roof vents, stacks and skylights on north facing slopes of the roof to allow maximum space for the solar modules. Roof vents, stacks and skylights can also be located in the ridge setback allowance above the allocated PV roof space, but not in the access pathway allowances.

If it is unavoidable, and roof vents must be located in the allocated PV roof space, they should be low profile models with a depth less than 6.5 cm (2 ½") when air is exhausted upward and less than 10 cm (4") when air is exhausted to the side.

NOTE TO BUILDERS – DESIGN CONSIDERATIONS

ROOF DESIGN

Roof designs with fewer hips and valleys and larger rectangular surfaces will maximize the usable roof area and facilitate the future installation of PV modules on the allocated roof space of the *PV Ready* home. Gable roof surfaces (see Figure 3) will allow the installation of the same number of PV modules in each row and result in a rectangular PV array that has straight-line edges running parallel to the edges of the roof. This may result in a PV array that looks integrated into the roof design.

Roof designs with hips and valleys will require stair-casing of the rows of PV modules to follow the diagonal of the hip or valley (see Figures 4 and 5). These stair-cased edges of the PV array may have a greater visual impact and make the PV array stand out more on this type of roof design.

AESTHETICS MATTER

From the Canadian Home Builders Association's (CHBA) consumer market research:

"CHBA has confirmed that aesthetics matter. Net Zero Energy Homes with PV systems that are visually integrated with roof lines are definitely favoured by consumers. By designing the roof for PV from the initial design stage, builders are able to ensure the system will look good and is adequately sized to meet Net Zero."

Canadian Home Builders' Association, 2017

NOTE TO BUILDERS – LOADING AND ATTACHMENT

To ensure roof structures can support additional loads associated with common solar photovoltaic systems, builders should advise their roof truss suppliers of the additional load that the roof must be designed to carry and ensure that this information is included in documentation that can be provided to the local authority when the panels are installed.

DEAD LOAD

When designing the roof structure to accommodate a photovoltaic system, an additional design dead load of at least 0.17 kPa (3.5 psf) accommodates the weight of solar PV modules as well as all mounting hardware for CSA certified components when they are mounted in parallel to the roof surface. Systems mounted at an angle to the roof surface (i.e., rack mounted systems) and ballasted systems may incur additional loads beyond the 0.17 kPa (3.5 psf) dead load.

It is the installer's responsibility to both select and install a solar photovoltaic system so that it does not exceed the load for which the roof was designed.

WIND and SNOW LOAD

Designers should refer to Sections 15 and 44 of Commentary G and Sections 53 through 57 of Commentary I of the "User's Guide – NBC 2015, Structural Commentaries (Part 4 of Division B)" for design considerations related to wind and snow loads of roof-mounted solar arrays.

METHOD OF ATTACHMENT

There are a variety of methods for attaching solar systems to the roof structure. Standard asphalt shingle and standing seam metal roofing are examples of the easiest surface materials to attach solar modules through. If possible, builders should avoid interlocking shingles and slate roofing.

When installing solar systems on *Photovoltaic Ready* homes, solar installers should identify the appropriate attachment method given the requirements of the system to be installed and the design capacity of the roof structure.

It should be noted that to use a desired attachment mechanism on a roof that is designed to withstand the additional load of a solar system, an installer may need to provide additional reinforcement to transfer loads appropriately to structural elements of the roof system. Particular consideration to future attachment mechanisms may be needed where attic space is difficult to access, such as is the case for roofs above cathedral ceilings.

TRUSS DESIGN PROCEDURE

In 2011, the Truss Plate Institute of Canada (TPIC) developed a “Solar Ready Truss Design Procedure” for solar systems installed on truss-based roofs. This procedure focuses on truss systems designed to carry the additional dead load and support typical methods of attachment currently being used by solar installers. Builders may wish to discuss, with their truss suppliers, the use of this procedure to address dead load and methods of attachment (refer to www.tpic.ca, Technical Bulletin #7 for details).

SNOW MANAGEMENT DEVICES

Photovoltaic arrays can represent a hazard when large sections of accumulated snow slide off the glazing. Snow management devices such as snow clips and fences are available for attaching to PV arrays to slow and breakup the release of snow. These attachments are typically limited to regions with snow loads up to 2.39 kPa (50 psf).

In regions with higher snow loads, builders are advised to allocate roof space and plan access to structural elements of the roof system for mounting snow management devices such as snow fences directly to the roof surface below the PV array.

NOTE TO BUILDERS – ROOF ACCESS PATHWAYS AND RIDGE SETBACKS

Builders should consult with their municipality to determine whether access pathways and / or ridge setbacks are needed for roof access and / or smoke ventilation. Should access pathways and / or ridge setbacks be required, the following section provides an approach based on best practices as informed during the development of the *PV Ready Guidelines*. Municipal requirements and fire department procedures evolve over time and builders are advised to check with the local municipality and fire authorities for additional guidance when planning their *PV Ready* roof layout.

Note that access pathways can significantly limit the ability of a home to achieve cost-effective net-zero energy construction, or to blend the PV array into the roof aesthetically. This should be taken into consideration when deciding on the need for roof access pathways.

This best-practice design would be applicable to all rooftop installations, regardless of roof type. To meet this best-practice design, PV modules should be installed at least 45.7 to 91.4 cm (18 to 36") below the roof ridgeline. Since this area is not a pathway, the ridge setback space need not be clear of obstructions (e.g., vents, stack, etc).

The PV array should not block access to the roof for firefighters attempting to gain access from the ground. Available roof access points should not be located directly in front of windows and doors. Guidance for pathway requirements have been established for three specific roof layouts: gable, hip, and hip-and-valley. These apply to roof slopes greater than 2:12 pitch and require the pathways to be located over structurally supported areas that can support the live load of a firefighter.

GABLE ROOF LAYOUTS require two 45.7 to 91.4 cm (18 to 36") wide, clear pathways from ridge to eave on each slope where modules are installed. The most convenient location for pathways will be on outer edges of the roof as long as they are structurally supported. Refer to Figure 3 for additional guidance.

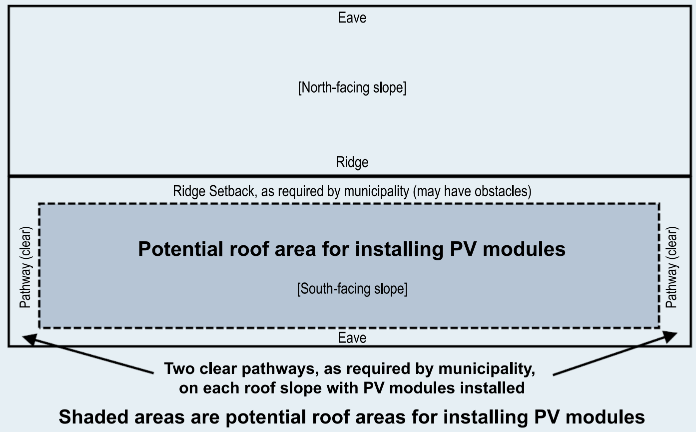

Figure 3: Gable roof ridge setback and pathway requirements

HIP ROOF LAYOUTS require a single 45.7 to 91.4 cm (18 to 36") wide, clear pathway from ridge to eave on each slope where modules are located. The most convenient location for pathways will be along the hips at the outer edges of the roof-face.

If there are modules on both sides of the hip then the minimum required pathway can be split across both sides of the hip to create a 45.7 to 91.4 cm (18 to 36") wide pathway. If the other side of the hip is without modules, the PV array can go all the way to the hip. Refer to Figure 4 for additional guidance.

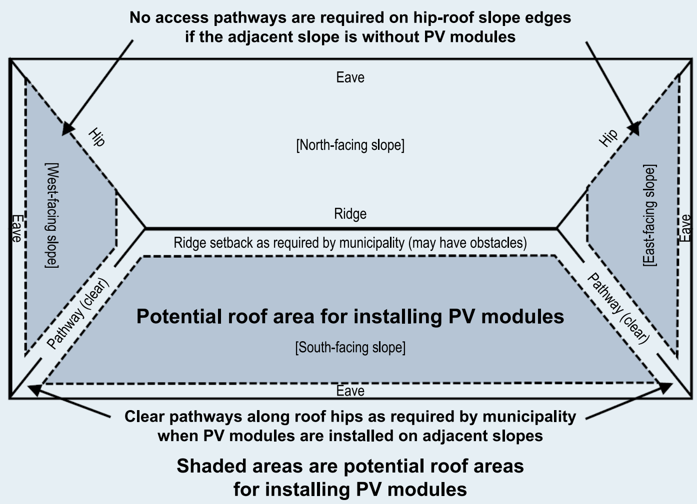

Figure 4: Hip roof ridge setback and pathway requirements

HIP-AND-VALLEY ROOF LAYOUTS require at least one 45.7 to 91.4 cm (18 to 36") wide, clear pathway from ridge to eave on the slope that has modules. The most convenient location will be along the hips and valleys at at the outer edges of the roof-faces. If there are modules on both sides of the hip or valley, then the minimum required pathway can be split across both sides of the hip or valley to create a 45.7 to 91.4 cm (18 to 36") wide pathway. If the other side of the hip or valley is without modules, the PV array can go all the way to the hip or valley. Refer to Figure 5 for additional guidance.

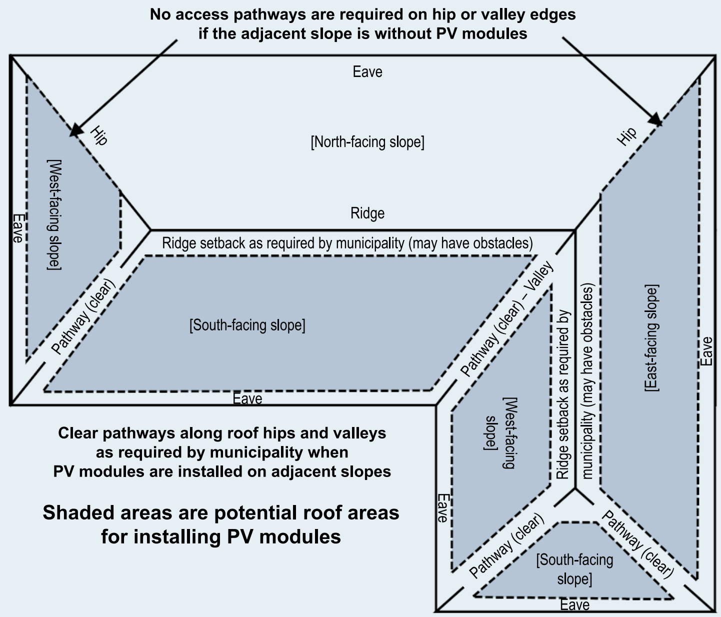

Figure 5: Hip and valley roof ridge setback and pathway requirements

PV MODULE ORIENTATION

From the standpoint of maximizing solar energy collected, the ideal PV module orientation is south facing. However, in cases where architectural controls and / or lot limitations prevent the installation of a south facing PV array, other orientations may be used.

PV MODULE MOUNTING ANGLE

From the standpoint of maximizing the annual solar energy collected, the ideal PV module mounting angle is generally 10 degrees less than site latitude. Builders can consult the Solar Resource Maps of Canada (see Section III, Part 7) for details.

For *Photovoltaic Ready*, the recommended roof pitch is 4/12 to 18/12, corresponding to angles of between 18° and 56° above horizontal (0°).

It should also be noted that systems mounted at low angles (generally 18° (4/12 pitch) or less) will not shed snow as well as systems mounted at slightly steeper angles and will thus not perform as well in winter months.

Angled roof mounting kits are available for low slope or flat roofs to achieve the desired mounting angle. Builders / installers should be aware of implications on roof load associated with using such kits, as well as increased solar system costs and reduced available roof area for modules as gaps are required between rows of PV modules to prevent self-shading at low sun angles.

Vertical mounting of PV modules is possible, but should generally be expected to yield 30-50% less than optimized roof mounted modules (depending on the roof's angle to south).

SEASONAL OPTIMISATION

Photovoltaic systems can be designed to perform best in summer or winter, depending on the intended use and site location. As most photovoltaic installations tend to "over-produce" in summer and "under-produce" in winter, some builders, particularly in extreme northerly locations, may wish to design for improved winter performance by allocating a steeper sloping area of roof space (or wall space) and / or allocating roof space with a modified orientation. As a general rule of thumb, photovoltaic systems optimized for winter performance will perform best at mounting angles 10 degrees greater than site latitude and oriented slightly west of due south. The effects become more pronounced the further north the site is located.

For grid-connected PV systems that are typically designed to maximize summer output, steeper mounting angles may be less desirable.

2 PV Conduit and Utility Connection Conduits

Note: The solar PV conduit should be installed entirely within the building envelope (except for conduits terminating above the roof).

The *Photovoltaic Ready Guidelines* suggest installation of one dedicated PV conduit of at least 2.5 cm (1") diameter if metallic or at least 5.1 cm (2") diameter if non-metallic for use by a future PV system. The larger non-metallic conduit diameter allows for the use of metallic sheathed or armoured cable as required by electrical codes. This conduit need not be straight, as wiring can be “fished” around bends and elbows, but it will be easier to pull wire through straight conduit, so elbows should be kept to a minimum. If the PV conduit is installed with any bends or elbows that are greater than 45 degrees, a nylon pull-rope (diameter of 6 mm (1/4") or larger) should be installed in the conduit to facilitate installation of conductors at a future date. The PV conduit details are described in Figure 6.

In a net metering configuration, utilities require an outdoor, fused, service entrance rated switch for the solar PV system, located adjacent to the home’s utility meter. This means that the output from the inverter must go out to the switch, and then back to the point of connection on the electrical panel. Therefore there is a need for utility connection conduits from the designated wall space to the switch location (beside the utility meter), and then back to the wall space. Two 2.5 cm (1-1/4") PVC conduit will allow sufficient space for metallic sheathed cable to be routed through it for this purpose.

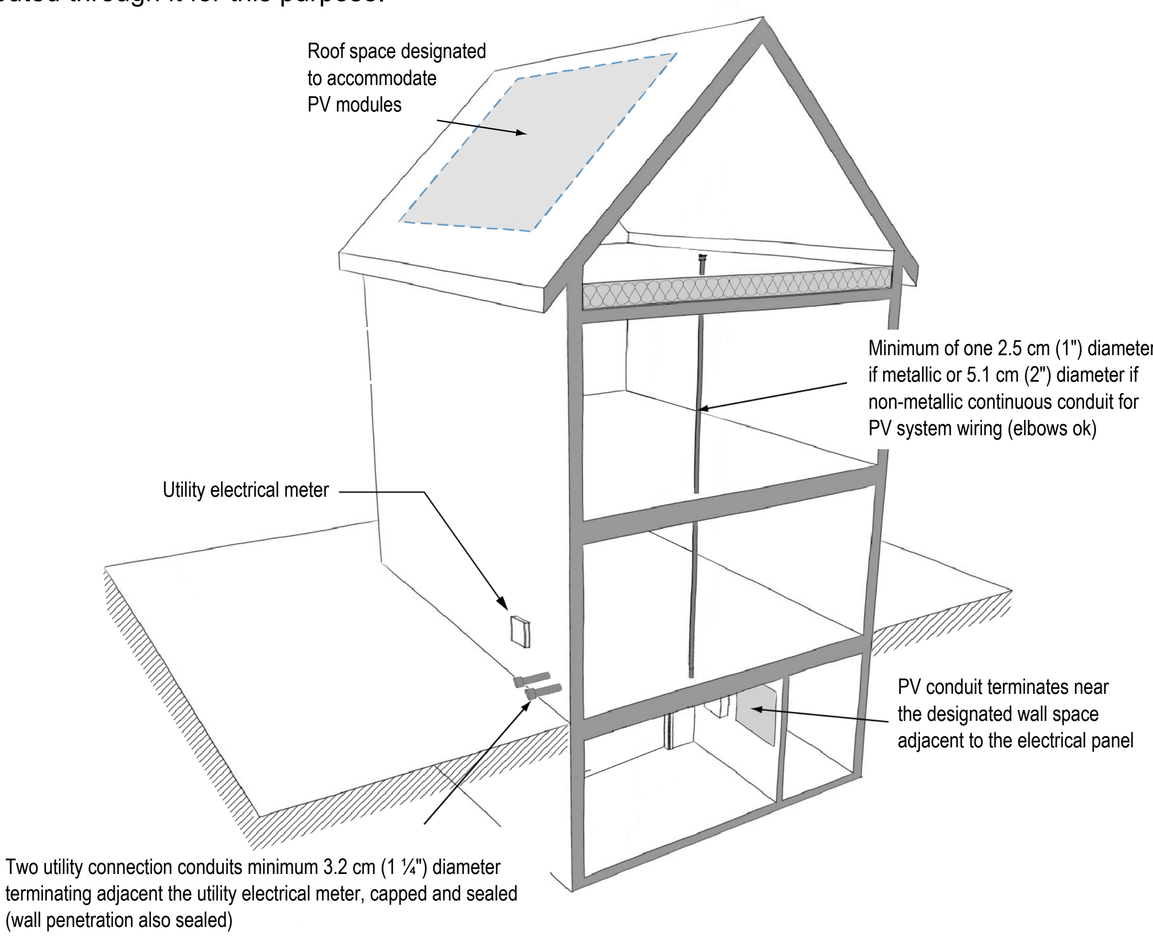

Figure 6: Specifications for PV conduit and utility connection conduits

3 Installation and Termination of PV Conduit and Utility Connection Conduits

The optimal roof location to terminate the PV conduit for use by a future PV system is difficult to ascertain ahead of time. It is for this reason that termination in the attic is preferred.

When terminating the conduit in the attic, the builder should ensure there will be adequate workspace for a future solar system installer to accomplish the work. The workspace specifications are explained in Figure 7.

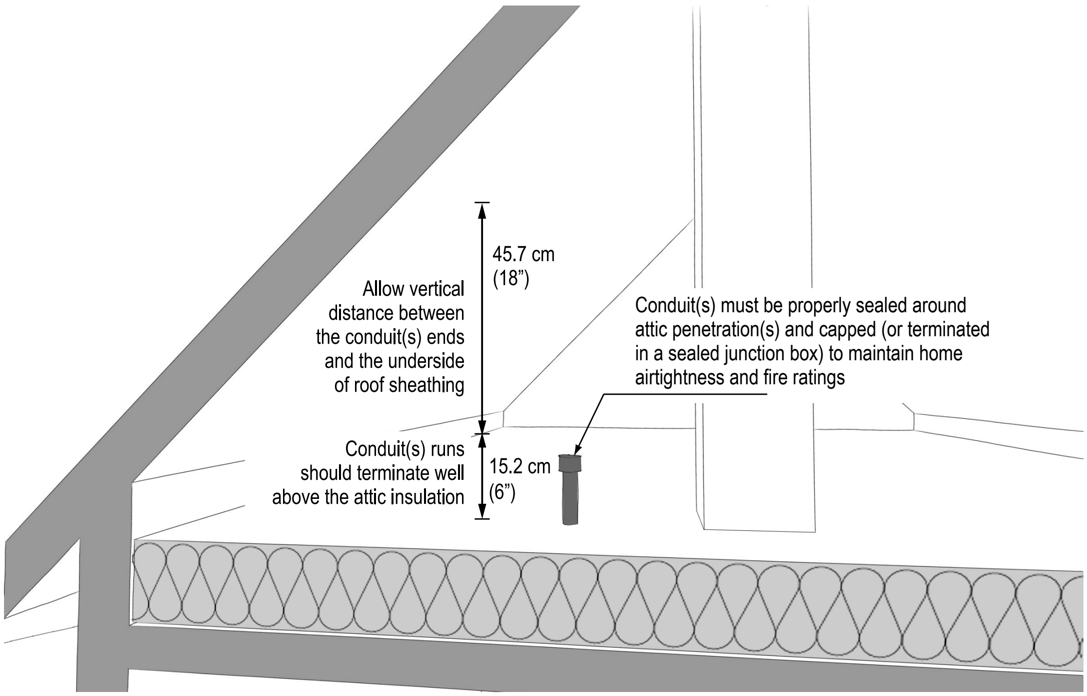

Figure 7: Workspace specifications for attic termination of PV conduit

For situations where attic termination is not feasible (e.g., cathedral ceilings), roof termination is also possible. For roof terminations, the builder should make every effort to locate the conduit protrusion as close as possible to the perimeter of the allocated roof space, while respecting the roof access pathway areas.

As with any element protruding through a roof, the builder should ensure the conduit is flashed and sealed to maintain envelope water tightness. The roof termination option is not preferred, and is not shown graphically in Figure 7.

The conduit termination in the electrical room should end near the wall space reserved next to the main electrical service panel. The end of the conduit should be easily accessible with sufficient surrounding workspace such that future solar PV system installers will be able to readily fish wires through the conduit to connect to the PV system on the roof. See Figure 8 for guidance.

The utility connection conduits (shown in Figure 8) should provide a continuous pathway (bends are acceptable) from a location adjacent the designated wall space for the PV system hardware to a location adjacent the home's outdoor utility meter. The utility connection conduits must also be properly sealed at the home's envelope penetration, and must be capped and sealed at the outdoor and indoor ends to maintain air tightness and fire separation.

4 Wall Space / Electrical Panel Rating / Breaker Slot / Network Communication

WALL SPACE FOR PHOTOVOLTAIC HARDWARE

Wall space should be allocated for the photovoltaic system inverter and connection hardware. Refer to Figure 8 for guidance.

NETWORK COMMUNICATION

In houses with wired networks, builders should install a wired network connection (ethernet jack) next to the allocated wall space for connection of the future PV inverter to the internet.

ELECTRICAL PANEL RATING

For net metering installations the ampere ratings of the electrical distribution panel and main breaker / disconnect may limit the size of the PV installation that can be connected to the electrical panel. Rule 64-112 of the Canadian Electrical Code, 2015 (CEC 2015) (formerly Rule 64-114 in CEC 2012) requires that the sum of breakers feeding a distribution panel in a dwelling unit not exceed 125% of the distribution panel's "busbar" ampere rating.

For example if a house has a distribution panel rated at 100-A, fed from a 100-A main breaker, Rule 64-112 (formerly 64-114) would limit the PV breaker to 25 A @ 240V, or 4.8 kW of PV. This calculation considers 80% loading of the rated breaker capacity (see "*Note to Builders – Distribution Panel Ampere Ratings*"). This corresponds to a PV system requiring about 25 m^2 (270 ft^2) of roof space.

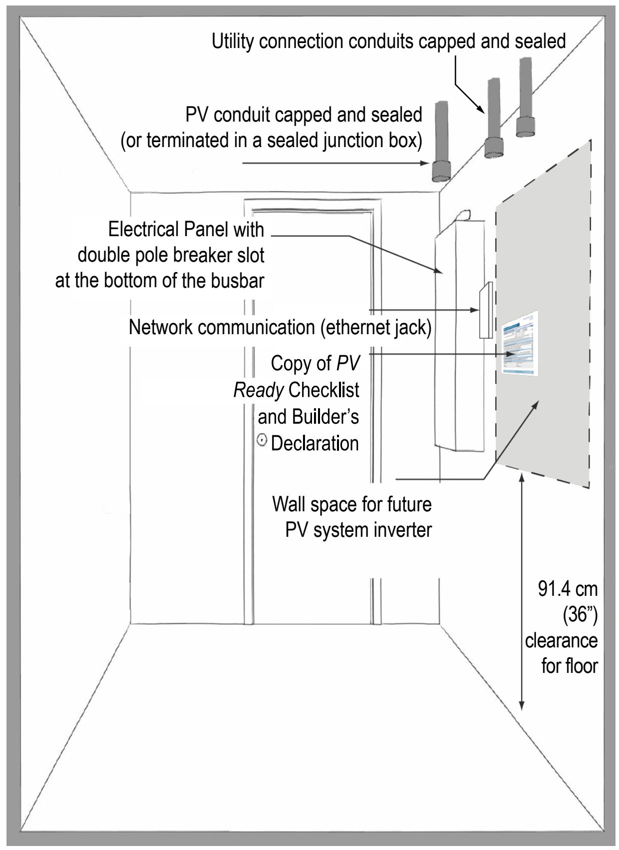

Figure 8: Allocation of wall space, network communication, termination of the PV conduit and utility connection conduits adjacent to the main electrical panel

Residential distribution panels may have ampere ratings that are higher than the main-breaker ampere rating feeding the panel (see *"Note to Builders – Distribution Panel Ampere Ratings")*. Builders and electrical contractors should check the ampere ratings of the distribution panel and main breaker being planned for the house and use electrical distribution panels with high enough ampere ratings to accommodate future PV arrays that could be installed on the roof space planned for the *Photovoltaic Ready* house.

For example, using a distribution panel rated at 125 A with a 100-A main breaker will allow PV breakers rated up to 56-A according to Rule 64-112 (formerly 64-114). A 50-A PV breaker would allow 9.6 kW of PV to be connected to the main panel, and corresponds to a PV roof area of about 50 m^2 (540 ft^2).

NOTE TO BUILDERS – DISTRIBUTION PANEL AMPERE RATINGS AND BREAKER RATINGS

Residential electrical distribution panels are often manufactured with busbars that have ampere ratings that are greater than the main breaker / disconnect that is commonly installed in the combination service panel. For example, 100-A electrical services may have distribution panels with busbars rated at 125 A, and 200-A electrical services may have distribution panels with busbars rated at 225 A.

Note that best practice is to limit circuit loading of breakers to a maximum of 80% of the breaker ampere rating, unless the breaker is specifically marked as capable of being loaded to 100% of its ampere rating (See Section 8 of the CEC, Part 1). This means that, for example, a 50A rated breaker may accommodate a maximum 40A continuous load. A 10kW PV array would therefore require greater than a 50A breaker, and thus may require a 200A electrical panel rating.

ELECTRICAL PANEL RATING (cont'd)

The maximum allowable PV breaker rating should be calculated using the following equation based on the ampere ratings of the electrical distribution panel and main breaker installed in the *Photovoltaic Ready* house.

Maximum Allowable PV Breaker Rating = 1.25 * Distribution Panel Ampere Rating – Main Breaker Ampere Rating

For example, in a *Photovoltaic Ready* house with a 125-A rated distribution panel and a 100-A main breaker, the maximum allowable PV breaker is equal to: 1.25 * 125 A – 100 A = 56 A.

The maximum allowable PV breaker rating should be recorded on the ***Photovoltaic Ready* Checklist and Builder's Declaration** sheet (see Section V).

DOUBLE POLE PV BREAKER SLOT

The builder should ensure there is an available slot for a double pole breaker at the bottom of the electrical panel busbar to allow for the future installation of a double pole breaker for the PV system supply feed.

5 Code Compliance

Builders must ensure that all elements related to the *Photovoltaic Ready Guidelines* are completed in accordance with the building and electrical codes and regulations that apply at the building site.

6 Identification Of *Photovoltaic Ready* Components

PROVIDED BY THE BUILDER TO THE HOME BUYER AND BUILDING PERMIT OFFICE:

A completed copy of the ***Photovoltaic Ready*** **Checklist & Builder's Declaration** should be provided to the home buyer for their records as well as to the local building permits office as part of the permitting package. It is also recommended that a copy of this documentation be attached to the wall space allocated for future PV hardware next to the main electrical panel of the *Photovoltaic Ready* house as shown in Figure 8.

7 Useful Documents and Links

Builders and others may find the following documents and links useful towards their implementation of the **Photovoltaic Ready Guidelines*:***

CODES:

Canadian Standards Association. Canadian Electrical Code, Part 1.

Note: Some provinces or territories may have requirements that vary from the Canadian Electrical Code Part 1 that affect PV installations.

National Research Council. National Building Code of Canada, 2015.

Note: While the National Building Code of Canada (NBC) serves as the basis for all building codes/regulations in the country, some provinces and territories that reference the NBC have amendments that may affect PV installations and some provinces have their own codes where requirements may also differ from the NBC.

National Research Council. User's Guide – NBC 2015 Structural Commentaries (Part 4 of Division B), 2017.

Note: See Sections 15 and 44 of Commentary G and Sections 53 through 57 of Commentary I for design considerations related to snow and wind loads on roof-mounted solar arrays.

CERTIFIED PRODUCTS LISTING:

Canadian Standards Association. Certified Products Listings

SOLAR PV TEST AND INSTALLATION STANDARDS:

Canadian Standards Association. Solar photovoltaic rooftop-installation best practices guidelines SPE-900.

OTHER REFERENCES:

National Renewable Energy Laboratory. PV Watt Solar Energy Calculator.

Natural Resources Canada. Comprehensive Energy Use Tables, Tables 39, 40, 42, and 43.

Natural Resources Canada. Photovoltaic Potential and Solar Resource Maps of Canada.

Natural Resources Canada. National Survey Report of PV Power Applications in Canada, 2014.

International Solar Energy Society. Spatial insolation models for photovoltaic energy in Canada, Solar Energy Journal, Volume 2, Number 11, 2008.

IV. WHAT HOMEOWNERS CAN EXPECT FROM A *PHOTOVOLATIC (PV) READY* HOME

The *Photovoltaic Ready* provisions will simplify and lower the cost of the future installation a photovoltaic system, within the allocated roof area.

- Homeowners can expect a roof space, clear of obstructions, which will facilitate the future installation of a PV array that is sized to offset a significant portion of the annual energy usage of their *Photovoltaic-Ready* home.
- Homeowners can expect to save about 50% on the installation of a PV mounting system in a house built *Photovoltaic Ready* versus a standard house. (Assumes *PV Ready* houses include Solar Ready Trusses, while standard houses often require additional structural support added to their standard trusses).

The following paragraphs provide an example of the anticipated performance of an installation as per the *Photovoltaic Ready Guidelines*. Installed system performance may vary according to, among other factors, allocated roof space, site location, system type and size and household energy usage.

SOLAR PHOTOVOLTAICS – PUT IN PERSPECTIVE

Canada has an average PV potential of about 1195 kWh (4.3 GJ)/kW_{peak} (*Source: Solar Energy Journal, Vol. 2, No. 11, 2008*). For location specific resource details, consult Section III Part 7.

Assuming a roof space allocation of 4.8m by 10.6m (i.e. ~51m^2) for a *Photovoltaic Ready* house, the installation of 8.4 to 9.6 kW of solar PV modules is possible (e.g., thirty 280-320 Watt PV modules of about 1.05m (3.4’) x 1.6m (5.2’) each).

At optimal tilt and orientation (south facing; tilt equal to 10 degrees less than site latitude), this represents an average system output of 10,040 to 11,470 kWh (36.1 to 41.3 GJ) annually, based on average weather conditions for urban centres across Canada (*Source: See Section III Part 7*).

The average Canadian household in a newly constructed home annually uses about 61 to 100 GJ of energy for lighting, appliances and space conditioning depending on the energy performance rating of the new home as shown in the middle three columns of the following table (*Source: See Section III Part 7*). The right-hand column shows the average energy usage of thirteen recently constructed *Net-Zero Pilot Homes* located across Canada. These detached homes had additional energy upgrades resulting in an average annual energy usage of 36 GJ.

Table 1: Table of energy generated by a PV Ready home compared to household annual energy use for four example home performance levels

New House Energy Rating	New Basic house	New Energy Star™ house	New R2000™ house	R-2000™ Net-Zero Energy Pilot house
Household Annual Energy Use	100 GJ	77 GJ	61 GJ	36 GJ
Energy from PV Array	36.1 to 41.3 GJ (10,040 to 11,470 kWh)	36.1 to 41.3 GJ (10,040 to 11,470 kWh)	36.1 to 41.3 GJ (10,040 to 11,470 kWh)	36.1 to 41.3 GJ (10,040 to 11,470 kWh)
Annual Energy provided by PV	36% to 41%	47% to 54%	59% to 68%	100% to 115%

The energy production of the PV array installed on this example *PV Ready* home would be sufficient to cover approximately 36 to 68% of the total household annual energy usage, depending on the energy performance rating of the new home and the peak power output of the installed PV array.

In the case of the *R-2000™ Net-Zero Energy Pilot house*, this PV array would meet or exceed the average annual energy usage of the household.

V. *PHOTOVOLTAIC (PV) READY* CHECKLIST AND BUILDER'S DECLARATION

Each of the following specifications shall be completed by the builder in accordance with Section II of the *Photovoltaic (PV) Ready Guidelines*.

1. On the Roof — Completed

Roof orientation and mounting angles: ☐
Area 1: _______ azimuth (*degrees*) _______ slope (*degrees*) or pitch (rise:run)
Area 2 (as required):_______ azimuth (*degrees*) _______ slope (*degrees*) or pitch (rise:run)
Area 3 (as required):_______ azimuth (*degrees*) _______ slope (*degrees*) or pitch (rise:run)

Unobstructed, unshaded roof space for PV system: ☐
Area 1:_______ *m*^{2} or *ft*^{2} (*circle one*) Area 2 (as required):_______ *m*^{2} or *ft*^{2} (*circle one*)
Area 3 (as required):_______ *m*^{2} or *ft*^{2} (*circle one*) Total Area:_______ *m*^{2} or *ft*^{2} (*circle one*)

Consulted with municipality to determine needs for ridge setbacks and / or pathway access ☐

Roof structure designed and constructed with Solar-Ready Trusses™ or equivalent and roof structure design will support additional loads of at least 0.17kPa or 3.5psf associated with PV system ☐

2. PV Conduit and Utility Connection Conduits

Minimum one PV conduit, sized 2.5 cm (1") if metallic or 5.1 cm (2") if non-metallic, run from the attic or roof to the electrical panel location ☐

Two utility connection conduits, sized 3.2 cm (1 1/4") run from the indoor electrical panel to the outdoor utility meter and back ☐

3. Installation and Termination of PV Conduit and Utility Connection Conduits

PV conduit installed entirely within the building envelope *(except for section terminating above the roof if applicable)* ☐

PV conduit with bends / elbows greater than 45 degrees requires pull-rope installed; *Check if pull-rope installed* ☐

Electrical panel termination workspace provided, conduit sealed and capped ☐

Check one: Attic termination workspace provided, conduit sealed and capped ☐

OR

Roof termination workspace provided, conduit sealed, flashed and capped ☐

Utility connection conduits capped and sealed ☐

4. Space / Electrical Panel Rating / Breaker Slot / Network Communications

Designated wall space near electrical panel provided for PV hardware ☐

Electrical panel will accommodate a PV supply breaker rated up to _______ Amperes in net-metering configuration ☐

Available double pole slot at bottom of electrical panel for PV breaker ☐

Wired network communications available: *Check if network jack provided at designated PV wall space* ☐

5. Code Compliance

Electrical Safety Code and Building Code inspections passed ☐

6. Identification of Components

Copies of the *PV Ready documentation* have been included in the home-buyer's information package, filed with the local building permits office, and affixed to the designated PV wall space on-site. ☐

7. Declaration, Name & Signature

I hereby confirm that the *PV Ready* upgrades have been installed in this house according to Section II of *NRCan's Photovoltaic Ready Guidelines*

Home Address	City, Province, Postal Code
Name	Signature
Company Name	Date (yyyy-mm-dd)