

Unit 1 - Introduction to Renewable Energy Answer Key

1. The industry average at the moment for a residential flush mount solar PV system is about \$3/W
2. Net-metering is a metering arrangement where excess energy exported to the grid is subtracted from what was used.
3. How would you debunk the myth that "solar is too expensive and will never give you a decent Return on Investment"?
4. A hybrid or grid-independent inverter can be connected to a battery bank.
 - a. **True**
 - b. False
5. List some of the solar programs available in Alberta.
Growing Forward 2 - On farm solar program
Municipal solar program
AISP - Alberta Indigenous solar program
AICEP - Alberta indigenous community energy program
Residential and commercial rebates
6. A PV system that is connected to the electric utility is called a _____ PV system.
 - a. utility-interactive
 - b. grid-connected
 - c. interactive
 - d. **all of the above**
7. Inverters can only be used for their designed purposes (off-grid, grid-connected, grid-independent).
 - a. **True**
 - b. False
8. An electrical load is any device, equipment, or appliance that consumes electrical power.
9. Future energy production will be composed of an increasing amount of _____ energy.
 - a. potential
 - b. fossil fuel
 - c. **renewable**
 - d. internal
10. Alberta receives roughly 3 times the sunlight that Germany receives.
11. What is grid parity?

12. List some of the factors that affect a Return on Investment calculation.

Cost of financing

Maintenance

Grid electricity prices

Benefits to environment, infrastructure, society, etc

Subsidies

Policy and support in AB

GHG emission reduction

End use efficiency measures

Reduction in transmission line construction

13. The fastest growing type of PV installation, most often used for single family homes, is the grid-connected system.

14. A 5 kW PV system in Edmonton could be estimated to cost about \$15,000 using the current industry pricing model.

15. distributed generation is a system in which many smaller power-generating systems create electrical power near the point of consumption.

16. A grid-connected inverter can be rewired to be used in an off-grid installation.

a. True

b. False

17. A Levelized Cost Comparison is a very simple method of comparing the long term electricity prices of solar PV installation against traditional fossil fuel sources. This uses the cost of a PV array divided its lifetime expected system production.

18. Describe a Feed-in-Tariff.

A FIT is a policy mechanism designed to accelerate investment in renewable energy technologies like PV and Wind power. It achieves this by offering long-term contracts to renewable energy producers, typically based on the cost of generation of each technology plus reasonable profit.

19. Where can you find environment data for municipalities across Canada?

Environment Canada website

20. A solar collector is a device used in a solar thermal system.

a. True

b. False

21. How would you debunk the myth that "There's not enough sunlight in Alberta for solar to work"?

22. Electricity can be created from the flow of water by using a micro-hydroelectric turbine.

a. True

b. False

23. The utility's network of conductors, substations, and equipment that is used to connect a central generation point to the consumer is called the grid.

24. Describe the difference between solar PV and solar thermal systems.

25. Alberta uses a Net Billing system for measuring energy sold back to grid from micro-generators.
- a. **True**
 - b. False
26. Micro-generation systems include _____.
- a. PV systems
 - b. Wind turbines
 - c. Engine generators
 - d. **All of the above**
27. PV generation sources can be located closer to populated areas because they do not involve hazardous materials nor do they cause air, water, or noise pollution.
- a. **True**
 - b. False
28. Solar thermal energy creates heat energy from solar radiation.
29. Typical ground mount installations can cost as much as \$4/W.
30. Passive solar design in a building will increase the energy requirements for lighting, heating, cooling, and other loads.
- a. True
 - b. **False**
31. What can solar energy be used for?
- a. Electrical loads
 - b. Domestic hot water
 - c. Space heating
 - d. Industrial process heating
 - e. **All the above**

Unit 2 - PV Systems and Electrical Components Answer Key

1. A(n) charge controller is used to control the charging voltage and/or current from a PV array to regulate battery charge.
2. The STANDATA can be used to find a list of acceptable certification marks.
3. Which device converts DC power to AC power?
 - a. Charger
 - b. Inverter**
 - c. Alternator
 - d. Rectifier
4. The PV array is the primary component to all PV systems.
 - a. True**
 - b. False
5. DC stands for direct current and AC stands for alternating current.
6. Ballast bays are typically used for flat roof installations. Weights are then added as required by a structural engineer.
7. Aside from the major system components required for a PV system, the electrical and structural components are called the _____ components.
 - a. completion
 - b. equilibrium
 - c. balance-of-system**
 - d. none of the above
8. Equipment can be installed without a certification mark.
 - a. True
 - b. False**
9. A Rapid Shut Down or RSD is used to reduce the voltage of a string to safe levels outside of a determined area.
10. Residential and commercial buildings are mainly comprised of DC loads.
 - a. True
 - b. False**
11. If using optimisers or micro-inverters, an RSD is required.
 - a. True
 - b. False**
12. A solar PV module is usually an AC source.
 - a. True
 - b. False**
13. A soladeck is one option for a rooftop penetration. It flashes into the shingles and provides a leak-proof junction box.
14. PV racking is used to mount the PV modules mechanically and electrically.

15. A DC source could be a battery.

a. True

b. False

Unit 3 - PV Modules and Electrical Theory Answer Key

1. Typical module cell are wired in series (series/parallel).
2. As the temperature around a module increases, the voltage will decrease.
As irradiance from the sun decreases, the current will decrease.
3. Select the correct order of PV module construction from smallest to largest.
 - a. Module, Cell, Panel, Array
 - b. Array, Panel, Module, Cell
 - c. Cell, Module, Panel, Array**
 - d. Cell, Module, Array, Panel
4. Solar cells are a combination of materials joined to form a PN junction.
5. What does "Pmax" stand for?
Maximum power
6. The average voltage for a solar PV cell is
 - a. 0.2 V
 - b. 4 V
 - c. 6 V
 - d. 0.6 V**
7. Which PV material is most commonly used in residential and commercial applications?
 - a. Amorphous silicon
 - b. Gallium arsenide
 - c. Polycrystalline silicon**
 - d. Cadmium telluride
8. Connecting the leads of a PV module together temporarily will
 - a. do nothing to harm the module**
 - b. cause damage to the module insulation if the short is not quickly cleared
 - c. immediately destroy the module
 - d. only cause damage if connected in series with other modules
9. How would you address a client's concern about hail damage?
10. What does "Isc" stand for?
Short circuit current
11. Micro-inverters can be used off-grid.
 - a. True
 - b. False**
12. What does "Vmp" stand for?
Volts at maximum power

13. What does "Voc" stand for?
Volts open circuit
14. What does "Imp" stand for?
Current at maximum power
15. What are the Standard Test Conditions (STC)?
1000W/m², 25C, 1.5atm
16. An industry standard type of connector is a(n)
a. MC4
b. AC90
c. Tygo
d. MC90
17. Polycrystalline modules are made from a single silicon crystal.
a. True
b. False
18. The IV Curve of a module tells us the
a. Max power current
b. Open-circuit voltage
c. Max power point
d. All the above
19. Grid-connected PV systems never require batteries.
a. True
b. False
20. polycrystalline and monocrystalline are two of the most common types of PV modules commercially available.
21. Describe the photovoltaic effect.
Sunlight strikes a semiconductor and electrons are pushed through a PN junction to generate DC electricity.
22. Monocrystalline modules are usually a black or iridescent blue in color.
a. True
b. False
23. An array's voltage and current can vary with _____.
a. temperature
b. irradiance
c. load
d. all of the above
24. Bypass diodes allow current to flow around PV cells that develop an open-circuit or high-resistance condition.
25. Connecting modules in series will build voltage while connecting them in parallel will build current

26. Solar PV cells are

a. *Semi conductors*

b. Insulators

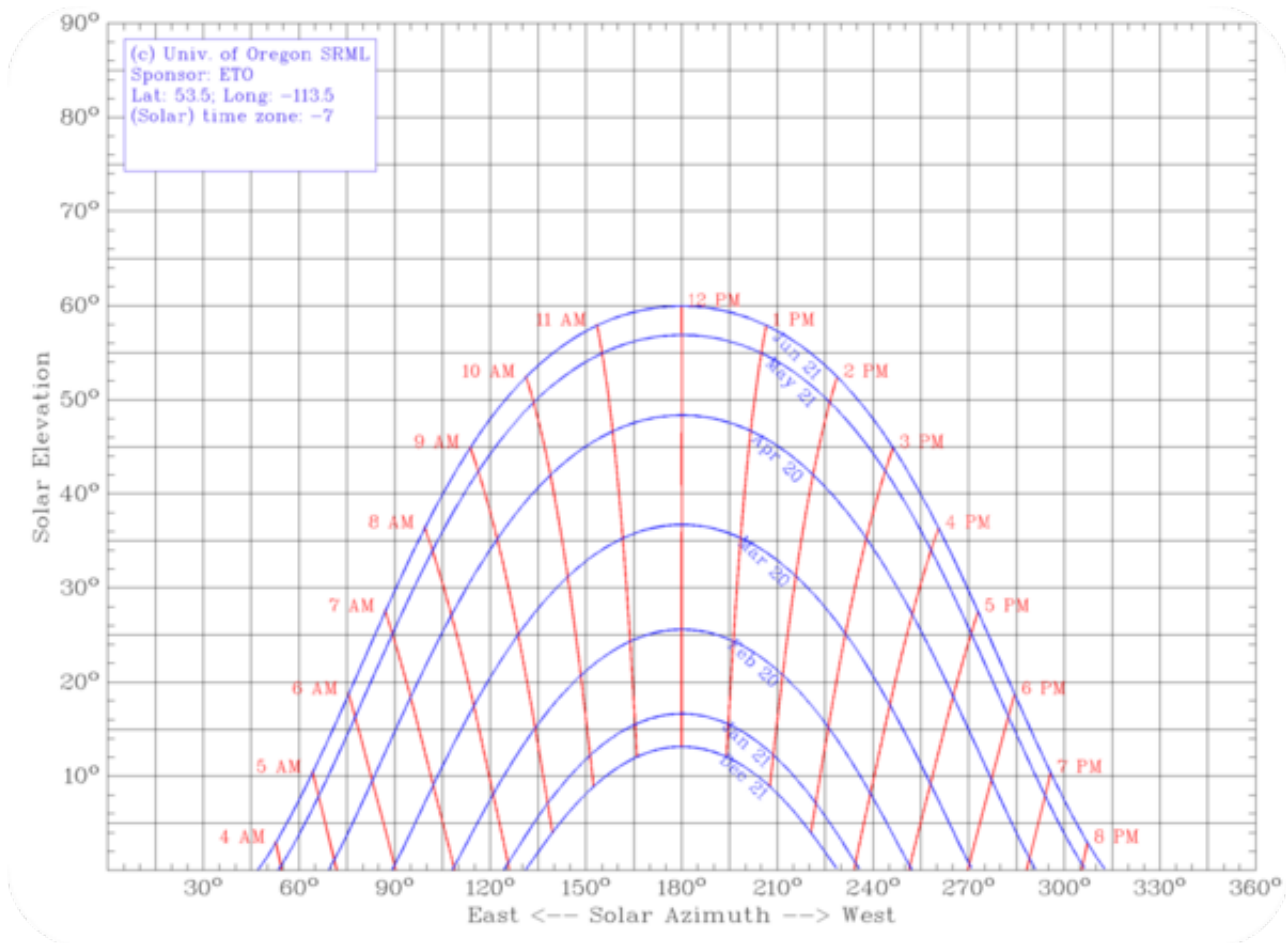
c. Conductors

d. Isolators

27. A module's voltage is inversely affected by temperature while the current is directly affected by irradiance.

Unit 4 - Site Analysis and Mounting Solutions Answer Key

1. A compass is used to determine the orientation of a sloped roof surface.
2. Below is an example of a Sun Path Chart.



3. Given the following formulas, calculate the inter-row shading for a rooftop array using modules that are 36" wide and mounted in a landscape orientation at 15 degrees tilt.

$$\sin\Theta = \frac{H}{D}$$

$$\tan 15^\circ = \frac{H}{L}$$

$$36" \times \sin(15) = 9.31$$

$$9.31 / \tan(15) = 34.77" \text{ between rows}$$

4. List some of the information that should be gathered during a site assessment.

Azimuth (Orientation)

Magnetic Declination

Tilt Angle

Shading, debris, other Losses

Roof type (material and condition)

Roof structure

Check electrical infrastructure

You must inform the owner of any repairs required especially if opening the panel (liability)

Service size (100A, 125A, 200A, 225A)

Underground? Overhead?

Voltage (600V, 480, 120/208, Single phase)

Age and type of panel board

Location and size of panel board (room for PV breakers)

Along with PV and EV, there will be many service upgrades

kWh usage per year

5. Given the following formulas, calculate the inter-row shading for a rooftop array using modules that are 39" wide and mounted in a landscape orientation at 10 degrees tilt.

$$\sin\Theta = \frac{H}{D}$$

$$\tan 15^\circ = \frac{H}{L}$$

$$39" \times \sin(10) = 6.77$$

$$6.77 / \tan(15) = 25.27" \text{ between rows}$$

6. Magnetic declination varies by location and changes slightly over time. Up-to-date maps are used to determine the necessary adjustment.
7. Dual Axis trackers can follow the sun across the sky in two directions.

Single axis trackers can only follow the sun by rotating left to right.

8. The solar pathfinder is a tool used to calculate shading losses that uses a reflective dome and a grease pencil to trace out shading patterns. The Solmetric Suneye is a digital tool that can be used to generate shading reports on site.

Unit 5 - Grid-Connected PV Systems Answer Key

1. A solar PV installation will reduce your electrical energy consumption.
 - a. True
 - b. False**
2. Micro-inverters and most string inverters are grid-connected inverters.
 - a. True**
 - b. False
3. Name two manufacturers of string inverters.
4. Name two manufacturers of micro-inverters.
5. A string inverter requires modules to be connected in series to build voltage.
6. A micro inverter converts DC to AC right behind the PV module.
7. A transformerless inverter will be lighter than a transformer based inverter.
 - a. True**
 - b. False
8. A transformer based inverter can be called a high-frequency inverter.
 - a. True
 - b. False**
9. What is the proper procedure for removing a micro-inverter
 - a. Cover module, disconnect DC, disconnect AC cable, switch off breaker, remove micro-inverter
 - b. Disconnect AC cable, switch off breaker, disconnect DC, cover module, remove micro-inverter
 - c. Switch off breaker, cover module, disconnect AC cable, disconnect DC, remove micro-inverter**
 - d. Switch off breaker, cover module, disconnect DC, disconnect AC cable, remove micro-inverter
10. Islanding is what happens when the grid goes down but a distributed generation source, such as PV, continues to operate and provide electricity to the otherwise de-energized grid.
11. How would you debunk the myth that "solar doesn't work in Alberta because of the snow"?
12. Determine an array size using basic sizing methods.
 - A. Annual consumption (kWh)
 - B. Sun hours per year (sh)
 - C. Percent offset requested by client
 - D. kW capacity of required system

$$\left(\frac{A}{B}\right) \times C = D$$

- A. Monthly usage of 720kWh, 1210sh, and 80% offset.
- B. Yearly usage of 6400kWh, 1220sh, and 50% offset.
- C. Daily usage of 15kWh, 2100sh, and 90% offset.

13. String inverters without optimisers are limited in system design parameters.

a. True

b. False

14. If a micro-inverter fails, the whole system shuts down.

a. True

b. False

Unit 6 - Off-Grid PV Systems Answer Key

1. Being "off grid" means that you are producing all of your electricity needs where it is needed independent of the utility (not connected to the local electrical transmission grid).
a. True
b. False
2. Battery banks store all of the electrical energy generated by the off-grid electrical generators like PV, wind and engine generator.
3. A charge controller limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may prevent against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk.
4. MPPT (MPPT/PWM) charge controllers can be used with widely dissimilar voltages between panels and loads.
5. PWM charge controllers are expensive and require greater technical skill to install.
a. True
b. False
6. MPPT charge controllers are not very scaleable and are limited to a fixed input voltage.
a. True
b. False
7. A client has asked that you design an off-grid installation for a maintenance shack.

They would like four 30W LED fixtures to be installed. An occupancy sensor will be installed, so average usage will be 2 hours per day.

- A. Calculate the total load

$$4 \times 30W = 120W$$

- B. Calculate the daily load

$$120W \times 2hrs/day = 240Wh/day$$

- C. Calculate for inverter inefficiency

Inverter is 90% efficient

$$240Wh/day \times 90\% = 266.67Wh$$

- D. Find the base battery bank size.

This is small system, so you decide to design for 12V.

$$266.67Wh / 12V = 22.22Ah$$

- E. The client has requested that the system continue to work even after 5 days of heavy clouds and snow fall.

Calculate for the days of autonomy.

$$22.22Ah \times 5 = 111.11Ah$$

- F. You find a battery from your wholesaler with a Depth of Discharge rating of 70%.

The batteries will be kept in a heated shed. The spec sheet shows you need to include a 5% derate for the temperature.

Calculate for Depth of Discharge and temperature.

$$111.11Ah / 70\% / 95\% = 167.08 Ah$$

- G. Find the size of PV array required.

Start with the daily PV requirement. Remember to account for battery charging inefficiency.

$$22.22 Ah / 0.9 = 24.69Ah$$

- H. Calculate for the minimum sun hours in the area to find the required charging current. This area your working in has 4sh on Dec 21.

$$24.69Ah / 4sh = 6.17A$$

- I. Oversize by 120% to allow for equalization charging.

$$6.17A \times 120\% = 7.4 A$$

- J. Using the Pmax and Vmp of your module, determine the Imp

$$P_{max} = 252W$$

$$V_{mp} = 37.8V$$

$$252W / 37.8V = 6.66A$$

- K. Determine the number of modules required.

$$7.4 A / 6.66 A = 1.1$$

8. Flooded battery cabinets need to be vented.

a. **True**

b. False

9. Tap water can be used to refill flooded batteries.

a. True

b. **False**

Unit 7 - Canadian Electrical Code Requirements Answer Key

1. List the common code sections that relate to Solar PV installations.

Section 0
Section 2
Section 4
Section 6
Section 8
Section 10
Section 12
Section 14
Section 26
Section 64
Section 84

2. Wires with larger diameters can carry more current.

a. True
b. False

3. According to the Alberta Trade Regulation for electricians, only certified or apprentice electricians may work on Solar PV systems.

a. True
b. False

4. Industry jargon may be used on applications and forms.

a. True
b. False

5. Circuit breakers labelled with "Line/Load" can be backfed.

a. True
b. False

6. An inverter may be installed in a separate room away from the AC panel without any additional equipment.

a. True
b. False

7. Loomex may be used to run DC strings from the roof to the inverter.

a. True
b. False

8. TECK90 cable may be used for all cable runs in a PV system.

a. True
b. False

9. GFCI and AFCI are required on all Solar PV inverters.

a. True
b. False

10. #8AWG wire may be used to run across the array rails to provide equipment bonding.
 - a. True
 - b. False**
11. Single line diagrams and lamicoids are only required at the AC service panel.
 - a. True
 - b. False**
12. Modifying a module for any reason will decertify the module.
 - a. True**
 - b. False
13. A typical solar PV installation will continue to provide power during a power outage.
 - a. True
 - b. False**
14. Off-grid installations may have 240V loads.
 - a. True
 - b. False**
15. A 100A panelboard will have a PV system added to it. What is the maximum size of PV array that is allowed to be installed if the busbars are rated at 125A?
7.5Kw
16. What should be included on the marking lamicoid?
 - a. Rated operating current and voltage
 - b. Maximum PV source circuit voltage
 - c. Rated short circuit current
 - d. All of the above**
17. If a voltage can be calculated to determine the max system voltage using temperature data, that may be used. Otherwise, the max system voltage must be calculated using 125%.
 - a. True**
 - b. False
18. Voltage drop may exceed 5% of the operating voltage.
 - a. True
 - b. False**
19. Overcurrent protection can be calculated using 155%.
 - a. True**
 - b. False
20. RPVU90 is the type of cable to be used on the DC side of PV installations.
21. Black PV cable can be field marked Red with tape for identification.
 - a. True
 - b. False**

22. Micro-inverters and optimisers comply with the rule regarding Rapid Shut Down.
- a. True**
 - b. False
23. PV attachment plugs must comply with the following
- a. There are exposed energized parts, whether the devices are connected or disconnected
 - b. The devices need not be polarized
 - c. The devices have a configuration that is interchangeable with receptacles or attachment plugs of other systems on the premises
 - d. The devices are of the locking type**
 - e. The devices need not be rated for the voltage and current of the circuit in which they are installed
 - f. The devices do not need to provide strain relief
24. Racking is part of the electrical system.
- a. True**
 - b. False
25. Corrosion can take place in warm, dry conditions.
- a. True**
 - b. False
26. Albertans are allowed to connect to the electrical grid and energy retailers must pay them for excess energy produced.
- a. True**
 - b. False
27. The client must pay for a new bi-directional meter.
- a. True
 - b. False**
28. Fortis will accept Epcor's micro-generation application.
- a. True
 - b. False**

Unit 8 - Installations and Maintenance Answer Key

1. A commissioning checklist will help you with post installation QA/QC. This is typically a list of voltages, torques, and confirmations regarding your system.
2. A detailed walkthrough allows the installer to explain the basic operation of the PV system and the maintenance requirements to the owner.
 - a. **True**
 - b. False
3. The following should be periodically inspected for:
 - a. Physical damage
 - b. Delamination
 - c. Burned connections
 - d. **All of the above**
4. A tree planted South of an array will not be a concern for the life of the system.
 - a. True
 - b. **False**
5. Any silicone based sealant will work on roof penetrations.
 - a. True
 - b. **False**
6. Flat roof penetrations can be completed by the PV installer.
 - a. True
 - b. **False**
7. List some common hazards and their controls.
8. Why are steel toed shoes recommended over steel toed boots?

Less aggressive and ankle movement.