# Grades 9 to 12
# Sustainable Energy

Manitoba Technical-Vocational
Curriculum Framework
of Outcomes

Manitoba

# GRADES 9 TO 12
# SUSTAINABLE ENERGY

Manitoba Technical-Vocational Curriculum
Framework of Outcomes

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This resource is available on the Manitoba Education and Training website at www.edu.gov.mb.ca/k12/cur/teched/sy_tech_program.html.

Available in alternate formats upon request.

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# Technical-Vocational Education Overview

In 2013, Manitoba Education released the document *Technical-Vocational Education Overview*, available at www.edu.gov.mb.ca/k12/cur/teched/sy_tech_program.html, to provide the philosophical and pedagogical underpinnings for curriculum development and the teaching of courses in the Senior Years Technology Education Program. This overview presents educators with the vision and goals of technical-vocational education (TVE) in Manitoba.

Topics include the following:

- curriculum revitalization and renewal
- curriculum framework and implementation
- articulation of programming
- assessment and reporting
- safety
- employability/essential skills and career development
- sustainable development

The TVE curriculum includes Grades 9 to 12 courses in a variety of areas, including sustainable energy.

# Sustainable Energy Overview

## Introduction

*Grades 9 to 12 Sustainable Energy: Manitoba Technical-Vocational Curriculum Framework of Outcomes* identifies the goals, general learning outcomes (GLOs), and specific learning outcomes (SLOs) for sustainable energy courses. This framework is intended for use in all Manitoba schools teaching sustainable energy courses as part of the Senior Years Technology Education Program.

## Curriculum Description

All the sustainable energy courses are intended for students who are pursuing a career in the sustainable energy industry. The courses focus on theoretical principles and their practical applications.

Most courses include learning outcomes related to

- health and safety practices
- the operation, handling, cleaning, maintenance, and storage of equipment, tools, materials, products, and consumable items used in sustainable energy
- demand-side management as it applies to sustainable energy systems
- the promotion, planning, installation, and maintenance of sustainable energy systems

Learning outcomes dealing with the following topics are also integrated into most of the sustainable energy courses:

- sustainability
- ethical and legal standards
- employability skills
- working conditions and career opportunities
- the evolution of sustainable energy, including its technological progression and emerging trends

Cross-curricular learning outcomes from a variety of subject areas are to be integrated into the authentic learning activities of the sustainable energy courses. These include, but are not limited to, learning outcomes from the following subject areas: English language arts, information and communication technology, mathematics, physical education/health education, and the sciences.

In the TVE curriculum, the emphasis is on hands-on learning activities. For instructional purposes, the sequence of learning outcomes and the learning outcomes included in each unit of study can vary, based on the learning activities within a course.

## Career Opportunities

The sustainable energy courses begin to prepare students for the following three general career opportunities:

- sustainability coordinators
- sustainable energy technicians
- sustainable energy system designers

Individuals wishing to pursue any of these three general career opportunities will need to complete post-secondary education specific to their area of interest.

### Sustainability Coordinators

*Sustainability coordinators* are involved in developing and/or implementing sustainability plans. These plans are intended to reduce an organization's environmental impact while maintaining its economic viability. Sustainability plans typically include strategies to improve energy efficiency, such as the installation of sustainable energy systems.

Typical post-secondary education requirements include

- a bachelor's degree in biology
- a bachelor's degree in environmental science

### Sustainable Energy Technicians

*Sustainable energy technicians* install and maintain sustainable energy systems. Careers as sustainable energy technicians can be found at large utility-scale operations (e.g., turbine technician at a wind farm). Sustainable energy technicians also install and maintain energy systems (e.g., ground source heat pumps, solar photovoltaic and solar heat systems, and small wind systems) within the residential and industrial sectors.

Typical post-secondary education requirements include

- a wind turbine technician program
- a heating ventilation and air conditioning diploma
- solar photovoltaic installer certification

### Sustainable Energy System Designers

*Sustainable energy system designers* design energy systems for their clients and/or employers. They are involved in projects such as developing sustainable heating and electrical systems for residential and commercial buildings. With comprehensive designs, buildings may qualify for Leadership in Energy and Environmental Design (LEED) certification.

Typical post-secondary education requirements include

- a bachelor's degree in engineering
- a bachelor's degree in architecture

## Sustainable Energy Goals and General Learning Outcomes (GLOs)

The specific learning outcomes for the sustainable energy courses, with the exception of *Current Topics in Sustainable Energy*, are based on the following curriculum goals and general learning outcomes (GLOs). **Please note that some sustainable energy courses do not address all these goals and GLOs.**

**Goal 1:** Describe and apply appropriate **health and safety practices** as they relate to the sustainable energy industry.

**GLO 1.1:** Demonstrate adherence to **safety practices and procedures** for **facilities, processes, tools, and equipment** used in the sustainable energy industry.

**Goal 2:** Demonstrate the safe and appropriate **operation, handling, cleaning, maintenance, and storage** of **equipment, tools, materials, products, and consumable items**.

**GLO 2.1:** Demonstrate the safe and appropriate **operation and handling** of equipment, tools, materials, products, and consumable items.

**GLO 2.2:** Demonstrate the safe and appropriate **cleaning, maintenance, and storage** of equipment, tools, materials, products, and consumable items.

**Goal 3:** Demonstrate an understanding of **demand-side management (DSM)** as it applies to sustainable energy.

**GLO 3.1:** Demonstrate an understanding of **DSM** as it applies to sustainable energy.

**Goal 4:** Demonstrate the knowledge and skills required to **promote and plan sustainable energy systems**.

- **GLO 4.1:** Demonstrate the knowledge and skills required to **promote** sustainable energy systems.
- **GLO 4.2:** Demonstrate the knowledge and skills required to **plan** sustainable energy systems.

**Goal 5:** Demonstrate the knowledge and skills required to **install or convert sustainable energy systems**.

- **GLO 5.1:** Demonstrate the knowledge and skills required to **perform the installation or conversion** of sustainable energy systems.

**Goal 6:** Demonstrate the knowledge and skills required to **maintain sustainable energy systems**.

- **GLO 6.1:** Demonstrate the knowledge and skills required to **perform preventive maintenance** of sustainable energy systems.
- **GLO 6.2:** Demonstrate the knowledge and skills required to **diagnose malfunctions** in sustainable energy systems.
- **GLO 6.3:** Demonstrate the knowledge and skills required to **repair** sustainable energy systems.

**Goal 7:** Describe and apply transferable **cross-curricular knowledge and skills** as they relate to sustainable energy. (information and communication technology, mathematics, chemistry, physical education/health education)

- **GLO 7.1:** Demonstrate **information and communication technology** skills required in the sustainable energy industry.
- **GLO 7.2:** **Read, interpret, and communicate information** related to the sustainable energy industry.
- **GLO 7.3:** Demonstrate knowledge of **mathematical** concepts and skills related to the sustainable energy industry.
- **GLO 7.4:** Demonstrate knowledge of **science** as it relates to the sustainable energy industry.
- **GLO 7.5:** Demonstrate knowledge of **physical education/health education** as it relates to the sustainable energy industry.

**Goal 8:** Demonstrate an understanding of the **ethical and legal standards** that pertain to the sustainable energy industry.

- **GLO 8.1:** Demonstrate an awareness of the **ethical and legal expectations** of the sustainable energy industry.

**Goal 9:** Practise **employability skills** required in the sustainable energy industry.

- **GLO 9.1:** Demonstrate **employability skills**.

**Goal 10:** Demonstrate an awareness of **sustainability** as it pertains to the sustainable energy industry.

- **GLO 10.1:** Describe the impact of **sustainability** on the **health and well-being** of sustainable energy industry workers, their customers, and those who are affected by their products and services.
- **GLO 10.2:** Describe the sustainable energy industry's **sustainability practices and their impact on the environment**.
- **GLO 10.3:** Describe the **relationship between the economy and sustainability practices** within the sustainable energy industry.

**Goal 11:** Demonstrate an understanding of **career options** in sustainable energy.

- **GLO 11.1:** Describe **apprenticeship, post-secondary education, and employment opportunities** related to sustainable energy.

**Goal 12:** Demonstrate an understanding of the **evolution** of sustainable energy, including its **technological progression** and **emerging trends**.

**GLO 12.1:** Demonstrate an understanding of the **evolution** of sustainable energy, including its **technological progression** and **emerging trends**.

The specific learning outcomes for *Current Topics in Sustainable Energy* are based on the following goals and GLOs.

**Goal 1:** Describe **health and safety** concerns associated with current topics, issues, and trends in sustainable energy, along with potential solutions.

**GLO 1.1:** Describe **health and safety** concerns associated with current topics, issues, and trends in sustainable energy, along with potential solutions.

**Goal 2:** Demonstrate the knowledge, skills, and attitudes required to **identify, investigate, and report** on current topics, issues, and trends in sustainable energy, and demonstrate the ability to integrate knowledge, skills, and attitudes from a variety of disciplines to develop potential **solutions**.

**GLO 2.1:** Demonstrate the knowledge, skills, and attitudes required to **identify, investigate, and report** on current topics, issues, and trends in sustainable energy, and demonstrate the ability to integrate knowledge, skills, and attitudes from a variety of disciplines to develop potential **solutions**.

**Goal 3:** Demonstrate the ability to describe the **interdependence** of sustainable energy systems, science, technology, society, government, the economy, and the environment.

**GLO 3.1:** Demonstrate the ability to describe the **interdependence** of sustainable energy systems, science, technology, society, government, the economy, and the environment.

**Goal 4:** Demonstrate an awareness of the **differences of scale** between various sizes of sustainable energy systems.

**GLO 4.1:** Demonstrate an awareness of the **differences of scale** between various sizes of sustainable energy systems.

**Goal 5:** Demonstrate appropriate **inquiry, problem-solving, critical thinking, and decision-making skills and attitudes** for exploring current topics, issues, and trends in sustainable energy.

**GLO 5.1:** Demonstrate appropriate **inquiry, problem-solving, critical thinking, and decision-making skills and attitudes** for exploring issues and problems in sustainable energy.

**Goal 6:** Demonstrate **cross-curricular knowledge, skills, and attitudes** as they relate to sustainable energy.

**GLO 6.1:** Demonstrate the **mathematical** skills and attitudes required to evaluate topics, issues, and trends and to identify potential solutions.

**GLO 6.2:** Demonstrate the **language arts** knowledge and skills required to evaluate topics, issues, and trends and to identify potential solutions.

**GLO 6.3:** Demonstrate the **scientific** skills and attitudes required to evaluate issues and problems and to identify potential solutions.

**Goal 7:** Demonstrate an understanding of the **ethical and legal aspects** of current topics, issues, and trends in sustainable energy, and their potential solutions.

- **GLO 7.1:** Demonstrate an understanding of **ethical** aspects of current topics, issues, and trends in sustainable energy, and their potential solutions.
- **GLO 7.2:** Recognize that decisions reflect **values** and consider own and others' values when making a decision.
- **GLO 7.3:** Demonstrate an understanding of **legal** aspects of current topics, issues, and trends in sustainable energy, and their potential solutions.

**Goal 8:** Demonstrate an awareness of **cultural proficiency** as it applies to current topics, issues, and trends in sustainable energy, and their potential solutions.

- **GLO 8.1:** Demonstrate an awareness of **cultural proficiency** as it applies to current topics, issues, and trends in sustainable energy, and their potential solutions.

**Goal 9:** Demonstrate an awareness of the **factors that influence research** in sustainable energy.

- **GLO 9.1:** Demonstrate an awareness of the **factors that influence research** in sustainable energy.

**Goal 10:** Analyze a controversial **issue** that involves the effect of an energy system on a **community**.

- **GLO 10.1:** Analyze a controversial **issue** that involves the effect of an energy system on a **community**.

**Goal 11:** Demonstrate an awareness of the use of **peer reviews and academic journals** in exploring current topics, issues, and trends in sustainable energy.

- **GLO 11.1:** Demonstrate an awareness of the use of **peer reviews and academic journals** in exploring current topics, issues, and trends in sustainable energy.

## Specific Learning Outcomes (SLOs)

*Grades 9 to 12 Sustainable Energy: Manitoba Technical-Vocational Curriculum Framework of Outcomes* identifies specific learning outcomes (SLOs) for use in all Manitoba schools teaching the Grades 9 to 12 sustainable energy courses as part of the Senior Years Technology Education Program. SLO statements define what students are expected to achieve by the end of a course.

It is essential for students to learn and to demonstrate safety practices and employability skills; therefore, some SLOs related to safety and to employability skills are repeated in all the sustainable energy courses.

## Course Descriptions

Course titles, descriptions, and codes for the sustainable energy courses follow. For an explanation of the codes, refer to the *Subject Table Handbook: Technology Education* (Manitoba Education and Training), available at www.edu.gov.mb.ca/k12/docs/policy/sthte/index.html.

### 8232 Exploration of Sustainable Energy (Optional) — 15S/15E/15M, 10S/10E/10M

This optional course can be taught as either a half credit or a full credit. It provides a broad introduction to the field of sustainable energy. Students will explore historical, current, and emerging alternative energy uses in Manitoba. They will also focus on safety practices and procedures.

### 8233 Introduction to Sustainable Energy — 20S/20E/20M

This course provides a broad introduction to the field of sustainable energy. Students will explore historical and current sustainable energy use strategies in Manitoba.

Topics include the following:

- the historical role of energy in Manitoba
- current conventional energy use in Manitoba
- emerging alternative energy use in Manitoba: electricity, heat, and transportation
- safety practices and procedures

### 8234 Sustainable Energy: Electrical Systems — 30S/30E/30M

This course explores systems that generate electricity without using fossil fuels as their primary energy source. Students will learn how to size, install, and maintain solar photovoltaic and small wind electrical systems.

Topics include the following:

- small wind electrical system installation
- solar photovoltaic system installation
- wind farm siting considerations
- safety practices and procedures

### 8245 Sustainable Energy: Heating/Cooling Systems — 30S/30E/30M

This course focuses on how to heat and cool residential and commercial buildings with ground-source heat pumps and with biomass and solar thermal systems.

Topics include the following:

- thermodynamics
- fundamentals of heat transfer as related to sustainable heating/cooling systems
- design and sizing of sustainable heating/cooling systems
- safety practices and procedures

### 8246 Sustainable Energy: Transportation Systems 30S/30E/30M

This course explores the advantages and disadvantages of using sustainable energy sources for transportation, as compared to using fossil fuels.

Topics include the following:

- transportation system design: city, rural, and northern
- vehicle design: aerodynamic
- hybrid and electric vehicles
- hydrogen-powered vehicles
- safety practices and procedures

### 8279 Sustainable Energy: Solar Systems 40S/40E/40M

This course focuses on solar energy technologies used to heat buildings and generate electricity. Students will become familiar with major solar energy installation sites in Manitoba (e.g., Manitoba Hydro Place—solar chimney, Manitoba Housing Authority—solar wall, Red River College—solar trough). Building on the solar energy basics explored in the Grades 9 to 11 sustainable energy courses, students will plan and contribute to the installation of a solar system (either solar photovoltaic or solar thermal).

Topics include the following:

- solar photovoltaic systems
- solar thermal systems
- safety practices and procedures

### 8292 Sustainable Energy: Wind Systems 40S/40E/40M

This course focuses on the use of wind energy for generating electricity. It explores both utility-scale wind farms and small wind systems (< 100 kW). Students will plan and contribute to the installation of a small wind turbine.

Topics include the following:

- baseline wind resource assessments
- geographic information system (GIS) data sets/maps for wind farm siting
- wind turbine product selection
- wind turbine installation
- safety practices and procedures

### 8293 Sustainable Energy: Biomass Systems 40S/40E/40M

This course focuses on the use of biomass energy for electricity, heat, and transportation (e.g., biodiesel). Manitoba is poised to be a leader in biomass energy, given its access to biomass resources (e.g., agricultural residues, forestry products) and government policies/legislation (e.g., *The Emissions Tax on Coal Act*). Students will explore significant biomass energy installation sites in Manitoba (e.g., Manitoba Hydro's Bioenergy Optimization Program sites), produce test-scale quantities of biodiesel, and plan a biomass heating or power system.

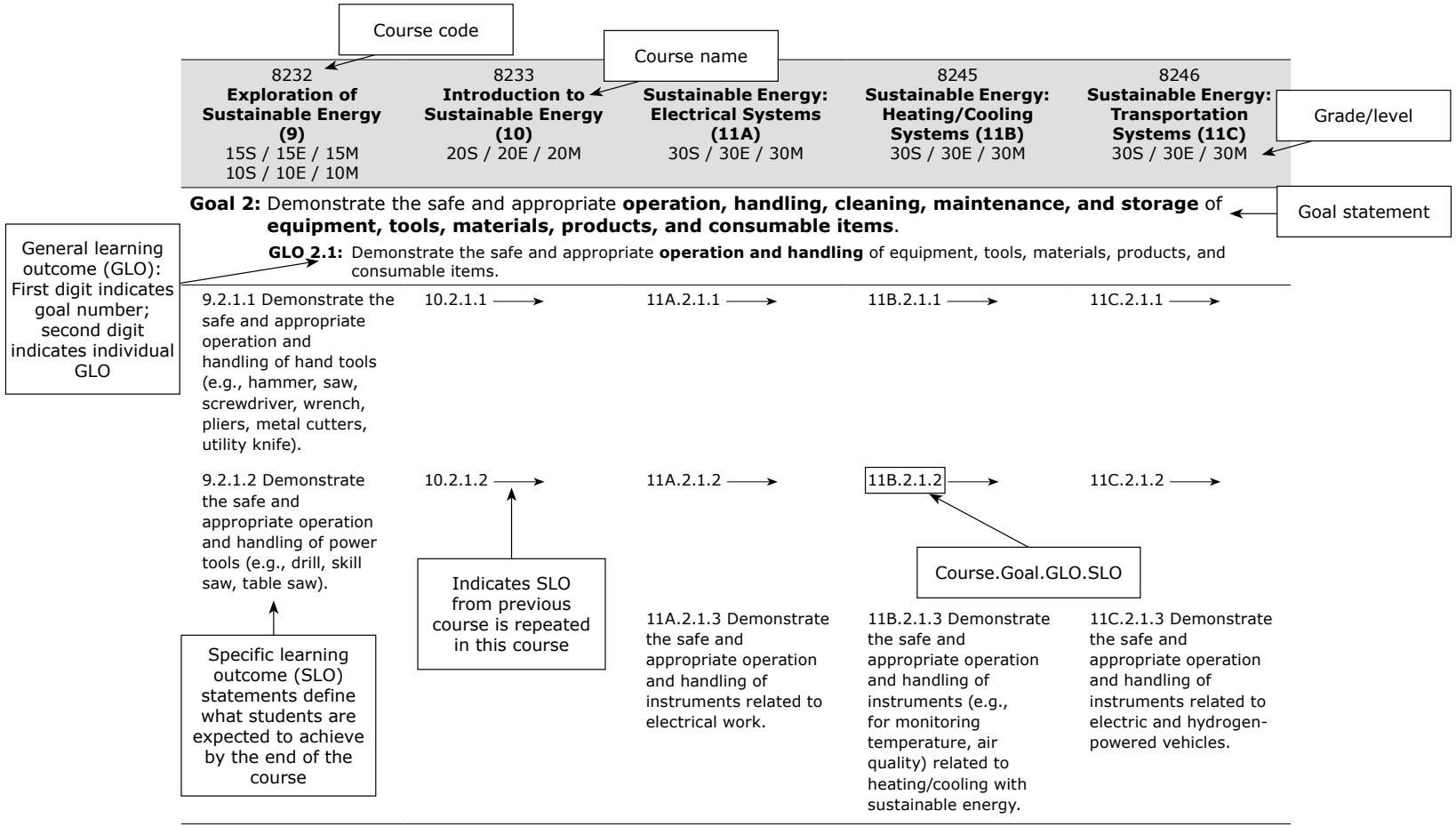
Topics include the following:

- biomass heating systems
- biomass power systems (e.g., synthesis gas, pyrolysis oil)
- combined heat and power systems
- biomass feedstock considerations (e.g., energy content, transportation, storage)
- safety practices and procedures

### 9175 Current Topics in Sustainable Energy — 40S/40E/40M

This course gives students the opportunity to investigate current topics, issues, and trends in sustainable energy. It is intended that students will determine the topics, issues, and trends they find engaging and relevant.

# Guide to Reading Sustainable Energy Goals and Learning Outcomes



# GRADES 9 TO 11
# SUSTAINABLE ENERGY

General and Specific Learning Outcomes by Goal

# Grades 9 to 11 Sustainable Energy: General and Specific Learning Outcomes by Goal

| 8232<br>**Exploration of Sustainable Energy (9)**<br>15S / 15E / 15M<br>10S / 10E / 10M | 8233<br>**Introduction to Sustainable Energy (10)**<br>20S / 20E / 20M | 8234<br>**Sustainable Energy: Electrical Systems (11A)**<br>30S / 30E / 30M | 8245<br>**Sustainable Energy: Heating/Cooling Systems (11B)**<br>30S / 30E / 30M | 8246<br>**Sustainable Energy: Transportation Systems (11C)**<br>30S / 30E / 30M |
|---|---|---|---|---|
| **Goal 1:** Describe and apply appropriate **health and safety practices** as they relate to the sustainable energy industry. | | | | |
| **GLO 1.1:** Demonstrate adherence to **safety practices and procedures** for **facilities, processes, tools, and equipment** used in the sustainable energy industry. | | | | |
| 9.1.1.1 Demonstrate adherence to safety practices and procedures for facilities, processes, tools, and equipment used in the sustainable energy industry. | 10.1.1.1 → | 11A.1.1.1 → | 11B.1.1.1 → | 11C.1.1.1 → |
| 9.1.1.2 Identify health and safety requirements. | 10.1.1.2 → | 11A.1.1.2 → | 11B.1.1.2 → | 11C.1.1.2 → |
| 9.1.1.3 Identify personal protective equipment (PPE) and procedures. | 10.1.1.3 → | 11A.1.1.3 → | 11B.1.1.3 → | 11C.1.1.3 → |
| 9.1.1.4 Identify electrical safety practices and procedures. | 10.1.1.4 → | 11A.1.1.4 → | 11B.1.1.4 → | 11C.1.1.4 → |

| 8232<br>**Exploration of Sustainable Energy (9)**<br>15S / 15E / 15M<br>10S / 10E / 10M | 8233<br>**Introduction to Sustainable Energy (10)**<br>20S / 20E / 20M | 8234<br>**Sustainable Energy: Electrical Systems (11A)**<br>30S / 30E / 30M | 8245<br>**Sustainable Energy: Heating/Cooling Systems (11B)**<br>30S / 30E / 30M | 8246<br>**Sustainable Energy: Transportation Systems (11C)**<br>30S / 30E / 30M |
|---|---|---|---|---|
| **Goal 1:** Describe and apply appropriate **health and safety practices** as they relate to the sustainable energy industry. *(continued)*<br>**GLO 1.1:** Demonstrate adherence to **safety practices and procedures** for **facilities, processes, tools, and equipment** used in the sustainable energy industry. *(continued)* | | | | |
| 9.1.1.5 Identify fire safety practices and procedures. | 10.1.1.5 → | 11A.1.1.5 → | 11B.1.1.5 → | 11C.1.1.5 → |
| 9.1.1.6 Identify ergonomic considerations related to the sustainable energy industry. | 10.1.1.6 → | 11A.1.1.6 → | 11B.1.1.6 → | 11C.1.1.6 → |
| 9.1.1.7 Identify hazard recognition and control practices. | 10.1.1.7 → | 11A.1.1.7 → | 11B.1.1.7 → | 11C.1.1.7 → |
| 9.1.1.8 Describe the hazards of confined space entry. | 10.1.1.8 → | 11A.1.1.8 → | 11B.1.1.8 → | 11C.1.1.8 → |
| 9.1.1.9 Identify safety requirements as they apply to the Workplace Hazardous Materials Information System (WHMIS). | 10.1.1.9 → | 11A.1.1.9 → | 11B.1.1.9 → | 11C.1.1.9 → |

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|---|---|---|---|---|
| **Goal 1:** Describe and apply appropriate **health and safety practices** as they relate to the sustainable energy industry. *(continued)*<br>**GLO 1.1:** Demonstrate adherence to **safety practices and procedures** for **facilities, processes, tools, and equipment** used in the sustainable energy industry. *(continued)* | | | | |
| 9.1.1.10 Describe the identification and control of specified hazards. | 10.1.1.10 → | 11A.1.1.10 → | 11B.1.1.10 → | 11C.1.1.10 → |
| 9.1.1.11 Identify safe work practices related to the sustainable energy industry. | 10.1.1.11 → | 11A.1.1.11 → | 11B.1.1.11 → | 11C.1.1.11 → |
| 9.1.1.12 Identify safety guidelines related to the sustainable energy industry. | 10.1.1.12 → | 11A.1.1.12 → | 11B.1.1.12 → | 11C.1.1.12 → |
| 9.1.1.13 Identify safe material-handling procedures. | 10.1.1.13 → | 11A.1.1.13 → | 11B.1.1.13 → | 11C.1.1.13 → |
| 9.1.1.14 Read, interpret, and communicate safety information (e.g., material safety data sheets [MSDS]) related to sustainable energy. | 10.1.1.14 → | 11A.1.1.14 → | 11B.1.1.14 → | 11C.1.1.14 → |

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|---|---|---|---|---|
| **Goal 1:** Describe and apply appropriate **health and safety practices** as they relate to the sustainable energy industry. *(continued)*<br>**GLO 1.1:** Demonstrate adherence to **safety practices and procedures** for **facilities, processes, tools, and equipment** used in the sustainable energy industry. *(continued)* | | | | |
| | 10.1.1.15 Demonstrate safe practices for working from heights, including ladder safety. | 11A.1.1.15 → | 11B.1.1.15 → | 11C.1.1.15 Demonstrate safe practices for working on vehicles. |
| | 10.1.1.16 Demonstrate safe practices for working with fire, including air quality considerations. | 11A.1.1.16 Demonstrate an understanding of work-site safety at wind farms. | 11B.1.1.16 Demonstrate safe practices for working with fire, including air quality considerations. | |
| | 10.1.1.17 Demonstrate safe boating practices. | 11A.1.1.17 Demonstrate safe practices for working with electrical systems.<br>11A.1.1.18 Demonstrate safe practices for solar panel installation. | 11B.1.1.17 Demonstrate safe practices for working in confined spaces. | |

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|---|---|---|---|---|
| **Goal 2:** Demonstrate the safe and appropriate **operation, handling, cleaning, maintenance, and storage** of **equipment, tools, materials, products, and consumable items**. | | | | |
| **GLO 2.1:** Demonstrate the safe and appropriate **operation and handling** of equipment, tools, materials, products, and consumable items. | | | | |
| 9.2.1.1 Demonstrate the safe and appropriate operation and handling of hand tools (e.g., hammer, saw, screwdriver, wrench, pliers, metal cutters, utility knife). | 10.2.1.1 → | 11A.2.1.1 → | 11B.2.1.1 → | 11C.2.1.1 → |
| 9.2.1.2 Demonstrate the safe and appropriate operation and handling of power tools (e.g., drill, skill saw, table saw). | 10.2.1.2 → | 11A.2.1.2 → | 11B.2.1.2 → | 11C.2.1.2 → |
| | | 11A.2.1.3 Demonstrate the safe and appropriate operation and handling of instruments related to electrical work. | 11B.2.1.3 Demonstrate the safe and appropriate operation and handling of instruments (e.g., for monitoring temperature, air quality) related to heating/cooling with sustainable energy. | 11C.2.1.3 Demonstrate the safe and appropriate operation and handling of instruments related to electric and hydrogen-powered vehicles. |

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| **Goal 2:** Demonstrate the safe and appropriate **operation, handling, cleaning, maintenance, and storage** of **equipment, tools, materials, products, and consumable items**. *(continued)*<br>**GLO 2.2:** Demonstrate the safe and appropriate **cleaning, maintenance, and storage** of equipment, tools, materials, products, and consumable items. | | | | |
| 9.2.2.1 Demonstrate the safe and appropriate cleaning, maintenance, and storage of hand tools (e.g., hammer, saw, screwdriver, wrench, pliers, metal cutters, utility knife). | 10.2.2.1 → | 11A.2.2.1 → | 11B.2.2.1 → | 11C.2.2.1 → |
| 9.2.2.2 Demonstrate the safe and appropriate cleaning, maintenance, and storage of power tools (e.g., drill, skill saw, table saw). | 10.2.2.2 → | 11A.2.2.2 → | 11B.2.2.2 → | 11C.2.2.2 → |

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| **Goal 2:** Demonstrate the safe and appropriate **operation, handling, cleaning, maintenance, and storage** of **equipment, tools, materials, products, and consumable items**. *(continued)*<br>**GLO 2.2:** Demonstrate the safe and appropriate **cleaning, maintenance, and storage** of equipment, tools, materials, products, and consumable items. *(continued)* | | | | |
| | | | 11B.2.2.3 Demonstrate the safe and appropriate storage of feedstock for use as biomass heating fuel.<br><br>11B.2.2.4 Demonstrate the safe and appropriate storage of solar thermal equipment and materials.<br><br>11B.2.2.5 Demonstrate the safe and appropriate storage of geothermal equipment and materials. | |

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| **Goal 3:** Demonstrate an understanding of **demand-side management (DSM)** as it applies to sustainable energy.<br>**GLO 3.1:** Demonstrate an understanding of **DSM** as it applies to sustainable energy. | | | | |
| | 10.3.1.1 Demonstrate an awareness of the benefits of reducing energy consumption. | 11A.3.1.1 Define *demand-side management* (DSM) and demonstrate an awareness of its place in energy systems, including the benefits of DSM and retrofitting existing electrical systems. | 11B.3.1.1 Demonstrate an awareness of energy-efficient heating and cooling systems. | 11C.3.1.1 Demonstrate an awareness of energy-efficient vehicles, transportation systems, mass transit, and active transportation systems. |
| | 10.3.1.2 Demonstrate an awareness of strategies for reducing energy consumption. | | 11B.3.1.2 Demonstrate an awareness of the retrofitting of existing heating and cooling systems. | |

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| **Goal 4:** Demonstrate the knowledge and skills required to **promote and plan sustainable energy systems**. | | | | |
| **GLO 4.1:** Demonstrate the knowledge and skills required to **promote** sustainable energy systems. | | | | |
| | 10.4.1.1 Describe the advantages and disadvantages of using hydrocarbons as an energy source. | 11A.4.1.1 Describe the advantages and disadvantages of different types of wind turbines. | 11B.4.1.1 Demonstrate an understanding of the different heating/cooling system options (e.g., ground-source heat pump [GSHP], solar air, solar water, biomass energy systems). | 11C.4.1.1 Describe the environmental, economic, and energy security advantages of electric and hydrogen-powered vehicles compared to those of fossil-fuel-powered vehicles. |
| | 10.4.1.2 Describe sustainable energy sources and how they differ from conventional energy sources. | 11A.4.1.2 Identify the advantages and disadvantages of wind- and solar-generated electricity. | 11B.4.1.2 Demonstrate an understanding of the energy savings of sustainable energy systems compared to those of conventional systems. | 11C.4.1.2 Demonstrate an understanding of the basic components of electric, hybrid, and hydrogen-powered vehicles. |
| | 10.4.1.3 Demonstrate an understanding of different uses of sustainable energy (e.g., electricity, heating/cooling, transportation). | 11A.4.1.3 Differentiate between direct and indirect solar energy, thermal and photovoltaic (PV) energy, and active and passive solar energy systems. | 11B.4.1.3 Demonstrate an understanding of the function of the basic GSHP components (e.g., heat pump, earth connection, heating/cooling-distribution system). | |

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| **Goal 4:** Demonstrate the knowledge and skills required to **promote and plan sustainable energy systems**. *(continued)*<br>**GLO 4.1:** Demonstrate the knowledge and skills required to **promote** sustainable energy systems. *(continued)* | | | | |
| | 10.4.1.4 Demonstrate an understanding of solar energy distribution and the role solar energy plays in sustainable energy sources. | 11A.4.1.4 Demonstrate an understanding of the function of the basic components (e.g., rotor, gearbox, tower, foundation, control system) of wind turbines. | 11B.4.1.4 Demonstrate an understanding of the function of the basic components (e.g., heating plant, heat-distribution system, biomass fuel-supply operation) of biomass heating systems. | |
| | 10.4.1.5 Calculate greenhouse gas emissions for various energy sources. | 11A.4.1.5 Demonstrate an understanding of the function of the basic components (e.g., collectors, batteries, inverters, controllers, structure) of solar PV systems. | 11B.4.1.5 Demonstrate an understanding of the function of the basic components (e.g., optimal window surface area, orientation, thermal properties) of passive solar heat systems. | |

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| **Goal 4:** Demonstrate the knowledge and skills required to **promote and plan sustainable energy systems**. *(continued)* | | | | |
| **GLO 4.1:** Demonstrate the knowledge and skills required to **promote** sustainable energy systems. *(continued)* | | | | |
| | 10.4.1.6 Conduct a home energy audit. | | 11B.4.1.6 Demonstrate an understanding of the function of the basic components (e.g., collection, transfer, storage) of solar hot water systems. | |
| | 10.4.1.7 Demonstrate an understanding of various economic incentives related to sustainable energy. | | 11B.4.1.7 Demonstrate an understanding of the function of the basic components (e.g., solar collector, air-distribution system) of solar air systems. | |
| | 10.4.1.8 Describe various sites in Manitoba that use sustainable energy or that conduct research and undertake development in the area of sustainable energy. | | | |

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| **Goal 4:** Demonstrate the knowledge and skills required to **promote and plan sustainable energy systems**. *(continued)*<br>**GLO 4.2:** Demonstrate the knowledge and skills required to **plan** sustainable energy systems. | | | | |
| | 10.4.2.1 Evaluate various sustainable energy options (e.g., using RETScreen software). | 11A.4.2.1 Conduct an economic feasibility analysis of switching from hydroelectricity to wind- or solar-generated electricity. | 11B.4.2.1 Demonstrate an understanding of the site considerations (e.g., permits, soil characterization, sun exposure) involved in planning sustainable heating/cooling systems. | 11C.4.2.1 Demonstrate an understanding of the importance of energy efficiency in designing electric and hybrid vehicles. |
| | | 11A.4.2.2 Conduct a wind resource assessment. | 11B.4.2.2 Demonstrate an understanding of how to size sustainable energy heating/cooling systems. | 11C.4.2.2 Demonstrate an understanding of the infrastructure needed to support electric and hydrogen-powered vehicles. |
| | | 11A.4.2.3 Determine the most appropriate sites for solar PV systems. | 11B.4.2.3 Demonstrate an understanding of proper product selection (e.g., tubing, collector, storage) related to heating/ cooling systems. | |
| | | 11A.4.2.4 Determine the most appropriate sites for wind farms. | | |

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| **Goal 5:** Demonstrate the knowledge and skills required to **install or convert sustainable energy systems**. | | | | |
| **GLO 5.1:** Demonstrate the knowledge and skills required to **perform the installation or conversion** of sustainable energy systems. | | | | |
| | | 11A.5.1.1 Demonstrate the skills needed to install a small wind turbine. | 11B.5.1.1 Demonstrate an understanding of GSHP installation basics (e.g., excavation, loop options, orientations). | 11C.5.1.1 Demonstrate an understanding of the basics of converting a vehicle from using conventional power sources (e.g., human-powered bicycle, gas-powered vehicle) to using electric power sources. |
| | | 11A.5.1.2 Demonstrate the skills needed to install a solar PV system. | 11B.5.1.2 Demonstrate an understanding of solar air system installation basics.<br>11B.5.1.3 Demonstrate an understanding of solar water system installation basics.<br>11B.5.1.4 Demonstrate an understanding of passive solar system installation basics.<br>11B.5.1.5 Demonstrate an understanding of biomass system installation basics. | |

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| **Goal 6:** Demonstrate the knowledge and skills required to **maintain sustainable energy systems**. | | | | |
| **GLO 6.1:** Demonstrate the knowledge and skills required to **perform preventive maintenance** of sustainable energy systems. | | | | |
| | | 11A.6.1.1 Demonstrate preventive maintenance of wind turbines and rotors. | 11B.6.1.1 Demonstrate adherence to manufacturers' warrantee conditions for installing sustainable heating/cooling systems (GSHP, solar air, solar water, passive solar, and biomass). | 11C.6.1.1 Demonstrate adherence to manufacturers' warrantee conditions for electric and hydrogen-powered vehicles. |
| | | 11A.6.1.2 Demonstrate preventive maintenance of solar PV systems. | 11B.6.1.2 Perform preventive maintenance of sustainable heating/ cooling systems. | 11C.6.1.2 Discuss the relationship between preventive maintenance and energy efficiency in transportation systems. |

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| **Goal 6:** Demonstrate the knowledge and skills required to **maintain sustainable energy systems**. *(continued)* | | | | |
| **GLO 6.2:** Demonstrate the knowledge and skills required to **diagnose malfunctions** in sustainable energy systems. | | | | |
| | | 11A.6.2.1 Demonstrate tests to diagnose failures in wind turbines and rotors. | 11B.6.2.1 Read site and system schematics for installing GSHP, solar air, solar water, passive solar, and biomass systems. | 11C.6.2.1 Demonstrate an understanding of vehicle diagnostics. |
| | | 11A.6.2.2 Demonstrate tests to diagnose failures in solar PV systems. | | |
| **GLO 6.3:** Demonstrate the knowledge and skills required to **repair** sustainable energy systems. | | | | |
| | | 11A.6.3.1 Demonstrate the knowledge and skills required to repair failures in small wind turbine systems. | 11B.6.3.1 Demonstrate an understanding of how to select an appropriate maintenance contractor for installing GSHP, solar air, solar water, passive solar, and biomass systems. | 11C.6.3.1 Demonstrate an understanding of how to select a qualified service provider for electric and hybrid vehicles. |
| | | 11A.6.3.2 Demonstrate the knowledge and skills required to repair failures in solar PV systems. | | |

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| **Goal 7:** Describe and apply transferable **cross-curricular knowledge and skills** as they relate to sustainable energy. | | | | |
| **GLO 7.1:** Demonstrate **information and communication technology** skills required in the sustainable energy industry. | | | | |
| 9.7.1.1 Demonstrate the use of information and communication technology to research topics in sustainable energy. | 10.7.1.1 → | 11A.7.1.1 → | 11B.7.1.1 → | 11C.7.1.1 → |
| | 10.7.1.2 Explore problems and issues that demonstrate the interdependence of science, technology, society, and the environment. | | 11B.7.1.2 Demonstrate an understanding of how to communicate with a variety of trade sectors (e.g., drillers, electricians, biomass feedstock providers).<br><br>11B.7.1.3 Demonstrate the use of spreadsheet-based software in modelling, and in calibrating models of, heating systems.<br><br>11B.7.1.4 Demonstrate project-management skills, such as procurement, tracking, and billing. | |

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| **Goal 7:** Describe and apply transferable **cross-curricular knowledge and skills** as they relate to sustainable energy. *(continued)* | | | | |
| **GLO 7.2: Read, interpret, and communicate information** related to the sustainable energy industry. | | | | |
| | | 11A.7.2.1 Demonstrate an understanding of provincial and federal policy related to solar- and wind-generated electricity. | 11B.7.2.1 Demonstrate the ability to read and interpret system schematics. | 11C.7.2.1 → |
| | | | 11B.7.2.2 Demonstrate the ability to read and interpret a manufacturer's warrantee. | |
| **GLO 7.3:** Demonstrate knowledge of **mathematical** concepts and skills related to the sustainable energy industry. | | | | |
| 9.7.3.1 Solve problems involving fractions. | 10.7.3.1 → | 11A.7.3.1 → | 11B.7.3.1 → | 11C.7.3.1 → |
| 9.7.3.2 Solve problems involving decimals. | 10.7.3.2 → | 11A.7.3.2 → | 11B.7.3.2 → | 11C.7.3.2 → |
| 9.7.3.3 Solve problems involving percentages and ratios. | 10.7.3.3 → | 11A.7.3.3 → | 11B.7.3.3 → | 11C.7.3.3 → |

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| **Goal 7:** Describe and apply transferable **cross-curricular knowledge and skills** as they relate to sustainable energy. *(continued)*<br>**GLO 7.3:** Demonstrate knowledge of **mathematical** concepts and skills related to the sustainable energy industry. *(continued)* | | | | |
| 9.7.3.4 Solve problems involving measurements. | 10.7.3.4 Solve problems involving metric and imperial measurements. | 11A.7.3.4 → | 11B.7.3.4 → | 11C.7.3.4 → |
| 9.7.3.5 Solve problems involving geometric formulas. | 10.7.3.5 → | 11A.7.3.5 → | 11B.7.3.5 → | 11C.7.3.5 → |
| | | 11A.7.3.6 Discuss the importance of the Reynolds number as it relates to wind turbines. | 11B.7.3.6 Calculate quality parameters (e.g., moisture content, volatile matter content) of biomass feedstock. | 11C.7.3.6 Demonstrate an understanding of Newton's laws of motion. |
| | | 11A.7.3.7 Discuss the importance of the angle of attack as it relates to wind turbines. | 11B.7.3.7 Demonstrate an understanding of the usable incident solar energy calculation. | |
| | | 11A.7.3.8 Discuss the importance of resultant velocity as it relates to wind turbines. | 11B.7.3.8 Demonstrate an understanding of the Fourier law of heat conduction. | |
| | | 11A.7.3.9 Discuss the importance of the power curve as it relates to wind turbines. | 11B.7.3.9 Demonstrate an understanding of Newton's law of cooling (R-value). | |

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| **Goal 7:** Describe and apply transferable **cross-curricular knowledge and skills** as they relate to sustainable energy. *(continued)* | | | | |
| **GLO 7.3:** Demonstrate knowledge of **mathematical** concepts and skills related to the sustainable energy industry. *(continued)* | | | | |
| | | 11A.7.3.10 Demonstrate an understanding of the importance of the Betz limit as it relates to wind turbines.<br><br>11A.7.3.11 Demonstrate an understanding of the importance of the tip speed ratio (TSR) as it relates to wind turbines.<br><br>11A.7.3.12 Calculate how much solar energy strikes various surfaces.<br><br>11A.7.3.13 Calculate solar collector efficiency.<br><br>11A.7.3.14 Describe solar orientation related to solar energy. | | |

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| **Goal 7:** Describe and apply transferable **cross-curricular knowledge and skills** as they relate to sustainable energy. *(continued)* | | | | |
| **GLO 7.4:** Demonstrate knowledge of **science** as it relates to the sustainable energy industry. | | | | |
| | 10.7.4.1 Differentiate between the various forms of energy. | 11A.7.4.1 Demonstrate knowledge of science as it relates to sustainable electrical systems. | 11B.7.4.1 Demonstrate knowledge of science as it relates to sustainable heating/cooling systems. | 11C.7.4.1 Demonstrate knowledge of science as it relates to sustainable transportation systems. |
| | 10.7.4.2 Differentiate between power and energy. | 11A.7.4.2 Demonstrate an understanding of electronic principles as they relate to generating electricity with wind and solar energy. | 11B.7.4.2 Describe the difference between heat and temperature. | 11C.7.4.2 Demonstrate an understanding of automotive aerodynamic considerations (e.g., drag, lift, down force). |
| | 10.7.4.3 Identify the origins and major sources of hydrocarbons. | 11A.7.4.3 Describe the electromagnetic spectrum in terms of frequency, wavelength, and energy. | 11B.7.4.3 Demonstrate an understanding of the laws of thermodynamics. | 11C.7.4.3 Demonstrate a basic knowledge of electric motors. |
| | 10.7.4.4 Convert between the various energy units (e.g., British thermal units [BTUs], joules). | | 11B.7.4.4 Demonstrate an understanding of latent heat. | 11C.7.4.4 Demonstrate an understanding of the process of hydrolysis. |

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| **Goal 7:** Describe and apply transferable **cross-curricular knowledge and skills** as they relate to sustainable energy. *(continued)*<br>**GLO 7.4:** Demonstrate knowledge of **science** as it relates to the sustainable energy industry. *(continued)* | | | | |
| | | | 11B.7.4.5 Demonstrate an understanding of heat-transfer mechanisms (e.g., conduction, convection, radiation).<br><br>11B.7.4.6 Demonstrate an understanding of combustion basics.<br><br>11B.7.4.7 Demonstrate an understanding of the refrigeration cycle. | |

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| **Goal 7:** Describe and apply transferable **cross-curricular knowledge and skills** as they relate to sustainable energy. *(continued)*<br>**GLO 7.5:** Demonstrate knowledge of **physical education/health education** as it relates to the sustainable energy industry. | | | | |
| | 10.7.5.1 Identify first aid and cardiopulmonary resuscitation (CPR) procedures. | 11A.7.5.1 Discuss the level of fitness needed to work on large wind turbines. | 11B.7.5.1 Demonstrate proper lifting techniques to avoid back injury. | |
| | | 11A.7.5.2 Discuss the stress (e.g., noise pollution, aesthetic concerns) experienced by neighbours of large wind turbines. | 11B.7.5.2 Ensure proper ventilation while working with biomass systems to avoid exposure to toxic exhaust. | |

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| **Goal 8:** Demonstrate an understanding of the **ethical and legal standards** that pertain to the sustainable energy industry. | | | | |
| **GLO 8.1:** Demonstrate an awareness of the **ethical and legal expectations** of the sustainable energy industry. | | | | |
| | 10.8.1.1 Demonstrate an understanding of the importance of accurate performance reporting of sustainable energy technologies. | 11A.8.1.1 Demonstrate an understanding of the ethical responsibility of communicating with neighbours prior to the installation of solar or wind systems. | 11B.8.1.1 Demonstrate an understanding of the importance of the contractor-consumer relationship, which should involve full disclosure. | 11C.8.1.1 Demonstrate an understanding of the importance of accurate performance reporting for electric vehicles. |
| | 10.8.1.2 Demonstrate an understanding of when sustainable energy projects legally require impact assessments. | 11A.8.1.2 Demonstrate an understanding of the criteria that trigger federal regulatory processes for solar and wind energy projects. | 11B.8.1.2 Demonstrate an understanding of the need to adhere to local authority requirements (e.g., permit regulations) related to heating/ cooling systems. | |

| 8232<br>**Exploration of Sustainable Energy (9)**<br>15S / 15E / 15M<br>10S / 10E / 10M | 8233<br>**Introduction to Sustainable Energy (10)**<br>20S / 20E / 20M | 8234<br>**Sustainable Energy: Electrical Systems (11A)**<br>30S / 30E / 30M | 8245<br>**Sustainable Energy: Heating/Cooling Systems (11B)**<br>30S / 30E / 30M | 8246<br>**Sustainable Energy: Transportation Systems (11C)**<br>30S / 30E / 30M |
|---|---|---|---|---|
| **Goal 9:** Practise **employability skills** required in the sustainable energy industry.<br>**GLO 9.1:** Demonstrate **employability skills**. | | | | |
| 9.9.1.1 Demonstrate problem-solving skills. | 10.9.1.1 → | 11A.9.1.1 → | 11B.9.1.1 → | 11C.9.1.1 → |
| 9.9.1.2 Demonstrate critical thinking skills. | 10.9.1.2 → | 11A.9.1.2 → | 11B.9.1.2 → | 11C.9.1.2 → |
| 9.9.1.3 Demonstrate regular attendance and punctuality. | 10.9.1.3 → | 11A.9.1.3 → | 11B.9.1.3 → | 11C.9.1.3 → |
| 9.9.1.4 Demonstrate accountability by taking responsibility for own actions. | 10.9.1.4 → | 11A.9.1.4 → | 11B.9.1.4 → | 11C.9.1.4 → |
| 9.9.1.5 Demonstrate adaptability, initiative, and effort. | 10.9.1.5 → | 11A.9.1.5 → | 11B.9.1.5 → | 11C.9.1.5 → |
| 9.9.1.6 Demonstrate the ability to accept feedback and to follow direction. | 10.9.1.6 → | 11A.9.1.6 → | 11B.9.1.6 → | 11C.9.1.6 → |

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|---|---|---|---|---|
| **Goal 9:** Practise **employability skills** required in the sustainable energy industry. *(continued)*<br>**GLO 9.1:** Demonstrate **employability skills**. *(continued)* | | | | |
| 9.9.1.7 Demonstrate teamwork skills. | 10.9.1.7 → | 11A.9.1.7 → | 11B.9.1.7 → | 11C.9.1.7 → |
| 9.9.1.8 Demonstrate the ability to stay on task and to make effective use of time in class and shop environments. | 10.9.1.8 → | 11A.9.1.8 → | 11B.9.1.8 → | 11C.9.1.8 → |
| 9.9.1.9 Demonstrate the ability to communicate respectfully and effectively with co-workers and customers. | 10.9.1.9 → | 11A.9.1.9 → | 11B.9.1.9 → | 11C.9.1.9 → |

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| **Goal 10:** Demonstrate an awareness of **sustainability** as it pertains to the sustainable energy industry. | | | | |
| **GLO 10.1:** Describe the impact of **sustainability** on the **health and well-being** of sustainable energy industry workers, their customers, and those who are affected by their products and services. | | | | |
| | 10.10.1.1 Discuss the impact of sustainable energy systems on human health and well-being. | 11A.10.1.1 Discuss the impact of sustainable electrical systems on human health and well-being. | 11B.10.1.1 Discuss the impact of sustainable heating/cooling systems on human health and well-being.<br><br>11B.10.1.2 Describe the relationship between the proper design and installation and the long-term sustainability of sustainable energy technologies.<br><br>11B.10.1.3 Describe how sustainable energy technologies address the issue of energy security. | |

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|---|---|---|---|---|
| **Goal 10:** Demonstrate an awareness of **sustainability** as it pertains to the sustainable energy industry. *(continued)*<br>**GLO 10.2:** Describe the sustainable energy industry's **sustainability practices and their impact on the environment**. | | | | |
| | 10.10.2.1 Describe how the use of sustainable energy can be sustainable from an environmental perspective. | 11A.10.2.1 Compare and contrast the environmental impact of hydroelectric dams and sustainable electrical energy sources. | 11B.10.2.1 Demonstrate the understanding that switching from conventional to sustainable heating/ cooling systems will reduce greenhouse gas emissions. | |
| | 10.10.2.2 Describe how sustainable energy use produces less greenhouse gas than conventional energy use. | 11A.10.2.2 Demonstrate an understanding of the impact of wind turbines on birds and bats. | | |

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|---|---|---|---|---|
| **Goal 10:** Demonstrate an awareness of **sustainability** as it pertains to the sustainable energy industry. *(continued)* | | | | |
| **GLO 10.3:** Describe the **relationship between the economy and sustainability practices** within the sustainable energy industry. | | | | |
| | 10.10.3.1 Describe how the use of sustainable energy can be sustainable from an economic perspective. | 11A.10.3.1 Describe Manitoba Hydro's economic strategy related to sustainable sources of electricity. | 11B.10.3.1 Describe Manitoba's provincial strategy for using energy as a source of economic development and wealth retention. | |
| | 10.10.3.2 Describe current economic factors that are promoting sustainable energy. | | 11B.10.3.2 Describe how biomass heating systems can add value to agricultural crops. | |

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| **Goal 11:** Demonstrate an understanding of **career options** in sustainable energy. | | | | |
| **GLO 11.1:** Describe **apprenticeship, post-secondary education, and employment opportunities** related to sustainable energy. | | | | |
| | 10.11.1.1 Demonstrate an understanding of the various sustainable energy training opportunities available locally, nationally, and internationally. | 11A.11.1.1 Demonstrate an understanding of the various apprenticeship programs available in the area of electrical systems, especially as they relate to sustainable energy. | 11B.11.1.1 Demonstrate an understanding of the various apprenticeship programs available in the area of heating/ cooling systems, especially as they relate to sustainable energy. | 11C.11.1.1 Demonstrate an understanding of the various apprenticeship programs available in the area of transportation systems, especially as they relate to sustainable energy. |
| | 10.11.1.2 Demonstrate an understanding of employment opportunities available within the sustainable energy sector. | 11A.11.1.2 Demonstrate an understanding of the various post-secondary degree and diploma programs available in the area of electrical systems, especially as they relate to sustainable energy. | 11B.11.1.2 Demonstrate an understanding of the various post-secondary degree and diploma programs available in the area of heating/ cooling systems, especially as they relate to sustainable energy. | 11C.11.1.2 Demonstrate an understanding of the various post-secondary degree and diploma programs available in the area of transportation systems, especially as they relate to sustainable energy. |

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|---|---|---|---|---|
| **Goal 11:** Demonstrate an understanding of **career options** in sustainable energy. *(continued)* | | | | |
| **GLO 11.1:** Describe **apprenticeship, post-secondary education, and employment opportunities** related to sustainable energy. *(continued)* | | | | |
| | | 11A.11.1.3 Demonstrate an understanding of the various entry- and advanced-level employment opportunities available in the area of electrical systems, especially as they relate to sustainable energy. | 11B.11.1.3 Demonstrate an understanding of the various entry- and advanced-level employment opportunities available in the area of heating/cooling systems, especially as they relate to sustainable energy. | 11C.11.1.3 Demonstrate an understanding of the various entry- and advanced-level employment opportunities available in the area of transportation systems, especially as they relate to sustainable energy. |

| 8232<br>**Exploration of Sustainable Energy (9)**<br>15S / 15E / 15M<br>10S / 10E / 10M | 8233<br>**Introduction to Sustainable Energy (10)**<br>20S / 20E / 20M | 8234<br>**Sustainable Energy: Electrical Systems (11A)**<br>30S / 30E / 30M | 8245<br>**Sustainable Energy: Heating/Cooling Systems (11B)**<br>30S / 30E / 30M | 8246<br>**Sustainable Energy: Transportation Systems (11C)**<br>30S / 30E / 30M |
|---|---|---|---|---|
| **Goal 12:** Demonstrate an understanding of the **evolution** of sustainable energy, including its **technological progression** and **emerging trends**.<br>**GLO 12.1:** Demonstrate an understanding of the **evolution** of sustainable energy, including its **technological progression** and **emerging trends**. | | | | |
| 9.12.1.1 Discuss how the cost of sustainable energy technologies per unit decreases and performance increases over time. | 10.12.1.1 → | 11A.12.1.1 → | 11B.12.1.1 → | 11C.12.1.1 → |
| 9.12.1.2 Discuss how sustainable energy systems will become economically more attractive as fossil fuels become scarcer. | 10.12.1.2 → | 11A.12.1.2 → | 11B.12.1.2 → | 11C.12.1.2 → |
| | 10.12.1.3 Demonstrate an understanding of the technological progression of and emerging trends in sustainable energy within Manitoba. | 11A.12.1.3 Demonstrate an understanding of the latest industry trends. | 11B.12.1.3 → | 11C.12.1.3 → |

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|---|---|---|---|---|
| **Goal 12:** Demonstrate an understanding of the **evolution** of sustainable energy, including its **technological progression** and **emerging trends**. *(continued)*<br>**GLO 12.1:** Demonstrate an understanding of the **evolution** of sustainable energy, including its **technological progression** and **emerging trends**. *(continued)* | | | | |
| | 10.12.1.4 Demonstrate an understanding of the history of human energy use and related changes to the environment. | 11A.12.1.4 Demonstrate an understanding of the rationale for utility-scale wind farms in Manitoba. | | 11C.12.1.4 Demonstrate an understanding of the provincial strategy for electric vehicles (e.g., *Manitoba's Electric Vehicle Road Map*, Manitoba Innovation, Energy and Mines). |

# GRADE 12 SUSTAINABLE ENERGY

General and Specific Learning Outcomes by Goal

# Grade 12 Sustainable Energy: General and Specific Learning Outcomes by Goal

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 1:** Describe and apply appropriate **health and safety practices** as they relate to the sustainable energy industry. | | |
| **GLO 1.1:** Demonstrate adherence to **safety practices and procedures** for **facilities, processes, tools, and equipment** used in the sustainable energy industry. | | |
| 12A.1.1.1 Demonstrate adherence to safety practices and procedures for facilities, processes, tools, and equipment used in the sustainable energy industry. | 12B.1.1.1 → | 12C.1.1.1 → |
| 12A.1.1.2 Describe health and safety requirements. | 12B.1.1.2 → | 12C.1.1.2 → |
| 12A.1.1.3 Describe personal protective equipment (PPE) and procedures. | 12B.1.1.3 → | 12C.1.1.3 → |
| 12A.1.1.4 Describe electrical safety practices and procedures. | 12B.1.1.4 → | 12C.1.1.4 → |
| 12A.1.1.5 Describe fire safety practices and procedures. | 12B.1.1.5 → | 12C.1.1.5 → |
| 12A.1.1.6 Describe ergonomic considerations related to the sustainable energy industry. | 12B.1.1.6 → | 12C.1.1.6 → |

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 1:** Describe and apply appropriate **health and safety practices** as they relate to the sustainable energy industry. *(continued)*<br>**GLO 1.1:** Demonstrate adherence to **safety practices and procedures** for **facilities, processes, tools, and equipment** used in the sustainable energy industry. *(continued)* | | |
| 12A.1.1.7 Describe hazard recognition and control practices. | 12B.1.1.7 → | 12C.1.1.7 → |
| 12A.1.1.8 Describe the hazards of confined space entry. | 12B.1.1.8 → | 12C.1.1.8 → |
| 12A.1.1.9 Describe safety requirements as they apply to the Workplace Hazardous Materials Information System (WHMIS). | 12B.1.1.9 → | 12C.1.1.9 → |
| 12A.1.1.10 Describe the identification and control of specified hazards. | 12B.1.1.10 → | 12C.1.1.10 → |
| 12A.1.1.11 Demonstrate safe work practices related to the sustainable energy industry. | 12B.1.1.11 → | 12C.1.1.11 → |
| 12A.1.1.12 Describe safety guidelines related to the sustainable energy industry. | 12B.1.1.12 → | 12C.1.1.12 → |

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|---|---|---|
| **Goal 2:** Demonstrate the safe and appropriate **operation, handling, cleaning, maintenance, and storage** of **equipment, tools, materials, products, and consumable items**. | | |
| **GLO 2.1:** Demonstrate the safe and appropriate **operation and handling** of equipment, tools, materials, products, and consumable items. | | |
| 12A.2.1.1 Demonstrate the safe and appropriate operation and handling of equipment, tools, materials, products, and consumable items used in solar energy systems. | 12B.2.1.1 Demonstrate the safe and appropriate operation and handling of equipment, tools, materials, products, and consumable items used in wind energy systems. | 12C.2.1.1 Demonstrate the safe and appropriate operation and handling of equipment, tools, materials, products, and consumable items used in biomass energy systems. |
| **GLO 2.2:** Demonstrate the safe and appropriate **cleaning, maintenance, and storage** of equipment, tools, materials, products, and consumable items. | | |
| 12A.2.2.1 Demonstrate the safe and appropriate cleaning, maintenance, and storage of equipment, tools, materials, products, and consumable items used in solar energy systems. | 12B.2.2.1 Demonstrate the safe and appropriate cleaning, maintenance, and storage of equipment, tools, materials, products, and consumable items used in wind energy systems. | 12C.2.2.1 Demonstrate the safe and appropriate cleaning, maintenance, and storage of equipment, tools, materials, products, and consumable items used in biomass energy systems. |

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 3:** Demonstrate an understanding of **demand-side management (DSM)** as it applies to sustainable energy.<br>**GLO 3.1:** Demonstrate an understanding of **DSM** as it applies to sustainable energy. | | |
| 12A.3.1.1 Demonstrate an awareness of designs and processes that maximize the efficiency of solar energy systems. | 12B.3.1.1 Demonstrate an awareness of designs and processes that maximize the efficiency of wind energy systems. | 12C.3.1.1 Demonstrate an awareness of designs and processes that maximize the efficiency of biomass energy systems. |
| 12A.3.1.2 Demonstrate the ability to conduct a cost-benefit analysis of solar energy systems. | 12B.3.1.2 Demonstrate the ability to conduct a cost-benefit analysis of wind energy systems. | 12C.3.1.2 Demonstrate the ability to conduct a cost-benefit analysis of biomass energy systems. |

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 4:** Demonstrate the knowledge and skills required to **promote and plan sustainable energy systems**. | | |
| **GLO 4.1:** Demonstrate the knowledge and skills required to **promote** sustainable energy systems. | | |
| 12A.4.1.1 Describe existing strategies, both in the private and public sectors (e.g., Manitoba Growth, Enterprise and Trade, Manitoba Sustainable Energy Association, EnergyManitoba), that promote solar energy systems in Manitoba. | 12B.4.1.1 Describe existing strategies, both in the private and public sectors (e.g., Manitoba Growth, Enterprise and Trade, Manitoba Hydro, Manitoba Sustainable Energy Association, EnergyManitoba), that promote wind energy systems in Manitoba. | 12C.4.1.1 Describe existing strategies, both in the private and public sectors (e.g., Manitoba Growth, Enterprise and Trade, Manitoba Hydro, Manitoba Sustainable Energy Association, EnergyManitoba), that promote biomass energy systems in Manitoba. |
| **GLO 4.2:** Demonstrate the knowledge and skills required to **plan** sustainable energy systems. | | |
| 12A.4.2.1 Perform an energy audit for a building proposed as a site for the installation of a solar (photovoltaic [PV] or heat) energy system. | 12B.4.2.1 Perform an energy audit for a building proposed as a site for the installation of a small wind energy system. | 12C.4.2.1 Perform an energy audit for a building proposed as a site for the installation of a biomass energy (heating or electrical) system. |
| 12A.4.2.2 Evaluate solar resources of a proposed solar energy installation site. | 12B.4.2.2 Collect and analyze relevant baseline data (e.g., wind speed, direction) that will determine the efficiency of a small wind energy system. | 12C.4.2.2 Evaluate the energy content of feedstock options for a biomass energy system. |
| 12A.4.2.3 Collect and analyze relevant baseline data (e.g., sunlight hours, shading concerns, temperature, precipitation) that will determine the efficiency of a solar energy system. | 12B.4.2.3 Size a wind energy system according to a baseline data analysis (e.g., required total watt-hours/day, peak instantaneous power use, duty cycle, peak load versus base load). | 12C.4.2.3 Size a biomass energy system according to the energy content of feedstock options (e.g., total watt-hours/day, peak instantaneous power use, peak heat use, duty cycle, peak load versus base load). |

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 4:** Demonstrate the knowledge and skills required to **promote and plan sustainable energy systems**. *(continued)*<br>**GLO 4.2:** Demonstrate the knowledge and skills required to **plan** sustainable energy systems. *(continued)* | | |
| 12A.4.2.4 Size a solar energy system according to a baseline data analysis (e.g., required total watt-hours/day, peak instantaneous power use, peak heat use, duty cycle, peak load versus base load). | 12B.4.2.4 Determine an appropriate location (e.g., tower or roof mount) for a wind turbine, taking into account bylaw considerations. | 12C.4.2.4 Determine the current local availability of biomass feedstock, and predict future feedstock availability. |
| 12A.4.2.5 Determine an appropriate location (e.g., rooftop, ground) for PV panel mounts. | 12B.4.2.5 Select an appropriate wind turbine for a specific location (e.g., horizontal or vertical axis, cut-in speed, rated power). | 12C.4.2.5 Plan appropriate biomass feedstock logistics (e.g., delivery, storage). |
| 12A.4.2.6 Perform a roof inspection for PV panel mounts. | 12B.4.2.6 Determine an appropriate battery bank set-up for a wind energy system. | 12C.4.2.6 Determine an appropriate battery bank set-up for a biomass electrical system. |
| 12A.4.2.7 Determine an appropriate battery size and battery bank set-up for a PV system. | | 12C.4.2.7 Plan a small-scale set-up to produce biodiesel. |
| | | 12C.4.2.8 Discuss logistics (e.g., removal, storage) related to ash content in feedstock. |

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|---|---|---|
| **Goal 5:** Demonstrate the knowledge and skills required to **install or convert sustainable energy systems**.<br>**GLO 5.1:** Demonstrate the knowledge and skills required to **perform the installation or conversion** of sustainable energy systems. | | |
| 12A.5.1.1 Participate in the installation or conversion of a solar energy system (either PV or heat). | 12B.5.1.1 Participate in the installation or conversion of a small wind energy system. | 12C.5.1.1 Participate in the installation or conversion of a biomass energy system (for either electricity generation or heat). |
| 12A.5.1.2 Frame and mount PV panels. | | 12C.5.1.2 Produce a test batch of biodiesel, and run a small diesel engine with the biodiesel. |
| 12A.5.1.3 Interpret a PV system schematic. | | |
| 12A.5.1.4 Demonstrate an understanding of the various components (e.g., panels, inverter, charger controller, battery charger) of a PV system. | | |

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|---|---|---|
| **Goal 6:** Demonstrate the knowledge and skills required to **maintain sustainable energy systems**. | | |
| **GLO 6.1:** Demonstrate the knowledge and skills required to **perform preventive maintenance** of sustainable energy systems. | | |
| 12A.6.1.1 Perform preventive maintenance of sustainable energy systems.<br><br>12A.6.1.2 Monitor a solar energy system to determine whether it is operating to its designed specifications.<br><br>12A.6.1.3 Perform a visual inspection of PV panels to ensure they are not covered (e.g., by debris, snow). | 12B.6.1.1 Monitor a wind energy system to determine whether it is operating to its designed specifications. | 12C.6.1.1 Monitor a biomass energy system to determine whether it is operating to its designed specifications. |

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 6:** Demonstrate the knowledge and skills required to **maintain sustainable energy systems**. *(continued)*<br>**GLO 6.2:** Demonstrate the knowledge and skills required to **diagnose malfunctions** in sustainable energy systems. | | |
| 12A.6.2.1 Diagnose both external malfunctions (e.g., shading, debris, wildlife damage) and internal malfunctions (e.g., wiring problems, loose connections, blown fuses, tripped breakers) in solar PV systems. | 12B.6.2.1 Diagnose both external malfunctions (e.g., wildlife damage) and internal malfunctions (e.g., wiring problems, loose connections, blown fuses, tripped breakers) in wind energy systems. | 12C.6.2.1 Discuss the relationship between malfunctions and energy efficiency in biomass energy systems. |
| 12A.6.2.2 Monitor and collect data on solar thermal energy system performance (e.g., temperature, pressure, voltage, amperage, resistance). | | 12C.6.2.2 Describe the two levels (component and system levels) of troubleshooting biomass energy systems. |
| | | 12C.6.2.3 Monitor and collect data on biomass energy system performance (e.g., temperature, pressure, voltage, amperage, resistance). |

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|---|---|---|
| **Goal 6:** Demonstrate the knowledge and skills required to **maintain sustainable energy systems**. *(continued)*<br>**GLO 6.3:** Demonstrate the knowledge and skills required to **repair** sustainable energy systems. | | |
| 12A.6.3.1 Read and demonstrate an understanding of product warranties. | 12B.6.3.1 → | 12C.6.3.1 → |
| 12A.6.3.2 Repair solar energy systems. | 12B.6.3.2 Repair wind energy systems. | 12C.6.3.2 Repair biomass energy systems. |
| 12A.6.3.3 Replace/repair fuses, broken wires, and loose connections. | 12B.6.3.3 → | |

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 7:** Describe and apply transferable **cross-curricular knowledge and skills** as they relate to sustainable energy. | | |
| **GLO 7.1:** Demonstrate **information and communication technology** skills required in the sustainable energy industry. | | |
| 12A.7.1.1 Demonstrate how geographic information systems (GIS) can be used to determine locations for solar panel installations. | 12B.7.1.1 Demonstrate how geographic information systems (GIS) can be used to determine locations for wind farms. | 12C.7.1.1 Demonstrate how geographic information systems (GIS) can be used to inform decisions on fuel selection for biomass energy systems. |
| **GLO 7.2: Read, interpret, and communicate information** related to the sustainable energy industry. | | |
| 12A.7.2.1 Read, interpret, and communicate information related to solar energy systems. | 12B.7.2.1 Read, interpret, and communicate information related to wind energy systems. | 12C.7.2.1 Read, interpret, and communicate information related to biomass energy systems. |
| 12A.7.2.2 Read, interpret, and communicate information from electrical schematics. | 12B.7.2.2 → | 12C.7.2.2 → |

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 7:** Describe and apply transferable **cross-curricular knowledge and skills** as they relate to sustainable energy. *(continued)* | | |
| **GLO 7.3:** Demonstrate knowledge of **mathematical** concepts and skills related to the sustainable energy industry. | | |
| 12A.7.3.1 Demonstrate knowledge of mathematics skills related to solar PV systems. | 12B.7.3.1 Demonstrate knowledge of mathematics skills related to wind energy systems. | 12C.7.3.1 Demonstrate knowledge of mathematics skills related to biomass energy systems. |
| 12A.7.3.2 Convert between imperial and metric systems of measurement. | 12B.7.3.2 → | 12C.7.3.2 → |
| 12A.7.3.3 Demonstrate the use of fractions, decimals, ratios, and percentages. | 12B.7.3.3 → | 12C.7.3.3 → |
| 12A.7.3.4 Apply mathematical formulas to electrical calculations. | 12B.7.3.4 → | 12C.7.3.4 → |
| 12A.7.3.5 Demonstrate knowledge of load-duration and demand-duration curves. | 12B.7.3.5 → | 12C.7.3.5 → |
| 12A.7.3.6 Demonstrate an understanding of declination and Cooper's equation. | 12B.7.3.6 Demonstrate an understanding of the Weibull probability density function. | |
| 12A.7.3.7 Demonstrate an understanding of how to calculate extraterrestrial solar radiation and the clearness index. | 12B.7.3.7 Demonstrate an understanding of the wind energy absorption rate. | |
| | 12B.7.3.8 Demonstrate an understanding of the wind farm capacity factor. | |

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 7:** Describe and apply transferable **cross-curricular knowledge and skills** as they relate to sustainable energy. *(continued)* | | |
| **GLO 7.4:** Demonstrate knowledge of **science** as it relates to the sustainable energy industry. | | |
| 12A.7.4.1 Demonstrate knowledge of science as it relates to sustainable solar energy systems. | 12B.7.4.1 Demonstrate knowledge of science as it relates to sustainable wind energy systems. | 12C.7.4.1 Demonstrate knowledge of science as it relates to sustainable biomass energy systems. |
| 12A.7.4.2 Apply scientific knowledge and equations to electrical Ohm's law formulas. | 12B.7.4.2 → | 12C.7.4.2 → |
| 12A.7.4.3 Define terminology associated with electrical fundamentals. | 12B.7.4.3 → | 12C.7.4.3 → |
| 12A.7.4.4 Describe current and electron flow in direct current (DC) and alternating current (AC) circuits. | 12B.7.4.4 → | 12C.7.4.4 → |
| 12A.7.4.5 Describe the relationships between voltage, current, resistance, and power. | 12B.7.4.5 → | 12C.7.4.5 → |
| 12A.7.4.6 Calculate voltage, current, and resistance in series, parallel, and combination circuits. | 12B.7.4.6 → | 12C.7.4.6 → |
| 12A.7.4.7 Identify, and describe the characteristics of, series, parallel, and series-parallel electrical circuits. | 12B.7.4.7 → | 12C.7.4.7 → |
| 12A.7.4.8 Demonstrate measuring voltage, resistance, current, and power. | 12B.7.4.8 → | 12C.7.4.8 → |

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 8:** Demonstrate an understanding of the **ethical and legal standards** that pertain to the sustainable energy industry. | | |
| **GLO 8.1:** Demonstrate an awareness of the **ethical and legal expectations** of the sustainable energy industry. | | |
| 12A.8.1.1 Demonstrate an understanding of the need to adhere to local authority requirements (e.g., permit, insurance, emission regulations) related to sustainable energy. | 12B.8.1.1 → | 12C.8.1.1 → |
| 12A.8.1.2 Demonstrate an understanding of the importance of accurate performance reporting for solar energy systems. | 12B.8.1.2 Demonstrate an understanding of the importance of accurate performance reporting for wind energy systems. | 12C.8.1.2 Demonstrate an understanding of the importance of accurate performance reporting for biomass energy systems. |
| 12A.8.1.3 Demonstrate an awareness of the certification requirements from a recognized certifying body for a solar PV system installer. | 12B.8.1.3 Demonstrate an awareness of the certification requirements from a recognized certifying body for a small wind system installer. | |

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 9:** Practise **employability skills** required in the sustainable energy industry.<br>**GLO 9.1:** Demonstrate **employability skills**. | | |
| 12A.9.1.1 Demonstrate problem-solving skills. | 12B.9.1.1 → | 12C.9.1.1 → |
| 12A.9.1.2 Demonstrate critical thinking skills. | 12B.9.1.2 → | 12C.9.1.2 → |
| 12A.9.1.3 Demonstrate regular attendance and punctuality. | 12B.9.1.3 → | 12C.9.1.3 → |
| 12A.9.1.4 Demonstrate accountability by taking responsibility for own actions. | 12B.9.1.4 → | 12C.9.1.4 → |
| 12A.9.1.5 Demonstrate adaptability, initiative, and effort. | 12B.9.1.5 → | 12C.9.1.5 → |
| 12A.9.1.6 Demonstrate the ability to accept feedback and to follow direction. | 12B.9.1.6 → | 12C.9.1.6 → |
| 12A.9.1.7 Demonstrate teamwork skills. | 12B.9.1.7 → | 12C.9.1.7 → |
| 12A.9.1.8 Demonstrate the ability to stay on task and to make effective use of time in class and shop environments. | 12B.9.1.8 → | 12C.9.1.8 → |
| 12A.9.1.9 Demonstrate the ability to communicate respectfully and effectively with co-workers and customers. | 12B.9.1.9 → | 12C.9.1.9 → |

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 10:** Demonstrate an awareness of **sustainability** as it pertains to the sustainable energy industry. | | |
| **GLO 10.1:** Describe the impact of **sustainability** on the **health and well-being** of sustainable energy industry workers, their customers, and those who are affected by their products and services. | | |
| 12A.10.1.1 Discuss the benefits of solar energy systems to human health and well-being. | 12B.10.1.1 Discuss the benefits of wind energy systems to human health and well-being. | 12C.10.1.1 Discuss the benefits of biomass energy systems to human health and well-being. |
| 12A.10.1.2 Discuss how solar energy systems can negatively affect humans (e.g., aesthetic concerns). | 12B.10.1.2 Discuss how wind energy systems can negatively affect humans (e.g., wind turbine syndrome). | 12C.10.1.2 Discuss how biomass energy systems can negatively affect humans (e.g., emissions). |
| **GLO 10.2:** Describe the sustainable energy industry's **sustainability practices and their impact on the environment**. | | |
| 12A.10.2.1 Describe sustainability practices related to PV energy systems and their impact on the environment. | 12B.10.2.1 Describe sustainability practices related to wind energy systems and their impact on the environment. | 12C.10.2.1 Describe sustainability practices related to biomass energy systems and their impact on the environment. |
| **GLO 10.3:** Describe the **relationship between the economy and sustainability practices** within the sustainable energy industry. | | |
| 12A.10.3.1 Discuss the effect of solar energy systems on the local and national economies. | 12B.10.3.1 Discuss the effect of wind energy systems on the local and national economies. | 12C.10.3.1 Discuss the effect of biomass energy systems on the local and national economies. |

| 8279<br>**Sustainable Energy: Solar Systems (12A)**<br>40S / 40E / 40M | 8292<br>**Sustainable Energy: Wind Systems (12B)**<br>40S / 40E / 40M | 8293<br>**Sustainable Energy: Biomass Systems (12C)**<br>40S / 40E / 40M |
|---|---|---|
| **Goal 11:** Demonstrate an understanding of **career options** in sustainable energy.<br>**GLO 11.1:** Describe **apprenticeship, post-secondary education**, and **employment opportunities** related to sustainable energy. | | |
| 12A.11.1.1 Describe apprenticeship, post-secondary education, and employment opportunities related to PV energy systems. | 12B.11.1.1 Describe apprenticeship, post-secondary education, and employment opportunities related to wind energy systems. | 12C.11.1.1 Describe apprenticeship, post-secondary education, and employment opportunities related to biomass energy systems. |
| **Goal 12:** Demonstrate an understanding of the **evolution** of sustainable energy, including its **technological progression** and **emerging trends**.<br>**GLO 12.1:** Demonstrate an understanding of the **evolution** of sustainable energy, including its **technological progression** and **emerging trends**. | | |
| 12A.12.1.1 Demonstrate an understanding of the evolution of solar energy systems, including their technological progression and emerging trends. | 12B.12.1.1 Demonstrate an understanding of the evolution of wind energy systems, including their technological progression and emerging trends. | 12C.12.1.1 Demonstrate an understanding of the evolution of biomass energy systems, including their technological progression and emerging trends. |

# Grade 12 Current Topics in Sustainable Energy

General and Specific Learning Outcomes by Goal

# Grade 12 Current Topics in Sustainable Energy (12Da): General and Specific Learning Outcomes by Goal

## Course Introduction

Manitoba Education and Training developed the *Current Topics in Sustainable Energy* course as part of the sustainable energy technical-vocational cluster. This flexible curriculum gives students the opportunity to investigate current topics, issues, and trends in sustainable energy. The curriculum does not mandate the topics. Instead, it is intended that teachers will teach students to identify, isolate, and clearly articulate topics they find engaging and relevant.

Students will synthesize the knowledge, skills, and attitudes they learned in the other sustainable energy courses to identify, investigate, and report on current issues and problems in sustainable energy, and integrate knowledge, skills, and attitudes from a variety of disciplines to develop potential solutions.

### Choosing a Current Topic

The flexibility of *Current Topics in Sustainable Energy* allows teachers to design meaningful and engaging interdisciplinary units based on current topics, issues, and trends. It is suggested that teachers develop three or four units for this course.

Choosing an effective topic is critical to the success of this course. Each topic should have most of the following characteristics:*

- includes a vocational component that refers to one or more occupations associated with sustainable energy (e.g., electrician, plumber, automotive technician)
- has a practical application related to the field of sustainable energy
- is age appropriate and accessible to a diversity of learning styles, interests, and abilities
- is meaningful and engaging to students
- is of current significance
- is framed within the context of a question or a problem
- provides opportunities for in-depth student-driven inquiry
- provides opportunities for both knowledge acquisition and skill development to arise naturally in context
- will result in a performance-based activity as a culminating experience

* Source of some of the above characteristics: Manitoba Education, Citizenship and Youth. *Senior 3 Current Topics in the Sciences: A Foundation for Implementation*. Winnipeg, MB: Manitoba Education, Citizenship and Youth, 2006. Section 2–22.

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**Current Topics in Sustainable Energy (12Da)**
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**Goal 1:** Describe **health and safety** concerns associated with current topics, issues, and trends in sustainable energy, along with potential solutions.

**GLO 1.1:** Describe **health and safety** concerns associated with current topics, issues, and trends in sustainable energy, along with potential solutions.

| | |
|---|---|
| 12Da.1.1.1 Describe health and safety concerns associated with current topics, issues, and trends in sustainable energy. | 12Da.1.1.2 Describe potential solutions to health and safety concerns associated with current topics, issues, and trends in sustainable energy. |

**Goal 2:** Demonstrate the knowledge, skills, and attitudes required to **identify, investigate, and report** on current topics, issues, and trends in sustainable energy, and demonstrate the ability to integrate knowledge, skills, and attitudes from a variety of disciplines to develop potential **solutions**.

**GLO 2.1:** Demonstrate the knowledge, skills, and attitudes required to **identify, investigate, and report** on current topics, issues, and trends in sustainable energy, and demonstrate the ability to integrate knowledge, skills, and attitudes from a variety of disciplines to develop potential **solutions**.

| | |
|---|---|
| 12Da.2.1.1 Demonstrate the ability to identify current topics, issues, and trends in sustainable energy. | 12Da.2.1.3 Demonstrate the ability to report on current topics, issues, and trends in sustainable energy. |
| 12Da.2.1.2 Demonstrate the ability to investigate current topics, issues, and trends in sustainable energy. | 12Da.2.1.4 Demonstrate the ability to integrate knowledge, skills, and attitudes from a variety of disciplines to develop potential solutions to issues in sustainable energy. |

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**Current Topics in Sustainable Energy (12Da)**
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**Goal 3:** Demonstrate the ability to describe the **interdependence** of sustainable energy systems, science, technology, society, government, the economy, and the environment.

**GLO 3.1:** Demonstrate the ability to describe the **interdependence** of sustainable energy systems, science, technology, society, government, the economy, and the environment.

| | |
|---|---|
| 12Da.3.1.1 Describe scientific and technological developments related to sustainable energy, past and present, and describe their impact on individuals, societies, the economy, and the environment, both locally and globally. | 12Da.3.1.2 Demonstrate the ability to describe the interdependence of sustainable energy systems, science, technology, society, government, the economy, and the environment. |

**Goal 4:** Demonstrate an awareness of the **differences of scale** between various sizes of sustainable energy systems.

**GLO 4.1:** Demonstrate an awareness of the **differences of scale** between various sizes of sustainable energy systems.

| | |
|---|---|
| 12Da.4.1.1 Demonstrate an awareness of the differences related to the planning, installation, and maintenance of sustainable energy systems of various scales (e.g., small-scale individual consumer systems versus large-scale industrial systems; small community systems versus larger regional systems). | |

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**Goal 5:** Demonstrate appropriate **inquiry, problem-solving, critical thinking, and decision-making skills and attitudes** for exploring current topics, issues, and trends in sustainable energy.

**GLO 5.1:** Demonstrate appropriate **inquiry, problem-solving, critical thinking, and decision-making skills and attitudes** for exploring issues and problems in sustainable energy.

12Da.5.1.1 Demonstrate the ability to use appropriate inquiry skills when seeking answers to topics, issues, and trends.

12Da.5.1.2 Demonstrate the ability to use appropriate problem-solving skills when seeking solutions to topics, issues, and trends.

12Da.5.1.3 Demonstrate the ability to use appropriate critical thinking and decision-making skills and attitudes when choosing a course of action.

12Da.5.1.4 Demonstrate the ability to recommend an alternative or to identify a position, and provide justification for it.

12Da.5.1.5 Demonstrate the ability to reflect on the decision-making process.

**Goal 6:** Demonstrate **cross-curricular knowledge, skills, and attitudes** as they relate to sustainable energy.

**GLO 6.1:** Demonstrate the **mathematical** skills and attitudes required to evaluate topics, issues, and trends and to identify potential solutions.

12Da.6.1.1 Evaluate the relevance, reliability, and adequacy of data (e.g., discrepancies in data, sources of systemic error, precision versus accuracy) and the methods used to collect data.

12Da.6.1.2 Interpret patterns and trends in data, and infer and explain relationships (e.g., line of best fit, regression equations, statistical analysis, modes of representation—visual, numerical, graphical, symbolical).

12Da.6.1.3 Analyze data or observations in order to draw conclusions consistent with the available results of an investigation, and identify the implications of these results (e.g., cause and effect relationships, alternative explanations, support for or rejection of a hypothesis or a prediction statement).

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**Current Topics in Sustainable Energy (12Da)**
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**Goal 6:** Demonstrate **cross-curricular knowledge, skills, and attitudes** as they relate to sustainable energy. *(continued)*

**GLO 6.2:** Demonstrate the **language arts** knowledge and skills required to evaluate topics, issues, and trends and to identify potential solutions.

12Da.6.2.1 Demonstrate the ability to evaluate gathered information (e.g., for scientific accuracy, reliability, currency, relevance, balance of perspectives, bias) to determine its usefulness for identified needs.

12Da.6.2.2 Demonstrate the ability to quote from, cite, and reference sources.

12Da.6.2.3 Compare diverse perspectives and interpretations in the media (e.g., how media treat issues or problems in sustainable energy).

**GLO 6.3:** Demonstrate the **scientific** skills and attitudes required to evaluate issues and problems and to identify potential solutions.

12Da.6.3.1 Demonstrate the appropriate scientific skills and attitudes required to evaluate issues and problems and to identify potential solutions.

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**Current Topics in Sustainable Energy (12Da)**
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**Goal 7:** Demonstrate an understanding of the **ethical and legal aspects** of current topics, issues, and trends in sustainable energy, and their potential solutions.

**GLO 7.1:** Demonstrate an understanding of **ethical** aspects of current topics, issues, and trends in sustainable energy, and their potential solutions.

12Da.7.1.1 Demonstrate an understanding of ethical aspects of current topics, issues, and trends in sustainable energy, and their potential solutions.

**GLO 7.2:** Recognize that decisions reflect **values** and consider own and others' values when making a decision.

12Da.7.2.1 Recognize that decisions reflect values and consider own and others' values when making a decision.

**GLO 7.3:** Demonstrate an understanding of **legal** aspects of current topics, issues, and trends in sustainable energy, and their potential solutions.

12Da.7.3.1 Demonstrate an understanding of legal aspects of current topics, issues, and trends in sustainable energy, and their potential solutions.

**Goal 8:** Demonstrate an awareness of **cultural proficiency** as it applies to current topics, issues, and trends in sustainable energy, and their potential solutions.

**GLO 8.1:** Demonstrate an awareness of **cultural proficiency** as it applies to current topics, issues, and trends in sustainable energy, and their potential solutions.

12Da.8.1.1 Demonstrate an awareness of the relationship between culture and topics, issues, and trends in sustainable energy.

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**Current Topics in Sustainable Energy (12Da)**
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**Goal 9:** Demonstrate an awareness of the **factors that influence research** in sustainable energy.

**GLO 9.1:** Demonstrate an awareness of the **factors that influence research** in sustainable energy.

12Da.9.1.1 Demonstrate an awareness of how research programs in sustainable energy are supported, funded, and influenced by the pressures of priority, merit, and foreseeable effects in the larger society.

**Goal 10:** Analyze a controversial **issue** that involves the effect of an energy system on a **community**.

**GLO 10.1:** Analyze a controversial **issue** that involves the effect of an energy system on a **community**.

12Da.10.1.1 Analyze a controversial issue that involves the effect of an energy system on a community (e.g., a community opposed to the installation of electrical transmission lines or a nuclear power plant).

**Goal 11:** Demonstrate an awareness of the use of **peer reviews and academic journals** in exploring current topics, issues, and trends in sustainable energy.

**GLO 11.1:** Demonstrate an awareness of the use of **peer reviews and academic journals** in exploring current topics, issues, and trends in sustainable energy.

12Da.11.1.1 Demonstrate the ability to identify an article in an academic journal that deals with topics, issues, and trends in sustainable energy.

12Da.11.1.2 Demonstrate the ability to reflect on an article from an academic journal that deals with topics, issues, and trends in sustainable energy.

# BIBLIOGRAPHY

# BIBLIOGRAPHY


Barber, Everett, and Joe Provey. *Convert Your Home to Solar Energy*. Newtown, CT: The Taunton Press, 2010.

Boxwel, Michael. *Solar Electricity Handbook: A Simple, Practical Guide to Solar Energy – Designing and Installing Photovoltaic Solar Electrical Systems*. 3rd ed. Warwickshire, UK: Greenstream Publishing, 2011.

Canadian Wind Energy Association. Home Page. www.canwea.ca/ (21 June 2013).

Chan, C. C., and K. T. Chau. *Modern Electric Vehicle Technology*. Oxford, UK: Oxford University Press, 2001.

EnergyManitoba.org. Home Page. www.energymanitoba.org/ (21 June 2013).

Garg, H. P., and J. Prakash. *Solar Energy: Fundamentals and Applications*. New Delhi, India: Tata McGraw-Hill Publishing Company Limited, 2000.

Hau, Erich. *Wind Turbines: Fundamentals, Technologies, Application, Economics*. 2nd ed. New York, NY: Springer, 2006.

Health Canada. *Workplace Hazardous Materials Information System – Official National Site*. https://www.canada.ca/en/health-canada/services/environmental-workplace-health/occupational-health-safety/workplace-hazardous-materials-information-system.html (24 Sept. 2018).

Hemami, Ahmad. *Wind Turbine Technology*. Clifton Park, NY: Cengage Learning Series in Renewable Energies, 2012.

Larminie, James, and John Lowry. *Electric Vehicle Technology Explained*. New York, NY: John Wiley & Sons, 2003.

Manitoba. *The Emissions Tax on Coal Act*. C.C.S.M. c. E90. Winnipeg, MB: Queen's Printer – Statutory Publications, 2012. Available online at http://web2.gov.mb.ca/laws/statutes/ccsm/e090e.php (25 Mar. 2014).

Manitoba: 50 by '30. Home Page. www.50by30.org/ (21 June 2013).

Manitoba Education. *Technical-Vocational Education Overview*. Winnipeg, MB: Manitoba Education, 2013. Available online at www.edu.gov.mb.ca/k12/cur/teched/sy_tech_program.html (25 Mar. 2014).

Manitoba Education and Training. *Education for Sustainable Development*. www.edu.gov.mb.ca/k12/esd/ (20 July 2016).

_____ . "Senior Years Technology Education Program." *Technology Education*. www.edu.gov.mb.ca/k12/cur/teched/sy_tech_program.html (20 July 2016).

_____ . *Subject Table Handbook: Technology Education: Student Records System and Professional School Personnel System*. Winnipeg, MB: Manitoba Education and Training. Available online at www.edu.gov.mb.ca/k12/docs/policy/sthte/index.html (13 Sept. 2018).

Manitoba Education, Citizenship and Youth. *Senior 3 Current Topics in the Sciences: A Foundation for Implementation*. Winnipeg, MB: Manitoba Education, Citizenship and Youth, 2006. Available online at www.edu.gov.mb.ca/k12/cur/science/found/c_topics30s/index.html (4 July 2016).

Manitoba Electric Vehicle Association (MEVA). Home Page. http://manitobaev.ca/ (21 June 2013).

Manitoba Geothermal Energy Alliance. Home Page. https://www.mgea.ca/ (21 June 2013).

Manitoba Growth, Enterprise and Trade. *Energy Division*. www.gov.mb.ca/jec/energy/index.html (20 July 2016).

Manitoba Hydro. *Bioenergy Optimization Program*. www.hydro.mb.ca/your_business/bioenergy_optimization (19 June 2013).

Manitoba Innovation, Energy and Mines. *Focused on What Matters Most: Manitoba's Clean Energy Strategy*. Winnipeg, MB: Manitoba Innovation, Energy and Mines, Dec. 2012. Available on the Manitoba Growth, Enterprise and Trade website at www.gov.mb.ca/jec/energy/cleanenergy.html (20 July 2016).

_____ . Home Page. www.gov.mb.ca/iem/energy/index.html (21 June 2013).

_____ . *Manitoba's Electric Vehicle Road Map: Driving toward Fossil Fuel Freedom*. Winnipeg, MB: Manitoba Innovation, Energy and Mines, Apr. 2011. Available on the Manitoba Growth, Enterprise and Trade website at www.gov.mb.ca/jec/energy/transportation.html (20 July 2016).

Manitoba Municipal Government. *Energy Division*. www.gov.mb.ca/ia/energy/index.html (29 Apr. 2014).

Manitoba Sustainable Energy Association (ManSEA). Home Page. https://sites.google.com/mansea.org/web/home (13 Sept. 2018).

Ochsner, Karl. *Geothermal Heat Pumps: A Guide to Planning and Installing*. London, UK: Earthscan, 2007.

RETSreen International. *Clean Energy Project Analysis*. 3rd ed. Ottawa, ON: National Resources Canada, 2005.

Scragg, Alan. *Biofuels: Production, Application and Development*. Oxfordshire, UK: CABI, 2009.

Solar Energy International. *Photovoltaics: Design and Installation Manual: Renewable Energy Education for a Sustainable Future*. Gabriola Island, BC: New Society Publishers, 2004.

Printed in Canada
Imprimé au Canada