TSC-4061-2

The Energy Challenge

Path:

Science and Technology

Applied Science and Technology

Québec

TSC-4061-2 The Energy Challenge

INTRODUCTION

The course entitled *The Energy Challenge* is aimed at enabling adult learners to function effectively in learning situations from the *Research* and *Expertise* families that involve a technological application that consumes electrical energy or transforms a resource into electrical energy.

In this course, adult learners will study environmental issues and seek answers or solutions by analyzing or designing applications that consume electricity or other resources. Thus, they will acquire more knowledge about *The Technological World*, which will help them gain a better understanding of technical objects and the factors at play in different technological problems involving electrical engineering. They will also be able to evaluate the solutions proposed. This knowledge, combined with that of electricity, electromagnetism and the organization of matter that they will acquire in their study of *The Material World*, will help them gain a qualitative and quantitative understanding of how the components of electrical and electronic circuits work. In addition, the knowledge they will acquire about *The Earth and Space* will help them understand the environmental impact of the transformation of energy resources into electricity in the lithosphere, hydrosphere and atmosphere, and of the stream of energy emitted by the Sun.

By the end of this course, in situations involving a technological application that consumes electrical energy or that transforms a resource into electrical energy, adult learners will be able to:

- ✓ design a simple electrical or electronic circuit to produce electricity, or transform electricity into another form of energy
- ✓ model the transformation of resources to produce electricity, or the operation of an electrical circuit
- ✓ determine the values of the parameters of an electrical circuit (resistance, potential difference, electrical current)
- ✓ analyze a technological application containing electrical or electronic components
- ✓ produce a graphic representation of the operation of an electrical or electronic circuit in a technical object
- ✓ follow a manufacturing process sheet for a prototype including electrical or electronic components
- ✓ follow an experimental procedure that deals with electricity or electromagnetism
- ✓ write a report on the production of a prototype or on an experiment involving electricity or electromagnetism
- ✓ take a stand on the use of energy resources

SUBJECT-SPECIFIC COMPETENCIES

The following table lists, for each competency, the key features studied in the course. The manifestations of the key features are presented in Appendix 4.

Competency 1 Seeks answers or solutions to scientific or technological problems	Competency 2 Makes the most of his/her knowledge of science and technology	Competency 3 Communicates in the languages used in science and technology
▪ Defines a problem ▪ Develops a plan of action ▪ Carries out the plan of action ▪ Analyzes his/her results	▪ Puts applications or scientific and technological issues in context ▪ Analyzes an application or an aspect of the issue from a scientific point of view ▪ Analyzes an application from a technological point of view ▪ Forms an opinion about the issue ▪ Forms an opinion about the quality of the application	▪ Interprets scientific and technological messages ▪ Produces scientific and technological messages

PROCESSES

The investigative processes enable adult learners to examine issues, solve problems and study applications. The following are the steps in an investigative process:

- Define the problem
- Formulate a hypothesis
- Test the hypothesis
- Draw conclusions and communicate

The most appropriate methods for this course are the experimental method, modelling, documentary research, the observation method and the technological design process. It is during hypothesis testing that these methods become distinguishable. Section 3.5 and Appendixes 1 to 3 present these investigative processes with their respective characteristics.

CROSS-CURRICULAR COMPETENCIES

The cross-curricular competencies supplement the subject-specific competencies. The development of one contributes to the development of the others. Course TSC-4061-2 allows for all the cross-curricular competencies to be put into practice. Some of them, indicated in grey shading in the table below, are especially targeted in the sample learning situation that will be presented in the last part of the course.

Cross-Curricular Competencies			
Intellectual	**Communication-Related**	**Personal and Social**	**Methodological**
Uses information	Communicates appropriately	Achieves his/her potential	Adopts effective work methods
Solves problems		Cooperates with others	Uses information and communications technologies
Exercises critical judgment			
Uses creativity			

SUBJECT-SPECIFIC CONTENT

A) KNOWLEDGE

The compulsory concepts and techniques are presented in the tables in the following two sections.

1. Concepts

❖ The Technological World	
General concept: Graphical language Based on conventional geometrical representations and inextricably linked to invention and innovation, technical drafting is a language that enables adult learners to develop, refine and give concrete expression to their ideas. Some drawings include information about industry standards in accordance with the rules of representation.	
Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Standards and representations: diagrams and symbols	• Represents the components and connections involved in the operation of an electrical circuit using the appropriate symbols

❖ The Technological World (cont.)

General concept: Electrical engineering

The design or analysis of electrical or electronic circuits in a technical object or technological system is based on fundamental concepts of electricity and electronics and on design and analysis processes specific to the field of engineering. Mastering these concepts enables adult learners to select and combine these components appropriately.

Such technological knowledge makes it possible to determine or justify the use of different shapes and materials, to apply or explain operating principles, and to use or suggest construction solutions.

Many objects, systems and types of equipment related to the environment have some of the characteristics described below.

Compulsory concepts	**KNOWLEDGE TO BE ACQUIRED**
Power supply	• Determines the source of current in technical objects with an electrical circuit (e.g. chemical battery, solar cell, alternator)
Conduction, insulation and protection: resistance and colour code, printed circuit	• Analyzes the factors that affect electrical conductivity (cross-sectional area, length, nature and temperature of a conductor) • Uses the colour code to determine the electrical resistance of a resistor • Describes the operation of a printed circuit
Control: lever, pushbutton, toggle, unipolar (single-pole), bipolar (double-pole), unidirectional (single-throw), bidirectional (double-throw)	• Distinguishes between unipolar (single-pole) and bipolar (double-pole) switches • Distinguishes between unidirectional (single-throw) and bidirectional (double-throw) switches
Transformation of energy: electricity and light, heat, vibration, magnetism	• Associates the transformation of energy with different components of a circuit (e.g. light bulbs transform electrical energy into light and heat) • Describes the energy transformations that take place in electrical or electronic appliances (e.g. in a cell phone, electricity is transformed into light for the display and vibrations for the sound)
Other functions	• Describes the function of certain electronic components (capacitor, diode, transistor, relay)

❖ The Material World

General concept: Organization of matter

Throughout history, different models of the structure of matter have been developed to explain its properties and the changes it undergoes. The classification in the periodic table shows how certain elements have similar properties. The properties of metals, non-metals and metalloids will be studied.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Periodic table: - metals, non-metals and metalloids	• Locates the metals, non-metals and metalloids in the periodic table • Describes the common characteristics of metals, non-metals and metalloids
Rutherford atomic model	• Describes the Rutherford atomic model
Subatomic particles	• Describes the position and electrical charge of the subatomic particles in an atom (proton, electron, neutron)

General concept: Electricity

The study of matter in the environment would be incomplete without an exploration of its electrical properties. Electrical charges can appear on certain neutral materials after they are rubbed with other materials. The appearance of electrical charges can be explained by the mobility of negative charges (electrons) and their accumulation on the surface of certain substances. The affinity of different materials for electrons helps explain a number of everyday electrical phenomena. Some elements and materials are good conductors of electricity: they are used to allow electrons to move through electrical circuits. Certain elements of a circuit also transform part of the electrical energy into another form of energy. Relationships are established between the consumption of electrical energy and the voltage in the circuit, current intensity and time. The electrical power of a device is determined by how much energy it consumes in a given unit of time. Each quantity has its own unit of measurement.

Note: *Students must analyze and design series-parallel circuits, but are not required to do mathematical calculations related to this type of circuit. Coulomb's law is studied both quantitatively and qualitatively.*

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Electrical charge	• Associates subatomic particles with their electrical charge • Describes the behaviour of electrical charges of opposite signs or of the same sign when close together
Static electricity	• Describes static electricity as the transfer of electrons from one body to another
Electrical current	• Defines electrical current as the quantity of electrical charges that flow through a conductor in a given period of time • Distinguishes between alternating and direct current • Applies the formula that expresses the mathematical relationship between current intensity, electrical charge and time (I = Q/t)
Electrical circuits	• Describes the function of different elements of an electrical circuit (e.g. the wires transmit electrons along the circuit; resistors transform electrical energy into another form of energy) • Describes the two types of connections in electrical circuits (series, parallel) • Distinguish between alternating current and direct current • Represents a simple electrical circuit using a diagram

❖ The Material World (cont.)

General concept: Electricity (cont.)

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Ohm's law	• Qualitatively describes the relationship between voltage, resistance and current intensity in an electrical circuit • Applies the mathematical relationship between voltage, resistance and current intensity in an electrical circuit (V = RI)
Kirchhoff's laws	• Describes the distribution of electrical current in the components of an electrical circuit • Determines the value of the current circulating in the different components of an electrical circuit connected in series or in parallel • Describes the distribution of the voltage across the terminals of the components of an electrical circuit • Determines the value of the voltage across the terminals of the different components of an electrical circuit connected in series or in parallel • Determines the equivalent resistance of a series or parallel circuit using Ohm's law and Kirchhoff's laws
Relationship between power and electrical energy	• Applies the mathematical relationship between power, voltage and current intensity in an electrical circuit (P = VI) • Qualitatively describes the relationship between the power of an electrical appliance, the electrical energy it consumes and the amount of time it is in operation • Applies the mathematical relationship between the electrical energy consumed, the power of an electrical appliance and the amount of time it is in operation (E = PΔt)
Coulomb's law	• Applies the mathematical relationship between electrical force, the quantity of the electrical charges and the distance that separates them ($F = kq_1 q_2 / r^2$)
Electrical field	• Describes the electrical field generated by electrical charges (point charges, charged plates)

General concept: Electromagnetism

The study of matter also involves an exploration of its magnetic properties. Some types of matter produce a magnetic field. Different poles attract, while similar poles repel. An electrical current also produces a magnetic field, whether the wire is straight or wound. Conventionally speaking, the magnetic field lines produced by a magnet, whether natural or artificial, are determined by the orientation (direction) of the north pole of a compass placed in the same field. The direction of magnetic field lines can be quickly identified by applying the right-hand or left-hand rule, depending on whether we are considering the conventional or actual direction in which electrons travel.

Note: *Only the qualitative aspects of electromagnetism are addressed.*

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Forces of attraction and repulsion	• Compares the behaviour of a compass in the magnetic field of a magnet and in the magnetic field created by a live wire
Magnetic field of a live wire	• Describes the magnetic field produced by a live wire (right-hand rule) • Names ways of modifying the intensity of the magnetic field produced by a live wire (type of wire, current intensity)
Electromagnetic induction	• Names ways of inducing electrical current in a wire (e.g. movement of a magnet, changing the intensity of a magnetic field)

❖ The Material Word (cont.)

General concept: Electromagnetism (cont.)

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Magnetic field of a solenoid	• Describes the magnetic field produced by a solenoid (right-hand rule) • Names ways of modifying the intensity of the magnetic field produced by a solenoid (nature of the core, intensity of the current, number of turns) • Explains the use of solenoids in technological applications (e.g. earphone, electric motor, magnetic crane)

General concept: Transformation of energy

Energy occurs in a number of forms in the environment, but it always corresponds to the amount of work a system is likely to produce. Work involves force and motion. Using the appropriate methods, it is possible to convert one form of energy into another.

In an isolated system, the total amount of energy is maintained during these changes. If the system is not isolated, it will lose a certain amount of energy, which is absorbed by the environment and neighbouring systems.

A warm body exhibits a characteristic behaviour: as it cools, it warms cooler bodies with which it is in contact.

Note: *Only the qualitative aspects of the transformation of energy are addressed.*

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Law of conservation of energy	• Explains the law of conservation of energy qualitatively • Applies the law of conservation of energy in different contexts
Energy efficiency	• Defines the energy efficiency of a device or system as the proportion of energy consumed that is transformed into effective work (amount of useful energy / amount of energy consumed x 100) • Explains how to improve the energy efficiency of an electrical appliance
Distinction between heat and temperature	• Describes heat as a manifestation of energy • Describes the relationship between heat and temperature

❖ The Earth and Space

General concept: Lithosphere

The lithosphere contains a wide variety of mineral resources essential to the development of societies, including metals, industrial minerals and construction materials.

Combustion engines and thermal power plants burn fossil fuels, which are non-renewable sources of energy, as are the radioactive materials used in nuclear power plants. The search for new energy sources and the use of renewable resources are both major concerns in today's world.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Minerals	• Distinguishes between minerals and ore • Describes some of the environmental impacts of mining and the transformation of minerals

❖ The Earth and Space (cont.)

General concept: Lithosphere (cont.)

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Energy resources	• Describes technologies employed to produce electricity using the energy resources in the lithosphere • Describes the main impacts of the use of energy resources in the lithosphere

General concept: Hydrosphere

Human activity in a catchment area, for example the creation of a reservoir upstream from the dam of a hydroelectric power plant, can disturb ecosystems.

Marine currents and tides can be used to create large quantities of energy. Tidal power plants use tides to produce electrical energy.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Energy resources	• Describes technologies employed to produce electricity using the energy resources in the hydrosphere • Describes the main impacts of the use of energy resources in the hydrosphere

General concept: Atmosphere

Wind is a resource. Whether it be to get around, perform mechanical tasks or produce electrical energy, humans take advantage of wind energy by using sails and blades whose shapes, materials and dimensions vary depending on the application. Wind is an abundant source of soft energy.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Energy resources	• Describes the technologies employed to produce electricity using the energy resources in the atmosphere • Describes the main impacts of the use of energy resources in the atmosphere

General concept: Space

The Sun emits a phenomenal amount of energy in every region of the electromagnetic spectrum. Humans have been using the Sun's heat to meet their needs for a very long time. The photovoltaic sensors on solar panels transform radiant energy into electrical energy.

The gravitational pull of the Moon on the Earth's large surfaces of water is in large part responsible for the tides. The energy of the tides is captured in tidal power plants.

Compulsory concepts	KNOWLEDGE TO BE ACQUIRED
Solar energy flow	• Describes the main factors that control the quantity of solar energy that reaches the Earth's surface (e.g. reflection and absorption of solar energy by the atmosphere or surfaces)
Earth-Moon system: gravitational effect	• Describes the tides in terms of the gravitational effect of the Earth-Moon system

2. Techniques

The techniques presented here are grouped in four categories. Many of the techniques require the use of instruments and tools. Safety and the use of safety equipment in the workshop must be a constant concern for all those using such techniques.

In the Workshop	
Techniques	**KNOWLEDGE TO BE ACQUIRED**
Experimentation - Safely using materials and equipment	• Uses materials and equipment safely
Graphical language - Drawing schematic diagrams	• Indicates all the information needed to explain the operation or construction of an object
Manufacturing - Safely using machines and tools	• Uses tools safely (e.g. disconnects the power source before making adjustments to an electrical circuit, keeps the work area tidy)
- Assembling and disassembling	• In the case of electrical circuits, identifies and gathers the electrical components • Chooses and places the electrical components in sequence based on the circuit diagram • Connects the components using wire, connectors or solders • In the case of electronic circuits, identifies and gathers the electronic components (e.g. connects the components on a printed circuit board) • Chooses and places the electronic components in sequence based on the circuit diagram • Performs the necessary operations to disassemble an electronic circuit (e.g. uses a desoldering bulb to remove a solder)
Measurement - Using measuring instruments	• Uses measuring instruments appropriately (e.g. ammeter, voltmeter, multimeter)

B) CULTURAL REFERENCES

Cultural references make learning situations more meaningful. The following table presents some of the references related to this course.

Cultural References				
Technical objects, technological systems, processes and products	– Petroleum industry equipment: extraction, refining, distribution, use – Wind turbines – Electric power plants – Dams – Turbines – Steam engines – Electric motors – Electrical household devices: lighting, heating, various appliances (e.g. dryer, stove, microwave oven, vacuum cleaner, iron, television, computer, tools) – Bicycle – Automobile – Hybrid vehicles – Street lights			
Area	**Scientists**	**Community Resources**	**Applications**	**Events**
The Technological World	Alessandro Volta Thomas Edison	Canadian Intellectual Property Office Canadian Patent Database Ordre des ingénieurs du Québec	Robotics Remote sensing Street lights	Industrial Revolution Establishment of labour standards Globalization
The Material World	Blaise Pascal Hans Christian Œrsted Joseph Henry Michael Faraday Albert Einstein James Watt Ernest Rutherford Niels Bohr James Chadwick	Faculties of Science and Engineering Museums of science and technology	Automobile industry Development of electrical grids Means of transportation	Construction of dams Construction wind farms
The Earth and Space	Joseph Henry Nicolas Sténon Henry Cavendish	Geological Survey of Canada Transition énergétique Québec Natural Resources Canada Greenpeace	Observation satellites Global positioning systems (GPS)	Meteorological phenomena Earth Summits

FAMILIES OF LEARNING SITUATIONS

The learning situations in this course, derived from the *Research* and *Expertise* families, involve the use of energy resources or electricity. The learning situations contain general concepts related to more than one area. The following paragraphs contain examples of tasks that could be assigned to adult learners in learning situations involving different combinations of general concepts.

In a situation involving electricity, electromagnetism and the hydrosphere, adults could learn how water falling from a certain height at a dam produces electricity by transforming the kinetic energy of the water into the mechanical energy of a turbine, then into electricity through electromagnetic induction between the rotor and stator of an alternator.

In a situation involving electricity, electrical engineering and graphical language, adult learners could model the direction of the current circulating in the components of an electrical circuit and represent it in a diagram. They could also observe the effect of electricity or electromagnetism on the operation of electrical components or, in the workshop, analyze the electrical engineering concepts involved in building a certain technical object, draw its circuit diagram and assess its energy efficiency.

In a situation involving the hydrosphere, the atmosphere, the lithosphere, space and electricity, adult learners could analyze different ways of transforming energy and form an opinion about the consequences of using one type of energy rather than another to produce electricity at a given location, taking political, economic, environmental and social constraints into consideration.

In the learning situation described below, the main tasks help adult learners develop the second and third competencies. This situation therefore belongs to the *Expertise* family.

BROAD AREAS OF LEARNING

Learning situations will have more meaning for adult learners if they are related to the broad areas of learning. All of the broad areas of learning are readily applicable to the learning situations for course TSC-4061-2. The example below reflects the educational aim of the broad area of learning *Environmental Awareness and Consumer Rights and Responsibilities*.

Broad Areas of Learning
Health and Well-Being
Career Planning and Entrepreneurship
Environmental Awareness and Consumer Rights and Responsibilities
Media Literacy
Citizenship and Community Life

EXAMPLE OF A LEARNING SITUATION

ELECTRIC MOTOR

A friend wants to build an electric motor and asks for your advice concerning the operation and construction of this technological system. You want to give your friend clear, precise and accurate information.

To that end, you identify technical objects around you that use electric motors. You take one of these objects and disassemble it to remove the motor. Motor in hand, you do research to understand the scientific and technological principles underlying its operation. You then reassemble the object and ensure that it is in good working order. Your information must include the details of your technological analysis of the electric motor, including a circuit diagram and an explanation of the scientific principles related to electricity and the transformation of energy.

END-OF-COURSE OUTCOMES

Learning situations are administered on the premise that the adult learner will become familiar with an investigative process involving the observation method, the design process, the experimental method, modelling or documentary research. The learning situations also enable adult learners to apply their problem-solving skills and knowledge, and to produce messages.

Adult learners engaged in the process of solving an open problem related to the production or consumption of electrical energy develop a representation of the problem in question after reading and interpreting scientific and technological messages. They establish a plan of action adapted to the chosen solution or hypothesis, relying on their knowledge of electricity or electromagnetism, and placing electrical or electronic components in sequence. They subsequently design a simple electrical circuit or choose a manufacturing process sheet. They implement their plan of action, constructing a prototype electrical or electronic circuit in order to validate their solution. They change or justify their plan of action, solution or answer based on the need to be met or the information given in the problem.

Adult learners studying an environmental issue or technological application involving the use of energy resources or electricity formulate questions related to the contextual elements presented. They identify the characteristics of the issue or the principles underlying the application as they relate to the resources found on Earth and in space. Using diagrams, concepts, laws, theories or models, they explain the operation or construction of the application and evaluate its energy efficiency. They calculate the parameters of an electrical circuit in the application and explain the transformations of energy that take place. In the case of an environmental issue, they explain the issue and take a stand on the environmental impact of using the energy resources on Earth and in space based on their scientific and technological knowledge.

EVALUATION CRITERIA FOR SUBJECT-SPECIFIC COMPETENCIES

Evaluation Criteria for Competency 1	Evaluation Criteria for Competency 2	Evaluation Criteria for Competency 3
▪ Appropriate representation of the situation ▪ Development of a suitable plan of action ▪ Appropriate implementation of the plan of action ▪ Development of relevant explanations, solutions or conclusions	▪ Appropriate interpretation of the issue ▪ Relevant use of scientific and technological knowledge ▪ Appropriate formulation of explanations or solutions	▪ Accurate interpretation of scientific and technological messages ▪ Appropriate production or transmission of scientific and technological messages

Éducation
et Enseignement
supérieur
Québec