© 2018 UniCourse Ltd. All Rights Reserved.

Pearson BTEC Levels 5 Higher Nationals in Engineering (RQF)

Unit 44: Industrial Power, Electronics and Storage

Unit Workbook 4

in a series of 4 for this unit

Learning Outcome 4

Integrating Renewable Energy to the Grid

Sample

edexcel Approved Centre

©2020 UniCourse Ltd. All Rights Reserved.

Contents

Sample

edexcel Approved Centre

©2020 UniCourse Ltd. All Rights Reserved.

Sample

edexcel Approved Centre

©2020 UniCourse Ltd. All Rights Reserved.

INTRODUCTION

Investigate the impacts of renewable resources to the grid and the various issues associated with integrating such resources to the grid

- *Impact of renewable resources:*
  - Safe and secure operation of a simple power system.
  - Standalone and grid connected renewable energy systems.
  - Introduction to smart grid, features, functions, architectures, and distributed generation. Grid interactive systems, grid tied systems, inverters, and application of its devices.
  - Smart homes, power management, smart grid, intelligent metering.
  - Communication technologies and power electronics modules for smart grid network, importance of power electronics in smart grid, for example energy storage (electrical, chemical, biological, and heat), and the future of smart grid.
  - Use of MATLAB/Simulink to model, simulate and analyse the dynamic behaviour of a standard smart grid.

GUIDANCE

This document is prepared to break the unit material down into bite size chunks. You will see the learning outcomes above treated in their own sections. Therein you will encounter the following structures;

Purpose

Explains *why* you need to study the current section of material. Quite often learners are put off by material which does not initially seem to be relevant to a topic or profession. Once you understand the importance of new learning or theory you will embrace the concepts more readily.

Theory

Conveys new material to you in a straightforward fashion. To support the treatments in this section you are strongly advised to follow the given hyperlinks, which may be useful documents or applications on the web.

Example

The examples/worked examples are presented in a knowledge-building order. Make sure you follow them all through. If you are feeling confident then you might like to treat an example as a question, in which case cover it up and have a go yourself. Many of the examples given resemble assignment questions which will come your way, so follow them through diligently.

Question

Questions should not be avoided if you are determined to learn. Please do take the time to tackle each of the given questions, in the order in which they are presented. The order is important, as further knowledge and confidence is built upon previous knowledge and confidence. As an Online Learner it is important that the answers to questions are immediately available to you. Contact your Unit Tutor if you need help.

Challenge

You can really cement your new knowledge by undertaking the challenges. A challenge could be to download software and perform an exercise. An alternative challenge might involve a practical activity or other form of research.

Sample

edexcel Approved Centre

©2020 UniCourse Ltd. All Rights Reserved.

Video

Videos on the web can be very useful supplements to your distance learning efforts. Wherever an online video(s) will help you then it will be hyperlinked at the appropriate point.

Sample

edexcel Approved Centre

© 2018 UniCourse Ltd. All Rights Reserved.

4 IMPACT OF RENEWABLE RESOURCES

Intro to Renewable Resources

4.1 Standalone and Grid Renewables

4.1.1 Standalone (Off-Grid) Renewable Energy Systems

For many people, powering their homes or small businesses using a small renewable energy system that is not connected to the electricity grid (called a stand-alone system) makes economic sense and appeals to their environmental values.

In remote locations, stand-alone systems can be more cost-effective than extending a power line to the electricity grid (the cost of which can range from £10,000 to £40,000 per mile). But these systems are also used by people who live near the grid and wish to obtain independence from the power provider or demonstrate a commitment to non-polluting energy sources.

Successful stand-alone systems generally take advantage of a combination of techniques and technologies to generate reliable power, reduce costs, and minimize inconvenience. Some of these strategies include using fossil fuel or renewable hybrid systems and reducing the amount of electricity consumed.

In addition to purchasing photovoltaic panels, a wind turbine, or a small hydropower system, some additional equipment (called "balance-of-system") to condition and safely transmit the electricity to the load that will use it is required. This equipment can include:

- Batteries
- Charge controller
- Power conditioning equipment
- Safety equipment
- Meters and instrumentation.

With stand-alone systems the amount of equipment needed depends on overall requirements. In the simplest systems, the current generated by the renewable system is connected directly to the equipment that it is powering (load). However, if power storage is required for use when the system isn't producing electricity, batteries and a charge controller are required.

A typical standalone AC system is shown in Figure 1.

Sample

edexcel Approved Centre

© 2018 UniCourse Ltd. All Rights Reserved.

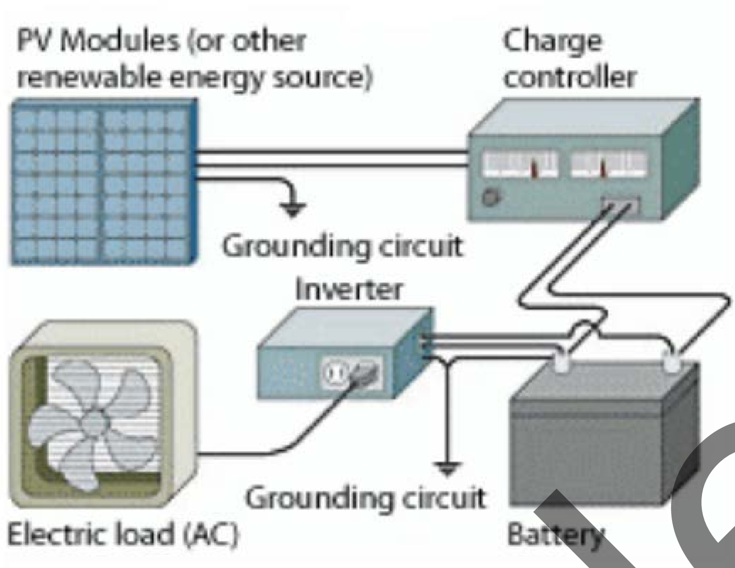

Figure 1 A typical standalone AC system

Depending on the needs, balance-of-system equipment for a stand-alone system could account for half of the total system costs. Typical balance-of-system equipment for a stand-alone system include batteries, charge controller, power conditioning equipment, safety equipment, and meters and instrumentation.

A grid-connected system requires balance-of-system equipment that allows safe transmission of electricity to system loads and to comply with the power provider's grid-connection requirements. Power conditioning equipment, safety equipment, and meters and instrumentation will be required.

4.1.1.1 Batteries for Stand-Alone Systems

Batteries store electricity for use during times that the system is not producing electricity (the resource is not available). Batteries are most effective when used in wind and photovoltaic systems (variations in micro-hydropower resources can be more seasonal in nature, so batteries may be less useful).

The "deep-cycle" (generally lead-acid) batteries typically used for small systems last 5 to 10 years and reclaim about 80% of the energy channelled into them. In addition, these batteries are designed to provide electricity over long periods and can repeatedly charge and discharge up to 80% of their capacity. Automotive batteries, which are shallow-cycle (and therefore prone to damage if they discharge more than 20% of their capacity), should not be used.

The cost of deep-cycle batteries depends on the type, capacity, climate conditions under which they will operate, frequency of maintenance, and chemicals used to store and release electricity. Wind or photovoltaic stand-alone system batteries need to be sized to store power sufficient to meet your needs during anticipated periods of cloudy weather or low wind. An inexpensive fossil fuel-powered back-up generator can be used to cover unanticipated or occasional slumps in the renewable resource.

For safety, batteries should be located in a space that is well ventilated and isolated from living areas and electronics, as they contain dangerous chemicals and emit hydrogen and oxygen gas while being charged. In addition, the space should provide protection from temperature extremes. Locate batteries in a space

Sample

© 2018 UniCourse Ltd. All Rights Reserved.

that has easy access for maintenance, repair, and replacement. Batteries can be recycled when they wear out.

4.1.1.2 Charge Controllers for Stand-Alone Systems

This device regulates rates of flow of electricity from the generation source to the battery and the load. The controller keeps the battery fully charged without over-charging it. When the load is drawing power, the controller allows the charge to flow from the generation source into the battery, the load, or both. When the controller senses that the battery is fully (or nearly fully) charged, it reduces or stops the flow of electricity from the generation source or diverts it to an auxiliary or "shunt" load (most commonly an electric water heater).

Many controllers will also sense when loads have taken too much energy from batteries and will stop the flow until sufficient charge is restored to the batteries. This last feature can greatly extend the battery's lifetime.

The cost of controllers generally depends on the ampere capacity at which the renewable system will operate, and the monitoring features required.

4.1.1.3 Power Conditioning Equipment

For both stand-alone and grid-connected systems, power conditioning equipment is required.

Most electrical appliances worldwide run on alternating current (AC) electricity. Virtually all the available renewable energy technologies, with the exception of some solar electric units, produce direct current (DC) electricity. To run standard AC appliances, the DC electricity must first be converted to AC electricity using inverters and related power conditioning equipment.

There are four basic elements to power conditioning:

1. Conversion (of constant DC power to oscillating AC power)
2. Frequency of the AC cycles (50 cycles per second in the UK)
3. Voltage consistency (extent to which the output voltage fluctuates)
4. Quality of the AC sine curve (whether the shape of the AC wave is jagged or smooth)

Simple electric devices, such as hair dryers and light bulbs, can run on fairly low-quality electricity. A consistent voltage and smooth sine curve are more important for sensitive electronic equipment, such as computers, that cannot tolerate much power distortion.

Inverters condition electricity so that it matches the requirements of the load. If you plan to tie your system to the electricity grid, you will need to purchase conditioning equipment that can match the voltage, phase, frequency, and sine wave profile of the electricity produced by your system to that flowing through the grid.

For connecting to the Grid in the UK see:

https://www.nationalgrid.com/uk/electricity/connections/applying-connection

Factors affect the cost of inverters:

Sample

edexcel Approved Centre