NATIONAL CERTIFICATES (VOCATIONAL)

ASSESSMENT GUIDELINES

RENEWABLE ENERGY TECHNOLOGIES
NQF Level 2

IMPLEMENTATION 2015
RENEWABLE TECHNOLOGIES– LEVEL 2

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SECTION A: PURPOSE OF THE SUBJECT ASSESSMENT GUIDELINES

This document provides the lecturer with guidelines to develop and implement a coherent, integrated assessment system for Renewable Energy and Energy Efficiency Technologies in the National Certificates (Vocational). It must be read with the National Policy Regarding Further Education and Training Programmes: Approval of the Documents, Policy for the National Certificates (Vocational) Qualifications at Levels 2 to 4 on the National Qualifications Framework (NQF). This assessment guideline will be used for National Qualifications Framework Levels 2-4.

This document explains the requirements for the internal and external subject assessment. The lecturer must use this document with the Subject Guidelines: Renewable Energy Technologies to prepare for and deliver Renewable Energy Technologies. Lecturers should use a variety of resources and apply a range of assessment skills in the setting, marking and recording of assessment tasks.

SECTION B: ASSESSMENT IN THE NATIONAL CERTIFICATES (VOCATIONAL)

1. ASSESSMENT IN THE NATIONAL CERTIFICATES (VOCATIONAL)

Assessment in the National Certificates (Vocational) is underpinned by the objectives of the National Qualifications Framework (NQF). These objectives are to:

- Create an integrated national framework for learning achievements.
- Facilitate access to and progression within education, training and career paths.
- Enhance the quality of education and training.
- Redress unfair discrimination and past imbalances and thereby accelerate employment opportunities.
- Contribute to the holistic development of the student by addressing:
  - Social adjustment and responsibility;
  - Moral accountability and ethical work orientation;
  - Economic participation; and
  - Nation-building.

The principles that drive these objectives are:

- **Integration**, To adopt a unified approach to education and training that will strengthen the human resources development capacity of the nation.
- **Relevance**, To be dynamic and responsive to national development needs.
- **Credibility**, To demonstrate national and international value and recognition of qualification and acquired competencies and skills.
- **Coherence**, To work within a consistent framework of principles and certification.
- **Flexibility**, To allow for creativity and resourcefulness when achieving Learning Outcomes, to cater for different learning styles and use a range of assessment methods, instruments and techniques.
- **Participation**, To enable stakeholders to participate in setting standards and co-ordinating the achievement of the qualification.
- **Access**, To address barriers to learning at each level to facilitate students’ progress.
- **Progression** To ensure that the qualification framework permits individuals to move through the levels of the national qualification via different, appropriate combinations of the components of the delivery system.
- **Portability** To enable students to transfer credits of qualifications from one learning institution and/or employer to another institution or employer.
- **Articulation** To allow for vertical and horizontal mobility in the education system when accredited pre-requisites have been successfully completed.
- **Recognition of Prior Learning** To grant credits for a unit of learning following an assessment or if a student possesses the capabilities specified in the outcomes statement.
- **Validity of assessments** To ensure assessment covers a broad range of knowledge, skills, values and attitudes (SKVAs) needed to demonstrate applied competency. This is achieved through:
  - clearly stating the outcome to be assessed;
  - selecting the appropriate or suitable evidence;
Renewable Energy Technologies
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National Certificates (Vocational)

- matching the evidence with a compatible or appropriate method of assessment; and
- selecting and constructing an instrument(s) of assessment.

- **Reliability** To assure assessment practices are consistent so that the same result or judgment is arrived at if the assessment is replicated in the same context. This demands consistency in the interpretation of evidence; therefore, careful monitoring of assessment is vital.

- **Fairness and transparency** To verify that no assessment process or method(s) hinders or unfairly advantages any student. The following could constitute unfairness in assessment:
  - Inequality of opportunities, resources or teaching and learning approaches
  - Bias based on ethnicity, race, gender, age, disability or social class
  - Lack of clarity regarding Learning Outcome being assessed
  - Comparison of students’ work with other students, based on learning styles and language

- **Practicability and cost-effectiveness** To integrate assessment practices within an outcomes-based education and training system and strive for cost and time-effective assessment.

2. **ASSESSMENT FRAMEWORK FOR VOCATIONAL QUALIFICATIONS**

The assessment structure for the National Certificates (Vocational) qualification is as follows:

2.1 **Internal continuous assessment (ICASS)**

Knowledge, skills values, and attitudes (SKVAs) are assessed throughout the year using assessment instruments such as projects, tests, assignments, investigations, role-play and case studies. The internal continuous assessment (ICASS) practical component is undertaken in a real workplace, a workshop or a “Structured Environment”. This component is moderated internally and externally quality assured by Umalusi. All internal continuous assessment (ICASS) evidence is kept in a Portfolio of Evidence (PoE) and must be readily available for monitoring, moderation and verification purposes.

2.2 **External summative assessment (ESASS)**

The external summative assessment is either a single or a set of written papers set to the requirements of the Subject Learning Outcomes. The Department of Education administers the theoretical component according to relevant assessment policies. A compulsory component of external summative assessment (ESASS) is the integrated summative assessment task (ISAT). This assessment task draws on the students’ cumulative learning throughout the year. The task requires integrated application of competence and is executed under strict assessment conditions. The task should take place in a simulated or “Structured Environment”. The integrated summative assessment task (ISAT) is the most significant test of students’ ability to apply acquired knowledge. The integrated assessment approach allows students to be assessed in more than one subject with the same integrated summative assessment task (ISAT). External summative assessments will be conducted annually between October and December, with provision made for supplementary sittings.

3. **MODERATION OF ASSESSMENT**

3.1 **Internal moderation**

Assessment must be moderated according to the internal moderation policy of the Technical Vocational Education and Training (TVET) college. Internal college moderation is a continuous process. The moderator’s involvement starts with the planning of assessment methods and instruments and follows with continuous collaboration with and support to the assessors. Internal moderation creates common understanding of Assessment Standards and maintains these across vocational programmes.

3.2 **External moderation**

External moderation is conducted by the Department of Education, Umalusi and, where relevant, an Education and Training Quality Assurance (ETQA) body according to South African Qualifications Authority (SAQA) and Umalusi standards and requirements. The external moderator:

- monitors and evaluates the standard of all summative assessments;
- maintains standards by exercising appropriate influence and control over assessors;
ensures proper procedures are followed;
ensures summative integrated assessments are correctly administered;
obsves a minimum sample of ten (10) to twenty-five (25) percent of summative assessments;
gives written feedback to the relevant quality assuror; and
moderates in case of a dispute between an assessor and a student.
Policy on inclusive education requires that assessment procedures be customised for students who experience barriers to learning, and supported to enable these students to achieve their maximum potential.

4. PERIOD OF VALIDITY OF INTERNAL CONTINUOUS ASSESSMENT (ICASS)
The period of validity of the internal continuous assessment mark is determined by the National Policy on the Conduct, Administration and Management of the Assessment of the National Certificates (Vocational). The internal continuous assessment (ICASS) must be re-submitted with each examination enrolment for which it constitutes a component.

5. ASSESSOR REQUIREMENTS
Assessors must be subject specialists and should ideally be declared competent against the standards set by the ETDP SETA. If the lecturer conducting the assessments has not been declared a competent assessor, an assessor who has been declared competent may be appointed to oversee the assessment process to ensure the quality and integrity of assessments.

6. TYPES OF ASSESSMENT
Assessment benefits the student and the lecturer. It informs students about their progress and helps lecturers make informed decisions at different stages of the learning process. Depending on the intended purpose, different types of assessment can be used.

6.1 Baseline assessment
At the beginning of a level or learning experience, baseline assessment establishes the knowledge, skills, values and attitudes (SKVAs) that students bring to the classroom. This knowledge assists lecturers to plan learning programmes and learning activities.

6.2 Diagnostic assessment
This assessment diagnoses the nature and causes of learning barriers experienced by specific students. It is followed by guidance, appropriate support and intervention strategies. This type of assessment is useful to make referrals for students requiring specialist help.

6.3 Formative assessment
This assessment monitors and supports teaching and learning. It determines student strengths and weaknesses and provides feedback on progress. It determines if a student is ready for summative assessment.

6.4 Summative assessment
This type of assessment gives an overall picture of student progress at a given time. It determines whether the student is sufficiently competent to progress to the next level.

7. PLANNING ASSESSMENT
An assessment plan should cover three main processes:

7.1 Collecting evidence
The assessment plan indicates which Subject Outcomes and Assessment Standards will be assessed, what assessment method or activity will be used and when this assessment will be conducted.

7.2 Recording
Recording refers to the assessment instruments or tools with which the assessment will be captured or recorded. Therefore, appropriate assessment instruments must be developed or adapted.
7.3 Reporting
All the evidence is put together in a report to deliver a decision for the subject.

8. METHODS OF ASSESSMENT
Methods of assessment refer to who carries out the assessment and includes lecturer assessment, self-assessment, peer assessment and group assessment.

<table>
<thead>
<tr>
<th>LECTURER ASSESSMENT</th>
<th>The lecturer assesses students’ performance against given criteria in different contexts, such as individual work, group work, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SELF-ASSESSMENT</td>
<td>Students assess their own performance against given criteria in different contexts, such as individual work, group work, etc.</td>
</tr>
<tr>
<td>PEER ASSESSMENT</td>
<td>Students assess another student’s or group of students’ performance against given criteria in different contexts, such as individual work, group work, etc.</td>
</tr>
<tr>
<td>GROUP ASSESSMENT</td>
<td>Students assess the individual performance of other students within a group or the overall performance of a group of students against given criteria.</td>
</tr>
</tbody>
</table>

9. INSTRUMENTS AND TOOLS FOR COLLECTING EVIDENCE
All evidence collected for assessment purposes is kept or recorded in the student’s PoE. The following table summarises a variety of methods and instruments for collecting evidence. A method and instrument is chosen to give students ample opportunity to demonstrate the Subject Outcome has been attained. This will only be possible if the chosen methods and instruments are appropriate for the target group and the Specific Outcome being assessed.

<table>
<thead>
<tr>
<th>METHODS FOR COLLECTING EVIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Observation-based</strong></td>
</tr>
<tr>
<td>(Less structured)</td>
</tr>
<tr>
<td><strong>Task-based</strong></td>
</tr>
<tr>
<td>(Structured)</td>
</tr>
<tr>
<td><strong>Test-based</strong></td>
</tr>
<tr>
<td>(More structured)</td>
</tr>
</tbody>
</table>

**Assessment instruments**
- Observation
- Class questions
- Lecturer, student, parent discussions
- Assignments or tasks
- Projects
- Investigations or research
- Case studies
- Practical exercises
- Demonstrations
- Role-play
- Interviews
- Examinations
- Class tests
- Practical examinations
- Oral tests
- Open-book tests

**Assessment tools**
- Observation sheets
- Lecturer’s notes
- Comments
- Checklists
- Rating scales
- Rubrics
- Marks (e.g. %)
- Rating scales (1-7)

**Evidence**
- Focus on individual students
- Subjective evidence based on lecturer observations and impressions
- Open middle: Students produce the same evidence but in different ways.
- Open end: Students use same process to achieve different results.
- Students answer the same questions in the same way, within the same time.
10. **TOOLS FOR ASSESSING STUDENT PERFORMANCE**

**Rating scales** are marking systems where a symbol (such as 1 to 7) or a mark (such as 5/10 or 50%) is defined in detail. The detail is as important as the coded score. Traditional marking, assessment and evaluation mostly used rating scales without details such as what was right or wrong, weak or strong, etc.

**Task lists** and **checklists** show the student what needs to be done. These consist of short statements describing the expected performance in a particular task. The statements on the checklist can be ticked off when the student has adequately achieved the criterion. Checklists and task lists are useful in peer or group assessment activities.

**Rubrics** are a hierarchy (graded levels) of criteria with benchmarks that describe the minimum level of acceptable performance or achievement for each criterion. Using rubrics is a different way of assessing and cannot be compared to tests. Each criterion described in the rubric must be assessed separately. Mainly two types of rubrics, namely holistic and analytical, are used.

11. **SELECTING AND/OR DESIGNING RECORDING AND REPORTING SYSTEMS**

The selection or design of recording and reporting systems depends on the purpose of recording and reporting student achievement. **Why** particular information is recorded and **how** it is recorded determine which instrument will be used.

Computer-based systems, for example spreadsheets, are cost and time effective. The recording system should be user-friendly and information should be easily accessed and retrieved.

12. **COMPETENCE DESCRIPTIONS**

All assessment should award marks to evaluate specific assessment tasks. However, marks should be awarded against rubrics and not be simply a total of ticks for right answers. Rubrics should explain the competence level descriptors for the skills, knowledge, values and attitudes (SKVAs) that a student must demonstrate to achieve each level of the rating scale. When lecturers or assessors prepare an assessment task or question, they must ensure that the task or question addresses an aspect of a Subject Outcome. The relevant Assessment Standard must be used to create the rubric to assess the task or question. The descriptions must clearly indicate the minimum level of attainment for each category on the rating scale.

13. **STRATEGIES FOR COLLECTING EVIDENCE**

A number of different assessment instruments may be used to collect and record evidence. Examples of instruments that can be (adapted and) used in the classroom include:

13.1 **Record sheets**

The lecturer observes students working in a group. These observations are recorded in a summary table at the end of each project. The lecturer can design a record sheet to observe students’ interactive and problem-solving skills, attitudes towards group work and involvement in a group activity.

13.2 **Checklists**

Checklists should have clear categories to ensure that the objectives are effectively met. The categories should describe how the activities are evaluated and against what criteria they are evaluated. Space for comments is essential.

**SECTION C: ASSESSMENT IN RENEWABLE ENERGY TECHNOLOGIES**

1. **SCHEDULE OF ASSESSMENT**

At NQF levels 2, 3 and 4, lecturers will conduct assessments as well as develop a schedule of formal assessments that will be undertaken in the year. All three levels also have an external examination that accounts for 50 percent of the total mark. The marks allocated to assessment tasks completed during the year, kept or recorded in a PoE account for the other 50 percent.
The PoE and the external assessment include practical and written components. The practical assessment in Renewable Energy Technologies must, where necessary, be subjected to external moderation by Umalusi or an appropriate Education and Training Quality Assurance (ETQA) body, appointed by the Umalusi Council in terms of Section 28(2) of the General and Further Education and Training Quality Assurance Act, 2001 (Act No. 58 of 2001).

2. **RECORDING AND REPORTING**

Renewable Energy Technologies, as is the case for all the other Vocational subjects, is assessed according to five levels of competence. The level descriptions are explained in the following table.

### Scale of Achievement for the Vocational component

<table>
<thead>
<tr>
<th>RATING CODE</th>
<th>RATING</th>
<th>MARKS %</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Outstanding</td>
<td>80-100</td>
</tr>
<tr>
<td>4</td>
<td>Highly Competent</td>
<td>70-79</td>
</tr>
<tr>
<td>3</td>
<td>Competent</td>
<td>50-69</td>
</tr>
<tr>
<td>2</td>
<td>Not yet competent</td>
<td>40-49</td>
</tr>
<tr>
<td>1</td>
<td>Not achieved</td>
<td>0-39</td>
</tr>
</tbody>
</table>

The programme of assessment should be recorded in the Lecturer's Portfolio of Assessment for each subject. The following at least should be included in the Lecturer's Assessment Portfolio:

- A contents page
- The formal schedule of assessment
- The requirements for each assessment task
- The tools used for each assessment task
- Recording instrument(s) for each assessment task
- A mark sheet and report for each assessment task

The college must standardise these documents. The student’s PoE must include at least:

- A contents page
- The assessment tasks according to the assessment schedule
- The assessment tools or instruments for the task
- A record of the marks (and comments) achieved for each task

Where a task cannot be contained as evidence in the PoE, its exact location must be recorded and it must be readily available for moderation purposes.
ASSESSMENT OF RENEWABLE ENERGY TECHNOLOGIES

LEVEL 2
### Topic 1: Introduction to Renewable Energy Resources, Energy Efficiency and Electrical Networks

#### SUBJECT OUTCOME

<table>
<thead>
<tr>
<th>ASSESSMENT STANDARD</th>
<th>LEARNING OUTCOMES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.1 Explain international and national climate change policies</strong></td>
<td></td>
</tr>
<tr>
<td>- The causes and impact of climate change and global warming is explained.</td>
<td>- Explain the causes and impact of climate change and global warming.</td>
</tr>
<tr>
<td>- The concepts of mitigation and adaptation are explained and intervention measures discussed using examples such as energy efficient green buildings and transport systems.</td>
<td>- Explain mitigation and adaptation concepts using practical examples.</td>
</tr>
<tr>
<td>- International frameworks and policies on climate change are explained. <em>Range: United Nations Framework Convention on climate change (UNFCCC), Kyoto Protocol and Clean Development Mechanism (CDM)</em></td>
<td>- Explain international frameworks and policy on climate change.</td>
</tr>
<tr>
<td>- The priorities of national strategies on Sustainable Development are introduced and explained, including the: Green Economy Accord and its commitments Importance of the Integrated Resource Plans and Goals of the National Energy Efficiency Strategy.</td>
<td>- List the priorities of the National Strategy on Sustainable Development.</td>
</tr>
<tr>
<td>-</td>
<td>- Explain the Green Economy Accord and its commitments.</td>
</tr>
<tr>
<td>-</td>
<td>- Explain the importance of the Integrated Resource Plans.</td>
</tr>
<tr>
<td>-</td>
<td>- List and explain the goals of the National Energy Efficiency Strategy.</td>
</tr>
</tbody>
</table>

#### ASSESSMENT TASKS OR ACTIVITIES

Students perform the followings:
- Written tests on the learning outcomes.
- Students organise a debate on the impact of climate change and global warming.
- Students develop and design posters for a local awareness campaign on climate change.
- Students do research with the material available on the CD or on the internet for international frameworks and policy on climate change.
- Students interpret maps and use table to locate provincial renewable energy projects.
### SUBJECT OUTCOME

**1.2 Explain the principals of power generation, transmission and the differences between energy resources**

<table>
<thead>
<tr>
<th>ASSESSMENT STANDARD</th>
<th>LEARNING OUTCOMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The three main components of the electrical networks are listed and explained. <em>Range: generation, transmission and distribution.</em></td>
<td>• List and explain the three main components of electrical networks (high and low ‘voltage’ transmission lines).</td>
</tr>
<tr>
<td>• Key terms such as used in electrical networks are explained and identified in annual usage diagrams. <em>Range: supply and demand side, base, seasonal and peak load and capacity.</em></td>
<td>• Explain and identify key terms as used in electrical networks (high and low ‘voltage’ transmission lines) and in annual usage diagrams.</td>
</tr>
<tr>
<td>• Energy resources, both fossil and renewable, used to generate electrical power and heat are listed and explained. <em>Range: Coal, Crude Oil and Natural Gas, Biomass and Wastes, Hydropower, Geothermal, Wind, Solar and Nuclear.</em></td>
<td>• List and explain the main energy resources</td>
</tr>
<tr>
<td>• The environmental problems associated with the use of fossil energy resources are explained.</td>
<td>• Distinguish between fossil and renewable energy sources.</td>
</tr>
<tr>
<td>• The advantages and disadvantages of renewable energy resources are listed. <em>Range: Solar Water Heating, Photovoltaic and Wind Turbine applications and smart-grids.</em></td>
<td>• Explain environmental problems associated with the use of fossil energy resources.</td>
</tr>
<tr>
<td></td>
<td>• List the advantages and disadvantages of renewable energy resources.</td>
</tr>
<tr>
<td></td>
<td>• Explain national grid development (power generation and high and low ‘voltage’ transmission lines) and the term ‘smart grid’ (balancing supply and demand)).</td>
</tr>
</tbody>
</table>

### ASSESSMENT TASKS OR ACTIVITIES

Students perform the followings:

- Written tests on learning outcomes.
- Students interpret load diagrams.
- Students use tables and diagrams to indicate which technologies are best suited for which power generation regime (base, intermediate and peak load)
- Students use tables to differentiate and explain energy resources (fossil and renewable) and to visualise the national energy mix projected for 2030.
<table>
<thead>
<tr>
<th>SUBJECT OUTCOME</th>
<th>ASSESSMENT STANDARD</th>
<th>LEARNING OUTCOMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3 Explain the significance of solar radiation as a source of energy</td>
<td>• The Sun as the principal source of energy is explained (energy conversion).</td>
<td>• Explain why the Sun must be considered as the principal source of energy.</td>
</tr>
<tr>
<td></td>
<td>• Key terms used in solar radiation terminology are explained and measured. <em>Range: Peak sun hours, Irradiance (direct and diffuse radiation) measured in W/m² and Lux.</em></td>
<td>• Explain key terms relevant for solar radiation.</td>
</tr>
<tr>
<td></td>
<td>• Irradiance from different sources of light are measured in watts per square meter (W/m²) and convert into illuminance (measured in Lux).</td>
<td>• Measure irradiance from different sources of light in watts per square meter and convert into illuminance.</td>
</tr>
<tr>
<td></td>
<td>• Key terms used for describing sun geometry are explained and sun path diagrams for different locations interpreted. <em>Range: Solar altitude, Azimuth, Sun path diagram.</em></td>
<td>• Explain key terms used in Sun geometry.</td>
</tr>
<tr>
<td></td>
<td>• The geometry for installing solar arrays is explained and their effect demonstrated through diagrams and calculations. <em>Range: Orientation, Tilt angle, Magnetic declination.</em></td>
<td>• Interpret Sun path diagrams for different locations.</td>
</tr>
<tr>
<td></td>
<td>• Explain why the Sun must be considered as the principal source of energy.</td>
<td>• Explain the effects of orientation and tilt of solar arrays on the amount of power produced by using diagrams and calculations.</td>
</tr>
<tr>
<td></td>
<td>• Explain key terms relevant for solar radiation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Measure irradiance from different sources of light in watts per square meter and convert into illuminance.</td>
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<td>• Explain key terms used in Sun geometry.</td>
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<td>• Explain the effects of orientation and tilt of solar arrays on the amount of power produced by using diagrams and calculations.</td>
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<table>
<thead>
<tr>
<th>ASSESSMENT TASKS OR ACTIVITIES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Students perform the followings:</td>
<td></td>
</tr>
<tr>
<td>• Written tests on learning outcomes.</td>
<td></td>
</tr>
<tr>
<td>• Measurement of irradiance from different sources of light.</td>
<td></td>
</tr>
<tr>
<td>• Students use gap texts to demonstrate their understanding on the significance of solar radiation for power generation and energy conversion.</td>
<td></td>
</tr>
<tr>
<td>• In diagram and table format students record and explain the effects of orientation and tilt on the amount of power produced by a PV module.</td>
<td></td>
</tr>
</tbody>
</table>
### Topic 2: Basic scientific principles and concepts

#### SUBJECT OUTCOME

<table>
<thead>
<tr>
<th>ASSESSMENT STANDARD</th>
<th>LEARNING OUTCOMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Explain energy concepts and investigate energy efficiency options</td>
<td>2.1 Explain work, energy and power in scientific terms.</td>
</tr>
</tbody>
</table>

- **Work** \((W)\), energy \((E)\) and power \((P)\) are explained in scientific terms, i.e. as:
  1. The application of a force \((F)\) over a distance \((W = F \times d)\) or power \((P)\) over time \((t)\): \(W = P \times t\) measured in watt hours, Wh;  
  2. The capacity to do work \((E = N \times m)\) measured in Joule; and  
  3. The rate at which work is done \((P = W/t)\) measured in watt = Joule/sec (instantaneous power).  
- The concepts of work, energy and power using electric household devices are applied to:  
  1. Calculate instantaneous rates of energy use (power in Watt);  
  2. Calculate how much energy is used over a period of time (in Wh or kWh); and  
  3. Calculate how much energy is stored in an electrical storage device (battery or capacitor).  
- Concepts for saving energy and energy conservation are explained.  
  - Range: Effective energy reductions in buildings, Energy efficient manufacturing etc.  
- Behaviour change is explained as an important step to achieve energy savings and environmental goals.  
- An audit on a residential or commercial environment is explained and appropriate energy efficiency solutions (technology & behaviour) are recommended. Energy assessor/auditor careers are introduced and advising households on how to reduce their energy consumption.  
- Power usage of various lighting devices and equipments, for example lighting systems (LED, CFL and Incandescent bulbs).  

#### ASSESSMENT TASKS OR ACTIVITIES

- Students perform the followings:  
  1. Written tests on learning outcomes.  
  2. Students use tables to explain base quantities and interpret free-body diagrams.  
  3. Students determine the power ratings of different electric appliances, and calculate their energy demand and operating costs.  
  4. Students conduct an energy audit at home or college and suggest ways to cut down on energy cost e.g. insulation, heating, cooling, windows, lighting, appliances, and office equipments.
<table>
<thead>
<tr>
<th>SUBJECT OUTCOME</th>
<th>ASSESSMENT STANDARD</th>
<th>LEARNING OUTCOMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2 Apply the principles of electric charge in direct current circuits</td>
<td>• Electric energy is explained, with reference to electrical charge (Q), conductivity and insulators.</td>
<td>• Explain the properties of electric charge (Q).</td>
</tr>
<tr>
<td></td>
<td>• Electrical potential difference (V) as an expression for the electromotive force (emf) which drives the electric current (I) around a closed circuit (DC) is described. This includes the base quantities in simple electric circuits and introducing the terms potential difference (V) (measured in volt), electric current (I) (measured in ampere) and resistance (R) (measured in ohm).</td>
<td>• Describe potential difference (V) and relate (V) to other base quantities (using formulas).</td>
</tr>
<tr>
<td></td>
<td>• Electric current (I) is explained as the charge flow rate and resistance (R) is represented as impedance to the flow of charge in a circuit.</td>
<td>• Explain why the popular term ‘voltage’ is misleading.</td>
</tr>
<tr>
<td></td>
<td>• Basic circuit diagrams including functions and symbols of control (switches), connecting wires (current path), load resistance (lamps, motors etc.), power sources (batteries) are sketched.</td>
<td>• Explain the term electric current.</td>
</tr>
<tr>
<td></td>
<td>• Ohm’s law is stated and explained and that potential, current and resistance interact directly in Ohm’s law, i.e. the ratio of potential to current is called resistance.</td>
<td>• Explain why the analogy of water flow to electric circuits (DC) is misleading.</td>
</tr>
<tr>
<td></td>
<td>• State and explain Ohm’s law.</td>
<td></td>
</tr>
</tbody>
</table>

### ASSESSMENT TASKS OR ACTIVITIES

- Written tests on the learning outcomes.
- Students investigate the effects of electric currents.
- Students determine current based on different potential and resistance levels.
- Students determine current, potential and resistance levels by using Ohm law.
## SUBJECT OUTCOME

### 2.3 Build simple DC circuits, test/fault finding and perform calculations

<table>
<thead>
<tr>
<th>ASSESSMENT STANDARD</th>
<th>LEARNING OUTCOMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Multi-meter connectivity is explained for the purpose of testing, fault finding and measuring base quantities.</td>
<td>• Explain how a multi-meter can be used for testing, fault finding and measuring base quantities.</td>
</tr>
<tr>
<td>• Various circuit diagrams of resistive configurations are sketched as a preparation to conduct experiments with series, parallel and series-parallel circuits to demonstrate ohm’s law.</td>
<td>• Sketch series, parallel and series-parallel circuit diagrams.</td>
</tr>
<tr>
<td>• The use and the relationship of base quantities are further demonstrated by introducing Ohm’s law and solving problems graphically and by calculation. <em>Range for calculations includes potential difference, total resistance and current, as well as power, energy and drop in potential across resistors.</em></td>
<td>• Use Ohm’s law and apply appropriate formulae in calculations.</td>
</tr>
<tr>
<td>• Experiments are conducted and their effects on base quantities measured using a multi-meter.</td>
<td>• Conduct experiments to demonstrate Ohm’s law using multi-meters for testing, fault finding and measuring.</td>
</tr>
<tr>
<td>• Factors that may cause variations between measured and calculated values are listed and explained.</td>
<td>• List and explain the factors that may cause variations between measured and calculated values.</td>
</tr>
</tbody>
</table>

## ASSESSMENT TASKS OR ACTIVITIES

Students perform the followings:
- Written and practical tests on the learning outcomes.
- Students use multi-meters for testing and fault finding, i.e. measure Volt (V), Ampere (I) and Ohm (Ω) in a circuit.
- Students build different circuits combinations using resistive loads and lamps.
- Students measure potential difference and current through various components in a circuit.
- Students investigate drop in potential in different circuit combinations.
- Students calculate values from given data for series, parallel and series-parallel circuits.
### Topic 3: Safety

<table>
<thead>
<tr>
<th>SUBJECT OUTCOME</th>
<th>ASSESSMENT STANDARD</th>
<th>LEARNING OUTCOMES</th>
</tr>
</thead>
</table>
| 3.1 Describe and explain safe work practices | - Basic terms as used in health and safety are explained.  
  Range: Health, safety, accidents, incidents, injury, risk, hazard, near misses and dangerous occurrence, controls, danger zone, emergency plan, health and safety policy, incident investigation, accident investigation, accident prevention, administrative controls, engineering controls, injury, analysis, task, work practices, workplace inspections, machine guarding and material safety data sheets. | - Explain basic terms used in health and safety. |
|                 | - Workplace health and safety are identified and explained.  
  Range: Unsafe acts and unsafe conditions, safety signs, housekeeping, cleanliness, hygiene, personal protective equipment, lifting and handling safety, working at heights, noise, flammable and explosive substances, storage of gas cylinders, stress and violence at work. | - Identify and explain workplace health and safety. |
|                 | - Potential workplace hazards are identified and explained.  
  Range: Physical, chemical, biological, electrical, slips, trips and falls, hazard register, hazard report, inspections, work area analysis and task analysis. | - Identify and explain potential workplace hazards. |
|                 | - The importance of clear and effective communication in the workplace is explained. | - Explain the importance of clear and effective communication in the workplace. |
|                 | - Arrangement of the work area is explained to minimise accidents and injury. | - Explain how work area is arranged to minimise accidents and injury. |
|                 | - A health and safety checklist that can be used at the workplace/learning institution for accidents prevention is designed. | - Design a health and safety checklist that can be used at the workplace/learning institution for accidents prevention. |
|                 | - The consequences of electrical shock and burns on the human body and electrical accidents involving property such as fires are explained. | - Explain the effect and consequences of electrical shock and burns on the human body. |
|                 | - The correct procedures for isolation of electrical equipment such as assuming equipment is energised unless proven otherwise, use the test-prove method, unplug equipment when | - Explain the effect and consequences of electrical accidents involving property such as fires. |
|                 |                                                                                                                                 | - Explain and demonstrate the correct procedures for isolation of electrical equipment. |
not in use, application of lock-out and tag-out, identifying the hazards of Electric charge and water are explained and demonstrated.

<table>
<thead>
<tr>
<th>ASSESSMENT TASKS OR ACTIVITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students perform the followings:</td>
</tr>
<tr>
<td>• Written tests on the learning outcomes.</td>
</tr>
<tr>
<td>• Demonstrate the correct use of PPE, follow safety rules, awareness of workplace hazards controls and compliance with signage.</td>
</tr>
<tr>
<td>• Identify potential hazards in the work area and suggest recommendation in the form of a report.</td>
</tr>
<tr>
<td>• Evaluate and report unsafe work practices and steps for any corrective action that need to be implemented by giving a task/case studies or scenario.</td>
</tr>
</tbody>
</table>
## Topic 4: Basic principles of Photovoltaic (PV) systems including experiments/simulations, testing/fault finding and repairs

<table>
<thead>
<tr>
<th>SUBJECT OUTCOME</th>
<th>LEARNING OUTCOMES</th>
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</thead>
<tbody>
<tr>
<td><strong>4.1 Explain the basic principles of Photovoltaic (PV) systems</strong></td>
<td></td>
</tr>
<tr>
<td><strong>ASSESSMENT STANDARD</strong></td>
<td><strong>LEARNING OUTCOMES</strong></td>
</tr>
</tbody>
</table>
| - The different components of PV systems and their principal functions are described and sketched.  
  *Range:* Off-grid and grid connected system components (module, array, charge controller, batteries, fuses, circuit breakers, luminaries, switches, earth leakage devises, isolators and inverter/transformer)  
  Differences/similarities between transformers and inverters, i.e. transformers increase or decrease alternating current (AC) from one potential level to another. Inverters take direct current (DC) as input and produce AC as output current. Inverters normally include a modified transformer in their design. | - Describe and sketch the different components of a PV system and their functions.  
- Understand the difference between transformer and inverter. |
| - Semiconductor materials used to manufacture the main types of solar cells are stated. | - State the semiconducting materials used to manufacture the main types of solar cells. |
| - The concept of how a solar cell converts sunlight into electrical power (photovoltaic effect) is described and explained. | - Describe and explain the photovoltaic effect. |
| - Solar cell and module efficiency is defined, explained and compared using different cell materials (mono-, poly-, and amorphous silicon and thin-film). | - Compare different PV technologies regarding efficiency. |
| - Surface area required to generate 1 kilowatt peak (kWp) is calculated. | - Calculate surface area required to generate 1 kilowatt peak (kWp). |
| - Standards, test conditions, certifications and warranties of solar module are interpreted and explained. | - Interpret sample datasheets of PV modules with reference to standards, certifications and warranties. |
| - Key electrical output parameters of solar cells are identified and measured.  
  *Range:* Voc, Isc, Vmp, Imp and Pmax | - Identify key electrical output parameters by using multi-meters for testing and fault finding. |
| - The current / voltage (I/V) curve of a solar cell and PV module are explained and sketched. | - Explain and sketch the I/V curve of a solar cell and PV module. |
| - List and explain the factors that affect the per- | |
### The factors that affect the performance of PV modules are listed and explained.

*Range: Cell materials, load resistance, temperature and shading, and sunlight intensity.*

### ASSESSMENT TASKS OR ACTIVITIES

<table>
<thead>
<tr>
<th>Students perform the followings:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Written and practical tests on learning outcomes.</td>
</tr>
<tr>
<td>• Explain the differences/similarities between transformers and inverters.</td>
</tr>
<tr>
<td>• Demonstrate and plot the I/V curve of a solar cell in a diagram.</td>
</tr>
<tr>
<td>• Determine the efficiency factor of solar cells and maximum power point using table formats.</td>
</tr>
<tr>
<td>• Measure key electrical output parameters using multi-meters (testing and fault finding).</td>
</tr>
</tbody>
</table>
### SUBJECT OUTCOME

#### 4.2 Using the Sun as a source of energy

<table>
<thead>
<tr>
<th>ASSESSMENT STANDARD</th>
<th>LEARNING OUTCOMES</th>
</tr>
</thead>
</table>
| • Individual components of training kits or industrial components for experiments are identified.  
  *Range:* Solar cells, shading plates, multimeter, halogen lamp (irradiation unit), storage (battery or capacitor), diodes, loads (small motor or lamp) and cables. Fuses, circuit breakers, luminaries, charge controller, inverter/transformer, switches, earth leakage devises and isolators. | • Identify training kit or industrial components for experimental purposes. |
| • Basic PV circuit diagrams including symbols are sketched and functions explained  
  *Range:* generators (solar cells), connecting wires (current path), load resistance (lamps, motors etc.), storage devices (capacitors and batteries), semiconductors (diodes) and resistors. | • Sketch basic PV circuit diagrams using symbols and explain their functions. |
| • Experiments are conducted demonstrating the function of solar cells as energy convertors using different irradiance values (brightness of lamp) and:  
  (i) State observations regarding the load (small motor or lamp) by different irradiance values,  
  (ii) Indicate the relation between irradiance and electrical energy, and  
  (iii) Specify the energy conversions. | • Demonstrate the function of solar cells as energy convertors.  
  • Explain how to test and find faults in electrical circuits and its components.  
  • Test the circuit in the experiments and its components (fault finding). |

#### ASSESSMENT TASKS OR ACTIVITIES

Students perform the followings:

• Written and practical tests on learning outcomes.
• Photovoltaic system components are connected using didactical training kits or industrial components to understand solar cell characteristics.
• Measure key electrical output parameters using multi-meters (testing and fault finding).
### SUBJECT OUTCOME

#### 4.3 Explain the characteristic of solar cells under different conditions

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><em>A completely shaded solar cell that functions as a diode (current flow in one direction only) is explained. Diodes are introduced as electronic semiconductors.</em></td>
<td><em>Explain how and why a completely shaded solar cell functions as a diode.</em></td>
</tr>
</tbody>
</table>
| *The effect of shading are demonstrated by conducting experiments such as*  
  (i) Determine the off-load potential of un-shaded and shaded solar cells;  
  (ii) Enter the different potential values (mV) in a table and diagram, i.e. off-load potential against shaded surface area; and  
  (iii) State which findings can be obtained from these measurements. | *Demonstrate the effect of shading by conducting experiments.*  
*Test the circuit in the experiments and its components (fault finding)* |
| *The effect of irradiance by conducting experiments are demonstrated such as*  
  (i) Determine the off-load potential and the short-circuit current at different irradiance values;  
  (ii) Use multi-meter as volt- and ammeter and enter the different current/potential value pairs (mV and mA) in a table and diagram, i.e. mV and mA values against irradiance (W/m²); and  
  (iii) State which findings can be obtained from the measurements. | *Demonstrate the effect of irradiance by conducting experiments.*  
*Test the circuit in the experiments and its components (fault finding)* |
| *The effect of tilt is demonstrated by conducting experiments such as*  
  (i) Determine the short-circuit current at different angles of irradiation using multi-meter as ammeter;  
  (ii) Enter the different values (mA) in a table and diagram, i.e. mA values against angle dimension (°); and  
  (iii) State which coherences between the angle of incidence (light onto the solar cell) and the intensity of the short-circuit current can be derived. | *Demonstrate the effect of tilt by conducting experiments.*  
*Test the circuit in the experiments and its components (fault finding)* |

#### ASSESSMENT TASKS OR ACTIVITIES

Students perform the followings:  
* Written and practical tests on learning outcomes.  
* Photovoltaic system components are connected using didactical training kits or industrial components to understand solar cell characteristics  
* Measure key electrical output parameters using multi-meters (testing and fault finding).
### SUBJECT OUTCOME

<table>
<thead>
<tr>
<th>ASSESSMENT STANDARD</th>
<th>LEARNING OUTCOMES</th>
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</thead>
<tbody>
<tr>
<td>4.4 Demonstrate the effect of series and parallel connections of solar cells under different conditions</td>
<td></td>
</tr>
<tr>
<td><strong>ASSESSMENT STANDARD</strong></td>
<td><strong>LEARNING OUTCOMES</strong></td>
</tr>
<tr>
<td>- The effects of series connections and shading are demonstrated by conducting experiments.</td>
<td>- Demonstrate the effects of series connections and shading by conducting experiments.</td>
</tr>
</tbody>
</table>
| - The off-load potential and the short-circuit current of four different single solar cells in series is determined as follows:  
  (i) Single cell, and two, three and four cells in series  
  (ii) Partly shaded, completely shaded and unshaded cells connected in series.  
  (iii) Enter the different values (mV and mA) in three different tables and state which findings can be obtained from the individual tables. | - Test the circuit in the experiments and its components (fault finding).  
- Determine off-load potential and the short-circuit current of four different single solar cells in series.  
- Test the circuit in the experiments and its components (fault finding). |
| - The function of bypass diodes is demonstrated by conducting experiments such as:  
  (i) Determine off-load potential and the short-circuit current of four solar cells with and without bypass diode.  
  (ii) Construct the circuit with one cell partly shaded and all cells in series connection.  
  (ii) Use a multi-meter as volt- and ammeter. Enter the different current/potential values pairs (mV and mA) in two different tables.  
  (iii) Plot the mV and mA values against each other and draw two lines representing measurements with and without bypass diode and (iv) State which findings can be obtained from the measurements. | - Demonstrate the function of bypass diodes by conducting experiments.  
- Test the circuit in the experiments and its components (fault finding). |
| - The effect of parallel connections and shading are demonstrated by conducting experiments. | - Demonstrate the effect of parallel connections and shading by conducting experiments.  
- Test the circuit in the experiments and its components (fault finding). |
| - The off-load potential and the short-circuit current of four different single solar cells in parallel is determined as follows:  
  (i) Single cell, and two, three and four cells in parallel and  
  (ii) Partly shaded, completely shaded and unshaded cells connected in parallel.  
  (iii) Use a multi-meter as volt- and ammeter. Enter the different values (mV and mA) in three different tables and state which findings | - Determine off-load potential and the short-circuit current of four different single solar cells in parallel.  
- Test the circuit in the experiments and its components (fault finding). |
A I/V curve diagram is established by conducting experiments.

The off-load potential and the short-circuit current of four solar cells connected in series using a high and a low irradiance level are determined as follows:
(i) Enter the different current/potential values pairs (mV and mA) for 12 different resistance levels in two different tables (high and a low irradiance level),
(ii) Plot the mV and mA values for each irradiance level against each other. The two lines shall represent the results for the high and a low irradiance levels, and
(iii) State which findings can be obtained from the I/V curve diagram.

The relationship between internal resistance of a solar cell and irradiance is demonstrated and experiments are conducted to determine efficiency of four un-shaded solar cells connected in series and the point of maximum output (MPP) is calculated. Results are tabulated and plotted in an efficiency curve diagram.

Experiments are conducted and measurement taken for potential and current of four solar cells connected in series as follows:
(i) Enter the different current/potential value pairs (mV and mA) in two different tables (high and a low irradiance level) for 12 different resistance levels into the tables.
(ii) Plot the mV and mA value pairs for each irradiance level against each other. Ensure that each line represents the results for the high and a low irradiance levels and
(iii) State which findings can be obtained from the I/V curve diagram.

Establish a I/V curve diagram by conducting experiments.

Determine off-load potential and the short-circuit current of four solar cells connected in series using a high and a low irradiance level.

Test the circuit in the experiments and its components (fault finding).

Demonstrate the relationship between internal resistance of a solar cell and irradiance.

Test the circuit in the experiments and its components (fault finding).

Conduct experiments and measure potential and current of four solar cells connected in series.

Test the circuit in the experiments and its components (fault finding).

Students perform the followings:
- Written and practical tests on learning outcomes.
- Photovoltaic system components are connected using didactical training kits or industrial components to understand solar cell characteristics.
- Measure key electrical output parameters using multi-meters (testing and fault finding).
4.5 Emulate the effect of diurnal variation and design a simple off-grid (low ‘voltage’) network

**ASSESSMENT STANDARD**

- The effect of diurnal variation on the maximum possible energy yield of a stationary solar cell is emulated by conducting experiments such as:
  1. Determine the short-circuit current of two solar cells connected in series for nine positions from East to West (E, ESE, SE etc.).
  2. Plot the mA values for each position in a diurnal variation diagram and state which findings can be obtained from the diagram.

- The operations of a simple off-grid network including an energy storage device (capacitor or battery) are designed and demonstrated. Range: testing and fault finding of fuses, circuit breakers, luminaries, capacitor or battery, charge controller, inverter/transformers, switches, earth leakage devises and isolators.

- The relationship between irradiance, charging conditions of the storage device and the operation of consumers (lamp, motor etc.) are explained.

**LEARNING OUTCOMES**

- Emulate the effect of diurnal variation on the maximum possible energy yield of a stationary solar cell by conducting experiments.
- Test the circuit in the experiments and its components (fault finding).
- Design a simple off-grid network including an energy storage device.
- Test and fault finding of the off-grid network and its components.
- Explain the relationship between irradiance, charging conditions of the storage device and the operation of consumers.

**ASSESSMENT TASKS OR ACTIVITIES**

- Students perform the followings:
  - Written and practical tests on learning outcomes.
  - Photovoltaic system components are connected using didactical training kits or industrial components to understand solar cell characteristics.
  - Measure key electrical output parameters using multi-meters (testing and fault finding).

4. **SPECIFICATIONS FOR EXTERNAL ASSESSMENT IN RENEWABLE ENERGY TECHNOLOGIES – LEVEL 2**

4.1 Integrated summative assessment task (ISAT)

A compulsory component of the external assessment (ESASS) is the integrated summative assessment task (ISAT). The integrated summative assessment task (ISAT) draws on the students’ cumulative learning achieved throughout the year. The task requires integrated application of competence and is executed and recorded in compliance with assessment conditions.

Two approaches to the integrated summative assessment task (ISAT) may be as follows:

- The students are assigned a task at the beginning of the year which they will have to complete in phases during the year to obtain an assessment mark. A final assessment is made at the end of the year when the task is completed.

**OR**

- The students achieve the competencies during the year but the competencies are assessed cumula-
tively in a single assessment or examination session at the end of the year.

The integrated summative assessment task (ISAT) is set by an externally appointed examiner and is conveyed to colleges in the first quarter of the year. The integrated assessment approach enables students to be assessed in more than one subject with the same integrated summative assessment task (ISAT).

### 4.2 National Examination

A national examination is conducted annually in October or November by means of a paper(s) set and moderated externally. The following distribution of cognitive application is suggested:

<table>
<thead>
<tr>
<th>LEVEL 2</th>
<th>KNOWLEDGE AND COMPREHENSION</th>
<th>APPLICATION</th>
<th>ANALYSIS, SYNTHESIS AND EVALUATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 - 40%</td>
<td>50 - 60%</td>
<td>0 - 10%</td>
</tr>
</tbody>
</table>