City & Guilds Level 3 Award in the Design, Installation and Commissioning of Small Electrical Energy Storage Systems (2923-34)

Version 1.1 (January 2025)

Qualification Handbook

Qualification at a glance

Subject area	Building Services Industry
City & Guilds number	2923
Age group approved	18+
Entry requirements	Please see the guidance on page 9
Assessment	Online multiple-choice knowledge test Practical assignment
Grading	Pass/Fail
Approvals	Full approval required
Support materials	Sample assessments
Registration and certification	Consult the Walled Garden/Online Catalogue for last dates

Title and level	City & Guilds qualification number	Regulatory reference number	GLH	TQT
City & Guilds Level 3 Award in the Design, Installation and Commissioning of Small Electrical Energy Storage Systems	2923-34	610/4840/9	15	22

Version and date	Change detail	Section
1.0 November 2024	Initial version	All
1.1 January 2025	Addition of ‘How is this qualification recognised?’ Learner entry requirement – updated to align across industry eligibility.	1. Introduction 2. Centre requirements

Contents

1 Introduction

This document tells you what you need to do to deliver the qualification:

Area	Description
Who is the qualification for?	This qualification is aimed at qualified and experienced electricians who wish to understand the requirements for design, installation and maintenance of EESS, typically within a domestic or small-commercial setting. Learners must be at least 18 years old to take this course as part of their CPD to undertake this 'Electrician Plus' qualification.
What does the qualification cover?	The purpose of this qualification is to cover the knowledge, understanding and skills required for the design, installation and maintenance of electrical energy storage systems (EESS). It follows the IET Code of Practice for Electrical Energy Storage Systems and industry guidance, together with the requirements of BS 7671. It will include a range of relevant outcomes covering statutory legislation applicable to EESS, the principles of batteries and EESS, how to specify and design EESS, installation, inspection and testing, and handover of an EESS and will be aligned with the MCS requirements. The qualification will also be mapped to the latest National Occupational Standard (NOS) SPV01.
What opportunities for progression are there?	On successful completion of this qualification, learners can progress on to City & Guilds Level 4 Award in the Design and Verification of Electrical Installations. As well as other CPD qualifications within Electrotechnical.

Area	Description
Who did we develop the qualification with?	TESP and other key training organisations.
Is it part of an apprenticeship framework or initiative?	No.
How is this qualification recognised?	The Joint Industry Board & Electrotechnical Certification Scheme recognises this qualification as CPD for an ECS Gold Card Installation Electrician, Maintenance Electrician, or Domestic Electrician. This qualification can be contained in the MyECS CPD record and printed on the reverse of the ECS card. This qualification has been endorsed by TESP (The Electrotechnical Skills Partnership) and awarded the Electrician Plus kitemark.

Structure

To achieve the City & Guilds Level 3 Award in the Design, Installation and Commissioning of Small Electrical Energy Storage Systems, learners must achieve:

City & Guilds unit number	Unit title	GLH
Mandatory units:		
Learners must achieve the following mandatory units.		
301	Design, installation and commissioning of small electrical energy storage systems – online knowledge test	15
302	Design, installation and commissioning of small electrical energy storage systems – practical assignment	

Eligibility for this qualification must be confirmed according to the learner entry requirements on page 9. Once eligibility is confirmed, proxy unit **2923-801** must be claimed to allow certification. Please see Walled Garden for details.

Total Qualification Time (TQT)

Total Qualification Time (TQT) is the number of notional hours which represents an estimate of the total amount of time that could reasonably be expected for a learner to demonstrate the achievement of the level of attainment necessary for the award of a qualification.

TQT consists of the following two elements:

1) the number of hours that an awarding organisation has assigned to a qualification for guided learning
2) an estimate of the number of hours a learner will reasonably be likely to spend in preparation, study or any other form of participation in education or training, including assessment, which takes place as directed by – but, unlike guided learning, not under the immediate guidance or supervision of – a lecturer, supervisor, tutor or other appropriate provider of education or training.

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2 Centre requirements

Approval

To offer this qualification, new centres will need to gain both centre and qualification approval. Please refer to the document **Centre Approval Process: Quality Assurance Standards** for further information.

Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualification before designing a course programme.

Resource requirements

Centre staffing

Staff delivering these qualifications must be able to demonstrate that they meet the following occupational expertise requirements. They should:

- be occupationally competent or technically knowledgeable in the area for which they are delivering training and/or have experience of providing training (this knowledge must be to the same level as the training being delivered)
- have recent relevant experience in the specific area they will be assessing
- have credible experience of providing training.

Continuing professional development (CPD)

Centres are expected to support their staff in ensuring that their knowledge remains current of the occupational area and of best practice in delivery, mentoring, training, assessment and quality assurance, and that it takes account of any national or legislative developments.

Quality assurance

Approved centres must have effective quality assurance systems to ensure optimum delivery and assessment of qualifications. Quality assurance includes initial centre approval, qualification approval and the centre's own internal procedures for monitoring quality. Centres are responsible for internal quality assurance and City & Guilds is responsible for external quality assurance. All external quality assurance processes reflect the minimum requirements for verified and moderated assessments, as detailed in the Centre Assessment Standards Scrutiny (CASS), section H2 of Ofqual's General Conditions. For more information on both CASS and City & Guilds Quality Assurance processes visit: the **What is CASS?** and **Quality Assurance Standards** documents on the City & Guilds website.

Standards and rigorous quality assurance are maintained by the use of:

- Internal quality assurance
- City & Guilds external quality assurance.

External quality assurance for the qualification will be provided by City & Guilds EQA process. EQAs are appointed by City & Guilds to approve centres, and to monitor the assessment and internal quality assurance carried out by centres. External quality assurance is carried out to ensure that assessment is valid and reliable, and that there is good assessment practice in centres.

The role of the EQA is to:

- provide advice and support to centre staff
- ensure the quality and consistency of assessments and marking/grading within and between centres by the use of systematic sampling
- provide feedback to centres and to City & Guilds.

Learner entry requirements

This course is intended for practicing electricians. Eligibility for this qualification must be confirmed according to the learner entry requirements as outlined below.

Evidence that eligibility requirements have been met must be kept by the centre for 3 years and will be subject to external quality assurance processes.

Learners **must** hold one of the following:

- City & Guilds Level 3 NVQ Diploma in Installing Electrotechnical Systems and Equipment (Buildings, Structures and the Environment) (2357)
- City & Guilds Level 3 NVQ Diploma in Electrotechnical Services (Electrical Maintenance) (2357)
- City & Guilds Level 3 Electrotechnical qualification (5357)
- City & Guilds Level 3 NVQ in Electrotechnical Services Experienced Worker (2356)
- City & Guilds Level 3 Electrotechnical Experienced Worker Qualification (2346)
- City & Guilds Level 3 Electrotechnical in Dwellings Experienced Worker Qualification (2347)
- Other Awarding Organisations equivalences will also be acceptable
- Equivalent historical qualifications: Electrotechnical Assessment Specification (see latest version link)
  or
- ECS Gold Card issued by the JIB or SJIB – Installation Electrician, Maintenance Electrician, or Domestic Electrician

For learners in Scotland:

- Any of the above or
- SVQ in Electrical Installation at SCQF level 7

For learners in Wales:

- Any of the above or
- EAL Building Services Engineering (Level 3) Electrotechnical Installation

For all learners, the qualifications above must have been achieved no more than 5 years prior to starting this qualification or there must be evidence the learner has remained current by holding the latest edition of the Wiring regulations qualification.

Age restrictions

This qualification is approved for learners aged 18 or above.

Access arrangements and reasonable adjustments

City & Guilds has considered the design of this qualification and its assessment in order to best support accessibility and inclusion for all learners. We understand however that individuals have diverse learning needs and may require reasonable adjustments to fully participate. Reasonable adjustments, such as additional time or alternative formats, may be provided to accommodate learners with disabilities and support fair access to assessment.

Access arrangements are adjustments that allow candidates with disabilities, special educational needs, and temporary injuries to access the assessment and demonstrate their skills and knowledge without changing the demands of the assessment. These arrangements must be made before assessment takes place.

The Equality Act 2010 requires City & Guilds to make reasonable adjustments where a disabled person would be at a substantial disadvantage in undertaking an assessment.

It is the responsibility of the centre to ensure at the start of a programme of learning that candidates will be able to access the requirements of the qualification.

Please refer to the JCQ access arrangements and reasonable adjustments and Access arrangements - when and how applications need to be made to City & Guilds for more information. Both are available on the **City & Guilds website**

3 Delivering the qualification

Initial assessment and induction

An initial assessment of each learner should be made before the start of their programme to identify:

- if the learner has any specific training needs
- support and guidance they may need when working towards their qualification
- any units they have already completed or credit they have accumulated which is relevant to the qualification
- the appropriate type and level of qualification.

We recommend that centres provide an induction programme, so the learner fully understands the requirements of the qualification, their responsibilities as a learner and the responsibilities of the centre. This information can be recorded on a learning contract.

Inclusion and diversity

City & Guilds is committed to improving inclusion and diversity within the way we work and how we deliver our purpose which is to help people and organisations develop the skills they need for growth.

More information and guidance to support centres in supporting inclusion and diversity through the delivery of City & Guilds qualifications can be found here:

Inclusion and diversity | City & Guilds (cityandguilds.com)

Sustainability

City & Guilds are committed to net zero. Our ambition is to reduce our carbon emissions by at least 50% before 2030 and develop environmentally responsible operations to achieve net zero by 2040 or sooner if we can. City & Guilds is committed to supporting qualifications that support our customers to consider sustainability and their environmental footprint.

More information and guidance to support centres in developing sustainable practices through the delivery of City & Guilds qualifications can be found here:

Our Pathway to Net Zero | City & Guilds (cityandguilds.com)

Centres should consider their own carbon footprint when delivering this qualification and consider reasonable and practical ways of delivering this qualification with sustainability in mind. This could include:

- reviewing purchasing and procurement processes (such as buying in bulk to reduce the amount of travel time and energy, considering and investing in the use of components that can be reused, instead of the use of disposable or single use consumables)
- reusing components wherever possible
- waste procedures (ensuring that waste is minimised, recycling of components is in place wherever possible)
- minimising water use and considering options for reuse/salvage as part of plumbing activities wherever possible.

Support materials

The following resources are available for this qualification:

Description	How to access
Sample multiple-choice test	www.cityandguilds.com

4 Assessment

Assessment of the qualification

Candidates must:

- successfully complete one online multiple-choice test and one practical assignment.

Assessment types			
Unit	**Title**	**Assessment method**	**Where to obtain assessment materials**
301	Design, installation and commissioning of small electrical energy storage systems – online knowledge test	Online multiple-choice test	City & Guilds e-volve test system
302	Design, installation and commissioning of small electrical energy storage systems – practical assignment	Practical assignment	2923 page on www.cityandguilds.com

Assessment strategy

City & Guilds has written the following assessment to use with this qualification

- Online multiple-choice test – externally set and marked
- Practical assignment – externally set, internally marked, externally quality assured.

Time constraints

Learner registration is valid for 12 months only as this is a short CPD course.

The course is expected to be covered in 3 days (2 days delivery and 1 day assessment).

Recognition of prior learning (RPL)

RPL is not allowed for this qualification.

Test specification for the online knowledge test

Permitted materials:
IET Code of Practice for Electrical Energy Storage Systems, 3rd edition
IET Wiring Regulations 18th Edition: BS 7671:2018 (latest amendment) Requirements for Electrical Installations
Calculator

Graded: Pass/Fail

Pass mark: the pass mark for this examination is set at approx. 75%

Test: 2923-301	**Duration: 60 minutes**		
Unit	**Outcome**	**Number of questions**	**Percentage %**
301	LO1 Know the key documentation and legislation in relation to design and installation of solar photovoltaic (PV) systems and electrical energy storage systems (EESS)	2	7%
301	LO3 Understand the characteristics of EESS, components and architectures	10	33%
301	LO4 Understand design and installation considerations for EESS	15	50%
301	LO6 Understand the use of micro-generation and EESS as part of prosumer's installations	3	10%
	Total	30	100%

Practical assignment

The instructions for the practical assignment are covered in the separate Assignment Packs for Candidates and Assessors.

5 Units

Structure of the units

These units each have the following:

- City & Guilds reference number
- title
- level
- guided learning hours (GLH)
- assessment type
- learning outcomes, which are comprised of a number of topics and content elements

Guidance for delivery of the unit

This qualification contains a single **unit**. A unit describes what is expected of a competent person in particular aspects of their job.

The **unit** is divided into **learning outcomes** which describe in further detail the skills and knowledge that a candidate should possess.

Each **learning outcome** has a set of **topics** that are simple and concise statements that indicates to a learner something specific they will be learning in relation to the learning outcome. It should provide clarity to a learner at a high level on what they should be expecting to learn or be able to do about a specific area of the learning outcome.

Content, the content sections define the 'depth and breadth' to which the teaching/learning must be delivered.

It is important that these sections define all the essential content that must be covered for learners to achieve the learning outcome. It is the information in this section that learners will be assessed on.

Important – the content must be taught in conjunction with:

- IET Code of Practice for Electrical Energy Storage Systems, 3rd edition
- IET Wiring Regulations 18th Edition: BS 7671:2018 (latest amendment) Requirements for Electrical

Unit 301/302 Design, installation and commissioning of small electrical energy storage systems

Level:	3
GLH:	15
Assessment type:	Online multiple-choice knowledge test and practical assignment
Link to Occupational Standards (NOS):	SPV01

Learning outcomes

1. Know the key documentation and legislation in relation to design and installation of solar photovoltaic (PV) systems and electrical energy storage systems (EESS)
2. Work safely with EESS
3. Understand the characteristics of EESS, components and architectures
4. Understand design and installation considerations for EESS
5. Test, commission and handover of EESS
6. Understand the use of micro-generation and EESS as part of prosumer's electrical installations

Learning outcome 1

Know the key documentation and legislation in relation to design and installation of solar photovoltaic (PV) systems and electrical energy storage systems (EESS)

Topics	Content elements
1.1 Statutory requirements and non-statutory guidance relating to the design, installation and commissioning of solar PV and EESS	1.1.1 Scope of statutory requirements and non-statutory guidance relating to the design, installation and commissioning of solar PV and EESS a) Statutory requirements i. Electricity at Work Regulations 1989 (EAWRA) ii. Health and Safety at Work etc. Act 1974 (HASAWA) iii. Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR) iv. Building Regulations • The Building Regulations 2010 (England and Wales)

- Part A – structure
- Part B – fire safety
- Part C – site preparation and resistance to contaminants and moisture
- Part L – conservation of fuel and power
- Part P – electrical safety – dwellings

- The Building (Scotland) Regulations 2004
- The Building Regulations (Northern Ireland) 2012

v. Planning permission
vi. Waste Batteries and Accumulators Regulations 2009
vii. Waste Electrical and Electronic Equipment Regulations 2013 (WEEE)
viii. Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2021 (CDG)

b) Non-statutory guidance

i. Building Regulation Guidance Documents
- Building Regulation Approved Documents (England and Wales)
- Building Standards Division (BSD) Technical Handbooks (Scotland)
- Department of Finance and Personnel Technical Booklets (Northern Ireland)

ii. IET Code of Practice for Grid-connected Solar Photovoltaic Systems/Electrical Energy Storage Systems
iii. IET Wiring Regulations 18th Edition: BS 7671:2018 (latest amendment) Requirements for Electrical Installations
iv. IET Guidance Notes:
- GN1 Selection & Erection
- GN3 Inspection & Testing
- GN7 Special Locations
- GN8 Earthing & Bonding

v. PAS 63100 Code of Practice for Fire performance of battery energy storage systems in dwellings
vi. The Microgeneration Certification Scheme (MCS) –
- The Solar PV standard MIS 3002
- The Battery Standard MIS 3012

vii. RC62 Recommendations for fire safety with photovoltaic panel installations
viii. Energy Network Association (ENA) – Engineering recommendations G98, G99 and G100
ix. Manufacturer's instructions
x. MGD 005 Solar PV Shade Evaluation Procedure

Learning outcome 2

Work safely with EESS

Topics	Content elements
2.1 Identifying and mitigating hazards	2.1.1 Be able to produce a risk assessment for the installation and maintenance of an EESS a) Risk of conductive items and their removal: i. Metallic jewellery ii. Metal-framed glasses on cords iii. Conductive clothing b) Requirements for insulated tools (VDE) c) Utilising test equipment that conforms to: i. BS EN IEC 61010-031 ii. HSE Guidance Note GS38 d) Requirements for use of insulating covers and shrouds when disconnecting leads and/or batteries e) Following specific procedure for removing barriers covering terminals and links f) Requirements for appropriate personal protective equipment (PPE), especially for systems with high discharge energies, including: i. Eye/face protection: • Face shields • Goggles • Light eye-protection (safety glasses) ii. Clothing: • Selection of appropriate arc-flash protective clothing – calculation of arc-flash incident energy (E_{im}) may be required • Flame retardant clothing • Protective gloves and/or gauntlets • Protective aprons iii. Safety footwear: • Toe protection from falling objects • Foot protection from chemicals g) Potential for electric shock or burns from AC equipment: i. PCE might still supply power, necessitating multiple isolation points ii. PCE output may remain live even when other isolators are opened iii. Isolators may have two supplies, one on each side, when open iv. PCE to be shut down to remove load/output, facilitating safe disconnection and maintenance

	h) Manual handling: i. PCE ii. Batteries iii. Cabinets/cubicles iv. Mounting frames 2.1.2 Produce a method statement for the installation and maintenance of an EESS a) Logical sequence of work b) Use of appropriate PPE c) Removal of conductive jewellery/clothing/accessories, as required d) Safety procedures required
2.2 Electrical isolation	2.2.1 Isolation of the AC and DC parts of the system, where relevant, prior to commencing the installation work a) Batteries/cells i. Connectors not to be disconnected under load ii. Batteries/cells to always be considered as live iii. Voltage could be present on either side of connector/link where batteries are in parallel and/or series b) Points of DC isolation i. Identify if point of isolation is suitable for switching/disconnection on load ii. Ensure no load where point of isolation is not suitable for DC switching c) PCE i. Ensure all sources of AC and DC supply/output are identified and isolated ii. AC output of the PCE may have a delay of up to 5 minutes after switching on PCE d) AC output from the PCE and other sources of supply i. All sources of supply to be isolated, where relevant, at other points within installation 2.2.2 Complete the correct safe-isolation procedures to ensure the safe installation of the assemblies and enclosures relevant to the EESS a) Shut down PCE using its internal control b) Isolation of DC components/circuits c) Isolation of input and output of the PCE d) Isolation of other sources of AC supply e) Prove dead at all relevant points and relevant times in process f) Lock-off and label all relevant points of isolation

Learning outcome 3

Understand the characteristics of EESS, components and architectures

Topics	Content elements
3.1 EESS components and architectures	3.1.1 Power coupling modes and understanding differences between them, and the considerations when selecting a) AC coupling i. Equipment • Wider range of compatible components that are more readily available • EESS is wholly separate to a grid-connected renewable system • System can be arranged so not wholly dependent on one PCE • Could be easier to integrate into an existing system • More choice of where batteries may be located • EESS and renewable energy system inverters can be sized independently, avoiding the need for oversizing ii. Circuits • Increased losses due to more power conversion stages b) DC coupling i. Equipment • Renewable system's PCE to be electrically compatible with the EESS • Renewable system's grid-connected inverter to be sized to suit the renewable generation • EESS is an integral part of the grid-connected renewable system • Inverter failure results in loss of generation from both battery and renewable energy source • Existing renewable inverter may need replacing • Battery may need to be located adjacent to renewable system components • Less choice in battery location unless longer DC cabling is used (could cause a significant issue with voltage drop) • Suitably rated DC switching and protection required for DC circuits, due to difficulties of extinguishing DC arcs ii. Circuits • Reduced losses due to fewer power conversion stages • DC to DC converters might be required

3.1.2 Types of system configuration

a) Grid-connected system without any other local generation sources
   i. Can only charge the battery from grid
   ii. Can be used with grid-connected vehicle as storage (V2X)
   iii. Can be used for arbitrage
b) Grid-connected system with other local generation
   i. Can charge the battery from grid
   ii. Can charge the battery from local generation
   iii. Can be used with grid-connected vehicle as storage (V2X)
   iv. Can be used for arbitrage
c) Grid-independent systems
   i. Can only charge battery from local generation
   ii. Can be used with vehicle as storage (V2X)
   iii. Cannot be used for arbitrage

3.1.3 Types of EESS and their advantages and disadvantages

a) Packaged – where PCE and battery are supplied as a complete package
   i. Advantages
      - Provides simpler approach in systems with export and/or import limitation
      - Manufacturer takes responsibility for extensive type-testing
      - Manufacturer includes and tests all relevant safety functions
      - Operators and maintainers can follow a single manufacturer's instructions
   ii. Disadvantages
      - Interface options, bespoke options and the range of system performance may be limited
      - Could be tied to replacement components supplied or recommended by manufacturer
b) Discrete component – where PCE and battery/batteries are supplied as individual items
   i. Advantages
      - Wider choice of interface options
      - Easier to make the installation bespoke to needs
      - Freedom to choose products from different manufacturers
   ii. Disadvantages
      - Technically more challenging to configure controls and integration for components and subsystems

- Greater reliance on the designer and installer of the system to correctly specify, source, install, test and commission
- The design and commissioning stages would require more documentation
- The designer and installer need to compile operation and maintenance information

3.1.4 Types of battery, their characteristics and typical applications

a) Lithium-ion/Lithium-polymer
   i. Applications:
   - Island-mode
   - Off-grid
   - Arbitrage
   - Increasing self-consumption

   ii. Advantages:
   - Suitable for frequent deep discharge
   - Suitable for arbitrage due to being less susceptible to memory effect

   iii. Disadvantages:
   - Costly application
   - Performance significantly affected by the extremes of ambient temperature
   - Very difficult to extinguish in the event of fire

b) Lead-acid (LA)
   i. Application:
   - Commonly used for back-up systems/UPS

   ii. Advantage:
   - Cheaper option than lithium-ion

   iii. Disadvantage:
   - Might not be suitable for regular deep discharge

c) Vanadium Redox Flow Batteries (VRFBs)
   i. Application:
   - Energy stored in liquid electrolyte solutions, allowing for significant storage such as large-scale grid-energy storage

   ii. Advantage:
   - VRFBs safer, lacking the fire risks associated with lithium batteries

   iii. Disadvantages:
   - Relatively poor energy-to-volume ratio
   - Requires more space than equivalent capacity lithium and lead-acid batteries

d) Vented nickel-cadmium (NiCd)
   i. Application:
   - UPS

ii. Advantages:
- Perform well over a range of ambient temperatures
- Deliver their full rated capacity at high discharge rates
- Commonly used for back-up systems/UPS

iii. Disadvantages:
- Relatively expensive in comparison to equivalent capacity lithium and lead-acid batteries
- Take up larger space in comparison to equivalent capacity lithium and lead-acid batteries

3.1.5 Types and functionality of electronic equipment that forms part of an EESS system

a) Inverter types – PCE that converts DC to AC types including:
   i. Grid-connected
      - Inverter is grid-connected and sits between a DC source and the grid
      - Converts DC source into an AC output that is synchronised with the grid
   ii. Stand-alone
      - Designed to be connected to a battery so that it provides AC power without grid present
      - Does not require grid synchronisation
   iii. Bi-directional
      - A PCE which can operate as an inverter converting DC to AC and as a battery charger converting AC to DC
   iv. Hybrid – allows batteries to be charged from AC and DC sources
      - Term ‘hybrid inverter’ (or ‘battery-ready inverter’) sometimes used to describe an inverter that has a compatible DC-coupled connected battery
      - Hybrid inverter can incorporate all functions of grid-connected, stand-alone, or bi-directional but has the provision for an additional DC source, such as Solar PV
b) Battery management system (BMS) - manages and protects rechargeable batteries. Functions include:
   i. Monitoring – keeps track of battery’s state of charge (SoC) and state of health (SoH)
   ii. Balancing – BMS ensures all cells in a battery pack are charged equally
   iii. Safety mechanisms to protect battery from damage, including overcharging or over-discharging
c) Equipment for monitoring, metering and indication, including:

	i. Battery SoC ii. Battery voltage iii. Battery charge/discharge current/power iv. Temperature: • Battery • Ambient • EESS electronics v. Output power, voltage and frequency vi. Grid voltage and frequency vii. Error logs viii. Calls for maintenance action ix. BS EN 61508 series of standards applies to functional safety of controls, monitoring and interlocks
3.2 Terminology used in design and installation of EESS	3.2.1 Terminology associated with the selection and installation of batteries a) Battery capacity – traditionally, battery capacity may be quoted in terms of: i. Ampere-hour(s) (Ah) figure at a particular discharge current ii. Watt-hour(s) (Wh) / kilowatt-hour(s) (kWh) / megawatt-hour(s) (MWh) b) Hour rating – maximum rate at which battery can be charged and length of time for which battery can be discharged at stated full discharge rate c) C-rate – discharge current that battery can evenly deliver over a period of time (usually hours). Commonly used with NiCd and LA d) Depth of discharge (DOD) – how fully battery has been discharged during discharge cycle, expressed as a percentage. Commonly used with lithium batteries e) Effective capacity – usable capacity of the battery, which could be the programmed limit of the PCE f) Battery round-trip efficiency – how efficient battery is throughout full cycle (percentage loss per kWh) g) Battery fault current – maximum fault current battery can deliver into a short-circuit across its output terminals h) Maximum power – maximum continuous power a battery can deliver i) Self-discharge – a normal characteristic of all batteries to gradually lose charge over time 3.2.2 Terminology associated with EESS a) Self-consumption – capability of homes or businesses to generate their own power and use it directly or store it for later use

	b) Time shifting – process where energy is stored during periods of low demand (off-peak hours) and used during periods of high demand (peak hours) c) Arbitrage services – storing electricity when price is low and selling or using it when price is high d) Uninterruptible power-system (UPS) – continual power system that provides automated backup electrical power to a load when input power source or mains power fails e) Power Conversion Equipment (PCE) – facilitates conversion of energy between different forms (AC to DC, DC to AC and/or DC to DC)

Learning outcome 4

Understand design and installation considerations for EESS

Topics	Content elements
4.1 General requirements and considerations prior to installation of EESS systems	4.1.1 Types of notification in respect of network connection and DNO/DSO approval a) Requirements for Engineering Recommendation G98 and G99 applications i. G98, where the total generation is 16 A, or less, per phase ii. G99, in all other cases iii. Additionally, G100 where export limitation is required by the DNO/DSO iv. Notification Timeframe Requirements for DNO/DSO 4.1.2 Requirements for isolation and switching a) General requirements for isolation and switching i. Warning notices where installation not capable of being isolated by a single device ii. All isolators should have their function clearly marked iii. Main isolators to disconnect all live conductors iv. Circuits to be arranged so is clear how to remove power from specific final circuits or appliances v. Off-load isolation may be facilitated by use of suitable connectors b) Avoidance of consequences of incorrectly selected switches and isolators in DC circuits: i. DC switch/isolator contacts must open swiftly, to immediately break the arc and prevent switch/isolator contact surface damage ii. DC switch/isolator contacts must open a sufficient distance, to ensure arc is extinguished, to ensure current flow is stopped when switch/isolator in open position

iii. Switch/isolator/contactor poles might require connecting in series to meet suitable DC switching safety requirements
iv. Manufacturer's DC ratings of current and voltage must be observed regardless of the AC ratings
v. Off-load isolators not to be operated while battery is charging or discharging (this requires the PCE to be switched off)

4.1.3 General considerations and requirements for battery location

a) General considerations
   i. Keep DC cable length, between battery and PCE, as short as possible
   ii. Workspace and access to equipment is adequate
   iii. Means of isolation and other protection clearly identifiable and readily accessible
   iv. Ambient temperature range and distance to other heat sources
   v. Weight – capability of the building fabric to support both the distributed, and point loading, weight of the EESS batteries
   vi. Installation of batteries in lofts is not recommended
   vii. Fire associated with the battery should not be liable to impede escape for the occupants of the premises
b) Specific considerations from PAS 63100 Protection Against Fire of Battery Energy Storage Systems for use in Dwellings
   i. Installation location in respect of safety and external influences that affect fire safety
   ii. Requirements for interlinked smoke detectors/alarms where batteries are installed in locations that are infrequently visited
   iii. Best place for storage of batteries is outside dwellings and away from habitable rooms

4.1.4 Additional considerations for installation of batteries

a) Manufacturer's safety data sheets (MSDS) to be consulted over chemical hazards contained within a battery
b) Adequate ventilation to be provided to mitigate the build-up of battery gasses
c) Battery terminals to be protected against short-circuits when in service
d) Access by ordinary persons to DC terminals by key or tool only
e) All accessories and equipment to be installed taking into consideration manufacturers' instructions and guidance
f) Ensure installation minimises risk of damage to, or puncturing of, cell/battery cases

	4.1.5 Requirements and considerations for PCE specification and location a) PCE to be installed in locations suitable to their design and manufacturer's specifications. Considerations include: i. Indoor or outdoor location (IP ratings) ii. Ventilation requirements iii. Access for servicing iv. Access by ordinary persons to DC terminals by key or tool only v. Proximity to DC components to minimise the length of DC cables vi. Weight and fixing requirements vii. Manufacturer's flammability requirements including fireproof mounting viii. Labelling and identification requirements ix. Other manufacturer's requirements
4.2 Requirements and considerations for the specifications and sizing of EESS	4.2.1 Considerations for system modelling a) Renewable system size kWp (Solar PV, other micro-renewable) b) Renewable system generation profile i. Varies seasonally c) Time-shifting requirements (maximising self-use) i. Intended use ii. Considerations for seasonal use iii. User profile (retired/works from home/away for long periods) iv. Variable tariffs v. Modelling software available d) Building/site load profile i. Peak power requirements ii. Considerations for large loads iii. Load characteristics, such as inductive loads with high start-up currents iv. Continuous loads v. Number of residents/workers e) Daily energy use f) Import/export constraints (G100 considerations) 4.2.2 Considerations for system sizing and specifications where grid-connected a) Capacity (kWh) i. Too small – low financial benefit ii. Too large – can't be fully charged b) Charge/discharge capability

	i. Comparison between battery discharge currents in relation to its C-rate for different discharge time periods 4.2.3 Considerations for sizing EESS for operating in island mode a) EESS might not be capable of providing long-term supplies to high power loads; load shedding might therefore be required b) Consider which loads are to be powered in island-mode (maintained) and which will not be powered in island-mode (non-maintained) c) EESS must be capable of supplying the maximum load current that will be applied at any one time d) Consider any equipment with a large in-rush current e) Calculation for sizing of an EESS for operation in island-mode over several hours: Energy (Wh) = Run time (hr) x Rating (W) x multiplier for losses
4.3 Requirements and considerations for EESS operating configurations	4.3.1 EESS operating in parallel with the grid a) Fault current i. EESS can contribute to the available fault current, consider the maximum short-circuit level (parallel energy sources plus grid-connected) b) Protective devices i. Required to be suitable for bi-directional overcurrent detection and current flow ii. RCDs to be of suitable type for the presence of DC harmonics/components (Type A/B/F) c) Current-carrying capacities i. Rating of cables, switchgear and controlgear, and other equipment considering simultaneous loads and supplies in conformity with BS 7671 Chapter 55 d) Inverters in three-phase installations i. Risk of single-phase inverters ensuring neutral current does not exceed line current in parallel three-phase system 4.3.2 EESS that switch between grid-connected and island-mode operation a) Earth fault current i. EESS likely to have considerably lower prospective fault current than the grid supply, therefore unable to operate protective devices within maximum permissible disconnection time ii. Requirements for protective devices to continue meeting maximum disconnection times when system switches to island-mode b) Short-circuit fault current i. Consideration for thermal effects due to low short-circuit fault current and increased

disconnection times addressed in BS 7671 using the adiabatic criterion: $k^2S^2 \geq I^2t$

ii. Electronic means of switching off EESS inverter in event of fault may be employed

c) Isolation and switching
   i. Requirement of ESQCR Regulation 21 'a means of disconnection from the grid (island-mode isolator) must be provided so that the 'islanded' (maintained loads) circuits cannot operate in parallel with the grid'
   ii. Island-mode isolator (or appropriate generator changeover arrangement) shall always break the neutral as well as other live conductors
   iii. Timing-sequence requirements for island-mode isolator and system referencing relay to ensure safety of switchover

d) Earthing arrangements for island-mode
   i. Existing grid-connected TN-C-S and TN-S earthing systems
      - EESS cannot rely on the means of earthing from grid, as this might be disconnected without notice
      - Additional supply earth electrode required for system in island-mode
      - Typically connected as a TN-S arrangement in island-mode
   ii. Existing grid-connected TT earthing systems
      - Existing TT consumer electrode may be used as the supply electrode in island-mode, providing it is suitable
      - Typically connected as a TN-S arrangement in island-mode
   iii. Considerations for circuits using another earthing arrangement
      - TT arrangement might be employed at one or more points in the installation (EV charge point, remote outbuilding)
      - Where TT arrangement is used when in island-mode, the electrode(s) must have a sufficiently low resistance to ensure compliance with Chapter 41 of BS 7671

e) Neutral-earth (system referencing) link when switching from grid-connected to island-mode
   i. Requirements for establishing new connection between neutral-earth (system referencing) link for duration of island-mode
   ii. Requirement to ensure all live conductors, including the neutral, of circuits to be powered in island-mode are disconnected from the neutral or PEN of the DNO supply

	iii. Neutral earth connection must be upstream of any RCD intended to provide fault protection and/or additional protection iv. Installations with existing local generation might not permit additional inverters to be installed without compromising earth fault protection v. No more than one neutral-earth (system referencing) link in the system at any one time to: • comply with the ESQCR • prevent unwanted operation of RCDs • reduce risks associated with surges and induced voltages vi. System earth referencing relay must be capable of making onto, and breaking, the sum of all prospective fault currents of systems operating in parallel
4.4 Labelling and identification requirements for the EESS and associated circuits	4.4.1 Labelling and identification requirements in accordance with BS 7671 and Engineering Recommendations G98 and G99 a) General warning notice to indicate the presence of EESS and the location of key components b) Identification of the mains AC isolator (point of emergency isolation) c) Isolators only suitable for off-load isolation must be labelled to this effect d) System schematic displayed at point of interconnection with the DNO's distribution system e) Notice identifying the location of any electrical energy storage batteries should be present at the origin of the installation f) 'Additional supply' label at the service termination, meter position and all points of isolation between the inverters and the main incoming supply g) PCE should contain a notice giving warning to isolate all AC and DC supplies before carrying out work h) Suitable hazard warning signs need to be displayed to highlight battery hazards. The appropriate signs will depend on the battery type i) Warning of the battery voltage to be provided on enclosures of batteries where the battery voltage exceeds 60 V DC j) DC wiring colours to conform to BS 7671 and BS EN IEC 60445

Learning outcome 5

Test, commission and handover of EESS

Topics	Content elements
5.1 Inspection, testing and commissioning	5.1.1 Requirements for Initial Verification a) General requirements for inspection and testing as per BS 7671 b) Additional for the remainder of the EESS, as set out in the IET Code of Practice for Electrical Energy Storage Systems i. Inspection requirements: • Isolation of grid supply current-carrying conductors • Provision of consumer's earth electrode • Presence of RCDs for fault protection and/or additional protection • Suitable and unobstructed ventilation arrangements for EESS and ancillary equipment • Clearance from adjacent objects as per manufacturer's specifications • Acceptable clearance from external heat sources • IP rating, of EESS components, suitable for the location • Presence of appropriate durable safety signage, warning notices and labelling • Installation according to manufacturer's requirements • Accessibility for maintenance and operation • Access to points of DC connection suitably restricted by use of key or tool ii. Testing requirements for the remainder of the EESS: • Staggered start and/or load-shedding on change-over • Measurement of earth electrode resistance • Functional checks: ○ PCE functions correctly (DC charge current and/or voltage), displays correct information including - Output AC voltage - Output DC voltage - Output AC current - Output DC voltage - Direction of power flow ○ Switching into and out of island-mode

	○ Confirm neutral-earth link switches in and out appropriately ○ Maintained and non-maintained loads • RCD testing: ○ In grid-connected mode, using the upstream/downstream method, for RCDs in series where selectivity may be an issue ○ In island-mode by connecting the tester to the line and earthing arrangement to ensure the RCD will function in earth-fault conditions
5.2 Handover and maintenance	5.2.1 Information and instructions to be delivered to the client including: a) Recognising components of the installation and describing their purpose b) Identifying health and safety factors during operation and maintenance c) Demonstrating typical operation and explaining how to detect faults or subpar performance d) Describing maintenance needs and procedures e) Providing system manuals, drawings, test certificates, and related paperwork to the client f) Responses to client queries 5.2.2 Requirements for scheduled maintenance including: a) Cleaning of inverter fans and ventilation systems b) Cycling switchgear and similar components c) Other general requirements for periodic inspection and testing of the installation d) Checking for accumulation of dust and other contaminants on batteries and terminals e) Checking fluid levels where appropriate to the type of battery f) Battery replacement at appropriate intervals

Learning outcome 6

Understand the use of micro-generation and EESS as part of prosumer's electrical installations

Topics	Content elements
6.1 Energy management systems and export to the grid	6.1.1 Definitions and explanations of key terms and acronyms relating to the use of vehicles as electrical energy storage systems a) Key terms: i. Prosumer ii. Prosumer's Electrical Installations (PEIs) iii. Electrical Energy Management System (EEMS) iv. Island-mode operation v. Arbitrage vi. Self-consumption vii. Time shifting b) Acronyms: i. V2G (Vehicle to Grid) ii. V2H (Vehicle to Home) iii. V2X (Generic term for vehicle as storage) 6.1.2 The requirements for an integrated EEMS a) Allows micro-generation to work alongside: i. Electrical energy storage ii. Vehicle-to-grid (V2G) iii. Vehicle-to-home (V2H) systems iv. Energy company infrastructure v. The Smart Grid b) This combination achieves several goals: i. Maximising grid independence ii. Minimising costs by leveraging lower tariffs through arbitrage iii. Taking advantage of tariffs and export payback during local or regional demand peaks by: • Providing grid support services • Supplying power from local battery storage • Utilising electric vehicle battery energy to support the grid supply 6.1.3 Requirements for Engineering Recommendation G100: export and import limitation, used in conjunction with G98/G99: a) Export limiting arrangements are a means to divert power when export is being limited or because the total site generation is larger than the site export capacity b) G100 also details the tests expected by a DNO, during the commissioning of an export limitation system, to prove the correction function of the system

6.2 Integration of EESS with microgeneration systems	6.2.1 Reasons for including battery storage systems a) To store generated electricity so it can be used later, increasing self-consumption rate b) To store electricity so it can be exported to the grid at peak demand, when export rates are higher c) To provide island-mode capability in case of grid failure

Additional guidance for delivering the practical outcomes (LO2 and LO5)
Although the following are not able to be assessed within the constraints of the practical assessment, it is suggested that learners are made aware of the following:

LO2: 2.1.1 Producing a risk assessment
Additional considerations:

- Requirements for chemical spill kits
- Requirements for portable gas detection
- Control of access to work area
- Requirements for the transportation of batteries
    - Ensure the safe transport of heavy equipment
    - Ensure the safe transport of Lithium batteries complies with Class 9 CDG regulations directive (fire and explosion risks)
    - Ensure the transport of Lead-acid batteries complies with Class 8 CDG regulations directive (corrosive substances)
    - Ensure the use of a licenced operator when transportation of waste batteries is required (regulated activity under the CDG)
- Potential for electric shock or burns from DC equipment
    - PCE might still supply power, necessitating multiple isolation points
    - PCE output may remain live even when other isolators are opened
    - Isolators may have two supplies, one on each side, when open
    - Battery terminals not to be disconnected under load
    - Assess if point of isolation is suitable for switching/disconnection on load
    - PCE to be shut down to remove load/output, facilitating safe disconnection and maintenance
    - Risk of short-circuit of the cell/battery of exposed links and terminals
    - Battery terminals to always be considered as live
    - Risk from connecting batteries in parallel when at a different state of charge

LO2: 2.1.2 Producing a method statement
Additional considerations:

- Transportation and/or disposal of waste equipment

LO5: 5.2.2 Requirements for scheduled maintenance
Additional considerations:

- Processes when replacing and disposing of equipment
    - Compliance with regulations for the disposal of electric and electronic equipment (WEEE)
    - Waste Batteries and Accumulators Regulations
    - Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (CDG)

Supporting information

Suggested learning resources

IET Code of Practice for Electrical Energy Storage Systems, 3rd Edition.

IET Code of Practice for Grid-connected Solar Photovoltaic Systems, 2nd Edition.

IET Wiring Regulations 18th Edition: BS 7671:2018 (latest amendment) Requirements for Electrical Installations.

Appendix 1 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the **Centre document library** on **www.cityandguilds.com** or click on the links below:

Centre Handbook: Quality Assurance Standards

This document is for all approved centres and provides guidance to support their delivery of our qualifications. It includes information on:

- centre quality assurance criteria and monitoring activities
- administration and assessment systems
- centre-facing support teams at City & Guilds/ILM
- centre quality assurance roles and responsibilities.

The Centre Handbook should be used to ensure compliance with the terms and conditions of the centre contract.

Centre Assessment: Quality Assurance Standards

This document sets out the minimum common quality assurance requirements for our regulated and non-regulated qualifications that feature centre-assessed components. Specific guidance will also be included in relevant qualification handbooks and/or assessment documentation.

It incorporates our expectations for centre internal quality assurance and the external quality assurance methods we use to ensure that assessment standards are met and upheld. It also details the range of sanctions that may be put in place when centres do not comply with our requirements or actions that will be taken to align centre marking/assessment to required standards. Additionally, it provides detailed guidance on the secure and valid administration of centre assessments.

Access arrangements: When and how applications need to be made to City & Guilds provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for candidates who are eligible for adjustments in assessment.

The **Centre document library** also contains useful information on such things as:

- conducting examinations
- registering learners
- appeals and malpractice.

Useful contacts

Please visit the **Contact us** section of the City & Guilds website.

City & Guilds

For over 140 years, we have worked with people, organisations and economies to help them identify and develop the skills they need to thrive. We understand the life-changing link between skills development, social mobility, prosperity and success. Everything we do is focused on developing and delivering high-quality training, qualifications, assessments and credentials that lead to jobs and meet the changing needs of industry.

We partner with our customers to deliver work-based learning programmes that build competency to support better prospects for people, organisations and wider society. We create flexible learning pathways that support lifelong employability because we believe that people deserve the opportunity to (re)train and (re)learn again and again – gaining new skills at every stage of life, regardless of where they start.

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City & Guilds
Giltspur House
5 – 6 Giltspur Street
London
EC1A 9DE

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