European Commission

JRC TECHNICAL REPORT

Standards for Photovoltaic Energy Systems

Summary of the Joint Research Centre's contribution to international and European standards in 2020 and 2021

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Contents

Abstract

This report outlines the European Commission's Joint Research Centre's contribution to standardisation activities within the field of Photovoltaic Energy Systems.

The Joint Research Centre (JRC) continues to play a significant role in European and international standardisation activities on Photovoltaic Energy Systems. In particular, JRC experts are the convenors of the International Electrotechnical Commission (IEC) and the European Committee for Electrotechnical Standardization (CENELEC) working groups; led projects which published 2 IEC standards in 2020; and are members of the project teams for 14 additional publications in 2020 and 2021. JRC is also the project leader for one standard under development and regularly contributes too many other documents under development.

Executive summary

Photovoltaics (PV) are expected to make a major contribution to European and global climate change mitigation goals. It is the renewable energy technology with the largest scope for cost reduction and efficiency gains, as well as exploiting the largest resource. Rapid technical evolution needs to be matched by standards developed and accepted at international level to ensure product quality, reliability and sustainability, as well as transparent market conditions. The JRC plays a prominent role in both International and European standards committees for PV. This exploits expertise developed in the European Solar Test Installation (ESTI), a European reference laboratory to validate electrical performance and lifetime of PV devices based on established as well as emerging technologies.

Policy context

The 2021 European Climate Law requires that EU becomes climate-neutral by 2050 and reduces net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. As a consequence the Commission is proposing a revision of the renewable energy directive to increase the renewables target to 40% by 2030. A substantial increase in solar photovoltaics installations is needed to help meet this target. The work programmes for European standardisation support these Energy Union priorities, notably the decarbonisation of the economy and support for green public procurement. A new standardisation activity will be required also in support of the introduction of consumer level regulations such as Eco-Design and/or Energy Label for PV modules and systems which are under consideration by the European Commission.

Key conclusions

The continued development of the PV sector as one of the main enablers for decarbonisation and climate change mitigation presents new challenges for the associated standards systems. This relates to innovation in the technology itself, its application and integration, and to sustainability requirements. The JRC has specific expertise in the field of photovoltaic energy to allow it to effectively contribute to achieving these goals.

Main findings

The JRC continues to play a significant role in European and International standardisation activities within the field of Photovoltaic Energy Systems. In particular JRC staff have been appointed convenors of working groups within the International Electrotechnical Commission (IEC) and the European Committee for Electrotechnical Standardization (CENELEC) technical committees.

The JRC was the project leader for two standards (IEC 60904-1 and IEC 60904-10) which were published in 2020 and 2021 respectively. The JRC was also project team member for fourteen additional publications during 2020 and 2021 (see section 2.3). The JRC is currently contributing to 16 standards under development in this period, the IEC 60904-2 as project leader, and an additional 15 standards (as part of the various project teams).

Related and future JRC work

The JRC work programme for 2022 foresees continued efforts to support the standardisation process in the following specific areas: a) power calibration, b) energy rating, c) reliability and lifetime, d) module electrical safety, e) PV products for buildings and f) Ecodesign, Energy Labelling, Ecolabel and Green Public Procurement policy tools.

The level of commitment in 2022 is expected to be roughly equal to that of 2021, with the support for the International Electrotechnical Commission's Technical Committee 82 Working Group 2 and the European Committee for Electrotechnical Standardization's Technical Committee 82 Working Group 1 being the most significant. The JRC will also continue to support the impact assessment for Ecodesign for PV modules and systems, including studies on the development of transitional methods for determining energy yield. Finally, the JRC will continue to support the exploitation of pre-normative work on standards and related in the EU-funding projects under Horizon 2020 and Horizon Europe.

1 Introduction

1.1 Background

The 2021 European Climate Law requires that EU becomes climate-neutral by 2050 and reduces net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. As a consequence the Commission proposes a revision of the renewable energy directive to increase the renewables target to 40% by 2030, compared to the current target of 32% ([1]).

Photovoltaics (PV) are expected to make a significant contribution to achieving these goals, being the renewable energy technology with the largest scope for cost reduction and efficiency gains. The sector is growing rapidly, with world-wide installed capacity increasing from around 40 GW in 2010 to over 900 GW at the end of 2021, with potential to reach up over 2 TW by 2030([2]). This growth is characterised by rapid technological development, not just scaling up existing systems. In this context, international standards are essential to ensuring market transparency, helping to cut costs and strengthening investor confidence. When correctly designed, they can also play a critical role in accelerating the uptake of innovative solutions ([3]).

The European Commission's work programme on standardisation ([4]) acknowledges the role of standardisation in the Energy Union strategy. It specifically notes that "to this end, standardisation has also been identified as an important enabler for market-adoption of low-carbon technologies in the Accelerating Clean Energy Innovation Communication. Specific action should target the interconnection of electricity networks, support diversified gas supply streams and integrate renewable energy into the consumption mix".

The JRC supports this by performing pre-normative R&D on technical areas within its competence and by taking a proactive role on International and European standardisation bodies. Its expertise in PV is based on 40 years of activity of the European Solar Test Installation (ESTI), which today provides a European reference laboratory for validating electrical performance and lifetime of PV devices based on traditional and emerging technologies. ESTI also performs pre-normative research to develop and improve traceable, accurate measurement techniques.

In particular, as part of the European Commission's liaison with the International Electrotechnical Commission (IEC), ESTI staff contribute to International Standards within Technical Committee 82 (TC 82) “Solar photovoltaic energy systems”. Many of the more than 170 publications issued by IEC TC 82 have been either based on original JRC Specifications (such as those on calibration and type approval) or to a larger extent developed or supported from JRC work results. They are in use world-wide and play an essential role for the high-quality level PV products maintain, no matter where they are produced or deployed. The International Standards in place allowed the PV industry a real global reach.

The JRC's contributions to the further development of IEC and CENELEC standards are summarized below in sections 2 and 3, respectively. Section 4 covers related initiatives likely to impact on future developments. Finally, section 5 summarises priorities for activities in 2022.

1.2 Relevance to EU Policies

EU policy on energy shall, under Lisbon Treaty Article 194/1c, "promote energy efficiency and energy saving and the development of new and renewable forms of energy". JRC’s activities provide scientific support to the EU policy introduced in 2015, in particular regarding the following aspects:

- Buildings resemble the complexity of energy systems. Historically an energy consumer only, they increasingly use renewable resources to provide their own energy (in particular PV and heat-pumps), and to deliver excess electricity to the electricity grid. With Europe's policy of making "Nearly Zero Energy Buildings" a requirement in 1.5 years from now under the Energy Performance of Buildings Directive, PV will have a strongly increasing market. The success of this market will depend also on the availability of

([1]) Directive 2018/2001/EU of 11 December 2018 on the promotion of the use of energy from renewable sources

([2]) A. Jäger-Waldau, Snapshot of Photovoltaics – 2021 EPJ Photovoltaics 12, 2 (2021)

([3]) COM(2016) 358, Standardisation package, European Standards for the 21st Century

([4]) COM(2017) 453 "The annual Union work programme for European standardisation for 2018"

building-specific PV modules, regarding their functionality as building product beyond their electricity production, like providing roof insulation and water protection, their cost-effective installation within current building technologies and the integration into the overall appearance and style of buildings.

- The 2015 SET-Plan ([5]) communication identifies the need to sustain technological leadership by developing highly performant renewable technologies, as well as recognising the role of standards as "additional enabling conditions".
- The 2018 revision of the Renewable Energy Directive (RED II) set a binding, renewable energy target for the EU for 2030 of at least 32%. With the increased ambition of the new 2021 Climate Law, the Commission has proposed an amendment of the RED-II directive that would increase the renewables target to 40%. This is expected to be adopted by the end of 2022.

The Ecodesign and Energy Labelling legislative framework has the dual purpose of ensuring that more energy-efficient products come to the market (through Ecodesign) while encouraging and empowering consumers to buy the most efficient products based on useful information (through energy labelling). The Ecodesign Working Plan 2016-2019([6]) foresees studies on energy-savings potentials of PV panels and inverters. A 2019 preparatory study on the environmental impacts – and related policy approaches at EU level – of PV modules, inverters and systems ([7]) was carried out by the Joint Research Centre of the European Commission. The study concluded, inter alia, that improvements in the energy yield and long-term performance of PV modules, inverters and systems could be ensured by mandatory legal instruments, in particular via the synergic application of implementing measures in the framework of the Ecodesign Directive ([8]) and labelling schemes in the framework of the Energy Labelling Regulation ([9]).

Implementing measures (i.e. Regulations) in the framework of the Ecodesign directive and the Energy Labelling Regulation typically foresee the use of harmonised standards, adopted by recognised European Standardisation Organisations (CEN or CENELEC), for the testing and calculation methods necessary for the compliance assessment. However, when harmonised standards are not available, other already existing standards or methods may be considered, when proved that they are suitable to the extent of assessing the compliance of products with the applicable requirements (Ecodesign or energy labelling).

([5]) C(2015) 6317 final Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation

([6]) COM(2016) 773 COMMUNICATION FROM THE COMMISSION Ecodesign Working Plan 2016-2019

([7]) Directive 2009/125/EC of the European Parliament and of the Council 1 of 21 October 2009 Establishing a Framework for the Setting of Ecodesign Requirements for Energy-Related Products, OJ L285, 31.10.2009, p. 10–35.

([8]) Regulation (EU)2017/1369 of the European Parliament and of the Council of 4 July 2017 Setting a Framework for Energy Labelling and Repealing Directive 2010/30/EU, OJ L198, 28.7.2017, p. 1–23.

([9]) Standards for the Assessment of the Environmental Performance of Photovoltaic Modules, Power Conversion Equipment and Photovoltaic Systems, Publications Office of the European Union, 29247 EN, ISBN 978-92-79-86608-1, 2018

2 IEC TC 82

2.1 IEC Background

The IEC is the partner organisation of the International Organization for Standardization (ISO) and forms, together with the International Telecommunication Union (ITU), the United Nations related, worldwide standardisation process. IEC is entrusted with all standards aspects in the electrotechnical field, and was founded in 1904. Membership is required for all countries which are part of the World Trade Organisation (WTO) as commitment to remove international trade barriers, but it is open to all other United Nations members.

IEC TC 82 was established in 1981 to deal with Solar Photovoltaic Energy Systems. Since then it has published more than 170 documents (as of 2021-12-17), which have laid the foundation for the strong increase of world-wide trade for PV products.

2021 saw the addition of the Republic of Philippines (observer country), to the list of TC 82 member states. IEC TC 82 currently has 54 member states (43 Participating countries and 12 Observer countries), see table 1.

Table 1 List of Countries

Africa:	Algeria, Côte D'Ivoire, Egypt, Kenya, Morocco, Nigeria, South Africa
Americas:	Brazil, Canada, Chile, Mexico, United States of America
Asia/Pacific:	Australia, P.R. China and independent Province of Taiwan, India, Indonesia, Japan, Republic of Korea, Republic of Philippines, Malaysia, New Zealand, Singapore, Thailand
EU27:	Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden, (19, all but CY, EE, HR, LV, LT, LU, MT, SK)
Europe:	Norway, Russian Federation, Serbia, Switzerland, Turkey, Ukraine, United Kingdom
Middle East:	Bahrain, Iran, Israel, Oman, Qatar, Saudi Arabia

(Source: IEC 2021)

TC 82 maintains formally a Type A Liaison with the European Commission, DG GROW. This is the highest possible level of Liaison, and puts the European Commission (and the JRC) on the same level as National Committees, however without voting rights.

TC 82 also has Type A Liaison with the International Energy Agency (IEA) and the International PV Quality Assurance Task Force (PVQAT), which was established in 2017.

Other IEC technical committees under the Type A Liaison with DG GROW (and thus JRC) are:

- TC 23 Electrical accessories
- TC 45 Nuclear instrumentation
- SC 45B Radiation protection instrumentation
- TC 59 Performance of household and similar electrical appliances
- TC 100 Audio, video and multimedia systems and equipment
- TC 105 Fuel cell technologies
- TC 106 Methods for the assessment of electric, magnetic and electromagnetic fields associated with human exposure
- ISO/IEC JTC 1/SC 25 Interconnection of information technology equipment

Technical committees under the Type B Liaison with DG GROW (and thus JRC) are:

- ISO/IEC JTC 1/SC 2 Coded character sets

2.2 Technical Committee 82 Solar Photovoltaic Energy Systems

The TC 82 Secretariat is traditionally provided by the US National Committee, which makes a secretary and two assistant secretaries available to assist in all standards processes. A technical officer from the IEC Central Office in Geneva assists in all formal aspects (aided by an administrative assistant and editor), as well as serving as the IEC direct contact for the chairman and the secretariat.

The current list of TC 82 officers and IEC Central Office contacts are listed in table 2 and 3 respectively.

Table 2 TC 82 Officers

Chair	Mr Michio Kondo (JP) Term of office : 2022-08
Vice-Chair	Mr Zhengxin Liu (CN) Term of office : 2023-06
Secretary	Mr George Kelly (US)
Assistant Secretary	Mr Howard O Barikmo (US)
Assistant Secretary	Mr Liang Ji (US)

(Source: IEC 2021)

Table 3 IEC Central Office Contacts

Technical Officer	Mr Anson Chiah
Administrative Assistant	Ms Anouchka Blattler
Editor	Ms Claire Louca

(Source: IEC 2021)

The organisation of TC 82 is arranged into a number of Working Groups (WG), Project Teams (PT) and Joint Working Groups (JWG), as detailed in table 4 below

Table 4 TC 82 Subcommittee(s) and/or Working Group(s)

Label	**Convenor**	**Title**
Working Groups		
WG 1	Mr Hidenori Shimizu	Glossary
WG 2	Mr Tony Sample	Modules, non-concentrating
WG 3	Mr Martin Cotterell Mr Ted Spooner	Systems
WG 6	Mr Greg J. Ball	Balance-of-system components

WG 7	Mr Kenji Araki Mr Shitao Wang	Concentrator modules
WG 8	Mr Hao Jin	Photovoltaic (PV) cells
WG9	Mr David Kresse Mr Shitao Wang	BOS Components – Support Structures
Project Teams		
PT 600	Mr Kenji Araki	Vehicle Integrated Photovoltaic Systems
PT 63092	Mr Thomas Moran	Building Integrated Photovoltaics (BIPV)
Joint Working Groups		
JWG 1	Mr Leon Andre Drotsché Mr Arne Jacobson	Photovoltaic off grid systems, including decentralized rural electrification and hybrid systems
JWG 11	Mr Y. T. Cheng Mr Thomas Moran	Building-Integrated Photovoltaics (BIPV) linked to ISO/TC 160/SC 1
JWG 10	Mr Giuseppe Dell'Olio Mr Liangzhong Yao	Distributed Energy Resources Interconnection with the Grid Managed by TC 8
JWG 4	Mr Qing LI	Grid code compliance assessment for grid connection of wind and PV power plants Managed by SC 8A
JWG 5	Mr Jiabing HU Mr Jason MacDowell	System issues regarding integration of wind and PV generation into bulk electrical grid Managed by SC 8A
JWG 82	Mr Herbert K. Giess	TC 21/ TC 82 - Secondary cells and batteries for Renewable Energy Storage Managed by TC 21
JWG 32	Mr Norman Graham Frederick Bird Mr Adrian Häring	Electrical safety of PV system installations Managed by TC 64

(Source: IEC 2021)

TC 82 continues to be the most active technical committee within the IEC, with the largest work-programme of any technical committee (currently 66 active documents), reflecting the nature of the rapidly growing and innovative PV industry.

In addition to the development of new standards, technical committees are also responsible for the maintenance of published standards. A simplified schematic of the standards process is show in Figure 1. Each published document has a stability date, which lists the time when the TC will verify the up-to-date applicability of the standard. Where appropriate, they will then make a revision of the document to adapt to progress in the field or, if no revision is necessary, confirm this fact and establish a new stability date. The development of new standards as well as the updating of existing standards through the maintenance cycle requires input from organisations familiar with the existing standards and the current state of the art in the particular field. The ESTI laboratory has a key role in delivering both of these aspects in the case of PV

measurement and characterisation (which can be overall summarised as "PV metrology"). The history of the ESTI laboratory over the last 40 years and its long-term involvement with the development of standards has ensured that technological developments within the PV industry are reflected within the standards. This is a role also played by several national laboratories around the world, with which ESTI has developed a solid scientific and technical collaboration; such as

- the National Renewable Energy Laboratory (NREL) USA
- the National Institute of Advanced Industrial Science and Technology (AIST) Japan
- the Physikalisch-Technische Bundesanstalt (PTB) Germany

Table 5 summarises the projects being currently handled by TC 82 (extract of 2021-11-26).

Figure 1. Simplified standards development process

(Source: IEC 2021)

Table 5. IEC TC 82 Projects (shading in light blue denotes significant JRC contribution, also see section 2.3)

Project Reference	Title	WG	Forecast Publication Date	Maintenance Cycle
IEC TS 60904-1-2 ED2	Photovoltaic devices - Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic (PV) devices	WG 2	2022-12	Yes
IEC 60904-2 ED4	Photovoltaic devices - Part 2: Requirements for photovoltaic reference devices	WG 2	2023-01	Yes
IEC 60904-5/AMD1 ED2	Amendment 1 - Photovoltaic devices - Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method	WG 2	2023-01	Yes

Project Reference	Title	WG	Forecast Publication Date	Maintenance Cycle
IEC 60904-8/AMD1 ED3	Amendment 1 - Photovoltaic devices - Part 8: Measurement of spectral responsivity of a photovoltaic (PV) device	WG 2	2022-11	Yes
IEC 60904-9-1 ED1	Photovoltaic devices - Part 9-1: Collimated beam solar simulator performance requirements	WG 7	2023-01	
IEC 61215-1-2/AMD1 ED2	Amendment 1 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-2: Special requirements for testing of thin-film Cadmium Telluride (CdTe) based photovoltaic (PV) modules	WG 2	2022-06	Yes
IEC 61215-1-3/AMD1 ED2	Amendment 1 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-3: Special requirements for testing of thin-film amorphous silicon based photovoltaic (PV) modules	WG 2	2022-10	Yes
IEC 61215-1-4/AMD1 ED2	Amendment 1 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-4: Special requirements for testing of thin-film Cu(In,Ga)(S,Se)2 based photovoltaic (PV) modules	WG 2	2022-10	Yes
IEC 61683 ED2	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency	WG 6	2023-10	Yes
IEC TS 61724-2 ED2	Photovoltaic system performance - Part 2: Capacity evaluation method	WG 3	2022-10	Yes
IEC TS 61724-3 ED2	Photovoltaic system performance - Part 3: Energy evaluation method	WG 3	2022-10	Yes
IEC 61730-1 ED3	Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction	WG 2	2022-07	Yes
IEC 61730-2 ED3	Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing	WG 2	2022-07	Yes
IEC TS 61836 ED4	Solar photovoltaic energy systems - Terms, definitions and symbols	WG 1	2022-10	Yes
IEC 61853-2/AMD1 ED1	Amendment 1 - Photovoltaic (PV) module performance testing and energy rating - Part 2: Spectral responsivity, incidence angle and module operating temperature measurements	WG 2	2022-12	Yes
IEC 62093 ED2	Photovoltaic system power conversion equipment - Design qualification and type approval	WG 6	2022-02	Yes

Project Reference	Title	WG	Forecast Publication Date	Maintenance Cycle
IEC 62108 ED3	Concentrator photovoltaic (CPV) modules and assemblies - Design qualification and type approval	WG 7	2022-05	Yes
IEC 62109-1 ED2	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements	WG 6	2022-12	Yes
IEC 62109-2 ED2	Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters	WG 6	2022-12	Yes
IEC 62116 ED3	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures	WG 6	2023-10	Yes
IEC TS 62257-7-2 ED1	Renewable energy and hybrid systems for rural electrification - Part 7-2: Generator set - Off-grid wind turbines	JWG 1	2022-08	
IEC TS 62257-9-5 ED5	Renewable energy and hybrid systems for rural electrification - Part 9-5: Integrated systems - Laboratory evaluation of stand-alone renewable energy products for rural electrification	JWG 1		Yes
IEC TS 62257-100 ED1	Renewable energy and hybrid systems for rural electrification - Part 100: General introduction to IEC 62257 series and rural electrification	JWG 1	2022-10	
IEC 62446-1 ED2	Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 1: Grid connected systems - Documentation, commissioning tests and inspection	WG 3	2022-11	Yes
IEC TS 62446-3 ED2	Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 3: Photovoltaic modules and plants - Outdoor infrared thermography	WG3	2023-09	Yes
IEC TS 62446-4 ED1	Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 4: Electroluminescence Measurement of Photovoltaic Arrays	WG 3	2022-11	
IEC 62548 ED2	Photovoltaic (PV) arrays - Design requirements	WG 3	2022-11	Yes
IEC 62688 ED2	Concentrator photovoltaic (CPV) modules and assemblies - Safety qualification	WG 7	2023-05	Yes
IEC 62759-1 ED2	Photovoltaic (PV) modules - Transportation testing - Part 1: Transportation and shipping of module package units	WG 2	2022-07	Yes

Project Reference	Title	WG	Forecast Publication Date	Maintenance Cycle
IEC 62788-1-1 ED1	Measurement procedures for materials used in photovoltaic modules - Part 1-1: Encapsulants - Polymeric materials used for encapsulants	WG 2	2022-11	
IEC TS 62788-2/AMD1 ED1	Amendment 1 - Measurement procedures for materials used in photovoltaic modules - Part 2: Polymeric materials - Frontsheets and backsheets	WG 2	2022-10	Yes
IEC 62788-2-1 ED1	Measurement procedures for materials used in photovoltaic modules - Part 2-1: Polymeric materials - Frontsheet and backsheet - Safety requirements	WG 2	2022-07	
IEC 62788-5-1/AMD1 ED1	Amendment 1 - Measurement procedures for materials used in photovoltaic modules - Part 5-1: Edge seals - Suggested test methods for use with edge seal materials	WG 2	2022-02	Yes
IEC TS 62788-6-3 ED1	Measurement procedures for materials used in photovoltaic modules - Part 6-3: Adhesion testing of interfaces within PV modules	WG 2	2022-10	
IEC TS 62788-7-2/AMD1 ED1	Amendment 1 - Measurement procedures for materials used in photovoltaic modules - Part 7-2: Environmental exposures - Accelerated weathering tests of polymeric materials	WG 2	2022-12	Yes
IEC 62788-7-3 ED1	Measurement procedures for materials used in photovoltaic modules - Part 7-3: Environmental exposures - Accelerated abrasion tests of PV module external surfaces	WG 2	2022-04	
IEC TS 62788-8-1 ED1	Measurement procedures for electrically conductive adhesive (ECA) used in crystalline silicon photovoltaic modules - Part 8-1: Measurement of material properties	WG 2	2023-06	
IEC TS 62804-1 ED2	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation - Part 1: Crystalline silicon	WG 2	2023-03	Yes
IEC TS 62804-2 ED1	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation - Part 2: Thin-film	WG 2	2022-09	
IEC 62817-1 ED1	Solar photovoltaic tracking systems - Part 1: Design qualification for horizontal one-axis solar tracking system	WG 9	2022-12	
IEC 62894 ED2	Photovoltaic inverters - Data sheet and name plate	WG 6	2023-05	Yes

Project Reference	Title	WG	Forecast Publication Date	Maintenance Cycle
IEC TS 62915 ED2	Photovoltaic (PV) modules - Type approval, design and safety qualification - Retesting	WG 2		Yes
IEC 62920 ED2	Photovoltaic power generating systems - EMC requirements and test methods for power conversion equipment	WG6	2024-02	Yes
IEC 63027 ED1	DC arc detection and interruption in photovoltaic power systems	WG 6	2022-04	
IEC 63092-3 ED1	Photovoltaics in buildings - Part 3: Evaluation methodology of SHGC for Building integrated photovoltaic modules with various designs	JWG 11	2023-12	
IEC 63104 ED1	Solar trackers - Safety requirements	WG 7	2022-11	
IEC TS 63106-2 ED1	Basic requirements for simulator used for testing of photovoltaic power conversion equipment - Part 2: d.c. power simulator	WG 6	2022-08	
IEC TS 63109 ED1	Measurement of diode ideality factor by quantitative analysis of electroluminescence images	WG 2	2022-08	
IEC TS 63202-2 ED1	Photovoltaic cells - Part 2: Electroluminescence image for crystalline silicon solar cells	WG 8	2022-04	
IEC TS 63202-3 ED1	Photovoltaic cells - Part 3: Measurement of current-voltage characteristics of bifacial photovoltaic cells	WG 8		
IEC TS 63202-4 ED1	Photovoltaic cells - Part 4: Measurement of light and elevated temperature induced degradation of crystalline silicon photovoltaic cells	WG 8	2023-03	
IEC TS 63202-6 ED1	Photovoltaic Cells – Part 6: Water Boiling Test for Crystalline Silicon Solar Cells	WG 8	2023-10	
IEC TS 63209-2 ED1	Extended-stress testing of photovoltaic modules – Part 2: Component materials and packaging	WG 2	2022-10	
IEC 63257 ED1	Power line communication for DC shutdown equipment	WG 6	2023-03	
IEC TS 63265 ED1	Reliability practices for the operation of photovoltaic power systems	WG 3	2022-08	
IEC TS 63342 ED1	Light and elevated temperature induced degradation (LETID) test for c-Si Photovoltaic (PV) modules: Detection	WG 2	2023-03	

Project Reference	Title	WG	Forecast Publication Date	Maintenance Cycle
IEC TS 63348 ED1	Evaluation of Photovoltaic (PV) Module to Mounting Structure Interface	WG 9		
IEC 63349-1 ED1	Photovoltaic direct-driven appliance controllers – Part 1: General Requirement	WG 6		
IEC TS 63349-2 ED1	Photovoltaic direct-driven appliance controllers - Part 2: Operation Modes and an Example of Display	WG 6	2022-08	
IEC TS 63371-1 ED1	Materials used in photovoltaic (PV) cells - Part 1: Specifications for electrical characteristics of crystalline silicon wafers	WG 8	2022-10	
IEC 63387-1 ED1	Hybrid CPV/PV modules: General characteristics and measurement procedures - Part 1: Performance measurements and power rating - Irradiance and temperature	WG 7	2024-02	
IEC TS 63392 ED1	Fire test for concentrator PV modules	WG 7	2023-04	
IEC TS 63397 ED1	Guidelines for qualifying PV modules for increased hail resistance	WG 2	2022-12	
IEC 63409-1 ED1	Photovoltaic power generating systems connection with grid - Conformity assessment for power conversion equipment - Part 1: Overall description of conformity assessment for grid connection	WG 6	2023-03	
IEC 63409-4 ED1	Photovoltaic power generating systems connection with grid - Conformity assessment for power conversion equipment - Part 4: Interface protection and fault ride through	WG 6	2023-03	
IEC 63409-6 ED1	Photovoltaic power generating systems connection with grid - Conformity assessment for power conversion equipment - Part 6: Power control functions and grid support	WG 6	2023-03	

(Source: IEC 2021)

2.3 TC 82 Working Group 2 Modules, non-concentrating

Like many organisations, the operations of the IEC TC 82 were impacted during the COVID pandemic. The work of the various project teams continued in much the same way as in the past, with online meetings and the exchange of documents for commenting via email. However, the twice yearly meetings of the WG 2 were cancelled as physical meetings, with online meetings substituted. Which had both positive and negative impacts on the running of the WG 2.

On the positive side, greater participation could take place at the meetings as the attendance was not limited to those who could physically travel. Such that daily numbers as high as 180 to 190 persons were registered for some days of the meetings.

On the negative side, given the nature of a fully online meeting with participants from all over the world, limited time slots could be utilised given the diverse time-zones covered. As such the WG 2 meeting was composed of 5 meetings during a single week, with 2-hour meetings on Monday and Friday and 3-hours meetings on Tuesday, Wednesday and Thursday. For the 3-hour meetings, this entailed the West Coast of the USA joining (5am until 8am local) while the Australian members being present (11pm to 2am local).

One obvious consequence of the limited time available for a week of online meetings (13 hours) compared to a traditional physical meeting (30 hours) is simply that less time is available for discussion. Less obvious, but no less serious a limitation of not having a physical meeting is losing the ability to have small ad-hoc discussions during coffee breaks, lunch or in the evening. These are usually invaluable to understand the point of view of some members, or for them to have a greater comprehension of what the writing team has proposed for a particular document

Physical meetings also aid the introduction of new members into the working group, as they can interact with different project teams for each document, which is much more difficult if they start in an online meeting and may find it intimidating to make comments or suggestions with up to 190 members presents.

WG 2 held two meetings in 2020 (April and October) and two in 2021 (April and October).

JRC is convenor of WG 2 (T. Sample) and chaired all of the meetings of WG 2.

Asian countries provide the largest delegations, confirming their commitment to the international standardisation process which fosters innovation and facilitates global trade in this very dynamic industry. Continuing progress was made on the new set of materials standards that underpin the production supply chain.

TC 82 continues to be the most active technical committee within the IEC, with the largest work-programme of any technical committee (currently 66 active documents), with WG 2 having the largest share within TC 82 with 27 active documents.

One of the IEC TC 82's most widely used document series (IEC 61215 for photovoltaic (PV) module design qualification and type approval) was published as a new edition on 2021. While the module safety standard series (the IEC 61730 for photovoltaic (PV) module safety qualification) is approaching the final submission of the FDIS. In both these series major improvements have been incorporated, in particular the ability to test bifacial PV modules.

The JRC acts as either a project leader for a particular standard or as a technical expert within the project team. The different roles are as follows.

The project leader shall act in a purely international capacity, divesting him- or her- self of a national point of view. The project leader should be prepared to act as consultant, when required, regarding technical matters arising at the proposal stage through to the publication stage.

Experts in relevant technical fields for each TC or Sub Committee are individuals appointed by their National Committees, via the Expert Management System, and designated to one or more working group, maintenance team or project team. They will have access (granted by their National Committees) to working documents located on the IEC website. In the case of the JRC, the experts are nominated under a type A liaison between the IEC and the European Commission.

The experts act in a personal capacity and not as the official representative of the organization by which they were appointed. However, it is recommended that they keep close contact with their organization (National Committee or other International Organization in liaison) in order to inform them about the progress of the work. Experts are capable of advising on technical issues in the field of the committee in which they have been appointed.

Those items to which the JRC has provided significant technical input in 2020 and 2021 include:

- IEC 60891 Ed. 3.0, Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics. **(Published October 2021)**. The JRC contributed as experts within the project team.
- IEC 60904-1 Ed. 3.0, Photovoltaic devices - Part 1: Measurement of photovoltaic current-voltage characteristics. **(Published September 2020)**. The JRC was the project leader.
- IEC 60904-4 COR1, Photovoltaic devices - Part 4: Photovoltaic reference devices - Procedures for establishing calibration traceability. **(Published September 2020)**. The JRC was the project leader.

- IEC 60904-9 Ed 3, Photovoltaic devices - Part 9: Solar simulator performance requirements. **(Published September 2020)**. The JRC contributed as experts within the project team.
- IEC 60904-10 Ed 3, Photovoltaic devices - Part 10: Methods of linearity measurement. **(Published September 2020)**. The JRC was the project leader.
- IEC TR 60904-14, Photovoltaic devices - Part 14: Guidelines for production line measurements of single-junction PV module maximum power output and reporting at standard test conditions. **(Published November 2020)**. The JRC provided the base document as a starting point for writing this new IEC document and contributed as experts within the project team.
- IEC 61215-1 Ed2, Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval Part 1: Test requirements. **(Published February 2021)**. The JRC contributed as experts within the project team.
- IEC 61215-2 Ed2, Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval Part 2: Test procedures. **(Published February 2021)**. The JRC contributed as experts within the project team.
- IEC 61215-1-1 Ed2, Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval Part 1-1: Special requirements for testing of crystalline silicon terrestrial photovoltaic (PV) modules. **(Published February 2021)**. The JRC contributed as experts within the project team.
- IEC 61215-1-2 Ed2, Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval Part 1-2: Special requirements for testing of thin-film Cadmium Telluride (CdTe) based terrestrial photovoltaic (PV) modules. **(Published February 2021)**. The JRC contributed as experts within the project team.
- IEC 61215-1-3 Ed2, Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval Part 1-3: Special requirements for testing of thin-film amorphous silicon based terrestrial photovoltaic (PV) modules. **(Published February 2021)**. . The JRC contributed as experts within the project team.
- IEC 61215-1-4 Ed2, Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval Part 1-4: Special requirements for testing of thin-film $Cu(In,Ga)(S,Se)_2$ based terrestrial photovoltaic (PV) modules. **(Published February 2021)**. The JRC contributed as experts within the project team.
- IEC 62790 Ed2, Junction boxes for photovoltaic modules - Safety requirements and tests. **(Published July 2020)**. The JRC contributed as experts within the project team.
- Amendment 1 to IEC 62852 Ed1, Connectors for DC-application in photovoltaic systems - Safety requirements and tests. **(Published March 2020)**. The JRC contributed as experts within the project team.
- IEC TS 63126 Ed1, Guidelines for qualifying PV modules, components and materials for operation at higher temperatures. **(Published June 2020)**. 2020-06-22 The JRC contributed as experts within the project team.
- IEC TS 63140 Ed1, Photovoltaic (PV) modules – Partial shade endurance testing for monolithically integrated products. **(Published April 2021)**. The JRC contributes as experts within the project team.
- IEC TS 63209-1 Ed1, Photovoltaic modules - Extended-stress testing - Part 1: Modules **(Published April 2021)**. The JRC contributes as experts within the project team.

- IEC TS 60904-1-2 Ed. 2.0, Photovoltaic devices - Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic (PV) devices. The JRC contributes as experts within the project team.
- IEC 60904-2 ED4, Photovoltaic devices - Part 2: Requirements for photovoltaic reference devices. CD submitted. The JRC is the project leader.
- IEC 60904-5/AMD1 ED2, Amendment 1 - Photovoltaic devices - Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method. CDV submitted. The JRC contributes as experts within the project team.
- IEC 60904-8/AMD1 ED3, Amendment 1 - Photovoltaic devices - Part 8: Measurement of spectral responsivity of a photovoltaic (PV) device. CD in preparation. The JRC contributes as experts within the project team.

- IEC 61215-1-2/AMD1 Ed2, Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval Part 1-2: Special requirements for testing of thin-film Cadmium Telluride (CdTe) based terrestrial photovoltaic (PV) modules. FDIS in preparation. The JRC contributes as experts within the project team.
- IEC 61215-1-3/AMD1 Ed2, Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval Part 1-3: Special requirements for testing of thin-film amorphous silicon based terrestrial photovoltaic (PV) modules. CDV submitted. The JRC contributes as experts within the project team.
- IEC 61215-1-4/AMD1 Ed2, Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval Part 1-4: Special requirements for testing of thin-film Cu(In,Ga)(S,Se)2 based terrestrial photovoltaic (PV) modules. CDV submitted. The JRC contributes as experts within the project team.
- IEC 61730-1 Ed. 3: Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction, FDIS in preparation. The JRC contributes as experts within the project team.
- IEC 61730-2 Ed. 3: Photovoltaic (PV) module safety qualification - Part 1: Requirements for testing, FDIS in preparation. The JRC contributes as experts within the project team.
- IEC 61853-2/AMD1 ED1, Amendment 1 - Photovoltaic (PV) module performance testing and energy rating - Part 2: Spectral responsivity, incidence angle and module operating temperature measurements. CD in preparation. The JRC contributes as experts within the project team.
- IEC TS 62788-2/AMD1 ED1, Amendment 1 - Measurement procedures for materials used in photovoltaic modules - Part 2: Polymeric materials - Frontsheets and backsheets. DTS in preparation. The JRC contributes as experts within the project team.
- IEC TS 62788-2-1 ED1, Measurement procedures for materials used in photovoltaic modules - Part 2-1: Polymeric materials - Frontsheet and backsheet - Safety requirements. FDIS in preparation. The JRC contributes as experts within the project team.
- IEC TS 62788-6-3 ED1, Measurement procedures for materials used in photovoltaic modules - Part 6-3: Adhesion testing of interfaces within PV modules. DTS in preparation. The JRC contributes as experts within the project team.
- IEC TS 63209-2 ED1, Extended-stress testing of photovoltaic modules – Part 2: Component materials and packaging. DTS in preparation. The JRC contributes as experts within the project team.
- IEC TS 63342 ED1, Light and elevated temperature induced degradation (LETID) test for c-Si Photovoltaic (PV) modules: Detection. DTS in preparation. The JRC contributes as experts within the project team.
- IEC TS 63397 ED1, Guidelines for qualifying PV modules for increased hail resistance. CD submitted. The JRC contributes as experts within the project team.

3 CENELEC TC 82

3.1 CENELEC Background

CENELEC is the European Standards Organisation in the electrotechnical field. CEN/CENELEC (+ ETSI) hold the European Union's mandate in relation to the "Completion of the Internal Market". The specific mandate for standardisation in the field of solar photovoltaic energy systems and components is M/089 EN.

This is implemented by TC 82: Solar Photovoltaic Systems. Under the terms of the Frankfurt Agreement between IEC and CENELEC, the latter transforms IEC standards into European standards, usually in a "fast track" procedure of 2 months, keeping the IEC document numbers. CENELEC together with the European National Committees (EU27+EEA) fosters also the translation of international standards into national languages. The Frankfurt Agreement requires mutual notification of standards work, and the commitment by either party not to engage in topics which the other party is already working on.

3.2 CENELEC TC 82

CENELEC TC 82 is organized in two working groups: WG 1 and WG 2. The scope of WG1 "WAFERS, CELLS AND MODULES" is to develop international standards for wafers, solar cells and terrestrial photovoltaic modules and related components. The scope of WG 2 "BOS COMPONENTS AND SYSTEMS" is to develop international standards for balance of systems (BOS) components, interfaces of PV systems and system integration.

Like many organisations, the operations of the CENELEC were impacted during the COVID pandemic. The work of the various project teams continued much the same way as in the past, with online meetings and the exchange of documents for commenting via email. However, the meetings of the WG 2 were cancelled as physical meetings, with online meetings substituted. These had both positive and negative impacts on the running of the WG 2.

The originally scheduled physical meeting was to be held in Brussels at the beginning of March 2020, however, it was eventually scheduled for December 2020. The JRC is convenor of CENELEC WG 1 (T. Sample) and chaired the annual meeting.

During 2020 and 2021 no specific CENELEC documents were prepared. IEC standards from TC 82 which are circulated for vote are also subjected to a parallel vote by the national committees of CENELEC, via the Frankfurt agreement, and if voted positively to be adopted as EN standards.

As the amendments of the IEC 61730-1 and IEC 61730-2 progress through the IEC stages, an assessment will have to be made on the impact the amendments have on the listing of the current EN IEC 61730-1 and EN IEC 61730-2, which were adopted as harmonised standards under the Low Voltage Directive (LVD) ([10]) through the publication in the Official Journal of the European Union.

([10]) Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits

4 Related Initiatives

4.1 International PV Quality Assurance Task Force (PVQAT, "PV cat")

The first International PV Module Quality Assurance Forum was held in July 2011, in San Francisco, California. The event fostered international participation to develop a rating system that meets the needs of all countries and customers so that PV manufacturers need to complete only a single test. At the Forum, the community expressed strong support for development of international PV QA standards, leading to the formation of The International Photovoltaic Quality Assurance Task Force (PVQAT). PVQAT is a purely voluntary organisation in which each individual participates to further the goals of developing the whole of the PV industry.

The PVQAT leads global efforts to craft quality and reliability standards for solar energy technologies. These standards will allow stakeholders to quickly assess a solar PV module's performance and ability to withstand local weather stresses, thereby reducing risk and adding confidence for those developing products, designing incentive programs, and determining private investments. As a result:

- Investors can gain confidence in solar PV investments.
- PV customers can use standards to choose products that meet their needs.
- Incentive programs can define a minimum durability for module designs.
- Insurance companies can adjust rates according to demonstrated reliability.
- PV module suppliers can optimize module design to minimize cost while still maintaining confidence in reliability for a specific use or application of the modules.
- The entire PV community benefits by reducing installed PV cost when standards are created that establish durability without adding unnecessary cost.

PVQAT strives to provide these benefits by coordinating international development of comprehensive technical standards for verifying PV component and system quality and bankability. To that end, PVQAT has a three-pronged approach that seeks to establish:

- A rating system to ensure durable design of PV modules for the climate and application of interest.
- A guideline for factory inspections and QA during manufacturing.
- A comprehensive system for certification of PV systems, verifying appropriate design, installation, and operation.

PVQAT now has 15 individual task groups focused on accelerating progress toward implementing these three approaches. Several hundred volunteers from around the world contribute to the various task groups within PVQAT and they have already made significant contributions to the standardisation activities. The JRC contributes to PVQAT activities based on the expertise developed at ESTI during the last decades.

In 2017 PVQAT attained a type A liaison with IEC TC 82 to enable close coordination of its work programme in support to standardisation activities.

The various task groups are undertaking basic research activities, intercomparisons and round-robin tests in a number of areas to define appropriate characterisation and testing methods for many of the basic material and component standards either under development or revision within IEC TC 82.

Additional information can be obtained via the PVQAT website www.pvqat.org

The JRC has supported the development of the PVQAT from its inception and is represented on the 5-person steering committee by Tony Sample, who also contributes to some of the task groups.

4.2 IECRE

The IEC System for certification to standards relating to equipment for use in renewable energy applications (IECRE System) aims to facilitate international trade in equipment and services for use in renewable energy (RE) sectors while maintaining the required level of safety (see the IECRE website, www.iecre.org).

To achieve this it:

- operates a single, global certification system
- aims for acceptance by local/national authorities or other bodies requiring and benefiting from certification
- will make use of high quality International Standards and allow for continuous improvement

To be effective and avoid double work of what information must be given when and to whom, the system will include a mechanism to solve disagreements between stakeholders both on the content and its correct application.

Its goal is to offer a harmonised application around the globe, which ensures a uniform implementation and:

- mutual recognition between certification bodies and test labs
- delivery of information by suppliers, sub-suppliers, end users and others providing documentation for certification
- clear understanding of all suppliers, sub-suppliers, end users and other applicants for the elements and modules as well as reports, statements and certificates of the certification processes

RE sectors are known by different names such as Marine Energy, Solar PV Energy and Wind Energy, and relate to areas characterised by systems which generate electricity from renewable natural sources. They consist of complex arrangements of sub-systems including structures, which are usually directly exposed to the natural environment and whose reliability and performance is affected by direct interaction with the natural environment.

These areas may include the equipment and processes to produce energy, as well as the equipment to manufacture, transport and service the energy-producing equipment. Relevant standards exist for specific industry sectors to which the conformity assessment and certification of the IECRE System is done.

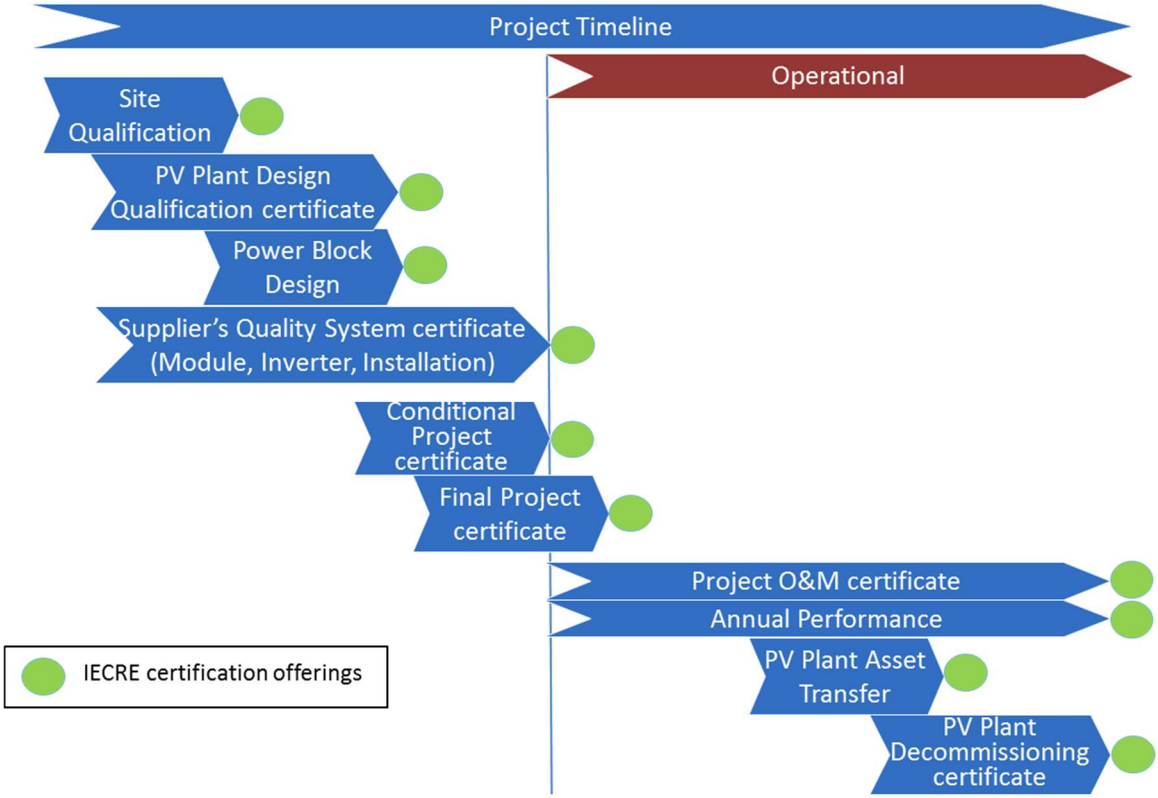
The IECRE was formed in 2014 and currently has 16 member bodies in total, of which 12 are part of the Solar PV sector. The JRC is not currently involved with the IECRE scheme, but we are watching the development of the certification scheme with interest.

Conformity assessment will be performed and certificate issued for an individual PV power plant on a specific site at various stages of its design and implementation (see figure 2).

The specific certificate categories could follow the following:

- PV site qualification certificate
- PV power block design qualification certificate
- PV plant design qualification certificate
- Conditional PV project certificate (construction complete / commissioning)
- Annual PV plant performance certificate
- PV asset transfer certificate
- PV decommissioning certificate

Figure 2. System timeline view



(Source: IECRE 2021)

4.3 TC 113 Nanotechnology standardisation for electrical and electronic products and systems

Nano-enabled PV are devices made from nanomaterial elements, involving a combination of organic and inorganic components and hard and soft matter, including liquid electrolytes, usually combined using low-cost preparation methods mainly by low temperature solution processing. In this class a variety of technical solutions and approaches are used to evaluate technologies.

The field has attracted the attention of the TC 113, which has published one technical specification IEC TS 62876-2-1 Nanotechnology - Reliability assessment - Part 2-1: Nano-enabled photovoltaic devices - Stability test (published 2018-08-29). It currently has two PV related items under consideration (extract of 2021-12-17) which are summarised below:

Table 6. IEC TC 113 Projects related to PV devices

Project Reference	Title	Forecast Publication
PWI 113-78 ED1	IEC 62607-7-1: Nanomanufacturing - Key control characteristics - Part 7-1: Nano-enabled photovoltaics measurement of the electrical performance and spectral response of tandem cells	
IEC TS 62607-7-2 ED1	IEC 62607-7-2: Nanomanufacturing - Key Control Characteristics - Part 7-2: Nano-enabled photovoltaics - Device evaluation method for indoor light	2022-11

(Source: IEC 2021)

The JRC does not take part in IEC TC 113 working groups, but is doing pre-normative research on performance testing of organic (OPV) and dye-sensitised (DSSC) devices, also in the framework of the International Summit on Organic Photovoltaic Stability (ISOS).

In this regard TC 82 has published (2019-07-08) an IEC technical report (TR) on the Measurement protocols for photovoltaic devices based on organic, dye-sensitized or perovskite material (IEC TR 63228). This TR may in part cover the area of characterisation under indoor lighting (i.e. much lower than natural daylight condition), which is the scope of the IEC TS 62607-7-2 (Nano-enabled photovoltaics - Device evaluation method for indoor light).

During 2020 and 2021 the IEC 62607-7-1 did not progress through the TC 113; this may be due to the publication of the IEC 60904-1-1 and IEC 60904-8-1 (published 2017-05) from TC 82, which cover the same application area. It is possible that the proposed activity on IEC 62607-7-1 will be stopped, especially as it has not progressed beyond and new work item proposal since it was initially proposed in October 2013.

4.4 Photovoltaics Products for Building Applications

Building integrated PV (BIPV) has long been recognised as an important area, but also one in which the lack of specific standards addressing both PV and building fields requirements is frequently cited as an issue. Given that in Europe the requirements of the Energy Performance in Buildings Directive is expected to push this market segment towards significant growth in the coming years, standards specific for BIPV products and systems are likely to be a priority area.

The publication, in January 2016, of the EN 50583-1 (Photovoltaics in buildings. BIPV modules) and EN 50583-2 (Photovoltaics in buildings. BIPV systems) standards was a major step forward in this complex area, which covers both building codes and standards as well as those standards aimed at PV devices.

The multifunctional role of PV products in such applications leads to different standards requirements:

- Electrical performance and safety, via CENELEC/IEC standards and the Low Voltage Directive.
- Building energy performance via CEN/ISO standards (as required under the Energy Performance of Buildings Directive)
- PV as building product, where PV is required to satisfy safety and performance specifications as any other product to be used in the building environment (related to the Construction Products Regulation).

EN 1999 provides a common approach for the design of buildings and other civil engineering works and construction products. They are the recommended means of giving a presumption of conformity with the basic requirements of the Construction Products Regulation (CPR) for construction works and products that bear the CE Marking, as well as the preferred reference for technical specifications in public contracts.

As part of the Frankfurt agreement both of the above-mentioned EN standards were sent to IEC TC 82 for their consideration for future work. A Project Team (PT 63092) was established to take these two standards forward. Although the two standards which were published in 2020-09-29, they were not subject to parallel voting at the European level due to significant differences compared to the original EN 50583-1 and -2.

- IEC 63092-1 ED1, Photovoltaics in buildings – Part 1: Building integrated photovoltaic modules, CDV submitted. Published 2020-09-29. The JRC contributed as experts within the project team.
- IEC 63092-2 ED1, Photovoltaics in buildings – Part 2: Building integrated photovoltaic systems, CDV submitted. Published 2020-09-29. The JRC contributed as experts within the project team.

Following the publication of the IEC 63092-1 and -2, a revision of the existing EN 50583-1 and -2 has been launched within the CENELEC TC 82 WG1.

The overlap in building integrated photovoltaics between the IEC and ISO was reflected in the establishment of the Joint Working Group 11 (JWG 11) Building-Integrated Photovoltaics (BIPV) linked to ISO/TC 160/SC 1. JWG 11 is made up of experts from both the IEC and ISO committees and will work on topics related to BIPV.

4.5 Product Environmental Footprint Category Rules (PEFCR)

The EU initiative on the single market for green products includes two methods to measure environmental performance throughout the product lifecycle: the Product Environmental Footprint (PEF) and the Organisation

Environmental Footprint (OEF). PV electricity generation was assessed as a pilot product, and the resulting Product Environmental Footprint Category Rules (PEFCR) provide a methodology for assessing the environmental impacts of PV technologies based on life cycle assessment. The document "Product Environmental Footprint Category Rules (PEFCR) Photovoltaic Modules Used “In Photovoltaic Power Systems For Electricity Generation" was released in November 2018 and is valid until 31 December 2021: see:

https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_PV_electricity_feb2020_2.pdf

For more information see the PEF site https://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm

4.6 Ecodesign preparatory study for solar photovoltaic modules, inverters and systems

The Ecodesign preparatory study was coordinated by the EC Directorate General Internal Market, Industry, Entrepreneurship and SMEs (DG GROW), with the active involvement of DG Energy (DG ENER) and DG Environment (DG ENV). The JRC provided technical and scientific support. In particular, unit B5 "Circular Economy and Industrial Leadership", which led the preparatory study, was also responsible for the analysis of the market and future prospects, modelling possible policy scenarios, as well as of the analysis of aspects such as life cycle assessment of different PV products, the methodology for the Ecodesign of Energy-related products (MERP) and techno-economical and environmental analyses. JRC unit C2 "Energy Efficiency and Renewables" provided technical and scientific support on aspects related to the considered PV products. It also provided a review of existing standards that could be relevant for the preparatory study and of the identification of those aspects not covered by any standard. For those aspects, the C2 unit was responsible for proposing transitional methods that could be adopted within the policy instruments until relevant European or international standards are developed.

The policy recommendations were published in December 2019 and are available on the website;

https://susproc.jrc.ec.europa.eu/solar_photovoltaics/documents.html

5 Planning

PV continues to be an area of strategic importance for EU policies and initiatives on renewable energy, energy performance of buildings and eco-industry. As such the JRC work programme for 2022 foresees continued efforts to a) support the standards process, b) perform relevant pre-normative research and c) promote harmonisation with international and European partners. This is consistent with the 2019 annual Commission work programme for European standardisation ([11]), in which energy is one of the main policy areas identified. The level of commitment in 2022 is expected to be roughly equal to that of 2020, with support for IEC TC82 WG 2 and CENELEC TC82 WG 1 being the most significant.

The JRC-ESTI staff will, via the PV-Energy institutional project, continue to support both IEC TC 82 and CENELEC TC 82. ESTI will prioritise technical input in the following areas:

a) Power calibration

The rated peak-power value remains the key parameter for commerce in PV products, as well as for regulatory purposes. Improving the standards used to define it brings benefits to producers and investors alike. JRC activities on this topic fall under two themes. Firstly, the improvement of existing procedures for PV products, specific items for 2022 include:

- revision of the standard IEC 60904-2 "Photovoltaic devices - Part 2: Requirements for photovoltaic reference devices." (IEC 60904-2 edition 4) JRC is project leader for the revision of the standard.
- revision of the standard IEC TS 60904-1-2 "Photovoltaic devices - Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic (PV) devices." (IEC TS 60904-1-2 edition 2) JRC is part of the project team and will bring the results from the PV-Enerate project ([12]) to the IEC revision team.

Secondly, the development of in-house methods to calibrate curved PV modules, which are increasingly being proposed for incorporation in electric vehicles.

b) Energy Rating

JRC has been active in promoting the development of energy rating for PV modules, on the basis that this would provide investors with additional important information on actual electricity generation capability of a product in a representative range of climates. It would also open possibilities for product differentiation, which the peak-power value does not provide. The IEC 61853-1 was published in 2011, the IEC 61853-2 in 2016, with the IEC 61853-3 and -4 published in 2018.

The ESTI laboratory was recently accredited to perform energy rating measurements and will promote its use in industry during 2022.

Although the standard series has just been completed, JRC is working towards the incorporation of bifacial module designs, and possibly also BIPV products, within the IEC 61853 standard series.

This work will be supported by the results generated from within the PV Enerate project ([13]), which was a EURAMET project under the European Metrology Programme for Innovation and Research (EMPIR) programme, co-financed by the Participating States and by the European Union's Horizon 2020 research and innovation programme.

c) Reliability and Lifetime

This topic had been partly addressed in 2021 focussing mainly on the revision of the PV type approval standard series IEC 61215, which now combines more stringent requirements with a broader technology scope and technology specific parts for:

- IEC 61215 Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules

([11]) COM(2018) 686, The annual Union work programme for European standardisation for 2019

([12]) Lopez-Garcia, J., Kenny, R. P., Sample, T., Pavanello, D., Muellejans, H., and Dunlop, E.D., Draft recommendations to the standardisation project IEC TS 60904-1-2 on two different methods to extend the standard test conditions (STC) to bifacial solar devices, JRC121371, European Commission, Ispra 2020

([13]) Gracia-Amillo, A.M., Kenny, R. P., Friesen, G., Reise, C., Lopez-Garcia, J., Extension of energy rating to bifacial modules – proposals from the PV-enerate project, JRC122448, European Commission, Ispra 2020.

- IEC 61215 Part 1-2: Special requirements for testing of thin-film Cadmium Telluride (CdTe) based photovoltaic (PV) modules
- IEC 61215 Part 1-3: Special requirements for testing of thin-film amorphous silicon based photovoltaic (PV) modules
- IEC 61215 Part 1-4: Special requirements for testing of thin-film Cu (In,GA)(S,Se)$_2$ based photovoltaic (PV) modules

The 2021 editions incorporated specific issues for the testing of flexible PV modules and bifacial modules. Where appropriate, additional tests were incorporated in the IEC 61215 standard series to cover specific failure modes (for example Potential Induced Degradation). While a simplification of the test sequence was achieved by the removal of the NMOT test, which now forms part of the IEC 61853-2.

Although significant progress was achieved with the publication of the second editions of the IEC 61215 series, some items had not reached consensus during the drafting process. One of these was the possibility of using a reduced mechanical load for modules used in interior rows of utility scale PV systems where wind load calculations show that a reduced load test can be appropriate. As such, amendments have been launched, initially for the monolithically integrated thin-film designs, but it could be envisaged for all PV module types.

The IEC TS 63126 Guidelines for qualifying PV modules, components and materials for operation at high temperatures was published in 2020. The technical specification outlines how to modify existing standards to take into account operation at higher temperatures (e.g. desert applications or module integration in buildings), which would lead to module or component temperatures above 90 °C. The publication of this technical specification has led to a significant change in how the scope of various documents approach the concept of operating temperature for PV devices.

In 2018 IEC TC 82 launched an activity (IEC TS 63209-1 Photovoltaic modules - Extended-stress testing - Part 1: Modules), intended to provide data for qualitative reliability risk analysis, highlighting potential failure modes, areas for improvement, and evaluating process changes. This was published in 2021. It is not intended to be used for service life prediction and, despite the use of quantitative data, is only useful for rank ordering modules and materials for special cases, for very large differences in performance, or with respect to specific understood failure modes and mechanisms. A robust module level rank ordering or service life prediction is beyond the scope of this document.

During the drafting of the IEC TS 63209-1 it was obvious the one of the major limitations was the extent of UV testing on full sized PV modules. As such the IEC TS 63209-2 (Extended-stress testing of photovoltaic modules – Part 2: Component materials and packaging) was started to expand the extended testing to the component or mini-module level to adequately test for the UV doses expected from long-term field exposure. The project is near its submission of the final DTS and therefore publication should be in Q2 of 2022.

d) Module Electrical Safety

A range of safety issues, including the use of voltage up to 1500 VDC, have been incorporated in the revision of the PV module safety standard series (IEC 61730 edition 2), which was published in 2016. Originally amendments to both IEC 61730-1 and -2 were envisaged to address specific weathering of components and to incorporate bifacial modules. However the scope and extent of the changes has meant a full revision of the standards are currently being prepared. The FDIS of both parts should be circulated at the beginning of 2022 with publication likely in Q2 of 2022. New approvals under the low voltage directive will have to be made once published.

e) PV Products for Buildings

As part of the Frankfurt agreement both the EN 50583-1 and EN 50583-2 (published in 2016) were transmitted to IEC TC 82 for their consideration for future work. This entailed forming project team PT 63092, which based much of its work on the existing EN 50583-1 and EN 50583-2 and consolidated the other BIPV activities within the PT 63092. Experts in the project team are drawn from all of TC 82 with experts from ISO and the IEA.

Although the two standards IEC 63092-1 and IEC 63092-2 were published in 2020-09-29, they were not subject to parallel voting at the European level due to significant differences compared to the original EN 50583-1 and -2.

As such, a revision of the existing EN 50583-1 and -2 has been launched within the CENELEC TC 82 WG1.

The overlap in building integrated photovoltaics between the IEC and ISO was reflected in the establishment of the Joint Working Group 11 (JWG 11) Building-Integrated Photovoltaics (BIPV) linked to ISO/TC 160/SC 1. JWG 11 is made up of experts from both the IEC and ISO committees and will work on topics related to BIPV.

f) Ecodesign, Energy Labelling, Ecolabel and Green Public Procurement policy tools

Following the publication of recommendations from the preparatory study in 2020, the Commission is performing an impact assessment on the application of mandatory Ecodesign requirements for solar panels and inverters, and Energy labelling for solar panels and for small PV systems.

The JRC has competence in several relevant aspects including energy yield assessment, operational lifetime and life cycle analysis to support such a consultation phase.

References

Directive 2018/2001/EU of 11 December 2018 on the *promotion of the use of energy from renewable sources*

A. Jäger-Waldau, *Snapshot of Photovoltaics* – 2021 EPJ Photovoltaics 12, 2 (2021)

COM(2016) 358, *Standardisation package, European Standards for the 21st Century*

COM(2017) 453 *The annual Union work programme for European standardisation for 2018*

C(2015) 6317 *final Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation*

COM(2016) 773 COMMUNICATION FROM THE COMMISSION *Ecodesign Working Plan 2016-2019*

Directive 2009/125/EC of the European Parliament and of the Council 1 of 21 October 2009 *Establishing a Framework for the Setting of Ecodesign Requirements for Energy-Related Products*, OJ L285, 31.10.2009, p. 10–35.

Regulation (EU)2017/1369 of the European Parliament and of the Council of 4 July 2017 *Setting a Framework for Energy Labelling and Repealing Directive* 2010/30/EU, OJ L198, 28.7.2017, p. 1–23.

Standards for the Assessment of the Environmental Performance of Photovoltaic Modules, Power Conversion Equipment and Photovoltaic Systems, Publications Office of the European Union, 29247 EN, ISBN 978-92-79-86608-1, 2018

Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the *harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits*

COM(2018) 686, *The annual Union work programme for European standardisation for 2019*

Lopez-Garcia, J., Kenny, R. P., Sample, T., Pavanello, D., Muellejans, H., and Dunlop, E.D., *Draft recommendations to the standardisation project IEC TS 60904-1-2 on two different methods to extend the standard test conditions (STC) to bifacial solar devices*, JRC121371, European Commission, Ispra 2020

Gracia-Amillo, A.M., Kenny, R. P., Friesen, G., Reise, C., Lopez-Garcia, J., *Extension of energy rating to bifacial modules – proposals from the PV-enerate project*, JRC122448, European Commission, Ispra 2020.

List of abbreviations and definitions

AIST	National Institute of Advanced Industrial Science and Technology (Japan)
BOS	Balance of Systems
CD	Committee Draft
CDV	Committee Draft for Vote
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CPR	Construction Product Regulation
CPV	Concentrator photovoltaic
DTS	Draft Technical Specification
EC	European Commission
EEA	European Economic Area
ESTI	European Solar Test Installation (at the JRC)
ETSI	European Telecommunications Standards Institute
EU	European Union
EU27	European Union 27 member states
EURAMET	The European Association of National Metrology Institutes
FDIS	Final Draft International Standard
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IEC/TR	International Electrotechnical Commission / Technical Report
IEC/TS	International Electrotechnical Commission / Technical Specification
IECRE	IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications
ISO	International Organization for Standardization
ISOS	International Summit on Organic Photovoltaic Stability
ITU	International Telecommunication Union
JRC	Joint Research Centre of the European Commission
JWG	Joint Working Group
PV	Photovoltaics
NREL	National Renewable Energy Laboratory (USA)
OPV	Organic Photovoltaics
PNW	Proposed New Work
PNW/TS	Proposed New Work/Technical Specification
prEN	project European standard
PTB	Physikalisch-Technische Bundesanstalt (Germany)
PVQAT	International Photovoltaic Quality Assurance Task Force
QA	Quality Assurance
RES	Renewable Energy Sources
SET Plan	Strategic Energy Technology Plan
TC	Technical Committee
TR	Technical report
TS	Technical specification
WG	Working Group

WTO	World Trade Organisation

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