Quality Requirements for LED lighting

EUDP 2010-II Kvalitetskrav til LED belysning - IEA 4E SSL

Slutrapport for EUDP 64010-0431

31 October 2014

Sammenfatning

Denne slutrapport er udarbejdet i samarbejde under IEA SSL 4E annex under ledelse af operating agent Nils Borg og operating agent support Michael Scholand samt management committee chair Peter Bennich.

IEA SSL arbejder på verdensplan for en harmonisering af krav til LED kvalitet og ydelse, indspil til standardisering gennem forarbejde til standardisering og sammenlignende test af lyslaboratorier centreret omkring kernelaboratorier i henholdsvis Europa, Japan, Kina og USA, samt på verdensplan ensartet certificering og akkreditering af lyslaboratorier. Arbejdet kan danne basis for politiske tiltag fra de deltagende regeringer.

Rapporten dokumenterer, at alle resultater og mål i projektet EUDP 64010-0431 er indfriet inklusiv de syv opstillede milepæle:

1. Udvikling af værktøjer for at sikre LED kvalitet
2. Minimumskrav for energieffektivitet, lyskvalitet, oplysning på emballagen og sikkerhed
3. Sammenlignende test på de fire kernelaboratorier i Europa, Japan, Kina og USA
4. Livscyklusanalyse rapport
5. Beskrivelse af ny testmetode og vejledninger til sammenlignende test centreret om hvert af de fire kernelaboratorier
6. Rapport fra sammenlignende test med deltagelse af over 110 laboratorier fra hele verden
7. Servicering og forberedelse af akkreditering af laboratorier (herunder Danmark) med kommunikation med de nationale myndigheder for akkreditering

Der er i projektperioden sket formidling af kriterier og gjort anvendelse af de indsamlede data fra IEA annexet f.eks. er det i 2013/14 sket i følgende sammenhænge:

- Assistance til det danske arbejde samt EU arbejdet med implementering af eco-design og energimærkningskrav.
- Underbygning af danske kommentarer til EU's opdatering af energimærkning af lyskilder i fordning 874/2012, hvor det med data fra IEA arbejdet lykkedes at skærpe kravene til A+ og A++ mærkning af LED lyskilder.
- Input til helt aktuelle overvejelser fra EU om erstatning af halogen med LED belysning i stage 6 af forordning 244/2009.
- Kommentering af EU udkast til implementering af forordning 1194/2012 "Ecodesign requirements for directional lamps, light emitting diode lamps and related equipment".
- Præsentation på konferencen "Strategies in Light Europe", 19-20. november 2013 in Munich.

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Acronyms and Abbreviations

AB	Accreditation Body
AIST	National Institute of Advanced Industrial Science and Technology
ANSI	American National Standards Institute
CEN	European Committee for Standardisation
CIE	Commission Internationale de L'Eclairage
CFL	Compact Fluorescent Lamp
CLASP	Collaborative Labelling and Appliance Standards Program
CNAS	China National Accreditation Service
DOE	Department of Energy (US)
ELC	European Lamp Companies Federation
EU	European Union
IC	Interlaboratory Comparison
IEC	International Electrotechnical Commission
IES	Illuminating Engineering Society (North America)
ILAC	International Laboratory Accreditation Cooperation
ISO	International Standards Organisation
LCA	Life Cycle Assessment
LED	Light Emitting Diode
MAP	Measurement Assurance Program (NIST)
MC	Management Committee
NIST	National Institute of Standards and Technology (USA)
NLTC	National Lighting Test Centre (China)
NMIJ	National Metrology Institute Japan
NVLAP	National Voluntary Laboratory Accreditation Program (US)
OA	Operating Agent
PT	Proficiency Test
SEAD	Super-efficient Equipment and Appliance Deployment
SSL	Solid State Lighting
VSL	National Metrology Institute of The Netherlands
WG	Working Group

Executive Summary

The SSL Annex was established in 2010 under the framework of the International Energy Agency's Energy Efficient End-use Equipment (4E) Implementing Agreement to provide advice to its ten member countries seeking to implement quality assurance programs for SSL lighting. This international collaboration brings together the governments of Australia, China, Denmark, France, Japan, The Netherlands, Republic of Korea, Sweden, United Kingdom and United States of America. China works as an expert member of the 4E SSL Annex.

The SSL Annex completed its first term in June 2014 and started on its second five-year term in July 2014. This report is part of the final reporting from the Annex's first term, during which time the Annex had undertaken three major collaborative tasks:

Quality Assurance

The Annex worked to clarify the needs of governments and consumers, with input from the SSL industry, on quality issues relating to SSL technology. The goal of this work was to reduce the risk in using SSL products and to provide Governments and consumers with recommendations that they can trust when investing in SSL products. As part of this task, a set of recommended performance tiers were developed to identify a suite of metrics and values related to minimum performance values of SSL for energy efficiency, lighting quality, and safety. Reports on SSL products and LCA aspects as well as SSL products and health aspects were developed within this task.

SSL Testing

The Annex has worked to harmonise SSL quality and performance testing around the world. Working with a network of test laboratories, the Annex's work has focused on, (1) assessing a range of existing SSL test procedures; (2) promoting a testing system that is manageable, robust and acceptable to a broad range of stakeholders; and (3) increasing the quality and confidence of SSL test results around the world. In 2012, the Annex completed its first set of tests designed to confirm the competence and equivalence of the "nucleus laboratories", and later carried out a large international test, the Interlaboratory Comparison 2013 (IC 2013), where the SSL testing proficiency of more than 110 laboratories worldwide was compared.

Standards & Accreditation

In the absence of a global test method, it has not been possible to set up a system for mutual recognition of regional laboratory accreditation programmes. This makes it difficult for Accreditation Bodies to carry out SSL Proficiency Testing (PT) as part of their ISO/IEC 17025 accreditation. Thus, the Annex worked to establish suitable accreditation frameworks for laboratories participating in IC 2013, promoting worldwide mutual recognition of PT. In the design and operation of IC 2013, the Annex conformed to ISO/IEC 17043. The Annex then worked to support laboratories who wish to apply for LED lamp testing accreditation to their respective accreditation bodies. In the future, a robust programme for SSL PT could be established based on an international test method, such as the draft CIE standard currently in the final stages of development. Countries would then choose whether to harmonise to this test standard based on its own needs and regulatory requirements, enabling worldwide mutual recognition of SSL product testing and laboratory accreditation.

A Second Term of the Annex

The Annex is now launching its second term, which will run from July 2014 through June 2019. The new work plan will continue some of the activities undertaken in the first term, but also tackle new challenges such as lifetime testing and market monitoring, verification and enforcement.

1 Introduction to the SSL Annex

The goal of the SSL Annex is to develop simple tools to help governments and consumers all over the world quickly and confidently identify which solid-state lighting (SSL) products have the necessary quality and performance levels to effectively reduce lighting energy demand. The Annex aims to work internationally to support this work that is being done on a national and regional level to address these and other challenges with SSL technologies.

The SSL Annex has worked very hard over its first four years to complete the list of activities from the original work plan adopted by the 4E Executive Committee (ExCo) in June 2010. The SSL Annex owes much of its success over these four years to the strong leadership and support from our three Task Leaders and group of SSL Experts. We are grateful for their in-kind contributions to help us achieve the deliverables and milestones.

The achievements of the first term are summarised in this report under the three tasks that were established in the June 2010 work plan. All of the tasks and subtasks have had their objectives and deliverables met, and this work helped to support LED adoption in markets and accelerate the transition to more energy-efficient lighting.

Over the four years, the SSL Annex has convened eight Expert Meetings. These Expert Meetings have played an integral role in the delivery of the work of the Annex, as they provide an opportunity for an open discussion, face-to-face, among the Experts. These meetings have enabled detailed planning, review, discussion and finalisation of deliverables for the SSL Annex.

1.1 Organisational Structure

The SSL Annex is overseen by the Management Committee[1], which is made up of representatives from each member country, thus ensuring that the work of the Annex is representative of the funding governments' priorities. At the time of this paper, the Chair of the Management Committee is Peter Bennich, from the Swedish Energy Agency in Stockholm. The Management Committee oversees all the decisions and actions taken by the Annex, as well as providing strategic direction on future work.

[1] At the time of this writing, the Management Committee of the 4E SSL Annex includes: Peter Bennich, Michiel Brons, David Boughey, Bjarke Hansen, Ashley Armstrong, Jin Soo Kim, Yoshihiro Kudo, Bruno Lafitte, Norihiko Ozaki and Mike Rimmer.

Table 1-1. Members of the IEA 4E SSL Annex Management Committee (June 2014)

Name	Organisation
Ashley Armstrong	Department of Energy, USA
Peter Bennich (Chair)	Swedish Energy Agency, Sweden
David Boughey	Department of Industry, Australia
Michiel Brons	Dutch Metrology Institute (VSL), The Netherlands
Bjarke Hansen	Danish Energy Agency, Denmark
Jin-Soo Kim	KEMCO, Republic of Korea
Bruno Lafitte	ADEME, France
Norihiko Ozaki	The Institute of Applied Energy, Japan
Mike Rimmer	Department of Energy and Climate Change, UK

Under the Management Committee are the SSL Annex Experts. This is a group of more than 20 technical experts from around the world who are involved in the technical consultations and projects conducted by the Annex. The Experts meet twice yearly at plenary events to review progress and set tasks for the next six months. Over the four years of the first term, the Experts have met face-to-face eight times. Some of the national experts are also management committee members.

Table 1-2. Members of the IEA 4E SSL Annex Experts Committee (June 2014)

Country	Experts
Australia	David Boughey; Steve Coyne
China	Hua Shuming; Liu Qian; ZHANG Wei
Denmark	Carsten Dam-Hansen; Casper Kofod
France	Christophe Martinsons; Georges Zissis
Japan	Masanori Doro; Yoshihiro Kudo; Koichi Nara; Tatsuya Zama
Korea	Jin Soo Kim; Stella Choi; Seil Park
Netherlands	Elena Revtova
Sweden	Christofer Silfvenius; Jonas Pettersson; Peter Bennich
United Kingdom	Mike Rimmer
USA	Cameron Miller; Marc R Ledbetter; Yoshi Ohno

The first term of the SSL Annex was structured around three specific Tasks which are described below. These three tasks each had a Task leader and small group of experts from the SSL Annex Expert team. The tasks constituted the day-to-day activities being conducted by the Annex in support of the SSL market.

1.2 Main Activities of the SSL Annex

As indicated above, the main activities of the Annex in the first term were divided into three specific work streams, Tasks 1, 2 and 3. Task 1 addressed quality assurance issues for LED lamps and luminaires and defined performance tiers for a number of different product categories. Task 1 also gathered and analysed available information on environmental and health effects of SSL technologies. Tasks 2 and 3 were closely related to each other, focused on the testing and accreditation of laboratories. Task 2 sought to develop a global interlaboratory comparison (IC) scheme to help support laboratories who are interested in applying for accreditation to testing LED products. This Task included the development of an interim test method for the IC that was based on combining the most stringent requirements of regional test methods from around the world. The SSL Annex's 2013 Interlaboratory Comparison (2013 IC) programme involved 110 SSL laboratories globally, the largest IC for LED products to date. Task 3 worked to establish suitable accreditation frameworks for laboratories participating in IC 2013, promoting worldwide mutual recognition of SSL proficiency testing. By using the results of the Task 2 test based on the SSL Annex test method, it is hoped that accreditation bodies can use the results of the 2013 IC as a proficiency test for a participating laboratory.

1.2.1 Task 1. Develop SSL Quality Assurance

All of the Annex Task 1 activities were led by Dr. Georges Zissis from Toulouse University in France. Task 1 was focused on developing generic performance tiers for various SSL products as well as making life-cycle assessment and health impact analyses of SSL products. Under Task 1 the SSL Annex published SSL performance tiers for the following products:

- Non-directional Lamps for Indoor Residential Applications
- Directional Lamps for Indoor Residential Applications
- Downlight Luminaires
- Linear Fluorescent LED Lamps
- Replacement Linear Fluorescent LED Lamps
- Street Lighting / Outdoor Lighting

For each of these products, several performance tier levels were set to address the various priorities and needs from each country. The performance tiers contain requirements for luminous efficacy, colour temperature and tolerance, chromaticity tolerance, colour maintenance, colour rendering index, lag start time, lumen maintenance, lamp lifetime, flicker, power factor, harmonic distortion, endurance test and other factors.

Task 1 was designed to help governments define minimum quality requirements in policy measures for SSL products. These requirements could be for bulk procurement contracts and incentive schemes, or national energy policies, standards and labelling programmes. The SSL Annex continues to monitor the market and the appropriateness of these published tier levels, and expects that additional levels will be added in the future as SSL technology advances. It should be noted that these performance tiers are not intended to be international standards or to be adopted as mandatory energy or performance regulations, but are aimed as a guide that provides unbiased information on realistic SSL performance levels. Given that similar guidance is not currently available in international standards this guidance should be useful to both member countries and the broader community.

1.2.2 Task 2. Harmonise SSL Performance Testing

All of the Annex Task 2 activities were led by Dr. Yoshi Ohno of the National Institute of Standards and Technology (NIST) in the USA. Task 2 worked to support the harmonisation of SSL testing around the world, developing an approach to compare and provide support for the accreditation of laboratories for their ability to measure LED products. The underlying motive for Task 2 was the fact that testing of SSL products is, in many ways, different from testing conventional light sources and a lab that can reliably test conventional light sources may not necessarily be able to provide accurate test results for SSL products.

Task 2 was built around four so-called Nucleus Laboratories: the National Institute of Standards and Technology (NIST) in the USA; the National Lighting Test Centre (NLTC) in China; the National Metrology Institute of The Netherlands (VSL) in The Netherlands; and the National Metrology Institute Japan in National Institute of Advanced Industrial Science and Technology (AIST, NMIJ) in Japan. Each of these nucleus laboratories served as a regional reference lab for a group of laboratories to be tested. In total, 110 laboratories were compared in this international comparison. Some of the positive outcomes that may be the result of the SSL Annex undertaking Task 2 are listed below:

- Lower development costs for preparing test methods, especially for emerging technologies such as SSL products;
- More accurate and comparable test results for products sold domestically and in neighbouring economies;
- The opportunity for participating laboratories to apply to their local accreditation bodies to be accredited to a test standard for LED lamps;
- The ability to transpose and adapt analyses from other markets to determine appropriate domestic efficiency requirements; and
- Faster and less expensive testing – for compliance and other purposes – as harmonized testing creates a larger choice of laboratories who can conduct product tests.

1.2.3 Task 3. Standards and Accreditation

All of the Annex Task 3 activities were led by Dr. Koichi Nara of the National Institute of Advanced Industrial Science and Technology in Japan. Task 3 was focused on disseminating the results of Task 2, and supporting laboratories who wish to apply for LED lamp testing accreditation to their respective accreditation bodies. In the design and implementation of 2013 Interlaboratory Comparison, the Annex agreed to conform to ISO/IEC 17043. The four Nucleus Laboratories are all National Metrology Institutes or National Testing Institutes and possess their own primary measurement standards and have developed a measurement method and validated it. All of the relevant measurement services carried out by them were accredited by International Laboratory Accreditation Cooperation Mutual Recognition Agreement (ILAC/MRA) signatories or peer reviewed against ISO/IEC 17025 and registered to Appendix-C, CIPM/MRA. Therefore, the basic competence of the institutions related to the measurements has been established.

In the absence of a global test method, it has not been possible for the international accreditation system to be set up a system for mutual recognition of regional accreditation programmes. It has been difficult for many Accreditation Bodies (ABs,) to carry out SSL Proficiency Testing (PT) as part of their ISO/IEC 17025 accreditation. While some ABs like CNAS (in China) or NVLAP (a US accreditation programme) carry out SSL PT or comparison test, the test is not within the scope of the ILAC MRA, and thus it is not possible for these PTs to be accepted globally. Due to the global fragmentation and disparities in SSL test methods, accreditation and PT for SSL products has been held back. In the future, a robust programme for SSL PT could be established based on an international test method, such as the draft CIE standard currently in the final stages of development. Countries would then choose whether to harmonise to this test standard based on its own needs and regulatory requirements, enabling worldwide mutual recognition of SSL product testing and laboratory accreditation. (Figure 4-1 on p 28 illustrates how accreditation for regional methods can be based on a common, global test method, and how IC 2013 has served as an interim for such a global method).

2 Results from Task 1 – Quality Assurance

Task 1 was focused on developing generic performance tiers for various SSL products as well as making life-cycle and health impact analyses of the SSL technology. There were five subtasks that were included in the June 2010 work programme adopted by the ExCo for Task 1.[2] The table below presents the work that was conducted as part of Task 1, in accordance with the work programme adopted by the ExCo.

Table 2-1. List of Activities included in Task 1

Task 1	Description of Subtasks in Task 1
1.1	Establish lamp and luminaire product categories and determine the key performance characteristics of these products, including luminous flux, luminous efficacy, chromaticity, colour rendering, life (lumen maintenance, switching cycles, etc.), safety and other attributes. For measurement of these characteristics, reference existing test methods.
1.2	Establish a suite of minimum performance values for these product categories, focusing on energy efficiency, lighting quality, and safety.
1.3	A study of SSL product labelling declaration marks certifying the product performance and quality attributes.
1.4	A report that reviews all the current Life Cycle Assessment (LCA) papers published on SSL products. A report that looks at the human health effects of LED products, and whether there are any potential risks or concerns to consider that are associated with this new technology.
1.5	A suggested set of harmonised specifications for LED replacement lamp equivalency claims of luminous flux when compared with common incandescent and fluorescent lamps.

[2] Annex 4E-SSL Solid-State Lighting 2010-2014, Work programme and budget, May 10. 2010; Prepared on behalf of ADEME, French Energy Management Agency by Professor Marc Fontoynont and Dr. Bruno Lafitte (ADEME).

2.1 Task 1 Activities Focused on Performance Values

Table 2-2. Task 1 Activities focusing on Performance Values

Subtask	Description of Subtasks	Deliverables
1.1	Establish lamp and luminaire product categories and determine the key performance characteristics of these products, including luminous flux, luminous efficacy, chromaticity, colour rendering, life (lumen maintenance, switching cycles, etc.), safety and other attributes. For measurement of these characteristics, reference existing test methods.	Selection of product categories covering both lamps and luminaires; defined key performance characteristics included in the performance review of products.
1.2	Establish a suite of minimum performance values for these product categories, focusing on energy efficiency, lighting quality, and safety.	Published documents providing minimum performance values of six SSL product categories, including efficacy and quality.

Subtasks 1.1 and 1.2 were completed for six product categories – (1) Non-directional Lamps for Indoor Residential Applications; (2) Directional Lamps for Indoor Residential Applications; (3) Downlight Luminaires; (4) Linear Fluorescent LED Replacement Lamps; (5) Linear Fluorescent LED Lamps; and (6) Street Lighting / Outdoor Lighting. For each of these voluntary performance tiers, there are a broad range of performance characteristics – including luminous flux, efficacy, chromaticity, colour rendering, lifetime, lumen maintenance, and so-on. The six product performance tier documents had originally contained four tier levels – a Tier 0 for “off-grid” applications where appropriate, and then three tiers for on-grid technologies: Tier 1 for minimum quality performance, Tier 2 for medium-performance and Tier 3 for best available technology. However, in 2013 it was agreed that the Tier 0 levels would be removed from the document and published in a separate ‘off-grid’ document that would be developed co-operatively with organisations like the United Nations Environment Programme, the Global Lighting and Energy Access Partnership (Global LEAP), the Global Off-Grid Lighting Association and Lighting Global (an IFC/World Bank venture).

By establishing and publishing performance levels, the SSL Annex expects to help participating governments define minimum and/or high performance of SSL products in their national energy policies, procurement and incentive schemes and eventually, regulatory requirements. The three performance tiers cover a range of high-volume, popular LED lamps and luminaires. In the new term, the SSL Annex will revisit these six sets of requirements and determine and add additional levels as SSL technology advances. The Annex will also add at least three new products in the second term (July 2014–June 2019), for which preliminary work was initiated in the final months of the first term.

Products published during First Term of SSL Annex:

1. Non-directional lamps for indoor residential applications
2. Directional lamps for indoor residential applications
3. Downlight luminaires
4. Linear fluorescent LED “retrofit” lamps
5. Linear fluorescent LED lamps

6. Street lighting / Outdoor lighting

New products planned for Second Term of SSL Annex:
1. Planar luminaires (under development)
2. Troffer retrofit kits (under development)
3. High- and low-bay luminaires (under development)

2.2 Task 1 Activities Focused on a Certification Mark

Table 2-3. Task 1 Activities focused on a certification mark

Subtask	Description of Subtasks	Deliverables
1.3	A study of SSL product labelling declaration marks certifying the product performance and quality attributes.	1) Support given to the SEAD Global Efficiency Award for LED lighting products. 2) A report that looks at the SSL labelling schemes in the member countries and provides best practice guidelines for other governments that may wish to provide similar information for their markets.

Under this subtask, the MC offered several days of in-kind support to the Super-Efficient Equipment and Appliance Deployment (SEAD) initiative for the purposes of supporting the development of a Global SEAD Award[3] for SSL. The MC approved twelve days of time of the Operating Agent Support, Michael Scholand, to develop the technical specification / criteria for the competition. This work involved the SSL Annex participating in and facilitating a series of phone calls with the SEAD stakeholder consultation group to develop the objectives and requirements for the competition. The SSL Annex then addressed all of this input, and prepared the competition rules. This draft was published by SEAD for industry review and comment. The SSL Annex addressed those industry comments, including input from the SSL Annex Experts, Yoshi Ohno, Steven Coyne and Marc Ledbetter. The competition was launched in May 2014 and is on-going at this time. The table below shows the products that are part of the competition, and the criteria and requirements of this programme that the SSL Annex has contributed to the SEAD programme are based on the Annex's Subtasks 1.1 and 1.2.

[3] The Global Efficiency Medal from SEAD is an established award that has already been published for televisions, displays and electric motors. For information on the SEAD awards, see: http://superefficient.org/awards

Table 2-4. Summary of the Product Categories Included in the SEAD Lighting Awards Competition

	General Service Lamps	Reflector Lamps	Planar Luminaires	Down Light Luminaires
Picture				
Description	Emit light in all directions (non-directional); e.g., A19, mains voltage replacement lamp	Lamps that emit directional light; e.g., MR16, PAR38, mains voltage replacement lamp	Recessed ceiling fixtures commonly used in offices for general illumination.	Recessed directional fixtures that deliver light to a space or highlight an object or area.
Sectors	Primarily residential, some commercial	Residential and commercial	Commercial	Commercial and residential

The second part of this Task is the development and publication of a research paper on labelling of lighting products. Energy labels, like other market transformation programmes, aim to shift markets toward using more energy-efficient products. Energy-labelling programmes provide consumers with information that enables them to make informed purchasing decisions. This has the effect of stimulating the market and can also encourage competition between manufacturers to produce and bring to market the most energy-efficient models. It can also engage other stakeholders in the supply chain to promote efficiency.

2.3 Task 1 Activities Focused on Life-Cycle Assessment

Table 2-5. Task 1 Activities focused on life-cycle assessment

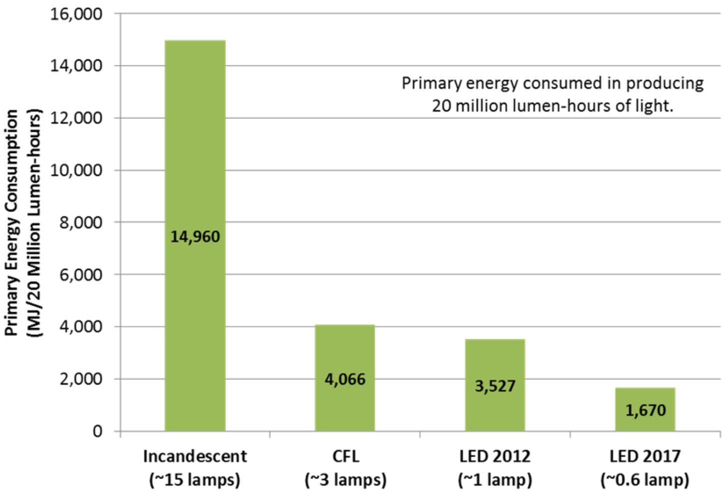
Task	Tools / Description	Deliverables
1.4	A report that reviews all the current Life Cycle Assessment (LCA) papers published on SSL products. A report that looks at the human health effects of LED products, and whether there are any potential risks or concerns to consider that are associated with this new technology	A report that compares the Life Cycle Assessment (LCA) reports on LED technology from around the world. A separate report that looks at the health effects of LED lamps and luminaires, identifying the risks that policy makers need to keep in mind for LED products.

The Task 1 team prepared and finalised a meta-study that reviews a series of life-cycle assessments on lighting products. The report presents an overview of published life-cycle assessments (LCA) of lighting equipment, answering the following questions on the basis of current research:

- What are the environmental impacts of LED products over their whole life cycle?
- What are the strongest contributors to the environmental impacts of LED products?
- How do SSL products compare with conventional lighting technologies?

- What are the main difficulties to perform a LCA of an LED lamp or luminaire?

The LCA methodology is used to assess the environmental impacts of LED products, including a comparison with different lighting technologies. In addition, the challenges and uncertainties associated with the published LED LCA studies are discussed. When the environmental performances of an LED product life cycle were assessed, the use stage was found to dominate the environmental impacts over the manufacturing and the end-of-life stages. On average, 85% of the environmental impact is linked to the use phase, while the remaining 15% is shared mainly between manufacturing and end-of-life treatment.



This figure to the left shows the findings of an LCA study by the US DOE that compares the primary energy consumed over the life cycle of three lighting technologies, incandescent, CFL and LED in 2012 and 2017. These technologies were compared for the same quantity of light output (i.e., 20 million lumen-hours), and incandescent technology was found to consume many times more primary energy, even when taking into account all stages of the lamps respective life-cycles.

The SSL Annex also prepared and published a report on the potential health impacts of LED lighting. This work focused on glare issues, photobiological effects caused by the optical radiation on the eye and the skin, flickering phenomena and non-visual effects of light, such as the effects on the circadian rhythm and the biological clock. The recommendations of the SSL Annex Experts are summarised in the report on the following health-related areas:

- Electrical risks
- Exposure to electromagnetic fields
- Glare
- Photobiological hazards
- Non-visual effects of light

Overall, the report concluded that in comparison with other lighting technologies, SSL technology is not expected to have more direct negative impacts on human health with respect to non-visual effects. However, SSL may indirectly be responsible for an increase in light exposure. The low cost of LEDs combined with their form factor and their low energy consumption makes them very attractive. More lighting points may be installed at home, at work or in the streets, thereby increasing the overall exposure to artificial light and the potential risks linked to non-visual effects such as the perturbation of the biological circadian clock. The experts recommend preserving a dark nocturnal environment while maintaining a suitable exposure level during daytime through daylight and artificial lighting.

2.4 Task 1 Activities Focused on a Lamp Equivalency Claims

Table 2-6. Task 1 Activities focused on lamp equivalency claims

Task	Tools / Description	Deliverables
1.5	A suggested set of harmonised specifications for LED replacement lamp equivalency claims of luminous flux when compared with common incandescent and fluorescent lamps.	Lamp equivalency claims developed and included in the quality and performance tiers for Task 1.

Subtask 1.5 addressed an issue relating to equivalency claims of replacement LED products. It sought to ensure that SSL products achieve a certain minimum performance in light output before they can be considered 'equivalent' products to the conventional technology lamps they are intending to replace. For example, if an LED lamp wishes to claim its equivalency to a 60W incandescent lamp, it would have to achieve a minimum number of lumens (e.g., 800 lumens) in order to make that claim. In this way, consumers will not be disappointed when they go to install an LED lamp because the light output is not as bright as they were expecting.

Each of the product quality requirements published in the Tiers documents (see Subtasks 1.1 and 1.2) contain a luminous flux output requirement when declaring equivalency. The Annex Experts developed and published specifications for luminous flux and published those for different categories of lamps – non-directional lamps, directional lamps and linear fluorescent LED lamps. The figure below presents those equivalencies for linear fluorescent lamps – both T8 and T5 – from the fluorescent lamp tiers documents published online.

Table 2-7. Lamp Lumen Equivalency Thresholds for T8 and T5 Lamps

	T8 Equivalent Wattage Minimum Initial Light output	T5 Equiv. Wattage: Min. Initial Light Output
Lamp minimum light output (lm) and equivalent	15 W: 945 lm	14W: 1350 lm (35°C) / 1200 lm (25°C)
	18 W: 1350 lm	21W: 2100 lm (35°C) / 1900 lm (25°C)
	25 W: 2000 lm	28W: 2900 lm (35°C) / 2600 lm (25°C)
	28 W: 2200 lm	35W: 3650 lm (35°C) / 3300 lm (25°C)
	30 W: 2400 lm	24W(HO): 2000 lm (35°C) / 1800 lm (25°C)
	32 W: 2700 lm	39W(HO): 3500 lm (35°C) / 3200 lm (25°C)
	36 W: 3000 lm	49W(HO): 4900 lm (35°C) / 4400 lm (25°C)
	38 W: 3348 lm	54W(HO): 5000 lm (35°C) / 4500 lm (25°C)
	58 W: 5220 lm	80W(HO): 7000 lm (35°C) / 6300 lm (25°C)
	70 W: 6230 lm	

3 Results from Task 2 – Laboratory Performance

Task 2 was focused on developing and implementing an international comparison testing programme for SSL laboratories. This testing programme was intended to support proficiency testing for lighting laboratories around the world and was designed around the following key stages: (1) development of a harmonised testing protocol (CIE, IEC, ANSI, etc.); (2) conducting a comparison test and calibration of the four nucleus laboratories; and (3) launching a global comparison test to any laboratory who wishes to participate, which was called "Interlaboratory Comparison 2013" (IC 2013).

All of the work in Task 2 is carefully designed to be in compliance with ISO/IEC 17043, a quality standard. This was to ensure that if successful, the work may be acceptable to an Accreditation Body (AB) as evidence of Proficiency Testing for any SSL method of measurement currently being used or in draft. The IC 2013 was designed to be run by the four regional Nucleus Laboratories:

- National Institute of Standards and Technology (NIST) in the USA;
- National Lighting Test Centre (NLTC) in China;
- National Metrology Institute of The Netherlands (VSL) in The Netherlands; and
- National Metrology Institute Japan in National Institute of Advanced Industrial Science and Technology (AIST, NMIJ) in Japan.

The table below presents the work that was conducted as part of Task 2, in accordance with the work programme adopted by the ExCo.

Table 3-1. List of Activities included in Task 2

Task 2	Description of Subtasks in Task 2
2.1	Develop a test method for testing the performance of SSL products based on the test methods used in existing LED testing standards (by IEC, CIE, ISO, ANSI, IESNA, JIS, CATS, BSI, SA, etc.)
2.2	Conduct a comparison among the 4 nucleus laboratories, to validate the proposed test method and calibrate the nucleus laboratories.
2.3	Conduct an international testing campaign of SSL products through the nucleus laboratories, inviting participation by public, private and industry-owned laboratories.
2.4	Develop a Final Report and communicate the results and findings of the interlaboratory comparison to IEA 4E SSL Annex member countries as well as to non 4E member governments, participating laboratories, accreditation bodies and other stakeholders.

3.1 Task 2 Activities Focused on Testing Standard for Laboratories

Task 2 worked to support the harmonisation of SSL testing around the world, by developing an approach to compare and ultimately accredit laboratories for their ability to measure LED products.

Table 3-2. Task 2 Activities focused on testing standard for laboratories

Subtask	Description of Subtask	Deliverables
2.1	Develop a test method for testing the performance of SSL products based on the test methods used in existing LED testing standards (by IEC, CIE, ISO, ANSI, IESNA, JIS, CATS, BSI, SA, etc.)	A test standard was developed that can be used for an interlaboratory comparison that draws upon the most stringent requirements from all the published and draft test standards.

The SSL Annex Experts prepared a test method for LED lamps and LED luminaires to be used in the 2013 Interlaboratory Comparison. The test standard also covers test methods for many of the performance characteristics included in the IEA 4E SSL Annex's "Performance Tiers" developed under Task 1.

The SSL Annex sought to develop one method for testing LED lamps and luminaires because its member countries recognised the benefits from the harmonisation of testing methods, including:

- lower development costs for preparing test methods, especially for emerging products such as SSL;
- comparative test results for products sold domestically and in neighbouring economies;
- the ability to transpose and adapt analyses from other markets to determine appropriate domestic efficiency requirements;
- adopting minimum performance thresholds and applying them as a starting point in a domestic regulatory programme;
- adopting a common set of upper thresholds that can be used for market pull programs such as labelling and incentive schemes; and
- faster and less expensive testing – for compliance and other purposes – as harmonised testing creates a larger choice of laboratories who can conduct product tests.

The test method was written in such a way that the measurement requirements encompass all of the most stringent requirements of those contained in IES LM-79-08, EN 13032-4 (Draft) prepared by CEN TC169 WG7 and CIE TC2-71 (excluding the parts on LED modules), the test methods drafts included in the Annexes of IEC performance standards (drafts) on LED lamps and LED luminaires, the test methods covering LED lamps and LED luminaires in the Japanese standards: JIS C 7801:2009, JIS C 8105-5:2011, and JIS C 7801 Amendment 1: 2012, and the test methods covered in the Chinese standards: GB standards Drafts for self-ballasted LED reflector lamps, and CQC3127-2010, CQC3128-2010, CQC3129-2010, CQC3130-2011. By complying with this IEA Interlaboratory Comparison Test Method, all the measurement requirements for LED lamps and luminaires in the above test methods are considered to be satisfied. The Annex standard was only intended to be a temporary solution to the absence of an available international standard for the purpose of the interlaboratory comparison. At the time of this work, the Annex was aware of international standardization activities currently underway by CIE and IEC, which would hopefully result in an on-going international test standard.

3.2 Task 2 Activities Focused on the Nucleus Laboratory Testing

Table 3-3. Task 2 Activities focused on nucleus laboratory testing

Subtask	Description of Subtask	Deliverables
2.2	Conduct a comparison among the 4 nucleus laboratories, to validate the proposed test method and calibrate the nucleus laboratories.	A comparison / calibration between the Nucleus Laboratories was conducted and a report summarising the findings was completed.

The testing conducted under the IEA 4E SSL Annex created an opportunity for a select group of laboratories (the "nucleus laboratories") around the world to demonstrate their capability to test a set of LED products accurately and to ascertain whether the test standards and samples selected were adequate for making that assessment.

The "nucleus laboratories", which are the National Institute of Standards and Technology (NIST, USA), the National Lighting Test Centre (NLTC, China), the Dutch Metrology Institute (VSL, The Netherlands) and the National Institute of Advanced Industrial Science and Technology, National Metrology Institute of Japan (AIST, NMIJ, Japan). As shown in the diagram, there three sets of test lamps were measured by NIST and then sent to each of the three laboratories (VSL, NLTC and AIST).

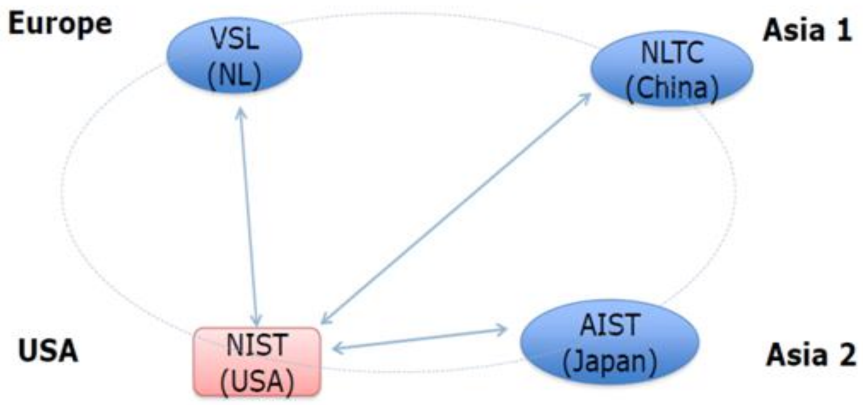


Figure 3-1. Illustration of the Star-Type Configuration for Nucleus Lab Calibration

A report was produced[4] summarising the test results from the nucleus laboratories and confirming the competence of these laboratories to make repeatable, reproducible and representative measurements of LED lighting products.

[4] http://ssl.iea-4e.org/files/otherfiles/0000/0047/4E_SSL_Annex_-_Nucleus_Laboratory_Comparison_Report_final..pdf

3.3 Task 2 Activities Focused on International Laboratory Testing

Table 3-4. Task 2 Activities focused on international laboratory testing

Subtask	Description of Subtask	Deliverables
2.3	Conduct an international testing campaign of SSL products through the nucleus laboratories, inviting participation by public, private and industry-owned laboratories.	A testing scheme of participating laboratories, coordinated by Nucleus laboratories; results and analysis of Round Robin 2 by Nucleus Labs

In mid-October 2012, the 2013 Interlaboratory Comparison (2013 IC) testing programme was launched, inviting lighting laboratories from around the world to participate. The Task 2 was carefully designed to be in compliance with ISO/IEC 17043 in order to ensure that if successful, the work may be acceptable to an Accreditation Body (AB) as evidence of Proficiency Testing for any of SSL method of measurement currently being used or in draft.

Several documents had to be finalised for the launch of the 2013 IC, which are briefly described below:

- Test Method – the SSL Annex conducted a comparison of the regional test methods and the CEN/CIE draft, and found that these test methods had similarities. In order to create a global IC testing programme, the laboratories will be asked to use a single, harmonised test method (called the IEA 4E SSL Annex Interlaboratory Comparison Test Method version 1.0 – discussed above in 2.1), which harmonises the requirements of the various SSL test methods in published or draft form. The Test Method takes the most stringent requirements from each of the aforementioned SSL test methods to ensure the best quality measurements.

- Generic Protocol – this document describes the generic protocol that will be adapted for use by each of the four nucleus labs as they work with other laboratories in their regions conducting the IC test. Any deviations in the regional protocols may be made with approval by the other SSL Annex Nucleus Labs. The generic protocol was prepared in compliance with ISO/IEC 17043:2010 to potentially enable it to be recognised by accreditation bodies (ABs) as evidence of the competence of participating laboratories for their ability to measure SSL products.

- Quality Policy – this document outlines the operation and its conformance to ISO/IEC 17043 of the Nucleus Laboratory Comparison and the 2013 Interlaboratory Comparison Testing conducted by IEA 4E SSL Annex (Version 1.0).

All of the testing of participants was completed and the final report was prepared and issued on 30 June 2014 and distributed to participating labs for final review. Comments were received and the updated version of the final report was made public on September 10th, 2014. The IC was designed to be used as proficiency testing for SSL testing accreditation and thus designed in compliance with ISO/IEC 17043. Measurements of photometric, colorimetric, and electrical quantities were compared using at least four different types of LED lamps. In total, the 2013 IC had 54 laboratories from 18 countries participate in the comparison. In addition, the recent results of 35 US laboratories in NVLAP PTs and NIST Measurement Assurance Program and the results of 21 laboratories in APLAC Proficiency Test T088 were linked to IC 2013, making total 110 laboratories and 123 sets of data included in IC 2013.

The results for total luminous flux and chromaticity x, y showed that the artefacts measured by most of the laboratories agreed to within ± 5 % in luminous flux and within ± 0.005 in x, y, overall for all artefact types, which are at expected levels of agreement. These results verified the levels of uncertainty of measurements by laboratories using a well-established test method, and that the test method compiled for the IC 2013 was effective in limiting measurement variations. On the other hand, a few extremely large deviations in results were observed, up to 30 % in luminous flux or up to 0.2 in chromaticity x, y for each artefact type. These extreme test results must be caused by some major flaws at the participant laboratories in meeting the requirements in the test method. Identifying these large deviations by some laboratories demonstrates the importance of proficiency testing, as these laboratories would not have become aware of their problems without participating in such an interlaboratory comparison.

The electrical measurement results also identified some issues. The variations in measured RMS current for LED lamps were primarily within ± 3 % (omnidirectional lamp) to ± 15 % (low power-factor lamp), with some deviations much larger than expected (up to 38 %), resulting in many high values of z' score and En number. This result indicates that the generic uncertainty and the participants' reported uncertainties for RMS current were significantly underestimated. However, looking at the results of luminous flux and chromaticity for low-power factor lamps, the effect of the RMS current variations on photometric and colorimetric values was found not significant, and thus it would appear that agreement in measured RMS current is not very critical. This is explained by the finding that deviations in RMS current were strongly correlated with power factor in the direction to cancel the changes in active power, though not all the cases. The variations in measured power factor were also larger than expected, mostly within ± 0.02 to ± 0.1 depending on the artefact type. These large variations in the electrical measurements may be caused by differences in the characteristics of the AC power supplies used by the participants, in particular, their output impedance. This is one of the remaining issues for the test methods in use today for LED lighting products, and future improvements are expected.

The uncertainties reported by the participants were found to be in a very large range (often more than two orders of magnitude), and were often significantly underestimated. Some laboratories reported unreasonably small uncertainties (e.g., 0.0001 in chromaticity x, y) or unreasonably large uncertainties (e.g., 10 % in luminous flux or 0.02 in chromaticity x, y). Several laboratories (not those linked) did not report uncertainties at all or did not report uncertainty of any colour quantities (i.e., chromaticity x, y, CCT, CRI). From these findings, it would appear that uncertainty evaluation, especially for colour quantities, is still very difficult for the SSL industry, and reported uncertainties are often not reliable. Practical methods and tools for uncertainty evaluation of measurements, as well as educational documents and training for the SSL industry on practical uncertainty evaluation are urgently needed.

In addition to the differences of participants results from the reference values, both z' scores and En numbers were calculated in IC 2013 for possible use by accreditation bodies. These results show that some laboratories would pass on En number but fail on z' score or vice versa. In particular, there were some cases where laboratories claiming large uncertainties would pass on En number though the deviations in their results were very large. Thus, the use of En number alone can be problematic when measurement variations need to be limited by the accreditation programme. In practice, the En number is suitable for the purpose of assessing the validity of claimed uncertainties (e.g., in calibration laboratory accreditation). The z' score is suitable for the purpose of testing laboratory accreditation, which examines a laboratory's competence and compliance to a test method which is developed to limit measurement variations as is often required in product certification activities. For laboratory accreditation programmes serving both purposes (i.e., serving for product certification activities as well as certifying the reported uncertainties), the use of the En number and z’ score would be appropriate. In this study, it was found that the En number could be problematic where laboratories had difficulty in uncertainty evaluation, as shown in IC 2013 for colour quantities. And, it was found that the z' score could be problematic if the denominator values were not appropriately specified, as was the case of RMS current measurements in this IC. The results of IC 2013 may be utilised for future SSL proficiency testing using z' score or a similar metric.

This IC 2013 was an attempt to establish a common PT for accreditation programmes supporting different regulations and government programmes using different regional test methods. For this purpose, a special test method was needed and developed by the SSL Annex. A solution for international harmonisation of SSL testing and accreditation would be to use one international test method for SSL products, which will be published soon by the International Commission on Illumination (CIE). Countries would then choose whether to harmonise to this test method standard based on their own needs and regulatory requirements, enabling worldwide mutual recognition of SSL product testing and laboratory accreditation.

The IC 2013 provided many laboratories in many countries with new knowledge and experience in PT for the measurement of SSL products. It also established a basis to promote SSL laboratory testing accreditation world-wide in support of regulations and government programmes to further accelerate the development of SSL.

3.4 Task 2 Activities Focused on Communication and Outreach

Table 3-5. Task 2 Activities Communication and Outreach

Subtask	Description of Subtask	Deliverables
2.4	Develop a Final Report and communicate the results and findings of the interlaboratory comparison to IEA 4E SSL Annex member countries as well as to non 4E member governments and other stakeholders.	Communication of the results to stakeholders and governments who are interested in LED lamp testing through a final report and press release.

Subtask 2.4 involved communicating the results and the work of the Annex to external parties, including governments, the lighting industry and other stakeholders involved in SSL. The following table provides a few examples of speaking engagements in the last year and meetings where the Management Committee Chair and/or the Operating Agent spoke about the SSL Annex.

Table 3-6. Sample of Recent Past and Future Meetings and Outreach Efforts

Event	Date	Location	Intended audience
Strategies In Light - Europe	September 2012	Germany	SSL stakeholders, investors and experts
ILAC Proficiency Testing Consulting Group meeting	October 2012	Rio, Brazil	Accreditation Bodies; Standardisation Bodies
CIE Technical Committee meeting	September 2012	Hangzhou, China	Standardisation Bodies, Lighting Metrologists, Lighting Industry
CIE Strategy Committee meeting	November 2012	Manchester, UK	Standardisation Bodies, Lighting Metrologists, Lighting Industry
Global Lighting Association LED working group meeting	20-21 December 2012	China	Industry Association for Lighting Manufacturers
LED conference and World Sustainable Days	1 March 2013	Wels, Austria	Practitioners, policy makers, NGOs
SSL Annex and global stakeholder organisation workshop	7-8 March 2013	Tokyo	Lighting industry, CIE and IEC decision makers
International Laboratory Accreditation Cooperation (ILAC) meeting	15-17 April 2013	Cape Town	Accreditation Bodies; Standardisation Bodies
European SSL Metrology Meeting	24-25 April 2013	Teddington, UK	Lighting Metrologists; Laboratories; Accreditation Bodies
eceee 2013 Summer Study – paper presentation	3-8 June 2013	France	Global energy-efficiency community; policy makers
International Conference on LED Lighting Promoting Policy (KEMCO)	3 September 2013	Seoul	SSL Market; energy experts; policy makers
Light + Building	4 April 2014	Frankfurt	Lighting sector; energy-efficiency experts
IEA 4E SSL Annex 8th Experts Meeting	7-9 April 2014	Delft	Annex Experts
14th International Symposium on the Science and Technology of Lighting (LS14)	22-27 June 2014	Como Lake (Italy)	Lighting researchers; Lighting scientists

In addition to this active outreach effort, the SSL Annex maintains a public website where material associated with its various efforts and programmes are published for stakeholder review and use. The website contains specific pages dedicated to communicating the work of all three Tasks. For more information, visit: http://ssl.iea-4e.org/

The following are some of the publications that were issued recently by the SSL Annex.

Table 3-7. Recent Publications of the SSL Annex

Name	Date	Access
Solid State Lighting Annex: Summary Report of Nucleus Laboratory Comparison – Final Report	August 2012	Public, IEA 4E SSL website
Performance Tiers: Non-directional Lamps for Indoor Residential Applications	August 2012	Public, IEA 4E SSL website
Performance Tiers: Directional Lamps for Indoor Residential Applications	August 2012	Public, IEA 4E SSL website
Performance Tiers: Downlight Luminaires	August 2012	Public, IEA 4E SSL website
Performance Tiers: Linear Fluorescent LED Replacement Lamps	September 2012	Public, IEA 4E SSL website
Solid State Lighting Annex: Interlaboratory Comparison Test Method, Version 1.0	October 2012	Public, IEA 4E SSL website
Solid State Lighting Annex: Interlaboratory Comparison Generic Protocol	October 2012	Public, IEA 4E SSL website
2013 Interlaboratory Comparison, Quality Policy Document (Version 1.0).	October 2012	Restricted to 2013 IC participants
Interlaboratory Comparison NLTC Protocol Interlaboratory Comparison NMIJ/AIST Protocol Interlaboratory Comparison VSL Protocol Interlaboratory Comparison NIST Protocol	October 2012	Restricted to 2013 IC participants
eceee 2013 Summer Study Paper: “*On the bright side of life: International efforts to accelerate market adoption of LEDs while avoiding the pitfalls of CFLs*”	June 2013	Public
Update of SSL Annex web site	July/August 2013	Public
Solid State Lighting Annex: Product Quality and Performance Tiers: Outdoor Lighting (Street Lighting)	October 2013	Public
Individual participant Result Reports sent to each participating lab in group Asia 1 (produced by Nucleus lab AIST, Japan)	October 2013	Report confidential - each PRR gets their own results
Regional Interim Report – Asia 1 (produced by Nucleus lab AIST, Japan)	October 2013	Restricted to participating labs in group Asia 1
Proposal for Annex second term (2014-2019) submitted to MC, then to ExCo.	November 2013	Restricted to Annex MC and ExCo
Individual participant Result Reports sent to each participating lab in group Asia 2 (produced by Nucleus lab NLTC, China)	December 2013	Report confidential – each PRR gets their own results

Name	Date	Access
Regional Interim Report – Asia 2 (produced by Nucleus lab NLTC, China)	December 2013	Restricted to participating labs in group Asia 2
Individual participant Result Reports sent to each participating lab in group Americas (produced by Nucleus lab NIST, USA)	December 2013	Report confidential – each PRR gets their own results
Regional Interim Report – Americas (produced by Nucleus lab NIST, USA)	December 2013	Restricted to participating labs in group Americas
Individual participant Result Reports sent to each participating lab in group Europe (produced by Nucleus lab VSL, the Netherlands(	January 2014	Report confidential – each PRR gets their own results
Regional Interim Report – Europe (produced by Nucleus lab VSL, the Netherlands)	January 2014	Restricted to participating labs in group Europe
Solid State Lighting Annex: Product Quality and Performance Tiers: Non-Directional Lamps	February 2014	Public
Solid State Lighting Annex: Product Quality and Performance Tiers: Directional Lamps	February 2014	Public
Solid State Lighting Annex: Product Quality and Performance Tiers: Downlights	February 2014	Public
Solid State Lighting Annex: Product Quality and Performance Tiers: Fluorescent Tubes (Non-Retrofit)	February 2014	Public
Solid State Lighting Annex: Product Quality and Performance Tiers: Fluorescent Tubes (Retrofit)	February 2014	Public
Communiqué of the IEA 4E SSL Annex and the Commission Internationale de l'Eclairage	12 February 2014	Public
Solid State Lighting Annex: 2013 Interlaboratory Comparison, Draft Final Report. SSL Annex Tasks 2 and 3.	30 June 2014	Limited draft to participants
Solid State Lighting Annex: 2013 Interlaboratory Comparison, Final Report. SSL Annex Tasks 2 and 3.	10 Sept 2014	Public
Solid State Lighting Annex: Life Cycle Assessment of SSL. Final Report. SSL Annex Task 1.	17 Sept 2014	Public
Solid State Lighting Annex: Potential Health Issues of SSL. Final Report. SSL Annex Task 1.	24 Sept 2014	Public

In the proposal for an extension to the SSL Annex, this Communications and Outreach activity has been detailed into a discrete activity called "Task 11". This Task is a cross-cutting Communications and Outreach activity which is intended to formalise a strategy targeting four key groups – (1) policy-makers and regulators; (2) standardisation bodies; (3) international lighting organisations and (4) lighting industry – to try and promote the work of the SSL Annex. This involves raising awareness amongst the relevant decision makers on SSL product quality, market support and test standard harmonisation. This task involves both general and specific communications activities that will engage experts and decision-makers in the market to make them aware of the Annex's work.

4 Results for Task 3 – Standards and Accreditation

Table 4-1. List of Activities included in Task 3

Task 3	Description of Subtasks in Task 3
3.1	Establish links with existing standardisation technical committees (IEC, CIE, ISO ANSI, IESNA, JIS, CATS, BSI, SA etc.), provide input on lessons learned through Task 2.
3.2	Investigate the possibility to coordinate international accreditation of testing laboratories for SSL measurement with a global architecture offering traceability of SSL worldwide.
3.3	Develop a recommendation for mutual recognition of accreditation programmes for SSL testing.

4.1 Task 3 Activities Focused on International Accreditation Bodies

Task 3 was focused on disseminating the results of Task 2, and supporting laboratories who wish to apply for LED lamp testing accreditation to their respective accreditation bodies.

Table 4-2. Task 3 Activities Associated with International Accreditation Bodies

Subtask	Description of Subtask	Deliverables
3.1	Establish links with existing standardisation technical committees (IEC, CIE, ISO ANSI, IESNA, JIS, CATS, BSI, SA etc.), provide input onlessons learned through Task 2.	Information/outreach to the international and regional accreditation bodies about the SSL Annex's Task 2 and possible coordination of work.
3.2	Investigate the possibility to coordinate international accreditation of testing laboratories for SSL measurement with a global architecture offering traceability of SSL worldwide.	Linking with accreditation bodies on the need for accreditation of SSL testing laboratory worldwide.

In the design and operation of the 2013 Interlaboratory Comparison, the Annex agreed to conform to ISO/IEC 17043. The four Nucleus Laboratories are all National Metrology Institutes or National Testing Institutes and possess their own primary measurement standards and have developed a measurement method and validated it. All of the relevant measurement services carried out by them were accredited by International Laboratory Accreditation Cooperation Mutual recognition agreement (ILAC/MRA) signatories or peer reviewed against ISO/IEC 17025 and registered to Appendix-C, CIPM/MRA. Therefore, the basic competence of the institutions related to the measurements has been established.

On the 5th of August 2013, the Annex issued eight letters with an attachment of supporting documents to eight accreditation bodies (ABs) in Europe. The list below provides the names and contact information for the eight European experts contacted:

- Belgium - BELAC, Belgian Accreditation Council
- The Netherlands - RVA, Raad voor Accreditatie
- Germany - DAkkS, Deutsche Akkreditierungsstelle GmbH
- United Kingdom - UKAS, United Kingdom Accreditation Service
- France - COFRAC, Comité français d'accréditation
- Denmark - DANAK, Danish Accreditation
- Sweden - SWEDAC, Swedish Board for Accreditation and Conformity Assessment
- Finland - FINAS, Finnish Accreditation Service

In addition to these, letters were also sent to the accreditation bodies for:

- Australia – NATA
- New Zealand – IANZ
- Hong Kong – HKAS
- Taiwan – TAF
- Canada – CALA
- Brazil – INMETRO
- Korea – KOLAS
- Russia – FSA
- USA – NVLAP and EPA

In addition to informing these AB's, the Task 3 leader, Dr. Koichi Nara, travelled to numerous international laboratory accreditation cooperation (ILAC) and regional accreditation meetings to present information on the SSL Annex and the work of Task 2. These presentations were helpful in establishing an understanding amongst the national AB's of the Annex's work so that participants in the 2013IC may be able to apply for accreditation to a national LED testing standard.

4.2 Task 3 Activities Focused on Recommendations to Accreditation Bodies

Table 4-3. Task 3 Activities on Recommendations to Accreditation Programmes

Task	Tools / Description	Deliverables
3.3	Develop a recommendation for mutual recognition of accreditation programmes for SSL testing.	Orignally it was planned to develop a recommendation (platform) for mutual recognition of accreditation programs for testing SSL products. However, no deliverable was possible to produce.

With the absence of a global test method, it has not been possible to set up a system for mutual recognition of regional accreditation programmes. Up to this point, it has been difficult for many Accreditation Bodes (ABs) to carry out SSL Proficiency Testing (PT) as part of their ISO/IEC 17025 accreditation. While some ABs like CNAS or NVLAP carry out SSL PT or comparison test, the test is not within the scope of the ILAC MRA, and it is difficult for these PTs to be accepted globally.

Due to the global fragmentation and disparities in SSL Test methods, accreditation and PT for SSL products has been held back. It is our hope that in the future a robust programme for SSL PT can be established when there is a new international published test method. In the meantime, it is hoped that this Interlaboratory Comparison activity will help reduce the risk and uncertainty of SSL testing so that governments and consumers can have reassurance on global SSL testing quality. The diagram below depicts the anticipated way in which Tasks 2 and 3 can help as an interim solution to address some of the problems of the past while also preparing the market for the adoption of a new international proficiency test.

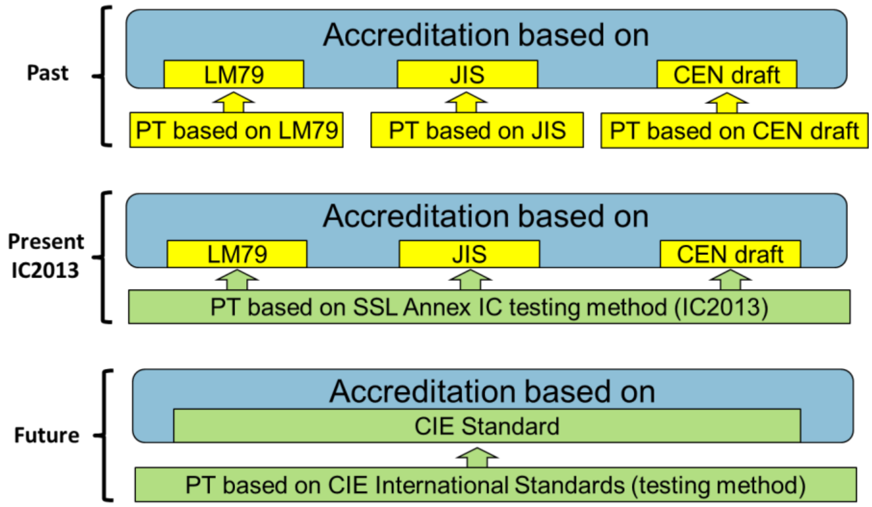


Figure 4-1. SSL Annex IC2013 Serves as an Interim Solution for Laboratory Accreditation

PTs are designed for a specific test method, however, since the SSL Annex has demonstrated that it is possible to create a harmonised test method between these very similar test methods, it is our hope that the 2013 IC test method will be seen as a PT or valid evidence of the competence of the laboratory for regional test methods, thus enabling the accreditation of laboratories for testing LED products.

5 Interaction with Stakeholders

5.1 Communique with CIE

In March 2013, the IEA 4E SSL Annex organised a meeting in Tokyo with CIE and IEC. This meeting was intended to clarify with these two important standards bodies the role of the SSL Annex and make clear that the Annex was not intended to replace or interfere with the role of either the IEC or CIE as currently implemented. As an outcome of that meeting, it was agreed that a communique would be drafted that clarifies the role of the SSL Annex for the CIE and how it related to their work. Although dialogue was held with the IEC, they were not able to achieve the same agreement, as the IEC continued to express concerns about parts of the work of the Annex, particularly in relation to guidance on LED quality and performance levels, even though IEC TC34 was not providing any similar guidance itself.

Thus, in February 2014, the SSL Annex signed a communique with the CIE to establish a recognition and endorsement of the 2013IC. The purpose of this document was to support the applications for Accreditation by the participant laboratories. A copy of the text appears below:

Communiqué of the IEA 4E SSL Annex and the Commission Internationale de l'Eclairage

12 February 2014, Stockholm and Vienna

The IEA 4E SSL Annex and the Commission Internationale de l'Eclairage (CIE) wish to express their support for the laboratory testing and accreditation activities being conducted by the SSL Annex through its 2013 Interlaboratory Comparison.

In a meeting held in Tokyo last year, the parties discussed the fact that:

1) The goal of the SSL Annex is to develop simple tools to help governments and consumers in various parts of the world to quickly and confidently identify which solid-state lighting (SSL) products have the necessary quality and performance levels to effectively reduce lighting energy demand. The Annex works internationally to support the work that is being done on a national level to address challenges with SSL technologies;

2) The Annex achieves this objective through various Tasks, two of which are the topic of this Communiqué – testing laboratory performance assessment (Task 2) and accreditation support efforts (Task 3);

3) Activities under Task 2 are designed to harmonise SSL testing around the world, by developing an approach to compare and assess test procedures, and support accreditation for participant laboratories who accurately measure LED products; and

4) Activities under Task 3 are designed to disseminate the testing results of Task 2, and support those participating laboratories who wish to apply for LED lamp testing accreditation to their respective accreditation bodies.

Following the Tokyo meeting, the SSL Annex and CIE resolved to agree that:

1) The interim measures of Task 2 and Task 3 undertaken by the IEA 4E SSL Annex provide a useful interlaboratory comparison basis in the absence of a common test method that should exist until such time as a global testing standard, such as the CIE standard, is published;

2) These efforts of the IEA 4E SSL Annex are important and deserve support and recognition by all involved parties, to help ensure they are effective in supporting the adoption of LED technology in the global market;

3) The IEA 4E SSL Annex 2013 Interlaboratory Comparison Test Method used in Task 2 was prepared only for the purpose of serving as a proficiency test (PT) and will not be promoted by the Annex for product testing or certification or accreditation;

4) The use of 2013 Interlaboratory Comparison Test Method provides objective evidence of the competence of a laboratory and will not affect the test standard against which accreditation is granted; and

5) If adopted, all parties will work together to promote the use of the CIE Standard on Test Methods for LED Lamps, Luminaires and Modules (CIE TC2-71) as the basis for laboratory proficiency testing and accreditation.

Signed for and on behalf of:

IEA 4E SSL Annex

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Peter Bennich, PhD
Management Committee Chair

International Commission on Illumination (CIE)

____

Martina Paul, MBA
General Secretary

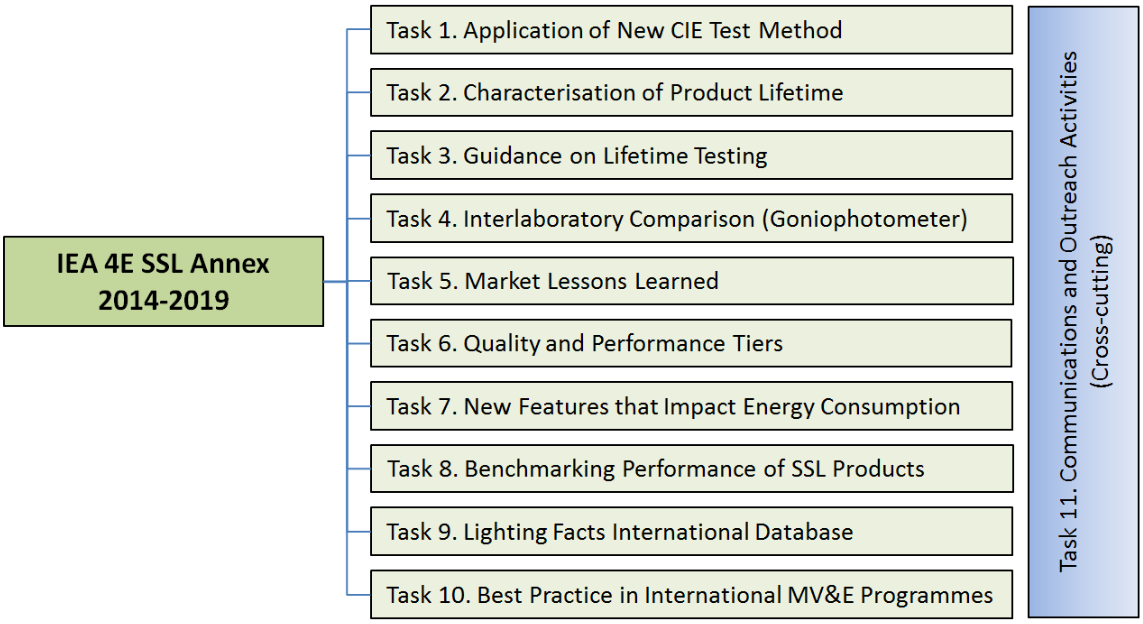
5.2 Communications and Outreach

Subtask 2.4 (summarised in section 3.4 of this report) provides a summary of the communications and outreach activity carried out by the SSL Annex. This includes numerous meetings and speaking engagements as well as many publications that were developed and shared internally as well as externally.

6 Potential Future Ideas for the Annex

The following is a summary of the 5-year workplan (from 1 July 2014 – 30 June 2019) for the SSL Annex. The potential future work for the second term of the SSL Annex was developed by the SSL Annex Management Committee and Expert Members, with critical formative input from Australia, Denmark, France, Japan and the United States.

The workplan consists of eleven tasks in the SSL Annex, ten focusing on core activities and one on cross-cutting communications and outreach. The diagram below offers an overview of the tasks and Tasks, and the following text provides a summary of the anticipated work. All of the SSL Annex work will continue to be focused on providing support to policy makers, government authorities and programme managers who are addressing issues relating to SSL in their respective markets.



Task 1. Application of new CIE Test Method – the CIE TC2-71 test method standard became available as a DS (Draft Standard) in September 2014 and is expected to be available as a CIE standard in early 2015 and later possibly as a joint CIE/IEC standard. The Annex welcomes this new effort, but some questions arise as to what extent the new CIE test method can be applied by governments for MV&E and other testing needs. This task looks at the application and relevance of the new test standard (TC2-71 CIE Standard on Test Methods for LED Lamps, Luminaires and Modules) to determine its potential to be used as a test standard for governments and product regulators. This study would help address questions like: which parameters can it test, how reliable are the results, what sample sizes are necessary, what tolerance values are assigned to measurements, and so on. The main output from this task will be a report that discusses the findings of the evaluation and a recommendation on how the new test standard can be used effectively by governments.

Task 2. Characterisation of Product Lifetime – this activity works to understand the lifetime issues of LED products. The task does not envisage the Annex doing primary research, but instead will be conducted as a meta-study based on papers published by academic researchers, international associations/societies (e.g., IES, CIE, etc.) and testing laboratories. This task will synthesise the information to help policy makers make decisions on SSL product lifetime. The Annex will prepare a summary of the findings explaining key features in defining, evaluating and testing for product lifetime in a format that is accessible and provide policy guidance. This task will not resolve the complexities of lifetime testing, but it is expected to provide greater understanding of the context and options, and contribute to the discussion through the development of an agreed position for policy-makers on the lifetime of LED products.

Task 3. Guidance on Lifetime Testing – this study will review the existing test methods for determining luminous flux maintenance and colour maintenance of SSL products (available from IEC SSL product performance standards and regional test method standards on SSL products and their components) and provide guidance to member country governments on lifetime testing of SSL products. It is therefore linked to Task 2 (Characterisation of Product Lifetime), but this task will focus on how to test the specific photometric aspects of SSL product lifetime.

Task 4. Interlaboratory Comparison (Goniophotometer) – this task will be to design and conduct a new global interlaboratory comparison test programme with the Nucleus Laboratories using a new artefact set including directional lamps (requiring use of a goniophotometer for measurement of *useful flux* or other flux definition according to beam angle, angular colour uniformity), light engines (e.g., Zhaga Consortium modules, etc.) and road/street lighting luminaires, which could not be included in the SSL Annex's Interlaboratory Comparison 2013 (IC2013). This task would also provide support for any follow-up work related to IC2013.

Task 5. Market Lessons Learned – this task will work to review the lessons learned by Annex member governments on the introduction of SSL products, including how the markets developed and evolved, extracting lessons learned and pitfalls to avoid (i.e., not repeating the mistakes surrounding the introduction of new technologies). Two reports are foreseen: one in year one and one update in year four (or five) of the Annex's term. The report is to support policy makers in making appropriate choices as they work to promote quality SSL products in their respective markets.

Task 6. Quality and Performance Tiers – this activity promotes the harmonisation of voluntary and mandatory programme performance requirements for SSL products around the world. Covering both lamps (e.g., non-directional lamps) and luminaires (e.g., street light luminaires), this activity seeks to maintain and perhaps slightly expand the Annex's current set of products for which there are three performance tiers – from minimum quality to best in market. This task also includes reviewing the latest literature on life-cycle assessment and health-related issues, as this may impact the tier levels. Off-grid lighting product performance recommendations will be retained and developed where applicable as a separate document.

Task 7. New Features that Impact Energy Consumption – LED products offer a number of opportunities to bring new features to the market that are not commonly associated with lighting technologies. These may be user-focused features such as colour-tunability and network access to controls, or features that are intended to prolong life and function of products such as active thermal control or regulation of drive current to maintain flux over time. This activity focuses on identifying and measuring the energy consumption (such as stand-by power) associated with some of the new features that are being incorporated into SSL products.

Task 8. Benchmarking Performance of SSL Products – this Task will establish an internal benchmark performance database of SSL products to enable the sharing of 1) claimed performance data and 2) test results on these products sampled and tested by accredited, independent laboratories. This internal database would be for Annex member governments only and would consist of data generated primarily through member government testing programmes. The database would have a limited set of criteria, based on the new CIE test standard, and will provide member governments with an on-going, independent assessment of SSL product performance over time. Six-monthly briefings for member countries will be published that query the database and extract information on the trends. This six-monthly briefing will also contain and compare with data from Lighting Facts International (Task 9).

Task 9. Lighting Facts International Database – this Task will work to make the US DOE's Lighting Facts database into a global platform that any government can opt-in to use it for domestic SSL promotion programmes through customised, country-specific user interfaces. The resulting Lighting Facts International database would follow the same quality control criteria of Lighting Facts. The database will be refreshed and updated on an on-going basis, and it will be used as input for a six-monthly briefing on product trends described under Task 8. This task may be coordinated in partnership with the Global Lighting Association, who expressed interest in the Annex supporting MV&E programmes globally. **Note**: The Lighting Facts International database is fundamentally different from the benchmarking performance database (Task 8) above. Lighting Facts International will be dependent on a supplier wanting to input its product data into the database and being willing to have the product tested on request. The benchmarking performance database in Task 8 is based on government agency input and kept as a resource for internal use only.

Task 10. Best Practice in International MV&E Programmes – this Task intends to help member governments develop more cost-effective and efficient Monitoring, Verification and Enforcement (MV&E) activities. This task focuses on gathering and sharing information and best practice on MV&E programmes globally. The output from this work is intended to serve as a guide for policy makers in countries who want to learn from the experience of running MV&E in other countries, including information on cost, test methods, sample sizes, performance metrics, results variability and so-on.

Task 11. Communications and Outreach Activities – this is a cross-cutting communications and outreach activity which is intended to formalise a strategy targeting four key groups – (1) policy-makers and regulators; (2) standardisation bodies; (3) international lighting organisations and (4) lighting industry – to try and promote the work of the SSL Annex. In addition, NGOs and consumer organisations are seen as relevant targets groups for information from the SSL Annex. This task involves raising awareness amongst the relevant decision makers on SSL product quality, market support and test standard harmonisation. This task involves both general and specific communications activities that will engage experts and decision-makers in the market to make them aware of the Annex's work.