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Achieving successful intergovernmental collaboration: A case study in lighting

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Abstract

Embracing the famous African proverb “if you want to go fast, go alone; if you want to go far, go together”, a group of governments decided to work together on lighting policy, recognising that their combined, collective efforts would achieve better outcomes than if they addressed the same issues on their own. The IEA 4E Solid State Lighting Annex (SSL Annex) was founded on the principle of intergovernmental collaboration on lighting. Over the last 14 years, the SSL Annex has demonstrated its value through its effectiveness and impact in the market. Now embarking on a new five-year term, the governments wish to continue developing this working relationship and sharing of information, data and research.¹

Founded in 2010 under the framework of the International Energy Agency’s Energy Efficient End-use Equipment (4E) Technology Collaboration Programme (at the time “Implementing Agreement”), the SSL Annex works to advise member countries seeking to promote energy efficient lighting and to implement quality assurance programmes for solid state lighting (SSL). This framework brought governments together to share research, collaborate and work together to accelerate global adoption of SSL through work in four critical areas: (1) SSL testing, metrics and standards: supporting the lighting metrology community and improving the comparability and accuracy of LED product testing; (2) Smart lighting, digitalisation and connectivity: working to minimise standby power losses and optimise energy savings through smart lighting systems including wireless communication and intelligent controls; (3) Public health, productivity and environmental impacts: help governments and the public understanding and track the latest science and research on how LED lighting impacts human health and the environment; and (4) SSL product quality and performance: publishing and promoting thoroughly researched quality and performance requirements which help to facilitate harmonisation on key quality and performance metrics globally. In this paper, an overview of this work is provided, followed by three in-depth examples of how this intergovernmental cooperation was absolutely pivotal to the positive outcomes realised in the market.

An important feature of the SSL Annex is the flexibility to conduct projects and publish deliverables that are responsive to emerging needs and are outside the scope of the original workplan. The fact that there is an institutionalised structure for cooperation between countries on lighting establishes foundation of trust, and lowers the barrier for quickly cooperating on unanticipated research and regulatory issues that could arise.

¹ Starting March 2024, the IEA is streamlining names of the Annexes and Tasks to “Platforms” under the Technology Collaboration Programmes, and the SSL Annex is entering its fourth term with a new name: Smart Sustainability in Lighting and Controls (SSLC) Platform.

This paper also looks at how the SSL Annex in particular, and IEA Technology Collaboration Programmes in general, serve as a structure that complements and supports international standardisation and regulatory efforts.

The 14 years of cooperation between the member governments, in combination with the published work, market impacts and achievements of the SSL Annex, culminated it receiving the coveted Award for Outstanding Achievement in Solid State Lighting in November 2023 from the International Solid State Lighting Alliance.

Introduction

The International Energy Agency (IEA) Technology Collaboration Programme (TCP)² on Energy Efficient End-Use Equipment (4E) was created by thirteen countries in 2008 to provide support to member governments when formulating effective policies that increase production and trade in energy efficient end-use equipment. The Solid State Lighting Annex (SSL Annex) was established under the IEA 4E in 2010 as one of the main collaborative research and development activities. The SSL Annex operated for three terms, the last of which ended in February 2024. Starting March 2024, the IEA is streamlining names of the Annexes to “Platforms” under the Technology Collaboration Programmes, and the SSL Annex is entering its fourth term with a new name: Smart Sustainability in Lighting and Controls (SSLC) Platform.

The SSL Annex supports countries seeking to implement quality assurance and product efficiency programmes for solid state lighting. It was founded by the governments of Australia, Denmark, France, Japan, The Netherlands, the Republic of Korea, Sweden, the UK and the USA, with China working as an expert member. Over the years, the SSL Annex has helped to address some of the significant challenges with SSL, for example, a lack of reliable, internationally recognised test methods for measuring SSL quality and lifetime, and limited information for policy makers on product quality parameters and market trends.

The SSL Annex is overseen by a Management Committee, which is made up of government representatives from each member country, ensuring that the Annex’s work is representative of its member governments’ priorities. The Management Committee oversees all decisions and actions taken by the Annex, as well as providing strategic direction on future work.

Under the Management Committee are the SSL Annex Experts who are a group of researchers and technical experts nominated by their member country governments for their individual expertise and experience with lighting. The SSL Annex’s technical experts typically have decades of experience in lighting, covering lighting metrology, design, manufacturing, marketing, sales, human factors and policy development. The Experts meet twice a year to review progress, participate in technical meetings, exchange information and review each other’s work.

IEA TCPs and international governance structures

In the case studies below, we argue that the IEA TCP structure allows for quicker and more flexible ways to address research needs and deliver results that provide important inputs to government policy-making processes. Working within that structure, the SSL Annex has proven itself to be a unique support structure that complements industry and standardisation bodies by conducting research, testing international standards and studying market trends.

In the following sections, we briefly explain the nature of the IEA Technology Collaboration Programmes, international standardisation and other forms of governance. We start with the mandate and structure of IEA’s Technology cooperation programmes (TCPs) within which the IEA 4E SSL Annex (now called the SSLC Platform) is a part. We go on to describe the standardisation bodies and the EU Ecodesign process as an example of a governance structure and process that establishes legally binding performance requirements for energy using products. In the final discussion section, we discuss differences and how the structures relate to and depend on each other.

The IEA Technology Collaboration Programmes (TCPs)

The International Energy Agency (IEA) describes itself as an “autonomous inter-governmental organisation within the OECD framework, headed by its Executive Director” (IEA, 2024a). Members are primarily OECD countries (31 members as of April 2024) but more countries are now being let in and the IEA web site lists five “Accession Countries” and a number of “Association Countries”. In the latter category one will, for instance, find three large BRICS (Brazil, China and India), but also other major developing economies such as Egypt, Indonesia and Kenya (IEA, 2024c).

² At the time, TCPs were mentioned Implementing Agreements by the IEA.

The IEA has a number of functions and governance structures, one of which is the Technology Cooperation Programme structure, which is described as follows:

The IEA Technology Collaboration Programmes (TCP) are independent, international groups of experts that enable governments and industries from around the world to lead programmes and projects on a wide range of energy technologies and related issues. The experts in these collaborations work to advance the research, development and commercialisation of specific energy technologies. There are currently 39 TCPs focused on topics across many sectors, including buildings, transport, industry, renewable energy, fossil energy and fusion power. (IEA, 2024a).

The Technology Collaboration Programmes are not part of the tasks carried out by the IEA as organization, and are described under the heading “Affiliated Groups”. The IEA thus provides a legal framework for cooperation between its Member Countries, enabling individual TCPs to be established and operate. The overall workplan, typically five years at a time as in the case of the IEA 4E TCP, is approved by one of the so-called Working Parties inside the Committee on Energy Research and Technology (CERT) of the IEA, but once established the TCP governs itself. Budgets are not supplied by the IEA centrally, but by the countries participating in a TCP. This includes a management budget for the TCP and its Platforms, as well as significant in-kind contributions in the form of consultants and research institutes supplied by the Member Countries. Platform Member Countries decide on budgets and workplan with a high degree of independence from the TCP Executive Committee.³

Standards

According to the International Electrotechnical Commission (IEC), an international standard provides “instructions, guidelines, rules or definitions that are then used to design, manufacture, install, test & certify, maintain and repair electrical and electronic devices and systems.” Most standards are voluntary without being mandated in law. Some standards become mandatory when they are adopted by regulators as legal requirements in particular domains, often for the purpose of safety or for consumer protection from deceitful practices. Other standards refer to how, e.g., physical units are defined, and other standards define how equipment can or should be tested in order to get uniform and comparable results, regardless of where and when the test is carried out.

The IEC provides an instructive description of the difference between regulation and standards:

International standards ... form the basis for testing and certification. [They are] also often adopted by countries or regions to become national or regional standards. For example, close to 80% of European electrical and electronic standards are in fact IEC International Standards.

On the other side, regulations are rules or directives that are made and maintained by a national or regional authority. Generally, compliance with regulations is a must. However, it is quite common for technical regulations to refer to international standards because standards help avoid that the law becomes too detailed or descriptive. (IEC b)

Standardisation organisations for light and lighting systems

Most lighting product standards are developed by three international bodies:

IEC –The International Electrotechnical Commission

IEC is a global, not-for-profit membership organisation that brings together approximately 170 countries and coordinates the technical work of over 20,000 experts globally on the development of international standards. IEC’s work underpins the design, manufacturing, testing and certification of all electrical and electronic technologies, since it was launched in 1906. The web site of IEC (www.iec.ch) describes its mandate and structure and the process to have a new standard developed through technical committees and various boards that adopt the standards, as well as the voting procedures (IEC, 2024a).

CIE – The International Commission on Illumination

CIE (<https://cie.co.at>) (usually abbreviated CIE for its French name, Commission internationale de l'éclairage) is the international authority on light illumination, colour, and colour spaces.

CIE publishes Technical Reports (TRs), International Standards (ISs) and Technical Notes (TNs). International Standards (ISs) are often further developed as dual standards with the ISO or IEC (CIE, 2024). The CIE has

³ Please note that this description is based on the IEA 4E and there may be some deviations in other TCPs.

fewer member countries than IEC (about 40) but is organized in a similar way with national committee, technical committees, a governing board, and adoption of standards and reports by voting. (CIE, 2024)

IEEE – the Institute of Electrical and Electronics Engineers

IEEE is a technical organisation dedicated to advancing technology through its publications, conferences, standards and professional work. IEEE has over 460 thousand members in more than 190 countries, with over two thirds outside the United States. IEEE is a leading developer of international standards and publishes extensive technical literature in electrical-engineering, computing and electronics. In the IEA 4E SSLC Platform Workplan for 2024–2029, cooperation with IEEE on technology roadmaps is foreseen, where the increasing integration of lighting controls and complex systems will be assessed.

Accreditation

According to the International Laboratory Accreditation Cooperation (ILAC), “Accreditation is the independent evaluation of conformity assessment bodies against recognised standards to carry out specific activities to ensure their impartiality and competence. Through the application of national and international standards, government, procurers and consumers can have confidence in the calibration and test results, inspection reports and certifications provided.” (ILAC, 2024)

In the SSL Annex context, accreditation is relevant for the Interlaboratory comparison testing carried out by the SSL Annex. A previous eceee paper by the SSL Annex describes how the SSL Annex carried out the world’s largest Interlaboratory Comparison (~110 labs involved) 2013–2014 to assess the applicability of a draft CIE test standard for LED lamps. Since the test requirements drew upon the most stringent elements of three regional test standards, it could be used by labs as the basis for accreditation for a test lab in one region testing lamps intended for sale in a different region. (SSL Annex, 2015)

An example of regulation: The EU Ecodesign process

The policy process developing product regulations under the EU’s ecodesign and labelling directives are rigorous, transparent and participative.⁴ Both ecodesign and mandatory labelling requirements for a product group is issued as a regulation that takes effect all over the EU as well as in some EEA countries, such as Norway that has committed to follow the regulations. The process and the rules are governed by the European Ecodesign and Energy Labelling of Products Directives respectively. Not all consumer products are labelled, but lighting products are. For products that are subject to the mandatory energy labelling, the performance requirements are developed in parallel for both regulations, they use the same standards and the requirements are harmonized in a logical fashion.

When the regulation is adopted, there is already a plan for the review (typically a five-year cycle). In order to prepare the review, the European Commission commissions a “preparatory study”, where technical, economic and environmental aspects are studied. Stakeholders are invited to follow the study. When the results are ready, the Commission typically prepares a draft regulation, which is then discussed in a “Consultation Forum”, where EU Member States and stakeholders from industry, environmental NGOs, consumer groups, and professional organisations also participate. Member States and other stakeholders can provide comments and present additional research during the process, that support or challenge the proposal from the Commission. The proposal is revised as a rule and subject to an Impact Assessment, after which it may undergo some additional review before it is formally adopted by a process where both member states, the European Commission and the European Parliament have a say (EU 2024, eceee 2024).

Comments are seldom based on new or additional research, but typically reflect the concerns of important groups or institutions in the Member States, industry and other entities. It would be unfair to say that all comments are solely based on the interests of the actors. Several important problems in the proposed regulations, such as inconsistent or vague language, are often addressed in the comments.

Intergovernmental cooperation facilitated by the IEA 4E SSL Annex

⁴ This short section is primarily based on the authors’ first-hand, 15+ years of experience of the ecodesign and labelling process. We have been involved in the regulation of various product categories representing an EU National Government as well as NGOs and all of us have been involved in providing evidence and additional research in the consultation process leading up the adoption of a regulation. eceee also ran a web site (www.eceee.org/ecodesign) that provided thorough documentation and explanation of the process, a site that is now dormant due to lack of funding.

The SSL Annex serves as an excellent case study for the benefits of international cooperation on emerging technologies. The cases below illustrate how the work of the SSL Annex has provided important input into both standardisation and regulatory processes.

Baked into the structure of the SSL Annex is a multi-disciplinary group of peer-reviewing experts who regularly review, critique, contribute to and improve each other's work. The SSL Annex serves as a forum to exchange ideas, test results, discuss market transformation initiatives and find solutions to challenges on regulations and enforcement. While the governments pay into a common fund for coordination and management, the Experts are supplied by each member country as in-kind contribution.

Over the last 14 years, the SSL Annex has developed and published information and analysis for market transformation programme managers and government policy experts, while also supporting the standardisation and metrology communities and engaging the lighting industry. This section provides an overview of some of the achievements and engagements that took place over the last decade across four areas of work: (1) SSL testing, metrics and standards; (2) Smart lighting, digitalisation and connectivity; (3) Public health, productivity and environmental impacts; and (4) SSL product quality and performance.

The established structure with a five-year work plan provides focus for the work but also establishes a formal structure that allows member countries to quickly address new research and regulatory challenges that arise. Examples are given below.

(1) SSL testing, metrics and standards

When a consumer purchases a lightbulb in a store, they have to place their trust in the information on the packaging. The box will tell them the stated light output, lifetime, wattage, colour temperature and other important features. For this reason, governments want to ensure that the information printed on the box is accurate, no matter which lab it was measured in. With this objective in mind, the SSL Annex organised two interlaboratory comparisons to support the global lighting metrology community, and a third is ongoing (January 2024). These activities were undertaken to improve the comparability and accuracy of LED product testing, which in turn will result in better information for consumers on product performance.

In 2013, the SSL Annex launched the world's largest interlaboratory comparison (IC) of lighting laboratories. This work involved four reference laboratories around the world and 110 participants measuring a range of critical parameters on a standard set of artefacts. At the time of this IC, there was no international test standard for LED Lamps, therefore IC 2013 established a common test method which looked across several different regional test methods and created one that could support and function as a Proficiency Test for any of those methods. The findings of the comparison, including issues where laboratories found instructions unclear or they deviated from best practice in measuring the products, were all useful findings that contributed the development of CIE S 025/E:2015, Test Method for LED Lamps, LED Luminaires and LED Modules, under a Communiqué between SSL Annex and CIE Division 2. Ultimately, IC 2013 provided many laboratories around the world with knowledge and experience testing SSL products. It also established a basis to promote SSL laboratory testing accreditation in support of government regulations and programmes to further accelerate the development of SSL. The cooperation between all the member countries in the SSL Annex was critical to the success of this global initiative. The Annex published a Final Report (SSL Annex, 2014a) on this study, providing detailed findings and comparisons across all the participants. The work is also summarised in a previous eceee paper (SSL Annex, 2015).

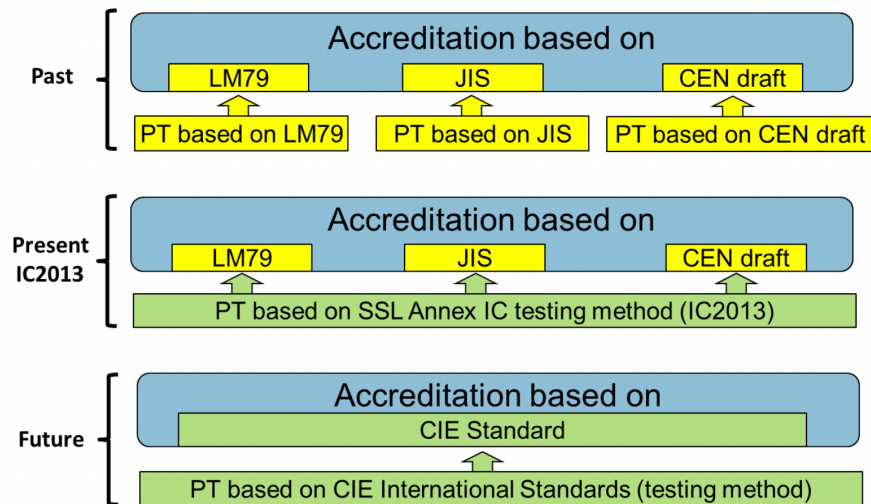


Figure 1. This illustrates how the IC 2013 took the most stringent requirements from three regional standards and arranged an Interlaboratory Comparison. When the CIE standard eventually was adopted, the labs had already been able to demonstrate their ability to test according to the new standard, and some cases they were also accredited to do so.

In 2017, the SSL Annex launched a second global interlaboratory comparison. This comparison focused on goniophotometers which are frequently used for measuring luminaires and directional lamps. This interlaboratory comparison is described more in detail below under case study #3.

In the last few years, governments in Africa, Europe and elsewhere have started to adopt lighting regulations that limit Temporal Light Modulation (popularly known as flicker) from LED lamps. These limits rely on two International Electrotechnical Commission (IEC) Technical Reports - IEC TR 61547-1 and IEC TR 63158 - which describe a methodology for measuring temporal light modulation quantities. The SSL Annex governments recognised that this was going to be a problem, as there was no accreditation scheme for these two metrics and yet the mandatory regulations were coming into effect. To address this gap in the market and building on the successes of IC 2013 and IC 2017, the SSL Annex designed and launched IC 2023 for temporal light modulation (TLM) measurements. IC 2023 will test measurements of flicker and stroboscopic effects of LED lighting products. IC 2023 is open to all photometric labs that have capability for testing TLM quantities including short-term flicker index, P_{st}^{LM} , and Stroboscopic effect visibility measure, SVM, of LED lighting products. This Task is led by Sweden, Australia, Korea and Denmark.

(2) Smart lighting, digitalisation and connectivity

Smart lighting is a rapidly expanding, continually evolving family of lighting products which provide an opportunity for the consumer to benefit from smart services, better quality lighting and energy savings. Several governments within the SSL Annex identified this emerging market nearly ten years ago and the Management Committee agreed that a detailed market assessment was needed. The SSL Annex Experts started meeting, merging datasets of smart lamp tests conducted around the world, and prepared a report that provides a comprehensive overview of various features, the system designs and their energy consumption. The tests conducted on a number of smart wireless LED lamps used in the domestic sector revealed that these products can have substantial standby power use – which, depending on hours of use, can even be higher than the energy consumed when the light is switched on. These test results are similar to experiences with standby consumption for other products where manufacturers initially focused on new features before turning their attention to reducing the standby power consumption. The report offered advice to stakeholders on important issues to consider when purchasing a smart lamp in order to maximise the savings potential of these lighting products (SSL Annex, 2016).

In the years that followed that report, the Member Countries continued to contribute data and market information to one of the technical Experts from Denmark. These data contributed to a second report on smart lighting products that was published in November 2022 (SSL Annex, 2022a). This second report included (a) guidance on how to test the smart lighting products, providing an update of the test procedure included in the first status report; (b) standby power analysis based on measurements performed in the period 2015-2020 including 236 smart lamps/luminaires coming from 67 different manufacturers; (c) an analysis on how dimming and colour

tuning influences efficacy and luminous flux; (d) impact on standby power consumption when the product becomes more complex by addition of new features; and (e) an assessment of smart lighting market barriers including user-friendliness, interoperability, consistency, open systems, standards, and connection/co-operation with existing wired control systems.

The SSL Annex Member Countries and their Experts are continuing to study Smart Lighting Systems, which will be a key part of the upcoming work over the next five years.

(3) Public health, productivity and environmental impacts

Another critical area for the governments collaborating through the SSL Annex is the impact of lighting on health, including people and the environment. Starting in 2011, the SSL Annex launched a three-year study to review all of the major health-related literature associated with LED lighting. The SSL Annex published a comprehensive review of the current literature on health-related impacts of energy-efficient LED systems in our homes, buildings and outdoor areas (SSL Annex, 2014b). The report found that SSL technology is not expected to have more direct negative impacts on human health with respect to non-visual effects than other light source technologies. Furthermore, for electromagnetic fields, human exposure emitted by SSL products does not appear to be a critical issue as their magnitude is generally much smaller than those corresponding to discharge lamps or certain household appliances. The report also provides advice on flicker and glare. Having the international team of Experts engaged in reviewing and contributing to the report meant that studies were included from around the world, and the breadth and depth of experience across many health-related issues were included in the report.

Continuing the collaboration in 2018, it became clear during an Expert meeting that there was an urgent need for public data on the human response to stroboscopic visibility measure (SVM), one of the two flicker metrics. SSL Annex Experts who are top health-researchers in Canada and France designed and conducted a study examining visual perception of SVM, to try and find a ‘safe’ maximum level for product policy. This work is described as one of the case studies below.

The SSL Annex is continuing to research health impacts of SSL and will publish an updated lighting and health report in 2024.

The SSL Annex also examined environmental impacts of lighting, launching a research project in 2011 to review of all the available literature associated with life-cycle assessments of LED lamps and luminaires compared to conventional light sources. The final report was published in 2014 (SSL Annex, 2014c) and brings together the findings of nine life-cycle assessment (LCA) studies of lighting products that compare LED lamps and luminaires with conventional sources. The study found that on average, 85% of the environmental impact of lighting linked to the energy in use phase, while the remaining 15% is shared primarily between manufacturing and end-of-life treatment. Over the last year, the SSL Annex Experts have been conducting a new LCA which compares fluorescent lamps with LED retrofits. This report is scheduled to be published in 2024.

(4) SSL product quality and performance

Governments around the world are concerned about the quality and performance of lighting products sold in their markets. Over the last decade, members of the SSL Annex decided to work together on developing a uniform set of quality and performance metrics, a task led by France and Australia. Drawing upon experts responsible for health, colour quality, lifetime testing, chip efficacy and other areas, the SSL Annex has developed and published and updated recommendations that encourage governments to harmonise around key quality and performance metrics for LED products’ performance. The requirements are based on extensive market research as well as on laboratory test data from participating governments. By providing these quality and performance tiers, governments and programme managers can develop programme specifications more quickly and at lower costs. The Member Countries also hope to bring some harmonisation to the market to avoid the situation where governments and programme managers act independently and “re-invent the wheel”, a situation that can result in a patchwork of regulations or specifications around the world that is both expensive and burdensome for suppliers.

Examples of successful intergovernmental collaboration

In the previous section, the four general areas of work undertaken by the SSL Annex were described in general terms, designed to be complementary and supportive of the work of governments, international standardisation bodies, and the research & development being conducted by industry and academia. In this section, the authors provide four case studies which drill down into four key activities undertaken by the SSL Annex which had a lasting, positive impact and which would not have happened except for the cooperation between the

governments working together in context of the Annex. Please note that these four cases are not from each of the four work areas described above.

Government cooperation case study #1: Accelerated lifetime testing

One of the areas of concern raised by the lighting industry during the last review of the lighting regulation in Europe was the amount of time involved for the lifetime test of an LED lamp. The previous regulation adopted in 2012 (EU No 1194/2012) had two lifetime related requirements, one to assess lumen maintenance (i.e., the degradation of light output over time) which involved switching the lamp on and operating it for 6000 hours – which is over 8 months of testing. A second test assessed the durability of the starting circuit (i.e., a switching cycle test), which was based on IEC 62612 and required the lamp to be turned on and off every 30 seconds. Together, these tests would take over 8 months to complete, and therefore caused a delay in the introduction of new LED lighting products to the market. Furthermore, it was found that they were not a good predictor of lamp lifetime, as consumers were experiencing premature failures.

The Australian SSL Annex expert studied this issue and noted that the thermal cycling of the LED lamps during the rapid switching cycle test were inadequate to properly stress the components and soldered joints on the circuit board. Figure 1 illustrates this point. This temperature graph of the LED chip shows a lamp that is being switched on and off for 1 minute (double the time of the EU regulation), and yet the chip board only experiences a change in temperature of about 3 degrees Celsius.

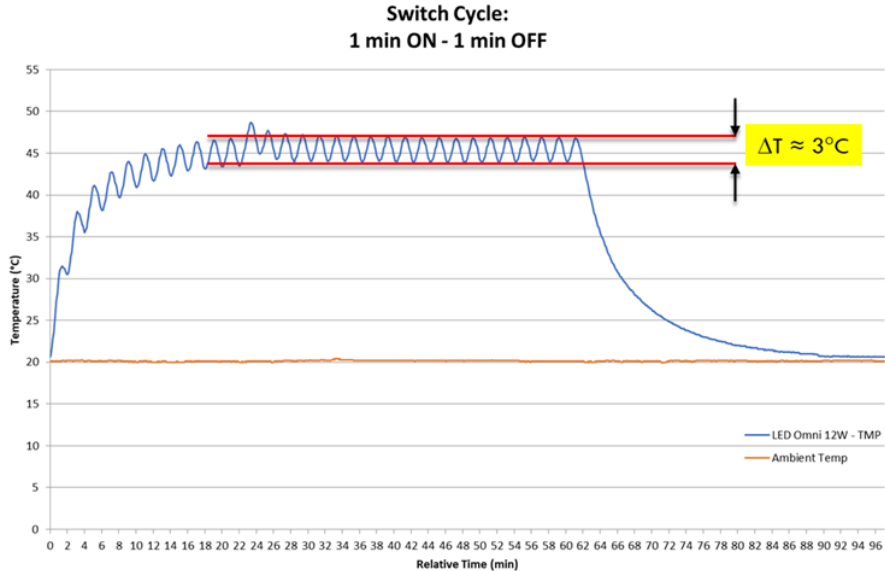


Figure 2. Temperature measurements of the LED chips, 1min on / 1min off.

The findings were discussed within the SSL Annex group of Experts. To address this issue and improve the overall test method, the SSL Annex Experts proposed instead to reduce the lumen maintenance test to 3000 hours, and to extend switching duration to much longer time periods that more closely represented use in real life. In addition, these two tests could be combined into a single test which would make testing by manufacturers and enforcement officers simpler – and less costly. A combined test was designed with long duration on and off cycles – 2.5 hours on and 0.5 hours off. And the number of cycles was set at 1200, so that the total “on” time totalled 3000 hours. Figure 2 shows the difference in LED circuit temperature – putting much greater thermal stresses on the electronics and therefore resulting in a more rigorous lifetime test.

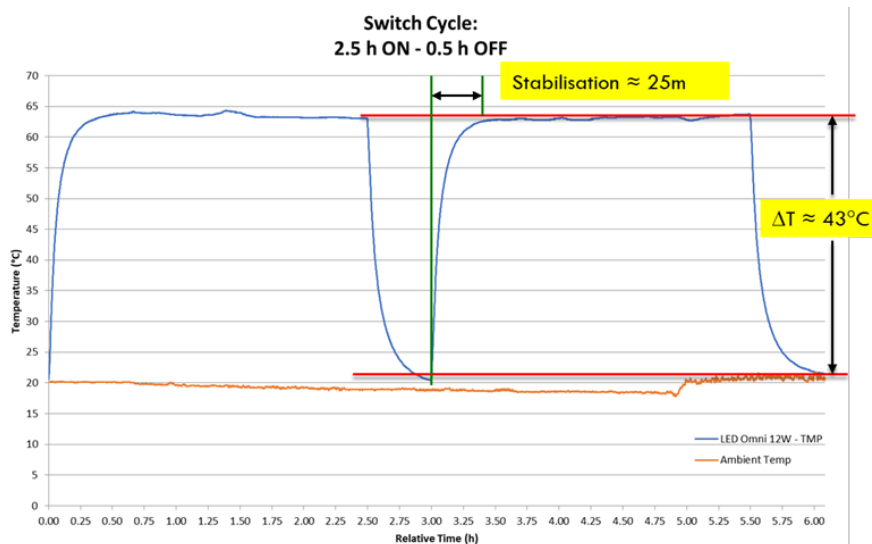


Figure 3. Temperature measurements of the LED chips, 2.5h on / 0.5h off.

Once this test method had been developed, Australia spent five months testing the lamps and then shared that data with the Swedish Energy Agency, another SSL Annex Member. The Swedish Energy Agency combined the data into a report that was published in December 2018 (SEA, 2018). This final report confirmed that the new test method was more effective at finding problems with the drivers of the lamps, experiencing a higher failure rate on the same model when compared to the 2012 tests. The new lifetime test method drafted by the SSL Annex Experts and supported by the test results prepared by some of its Member Countries, was adopted as the new lifetime test method for Europe in the most recent lighting regulation, EU No 2019/2020. Since publication by the EU, the new test method has been adopted by numerous other countries around the world – improving the quality of all the LED lamps we use today.

This work was not originally foreseen in the work plan. The method was conceived during SSL Annex Expert, following meetings and ensuing cooperation among Experts under Australian leadership.

Government cooperation case study #2: Temporal light modulation study

This study Stroboscopic Visibility Measure (SVM) is an excellent example of the value of having an established and structured cooperation over several years which enables a quick pathway to design and execute a research study that was urgently needed. During an Expert Meeting in Canada in October 2018, the Experts were discussing a draft lighting policy proposal that had been published by the European Commission which suggested setting Temporal Light Modulation (TLM) limits SVM at less than or equal to 1.6. The Experts expressed concern because at those levels, approximately half of the population may detect the light modulation (commonly known as “flicker”), and thus there could be significant negative health impacts. The Experts also noted that since the SVM metric was so new, there weren’t any public data on human subject studies of SVM sensitivity.

Two SSL Annex Member Country laboratories – Canada and France – offered to work together and quickly organise an SVM - human subject study and publish that data for all stakeholders in the Ecodesign Consultation Forum to review. The Member Countries of the SSL Annex were motivated to act because they recognised that the European lighting regulation would likely be in place for 5 years, and over that time more than one billion light sources will be sold and installed in Europe – which, without better evidence-based policy making, could have harmful or even dangerous levels of flicker.

The study was conducted by the National Research Council of Canada (NRC) and the Centre Scientifique et Technique du Bâtiment (CSTB) in France, two of the world’s leading research institutions on lighting and health. Supporting this study were the governments of Australia, Denmark and Sweden, with input from the UK (Public Health England) with additional contribution of resources outside the work plan. An interim results report was published in December 2018 (NRC and CSTB, 2018) which provided data on over 30 subjects. By dividing the work between two labs, this enabled the report to double the number of subjects to be studied in the limited time.

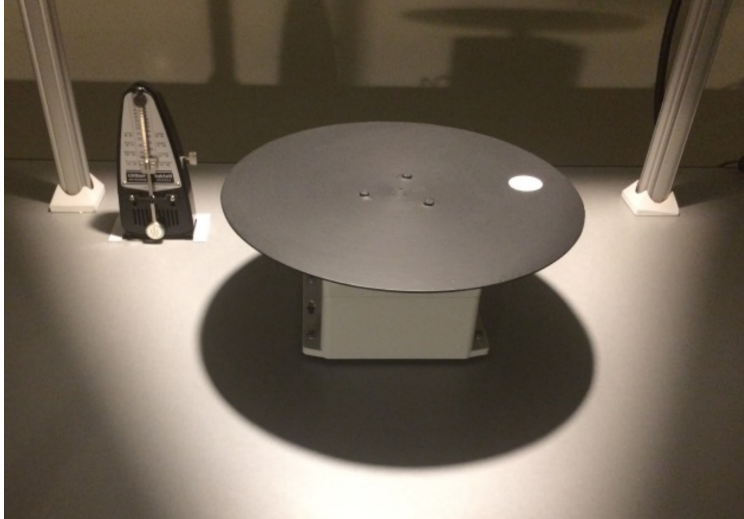


Figure 4. Photograph of the SVM test setup in France.

The final report on this work provides insight into both stroboscopic visibility and the acceptability of the conditions for the full sample of 85 people and for the more sensitive individuals. The report Visual Perception under Energy-Efficient Light Sources – Detection of the Stroboscopic Effect under Low Levels of SVM, is available for download on the SSL Annex website (SSL Annex, 2019). The report follows the publication of a peer-reviewed journal article in *Lighting Research and Technology* by the researchers behind the report (Veitch and Martinsons, 2020).

The report was also submitted to the European Commission’s Ecodesign Consultation Forum by European SSL Annex Member Countries during the review of European regulations on light sources. This input was reviewed by the Regulatory Committee and supported the final decision made by the EU Member States. The recommended limit of $SVM \leq 0.4$ was adopted by the EU in 2019, then later amended temporarily to $SVM \leq 0.9$ and will be returning to $SVM \leq 0.4$ on 1 September 2024 (EU No. 2019/2020).

Government cooperation case study #3: Goniophotometer interlaboratory comparison

The primary laboratory instrument for measuring luminaires (often called “light fixtures”) is the goniophotometer. As the world’s lighting market moves away from replacement lamps and towards integrated, dedicated LED fixtures, goniophotometers – and the accuracy of the measurements they produce – are going to be of increasing importance. Goniophotometers are also needed to establish performance of directional lamps, such as spotlights.

There are principally three main types of goniophotometers used: mirror type, near-field type, and source-rotating type, all of which were covered in this study.

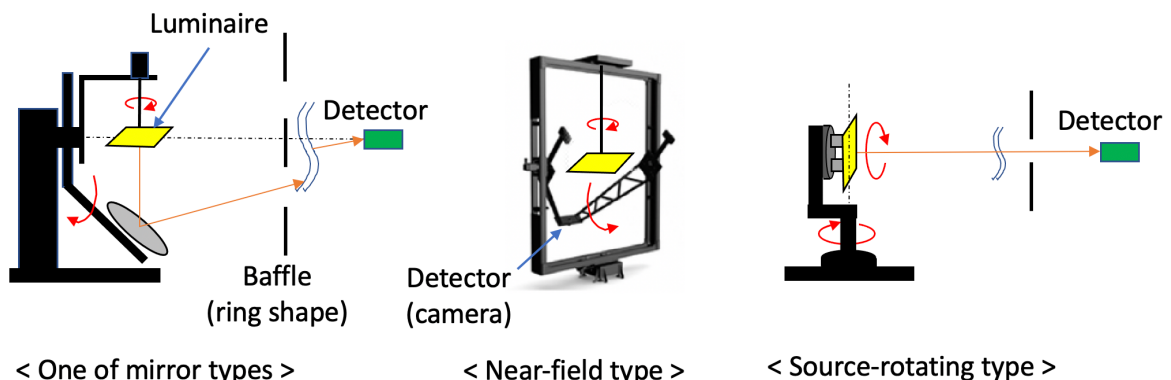


Figure 5. Schematics of three types of goniophotometers covered.

An interlaboratory comparison of goniophotometers was designed by the SSL Annex Experts, led by the National Institute of Standards and Technology (NIST) in the United States, and two reference laboratories having large mirror-type goniophotometers (called Nucleus Laboratories) that were assigned to carry out the measurement rounds. These two reference labs were the Korea Institute of Lighting and ICT (KILT, since 2023

known under the new short name “KIEL”) in the Republic of Korea, and Laboratoire National de métrologie et d'Essais (LNE) in France.

Test luminaires and one lamp were selected from different countries around the world, to create a challenging set for participants. Having the SSL Annex Experts from several different member countries meant the selection was accomplished without major difficulty. IC 2017 was designed to comply with ISO/IEC 17043, serving as a proficiency test for SSL testing accreditation programmes that recognise this comparison. IC 2017 used the recently published international test standard, CIE S 025/E:2015 as the measurement method of artefacts covering 15 measurement quantities. Some of the challenges and issues identified with the test method while conducting this work were shared with CIE Division 2, enabling improvements to the standard. IC 2017 served to improve the understanding of using near-field goniophotometers and source-rotating type goniophotometers (both do not require the large laboratory space needed for mirror-type goniophotometers) and at what degree of accuracy.

The interlaboratory comparison was publicly launched in 2017 (IC 2017) and was organised to investigate the level of agreement in measurements of SSL products by various types of goniophotometers including near-field type and source-rotating type, as well as mirror-type goniophotometers which are most commonly used. IC 2017 had 36 participating laboratories from 19 countries with a total of 42 goniophotometers participating, representing the largest interlaboratory comparison of such equipment ever undertaken. IC 2017 verified reasonable agreement overall among the participants' measurements of the important quantities such as total luminous flux, luminous efficacy, and chromaticity, while it showed unexpected larger variations for some electrical quantities, and revealed a number of specific problems in the measurements of goniophotometric quantities. The results indicated that more guidance is needed in CIE S 025 or other relevant standards for goniophotometric measurements of SSL products. (SSL Annex, 2021)

Ultimately, the SSL Annex hoped that IC 2017 would help bring down testing costs and make testing more accurate. The outcome of IC 2017 was important for member countries and others involved in regulatory development, market surveillance and test standards development, and will foster the understanding of how directional lighting products and luminaires such as planar fixtures and streetlights can be tested accurately. By comparing results across the different instruments used by the participants, IC 2017 also helped to address the question of whether near-field goniophotometer testing is as accurate as testing conducted on traditional far-field goniophotometers. The comparison verified that the near-field goniophotometers and source-rotating type goniophotometers that participated in IC 2017 had overall equivalent accuracies to (far-field) mirror-type goniophotometers for the types of light source used. A final report (SSL Annex, 2021) was published, summarising the findings of all the participants and recommendations to industry.

Government cooperation case study #4: Quality and performance tiers

In 2009, government officials from the 13 initial countries participating in the International Energy Agency's Energy Efficient End-use Equipment (IEA 4E) Implementing Agreement identified solid state lighting (SSL) technologies as having the potential to cut global electricity consumption for lighting by 30%. While SSL technology promised high performance, experiences at that time with poor quality compact fluorescent lamps demonstrated the need to try and prevent SSL products from following the same path. Governments wanted to try and ensure SSL technology performed well and didn't make unwarranted claims, so as to avoid damaging consumer confidence and slowing down market acceptance and transition to SSL. Thereby the foundation of the SSL Annex's tiered quality and performance recommendations was established. This process was described in detail in a 2013 eceec paper: *On the bright side of life: International efforts to accelerate market adoption of LEDs while avoiding the pitfalls of CFLs* (SSL Annex 2013).

The quality and performance requirements are designed to offer a consistent set of evidence-based specifications that will support and accelerate market adoption of LED lighting products. They are intended to assist both governments who are looking to adopt regulations for these products as well as other organisations such as market transformation programme managers trying to accelerate market adoption of LED lighting products. The IEA 4E also hopes to bring some harmonisation to the market to avoid the situation where governments and programme managers act independently and “re-invent the wheel”. That approach can result in a patchwork of regulations or specifications that is both expensive and burdensome for suppliers.

Drawing upon its experts with an expertise in areas such as health, colour quality, lifetime testing, chip efficacy and other areas, the SSL Annex developed and published quality and performance recommendations starting in 2012. The quality and performance tiers were updated in 2014 and again in 2016. The current version was published as draft in 2020 for public review/comment and then as a final version in 2022 (SSL Annex, 2022b),

offering quality and performance requirements that are future-oriented and account for projected performance improvements.

Over twenty technical experts from the SSL Annex contributed to the 2022 version of the recommendations. The performance requirements established levels for the most common LED lamps and luminaires: (1) Non-directional Lamps; (2) Directional Lamps; (3) Strip Lights; (4) Integrated LED Luminaires; (5) Integrated Downlights; (6) Planar (or Panel) LED Luminaires, (7) Linear Batten LED Luminaires; (8) Linear Troffer LED Luminaires; (9) High-Bay / Low-Bay LED Luminaires; (10) Area (Floodlight) Integrated Luminaires and (11) Roadway Integrated Luminaires. These requirements could be utilised by government, non-profit organisations and donor agencies when designing programmes and policies.

The SSL Annex is continuing to monitor the market and the appropriateness of these published quality and performance requirements, and fully expects that further revisions will be made in the future as SSL technology continues to advance.

New Term (2024-2029): SSLC Platform

After 14 years of successful collaboration, the Member Countries of the IEA 4E SSL Annex wish to continue to actively engage with each other on key areas related to digital lighting technologies. The proposed work under the umbrella of the IEA 4E TCP – the Energy Efficient End-Use Equipment Technology Collaboration Programme – will take the SSL Annex’s work to a new platform called Smart Sustainability in Lighting and Controls, the SSLC Platform. The IEA Technology Collaboration Programme structure establishes a set of rules and an international legal framework for multilateral collaboration on thematic issues centred around various technologies or applications⁵ (SSL technologies in this case) over a period of time, typically five years at a time (IEA, 2024). The TCP framework defines how resources are pooled and shared while giving great freedom to member countries in organising the work. It thus creates an infrastructure for collaboration that goes beyond the actual work programmes.

Although the phrase “Technology Collaboration” implies a strict focus on technology, it should be noted that all work, although based on technology and how it relates to humans and the society, is focused on meeting the energy policy and regulatory needs of the member governments.

The SSLC Platform work complements on-going research, standardisation and product development being conducted by industry and academia. All the activities of the Platform are policy-driven with a focus on how to best implement policy and standards.

For the Fourth Term, the SSL Annex Management Committee placed greater emphasis on systems integration, digitalisation, demand flexibility and controls. They prepared the following Mission Statement and Vision Statement for the SSLC Platform in its Fourth Term.

SSLC Platform – Mission statement

To support governments in policy making, decarbonisation and energy security through investigating, analysing and defining sustainable, appropriate and adaptive lighting systems that emphasise health, performance, circular economy and sufficiency. The goal of these actions is to integrate the best available technologies into high-quality, energy and resource-efficient lighting solutions.

SSLC Platform – Vision statement

Implementation of solid-state lighting has achieved tremendous energy savings, but significant opportunity for further savings remains. The vision of the IEA 4E SSLC Platform is to capture substantial energy savings along with material and resource efficiency gains through the promotion of sustainable, appropriate and adaptive lighting systems. This will be accomplished using the embodied knowledge and experience of the SSL Annex Experts applied to the analysis of the integration of lighting products and controls into systems that are mindful of the circular economy, and by evaluating the effect of technological advances on resources and the environment. To achieve this vision and advise governments, the SSLC Platform will cluster policy and technical expertise from member countries across various horizons and disciplines, including other IEA Technology Collaboration Platforms and initiatives.

⁵ One of the TCPs that was formed in the 90s have a stronger policy and behavioural focus, namely the User-Centred Energy Systems. It works more on behavioural issues related to energy policy as well as the organising consumer and end-user focused programmes (<https://userstcp.org>).

Discussions and conclusions

When governments work together, their collective efforts can achieve better outcomes than if they addressed these challenging issues separately. While this statement is true for many areas of international collaboration, it is particularly true for product regulation of globally traded products, where a technology is rapidly evolving as it works to supplant incumbent technologies. The benefits of international collaboration within the IEA TCP framework were discussed in this paper and illustrated through the effectiveness and impact of the IEA 4E SSL Annex (from March 1st, 2024 called the SSLC Platform). The nature of the collaboration is important: The IEA Technology Collaboration Programme offers an institutionalised framework for multilateral collaboration on thematic issues centred around various technologies or applications – in this case SSL technologies – and the TCP gives great freedom to member countries in organising the work.

A structure for collaboration outside the workplan

In the case of the SSL Annex (as it enters a new five-year term as the SSLC Platform) it is clear that some of the problems that were addressed were not foreseen in any of the three terms' work programmes. It provides an organised structure for cooperation, enabling its member countries to respond quickly and effectively to regulatory and research issues that arise. Case Study #1 (Accelerated Lifetime Testing) and Case Study #2 (Temporal Light Modulation Study) described above are perfect examples of cooperation that was not foreseen and budgeted for in the workplan. This flexibility to address issues that were not foreseen is of great value to the member countries. The institutionalised cooperation between countries on lighting establishes a foundation of trust and lowers the barriers for quickly cooperating on unanticipated research needs or regulatory issues that may arise. The Member Countries act as a group rather than as individual countries, enabling the research to be conducted faster, with more Expert input and review, enhancing the quality of the work produced.

The importance of size, ambition and independence from international governance bodies

The authors of this paper strongly believe that the size and ambition of the group matters. The authors also believe that the fact that the group represent governments, while not being part of formal international bodies for standardisation and regulation matters.

The SSL Annex is not, and cannot be, a regulatory body, nor is it a standards organisation. However, it is closely linked to policy making and regulation in several economies (EU, South Korea, Australia and the UK) through its Member Countries, which ensures that the work stays relevant. But in a regulatory framework, such as the EU Ecodesign Consultation Forum and Regulatory Committees, the process must, by nature, be representative of the countries concerned. The outcomes must be compromises that all or most can accept. This is true also for a single country, where the process needs to take views and needs of various stakeholders into account. Also, the regulatory process seldom allows countries to start research to find answers to questions that arise once consultation with other countries or stakeholders begins; the processes rather rely on existing knowledge once the preparatory work has been done. In the SSL Annex (and the SSLC Platform that continues its work), member governments can allow themselves to be more ambitious and agile, and develop new knowledge without looking at specific formal processes. The time frame of the SSL Annex/SSLC Platform is also long; in the case of the SSL Annex, the collaboration has been going on for 14 years and will continue, so there is an opportunity to think in the long-term while at the same time addressing more urgent issues as well.

In terms of standardisation, the SSL Annex supports governments in assessing the applicability of particular test standards, as is shown in the cases with life time testing and the Annex's interlaboratory comparisons.

We have provided examples of the output in four critical areas: (1) SSL testing, metrics and standards – the SSL Annex worked and works to support the lighting metrology community and improve the comparability and accuracy of LED product testing; (2) Smart lighting, digitalisation and connectivity – recognising that smart lighting systems including wireless communication and intelligent controls are the future, the SSL Annex works to ensure standby power was minimised and will increase its focus on systems in the new five-year term under the SSLC Platform; (3) Public health, productivity and environmental impacts – the SSL Annex worked to help governments and the public understanding and track the latest science and research on how LED lighting impacts human health and the environment and what the consequences are for regulation and public information; and (4) SSL product quality and performance – the SSL Annex regularly developed and published recommended quality and performance requirements which help to facilitate harmonisation on key quality and performance metrics globally.

In addition to the reports and formal deliveries, there is a continuous exchange of crucial information and key knowledge between member governments and experts on issues where one or more countries may need advice and assistance. The cooperation around lighting between these countries and their experts will continue now for another five-year term under the new name, the SSLC Platform.

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