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SSLand Its Standardization – Growth Avenues and Challenges

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Abstract: *The aim of the article is to investigate and assess the domestic SSL(Solid State Lighting) ecosystem which has been flourishing rapidly for last few years.The analysis is carried out in context of recent developments in standardization, domestic quality infrastructure, R&D, policy framework and possibilities of tangible solutions for the end users (consumer/manufacturer/importer/exporter/technologist/researcher etc). Moreover, it is intended to take a step forward to bridge the gap between assumptionsof end users regarding domestic SSL ecosystem and actuality thereof.*

KeyWords:*Solid State Lighting, LED, Standardization, IEC Standards, BIS Standards*

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I. Introduction

In last few years, the light-emitting diode (LED) or technically SSL has been regarded as an important source of smart lighting due to its potential advantages of high efficiency, small size and low power consumption [1,2]. Apart from the smart lighting solutions [3], its applications are being exploited in the field of visible light communication (VLC) [4], sensing [5], dimming [6], navigation [7] etc. LED is called future of lighting due to its great potential for energy-efficient general illumination [8], thus, worldwide it becomes a great area of research.Owning the potential advantages [9] and unique properties [10] of SSL technologies, these are being adopted and implemented by large economies to get edge over cutthroat global competition.Being one of the large economies and identifying LED lighting as a key technology to control energy demand [11],India is also striving hard to push SSL technologyin its main stream and aiming high to get achievable momentum to accomplish its ambitious and widely discussed national missions like "Make in India", "Smart City Mission" etc.

On the other hand, in the era of globalization, where the entire world has been transformed into a global market. The trade policies and strategies are changing dynamically.To be competitive in the world arena,international standards are being adopted and implemented[12] by leading countries. Moreover, eventhe international standards are also being used as magical toolsin various internationaltrade negotiations. It is well known that the international trades are regulated by WTO (World Trade Organization) which is an intergovernmental organization. Some widely discussed WTO agreements are WTO-TBT (Technical Barriers to Trade)Agreement [13], WTO-NTB (Non-tariff Barriers) [14]etc.Since the "International Economic Diplomacy" is also reforming [15], international standards and standardization in key areas like products, services, process etc are becoming game changer. According to basic definition, the process of making something conform to a standard is termed as standardization. It brings innovation, by providing structured methods and reliable data that save time in the innovation process and, by making it easier to disseminate groundbreaking ideas and knowledge about leading edge techniques.

In view of above, it is pertinent to investigate the domestic SSL ecosystem in context of domestic quality infrastructure, standardization strategy, policy framework and adoptability of the end users. The elements of SSL ecosystem are mapped with available resources and ongoing advancements in relevant fields, thus, the article may be useful for the end users in their own context. For example, a consumer may find answer of his question like "what is going on to improve the quality of LED product ?", a manufacturer/importer/exporter may find a holistic overview on national/international policy framework which may directly/indirectly influence his business, while technologist/researcher must think that whatever product/device they are designing/inventing should be compliant to international standard so that their efforts can be converted into globally marketable "end product".

II. Topology of SSL ecosystem

Fig. 1 illustrates an overview of the SSL ecosystem which is flourishing rapidly worldwide. The figure is self-explanatory, where one can easily correlate different key elements(i.e., industry, SSL technology, consumer and government) of the system in context of underneath drives (i.e., R&D, market and

administrative), their role, characteristics, involved issues, connectivity, inter-dependability and thrust areas. To explore the things incomprehensive manner, let us view the components of SSL ecosystem in the light of the beneath drives.

1.1 R&D Drives

According to a research report [16], the artificial lighting for general illumination purposes accounts for over 8% of global primary energy consumption. However, the traditional lighting technologies in use today (i.e., incandescent, fluorescent, and high-intensity discharge lamps), are not very efficient, with less than about 25% of the input power being converted to useful light. On the other hand, SSL is a rapidly evolving, emerging technology whose efficiency of conversion of electricity to visible white light is likely to approach 50% within the next few years. Moreover, side by side this technology is also taking place in different application areas, e.g., VLC. The aforesaid reasons are forcing the researchers to come up with energy efficient lighting solutions at affordable price range.

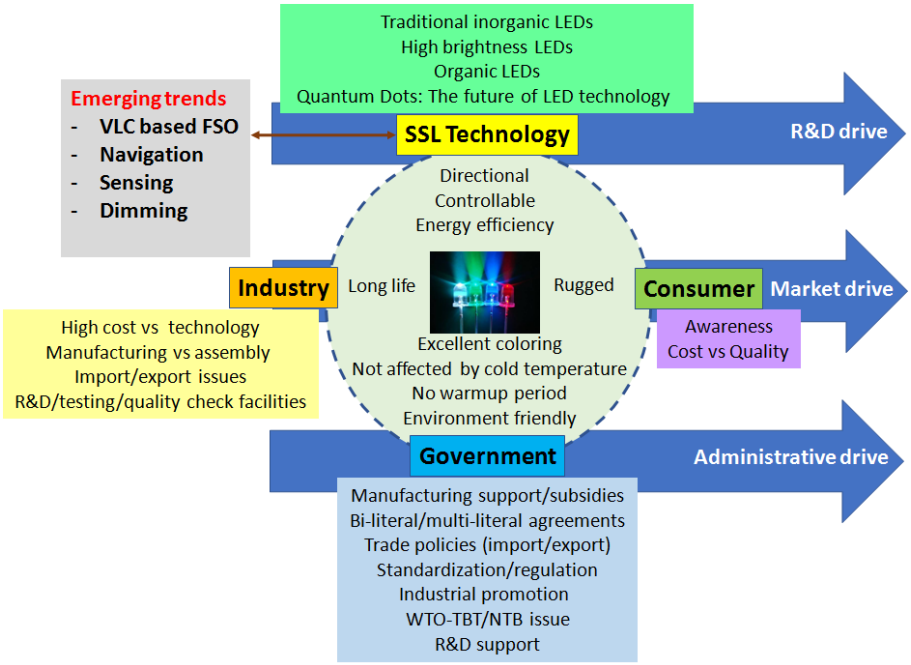

Figure 1. Emerging SSL ecosystem.

1.2 Market drives

According to a report by US-based consulting firm, Frost & Sullivan (F&S), the Indian LED market is expected to grow by over US$ 1 billion in the next few years [17]. The market is likely to witness a growth rate of more than 40 % in forthcoming years. F&S has also predicted that the LED lighting market in India will move towards high quality, adaptable lighting with more efficient output. According to another report [18], even though Indian market is facing many challenges, the LED market is likely to increase its footprint against the no-LED segment of this market with significant momentum in the next few years. Indeed, this is happening due to the changes in demand-supply scenario, favourable government policies, growing awareness about clean energy and boost in domestic manufacturing of LED products.

1.3 Administrative drives

Owing to promising applications of the SSL technologies in the growth of national economy and welfare of the end users, government agencies are striving hard to push LED products and their domestic manufacturing by the way of various kind of subsidies and supports. In last few years, the process becomes more intense. For example, Domestic Efficient Lighting Programme (DELP) or UJALA (Unnat Jyoti by Affordable LEDs for All)[19] scheme was launched in 2015 urging the people to use LED bulbs in place of incandescent bulbs, tube lights and CFL as they are more energy efficient, long lasting and economical in their life cycle duration. On the other hand, followings are some widely discussed schemes initiated by Government of India to boost domestic manufacturing

(i) "Modified Special Incentive Package Scheme (M-SIPS)", it was notified in 2012 to attract investments in electronic manufacturing. The investment threshold varies from Rs. 1 Crore to 5000 Crores depending upon a type of project [20].

(ii) "Make in India" a type of Swadeshi movement covering 25 sectors of the economy, was launched in 2014 [21].
(iii) "Startup India" was launched in 2016. The action plan of this initiative is (a) simplification and handholding (b) funding support and initiatives, and (c) industry-academia partnership and incubation [22].

III. Infrastructurescenario

To develop "Quality Infrastructure (QI)" in any nation, establishment and intense coordination of dedicated entities are required [23]. As depicted in Fig. 2, the ecosystem of QIlargely grows over four key pillars namely standardization, metrology, conformity assessment and accreditation. However, the key elements of the QI are dynamic rather than static. The major driving force behind all components is strategic planning and continuous research in every sector. Where domestic scenario is concerned, every component of QI ecosystemalready has dedicated institutional mechanism for seamless functionalities.Moreover, a comprehensive national policy, "Indian National Strategy for Standardization (INSS)" has been released on 19th June 2018to implement and monitor the standardization[24], which is a milestone in the national standardization mission.To scale the impact of domestic SSL ecosystem, let us explore details of the key components of the domesticQI ecosystem.

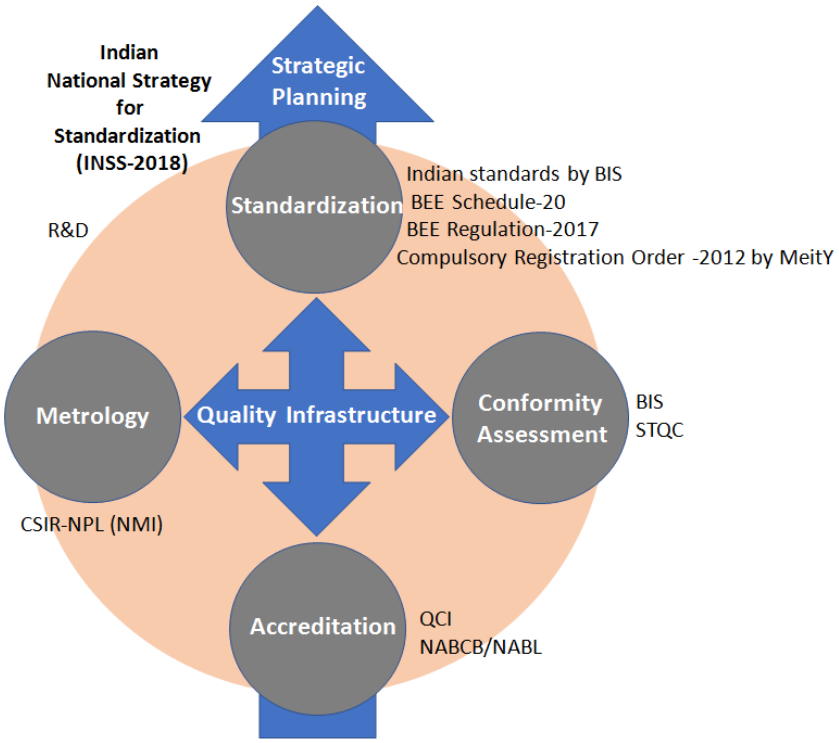

Figure 2.QI ecosystem.

1.4 Standardization

As mentioned earlier, the process of making something conform to a standard is termed as standardization wherein standards remain at core. Basically, standards set out specific characteristics of a product — such as its size, shape, design, functions and performance, or the way it is labelled or packaged before it is put on sale. In short, if a product is conforming to a relevant standard, it implies that major and essential parameters of safety, quality and performance are taken care before launching it into the market.
Standardization is a typical process, it may be voluntary or regulatory. If any manufacturer is voluntarily adopting any standard, it means,he is willing to make his product a "high quality product" and is ready to comply with all the technical specifications of the relevant standard and conformity assessment process thereof. On the other hand, in case the standards are made "mandatory" by government or any authority, that implies; no person shall by himself or through any person on his behalf manufacture or store for sale, import, sell or distribute goods which do not conform to the specified standard and do not bear the "Standard Mark" as notified by the issuing authority for the goods.

Depending on market dynamics and socio-economic conditions, the standards are adopted or implemented. For instance, in developed countries the end users are quite safety and quality cautious, thus, the market moves accordingly, and the manufacturer voluntarily adopts relevant international standards to improve their product quality. In contrary, largely the standards are implemented by governmentin developing countries, because, in such countries, the socio-economic conditions, demand and supply impact, and domestic needs are quite different than developed countries. Mostlypeople are more price cautious than safety and quality, in addition, degree of awareness is also very low. To protect the interest of the end users and to curb the inflow of sub-standard products into market, the government makes standards mandatoryfor specific product categories/sectors wherever she deems fit. In India, Bureau of Indian Standards (BIS) develops/harmonizes/provides the required national standards. For ready reference, a list of popular Indian standards and equivalent international standards for LEDs products[25] is given in Table-I.

1.4.1 LED products under CRO

As mentioned earlier, according to requirement, government makes standards mandatory. In this regard, to assure safety of consumers and to curb sub-standard product in domestic market, Ministry of Electronics and Information Technology (MeitY) has notified "*Electronics and Information Technology Goods (Requirements for Compulsory Registration) Order, 2012 (CRO)*" mandating safety standards for notified product categories. Till date the CRO has come into effect for 44 notified product categories including nine LED product categories (S. No. 2 to 10 in Table-I) [26].

Table I. Standards for LEDs.

S. No.	Title of Standard	Standard
1	General Lighting - LEDs and LED modules – Terms and Definitions	16101 : 2012/ IEC 62504 TS
2	Self- Ballasted LED Lamps for General Lighting Services Part 1 Safety Requirements	16102(Pt. 1) : 2012/ IEC 62560
3	Safety of Lamp Control Gear Part 2 Particular Requirements Section 13 d.c. or a.c. Supplied Electronic Controlgear for Led Modules	15885(Part2/Sec13):2012/ IEC 61347-2-13
4	Fixed General Purpose LED Luminaires	IS 10322 (Part 5): 2012 (IEC 60598)
5	Recessed LED Luminaries	IS 10322-5-2 (*IEC* 60598-2-5:2002)
6	Luminaires for road and street lighting	IS 10322-5-3 *(IEC* 60598-2-3:2002)
7	LED Flood Lights	IS 10322-5-5 (*IEC* 60598-2-5)
8	LED Hand lamps	IS 10322-5-6
9	LED Lighting Chains	IS 10322-5-7
10	LED Luminaires for emergency lighting	IS 10322-5-8
11	Self-Ballasted LED Lamps for General Lighting Services Part 2 Performance Requirements	16102(Pt. 2) : 2012/ IEC 62612
12	Led Modules for General Lighting Part 2 Performance Requirements	16103(Pt. 2) : 2012/ IEC 62717
13	D.C. or A.C. Supplied Electronic Control Gear for LED Modules - Performance Requirements	16104 : 2012/IEC 62384
14	Luminaire performance - Part 2-1: Particular requirements for LED luminaires	IEC 62722-2-1:2014
15	Method of Electrical and Photometric Measurements of Solid-State Lighting (LED) Products	16106 : 2012/LM 79
16	Luminaires Performance Part 1 General Requirements	16107 (Part 1):2012/ 34D/950/NP
17	Luminaires Performance Part 2 Particular Requirements Section 1 LED Luminaire	16107-1:2012/34D/977/DC
18	Led Modules for General Lighting Part 1Safety Requirements	16103(Pt. 1) : 2012/ IEC 62031
19	Method of Measurement of Lumen Maintenance of Solid State Light (LED) Sources	16105 : 2012/LM 80
20	Photobiological Safety of Lamps and Lamp Systems	16108 : 2012/IEC 62471

1.4.2 Performance check over LED products

LED has many special photometric and electrical characteristics that make them a unique light source. To exploit their potential at maximum level, curb sub-standard LED products and keeping performance standards in mind, Bureau of Energy Efficiency (BEE) has released *Schedule-20*: *LED Lamps* on 7th July 2015 and has also notified "*Bureau of Energy Efficiency (Particulars and Manner of their Display on Labels of Self-ballasted LED Lamps) Regulations, 2017*" on 27th December 2017 mandating star labellingfor self-ballasted

LED lamps [27]. Popular performance standards for LED product categories are given in Table-I at S. No. 11 to 17while the important test parameters included in the BEE Schedule are given in Table-II for ready reference.

Table-II. Required test parameters for BEE labeling.

S. No.	Test parameters	Standard
1	Wattage	IS 16102 Part 2
2	Initial Luminous Flux	IS 16102 Part 2 and IS 16106
3	Colour chromaticity and colour rendering index (CRI)	IS 16102 Part 2
4	Life	IS 16102 Part 2
5	Harmonics IS 14700 (Part 3/Sec 2)	IS 14700 (Part 3/Sec 2)
6	Limits and methods of measurement of radio disturbance characteristics : Part 5 Electrical lighting and similar equipment	IS 6873 (Part 5): 1999
7	Lamp efficacy	The lamp efficacy shall be derived from the measured value of lumen output and the wattage at the rated voltage and frequency

1.5 Conformity Assessment

To maintain quality in products, the checking of compliance to prescribed standards (whether it is regulatory or voluntary) is required. "Conformity Assessment" is a process of inspection/testing/certification – or a combination of the aforesaid exercises. Worldwide there are two major issues (i) confidence in conformity assessment, and (ii) international acceptability for facilitating trade that is the need for recognition of inspection/testing/certification across borders. These are accomplished through accreditation [28]. Where SSL products are concerned, there is no need of additional/specific requirement, present domestic infrastructure is enough to meet the requirements. However, BIS has major role in this segment because the BIS recognizes labs for testing the notified products under BIS Act & BIS Rules. IS wise list of BIS recognized lab can be explored at [29].

1.6 Accreditation

In simple words the accreditation means a third-party attestation related to a conformity assessment body conveying formal demonstration of its competence to carry out specific conformity assessment tasks in a reliable credible and accurate manner. Quality Council of India (QCI) [30] is responsible for national accreditation structure. It is set up as India's part in the growing international system. The supply chain in conformity assessment starts for International Accreditation Forum (IAF) – Pacific Accreditation Cooperation (PAC) where the National Accreditation Board for Certification Bodies (NABCB) [31]is the member from India. Similarly, at international level, International Laboratory Accreditation Cooperation (ILAC) and in Asia continent, Asia Pacific Laboratory Accreditation Cooperation (APLAC) are active where NABL [32] represents India.

1.7 *Metrology*

The science of measurement is called metrology. The Council of Scientific and Industrial Research-National Physical Laboratory (CSIR-NPL) [33] is the National Metrology Institute (NMI) of India. To serve the nation as a NMI, there is a dedicated division, called Physico-Mechanical Metrology. This division is taking care of all the seven base units of metrology.The main responsibility of the said division is the realization, establishment, custody, maintenance, dissemination and upgradation of the national standards for Physico-mechanical, Electrical, Optical and Thermal precision parameters. Further, Optical Radiation Standards (ORS) is a specifically dedicated section of Physico-Mechanical Metrology Division where all required facilities are available to measure photometric, radiometric and spectroscopic characteristics ofall types of light sources.Moreover, the ORS is presently in process of establishing a world class R&D facility for indigenous SSL technology and cutting-edge measurement facility for all kind LED products.

IV. Challenges Versus Initiatives

Like all over the world, the Indian markets are being flooded with various kinds of LED products. The domestic manufacturing of LED products is at its budding stage as largely components like bare LEDs, diffusers, LED driver modules etc. are being imported than manufactured; as a result, assembling of LED products is more dominating than domestic manufacturing. On the other hand, despite all claims by vendors, manufacturers and their respective technologists, the quality and performance determination of these products and measures to provide safeguard to consumer are emerging as big challenges for government agencies. Despite various initiatives by different agencies, according to some reportingby different analysts,the Indian industries and consumers are facing many challenges[11, 18]. An overview on the major challenges and solution possibilities are given in Table-III.

Table-III – Challenges versus possibilities

(a)	At present, Indian consumer awareness about LEDs is very low	This is one of the basic issues, proper campaigning and initiatives may reduce the problem up to negligible level. In this department one can observe good progress as campaigning by different agencies are on full swing.
(b)	Cost of LED products	Cost is being reduced day by day and it will further decline with time and degree of competition in LED product manufacturing.
(c)	The high initial cost of LEDs makes the pay-back period very long	These points are related to the basic problems of domestic industries, in this regard, initiatives are being taken in the form of government adds to establish domestic manufacturing units. Potential end user may explore possibilities in the schemes mentioned in Sec. 1.3, Electronic Manufacturing Cluster (EMC) scheme [34], Electronics Development Funds (EDF) [35] and various state government schemes.
(d)	There is less incentives to setup manufacturing facilities in India as compared to China and other developing country	
(e)	Lack of confidence of designers on SSL products	These issues require indigenous research and efficient testing mechanism, potential is available, but more attention, focused approach and time bound deliveries of indigenous technologies are desirable.In this department, some encouraging developments are as follows: ➢ As mentioned in Sec. 1.7, a world class R&D and measurement facility for LED products is under development at ORS, CSIR-NPL to cater future industrial need in the field of SSL technology. ➢ MeitY also has a scheme entitled *"Scheme for setting up/ up-gradation of Electronics Product testing/ Quality Control Laboratories*"by which new testing labs are being established in collaboration with IIT, CSIR etc [26].
(f)	Inadequate information on product performance	
(g)	There is limited availability of LED technology in India	
(h)	There is a luck of testing protocols, facilities and accredited laboratories at national level	
(i)	Some low-quality product in market affecting confidence of users	These issues are pertaining to deceptive practices by some manufacturers/vendors/importers/traders and gaps between quality check policies and their implementation, obviously, this segment require immediate attention. To curb the substandard SSL products (whether it is indigenous or imported), well defined set of rules are very essential to check performance of the products. In this connection, theinitiatives taken so far are listed below: ➢ Nine LED products have been covered in CRO mandating Indian safety standards. ➢ BEE has already released Schedule-20 and notified BEE Regulation-2017 for Star Rating on LED lamps.
(j)	Unsubstantiated and inaccurate quality claims	
(k)	There is no performance check by government entities on LEDs hence the industry is prone to import and supply sub-standard products to market.	

V. Conclusion

Many things are happening, and various developments are taking place around us but sometimes some of them remain unnoticed, thus, the article is aninitiative to bring various things together by assessing the hypothetical model of SSL ecosystem and QI ecosystem in context of ongoing domestic advancements in the relevant sectors. Moreover, it is intended to ignite a fresh think process in the mind of end users (consumer/manufacturer/importer/exporter/technologist/researchers etc.), so that they can get down to the nitty-gritty of finding a best solution of their issues in their own context.

Disclaimer

Views presented in this paper pertain to author only and does not represent Government of India's views on the subject matter.

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