Non-economic benefits of standards

Shenzhen LED Standards Alliance, China

Country: China

ISO member body: Standardization Administration of the People's Republic of China (SAC)

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1 Objectives and organization of the pilot project

In the past few years, ISO developed a methodology for the assessment of economic benefits of standards (the "ISO Methodology"). This methodology can be adapted to describe and quantify the non-economic benefits of standards, which benefit the society and/or the environment and which can be traced back in full or in part to the use of standards by enterprises.

The main objective of this project is to adopt the ISO methodology to assess the non-economic benefits, i.e. the social and environmental benefits resulting from the use of the alliance standards developed by the Shenzhen LED Standards Alliance (LSA). Unless otherwise specified, all references to alliance standards relate to the standards developed by LSA.

As a result of this project, the following objectives could be set: first, this study could become a reference case giving a model for assessing the non-economic benefits of standards with the ISO methodology; second, the quantitative results of this study may contribute to raising awareness among LED companies or related institutions of the importance of standards and motivate them to join LSA to develop and use alliance standards.

The assessment is structured mainly in the following stages:

1. Select a number of enterprises and institutions which are standard-conscious and have a strong record in the use of standards as assessment samples in the LSA
2. Analyze the value chain of the LED industry and the LSA
3. Conduct interviews with the management and senior technical staff of the selected enterprises in order to obtain necessary information for the project

4. Identify the key value drivers and assess the business functions that are most impacted by standards
5. Determine operational indicators and assess the impacts of standards in the relevant activities and finally quantify the impacts from standards with regard to societal and environmental (non-economic) benefits

The case study to assess the non-economic benefits of standards in the LSA was carried out between June and July 2013, and the report was finalized in August 2013. This study was led by the Standardization Administration of China (SAC), and implemented by the Shenzhen Institute of Standards and Technology (SIST) under the guidance of the ISO Central Secretariat. It was undertaken in close cooperation with LSA and its members and received strong support from the ISO Central Secretariat project advisor.

2 Introduction to the project

2.1 Introduction to LSA

LSA is a cooperative organization established voluntarily by entities, which actively promote the development of standardization in the LED industry and are committed to LED industry alliance standards for research, development, application and service. LSA is anchored in the Shenzhen Metrology and Quality Inspection Institute which is affiliated to the Market Supervision Administration of Shenzhen.

Since its foundation in July 2009, LSA has always insisted on building an advanced LED industry standardization system, and promoting healthy and rapid development for the purpose of improving the core competitiveness of enterprises. LSA promotes resource sharing

among members and mutual benefit, and has developed principles and policies in favour of developing LED industry standardization to enhance the competitiveness of the members of the group.

In June 2013, LSA had 94 member companies and institutions mainly from Southern China and Shenzhen, but also from other regions in China. In terms of membership, a distinction exists between core and common members.

By mid-2013, LSA had developed 22 LED-standards, most of which are first-time standards in the industry. Within the LSA-membership, the majority of companies belong to the lighting segment of the industry.

2.2 Selection of the assessment sample

LED is a new semiconductor light-emitting material with numerous advantages such as long life, energy conservation, environmental protection, and others. LED can be used in many applications, such as backlight, outdoor display, automotive, lighting, etc. According to the different usage of LED, the LED industry can be divided into many segments, for example : LED display industry, LED lighting industry. Most of the LSA members are concentrating on the field of LED lighting and cover the whole industrial chain.

The sample selected for this case study is based on the following criteria :

- the selected enterprises must have a deep understanding of standardization and especially strong enforcement of alliance standards
- since the objective of the project is to assess the effect of alliance standards, the selected enterprises must be members of the LSA
- due to the complexity of the LED industry, limitations in time and resources, and the fact that most alliance members are LED lighting enterprises and institutions, the scope of this study is

restricted to the LED lighting segment of the industry. Unless otherwise specified, all references to the LED industry are therefore references to the LED lighting industry

Based on these principles and considerations, we have selected the following types of organizations in LSA : Two manufacturers, three suppliers and one consumer of the LED lighting enterprises and institutions in LSA (see **Table 1)**. The suppliers include two power suppliers as well as an intelligent module supplier whose customers are power suppliers. The consumer is a Municipal Institute of Shenzhen, responsible for the procurement, installation and maintenance of road lighting in the city of Shenzhen.

Type of LSA member organization		Company name
Manufacturers	luminaire	Shenzhen Bang-Bell Electronics Co., Ltd.
	luminaire	Shenzhen SED Baili Electric Co., Ltd.
Suppliers	power supply	Shenzhen Moso Power Supply Technology Co., Ltd.
	power supply	China Great Wall Computer Shenzhen Co., Ltd.
	intelligent module	China Wisest Technology Co., Ltd.
Consumers		Shenzhen Lighting Environment Management Center

Table 1 – Assessment sample

3 Attitude of the LSA towards standardization

LSA is committed to research, development, application and services of the LED industry alliance standards across all its members in the LED industry value chain. LSA is convinced that standardization significantly helps regulate trade and guide the development of the industry. Especially for a new industry such as LED, the development and application of standards can effectively help to introduce a structure and organization to the market in the early days of the industry's development, build up a positive and healthy industry image, and obtain recognition from society.

Most of the LSA members have been beneficiaries of standardization, and already had abundant experience in standardization before joining the LSA. The majority have obtained certification against ISO 9001 for their quality management systems and ISO 14001 for their environmental management systems. Their products have successfully entered more than 140 countries after obtaining certifications from UL, TUV, CE, CSA, 3C, etc. Many technical experts from the member units who serve in LSA are participating in the development of national/local standards as members of the national/local standards technical committee and have therefore accumulated a rich experience in standardization. Some members adopt standardization-oriented strategies and use standards as a tool to promote their products, strengthen the LED industry market segments and establish a leading position in this market segment.

Owing to the importance LSA companies attach to standardization and the pursuit of excellent products, there is a pressing demand for LED industry standards. Consequently, these companies have voluntarily joined the LSA and participate in the development and application of alliance standards. The standards are developed on a consensus-basis, integrating the views of the industry and achieving unified understanding on this platform, before establishing technical standards and promoting cooperation in the industry value chain.

4 Analysis of the value chain

4.1 The LED industry value chain

The core participants of the LED industry are suppliers, manufacturers, engineering companies and consumers. The LED industry life cycle is divided into 8 stages : design and development, parts production, lamp production, marketing & sales, engineering, after-sales service, use, and recycling. The duration and stages of participation differ. The orange boxes in **Figure 1** represent the position of the different actors in the LED industry value chain.

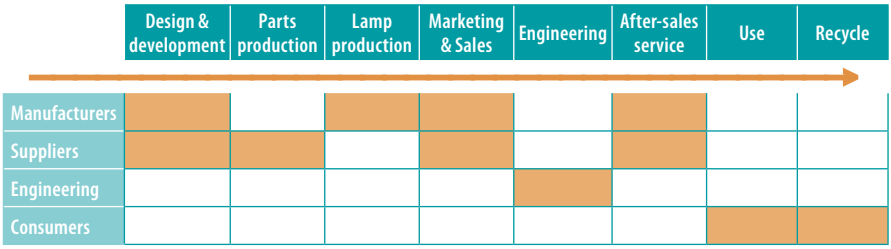

Figure 1 – Position of the different types of members in the LED industry value chain

4.2 The LSA value chain

Except for engineering, LSA comprises the following three types of industry participants in the LED industry value chain : Manufacturers, suppliers and consumers. Manufacturers and suppliers are typically production enterprises. Their value chains consist of seven major business functions (see the orange section in **Figure 2)** : Administration, research and development, procurement, production, logistics, marketing/sales and after-sales service. Since consumers do not engage in production, the value chain of consumers contains the following three business functions (see the dark orange section in **Figure 2)** : Procurement, engineering, use/maintenance.

	Manufacturers	Suppliers	Consumers
Administration			
Research and development			
Procurement			
Production			
Logistics			
Marketing/sales			
After-sales service			
Engineering			
Use/maintenance			

Figure 2 – The LSA value chain

4.3 Key value drivers

In the ISO methodology, value drivers are defined as crucial organizational capabilities that give a company a competitive advantage over similar companies in the industry. In this study, the understanding of value drivers can be extended as key factors that drive organizations to create social and environmental value. Through interviews with several senior managers, the key value drivers of the enterprises selected for the assessment are shown in **Table 2.**

LSA member type	Key value drivers	Description
Manufacturers and Suppliers	Building a common basis for the industry	Regulating the industry terminology, and unifying industry interfaces, reduces industry communication barriers and smoothens supply within the industry chains. Developing the industry in a healthy and orderly way, and fostering a promising image of industry to enhance public and investors' confidence in the LED lighting industry.
	Higher quality products	Reduction of parts' types results in storage and R&D costs savings. More resources shift into standardized components, and makes mass production possible. Combined with testing and certification that helps improve product quality, by conforming to and exceeding relevant international and national standards and regulations, consumers can benefit from higher-quality products.
	Enhanced customer confidence	Enhance customer confidence by providing better quality products/services, through implementing strategies of standardization and other measures
Consumers	Reduce costs and market prices	Healthy competition leads to more and better quality products on the market, and improved after-sales services which results in a reduction of maintenance costs
	Provide better lighting environment for the public	Providing a better lighting environment for the public through the deployment of better quality products/services.
	Reduce manpower and energy consumption	Better product quality and interchangeability helps to reduce the frequency of maintenance which in turn contributes to manpower reduction. Adopting standardized products is conducive to reducing energy consumption and carbon emissions.

Table 2 – LSA key value drivers

5 Scope of the pilot project assessment

The scope of the assessment is limited to the business functions that achieve significant non-economic benefits through standards and to those activities that are closely related to the key value drivers in the organizations. The business functions from the LSA value chain chosen for this study are those which have a significant impact on the generation of non-economic benefits. The results from the question-

naires and interviews showed that the amount of benefit generated differs depending on the type of the LSA-member company and its position in the industry value chain (see **Figure 3)**.

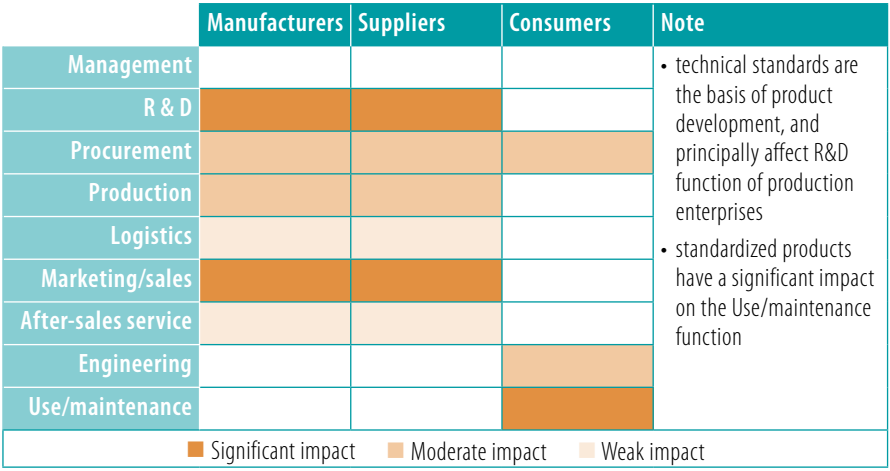

Figure 3 – Intensity of the impact of standards for the three LSA-member types and their business functions

As shown in **Figure 3,** for manufacturers and suppliers, the business functions mostly affected by standards are research and development, and marketing/sales. For organizations in the consumer segment of the industry, it is the use/maintenance function. Since this study focuses on those business functions that are mostly affected by standards, the scope of the assessment has been defined as shown in **Table 3.**

LSA member type	Scope of assessment
Supplier	R&D
	Marketing/sales
Manufacturers	R&D
	Marketing/sales
Consumers	Use/maintenance

Table 3 – Scope of the assessment

6 Standards used in the LSA value chain

After determining the key business functions of the three types of the selected LSA member organizations, the standards used in their key business functions have been determined through desk research, questionnaires and interviews, as shown in **Table 4**:

Member type	Business function	Activity	Standard	Description
Manu-facturers	R&D	Customer needs survey	SQL/LSA 007-2012	Terms and definitions for LED lighting and LED display
			SQL/LSA 003-2011	Interchangeability of key components and general interfaces for LED street lights
		Product design & Inspection	SQL/LSA 001-2012	Technical specification and energy efficiency requirements for LED street lighting products
			SQL/LSA 005-2011	On-site test methods of LED lamps for street lighting
			SQL/LSA 006-2011	Technical specification for the control gear of LED tunnel lamps
	Marketing/ Sales	Product certification	GB 24906-2010	Self-ballasted LED-Lamps for general lighting services >50V safety specifications
			GB 24819-2009	LED modules for general lighting – Safety specifications
			GB/T 20145-2006	Photobiological safety of lamps and lamp systems
			GB 19651.3-2008	Miscellaneous lamp holders – Part 2-2 : Particular requirements – Connectors for LED-modules
			UL 8750	Standard for light emitting diode (LED) Equipment for use in lighting products
			UL 1598	Luminaires
			EN 55015	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

Member type	Business function	Activity	Standard	Description
Manu-facturers	Marketing/ Sales	Product certification	EN 61000	Electromagnetic compatibility (EMC)
			EN 62031:2008	LED modules for general lighting – Safety specifications
			ENERGY STAR standards	
Power suppliers	R&D	Customer needs survey	SQL/LSA 001-2012	Technical specification and energy efficiency requirements for LED street lighting products
			SQL/LSA 003-2011	Interchangeability of key components and general interfaces for LED street lights
		Product design & inspection	SQL/LSA 002-2011	Technical specification for the control gear of LED street lights
	Marketing/ sales	Product certification	EN 61000	Electromagnetic compatibility (EMC)
			EN 61347-2-13	Lamp control gear Part 2-13 : Particular requirements for d.c. or a.c. supplied electronic control gear for LED modules
			GB 19510.14-2009	Lamp control gear – Part 14 : Particular requirements for d.c. or a.c. supplied electronic control gear for LED modules

Member type	Business function	Activity	Standard	Description
Intelligent module suppliers	Marketing/ sales	Customer needs survey	SQL/LSA 001-2012	Technical specification and energy efficiency requirements for LED street lighting products
			SQL/LSA 003-2011	Interchangeability of key components and general interfaces for LED street lights
	R&D	Product design & Inspection	SQL/LSA 004.1-2011	Intelligent lighting technical specification for LED street lights – Part 1 : Control system
			SQL/LSA 004.2-2011	Intelligent lighting technical specification for LED street lights – Part 2 : Power line carrier control module
			SQL/LSA 004.3-2011	Intelligent lighting technical specification for LED street lights – Part 3 : Application layer communication protocol based on PLC
			SQL/LSA 004.4-2011	Intelligent lighting technical specification for LED street lights – Part 4 : Information safety
Consumers	Use/ maintenance	Use	SQL/LSA 005	On-site test methods of LED lamps for street lighting
			SQL/LSA 001	Technical specification and energy efficiency requirements for LED street lighting products
			CJJ 45-2006	Standard for lighting design of urban road
		Maintenance	SQL/LSA 003	Interchangeability of key components and general interfaces for LED street lights

Table 4 – Standards used in key business functions

7 Operational indicators to calculate the impact of standards

7.1 Key standards

Through questionnaires and interviews, the standards shown in **Table 5** have been identified as the most relevant for the generation of non-economic benefits. From interviews with individuals involved in the business process, it became apparent that suppliers and manufacturers are willing to follow some common agreement in order to maintain the smooth flow of the upstream and downstream supply and consider consumers' demand. These agreements are reflected in the LSA alliance standards, such as SQL/LSA 001, *Technical specification and energy efficiency requirements for LED street lighting products*, and SQL/LSA 003, *Interchangeability of key components and general interfaces for LED street lights*, shown in **Table 5.** In order to meet the requirements of the consensus-based standards, some restrictions regarding certain standardized components need to be applied in addition to SQL / LSA 001 and SQL / LSA 003 by all suppliers, through the product standards for standardized components shown in **Table 5.**

	Standards number	Standards name
Manufacturers	SQL/LSA 001	Technical specification and energy efficiency requirements for LED street lighting products
	SQL/LSA 003	Interchangeability of key components and general interfaces for LED street lights
Power suppliers	SQL/LSA 001	Technical specification and energy efficiency requirements of LED street lighting products
	SQL/LSA 002	Technical specification for the control gear of LED street lights
	SQL/LSA 003	Interchangeability of key components and general interfaces for LED street lights

	Standards number	Standards name
Intelligent module suppliers	SQL/LSA 003	Interchangeability of key components and general interfaces for LED street lights
	SQL/LSA 004.1	Intelligent lighting technical specification for LED street lights – Part 1 : Control system
	SQL/LSA 004.2	Intelligent lighting technical specification for LED street lights – Part 2 : Power line carrier control module
	SQL/LSA 004.3	Intelligent lighting technical specification for LED street lights – Part 3 : Application layer communication protocol based on PLC
	SQL/LSA 004.4	Intelligent lighting technical specification for LED street lights – Part 4 : Information safety
Consumers	SQL/LSA 005	On-site test methods of LED lamps for street lighting
	SQL/LSA 001	Technical specification and energy efficiency requirements of LED street lighting products

Table 5 – Key standards for assessment

7.2 Key operational indicators

Following detailed interviews and follow-up studies for the three different types of LSA members as well as data collected from department heads, the operational indicators shown in **Table 6** were defined to measure the impacts of standards.

Business function	Operational indicators	Relevant standards	Definition of the indicators
LSA-members of type : Manufacturers and suppliers			
R&D	Streamlining of the industry structure	SQL/LSA 001 ; 003	Compare the situation before and after implementation of the standards, and assess the degree to which : • communication in the industry has become easier • it is possible to segment markets • communication between different suppliers and manufacturers through unified terminology and classification has become easier
	Product quality	SQL/LSA 001 ; 002 ; 004	Increase in all relevant technical indicators of LED-products after implementation of the standards
	Resource use	SQL/LSA 001 ; 003	Reduction in the use of human resources, storage space, materials and other resources after the introduction of a unified classification and the resulting reduction in product variety
	Degree of specialization of workers	SQL/LSA 001 ; 002 ; 004	Increase in the degree of specialization of the workers as a consequence of gaining practical experience in the use of standards and through training
Marketing/ Sales	Market power	SQL/LSA 001 ; 002 ; 003 ; 004	Improvement of competitiveness, shortening of time-to-market, access to global markets and increase in market power due to implementation of standards and participation in standardization
	Customer confidence	SQL/LSA 001 ; 002 ; 003 ; 004	Increase in customer confidence in LSA member companies as a consequence of the implementation of quality management standards and participation in standardization
LSA-members of type : Consumers and End users			
Use/ Maintenance	Financial expenditures	SQL/LSA 001 ; 005	Reduction in maintenance and energy costs following the replacement of traditional products by standard-compliant LED products
	Consumption of resources	SQL/LSA 001 ; 005	Reduction in frequency, time and workload needed for maintenance due to higher quality products
	Energy	SQL/LSA 001	Reduction in the use of electrical energy due to the use of LED lighting and intelligent control systems
	Environment	SQL/LSA 001	CO_2-reduction due to the use of LED-lighting
	Satisfaction of the public	SQL/LSA 001 ; 005	Standards-compliant products result in safer and better illumination and generate increased satisfaction of the general public

Table 6 – Indicators for different LSA-members

8 Qualitative and semi-quantitative considerations

8.1 Impacts of standards

1) Impact of standards on manufacturers and suppliers

Suppliers and manufacturers in the LED industry are production enterprises and have a similar value chain. Our investigations showed that the R&D and Marketing/Sales business functions are those mostly affected by standards, and the impacts generated by the standards introduced are almost the same for both types of enterprises.

As a new industry, LED benefits greatly from the introduction of standards. Especially for production enterprises (suppliers and manufacturers), standards have a chain effect on many aspects. Standards developed by the LSA are mainly technical standards that are used by LED enterprises within the LSA as the basis in their R&D business function. Based on the requirements of these standards, product safety, performance and interfaces are considered in the top-level design in order to satisfy the demand of clients, to conform to test standards, to obtain certifications and to enter the global market. The impact of standards is particularly apparent in R&D, because all activities in production and quality management are based on the results from R&D.

Standards also have obvious impacts on the Marketing/Sales business function for production enterprises, i.e. suppliers and manufacturers. The main reason is that it is difficult to distinguish between good and bad products and to win the trust of clients in an industry during its early stages of maturity. Consensus-based standards, especially those for the classification of products into different grades according to specified performance indicators, make it easier for customers to

understand the quality level of a product on the market. In addition, some interviewees held the view that customers prefer enterprises that participate actively in standardization, because customers, in particular international customers, believe that only those with a strong competitiveness are capable of participating in standardization.

The key impacts of standards for manufacturers and suppliers are shown in **Table 7.**

Business function	Operational indicator	Impact of standards
R&D	Streamlining of the industry structure	Before LSA standards were published, hundreds of types of LED products existed among the power demands from zero Watts to hundreds Watts. Considering the differences of voltage and current of LED products, the number expanded to thousands. Following the release of SQL/LSA 001, LSA members started to design and produce their products according to the classification rules in this standard. Through promotion by LSA, word-of-mouth, and communication between LSA members and their clients and suppliers, most LED products on the market are likely to follow the classification rules in SQL/LSA 001. As a consequence, the number of power types for LED products has effectively reduced to 7. SQL/LSA 003 specifies the interface requirements between luminaries and lampposts, luminaries and control gear from different suppliers and manufacturers in order to achieve product interchangeability. The effect is a streamlining of the industry structure and higher efficiency in the supply chain of the LED industry.
	Resource consumption	Before the LSA standards were published, the market was flooded with hundreds of types of LED products. Each product required the design of a specific mould which caused a huge waste of money and materials. Too many product types resulted in a waste of research resources, especially human resources. In addition, the more product types were developed, the more storage facilities were needed. Due to the introduction of standards, the number of different product types reduced sharply and, as a consequence, resources like materials, human and storage resources also reduced.

Business function	Operational indicator	Impact of standards
R&D	Production quality	Before the LSA standards were published, the many different types of LED products made mass production impossible. Without scale, the market is flooded with incompatible products of a highly varied quality. Standards reduce the number of different product types to a reasonable level, and, at the same time, reduce resource wastage and production costs. Resources and money saved can be allocated more appropriately. R&D can be more focused, and the scale larger, leading to better product quality. The technical requirements defined in standards are helpful in setting a market entrance threshold and in driving out inferior products from the market. Product quality is ensured and consumer rights are protected. Further, LSA standards are very flexible and can be updated in a timely manner according to the raise in the industry's technical level.
	Technical skills	Before the LSA standards were published, researchers had to handle hundreds of types of LED products, resulting in a lack of focus on R&D, which made it difficult for technicians to focus on certain standards to improve their skills. Since the introduction of standards has resulted in a reduction of the number of product types, R&D and professional training can be more focused and efficient.
Marketing/ Sales	Market influence	Reference to standards can be an effective means in advertising. First, as consensus-based standards, LSA standards specify product parameters and requirements clearly. By declaring conformance of its products with standards or with performance levels defined in standards, it is easier for customers to compare similar products and understand the quality level of a product on the market. Using standards in this way, can greatly help enterprises win a competitive advantage in the marketplace. Second, some companies use a " standard first " strategy. Chinawisest Technology Co., for example, has become a leader in its market segment by spreading standards to develop its market and using them to promote its products. Third, if companies participate actively in setting or rapidly implementing standards they can timely launch their new products, gain advantage in the competition with those non-standard products, expand their market share and market influence.

Business function	Operational indicator	Impact of standards
Marketing/ Sales	Customer confidence	Before standards were introduced, the market was confusing and products varied significantly in quality, making it difficult for customers to assess the quality of products. The introduction of standards can dispel customer doubts. The reason is that LSA standards are developed jointly by dozens of enterprises on a consensus basis. In addition, standards make the communication between suppliers and customers more efficient. Standards define specific requirements and performance levels for products which helps customer understanding and makes purchasing decisions much easier and faster. They also make it easier to conclude contractual agreements. Participation in standardization activities also improves customer confidence as it is seen as a demonstration of the enterprise's strength.

Table 7 – Impact of standards on manufacturers and suppliers

2) Impacts of standards on consumers

The value chain of the consumer segment is quite different from that of production (suppliers and manufacturers) and other business functions the most affected by standards. For consumers, the business function standards affect most is Use/Maintenance. The example of the consumer segment chosen in this study is the Lighting Environment Management Center of Shenzhen (LEMC), an administration institute affiliated to the Urban Management Administration of Shenzhen, which is responsible for lighting of the city and streets. As LEMC street lighting products are purchased by government, all procurement and routine maintenance are financed through public taxes. Standards used by LEMC generate both direct and indirect impacts on their key business functions (see **Table 8)**.

Business functions	Operational indicators	Impacts of standards
Use/ Maintenance	Financial expenditures	Before the LSA standards were published, HPSL (high pressure sodium lamp) was mainly used for street lighting. LSA standards make the replacement of HPSL with LED street lamps possible. This reduces costs for maintenance work and saves government expenditures. Moreover, the electricity consumption of LED street lamps is much less than that of HPSL under the same lighting circumstance, so expenditures are reduced.
	Resource consumption	LSA standards make the replacement of HPSL with LED street lamps possible. The average life time of LED street lamps is much longer than that of HPSL. Moreover, LSA standards ensure higher quality products, simplify the lighting system control procedures, and improve the interchangeability of LED street lamps. Consequently, many advantages for post-use maintenance are generated that result in resource savings such as time for maintenance, manpower and materials.
	Energy saving	LSA standards make the replacement of HPSL with LED street lamps possible. The average electricity consumption of LED street lamps is much less than that of HPSL. Moreover, if an intelligent controlling function were introduced in the street lighting system according to the LSA standards, secondary electronic savings would be possible and energy consumption would further decline.
	Environment	As mentioned above, the introduction of LSA standards helps reduce electricity consumption resulting in lower carbon emissions.
	Public satisfaction	LSA standards make the replacement of HPSL with LED street lamps possible. LED lamps have a unique feature of dimming which improves the lighting environment significantly, especially in environments with high contrasts between light and dark such as in tunnels. A LED lighting system can reduce the glare caused by altering between light and dark which is an effective way to reduce the number of accidents in traffic . A more secure lighting environment increases public satisfaction.

Table 8 – Impact of standards on consumers

8.2 Calculation of the non-economic benefits of standards

In the following we will review the non-economic benefits from the use of standards for manufacturers, suppliers in the LED-industry and for consumers.

8.2.1 Manufacturers and suppliers

Through interviews of senior managers and directors of the selected key business functions, the impacts of standards on key business functions have become clearer. Following an analysis and company-internal discussions, the interviewees provided estimations for the operational indicators by comparing the situation before and after the introduction of the standards as shown in **Table 9.** We would like to underline that these are estimations by the company representatives who were interviewed separately, but showed a significant degree of consistency. To use one example in order to explain the data in **Table 9,** company representatives were convinced that the impacts of standards developed by the LED-Alliance contributed significantly to the fact that the industry and key products had undergone a process of streamlining and estimated that the contribution of standards was around 60 % of the factors that together achieved these results.

	Business function	Operational indicators	Degree of impact	Explanation of the data
Manu-facturers & suppliers	R&D	Streamlining the industry	60 %	The estimated value given by different interviewees varies between 60 % and 80 %. For this reason, we have selected the minimum value of 60 %.
		Resource use	20 %	The estimated value from different interviewees is between 10 % and 30 %. This difference results from the fact that different products from different enterprises are included for which resources differ significantly. For this reason, we have chosen the average value.
		Skills of technicians	5 %	
	The total impact of standards on the R&D business function estimated by interviewees : 60 %			
	Marketing & Sales	Market influences	50 %	
		Customer confidence	100 %	Interviewees agreed that standards have a significant impact on customer confidence but that it is difficult to apply a numerical value. The percentage chosen is 100 %.
	The total impact of standards on Marketing & Sales business function estimated by interviewees : 50 %			

Table 9 – Calculation of the non-economic benefits of LSA standards

First, through interviews with enterprise staff, estimations of the contribution rate of each business function to the whole enterprise have been obtained. Second, the non-economic benefits of standards have been calculated by multiplying the estimated contribution of the business function to the enterprise by the impact of standards on the respective business function. Details are listed in **Table 10**.

Non-economic benefits of standards = ∑ (contribution rate of a business function) to enterprise × impact of standards on the business function)

	Business function	Contribution rate of the business function to the enterprise	Impact of standards on the business function	Non-economic benefits
Manu-facturers & Suppliers	R&D	35 %	60 %	21 %
	Marketing/Sales	40 %	50 %	20 %
	Total non-economic benefit of standards for manufacturers and suppliers : 41 %			
*Data from the estimation of interviewees				

Table 10 – Total non-economic benefits of standards for manufacturers and suppliers

8.2.2 Consumers

The Lighting Environment Management Center of Shenzhen (LEMC), the sample organization chosen for the consumer segment in this study is affiliated to the Urban Management Administration of Shenzhen and responsible for the lighting of the city and streets. All costs are paid through governmental expenditure. The impacts of standards on LEMC are generated in the process of replacing HPSL with LED street lamps according to relevant standards. For Shenzhen, the requirements are specified in SQL/LSA 001, SQL/LSA 003 and SQL/LSA 005. For example, performance and energy efficiency requirements of LED street lighting are defined in SQL/LSA 001 and interchangeability requirements in SQL/LSA 003. After installation, the lighting environment must be tested according to SQL/LSA 005, and also comply with relevant national standards. Only if all the conditions of the three standards mentioned above are satisfied, can the replacement be approved. The impacts of non-economic standards on consumers can be qualified by contrasting the situation of HPSL versus LED lamps. The calculation is done as follows :

- **Energy savings**

  Based on information from the directors of LEMC since 2013, 40,000 traditional street lamps have been replaced by LED

lamps according to standards. According to the calculation methods specified in **Annex 1,** this will bring an annual energy saving of 21,754×10^3 kW.h and an annual energy saving rate of about 54 %.

- **Governmental expenditures**
  In terms of 0.8 Yuan/kW.h, the annual electricity saving is 17,403.2×10^3 Yuan. Therefore, using standards to maintain the energy efficiency of LED road lamps results in an annual reduction in expenditure of 17,403.2×10^3 Yuan.
- **Environmental improvements**
  Improving the energy efficiency of LED road lamps through standards, not only reduces the power consumption, the emission of gaseous pollutants is also decreased, which is an environmental benefit. It is difficult to estimate the energy saving and environmental protection of the LED manufacturing process. For this reason, we have chosen to express the emission reduction by calculating the emissions from producing the amount of electricity that has been saved. The emission reduction rate is equal to the energy saving rate, which is about 54 %. Based on the power source structure of Shenzhen and the calculation methods detailed in **Annex 2,** the following result has been calculated : the annual CO_2 emission reduction is 12,943.29 tons ; SO_2 emission 98.77 tons ; NO_x emission 84.87 tons ; industry fumes and soot 41.21 tons.
- **Public satisfaction**
  Interviews with the public have shown that, due to the use of standards-conformant products, satisfaction with the illumination in public areas increased by around 10 %.

9 Evaluation of the results

Compared with other case studies, the contribution rate of standards to non-economic benefits is significantly higher. The main reason may be that standards can generate huge impacts on industries such as the LED industry in its early stages of maturity. As the LED industry develops, standards contribute significantly to the stability of the industry's structure and maturity. However, once the industry reaches a more stable status, the measurable impact of standards gradually decreases.

Concerning the methodological approach, the limitations can be expressed as follows:

First, most assessments of impacts have been based on best estimates by the participants in the assessments. Only for some cases could actual data be obtained and included in the calculations. To a large extent, estimates of participants are naturally influenced by subjective perception.

Second, data estimated by different enterprises show a significant margin of variance. It is sometimes very challenging to decide which estimates should be used to assess the impact of standards for a business function.

Moreover, the aspect of social responsibility covers the whole enterprise which is hard to assess separately as activities related to social responsibility are often embedded in the regular business functions of enterprises.

10 Conclusions

The quantification of the impacts of standards shows that LSA standards generate significant economic and non-economic benefits for the LSA-members as well as for the society as a whole. The amount of benefits generated differs based on the type of the LSA-member company and its position in the industry value chain.

For suppliers and manufacturers in the LSA, both of which are production enterprises, the R&D and Marketing/Sales business functions are those mostly affected by standards. Combined with the contribution of key functions, the non-economic benefits of standards on suppliers and manufacturers amount to about 41 %. This figure is based on estimations by LSA-industry representatives when interviewed about the importance of the business functions that were mostly affected by the standards and the degree of impacts achieved by the standards on these functions.

For consumers, end users and the society at large, the LSA-standards have a significant impact through standards-compliant products. Evident non-economic benefits were achieved in the area of energy and resource-savings and better environmental performance : The study showed that energy savings amount to 54 % ; CO_2 emissions are reduced by 12,943.29 tons annually ; SO_2 emissions by 98.77 tons ; NO_x emissions by 84.87 tons and industry fumes and soot by 41.21 tons. Interviews with the public have shown that, due to the use of standards-conformant products, satisfaction with illumination in public spaces increased by around 10 %.

The results of this study show that the impacts are significantly higher than those found in similar studies of other industries. One explanation is that a new industry may be affected by standards more significantly, especially in the early stage of its development. For the purpose of maximizing profits, enterprises take part in developing

and using consensus-based standards voluntarily, thus optimizing the industry's market structure and improving the industry's organization. These developments result in social benefits and in significant economic benefits for the industry players. Both types of benefits (economic and social) finally reach the consumers and end users in the form of lower prices, longer lifetime of the products as well as through environmental benefits in the form of energy savings and environmental protection effects of LED-products.

This case study shows that new industries like LED can significantly benefit from standardization in both economic and non-economic aspects.

Annex 1 : Calculation of energy benefits

Since the beginning of 2013, 40.000 street lamps have been replaced with LED lamps according to LSA standards in Shenzhen. Based on the assumption that the lighting time is 10 h/day, a comparison of annual power consumption of HPSL with LED road lamps is given below.

The rated power of general HPLS is 250 W, considering 10 % electrical appliances loss, the annual power consumption of each HPLS is :

a) A : Power consumption of single lamp per day :
250 W/lamp +10 % × 10 h/day = 2.75 kW.h/lamp

b) B : Power consumption of 40 thousand lamps per day :
40×10^3 lamps × 2.75 kW.h/lamp = 110×10^3 kW.h

c) C : Annual power consumption of 40 thousand lamps :
110×10^3 kW.h × 365 days = $40{,}150\times10^3$ kW.h

d) D : Annual electricity charges of 40 thousand lamps :
$40{,}150\times10^3$ kW.h × 0.8 Yuan/kW.h = $32{,}120\times10^3$ Yuan

To obtain the same lighting effect as 250 W general HPSL, the rated power of LED lighting needs to be 120 W. If we consider 5 % electrical appliances loss, the annual power consumption of one LED light is :

a) A : Power consumption of single lamp per day :
120 W/lamp + 5 % ×10 h/day = 1.26 kW.h/lamp

b) B : Power consumption of 40 thousand lamps per day :
40×10^3 lamps × 1.26 kW.h/lamp = 50.4×10^3 kW.h

c) C : Annual power consumption of 40 thousand lamps :
50.4×10^3 kW.h × 365 days = $18{,}396\times10^3$ kW.h

d) D : Annual electricity charges of 40 thousand lamps :
$18{,}396\times10^3$ kW.h × 0.8 Yuan/kW.h = $14{,}716.8\times10^3$ Yuan

Based on the calculations above, the power saving rate of LED lighting compared with HPSL is as shown in **Table 11**.

No.	Indicators	HPSL	LED lamps	Notes
1	Rated power(W)	250	120	
2	Actual power(W)	275	126	149 W saving
3	Power consumption of single lamp per day(kW.h)	2.75	1.26	1.49 kW.h saving
4	Power consumption of 40000 lamps per day(kW.h)	110×10^3	50×10^3	60×10^3 kW.h saving
5	Annual power consumption of 40 thousand lamps(kW.h)	$40{,}150\times10^3$	$18{,}396\times10^3$	$21{,}754\times10^3$ kW.h saving
6	Annual electricity charges of 40 thousand lamps (Yuan)	$32{,}120\times10^3$	$14{,}716.8\times10^3$	$17{,}403.2\times10^3$ Yuan saving
7	Operating cost (Yuan)	$32{,}120\times10^3$	$14{,}716.8\times10^3$	$17{,}403.2\times10^3$ Yuan saving
8	Energy saving rate			About 54 %

Table 11 – Power saving rate of 40 thousand LED instead of HPSL lamps

Annex 2 : Calculation of environmental benefits

Due to standards, the use of LED road lamps not only reduces the power consumption but also the emission of gaseous pollutants. Since it is difficult to estimate the energy saving and environmental protection effects in the LED manufacturing process, the method used to assess environmental benefits in this study is to calculate the carbon emission that would occur in the generation of the same amount of electricity that has been saved due to the use of LED road lamps, i.e. the amount of " emission reduction ".

From **Annex 1,** the annual electricity saving amounts to $21{,}754\times10^3$ kW/h and the energy saving rate is 54 %, when HPLS lamps are replaced with LED lamps. Data offered by China Southern Power Grid, the main electricity supplier of Shenzhen, reveals that since the end of 2012,

of the whole power structure under the Guangdong Province unified management, coal-fired power accounts for 56.54 %, hydropower for 35.48 %, pumped storage power 2.2 %, nuclear power 3.16 % and other 2.26 %. Among the whole power structure, hydropower and nuclear are clean energy, pumped storage power and other types can be considered negligible. Therefore, the focus for the assessment of environmental benefits is on coal-fired power. This means that 56.54 % (about 12.3×10^6 kW.h) of the saved $21{,}754\times10^3$ kW.h energy is from coal-fired power which has a significant influence on the environment.

The emission reduction is calculated by multiplying the power savings by the emission coefficient of coal-fired power,

Emission reduction = power-saving rate × emission coefficient of coal-fired power

The emission coefficient of coal-fired power, released by the Energy Research Institute of the National Development and Reform Commission, is listed in **Table 12**. The annual emission reduction rate generated by the LSA-standards is shown in **Table 13**.

	CO_2	SO_2	NO_X	Industry fumes and soot
Emission coefficient of coal-fired power (g/kW.h)	1,052.3	8.03	6.9	3.35

Table 12 – Emission coefficient of coal-fired power

Annual emission reduction (ton)			
CO_2	SO_2	NO_X	Industry fumes and soot
12,943.29	98.77	84.87	41.21

Table 13 – Emission reduction of 40 thousand LED instead of HPSL lightings

Annex 3 : Project participants

In addition to the individuals listed on the cover of this report, the following have participated in the project :

- **Member – Standardization Administration of the People's Republic of China (SAC)**
  - Mr. Li Dongfang, Standardization Officer, International Organizations Division
- **Members – Market Supervision Administration of Shenzhen Municipality (MSA)**
  - Mr. Tan Jianjun, Division Director, Standardization Division, MSA
  - Mr. Cheng Shengtao, Principal Staff Member, Standardization Division, MSA
- **Member – Shenzhen Academy of Metrology & Quality Inspection (SMQ)**
  - Ms. Li Jianhua, Test Engineer, Optoelectronic Product Laboratory, SMQ
- **Members – Shenzhen LED Standards Alliance (LSA)**
  - Mr. Huang Wei, General Manager Assistant, China Great Wall Computer Shenzhen Co., Ltd.
  - Mr. Luo Qiang, R&D Project Manager, China Great Wall Computer Shenzhen Co., Ltd.
  - Mr. Tang Tingrong, Director Assistant, Shenzhen Moso Power Supply Technology Co., Ltd.
  - Mr. Chen Hao, Product Manager, Shenzhen Moso Power Supply Technology Co., Ltd.
  - Mr. Wu Guan, R&D Manager, Shenzhen SED Baili Electric Co., Ltd.
  - Mr. Su Zunhui, Chief Engineer, Shenzhen Bang-Bell Electronics Co., Ltd.
  - Mr. Mao Zhouming, President, Chinawisest Technology Co., Ltd.
  - Mr. Wu Chunhai, Director, Shenzhen Lighting Environment Management Center

- **Members – Shenzhen Institute of Standards & Technology (SIST)**
  - Mr. Zhou Wen, President, SIST
  - Mr. Wang Ke, Deputy Director, Standardization Application Research Centre, SIST