



Economic benefits of standards



City Square Mall, Singapore

Country: Singapore

Project team:

Project leader: Dr. Lim Lan Yuan, Associate Professor, Department of Real Estate, National University of Singapore, Chairman of Technical Committee on Building Maintenance and Management

Deputy project leader: Mr Vincent Low, Vice-President, Business Development, G-Energy Global Pte Ltd, Singapore

Member: Mr. Anthony Goh, Deputy General Manager, Property & Facilities Management Division, City Developments Limited

Member: Ms. Barbara Bok, Senior Manager, SPRING Singapore

Member: Mr Nicholas Huang, Manager, SPRING Singapore

Member: Ms Kok Pei Shi, Undergraduate Student, Nanyang Technological University

ISO Central Secretariat advisor: Reinhard Weissinger, Manager, Research, Education and Strategy

Duration of the study: May – December 2012



International Organization for Standardization

ISO Central Secretariat
1, chemin de la Voie-Creuse
Case postale 56
CH - 1211 Genève 20
Switzerland
www.iso.org

© ISO, 2013
All rights reserved

ISBN 978-92-67-10618-2

Table of contents

1	Objective and organization of the case study	3
1.1	Objective	3
1.2	Methodology	3
2	Introduction to the selected standard	4
3	Introduction to the project	5
4	Background of City Square Mall	6
5	Attitude of the company towards standardization	7
6	Analysis of the value chain	8
6.1	Industry value chain	8
6.1.1	Planning, procurement and installation	8
6.1.2	Monitoring/Review	9
6.1.3	Maintenance	9
6.2	Key value drivers	10
7	Scope of the case study	10
8	Selection of operational indicators to measure the impacts of standards	11
9	Calculation of the economic benefits of standards	13
10	Qualitative and semi-quantitative considerations	16
11	Evaluation of the results	17
12	Conclusion	18

1 Objective and organization of the case study

1.1 Objective

The objective of this project was to carry out a company case study applying the ISO methodology to assess the economic benefits of standards in terms of energy cost savings. Focusing on one particular standard having a key impact, Singapore Standard SS 530:2006, the study aims to raise awareness on the importance of standards and standardization, and thus encourage greater stakeholder participation.

1.2 Methodology

The primary scope of the ISO methodology is assessing and quantifying the impacts of standards from the perspective of a selected company. We organised our assessment in this project in the following sequence:

Step 1: Understand the value chain¹⁾

Desk research was undertaken on the building services and equipment value chain for the building and construction industry.

Step 2: Analyse the value drivers and define operational indicators

Value drivers are crucial organizational capabilities for the success of each business function that forms the value chain. In this assessment, value drivers specific to the selected company are mapped for each business function of the value chain. In doing so, the value chain is analysed with the help of key operational indicators.

1) A value chain is a chain of activities. Products (or services) move through all the activities in a prescribed order, gaining value in some way at each stage of the chain. It was first described and popularised by Michael Porter in his 1985 best-seller, *Competitive Advantage: Creating and Sustaining Superior Performance*.

Step 3 : Identify the impact of standards

Once the pertinent value drivers and key operational indicators have been identified, the relevant standards are described and their impact on all activities of the business functions is mapped through a series of interviews with the organization's senior management.

Note: In this particular case study, the focus is given to one particular standard having a key impact, SS 530:2006.

In order to quantify the impact, an analysis was carried out to examine whether the impact on the financial performance of the organization could be measured after the introduction of the standard. The quantification was carried out on an annual basis; however, the impact projected spans over a 5-year period from the introduction of the standard after which the improved operations become an integral part of the company's normal operating procedures.

Step 4 : Assess and consolidate results

After quantifying the impact of different standards, the value creation of standards in each business function is aggregated and calculated against the profit of the selected company. Important qualitative impacts of the standards are also included.

2 Introduction to the selected standard

Singapore Standard SS 530:2006 "Energy efficiency standard for building services and equipment" provides minimum energy-efficiency requirements for new installation and replacement of systems and equipment in buildings. It covers the criteria for determining compliance with these requirements and applies to air-conditioning and heat rejection equipment, water heaters, motor drives and high efficiency lighting used in buildings.

3 Introduction to the project

The key objective of this project is to examine the energy saving impacts of SS 530. Initiated in May 2012, the project was led by SPRING Singapore in collaboration with City Developments Limited (CDL) and G-Energy Global Pte Ltd, with the guidance of the ISO Central Secretariat Advisor and the support of an intern from the Nanyang Technological University, Singapore. SS 530 was examined in the context of its use in a large retail building known as City Square Mall, owned by CDL.

As part of the nation's effort to raise environmental awareness and promote energy efficiency, standards such as SS 530 have been introduced in Singapore with a view to achieving greater energy conservation in buildings. These standards have been implemented and modified throughout the years following technological advancements. Published by SPRING Singapore in support of national efforts towards greater energy efficiency, SS 530:2006 is a revised edition of the former standard (SS CP 24:1999) that contributed to increased energy savings. Today, SS 530 is a regulated standard, adopted by the Building and Construction Authority (BCA), Singapore's governing authority for the construction industry. In January 2005, the standard was launched together with the BCA Green Mark Scheme, a green building rating system to evaluate a building for its environmental impact and performance. To encourage companies to participate actively in the scheme, incentives are given for new building projects that meet the stringent requirements. Different levels of certification (namely: Certified, Gold, GoldPlus and Platinum) are issued based on the extent of the environmental efforts put into the design of the building and its subsequent operation and management to achieve sustainability.

Air-conditioning takes up a huge fraction in the total energy consumption of buildings. Hence, in this project, occasional cross referencing has been made to SS 553:2009 "Air-conditioning and mechanical ventilation in buildings", a revised edition of a former standard (SS CP 13:1999) that provided detailed guidelines on the energy efficiency of air-conditioning in buildings. In the analysis of the economic benefits of SS 530, comparisons have been made to show the accumulated energy savings from the transition of the old codes of practice to the updated standards SS 530 and SS 553, and how these standards have been used as a stepping stone to propel the building industry towards higher levels of performance and efficiency.

4 Background of City Square Mall

City Square Mall (CSM) is located at the junction of Serangoon and Kitchener Roads in close proximity to the Housing & Development Board public housing estates as well as some private residential developments, a short distance from Singapore's city centre. It is directly connected via underpass to the Farrer Park MRT Station. CSM is one of the largest malls in Singapore with 700,000 square feet of gross retail space. The building comprises 7 retail levels (B2 to L5), an educational hub (L6 to L9) and 2 basement level car parks (B3 & B4). It houses over 200 retailers and operators spread across its seven retail levels. The total site area of CSM is 17,647 m² (189,956 sq. ft.) of which about 40% was designed "Green".

Owned and managed by CDL, CSM was designed to be a leading eco-friendly family mall. Working towards this vision, CDL made substantial efforts in ensuring environmental sustainability from the building's construction process and blueprinting of its features to its maintenance and management. Apart from housing a 49,110 square

feet urban park named City Green, designed to promote educational awareness about ecology and the natural environment, an intensive “Green” roof was also incorporated in CSM to mitigate the urban heat. The paramount view, greenery and the serenity together serve as an ideal recreational place for shoppers and consumers.

5 Attitude of the company towards standardization

As Singapore’s first eco-mall, CSM is fully dedicated to adopting conservation methods and achieving energy efficiencies. Singapore Standards such as SS 530 and SS 553 have been implemented in the building’s design and all core divisions and supporting operations, including CSM’s facilities management arm, conform to ISO 14001, *Environmental management systems*. In addition to conforming to ISO 14001, CDL’s property & facilities management division was also certified ISO 9001, *Quality systems*, and OHSAS 18001, *Occupational health and safety*, in 2010. In recognition of its leadership in the development of Singapore’s built environment, CDL is the first and only Platinum winner of the Built Environment Leadership Awards granted by BCA. CSM also became the first eco-mall to be awarded the Green Mark Platinum Award by the BCA.

The foregoing make CSM ideal for the case study analysis as the requirements of the Standards have been complied with and a higher building performance has been achieved.

6 Analysis of the value chain

6.1 Industry value chain



Figure 1 – Industry value chain

6.1.1 Planning, procurement and installation

An efficient building design is an important component to a good sustainable building owing to its great impact on the building's construction and operating costs. Before the construction of CSM, the orientation and building design was carefully analysed and simulated using a computerised software. Simulations enabled planners and designers to orientate the building along the North-South direction to reduce the absorption of solar radiation and thereby reduce the energy required to cool the building.

CSM was designed according to six concept considerations – Scale, Convenience, Ambience, Community, Value and Eco-Sensitive/Sustainable. Since the air-conditioning system is conventionally the highest consumer of energy for every building in Singapore, the plant system design and selection of equipment, piping, layout and configuration are set up so that the air-conditioning system operates at its optimal efficiency. Apart from the air-conditioning system, CSM also uses an energy efficient lighting system for the mall. The lighting and ventilation fans in lift cars are also engineered to automatically shut down during stand-by.

6.1.2 Monitoring/Review

Focusing on sustainability and energy efficiency, CSM has engaged G-Energy Global Pte Ltd to conduct energy monitoring using a remote monitoring system (RMS), to ensure that designed efficiencies are met and to identify possible areas for improvement. Early identification of problems in the system by RMS has reduced the cost of potential repairs or replacements.

6.1.3 Maintenance

CSM management recognises that preventive maintenance is a must for maintaining equipment efficiency. Consequently, and in view of the fact that the chiller plant is the major energy consuming system in the building, CSM has incorporated an automatic tube brushing system to regularly clean the chiller condenser tube during operation and maintain optimum efficiency of the chiller.

The building uses Siemens' Building Management System (BMS) for the management of its systems like Air Handling Unit (AHU) controls, lighting, fire safety, mechanical ventilation and lifts. BMS coordinates and organises all the information logically, and ensures that systems function automatically according to prior set-up. It also monitors and logs the performance trend of the chiller plant system for analysis purposes.

G-Energy Global Pte Ltd has also been engaged as the energy service company for the remote monitoring of the system, to ensure continuous optimal efficiency of the chiller plant. In the case where the plant does not operate within an acceptable range, the system acts as an early detection device, and the management is able to take immediate corrective action.

In addition to the computerised automation (i.e. BMS) installed, CSM has in place a regular preventive maintenance that includes the following :

- Monthly check and monitoring to ensure that the building and equipment operate at the most optimum level ;
- Quarterly checking of the accuracy of the sensors to ensure that the BMS is able to control the equipment so that it operates at its optimum level ; and
- Annual shut down to service the equipment (condition checking, cleaning, oil change) to ensure its optimum level of operation.

6.2 Key value drivers

Unlike many shopping malls, CSM is the first eco-mall in Singapore, which gives CSM a competitive edge. Due to the implementation of the BCA Green Mark Scheme and the regulation of SS 530, there is a higher demand for buildings complying with the scheme. Holding high platinum scores in Green Mark, CMS also achieves a higher rental value.

7 Scope of the case study

Key players/ Business function	Planning	Procurement	Installation	Monitoring/ Review	Maintenance
Manufacturers					
Suppliers					
Logistic service					
Technology service					
Human resource					
Financial service					

Figure 2 – City Square Mall’s value chain and key business functions

Figure 2 illustrates the relationship between CSM's value chain and the key business functions in the industry value chain. Although procurement, installation and monitoring cover a wider scope in relation to the industry value chain, the focus of this ISO case study is on the savings incurred from the building upon completion instead of the entire construction process. Henceforth, the project's scope focuses on maintenance as it is the operation the most affected by compliance to the standards discussed.

8 Selection of operational indicators to measure the impacts of standards

SS 530 covers the energy efficiency for the following equipment: air-conditioning, heat rejection, water heaters, motor drives and high efficiency lighting. Since air-conditioning is the most energy consuming among all the equipment in a building, it is used to illustrate the huge economical savings resulting from the implementation of standards like SS 530. Other indicators like water heaters and motor drives are not taken into consideration for the following reasons: 1) the lack of comprehensive data for monitoring and analysis, and 2) the energy savings derived as a result of implementing the standards are not significant due to the equipment's low energy consumption compared to the building's overall energy consumption. The following **Table 1** illustrates the minimum requirements for chiller plant efficiencies for both CP 24:1999 and SS 530:2006.

		CP 24	SS 530	
Equipment type	Size category	Min. efficiency *	Min. efficiency *	Test procedure
Air cooled, with condenser, electrically operated	< 527.5 kW	2.70 COP	2.8 COP	ARI 550 (Centrifugal / Rotary System)
	≥ 527.5 kW	2.50 COP		
Air cooled, without condenser, electrically operated	All capacities	3.10 COP	3.1 COP	ARI 550 (Reciprocating)
Water cooled, electrically operated, positive displacement (Reciprocating)	All capacities	3.80 COP	4.2 COP	
Water cooled, electrically operated, positive displacement (Rotary screw and scroll)	< 527.5 kW	3.80 COP	4.45 COP	
	≥ 527.5 kW and < 1055.1 kW	4.20 COP	4.9 COP	
	≥ 1055.1 kW	5.20 COP	5.55 COP	
Water cooled, electrically operated, centrifugal	< 527.5 kW	3.80 COP	5.0 COP	ARI 550 (Reciprocating)
	≥ 527.5 kW and < 1055.1 kW	4.20 COP	5.55 COP	
	≥ 1055.1 kW	5.20 COP	6.10 COP	
* The chiller equipment efficiency requirements do not apply for chillers used in low temperature applications where the designed leaving fluid temperature is less than 4.4°C.				

Table 1 – Chiller plant minimum requirements for respective standards

In **Table 1**, comparisons made between CP 24 and SS 530 clearly illustrate an improvement in energy efficiencies, (as seen from the Coefficient of Performance (COP) due to the implementation of the

standards. This lower energy consumption from the use of more efficient chillers translates into lower electricity bills and thus cost savings for the user.

However, having a highly efficient chiller alone does not necessarily equate to cost savings. It is imperative to also look at the plant system design/performance as a whole (cooling towers, chillers, chill water pump (CHWP), condensate water pump etc.) for optimal efficiency. For instance, the installation of auxiliary equipment such as variable speed drives for CHWP and AHU, variable air volume for Fan Coil Units (FCU) improve the overall system performance and lower energy consumption.

9 Calculation of the economic benefits of standards

CSM is used as a case study to illustrate the potential economic benefits of implementing standards like SS 530.

Figure 3 hereafter shows the tonnage profile of the entire CSM building from 0800 hrs. to 2200 hrs., which are the standard operating hours of a mall over a period of 2 weeks. It is observed that the average tonnage is approximately 2300 ton.

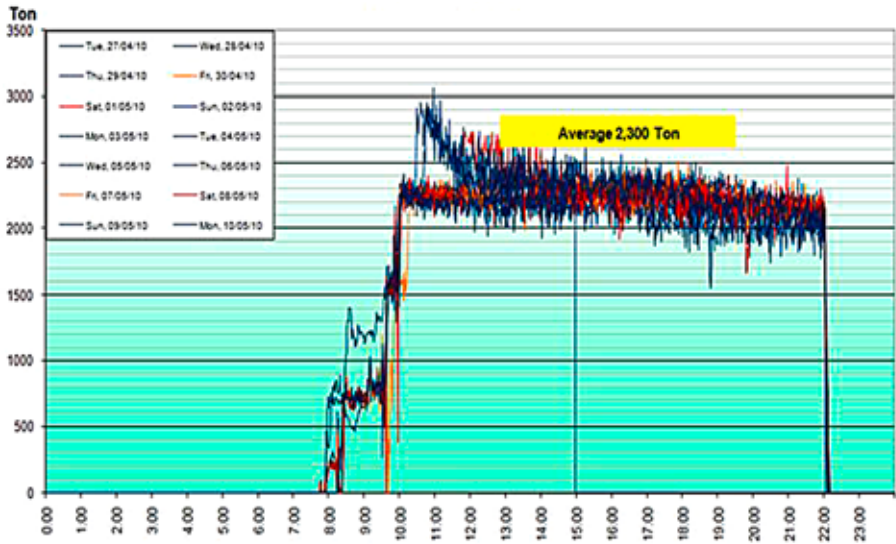


Figure 3 – Building tonnage profile of City Square Mall

For water-cooled and electrically operated, centrifugal chillers ≥ 1055 kW which CSM is using, the minimum efficiency requirements based on CP 24 is 5.20 COP (= 0.676 kW/RT) and 6.10 COP (= 0.577 kW/RT) based on SS 530. Assuming a 14-hour operation period with an average of 2300 Ton, the projected electrical consumption for CSM is 7.95 million kW/year and 6.78 million kW/year based on CP 24 and SS 530 respectively. This roughly translates into cost savings of more than \$320,000 a year for CSM, due to the adoption and implementation of standards like SS 530 using CP 24 as a benchmark. In fact, CSM exceeded the requirements of SS 530 by complying with BCA's Green Mark requirements, which are more stringent. CSM managed to achieve an efficiency of 0.48kW/Ton for its chillers, which translates into an annual cost savings of more than \$630,000. **Table 2** hereafter shows a summary of the comparisons between CP 24, SS 530 and the actual readings on-site.

	Air-conditioning equipment		
	CP 24	SS 530	Actual on-site
Minimum efficiency requirements	5.20 COP = 0.676 kW/RT	6.10 COP = 0.577 kW/RT	0.484 kW/RT
Total energy consumption (kWh/year)	7,945,028	6,781,484	5,641,440
4 th Qtr. 2012 tarif rate (high tension)	\$ 0.2752/ kWh*Taken from SP services Pte Ltd		
Electricity bill (\$/year)	2,186,471.71	1,866,264.40	1,552,524.30
Potential annual savings	Benchmark	\$320,207.31	\$633,947.42
Savings (in %)	-	14.64 %	28.99 %

kW = kiloWatts, RT = Refrigeration tons

Table 2 – Comparison of various parameters between respective standards

From **Table 2**, we observe that, by implementing SS 530, CSM is able to reduce its electricity bill by 14.64 %, reaping economic benefits of more than \$320,000/year. A savings of 29% was achieved in actual fact, due to its compliance to Green Mark criteria.

Although it is undeniable that higher efficient chiller plants are more expensive, it makes economic sense to go green as the economic benefits outweigh the capital cost. Comparisons are made in

Table 3 hereafter, illustrating the potential economic benefits reaped as opposed to the increase in the capital cost incurred.

Based on HVAC supplier “Trane”, for a 800 RT chiller plant, the costs are as follows :

CP 24	Chiller 800 RT efficiency : 0.676 kW/RT = S\$ 470/RT
SS 530	Chiller 800 RT efficiency : 0.577 kW/RT = S\$ 489/RT

	Air-conditioning equipment	
	CP 24	SS 530
Minimum efficiency requirements	5.20 COP = 0.676 kW/Ton	6.10 COP = 0.577 kW/Ton
Cost of equipment (based on 4 units of 800 RT)	\$1,504,000	\$1,564,800
% difference in chiller prices	Benchmark	4.04 %
Potential annual savings (%)	Benchmark	14.64 %
No. of months for ROI	–	2.5

Table 3 – Cost comparisons and return on investment (ROI) for implementing SS 530

Table 3 shows that, despite the increase in capital cost of 4 % due to SS 530, there are potential annual savings of 14.6 % due to lower energy consumed. Using CP 24 as a benchmark, the return on investment in more efficient chillers due to implementation of SS 530 is about 2.5 months.

10 Qualitative and semi-quantitative considerations

Energy-efficient equipment generates a high performance level which in turn creates a more comfortable environment for the occupants of the CSM building. With the installation of energy-efficient equipment, less energy is required to keep them running. As a result, the physical damage imposed onto the natural environment has been reduced. Further environmental efforts and building features installed for the public such as the sky park also increase the public's environmental awareness.

11 Evaluation of the results

Although potential annual savings due to the implementation of SS 530 through the selection of a highly efficient chiller can be reaped, it must be coupled with proper system design, system configuration and constant monitoring of system performance. Chillers, together with condenser pumps, chill water pumps and cooling towers, form the entire air-conditioning system. Improper configuration and operation of the system will result in an adverse effect, even with the use of highly efficient chillers.

The air-conditioning system of CSM is designed to provide comfort levels of indoor temperatures ranging from 22.5°C to 25.5°C and relative humidity <70%. CSM uses variable speed drives to regulate fan power in response to cooling demand on the air handling units. For the fan coil units, the fans are driven by a step-less DC motor that allows for variable airflow with speed modulation. In addition to the efficient chiller plant system equipment, CSM further optimises the air-conditioning plant's operating efficiency by adopting strategies such as maximising the condenser evaporative area with additional

cooling towers. These measures allow CSM to achieve an overall improved air-conditioning system of 0.637kW/RT, which meets the more stringent Green Mark requirements required by BCA.

12 Conclusion

The air-conditioning system was chosen for the main focus of this case study and was highlighted as the building's main operational indicator as it is conventionally the highest consumer of energy for every building in Singapore, including City Square Mall. Despite the increase in capital investment for the purchase of higher efficiency chillers, the potential savings from consuming less energy justifies thoroughly the benefits of adopting and implementing standards such as SS 530, although factors such as plant system design, layout and configuration must also be taken into account. Chillers should not be viewed in isolation as these key factors play a role in ensuring that the air-conditioning system is operating at optimal efficiency and performance.

