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A Study on Green Industry Project Construction Experience

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Abstract: China is s faced with a heavy pollution issue while industrialization process. Millions of manufacture factories had been built every year discharging waste water, exhaust gas and useless solid material. Construction industry as one major polluted source was focused by China government more and more. Green building solution was encouraged to use for all types of building in last five years. But finally only 1% manufacture plant had been built following green label standard due to less of incentive policy and self-motivation. Most plant owners who are facing severe competition and survive pressure in China market do not willing to spend money and time for environment protection.

This paper summarizes a case study on an industrial project in China. Buildings in this project obtained both China 3 stars Green Building Label and US LEED Platinum (office) & Gold (factory) Certificate. The author involved in whole practice wishes to share experience from planning, design, construction, commissioning to operation process. Base on characteristics of factory building, an appropriate green building developed strategy is evidently helpful for green practice to balance performance, investment and payback period.

Key words: Integrative process; Portfolio, Commissioning

1. Introduction

China now becomes a real world manufacture centre with huge capacity on multiple products. Year by year, millions of manufacture factories had been built all around country (550M SQM factory was built in 2015).

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Meanwhile, the pollution during the production process heavily influenced human living environment and sustainable development of the industry. Since 2015, the green development had been affirmed as one of five main strategies by China government and construction industry as one major polluted source was quite focused. The green building concept had been adopted broadly and the number of projects rapidly increased in the last 5 years. By the end of year 2016, 4221 projects got Green Label certificate but only 44 of them were industrial projects. The reason is not only because less of incentive policy but also complicate production environment in different industrial sectors.

Located in Xi'an High-tech Industry Development Zone (XHTZ) with a total construction area of 50,000 square meters occupying 190 Mu of land, BlueScope Buildings (Xi'an) Co. Ltd. consist of Admin office, manufacture plant, ancillary office, and raw material warehouse that all were built of steel structure was under construction from May 2012 to June 2013 then fully operated since July in the year. The project was successfully achieved all construction targets especially on green feature. It achieved LEED Platinum certification for Admin office and LEED Gold certification for the workshop. Meanwhile it became first 3 stars green design label in China and green demonstration project by Ministry of House and Urban-Rural Development of the People's Republic of China (MOHURD). Furthermore the project certified as Green Construction demonstration project in 2013 and Green innovation award in 2015 by MOHURD again.

The project has very outstanding feature to realize entire green process which can rarely find among most green projects. It needs set a green target in pre-design stage, executed through design and construction, enhance commissioning by third party, operated with data collection and monitor system. With around RMB 10M incremental green cost, more than twenty green techniques selecting by owner, consultant and design institute was implemented. As calculation, the incremental investment can be returned back within six years. The below content in this article will give you full penetration of this project case.

1. Economic Target

As a manufacture company, it is priority to control the investment tightly to achieve lower cost base for future factory operation. Even consider to achieving higher green level, the project team chose every technique carefully above bottom line which its return period should be less than eight years. Meanwhile one "Cost and Benefits" model was used to help on decision making, e.g. see Figure 1. It identifies right sequence from bottom to top visually which should use passive technology as priority, then active technology. And the renewable energy should be used rarely because big investment and relative small return. For instance, improving building envelope performance which belongs to passive technology only cost little money but can get quite huge improvement on energy saving.

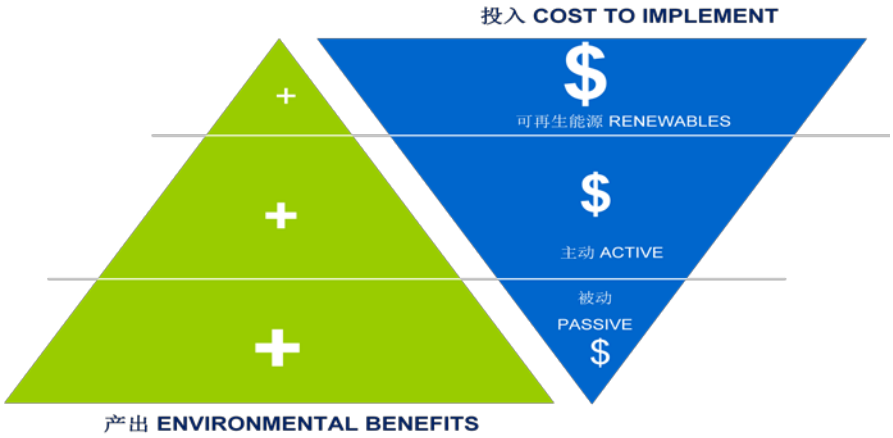

Figure 1 Environmental Benefit vs. Cost to Implement

2. Environmental Protection

Minimum environment influence from production process is a basic requirement for green plant. The project team needs to identify any small pollution possibility caused by solid waste, water discharge, and exhaust gas emission. In this case, the solid waste such as steel scrap was stored in a special shed which far from production area and sold to third party for recycle purpose. The waste water only comes from worker's shower room was collected, filtrated and disinfection in a set of containers. The recycle rate was calculated as 42% yearly. The exhaust gas causing by welding and painting process was gathered and burnt in a special container to achieve national gas discharge standard. Any environment incident will be reported monthly to senior leader team of the company.

3. Social Commitment

To realize sustainable development, corporate social responsibility will be final measured by social community. A big residential community just locates cross the road of this project. The equipment noise could heavily influence people's life as well. So the project team had to identified the noise source and put it as far as possible from inhabitant at schematic design stage. Then the master plan can be laid out properly even the gate of factory can't face to residential building. Internally, the noise can also hurt the hearing ability of the workers in the long period. Certain noise reduction action had been taken such as perforated panel on the ceiling and rubber padding block under the equipment.

2. Methodology

1. Integrative process

Integrative planning involves group people who expert in different aspects can maximum opportunity for cost effective adoption of green design and construction strategy, emphasizing human health as a fundamental evaluative criterion. Conclusion from this practice, any project should identify the main resource consumption in production activity and the local characteristics include weather condition, local plant and material resource, etc. The diversity of the team members did support to discover more synergy strategies and review carefully on trade-off strategies. Thus the negative impact was eliminated from whole green portfolio. For instance, good day lighting design will cause more indoor heat and glare.

1.1 Water Efficiency

Rain water collection and bath water recycle techniques are both used in this project. Rain water is free and clean resource can generate from factory's roof which is large enough normally. The bath water is more stable source relatively to fill in the tank. In the design, two kinds of water are collected separately but come together used for irrigation and some cleaning purpose. As synergy strategy, rain water collection can help to reduce runoff volume and make water balance on site. The water collected from bathroom need be purified with recycle facility cost little but reducing the waste water discharge to environment. Meanwhile all water used for landscape, irrigation, and cleaning purpose can contribute on cost saving, more important to save precious natural water. The whole water collection system in the factory with recycle concept can be described as below picture, e.g. see Figure 2.

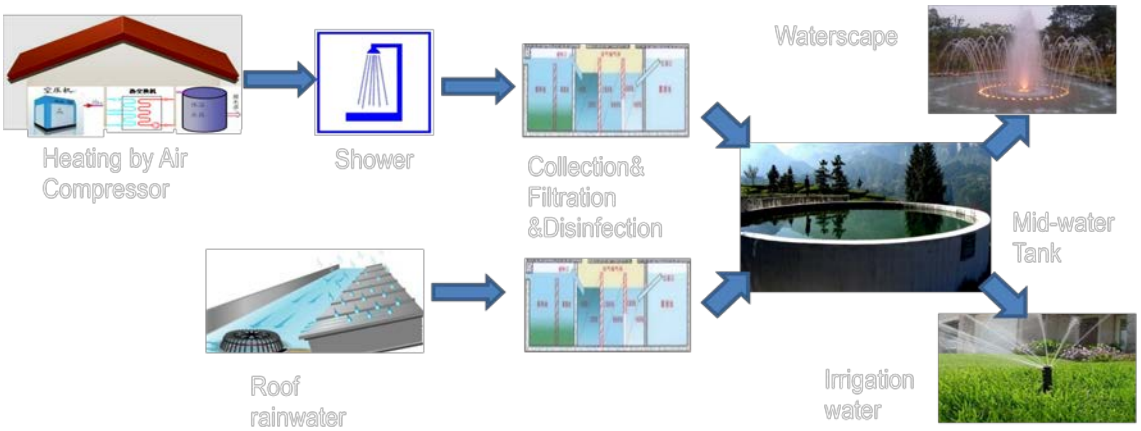

Figure 2 Water Recycle Process

The figure also shows the shower water is heated by waste heat generated from equipment during the manufacture process. There is a good synergy to reduce both energy consumption on heating and heat emission to the atmosphere at same time.

1.2 Air-condition System

Ground source heat pump system had been selected based on good test result of the site soil. The struggle issue is what kind of air-condition system should be fitted for admin office around 6000 SQM. Variable Air Volume system was suggested by consultant company as new popular solution for energy saving. VAV system could adjust the supply air volume automatically according to the indoor heating and cooling load that can save AHU power consumption during partial load time and to control the temperature of each zone separately. The main weakness is also very obviously for this system include system noise, less of fresh air and bigger initial investment on equipment. Fan Coil Unit is another choice as traditional way design for office which can be controlled by occupant with different comfortable sensation. The problem is higher maintenance cost on complicate FCU system and condensation at air outlet. The expert group, owner and design institute had strong debate on these two systems. Finally FCU plus fresh air system was chosen consider the office is a open space without big heating or cooling load variation at working time since office staff usually start and end working at same time. Furthermore FCU system can save initial investment tremendously, easy to find maintain resource in a manufacture factory and condensation can be avoided if package the insulation well on the pipe system.

1.3 Energy Saving Portfolio

Air condition optimization is main part in energy saving pie in most projects. The other energy saving strategy, however, should not be neglected in green building design. Up to 40% energy saving target was made in this project, thus the project team needs define contribution from building envelope, glass of windows, exterior and interior lighting, day light control, variable frequency drive pump, heat recovery and solar water heating system. Some strategy even only counts less than 1% but still used to accumulate to big proportion, e.g. see Figure 3. The energy simulation model was built in Designbuilder software indicating the separate saving percentage of heating, cooling, lighting, and power system. In practice, the designer and consultant always prefer to choose new technology, product and material. The owner especially for manufacture industry, need balance on additional cost with the real benefit output.

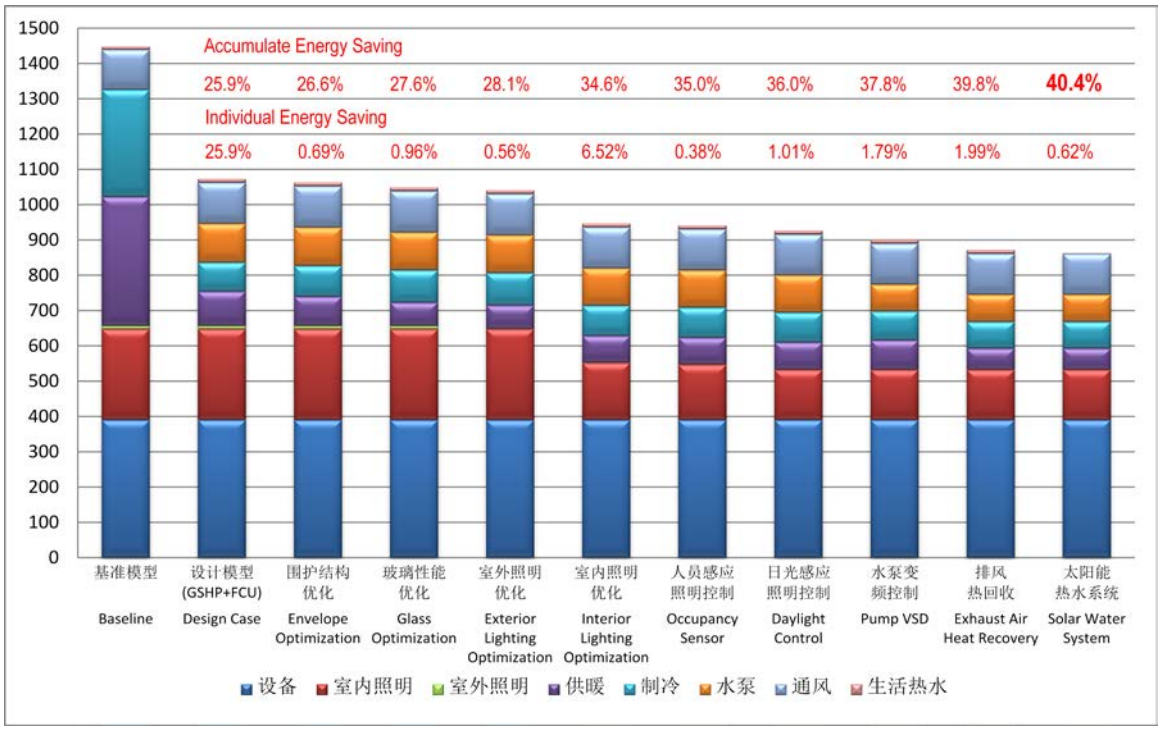

Figure 3 Energy Saving Contribution by Green Strategy

2. Constrction and Commissioning

Construction to realize all design intent is not easy especially for green technique. That's why only around 5% projects will get green operation label award after got design certification. Generally it is many and miscellaneous trifles job and could lead to even schedule delay. In this case, a small green construction office had been established on site to focus on daily green job. Most construction supervisors were trained several times on relative green knowledge before construction commenced.

Commissioning classified as fundamental and enhanced commissioning stages. Normally the fundamental commissioning will be done right after construction but enhanced commissioning need invite third party to complete by experienced people. An enhanced commissioning contract was signed which covered air-condition, electricity, pipe system, pump, envelope, training, etc. It allows the commissioning authority can involved in design and construction stage to deep understood project requirement.

2.1 Environmental Site Assessment

Many construction sites may contain contaminants that could harm the health and well-being of future occupants. It even will damage company reputation and devaluate the land when the factory needs to be sold to others with unexplained contaminants issues. The soil and underground water was sampled and sent to certified laboratory in Shanghai for testing. Unfortunately the hexavalent chromium was detected at that time in the underground water at South-west corner of project land. Meanwhile approximately 6 m2 oil stain area was found at North-east portion. Then the phase Ⅱ environmental assessment needs to be implemented with 12 wells to pick more soil and water sample in different portion of the land. The purpose is to identify the distribution map of heavy metal.

The treatment process last about 3 months to fill clean water through the wells to dilute the concentration of the contaminant. The monitor data shows the chromium concentration was dropped but rebound again after stop water filling. The project team decide to leave this corner out of the boundary and keep monitor well for future action. The oil contaminated soil around 4 meters deep was evacuated and treated by a licensed hazardous waste treatment vendor.

2.2 Construction Management

The construction activity not only produces light pollution and noise to neighbouring property but also make soil erosion, waterway sedimentation and airborne dust on site itself. The green construction plan has been made in advance by green construction office and many new initiatives were created during brainstorming meeting among owners, construction team, design institute and consultant. For example, the site discharge pipe system used to be laid down at last. Now it becomes first step of construction to ensure it can used for site rainwater and domestic sewage management during construction period; the temporary landscape and waterway can better control raising dust, e.g. see Figure 4; the waste material was gather by different category, e.g. see Figure 5; the proper boundary wall and buffer zone were set up to control the mud fluid. Especially the construction road was built as same standard as formal factory road without surface course. The road surface will be final paved after most construction activity completed. The new method reduces solid waste when the temporary construction road is demolished as traditional way. With same methodology, the temporary construction office right locates on storage yard of the factory. The ground of the office had been built according to heavy load storage standard at beginning to avoid reconstruction. Moreover the construction team can save cost both on abolish temporary road and waste material recycle.

Figure 4 Temporary Plant and Waterway

Figure 5 Waste Material Collection

3. Operation Management

At operation stage equipments need to be well maintained to keep running well to generate return to owner. A small green facility group is responsible for observing parameter and recording the daily data in this project. They can monitor any problem happen tracking by a data collection system covering every meter which can transfer data automatically. On the other hand, occupants training for behaviour change will become headache and long term job by this group. In real case, people open the windows as while as using the air-condition system; use electrical lighting when it is sunshine. So the actual performance results of green building maybe far behind the design objective if don't focus on daily operation management in detail.

3.1 Indoor Environment

Like most factory air-condition was not installed in the manufacture workshop. To avoid high temperature in summer and too cold in winter, the envelope design becomes very important part. The project team use reflection painting on the roof to reflect sunlight and also use 150mm thick fibreglass insulation to reduce heat penetration at day time. Hard thermal block was used at everywhere when insulation was compressed due to fixing on structural components. The windows and a small piece of curtain wall was tested to meet coefficient of heat transfer lower than 1.8. Actually natural lighting skylight on the roof was used for interior day lighting instead of setting more windows on sidewall.

Two temperature meters were installed both inside and outside factory to measure the actual temperature difference. The statistic shows the highest indoor temperature was 32.5 degree while outdoor is above 42.7 degree in summer, e.g. see Figure 6. It's quite successful result since 33 degree is critical point that people will be sweaty and influences their working efficiency as while. To provide comfortable indoor working environment was another basic task for green industrial building.

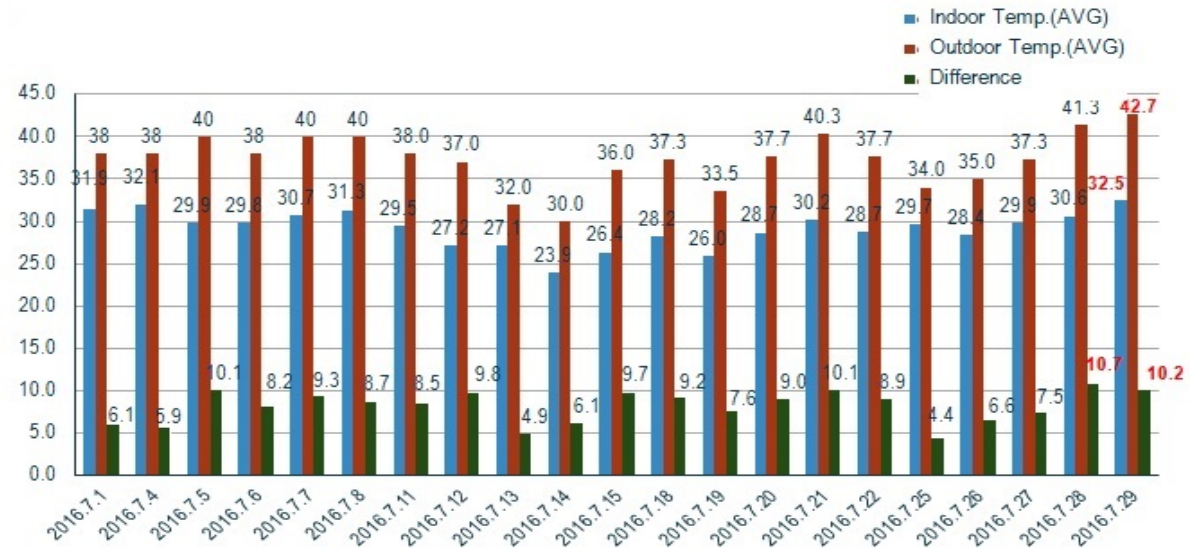

Figure 6 Indoor and Outdoor Temperature Difference

3.2 Data Collection and Analysis

Both building-level and system-level metering system was constructed and working continuously to collect operation data in this project. All data was sent to specified computers and synchronously show on monitor screen. The system can also generate daily, monthly and annual report as required. Any leakage or damage issues will be identified quickly by facility maintenance team base on abnormal data. It also provides possibility for the team to find system bottleneck and opportunity to improve performance continuously. For instance, the team member found the difference in temperature of supply and return water of air-condition is not as big as design. It lead to indoor temperature can't drop quickly in hot weather. Then the issue was delivered to maintenance team and supplier to figure out solution.

3. Conclusion

Life cycle concept of green building runs through design, construction, commissioning, operation, and demolish stage. This project case introduced here had experienced entire journey to realize high standard green industry factory sample in China. The initial building investment increase around 9% but owner will get quick return and tremendous potential benefits during the building life cycle such as people with good feeling of working environment will be more innovative and efficient on their job. Meanwhile it can sufficiently prove the corporate social responsibility and support for sustainable development in near future.

Green building practice is not difficult but need consider in every detail. The success for this project is mainly by two reasons: The project team set green target at very beginning and interactive each other to choose suitable strategy and technology to approach cost-effective and better performance green building; green vision and strong executive ability of project members is another engine that make all conception in design drawing comes true.

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