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Subject:	Sustainability/Green/Energy
Keywords:	Energy Conservation Energy Efficiency Integrated Design Project Management Sustainability Certification
Publication Date:	2013
Original Publication:	International Journal of High-Rise Buildings Volume 2 Number 2
Paper Type:	1. Book chapter/Part chapter 2. **Journal paper** 3. Conference proceeding 4. Unpublished conference paper 5. Magazine article 6. Unpublished

International Journal of High-Rise Buildings
June 2013, Vol 2, No 2, 93-96

International Journal of
High-Rise Buildings
www.ctbuh-korea.org/ijhrb/index.php

Meeting the Energy Reduction Goal on a High Rise Building thru IPD Framework

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Abstract

Greenhouse gas emissions and excessive energy consumption have been an on-going world issue nowadays. We can find that the majority portion is caused by high-rise office buildings. In order to resolve these problems, it is extremely important to implement various active or passive strategies in a building design. To successfully meet these design goals and energy reduction approaches, a project building must utilize an efficient design process from the early start. One of the most effective project delivery process called Integrated Project Delivery (IPD) will be implemented in a case study project building (KEPCO) during design phase and show how important it is to plan a project's green environmental performance goal together through an early collaboration from all key project participants, which helps to construct an successful green building design without any critical construction pitfalls.

Keywords: Integrated Project Delivery, IPD, Integrated design, Energy reduction, LEED

1. Introduction

As of today, one of our worldwide top priorities is to make effort in reducing energy consumption and greenhouse gas emission in construction business. Due to the rapid urbanization we see in the world, the proportions at which the buildings consume energy are equally increasing on global scale. As a practical method to achieve energy efficiency, it is crucial to plan a project's green environmental performance goal together through an early collaboration and to establish a consistent and accurate communication process for all parties involved.

In this paper, an effective project delivery process which can lead to energy efficiency for high-rise buildings will be introduced through a case study on "Korea Electric Power (KEPCO)" project headquarters building.

2. Project Status

The corresponding project's previous headquarters building, located in Seoul, had an energy consumption rate of 304 kwh/m^2 per year. The relocation of the headquarter building to Naju City, as seen in Figure 1, gave the developer an opportunity to establish and implement new guidelines for its building. One of the key goals of the Owner's Project requirement was to implement 50% energy reduction compared to the previous headquarters building in addition to achieving domestic and international Green building certification whilst complying with related local laws and regulations.

3. Integrated Design Process

The essential key to a successful start of any green buildings design is getting the architects and the engineers to approach the project thru cooperation and to agree to

Figure 1. KEPCO HQ Project Rendering.

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have series of discussions to establish common goals. This Integrated Design Process allows for the design team to meet the owner's requirements and achieve each discipline's specific design goals. However, often times it is nearly impossible to carry the cooperative working environment throughout the entire building design and construction phase when implementing green buildings, particularly through the traditional linear business structure/process, Therefore, our project adopted an Integrated Project Delivery (IPD) process to maintain and deliver our design goal.

4. IPD Introduction

Integrated Project Delivery is a project delivery method proposed by AIA (American Institute of Architects) to overcome the constraints arising from the traditional construction process. Mainly due to the work scope specialization, each discipline tends to bring limited perspective to the table and achieving collaboration throughout the life cycle of the project is often costly and time consuming. The IPD process unifies all key participants such as the owner, architects, engineers, constructors into a single team and offers guidance to the members until the end of the project. As seen in Figure 2, the main difference between the IPD and the traditional project delivery method starts from the early stages of design. In an IPD, architects, engineers and constructors attend these preliminary meetings to share each other's opinions on the design proposals and to establish a communication protocol throughout the life cycle of the project. Establishment of this particular working environment is conducive to meeting project goals and eco-friendly goals can be defined and successfully implemented at the end. Although the work load may increase at the initial phase, IPD process has shown that the negative cost impact events such design change due to missing information or field conflicts, can be avoided and thus save overall project cost.

In a typical design process using a traditional top-down method, an architect designs the building often with limited regard to the mechanical and the electrical engineering needs, and thus deprive the engineers an opportunity to efficiently implement energy performance goals. Whereas in an IPD process, engineers and sustainable design consultants are given the opportunity to give feedback to the architects and to share each disciplines impact resulting from any architectural approach.

As an outcome to this working relationship, more opportunities can be obtained to implement green building features. For example, usage of solar and wind energy can be increased at no cost increase through the building's proper placement on its site, based on its orientation. Also summer cooling load or winter heating load can be decreased by taking advantage of surrounding area. For example, placing the building next to trees can block out radiant energy from the sun to decrease the cooling load in the summer. But it limits the passive heating in the winter, and thus increasing the heating load. Thorough analysis of the site and its climate condition, will give a clear direction to the tree's impact to the building.

Thus, IPD is essential to the design team members as it facilitates greening of the design during the design phase and it maintains the working structure to allow passive design elements to be incorporated thru engineering and architectural analysis.

5. Owner's Requirement

The goal of this project is to achieve 50% energy reduction compared to the previous headquarter building as well as satisfying LEED Platinum certification, Green Building Certification (Korean Green Building Certification), and all other energy-related local laws and regulations. Other than meeting these eco-friendly performance goals, the building must maintain its function as a Headquarter building for energy related Corporation.

6. IPD for KEPCO HQ

In order to achieve owner's project requirement, architects, facility engineers, energy simulation experts, constructors, engineers from other fields, and consultants for

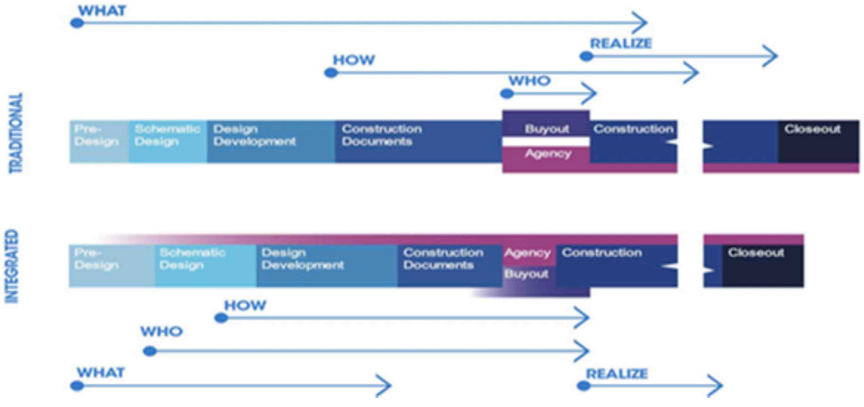

Figure 2. A working Definition - Integrated Project Delivery; AIA National & AIA California Council.

various eco-certifications were involved in the early stages of design. To increase the communication efficiency with each member, the corresponding team members were housed in the same office.

LEED certification, founded by United States of Green Building Council (USGBC), is a green building certification system currently used worldwide as an objective and quantitative indicator to verify an eco-friendly building. There are 5 categories emphasized within the LEED certification system; Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials and Resources, and Indoor Environmental Quality. Among these categories, Energy & Atmosphere has the largest proportion. Thus, it is not an overstatement when we say energy saving is the most essential element when pursuing a high level LEED certification rating.

In addition when targeting the highest LEED certification rating, besides maximizing energy performance, making correct and efficient decision on related requirements among all project participants is critical. By having all members in a single office, implementing LEED elements into the design was much more conducive. By blending LEED requirements into the IPD work frame, we were able to plan out and anticipate critical construction pitfalls while still meeting the energy reduction goal set forth by the owner.

7. Climate Analysis and Design

When maximizing the energy performance, it is important to analyze the site's climate first during the early design phase to identify passive strategies. When we analyzed the project's region, located at Naju city, the midterm average dry-bulb temperature was 15.15°C, wet-bulb temperature was 10.8°C, and relative humidity had a range of 37~75%; typical of a temperate climate zone. It also showed fairly good amount of potential to take advantage of diurnal temperature in swing seasons. Moreover, Natural ventilation was highly desirable since the region had a large number of hours in usable condition, mainly coming thru north-east and south-east wind direction. Also, the building's bearing placement of south-east 7~9° was determined to be reasonable for maximizing daylight luminance. In the case of potential direct daylight power, an average of 349 W/m^2 was possible for photovoltaic power production. It also showed the potential wind power generation of 3,081 hours per year with a wind velocity time range over at least 3 m/s. In addition, geothermal heat pump was found to be highly desirable through a soil temperature analysis as the result showed that a constant temperature of about 16°C was maintained at over 7 m in depth all year-round.

Based on the climate characteristics, the key passive and active strategies that we decided to implement were natural daylighting with sensors, geothermal source radiant panels, geothermal heat pumps, central VAV air handling units, highly efficient electric chillers, pumps with VFD, and LED lighting, building integrated photovoltaic panels, roof mounted PV panels, solar thermal water heaters, wind turbines utilizing building's exhaust air, night purge operation, natural ventilation induced from air shafts, and daylight ducts. All of the major green design attributes implemented on KEPCO project headquarters building are seen in Figure 3.

In addition, instead of using conventional district heating for cooling and heating thru absorption machines system per local regulation, we were able to demonstrate superior performance of our building and get an exception to the rule.

Thru energy modeling using EnergyPlus program, we anticipate the total energy use of 68 kWh/m^2 year, which is a 52% reduction over ASHARE 90.1-2007 standard. In addition this figure is a 77% energy reduction over previous Headquarters building, far exceeding the owner's minimum requirement of 50% reduction.

8. LEED Program and IPD

These results were possible through our adoption of IPD and retaining the working structure thru the pursuit of LEED certification.

In order to successfully implement LEED requirements, a LEED facilitator with sufficient experience and knowledge has to convey the owner's project requirement (OPR) on the project design by actively managing the designers from the start of design phase, thereby limiting unnecessary design changes and its consequential impact. This allows for the group to stay focused.

As for our project, our adoption of IPD and consequently residing in the same office allowed for the LEED

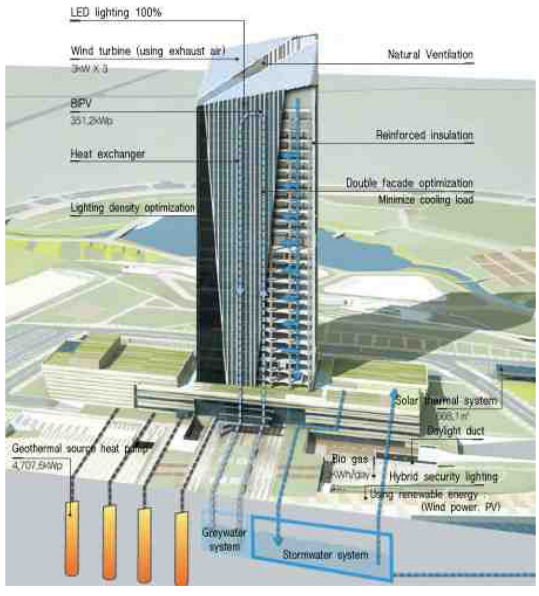

Figure 3. KEPCO Green Design Comcept.

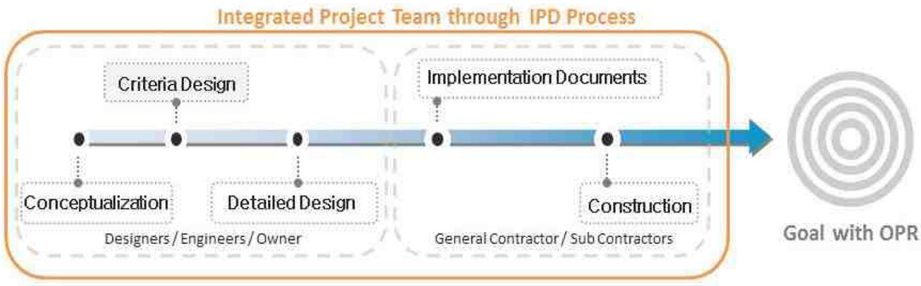

Figure 4. IPD Process towards Project Goal.

facilitator to actively communicate with the architect, engineers, and general contractor during the design phase for a more efficient communication and for informed decision-making, which allowed the entire team to meet the energy goals. The IPD process and its integrated project teams are seen in Figure 4.

Pursuit of other LEED credits with our working environment in place allowed the design team to improve the performance of the building throughout the design process, including during the Value Engineering.

For example, the insulation performance of the building's façade improved from 0.87 W/m^{2}K to 0.54 W/m^{2}K without much cost increase, with the general contractors input. Improvements on façade gave the design team and the general contractors an opportunity to seek cost reduction elsewhere without sacrificing the project goals.

At the moment, Enhanced commissioning is planned to confirm and verify the energy performance thru design reviews and functional tests. It will also require the building operators to take training, in order to ensure that the building is operated as intended. The Measurement & Verification plan will also be implemented and allow the building operators to identify the actual usage of energy performance during the occupancy. The opportunity to continuously improve and fine tune the building performance will be provided.

9. Conclusion

The project was able to successfully meet LEED design goals and energy reduction requirement of 50% over previous building thru IPD framework by setting a clear goal for the designers during the early stages of design phase. The other key factors that contributed to fulfill the owner's project were the project stakeholder's early involvement and collaboration within the same office space when deciding on design goals. Whilst the building is in the construction phase at the moment, the same IPD framework applies and the members are able to continue to evaluate and execute project goals. It should be noted that the critical and often underestimated contributions that make this possible are the owner's continued commitment to the project goal and the designer's commitment to invest more time during the design phase.

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