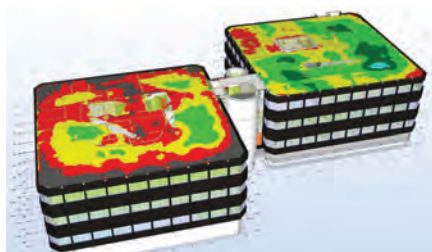
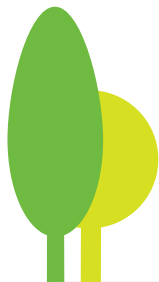
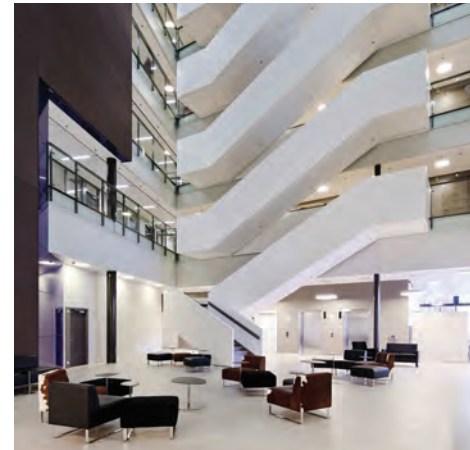


Green BIM Innovation at Skanska

We have long been an industry leader in adopting BIM for managing project cost, schedule and quality. With the arrival of Green BIM we can now optimize the environmental performance and life cycle cost for our customers using the same information. This is a welcome tool to progress our Journey to Deep Green™ and better serve our customers.

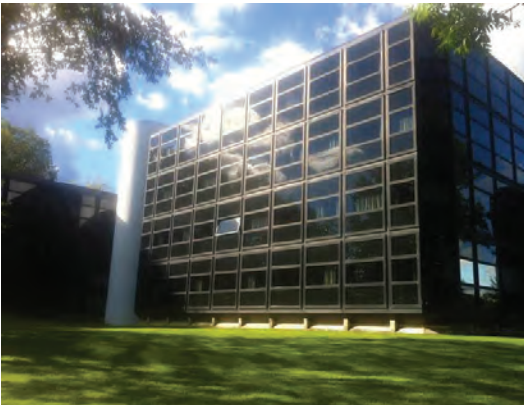
Tiina Koppinen
Global BIM Knowledge Manager



Skanska and Green BIM

Where the construction industry is facing increasing complexity and demand for green solutions, Green BIM has significant potential to offer added value. By facilitating informed decisions on green solutions, it helps to achieve improved whole building or district performance while reducing risk and life cycle cost.

Skanska's ambition is to work with customers and project stakeholders towards the delivery of future proofed Deep Green projects – high quality buildings and infrastructure with nearly zero environmental impacts that mitigate climate, legislative and energy price escalation risks. This is articulated in Skanska's Journey to Deep Green™. BIM and Green BIM support this Journey by serving as an essential tool.



What is BIM?

Building Information Modeling (BIM) is the practice of creating and managing three-dimensional (3D) representations of the physical and functional characteristics of a facility. These are housed on databases shared by the various stakeholders involved in the project and can be continuously updated to ensure that owners, architects, design teams, suppliers and building managers can work with the same information.

Visualization of the model, whether it's an illustration or the ability to walk through or fly around the virtual project, means the project stakeholders can better understand solutions and alternatives available for the project. The model contains all the phases, angles and details of the project. This provides a reliable basis for making informed decisions throughout the project's lifespan, from design and construction, through to its operation and eventual demolition.

BIM supports Skanska in making its operations more efficient. Its benefits can be seen across every aspect of business, including environmental responsibility, safety, quality and the use of sound financial practices to deliver positive results. BIM impacts each of these by improving safety planning, making possible the creation of enhanced, flawless design and construction, and enabling zero defects during the construction phase.

What is Green BIM?

BIM offers new opportunities on Skanska's Journey to Deep Green™ when combined with environmental project data and used to promote project sustainability, for example in optimizing building energy efficiency or managing waste. When applied in this context, it is called Green BIM.

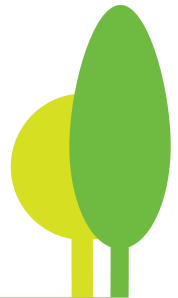


Green BIM and Life Cycle Costing

With growing demand from customers for Green BIM, the practice of implementing models into project planning is moving the industry away from a linear outlook to a life cycle approach. The use of BIM and Green BIM makes Life Cycle Cost (LCC) analysis easier and more reliable, allowing a long term holistic approach to project decision-making that considers both the cost and environmental impacts of materials, equipment and technology not only now, but also in the future.

Green BIM and LCC analyzes are both vital tools to help implement Skanska's vision of promoting a Deep Green society throughout project design, construction, operation and maintenance phases.

For example, before the introduction of Green BIM at **New Karolinska Solna** hospital in Sweden, maintenance LCC was conducted with time-consuming designs and calculations that often lacked accuracy and quickly became outdated as the design phase progressed. This resulted in expensive LCC calculations with large margins of error. To overcome this, Skanska used its Green BIM model in LCC to promote green design and construction options that are the most cost effective from a life cycle perspective.



The business case for **Green BIM** – why does Skanska do it?

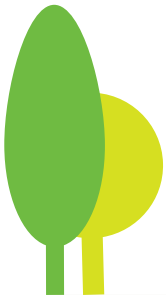
The potential for Green BIM to transform the way in which construction projects are delivered is increasingly recognized across the industry, and customer demand is growing.



Green BIM benefits

- Faster and more effective processes as information is more easily shared and reused, allowing for early technical and cost evaluation (optioneering) of multiple green solutions in limited time.
- Better design due to improved collaboration with the supply chain and customer, facilitating green innovations, holistic solutions and better integration of supplier products, reducing errors and risk.
- The provision of as-built information for handover, improving facility management and enabling the verification and improvement of the building's environmental performance.

- Lower life cycle cost and environmental impact of the building through its construction and operational phase delivering enhanced asset value.
- Improved indoor conditions such as climate and lighting, driving improved occupant well-being and productivity.
- Lower material wastage and improved hauling during construction due to better project definition, lowering the cost and environmental impact of construction.
- Performance monitoring using BIM leading to an improved understanding of building performance and thus future design improvements.

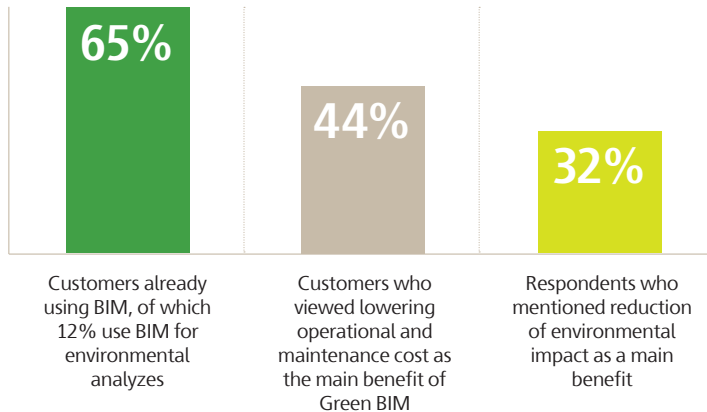


Drivers of Green BIM

Whilst Skanska has been driving the use of Green BIM internally in order to make its operations more efficient and support its Journey to Deep Green™, it has also found that customers, contractors and design consultants have become more aware of the importance of addressing and improving the environmental risks associated with projects. This has occurred alongside the development of BIM, which in turn has supported the incorporation of Green objectives with BIM practices.

According to a recent survey¹ 65% of our customers are using BIM, of which 12% already use BIM at some level for environmental analyzes. The survey showed that 44% of our customers viewed lowering operational (energy and water) and maintenance cost as the main benefit of Green BIM. 32% of the respondents mentioned reduction of environmental impact as a main benefit and 32% included “as-built information platform” for handover and facility management as a benefit of Green BIM.

According to a McGraw Hill study on Green BIM², 78% of BIM users not utilizing Green BIM expect they will use Green BIM soon. The number one driver mentioned for this by contractors is the foreseen increase in customer demand (88%).



Green BIM in practice

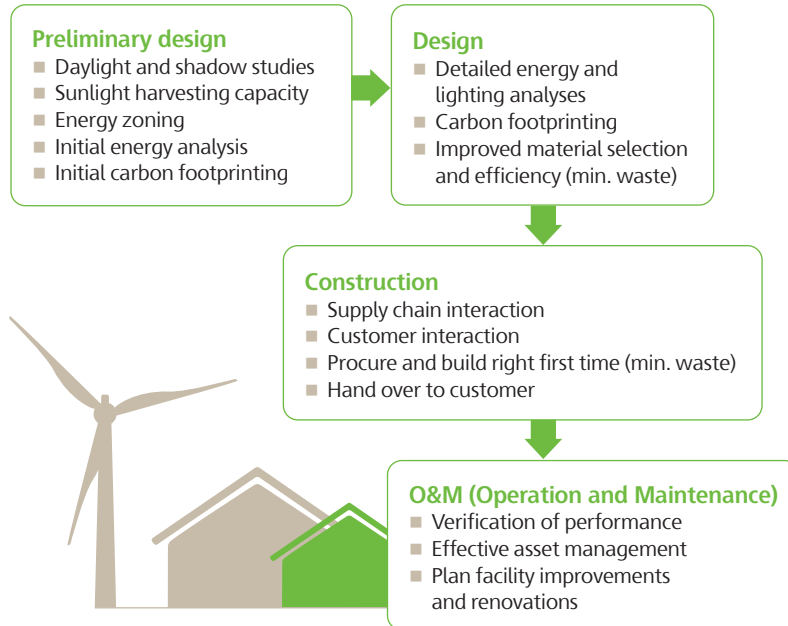
Skanska has implemented BIM and Green BIM on many types of projects such as buildings, roads, bridges, tunnels and industrial plants, and has realized various benefits. These include improved communication amongst project stakeholders, enhanced efficiencies, improved environmental performance, greater certainty in both scheduling and costs and the reduction of risk.

Integrated multi-discipline building models

Green BIM allows Skanska to develop integrated multi-discipline building models – designs developed in close cooperation with relevant project stakeholders from the start. This collaborative approach means various stakeholders are able to work simultaneously on the design and it provides an opportunity for the owner, users, key suppliers and design teams to be involved in the process. The result is better performing buildings and infrastructure because complex information is combined to allow for informed decisions to be made early in the design stage.

Energy modeling

Using Green BIM to model a project's energy performance helps to identify choices that optimize the building's life cycle energy efficiency during the early design phase, when changes can be made without incurring high costs. By allowing for revisions to be made during the design phase, project teams can ensure that customers' green ambitions beyond compliance are realized and relevant building codes or baselines are technically and cost effectively adhered to. The models can also be used during the operation and maintenance of the building to validate its energy consumption.



Going beyond compliance

As part of our commitment to reduce the environmental impact of the built environment, Skanska has defined and embarked on its Journey to Deep Green™. The Color Palette is the strategic framework and communication tool we have developed to measure and guide our performance on this journey, with Deep Green as the destination. The starting point is 'vanilla', which means complying with today's regulations and baselines. However, for us this is only the beginning. With the help of our customers, we're already pushing our projects into Green and Deep Green.



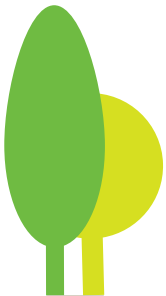
Figure 1: The Skanska Color Palette™ for Green Buildings

Skanska is pioneering the use of Green BIM and LCC to cost effectively facilitate the holistic and integrated design, construction and maintenance of low-energy, nearly Zero Energy (nZEB) and positive energy buildings.

At the **Härmälänranta** residential development in Finland, Skanska used BIM energy modeling techniques to conduct LCC analyzes in order to identify design options with the lowest life cycle costs over a 40-year period.

Green BIM was used together with project partners during the design of the energy-positive **Powerhouse One** development in Trondheim, Norway. BIM models and 3D geometry were used to orientate the direction and inclination of the roof to the sun in order to optimize energy generation from solar power systems. The roof orientation and building footprint were then used to design the envelope and the building interior.

During the **New Karolinska Solna** Hospital project in Sweden, Green BIM was used to calculate life cycle risks over Skanska's 28-year operation and maintenance contract, including the regular upkeep of components and the periodical replacement of larger equipment. The models are also used in energy simulations for the building, which will support the project in achieving its ambitious energy targets.



Reduced embodied carbon

When conducted during the design phase, BIM-based carbon footprinting allows informed decisions to be made from the start. This can contribute to a reduced embodied carbon footprint and help to deliver cost effective green buildings and/or infrastructure.

Skanska uses Green BIM to calculate a project's carbon footprint, and then identify and build in low-carbon, cost-effective design features.

Skanska House in Finland (Skanska Finland's head office) was used to develop Skanska's BIM carbon footprinting techniques. Consequently, Skanska has been able to offer BIM-based carbon analyzes to both internal and external clients since 2010.

Additionally, the insights gained from BIM tools can help to generate greater awareness of green building across the industry. For example, working together with suppliers, Skanska has used Green BIM to initiate a project to reduce embodied carbon emissions in its supply chain. By identifying carbon intensive construction materials and sharing this information with suppliers, Skanska can ensure that its supply chain understands its requirements and is challenged to develop lower-carbon products.



Waste reduction

Skanska uses Green BIM to minimize construction waste through the accurate procurement of construction materials. Project information, such as material dimensions, quantities, characteristics and environmental ratings can be exported from BIM to enable the procurement team to more accurately estimate the quantities and qualities required. Conventional estimation techniques tend to be less accurate and can result in significant construction waste, a greater number of deliveries and pick-ups to and from a site, and unnecessary costs associated with surplus materials and waste disposal.

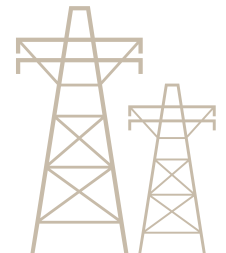
A Skanska study into residential construction in Finland concluded that the use of Green BIM enabled processes that led to a 49% reduction of waste. The study included 9 Green BIM residential projects and 25 non-Green BIM residential projects.

Water

Green BIM helps to quantify the amount of water used in a building by calculating the number of fixtures, such as sinks and toilets, and their related water usage. This also helps us measure the potential for greywater reuse, which is highly beneficial for reducing the demand on local water supplies. The amount of water available for harvesting can be calculated using Green BIM, based on the site, harvesting system, and size of the building. This approach was for example used to size the rainwater harvesting system on Skanska House in Finland.

Enhancing facilities management

BIM can also provide support during the operational lifespan of buildings. Using Green BIM can make facilities management more efficient and cost-effective by making vast amounts of information available to the facilities management team and allowing this to be easily updated, modified and extrapolated during the building's operation to obtain accurate and timely data. The models also ensure that no building component is overlooked during maintenance routines, which means that contractual obligations are fulfilled and operational performance is promoted in terms of energy, water and materials.



Leading the industry

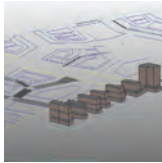
As part of its Journey to Deep Green™, Skanska has been involved in industry-focused BIM and Green BIM-based research projects in its various markets.

One such project Skanska has been leading is the BIMCON research program in Finland, a **USD4.9m (SEK 32m)** project running between 2010 and 2013. The aim of the program is to use Information and Communications Technology (ICT) to promote productivity and profitability in the construction industry supply chain. Green BIM is a fundamental part of the BIMCON research, providing material information for various green analyzes during the construction process. As part of BIMCON, Skanska, material suppliers, software companies and researchers are looking into what kind of environmental indicators should be analyzed, in which phases of the project life cycle and with what product and other relevant data. The purpose is to achieve stepwise transfer from using generic information in early phases to using supplier specific information later in the process.

In Norway, Skanska is leading a large research project "Collaboration in the Building industry with BIM as a catalyst" or Sam-BIM. The project aims to develop and establish processes and collaborative models to maximize potential value in the entire building process and the industry as a whole. Sam-BIM carries out research on Integrated Project Delivery systems and how these can be implemented in the context of the Norwegian building industry. One of the project ambitions is to establish Green BIM as a standard part of the design and construction process. Sam-BIM is undertaken in close cooperation with several leading partners in Norway and is partially funded by the Research Council of Norway.



Project examples



Finnoo Metro Center, Finland

Skanska is using BIM energy modeling techniques on the **Finnoo Metro Center**, which includes the development of around 22,500m.sq. of residential space and 2,500m.sq. commercial space in Espoo, Finland. Green BIM was used to identify and demonstrate

design improvements to ensure that the project's nearly Zero Energy Building (nZEB) objectives will be met. For example, a 3D BIM model was developed to optimize the generation of photovoltaic solar energy, building mass, wind direction and achieving nZEB level through various energy efficiency measures.

High-quality information modeling is an invaluable basis for decision-making to achieve cost-effective nZEB buildings and districts. BIM and LCC tools also enable joint public and private contract-based planning when creating nZEB districts, whereby economical benefit and investment risks can be shared.

Robert Eriksson

Project manager, city planning – climate and energy issues, Espoo Municipality



Powerhouse Kjørbo, Norway

Powerhouse Kjørbo will be Norway's first, as well as the world's first, refurbished positive energy building. 5200m² of inefficient office building from the 80s will be renovated to produce its own energy and deliver excess energy to the grid. Models created from laser-scanning were used to analyze the effects of shade from trees on the planned solar panel placements. The original building's concrete superstructure has been preserved and was scanned after the demolition phase. This scan was used to develop the structural as-built model, allowing for collision-testing of the architectural and Mechanical, Electrical and Plumbing (MEP) models. The finished building will have an annual energy consumption

BIM gives us, as owners and developers, improved insight into the building we have ordered. On Powerhouse Kjørbo the use of BIM strengthens my confidence that Skanska will achieve the quality needed to deliver an energy-positive building in Norway.

Einar Børve
Entra

of 100MWh achieved through façade insulation, low-energy hybrid ventilation and heating and low power consumption technology. It will produce 200MWh using solar panels and geothermal wells. Powerhouse Kjørbo goes into production in 2014 and is aiming for BREEAM Outstanding certification.



Veitvet School, Norway

Green BIM modeling was used on the Veitvet School project in Oslo. Green BIM allowed the team to consider the embodied carbon of the various design options whilst developing the building design, which led to the optimization of the building's carbon footprint without compromising design quality. The use of Green BIM will help to reduce carbon emissions from energy use, construction materials and operational transport by 42% compared with current standards, which will allow the building to be certified according to Norway's FutureBuild standard. Significant design alterations included the use of laminated timber beams as part of the load-bearing structure on the top floor of the school.



Barts and the London Hospitals, UK

St Bartholomew's (Barts) and the Royal London Hospitals in London are being redeveloped into state-of-the-art facilities between 2006 and 2016 as part of a PFI (Private Finance Initiative) led by a consortium including Skanska. Skanska used Green BIM to reduce waste plasterboard, brick and flooring materials on the project. Waste plasterboard, for example, was reduced by over 44 tons, which saved around **USD6,800 (SEK44,000)** in waste disposal costs and decreased the number of deliveries to and from the site in the early phases of the project. The Barts and The London waste management strategy won the CIWM (the Chartered Institution of Wastes Management) award

in 2009. The ability to move objects around the virtual world and check for clashes has also been used to check the installation and removal strategies for all the large pieces of plant and medical equipment. For example, increasing the size of three doors and reducing the depth of a downstand beam at the design stage has saved **USD187,000 (SEK1.2m)**.



New Karolinska Solna Hospital, Sweden

New Karolinska Solna (NKS) is the first project in Sweden to use BIM in facilities management and the project has become a test-bed for innovative BIM techniques. The BIM model is to be handed over to the client following construction to support facilities management over a 28-year period until 2040. Coor Service Management, the facility management company responsible for NKS, will use the BIM model on a daily basis to manage task handling. Hospital personnel, patients and other visitors will report tasks to the Help Desk or Service Center by stating the relevant BIM code or through their smart phones, telephone or web service portal. LCC information will also be used to devise maintenance and service plans.



On the NKS project, BIM provides us with a powerful information management tool during the building's design and operation, which can keep the enormous amount of data in order and helps to promote the leaner and greener management of the facility. I believe that we are the first project of this size in the world to actually utilize BIM from the design to the facilities management phase.

Peter Sundström
Swedish Hospital Partners



The NKS BIM model offers us tremendous opportunities to realize hard and soft FM service, environmental and financial savings during the operational phase of the facility.

Per Bjälnes
Coor Service Management AB

Conclusion

The practice of BIM is still in its infancy and whilst business case data is still being collected, the significant life cycle benefits it offers to all involved are evident. Green BIM enables Skanska to provide added value to its customers and make progress towards future proofed Deep Green projects for its customers. Thanks to BIM, project schedules and costs can be more accurately estimated. It also enables smoother operations with increased operational safety and without unexpected interruptions. As part of its industry leading work on its Journey to Deep Green™, Skanska is implementing Green BIM to promote the business case and help drive demand for it.



Facts and trends

Public and governmental clients are demanding the use of BIM in their projects, for example:

- Senate Properties, Finland
- General Services Administration, USA
- US Coast guard, USA
- UK Government (starting 2016)
- Statsbygg, Norway
- The Norwegian Defence Estates Agency



71%
2012

28%
2007

Use of BIM is increasing fast. For example, in US, industry-wide BIM adoption was only at 28% in 2007. In 2012 the level of adoption was already 71% and still growing.³



¹ KTH (Royal Institute of Technology)/Skanska, Stockholm, Sweden, 2012

² SmartMarket Report 2010: Green BIM. McGraw Hill Construction

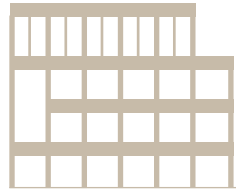
³ SmartMarket Report 2012: The Business Value of BIM in North America McGraw Hill Construction

⁴ SmartMarket report 2009: The business value of BIM

93%

of BIM users believe there is potential to gain more value from BIM in the future.

ROI



Two-thirds of BIM users say they see positive ROI on their overall investment in BIM.⁴

87%

of expert users are experiencing positive ROI with BIM



Lower project cost

is among the top rated ways users expect BIM to bring high value.²



Skanska AB
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A part of
Skanska's
Green
Initiative

If you are looking for more information, please contact:

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