Manitoba Hydro Place:
Design, construction, operation - lessons learned

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ABSTRACT: In 2009, five months prior to completion, Manitoba Hydro Place was presented at the PLEA Conference. Three years after opening, the building has surpassed original targets including achieving LEED Platinum (surpassing Gold), 65% higher energy savings, a drop in absenteeism and most importantly, a greater feeling of health and well-being in the occupants. Buildings are conventionally presented based on expectations, but it is less common to revisit projects and report on actual building performance and lessons learned. The main participants – the design architect, the climate engineer and the client – will demonstrate that the Integrated Design Process was essential to balancing energy performance goals against objectives of the signature architecture, urban revitalization, and creation of a supportive workplace, all while achieving a daunting goal of 85 kWh/m2/year for a 64,650 m² office building in an extreme climate that fluctuates from -35℃ to +35 ℃ annually.
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INTRODUCTION
At first glance Manitoba Hydro looks like a classic, modern glass office tower. In actuality, it is a large, highly complex, energy-efficient building that offers a new paradigm for thinking about the design and delivery of low-carbon contemporary architecture in a manner that simultaneously contributes to urban revitalization and superior quality of space. It is also a model for innovation using a formal Integrated Design Process (IDP), and is further distinguished by the fact that it was designed for an extreme climate (ASHRAE Zone 7). At the time of publication, Manitoba Hydro Place had recorded over 70% energy savings beyond the Canadian Model National Energy Building Code (MNEBC). Manitoba Hydro's regulated energy usage is under 85 kWh/m²/year compared to conventional office towers which typically use over 300 kWh/m²/year.

Three years after the official opening, key members of the Design Team met for a full day workshop reviewing the lessons learned, and developing strategies to disseminate the lessons and process to future designers, engineers and builders. This paper represents the first formal presentation of the findings to date.

BACKGROUND
Manitoba Hydro Place is the new headquarters for Manitoba Hydro, a crown corporation, the primary energy utility in the province and the third largest integrated energy utility in Canada. In 2004, Manitoba Hydro committed to relocating its headquarters to a new 64,650 m² office building in downtown Winnipeg. The act of bringing 2000 employees from leased offices in the suburbs would make a significant contribution to the City's downtown revitalization strategy.

Recognizing that its employees are its most valuable resource, the primary design goal was to ensure a healthy, supportive work place. Furthermore, as an energy utility corporation, Manitoba Hydro wished to create a landmark building showcasing its commitment to energy efficiency through its Power Smart brand. On paper, Manitoba Hydro knew that a 52-53% energy efficiency improvement was achievable using state of the art strategies (reduced glazing ratios, improved airtightness, and efficient equipment), but decided to set a daunting goal of 60% reduction. This target was particularly challenging because of Winnipeg's extreme climate. Temperatures fluctuate from -50 ºC with the wind chill factor in the winter months to +40ºC with the humidex during the summer months.

Manitoba Hydro realized that the only way to achieve its objectives was to assemble a "Blue Label Team" and count on the synthesis of ideas through an IDP. A clear business case model was developed to ensure balanced decision-making related to design, energy and cost goals throughout all phases.

INTEGRATED DESIGN PROCESS (IDP)
The first task was to form the Integrated Design Team (IDT). The client hired an advocate architect to champion the project goals and oversee process management, inclusive of the submission under the LEED program.

In contrast to the conventional design process where it is the responsibility of the principal architect to assemble a team of engineers and specialists, Manitoba Hydro conducted an intensive search for a design architect. The design architect's role included leadership of the IDT and invitation to participate in the selection of the architect of record, energy engineer, building system engineers, cost estimator, and contractors.

Lesson Learned: By selecting the design architect independent of the overall team, it ensured that the client chose individuals who they could work with and it empowered the architect to be a decision maker and professional advisor. Personalities were a key selection criteria as relationship building was fundamental to the synthesis of ideas.

PROJECT CHARTER

The next major task was to bring the client and IDT members together to create the project charter. It was produced during a two-day workshop held off-site, and signed by all, including Manitoba Hydro's CEO. It summarized the 6 core goals of the project as follows:

- Supportive Workplace: Healthy, effective, adaptable contemporary office environment.
- World Class Energy Efficiency: 60% more energy efficient than the MNECB.
- Sustainability: LEED Gold Level Certification.
- Signature Architecture: Celebrate Manitoba Hydro and enhance downtown Winnipeg's image.
- Urban Regeneration: Strengthen and contribute to the sustainable future of Winnipeg's downtown.
- Cost: Cost-effective, sound financial investment.

Lesson Learned: The charter was critical to the success of the project. By clearly defining the client's objectives with input from the team, it generated a sense of collective ownership and personal investment. It was essential to decision making at every stage, insuring that all team members were on the same page and improving the typical client-architect-engineer contract in which goals are largely undefined.

INVESTING TIME FOR DESIGN INNOVATION

Two years were dedicated to design. The first year focused on the design concept, and involved a monthly schedule of facilitated workshops and design charettes. Key milestones included four design charettes to explore 16 form and massing alternatives and select three options for testing, leading to a final concept for development. The second year was committed to the development of the design and involved a schedule of bi-weekly meetings to fully integrate architecture, structure, energy performance, cost, constructability, commissioning and LEED into the final design solution.

Lesson Learned: Strong leadership to chair the design meetings is as critical to the success of the IDP as the expertise of the consultants. The IDP facilitator had to maintain the meeting focus while ensuring that all consultants were afforded an appropriate level of contribution. Extra time was critical to explore multiple design options. By including commissioning early on in the process, integration of the building systems could be well thought through, reducing future construction problems and additional costs.

EXTREME CLIMATE – AN OPPORTUNITY

At first, the extreme climate was perceived as a major obstacle to achieving the ambitious energy goals. During analysis, the climate engineer confirmed that while Winnipeg is a northern city, it has unusually dominant south winds and an abundance of sunlight in the winter months which offer great potential for harnessing passive energy (Fig. 1). The tools to model alternatives and to explore the selected concepts included: CFD wind analysis with physical model testing, dynamic thermal model simulations to predict passive efficiencies and full annual daylight autonomy simulations.

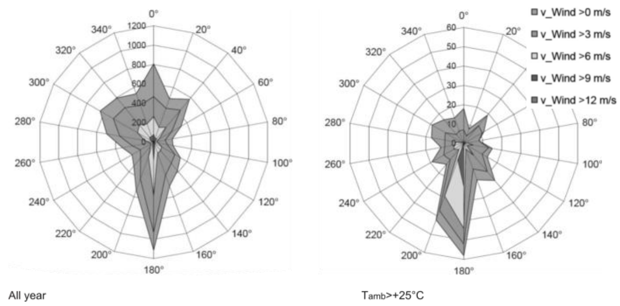

Figure 1: Wind rose diagrams, all weather and warm weather.

Lesson Learned: The innovative design concept of Manitoba Hydro Place led some to question the heightened level of risk undertaken by the client. Simulation tools, in particular dynamic thermal simulations, were used to accurately model the building, reducing the risk associated with innovative concepts such as the double façade in Winnipeg's climate. Performance assumptions developed during the design phase have since been verified by metered data.

DESIGN: ARCHITECTURE + PERFORMANCE

While the overall design is conceived as an integrated whole fusing all aspects of design, form, expression, and technology to meet every goal in the Project Charter, the depth and extent of innovation and creative integration is embodied in the design of a series of individual signature elements. Through the fusion of aesthetics and energy performance, these elements represent parts of the whole, collectively essential to the overall performance of the building.

Form, Orientation, Massing
Form, orientation and massing are fully integrated to capitalize on passive energy from Winnipeg's extreme climate. By siting the building on a 20° angle to face due south, additional outdoor space was created for a new urban park on the Graham Street transit corridor. The orientation also establishes visual connections to the city's legislative buildings and its historic centre.

The massing integrates a 22-storey triangular 'flatiron' glass tower form with a masonry-clad podium base. The form extrudes a typical floor plan that takes the form of a capital 'A' with east and west wings. The towers fuse at the north and splay open to the south. At the north end a 115-metre solar tower marks the main entrance on Portage Avenue. The tower is set back from the edges to mitigate shadow impact on the street and park while the podium addresses and responds to the varying scale of adjacent buildings. This also results in minimizing down drafts on the east and west sides.

Expression
Ironically, a glass tower in this extreme climate proved to be the most effective solution: when it is cold it is also sunny – ideal to maximize solar gains. The transparency of the glazing system also mitigates the overall mass and scale of the building on the streetscape.

The entire tower is wrapped in a double façade with the exception of the south facing lofts, either through the double east-west curtain wall or the south and north facing winter gardens. The envelope has a single-glazed inner and double-glazed outer wall with a minimally-conditioned 1-meter-wide buffer zone in between. Motorized operable windows on the outer wall modulate conditions within the interstitial space and support natural ventilation. Manually operated vents in the inner wall allow for individual comfort management. The modulation of the exterior double façade windows has become an iconic feature of the design; the first opening of the windows marking the start of spring each year.

Solar Chimney
In addition to its function as an iconic element of the Manitoba Hydro Place aesthetic, the solar chimney is the main exhaust plenum for the building. From spring to fall, stack effect in the building naturally draws exhaust air up and out of the occupied spaces. The stack effect is supported by the glass enclosure at the top of the chimney. The greenhouse effect heats up the upper airspace, which, like a straw, supports the chimney flow by generating a negative pressure at the top. In the winter, exhaust air from the building is drawn to the bottom of the solar chimney by a fan. A portion of the heat from this exhaust air is used to heat the parkade while the remaining heat is used to pre-heat the incoming cold air in the south winter gardens.

Public Gallery and Lobby
A three-storey high galleria divides the podium mass along the solar axis and serves as a lobby for the 2000 employees as well as sheltered pedestrian route for the public. It has become a major corporate, cultural and social event venue in the city. The monumental scale and material expression of two large water features which serve to humidify/dehumidify the space was inspired by the hydroelectric dam.

Winter Gardens
The space formed by the splay of the towers at the south is filled with a series of three stacked, six-storey high atria – referred to as 'winter gardens'. The winter gardens are unique in the context of conventional hermetically-sealed North American office buildings. In combination with the solar chimney, they act as the lungs of the building, passively conditioning the air before it enters the building and providing 100% fresh air year round. Each of the three south winter gardens feature a 24-metre custom-designed water curtain comprised of 280 tensioned mylar ribbons which humidify or dehumidify the fresh air by modulating the water supply temperature. The water curtains epitomize the fusion of aesthetics and performance that characterize every aspect of the building. The winter gardens also function as a common area and offer vertical connectivity between workgroups.

Vertical Neighbourhoods
The plan highlights the symbiotic relationship between the building's respiratory system (winter gardens) and the organizing principle of vertical neighbourhoods. The standard floor plate is divided into smaller precincts organized by shared atria with interconnecting stairs to support internal communication and interdepartmental exchange. The 11.5-metre-deep, column- and grid-free interior creates an open, loft space with unlimited capacity to facilitate change and adapt new technologies.

PERFORMANCE

Thermal Mass
The 35,600 m^3 concrete structure is designed with sufficient thermal mass to moderate the impact of daily temperature swings and to provide a flexible, column-free loft space for maximum flexibility. Radiant cooling and heating systems located within the exposed concrete ceiling maintain a comfortable temperature year round.

100% Fresh Air, All Year
Compared to a typical North American building where as much as 80% of the air is recirculated, Manitoba Hydro Place was designed to provide 100% fresh air all year. Incoming cold air is pre-heated via a run-around heat recovery loop from the exhaust air. The combination of pre-heating by exhaust air and the

passive solar gain in the atria bring fresh air to a comfortable temperature with minimal energy. During the shoulder seasons, the majority of mechanical ventilation systems are turned off. Fresh air enters the building passively through occupant controlled operable windows in the double façade and is exhausted through the solar chimney.

Geothermal

The foundation of the building's heating and cooling system is a closed-loop geothermal system consisting of 280 six-inch boreholes, 120 m deep. Conditioned water is circulated in the exposed ceiling slabs, providing 100% of the summer temperature conditioning. In the winter the process is reversed and the geothermal installation provides over 80% of the heating, with high efficiency condensing boilers providing the balance during the coldest months.

Supportive Work Place Environment

In addition to the vertical neighbourhood concept and emphasis on thermal comfort (described below), façade access and natural lighting are available to all. Occupants use operable windows, task lighting and shading devices to control their environments. Displacement ventilation is deployed via a raised floor, providing flexibility and allowing workstations to be moved and reconnected to electrical and air supplies located throughout the space.

Materials

Exposed architectural concrete, locally quarried Tyndall stone and locally sourced granite were selected to relate to Winnipeg's urban fabric of masonry buildings. Reclaimed Douglas fir from the former building that occupied the site is reused for soffits and benches. Large portions of the structure are left exposed to increase the conductivity of the radiant concrete mass, and for an open loft studio environment. The embodied energy of all materials was considered before selection.

LESSONS LEARNED

User Comfort

The predominant goal for Manitoba Hydro Place was to achieve the highest possible quality of space for the employees. Transitioning from their previous traditional office space, employees appreciate the abundant daylight, universal access to outdoor views, and excellent air quality. There was an initial spike in service calls submitted to the building operations group when the building was first occupied. The building operators required time to adapt to a non-traditional building, particularly with respect to the radiant slab system which required subtle setpoint adjustments to maximize comfort.

Since commissioning, service calls relating to thermal comfort along the east and west double façades have been largely non-existent. Unlike a traditional all-air building that places limited emphasis on long-wave radiation exchange between surfaces, Manitoba Hydro Place maximizes comfort by emphasizing moderate surface temperatures. The double façade offers two main advantages in this regard. In the winter, the buffer space is heated up by passive solar gains which lead to warmer surface temperatures along the interior glazing. In the summer, the inner surface temperature is modulated by automated shades within the interstitial space. The short-wave radiation from the sun is reflected before entering the occupied space, reducing overheating on the interior surface of the façade.

The south tips of the tower lofts are the two areas without the double façade and thermal comfort in these areas is somewhat compromised. The triple-glazed curtain wall with interior shades leads to higher surface temperatures at the window during sunny days, even with a high performance interior shade. The short-wave radiation cannot be effectively reflected back outside with the low-e coated triple glazing, causing the shade surface to absorb energy and heat up, reaching 40°C on a sunny day. This is a particular challenge in the shoulder seasons, when the low sun angle and moderate air temperatures lead to a worst-case scenario. Two main solutions have been found to mitigate this issue. First, adding a gap between the employee workspace and the façade reduces the view factor between the warm shade surface and the individual, and provides a mixing zone for the incoming fresh air. Second, the double façade on the east and west sides adjacent to these areas can be opened to introduce cooler outside air into the space. These solutions have minimized overheating complaints in these areas, while the overall issue has emphasized the value of a double façade in Winnipeg's climate.

Various shade materials were also evaluated for impact on thermal comfort. Increased reflectivity on the exterior side of the shading leads to improved conditions, but the solar energy could not be fully rejected back to the exterior. A low-e coating on the inner surface of the shade material is currently yielding promising results.

These thermal comfort solutions are examples of Manitoba Hydro Place's use as a living laboratory. As a leader in energy efficiency, Manitoba Hydro uses the building to study various aspects of a high performance design and provides this information to the general public. For example, the extensive metering devices were used to evaluate thermal comfort at the south workstations while the various solutions were tested.

Energy

It was clear during the design phase that Manitoba Hydro Place had the potential to be a high-performance building. This potential was only realized after two years of intensive optimization, which involved the Manitoba Hydro building operations group and key members of the IDT. There were three primary elements to this optimization phase. First, building operations staff were involved in the project during the design and construction phase, allowing them to identify potential maintenance issues and better understand the unique systems. Secondly, extensive metering equipment was carefully incorporated during the design phase and emphasized directly in the mechanical specifications (there are over 20,000 thermal and electrical flow points). Finally, the design team, with access to the energy data, was directly involved in the optimization phase and able to delineate aspects of the building that were not meeting the functional requirements.

A measurement and verification (M&V) plan was developed for Manitoba Hydro Place which required monthly reporting of energy data. The data was reported at both a summary level, providing load categories (pumps, fans, heating & cooling), and a detailed level (an individual pump, for example). The metered data was then compared to a model to identify aspects of the operation which could be optimized.

The double façade performance is one of the most successful design elements of the building. As one of the first, and certainly the largest, installations in North America, there was considerable scepticism about the concept and its performance in a cold climate. The key design elements include placing the insulated double-glazing unit to the outside, with the single pane separation on the inner surface (a reversal of the typical design), and achieving extremely high air tightness. When fully sealed in the winter, the minimal leakage in the double façade allows the sun to heat up the air gap.

During a typical winter week (Fig. 3), the outside air temperature ranges between -15°C and -30°C. Even during design heating days, the interstitial air temperature rises above 20°C due to solar heating.

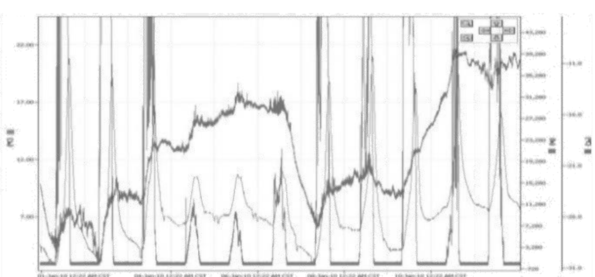

Figure 3: Temperature within the double façade during a winter week.

Overcast days also provide positive results, with interstitial air temperatures rising up to 10°C. These warmer temperatures in the double façade function as a dynamic insulation for the building, reducing the temperature difference across the building envelope and minimizing heat losses. While a typical Winnipeg building requires more than 200 kWh/m^2/year of end-use heating energy, the thermal requirement at Manitoba Hydro Place is only 44 kWh/m^2/year, due in large part to the double façade.

During the shoulder seasons, the double façade supports the use of natural ventilation by extending the range of outside air temperatures and wind speeds which are conducive to this mode. During the shoulder seasons, the outer façade vents automatically open, and employees are able to open the interior glass façade manually to optimize their local air movement and quality. The buffering effect of the double façade allows the mechanical ventilation system to be shut down for 35% of all operating hours–an unexpected result considering the challenging climate conditions (Fig.4).

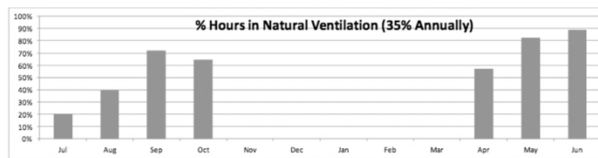

Figure 4: Use of natural and mechanical ventilation.

In addition to the excellent thermal and ventilation performance, the double façade also offers better natural lighting and views, and allows for a completely open loft space by pushing the columns into the façade.

In the first two years of operation, the M&V Plan for Manitoba Hydro Place optimized energy performance in all primary categories. Other highlights include:

- Reducing lighting energy use by improving the functionality of occupancy sensors.
- Integrating a ventilation mode icon into employee computers to educate about natural ventilation.
- Optimizing pump settings and installing differential pressure control for major units.
- Reducing return temperature for boiler heating loop to increasing condensing and efficiency.
- Optimizing heat pump settings (increasing cooling supply temperatures) to improve COP.

These and other strategies have led to a steady reduction in energy loads (Fig. 5). In the first year of operation, energy usage was 161 kWh/m^2 (without process loads). By 2013 this had been reduced to 85 kWh/m^2/year, going beyond the modelled target of 120 kWh/m^2/year and surpassing the project goal by reducing energy usage by almost 70% of the MNEBC.

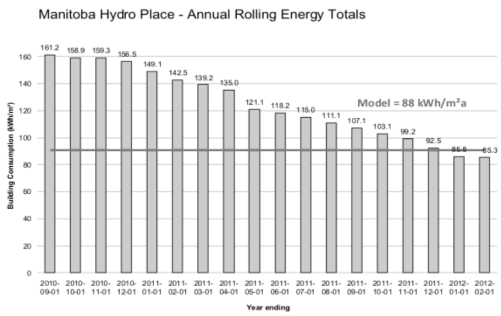

Figure 5: Reduction in energy loads.

COST: PERCEPTION + REALITY

Integration of the energy systems into the building design was vital to keep costs down. The building energy measures are positive from a life cycle cost perspective and are expected to pay for themselves in less than ten years. The costs of the energy efficiency elements were treated holistically, as each measure contributes to the overall performance. Eliminating any of the components would have had an effect greater than the loss of that measure alone. Although the building has a positive outcome from an energy perspective, the real successes are the softer benefits such as reduced absenteeism and increased employee productivity.

URBANISM AND SUSTAINABILITY

Winnipeg, as with many cities in North America, struggles with urban sprawl. The decision in 2004 to move 2000 Manitoba Hydro employees downtown has boosted local business and new development [1].

The galleria is programmed for tenant space: restaurants, cafes and banks. This usage enhances street activity and allows the area to be active after work hours. An effort was made to encourage employees to utilize existing downtown services. Rather than provide amenities such as a cafeteria or fitness centre, employees are encouraged to leave the facility and support the existing amenities in the downtown area.

Another key element of Manitoba Hydro Place is its impact on employee transportation choices. At the previous suburban office location, 95% of staff travelled to work in individual vehicles. At the downtown location, with good access to bike and transit routes, 80% of staff are now using green commuting options; public transportation, carpooling and cycling which in turn has increased street animation.

CONCLUSION

Manitoba Hydro Place is a visible testament to the corporation's commitment to the delivery of innovative clean energy solutions. More importantly, the project offers a new way to think, design and deliver climate responsive architecture in the 21st century – both for an extreme climate as well as to anticipate extreme weather fluctuations.

As a reflection of the sustainable design and operation of Manitoba Hydro Place, the project was awarded LEED Platinum certification in 2011 and became the first office tower in Canada to achieve the highest level of sustainability under the LEED rating system.

The distinctive design has created an iconic addition to Winnipeg**'s** skyline and **catalysed the** economic and civic revitalization of the downtown, instilling a pride of place among citizens. To date it has received 17 awards for architectural and urban design excellence, sustainability and green design innovation. Three years after opening, it continues to be published internationally and is recognized as one of the top 15 buildings in the world on the subject of green architecture.

Ultimately, the design has realized the most important objective which was the creation of a supportive, comfortable and healthy workplace for the well-being of the employees, Manitoba Hydro's greatest asset. Partly as a result of having 100% fresh air year round, absenteeism due to illness is down by 1.5 days per employee and productivity has risen. The combination of vertically integrated, open work spaces, access to views and natural light, and the shift to public transit has placed a premium on face-to-face interaction in real time and space, and created an enhanced culture of team work and sense of community.

Designed and delivered through a formal Integrated Design Process (IDP), Manitoba Hydro Place offers a new paradigm for the design and construction industry to lead us towards a carbon-neutral future in which the health and well-being of the human experience is first and foremost respected and prioritized.

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