The UnTower: Forging an Adaptable Design For Evolving Real-Estate Conditions


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Abstract

Designing for sustainability, adaptability and reuse can extend a building's life cycle and substantially lower embodied carbon. This research paper examines the design and cost feasibility for a use-neutral typology in North America, featuring an external elevator core and vertical infrastructure. The program adaptability, paired with modular prefabrication, underpins a highly sustainable, scalable, circular solution. Componentized structures have enabled Asian temples to function for over a millennium. Similarly, in this tower pair, two principles are at play: an architectural geometry, with structure and systems that permit adaptability over time, and a design philosophy in which individual building components can be easily replaced at the end of their lives, expanding the building's usefulness and performance.

Keywords: Adaptability, Carbon Life-Cycle, Modular Construction, Steel-Timber Hybrid

Introduction: A Brave New World

Today's state-of-the art is tomorrow's empty lease. In 2022, the world needs new models for a circular economy, not only to improve the agility and value retention of real estate, but also for the decarbonization and environmental resiliency urgently required to reduce the impact of climate change.

Most buildings are designed and built for a specific use or program mix. Occupant needs and desires are ever-changing. Increasingly, in the time it takes a building to go from concept to occupancy, program needs change, causing costly delays and revisions.

What if buildings were use-neutral?

The unTower (see Figure 1) is a Use-Neutral building concept. The design has a distinctive ring-like, cylindrical form that enables easy adaptations between residential, commercial, and hospitality program functions (see Figure 2).

Figure 1. Aerial view of the unTower, Burnaby, Canada–looking southeast. © B+H Architects

This doughnut-shaped concept pairs program adaptability with modular prefabrication to offer a circular economic solution that allows easy assembly and disassembly, as well as reuse of spaces, building components, and materials. This philosophy extends the building's useful lifetime by allowing it to take on new forms and adapt to new uses, lowering its embodied carbon footprint.

The unTower team researched two sites for design and cost feasibility of a use-neutral typology: Bellevue, Washington, USA, and Burnaby, British Columbia, Canada. While this analysis is for sites in North America, its findings apply globally.

Features of the unTower

Use-neutrality is created by adaptable modularity of the floor plan, distribution of services and circulation, infrastructure, and construction assemblies that accommodate various program uses.

The traditional central elevator core layout and its resulting lease spans limits building use. The innovative installation of the unTower's elevators and vertical infrastructure outside the main building enables the towers to adapt efficiently and economically to changing program needs.

> "The design geometry is based on a lease-span dimension of 11 meters that suits the common uses of residential/senior living, hotel, and office environments."

Volumetrically, the unTower is a cylinder. Its circular floor plates are stacked and open to both the interior atrium (see Figure 3) and the exterior. The rings' geometric layout and their point-symmetrical origin enable structural and systems efficiencies, easy modulation, and expedited manufacturing and construction.

This adaptable design is cost-competitive with traditional, singular, and custom-use designs. The unTower is ideal for fast-paced, unpredictable program scenarios, and for projects in rapidly expanding cities, where adaptability, resiliency, and sustainability drive value.

The base and top of the tower and its enclosure treatment are tailored to site context and climate conditions. Structural, mechanical, and circulation needs are designed to accommodate the tower's site parameters, soil condition, height, and anticipated uses.

Basis of Use-Neutral Design

Between now and 2060, the world will build an entire New York City every month for 40 years—that is 230 billion square meters of new construction worldwide (Architecture 2030 2018). Net-zero energy buildings are the "Teslas" of sustainable architecture. Yet, like the electric car, their carbon performance relates only to operational energy use. Embodied carbon will be responsible for almost 50 percent of total new building-related emissions between now and 2050, putting it on par with operational carbon emissions over the next 30 years (ibid.)Mitigating this impact requires rethinking how buildings are constructed and adapted over time.

Componentization is Key

Demolishing and rebuilding structures to meet the modern city's ever-changing use

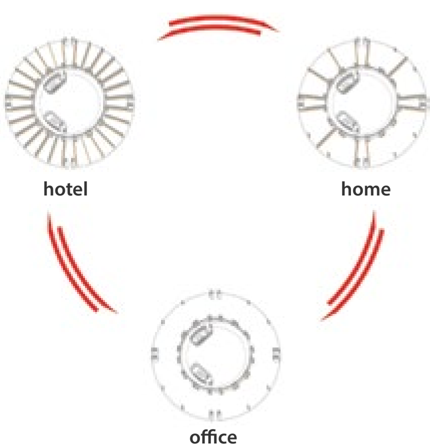


Figure 2. The unTower's program adaptability draws from its ring-like, cylindrical form.

Figure 3. The atrium is designed as a community and character-building, biophilic element of the unTower. © B+H Architects

Figure 4. Tō-ji Temple, Kyoto, Japan, originally constructed in 769 CE and last renovated in 1643, features a modular pagoda.

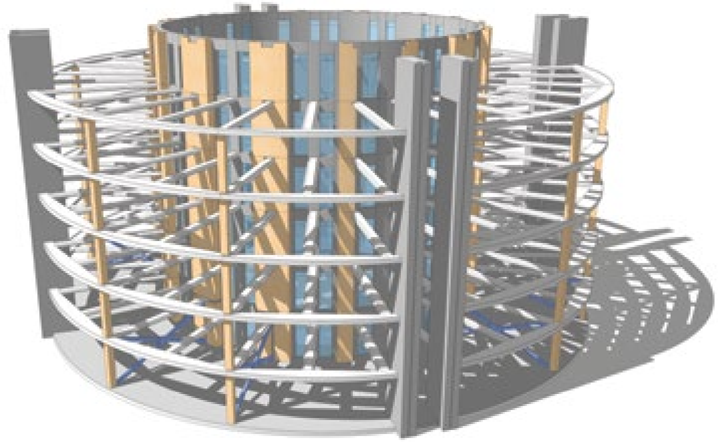
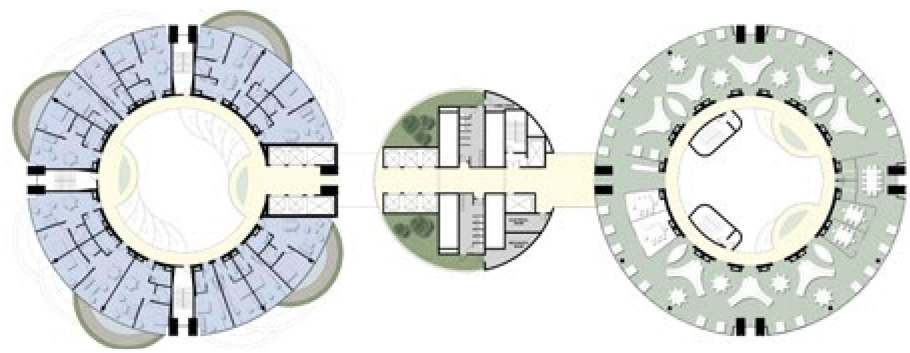


Figure 5. unTower conceptual assembly diagram. The modular, component-based approach is key to program flexibility.



Residential/hotel

Office

Figure 6. unTower, Burnaby – typical floor plans. The tower pair achieves economic viability partly through a shared service core.

requirements remains one of the leading causes of environmental loads, such as carbon emissions and construction waste (Ellen MacArthur Foundation 2021).

Building for longevity reduces carbon emissions, improves performance, and enhances revenue opportunities.

Componentized structures have allowed Asian temples to remain operational for over 1,000 years (Nishi & Hozumi 1996). Their design is underpinned by two guiding principles that establish the basis of the unTower solution:

- An architectural geometry, structure and systems infrastructure that enables use adaptations over time, and
- A kit-of-parts design, in which individual building components can be easily replaced at the end of their component lives.

Examples of this approach can be found in Japan, a leader in innovating modular prefabrication and replacement processes, rooted in design ideology, material science, and engineering. For example, the Tō-ji Temple, Kyoto, Japan was built in 796 CE, and its current state dates from 1643 (Cartwright 2017). The modular pagoda is 55 meters high and is the tallest wooden tower in the country (see Figure 4).

Similarly, the Grand Shrine in Ise is made from renewable materials like wood and thatch, and has been systematically rebuilt since 692 CE. There is a millennium of proof that modular structures, designed for independent component replacement, stand the test of time.

Speed-to-Changing-Markets

The unTower quickly adapts to rapidly changing market conditions and new program uses with integral geometry and technological innovations. From concept to occupancy, program requirements frequently change, causing costly delays, revisions, and empty leases. At the time of writing, the office vacancy rate in the United States was 12.3 percent (Statista 2022). Most buildings are designed and built for a specific use or program mix. These program-driven designs are constrained and can lead to redundancy, representing an environmental, economic, and social burden (see Figure 5).

Economy

The unTower is cost-competitive with traditional tall buildings. The unique plan geometry enables a high degree of systems repetition, duplication, modular prefabrication opportunities, and economies of scale. Tangible measures include the ability to add or subtract space and select in-floor beams (or beamless ceilings) that provide a consistent clear height. The economic viability of the unTower is achieved through the intrinsic concept of shared amenities, infrastructure, and circulation for all program elements and building uses (see Figure 6).

Mass timber (MT), wood laminated for strength, is the only renewable structural material available. MT and reinforced-concrete hybrids are cost-competitive with conventional reinforced concrete structures (DLR Group 2018). Prefabricated components can be installed with less on-site labor and lead to faster construction schedules with lighter foundations and fewer finishes.

Biophilia

Biophilia, our affinity for natural systems, determines the types of spaces to which we are subconsciously drawn. The unTower provides a biophilic user experience in the following ways:

Nature at Every Floor

Access to the sights, sounds and feel of nature are scientifically proven to lower breathing and heart rates and reduce the release of stress hormones (Ikei, Song & Miyazaki 2017). Buildings that promote holistic health and well-being are in high demand. Imagine what a reduction of five to 10 beats per minute would do to occupant health.

Step Outside

Balconies attached to individual units, atrium corridors and the central core, provide outdoor gathering and relaxing space at every floor, for all tenants.

Organic Form

The sight of curvilinear shapes activates a positive emotional response in the human brain. People are drawn to the beauty of spaces that echo nature's curved lines (Vartanian et al. 2019). In addition, circular building enclosures minimize direct solar heat gain, increase occupant comfort, and can improve space utilization.

Cross-Ventilation

The ring formation offers ample opportunities for cross-ventilation, alongside green balconies and communal gardens. Occupants have indoor spaces that benefit from constant fresh air.

Daylight and Views

With a hollow core or tall atrium, even rooms along interior walls can have access to diffuse daylight—a vitally important factor in human health and happiness.

Biomorphic Atrium

The atrium is a central, character-building element of the tower design. It is activated with an organic and curvaceous cascade of landscaped balconies and "hanging gardens" that evoke naturally occurring forms such as the "Chicken of the Woods" mushroom.

The atrium landscape design features extensive use of low-light plantings to ensure long-term growth rates of lush and healthy vegetation.

Access to natural ventilation, improved cross-ventilation via operable windows, and access to daylight and views are crucial drivers of post-pandemic architectural design. This inevitably results in a cost premium for an increased atrium façade area and higher performance specifications for the enclosure. The unTower design offsets these upfront costs through the building's extended life term, and the higher lease attraction and retention rates commanded by healthy, biophilic buildings.

For example, the atrium can be glass-enclosed and compartmented (with smoke evacuation and fire suppression systems) or open to the sky (with higher performance specifications for the atrium wall) depending on climate, culture, and market conditions. For the Bellevue site, the cost of a version with an enclosed atrium was US$7.03 million, compared to US$7.29 million for an open atrium.

Sustaining Systems

An easy, simple geometry, repeatability, and a high integration of modular building systems are the key elements of successful, adaptable architecture (see Figure 7).

Infinity Floor Plans

The point-symmetrical plan geometry enables a high degree of repetition, duplication, and opportunity for prefabrication, resulting in opportunities for economies of scale that reduce construction time, cost, and exposure to volatility in the labor and materials markets.

The radial floor plan layout is organized around a central atrium that can be open or glass-enclosed. The circular form makes adding or reducing spaces easy. Column-free lease spans accommodate all uses, on all floors.

The design geometry is based on a lease-span dimension of 10.7 meters that suits the common uses of residential/senior living, hotel, and office environments. This

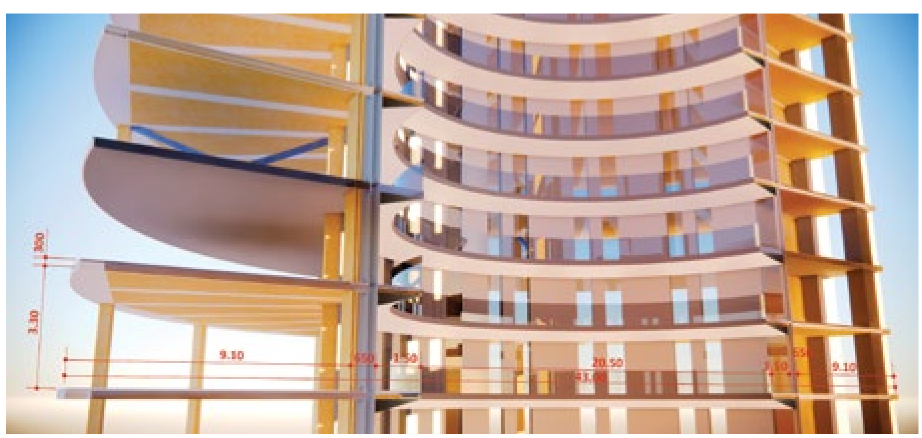


Figure 7. Conceptual partial section. An in-floor steel beam system minimizes the required structural floor assembly heights to 300 mm, resulting in reduced floor-to-floor heights, material volumes, and associated costs.

> "The efficiencies of circular trunk lines, radial floor distribution, and an increased life term of the building help offset inefficiencies associated with an external core and a more-remote location of the electrical, mechanical, and communication rooms."

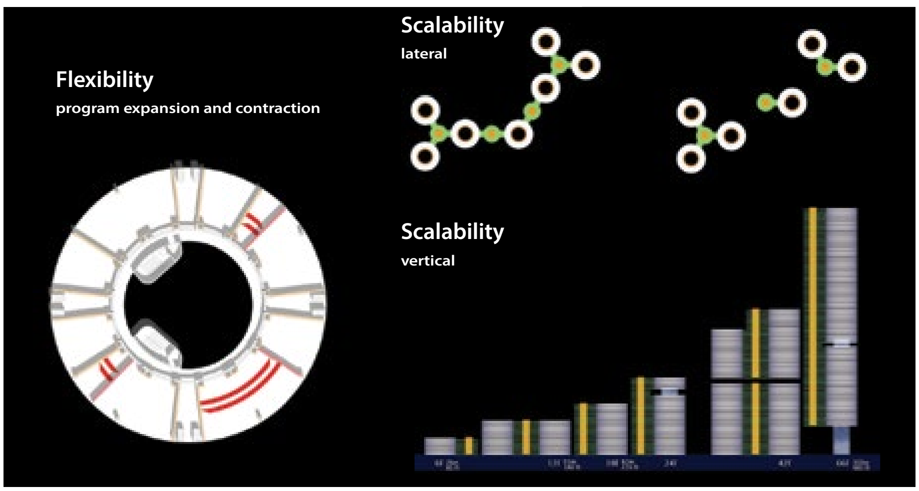


Figure 8. The unTower is designed for horizontal and vertical scalability. The number of towers and variations in building heights can be implemented with minimal design changes.

dimension reflects an industry-standard depth of 9.1 meters for residential and hotel-unit or workplace layouts, and a 1.5-meter circulation corridor.

In-Floor Beams

The in-floor composite beam system allows the beam to be recessed within, and flush to the underside of the slab. Segmented and curved in-floor edge beams define the perimeter. This enables reduced floor-to-floor heights, which can have many impactful benefits, including:

- Reduced thermal energy loads, as there is less air to condition.
- Increased number of stories in towers limited by building height, which in turn maximizes yield and generates material savings.
- Lower first costs and lower embodied carbon because of these attributes.

Ceiling clear heights of 3 meters, and 2.7 meters to the underside of structure and MEP systems, are standard in commercial office planning, resulting in office floor-to-floor heights of 4.1 meters. Floor-to-floor heights of 3.0 meters are most common in residential and hotel environments. The proposed in-floor beam system results in a total floor assembly depth of only 300 millimeters. For the unTower, a consistent floor-to-floor height for office, residential, and hotel programs of 3.3–3.6 meters is economically feasible. The additional floor height and subsequent cost impact for residential/hotel product are negligible when considering the gains in use adaptability, market and brand potential, and implicit life-term extension of the building.

Floor Assembly Choices

Floor assemblies can be built with five-ply CLT panels, hollow-core concrete, or long-span metal deck as inlays between in-floor beams. The project pencils across all these material choices, ensuring compliance with local code and market conditions. All assemblies are designed to meet wind/seismic, fire-safety, smoke control, and sound-attenuation requirements.

Shrink + Grow as Needs Change

The interior walls and partitions are non-load-bearing and independent from the superstructure and the MEP chases. The tower's mechanical systems are integrated into the reinforced concrete core and stair towers, and are radially distributed in the soffit above the corridor. This allows for easy access at each opening in the structural core, to make modifications as desired based on the tenants' needs. Partition walls are modular and can be moved as program and tenant needs change over time. This allows owners, landlords and tenants to maximize convenience, spatial and program needs and ROI.

Scalable Design

Scalability is the ultimate adaptability. The unTower is designed for horizontal and vertical scalability. It includes flexibility to connect more than one tower to a single services core or adjust the service core to the desired gross floor area and building heights as needed (see Figure 8).

Depending on site-specific requirements, changes to the number of towers and building heights can be implemented with minimal design changes. Material selection is flexible, allowing the owner to select the most appropriate construction for project needs. With the ability to both shrink and grow the tower dependent upon the needs of the site, the unTower can work at a variety of scales and site locations.

Every project starts with basic program assumptions, and designing the unTower is no exception. A vague understanding of a likely use distribution creates the initial Basis of Design for site planning and cost modeling. For example, in Burnaby, the designers assumed that half of the project's adaptable program would be dedicated to workplace and the other half to residential and mixed-use functions. The team then devised vertical transportation and life-safety strategies to consider other site and zoning parameters. The layout configuration and geometry of the unTower enable program changes at any stage of design, construction, and occupancy, through adaptations and conversions that are clean, quick, and cost-effective. Consequently, the initial cost model is appropriated to the most likely initial use scenario defined by the Basis of Design.

Similarly, in the jurisdictional design review process, during entitlement, land-use planners are typically focused on urban design impact, i.e., the contextual issues that are external to the building. Therefore, changes to program or vertical transportation distribution can be accommodated independently, without impacting the jurisdictional process and schedule.

Multi-Use System Adaptability

Until now, changing use from office to residential, or vice-versa, required structural retrofits and significant MEP modifications. The unTower concept demonstrates that a building can be designed with multiple tenant types in mind. The design DNA (see Figure 9) ensures that modular spaces can be repurposed, and their components adapted, reused, and recycled easily and economically, with minimal rework.

Structural Economy

The key structural benefits of designing an adaptable building are cost and schedule savings and the reduction of carbon emissions associated with upgrading the structure for higher live loads than originally assumed. Designing the floor system for office live loads (taken as 488 kg/m^2), instead of residential or hospitality loads (195 kg/m^2), creates some structural redundancies, first-cost inefficiencies, and an initially higher embodied carbon content. However, it allows a tenant to switch seamlessly between uses without requiring structural retrofits. Therefore, the program and use-interchangeability will result in a significantly extended life term. Structurally, the framing layout with long-span decks minimizes the number of oversized structural elements, reducing the initial cost associated with larger beams and columns required for office loading.

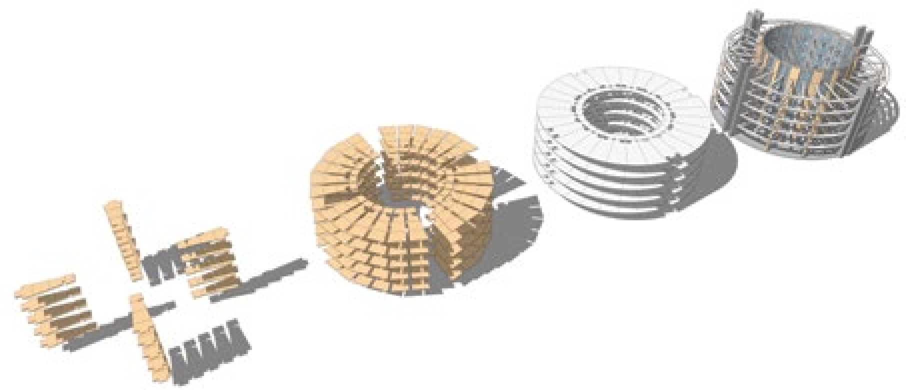


Figure 9. Modular, prefabricated and largely reusable building components provide for an adaptable building and use typology.

The vertical transportation and life-safety requirements of the service core can be adjusted without impacting the structural integrity of the tower. Their external configuration allows for maximum program adaptation and accessibility. For example, additional egress stairs required for office uses can be integrated on day one (see Burnaby example) or added later to the service core or inside the atrium, without implications to the integrity of the tower structure.

Mechanical Economy

Balancing user comfort, use adaptability, infrastructure sizing and optimization, and cost are key drivers in sustainable MEP systems design. The goal is a design that accommodates a variety of occupancies and requires upgrades only as needed. The mechanical circulation and distribution are optimized through a radial riser configuration at the inner ring of the programmable tower. The efficiencies of circular trunk lines, radial floor distribution, and an increased life term of the building help offset inefficiencies associated with an external core and a more-remote location of the electrical, mechanical, and communication rooms (see Figure 10).

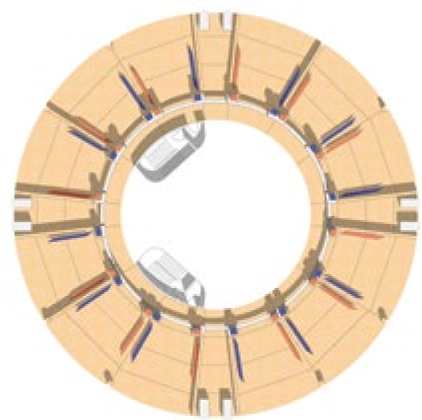


Figure 10. MEP distribution at the inner ring. The mechanical circulation, trunk lines and distribution are optimized through a radial riser configuration at the inner ring of the use-neutral tower.

The ability to separate systems is desirable, as it allows billing to separate occupancies. This includes dedicated Energy Recovery Ventilation (ERV) units for hotel and assisted living occupancies, and small Variable Refrigerant Flow (VRF) units that can easily be broken out. ERV and VRF units are contained within the floor area. They have direct access to outside air via the exterior louvers in the enclosure. They are in floor quadrants that do not share adjacencies with the service core or other amenity spaces.

Bellevue, WA, USA Cost Performance Indicators (Revised Crescent Scheme)		**Burnaby, BC, Canada** Cost Performance Indicators	
Total Construction Cost:	**$404,557,000**	**Total Construction Cost:**	**$1,334,908,000**
Unit Price:		Unit Price:	
South Tower, Hotel:	$4869/$m^2$ ($388,521/key)	West Tower Shell:	$4,092/$m^2$
		Hotel Buildout:	$1,955/$m^2$
South Tower, Sr. Living:	$5,604/$m^2$ ($453,634/unit)	Residential Buildout:	$2,235/$m^2$
		Sitework:	$22.50/$m^2$
North Tower Housing:	$5,260/$m^2$ $545,195/unit	East Tower Shell:	$4,211/$m^2$
		External Tower Core:	$6,018/$m^2$
Podium:	$6,180/$m^2$	Podium:	$3,390/$m^2$
Parking:	$3,139/$m^2$ $109,665/stall	Parking:	$2,214/$m^2$

Table 1. unTower construction cost comparison of Bellevue, WA, USA and Burnaby, BC, Canada.

	A Standard Tower	B Use-Neutral	= A-B Variance
Land Cost/m^2	$1,000	$1,000	$0
Hard Cost/m^2	$6,000	$6,600	-$600
Soft Cost/m^2	$1,200	$1,200	$0
Total Cost/m^2	**$8,200**	**$8,800**	**-$600**
Yield on Cost	7.0%	6.5%	0.5%
NOI/m^2	$574	$574	$0
CAP Rate	5.5%	5.5%	0%
Sale Price/m^2	$10,436	$10,436	$0
Profit/m^2	**$2,236**	**$1,636**	**$600**

Table 2. First cost evaluation (static).

	A Standard Tower	B Use-Neutral	= A-B Variance
Conversion Cost/m^2 (2021)	$3,000	$1,000	$2,000
Annual Cost Escalation	5%	5%	
Conversion Cost/m^2 (2035)	**$6,240**	**$2,080**	**$4,160**
Discount Rate	8.5%	8.5%	
Conversion Cost/m^2 (2021)	$1,834.50	$611.50	$1,223
Scenario Probability		50%	
Savings/m^2		50% x $1,223 = $611.50	
Cost/m^2		= $600	
Value Proposition/m^2		**$611.50 - $600 = $11.50 (cost neutral)**	

* Costs are theoretical and calculated using 2021 conversion costs as a baseline and growing costs for 15 years at an assumed construction cost inflation index rate.

Table 3. Life-cycle evaluation (dynamic), © SilentWater Real Estate, 2021.

ERV will provide mechanical ventilation needs for all occupancies, including affordable housing, hotel, residential, assisted living, and office.

VRF will provide conditioning for most occupancies. An alternative to consider is Hybrid VRF to reduce refrigerant limit concerns, or electric wall heaters for tenant types like affordable housing.

Cost Modeling and Value

The economic viability of the unTower is achieved through the intrinsic concept of shared amenities, infrastructure, and circulation for all program elements and building (see Table 1). Spaces that can adapt to senior living, residential, office, and hotel uses are activated and brought to life through shared basic amenities and access to specialty program elements such as pool areas, co-workspaces, learning hubs, and entertainment.

Quantitative Value

The strength of the unTower concept lies in the physical separation between the programmed tower(s) and the service core. This relationship between occupied floors and service floors ensures maximum use adaptability and cross access for ventilation, daylight, and views. Program and site requirements permitting, greater efficiencies can be achieved if the service tower core is shared with more than one programmed tower (see Burnaby example).

The first cost evaluation indicates a premium over a standard tower. This cost premium reflects larger enclosure area and specification performances due to the atrium and the external service core.

First Cost Evaluation vs. Life Cycle Evaluation

The unTower offers the developer the ability to begin construction without being locked into a planned use, leaving the option for it to become office, residential, hotel, etc., based on market demands after construction has started. However, as current financing options are generally use-specific, and different uses are valued using different rates of return, the comparisons in Table 2 assume the tower is built as office space, and the use change occurs later in the asset's life.

The traditional first cost approach is a static financial perspective that looks at development costs and sale price. The Table 1 is exemplary and shows how the cost of the unTower compares to the cost of a standard tower, when we evaluate it using a traditional static yield approach.

For the Bellevue site, cost analysis found that the external core configuration is not cost-competitive for a shorter, single tower. Integrating the core back into the building preserved the spirit of the cylindrical tower form without sacrificing cost efficiency.

Assuming that a conversion would occur after an initial office lease term of 15 years, the highest and best use of the space is now residential. The life cycle approach is a dynamic approach that accounts for the building's yield over time. Table 3 shows how the cost of the unTower compares to the cost of a standard tower when we evaluate its yield potential over time.

Qualitative Value

The adaptive re-use conversion of a standard tower typically triggers costly changes to the structural system due to modified load paths, mechanical distribution of control rooms, chases, and trunk lines, and implicit acoustic and fire safety control measures. From project experience in the central business districts of North American cities and for this study, the authors estimate that the cost of use conversions of a standard tower is three times more than the unTower, into which structural, mechanical, and architectural infrastructure were designed with adaptive reuse as a driver.

Unlike the unTower, the adaptation of a standard tower, if feasible, is expensive and, in most cases, results in steep compromises that negatively affect functionalities and efficiencies of the building core, the circulation system, and design aesthetics.

The preceding cost comparison demonstrates that, when evaluated over time, the unTower is cost-competitive with today's standard construction. What this analysis does not quantify in dollar terms are the many economic, social, and environmental benefits that accrue as a result of the foresight and adaptability for design and planning.

People, Planet, and Profit

The unTower is an agile solution for commercial property that allows for easy program adaptations over time, reduces environmental impact, and supports human health and well-being.

As Mark Carney, former governor of the Bank of England, put it, climate change is "the greatest commercial opportunity of our time." The unTower responds to this challenge.

Its universal, program-neutral geometry and modular construction extend the building's useful life, quickly and cost-effectively adapting to new uses over time. This represents an attractive, risk-mitigated proposition in times of constant change.

An emphasis on the use of natural materials, access to ample daylight, outdoor spaces and views provides tangible occupant health benefits and attractive amenities that also translate to higher lease rates and revenue.

Higher Value
The unTower's unique shape, environmental performance and biophilic design attributes increase the property value, rent potential, tenant retention, and user engagement.

Strong Brand (Lease Up)
The tower's unique geometry stands out against a skyline dominated by rectangular buildings. Its "inside-out" experiences increase leasing and foster higher tenant retention.

Faster Turn Around
The typology may result in a quicker turnaround, with easy access to MEP systems and without the need for structural modifications.

Faster Schedule
Construction time is significantly shortened by a high degree of component prefabrication.

Lower Operating Costs
Reduced electrical and mechanical loads for lighting, air conditioning, and ventilation can be achieved with two-sided access to daylight and distributed cross-ventilation.

Shared Costs
The unTower's external core and shared functions and uses at podium level provide opportunities to share amenity and service costs with adjacent uses and buildings, reducing capital and operational costs.

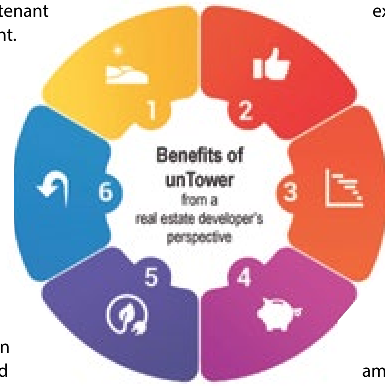


Figure 11. Benefits of unTower from a real estate developer's perspective.

Most significantly, the unTower represents a departure from carbon-intensive, traditional building methodologies and instead responds to the imperative to decarbonize the building industry. Its easy assembly and disassembly, reuse of spaces, building components and materials, shared services and amenities and extended life span, all represent a reduction in embodied and operational carbon footprint.

Buildings that promote human health and well-being lease up faster, command higher rent potential, and increase tenant retention (Cover 2020).

Climate change is the existential challenge of our time. As architects and designers, we have a responsibility to decarbonize buildings by exploring renewable materials, low-carbon processes, and carbon-neutral operations. Achieving environmental, social, and economic resiliency will redefine the future of business and the meaning of profit (see Figure 11). ■

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