Sustaining Technology:

Questioning the Role of Efficiency in Environmentally-Sustainable Architecture

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Abstract

This thesis examines the role of 'efficiency' in environmentally-sustainable architecture. Specifically, it argues that when efficiency is the overarching design value of an environmentally-sustainable architecture, the technological systems employed by that architecture inevitably remove the user from the means of producing his or her desired ends, such as heating the interior spaces. A technological system that does consciously engage its users subsequently does not engage the users' attention, aid, skill, or joy.[1] This thesis calls into question a technological system that renounces such essential, life-enriching qualities as the foundation from which to build a sustainable future.

The following thesis proposes an environmentally-sustainable condominium in New York City that employs technological systems in which its users are consciously engaged with the means of producing the desired ends, thus allowing essential, life-enriching qualities to flourish.

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[1] Aidan Davison, Technology and the Contested Meanings of Sustainability. (Albany: State U of New York P, 2001) 112.

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This thesis assumes that global environmental change and ecological degradation are real, and, subsequently, architecture can play a role in addressing this unprecedented predicament.

Introduction

"There are no simple, universal, or transparent answers to the questions of sustainability."

- Aidan Davison, *Technology and the Contested Meanings of Sustainability*

Contemporary practices of environmental sustainability in architecture are falling short of achieving symbiotic relationships with the natural environment. The issue, which is the premise of this thesis, is that these architectures hold 'efficiency' as the driving value in their conception and realization. Efficiency inevitably leads to an objectifying, domineering relationship with the natural environment and, more important, encourages technological systems that, in their quest for efficiency, distance even the most well-intentioned user from the means of producing benevolent ends. This thesis does not accept a technological system that denies our attention, aid, skill, or joy[2] as the foundation from which to build a sustainable future.

The role of efficiency in environmentally-sustainable architecture is explored through two case studies: one urban and one rural. "In 1950, just over one third of the world's population were city dwellers, a total of 860 million. By the close of the century, this number had grown to just under three billion, forty-eight percent of total population. But in just the coming fifteen years, it is expected that four billion people will live in cities, or fifty-five percent of the global population."[3] Reevaluating practices of environmentally-sustainable, urban architecture has never been more timely or critical.

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[2] Davison 112.

[3] Bjorn Lomborg, The Skeptical Environmentalist: Measuring the Real State of the World. (London: Cambridge, 2004) 49.

The Currents, the first case study, is a 'green' condominium project presently under construction in Ottawa, Ontario. This building is expected to become Canada's first *Leaders in Energy Efficient Design* (LEED) Gold-certified work of domestic architecture.[4] This unprecedented achievement will set the bar for environmentally-sustainable works of multi-unit, residential urban architecture in Canada, if not North America. As such, this work provides an appropriate vehicle for examining the role of efficiency in contemporary practices of urban, environmentally-sustainable architecture.

The second case study that builds a foundation for this thesis is Glenn Murcutt's *Magney House* in New South Wales, Australia. The *Magney House* is an environmentally-sustainable architecture that was derived from design values other than efficiency. As a result, this architecture is able to require of its occupants the adjustment of hand-operated apertures through which the natural elements condition and enrich the interior spaces. While applauding Murcutt's application of technological systems, this thesis, however, posits that the *Magney House's* rural site is not subject to the design constrictions imposed on an architecture of the city, such as constrained building orientation.

This thesis proposes an urban, environmentally-sustainable condominium that employs technological systems in which its inhabitants are consciously engaged with the means of producing the desired ends. Such technological systems would nourish, not deny, essential qualities that enrich our lives, such as attention, aid, skill, or joy. This proposition requires a fundamental shift in contemporary attitudes towards technology and efficiency. An "understanding of technology that can move into the aspirations that animate our moral lives, aspirations about what we most want to sustain in our experience"[5] is required.

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[4] Windmill Developments Website <http://windmilldevelopments.com/currents/lifestyle.htm>
[5] Davison IX.

Theoretical Premise

Theoretical Premise

The natural environment is in a state of perpetual decline, and it is widely accepted that human activity (i.e. our technological way of being that results in the proliferation and application of technology) is responsible for this unprecedented ecological degradation. Ironically, however, works of environmentally-sustainable architecture consistently and blindly employ technological means to temper the devastation initially caused by the ubiquitous implementation of technological 'innovation'. The *Theory* component of this thesis investigates the link between technology and ecological degradation, our ontological connectedness to technology, the root of technology that is efficiency, and the inevitability and implications of technology's users being removed from the means of the technological process as a result of efficiency.

The *Intergovernmental Panel on Climate Change* (IPCC) estimates that "during the twentieth century, the earth warmed up between 0.3 and 0.6°C, while sea levels rose on average by 15 to 25cm"[6]. Unless we significantly change our actions, it is predicted that, in the twenty-first century, average temperatures are likely to increase between 2°C and 5°C, while sea levels will reach destructive levels.[7] Moreover, as of 1750, "the atmospheric concentration of carbon (CO_2), which accounts for 60% of the greenhouse effect, has increased by 30%."[8] This date coincides with the beginning of the industrial revolution, indicating a correlation between industrialization and ecological degradation.

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[6] Dominique Gauzin-Muller, Sustainable Architecture and Urbanism: Concepts, Technologies, Examples. (Basel: Birkhauser, 2002) 12.
[7] Ibid 12.
[8] Ibid 13.

Construction and subsequent usage of human-made environments (cities, infrastructure, architecture) is the largest contributor to environmental degradation. It is estimated that the built environment accounts for "50 percent of natural resource consumption, 40 percent of energy, and 16 percent of water use. In addition, building construction and demolition produce more waste than the combined volume of household waste."[9] Further, the building industry, on average, accounts for 30 percent of CO_2 emissions[10]. Reevaluating construction and dwelling practices has never been more imperative.

In response to this exorbitant consumption of natural resources and the associated ecological degradation, environmental-sustainability initiatives in architecture consistently default to an instrumentalist rhetoric. For evidence of this rhetoric, one need look no further than the national environmental-sustainability initiative *Leaders in Energy Efficient Design* (LEED), considered the North American standard for 'green' construction practices. LEED promotes its agenda as one "based on well-founded scientific standards," advocating "state-of-the-art strategies for sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality"[11] While LEED's pursuit, at first glance, seems straightforward and virtuous, it presents a paradox whereby 'scientific' technological means are invoked to mitigate the environmental devastation caused by the ubiquitous implementation of technological 'innovation'.

A strong, direct link exists between environmental degradation and the proliferation of technology. Therefore, any inquiry into environmental sustainability must clearly address technology in all of its manifestations, including the two

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[9] Gauzin-Muller 15.
[10] Ibid 16.
[11] U.S. Green Building Council Website <http://www.usgbc.org/DisplayPage.aspx?CategoryID=19>

predominant, opposing theories of technology: *Instrumental Theory* and *Substantive Theory*.

Instrumental Theory is the most generally accepted view of technology. This theory is predicated upon "the common sense idea that technologies are tools standing ready to serve the purposes of their users."[12] Technology, as per this theory, can thus be defined as "tools, machines, utensils, apparatus, utilities, clothes, structures, and automata", as well as the associated activities, such as "invention, design, manufacture, maintenance, and craft."[13] *Instrumental Theory* deems technology as the neutral instruments of human ends, denying an ontological connectedness to technology. This 'oversight' within *Instrumental Theory* is precisely the premise of *Substantive Theory*.

Substantive Theory, conversely, declares "technology constitutes a new type of cultural system that restructures the entire social world as an object of control."[14] This theory labels technology as the organizing principle of our lives and examines the extent to which it determines our social, economic, and ecological relationality. "These explanations uncover the ways in which technology is constitutive of our experience and thereby has substantive social character in its own right."[15]

Both theories have virtues and limitations. *Instrumental theory's* limitation is that it considers "the partial truth to be the whole truth about technology."[16] From an environmental perspective, are we really to accept that it is only a matter of technology becoming sufficiently efficient in order to sustain irresponsible patterns of over-consumption? Are we really to accept that technology in no way influences or

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[12] Andrew Feenberg, Critical Theory of Technology. (New York: Oxford University Press, 1991) 5.
[13] Davison 96.
[14] Feenberg 7.
[15] Davison 96.
[16] Ibid 96.

embodies who we are or how we operate in this world? *Substantive Theory*, on the other hand, also claims that technology is completely external to our human condition. However, *Substantive theory* inverts the *Instrumentalist* position, arguing that we have ultimately become the 'faithful servants' of technology. This thesis rejects the *Substantivist* premise that we are completely enslaved by technology and are no longer able to exercise our intellect or make intelligent decisions about our engagement with technology.

Nonetheless, "it has become fashionable to say that where science and technology have created problems, it is only more scientific understanding and better technology that can carry us past them. What the idea of technology rarely elicits from latemoderns is an appreciation that technology has become the defining characteristic of our social and ecological relationality."[17] Consequently, when considering resolutions to technological or ecological problems, discussion inevitably defaults to an *Instrumentalist* rhetoric. Australian critic of ecology and technology Aidan Davison, author of *Technology and the Contested Meanings of Sustainability*, illustrates this point well:

> When we learn that radiation from Australia's mobile phones — and there are now more than six million in a human population that has only recently grown to nineteen million — might be suppressing immune function, damaging memory, and inducing brain tumors in their users, the best we can do is hope that a radiation shield will soon be on the market: it seems inconceivable that we would hang-up our phones.[18]

When we deny technology's ontological connectedness, we are confronted with countless contradictions. We need think only of the camper or cottager who, in seeking reprieve from the highly-technological city, drives his or her S.U.V to the 'wilderness', equipped with a cell phone, gas barbeque, watch, and compass.

[17] Ibid 97.
[18] Ibid 98.

Carleton University professor and author of *The Feast: Meditations on Politics and Time* and contributor to *Sojourns in the New World: Reflections on Technology* Tom Darby, astutely asserts that "these odd contradictions appear because it is difficult to be consistent in our actions and speech when we try to deny that technology is the prime organizing principle of life today."[19] Moreover, because technology is the "prime organizing principle of our lives", for most, technology is beyond question — beyond reproach; Darby continues:

> Our age is one in which nature and human nature increasingly become malleable and progressively less is left untouched by our hands or by our questions. But one of the few things, if not the only thing, that most of us do leave unquestioned is technology. Because technology is that which informs us most, either it is like that which rests on the tip of our noses and which we therefore do not see, or it is like that which we fail to see because it is everywhere and everything for us and to us. But when this is seen today, few question its meaning, much less its authority and legitimacy.[20]

This is not to suggest that we cannot, or do not, make decisions or have opinions about what we deem to be good or bad technologies. Davison, again, illustrates this point well, rhetorically asking: "Many of us reel in fear and disgust from nuclear reactors, strip mines, and genetically modified organisms. And who cannot be anxious at reports that synthetic chemicals are causing nonhuman and human testicles alike to shrivel? Yet, most of us would welcome the security of crawling into a marvelously strong yet light weight tent as a blizzard sets in over an isolated camp?"[21] Clearly, technology is an integral component of daily life, and the answer does not lie in giving up technology; but why do we rarely question the substantive or culture-defining essence of technology?

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[19] Darby 18.
[20] Ibid 16.
[21] Davison 101.

Since technology is the "prime organizing principle of our lives" and has become one of the few cultural components — if not the only component — that we do not truly question, following Darby, "it is also our civilization's most primal value. This is the deeper reason why the meaning, authority, and legitimacy of technology are not to be questioned by most of us."[22] This primal value is at the root of our ecological predicament and the limitation of our "environmentally-sustainable" architecture.

The underlying issue with technology as the driving value in the conception and realization of environmentally-sustainable architecture is that the essence of technology is 'efficiency'. Efficiency is a self-perpetuating system that fosters an aggressive control over the natural environment — a relationship that is domineering and unsustainable. To understand this position, one must first consider the construct of the technological process. For this, Tom Darby's philosophical theory is again apt. The technological process, he clarifies, is such that the means to a specified end are objective and known. This explicit understanding of the relationship between means and ends — the quantitative, catalogued process of the means to some specified end — is what allows for technological innovation. Because the technological process is explicit, we are able to create a 'discontinuity' in the process (the means), thus altering the end as we choose or are technically able. This disruption in the process inevitably results in greater efficiency because there is now a more explicit, direct relationship between means and ends.

The aforementioned innovation — the disruption and adjustment of an existing technological process — will always occur internally, within the means. This is so, because there is "no external end or standard that limits the selection of the

[22] Darby 18.

material used, the object's form, the procedure followed, or even the specific use to which the object will be put."[23] Therefore, the ends are never fixed: they are always changing/adapting as the means are adjusted. Moreover, "the circularity of the technological process indicates that its means become its own end;"[24] Darby explains:

> It follows that for technology the standard or end is simply the most efficient means, the means that best justify the object at a particular moment. This is the meaning of efficiency: the best and thereby closest possible ratio between means and ends at a given moment within a particular technical milieu and at a given state of the art. Thus, the greater the identification of means and ends, the greater the efficiency.[25]

With efficiency as the end, or standard, of technology — with no external limiting factors — it provides the framework for an internal system that can always be reflected upon and adjusted for greater efficiency. In this way, technology becomes self-perpetuating. This system "gives shape to the ever increasing efficiency that constitutes technology's underlying principle. Through a discontinuous and thereby cyclical process, technology continually tends toward increased efficiency."[26]

With respect to the natural environment, the problem with technology "continually tending toward increased efficiency" is that technological efficiency is directly related to the amount of control humans have over the natural environment: the more precise the system, the more effective control it possesses. Further, this relationship constructs the framework from which we relate and engage the natural environment:

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[23] Darby 7.
[24] Ibid 7.
[25] Ibid 7.
[26] Ibid 8.

> The essence of technology lies in its progressive disclosure to man that the world consists of quantifiable, calculable, manipulatable stuff whose primary value only can be understood and appreciated in relation to the increase of human power... in this way, everything that exists becomes increasingly caught up in technology's circular self-referring process, losing thereby its objectivity and dissolving into raw material to be shaped by human will.[27]

This quote makes the limitation of efficiency explicitly clear: by virtue of its own construct, technology's perpetual quest for greater efficiency reduces natural resources to quantifiable, 'raw material'. This is because efficiency is both self-perpetuating and the ultimate — but ironically never-attainable — end of technology. Everything else, including our natural environment, is subordinated to that end. As a result, it is most efficient for natural resources to be characterized as 'raw material', as simply the unquestioned means to some specified end. Thus, efficiency's relationship to the natural environment is, to say the least, aggressive and supports a human-against-nature, adversarial relationship.

Twentieth-century philosopher and primary advocate of *Substantivism*, Martin Heidegger, labels this aggressive attitude towards nature as 'technicity'. Technicity, he professes, is revealed by a "decisive break in the evolution of technology, which can only be detected by an aggressive and domineering attitude toward nature." The fundamental difference between what he refers to as 'pre-scientific' technologies and 'scientific' technologies "lies in the illusion of domination and the absence of the necessary attempt at domination in the earlier technologies. In pre-scientific technologies, man was a being within nature, whereas in contemporary scientific technologies man sees himself as being over nature."[28]

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[27] Ibid 8.

[28] Harold Alderman, "Heidegger's Critique of Science and Technology." Heidegger and Modern Philosophy: Critical Essays. (New Haven: Yale UP, 1978) 48.

This relationship is clearly articulated by Harold Alderman, a Heideggerian scholar and professor emeritus of philosophy at Sonoma State University, in *Heidegger's Critique of Science and Technology*. Alderman uses his own and one of Heidegger's examples to illustrate this notion of technicity. The first example compares the construction of a pedestrian bridge over Germany's *Rhine River* and the construction of a hydro-electric plant adjacent to the *Rhine*. The pedestrian bridge, he notes, is built into the *Rhine*, but 'allows' the water to move freely around the pillars buried deep in the river's bed. With this construction, the water maintains its 'riverly character' while the bridge fulfills its objectives in allowing pedestrians to cross from one shore to the other. Alternatively, the hydro-electric plant literally and figuratively displaces the river by drawing it into the plant to propel the electricity-generating turbines. With this construction, not only is the river physically displaced, but, more important, the 'riverly character' of the river is denied as it becomes a mere resource used to drive the generators. The mechanical force of the river is transformed into electrical force and the river becomes 'technologically identified' with electrical power. Alderman underscores this position by comparing the hydro-electric plant to a windmill. The windmill, he asserts, uses the wind to rotate its blades, but the character of the wind is never transformed: the windmill "lets the wind be itself, and does not move into a position as a mere resource. In fact, the windmill makes the direct power of the wind stand out more clearly."[29]

The third example compares a sailboat, which uses the natural elements to fulfill its objectives, to a motorboat, which dominates nature to achieve its objectives:

[29] Ibid 48.

> In the use of a sailboat one moves on the water through the use of currents and wind directions. In sailboating there is a dependency of the boat upon the wind and the water, and one is always very aware of this dependency. A sailboat is a thing of the water. By contrast, a motor boat is a machine used to overcome the water through the power of its engines. The currents and the winds around the body of water also enter into motorboating, but do so as obstacles to be surmounted. In motorboating one attempts to dominate the river, and can gain the illusion that the domination is possible. No such illusion is possible in sailboating. It is precisely such an illusion of domination that lies at the core of scientific technology.[30]

What is important to take from these three examples is an appreciation of technology's capacity to objectify nature — a position that is inevitable whenever efficiency is a driving value. Returning to the example of the *Rhine*, technology's ability to deny the 'riverly character' of the water is important because in stripping the river of this quality, the essence of the river is unable to enrich our lives and, in becoming mere resource, it fosters a complacent attitude towards our relationship with the river. This type of situation does not produce the foundation for a symbiotic relationship with our natural environment. The reduction of nature to simply resource and the subsequent human-against-nature, domineering relationship, is inevitable when efficiency is made the predominate value.

This thesis is not advocating that all aspects of efficiency be rejected entirely. Eco-efficient initiatives have had success in reducing negative environmental impact and spreading the message that there is an unprecedented need to mitigate ecological degradation. However, efficiency should not be the *driving* value in the conception and realization of environmentally-sustainable architecture. Efficiency's virtue lies in reducing the environmental strain imposed by technological systems that are not striving towards increased efficiency. It would be counterproductive and naïve to

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[30] Ibid 49.

argue against making a system or material more efficient if it did not impede overarching values that enrich our lives.

Contemporary architecture, including environmentally-sustainable architecture, employs technological systems to provide the life-giving elements that the inhabitants necessitate and desire, such as light, heat, water, and ventilation. Technological systems employed promise "to liberate humanity from physical hardship, scarcity, and danger and to present before us, instantaneously, ubiquitously, safely, and easily the things for which we once had to strive."[31] However, the more efficient the system, the further removed the user becomes from the process of producing his or her desired ends; Davison elaborates:

> The defining fact of a device is its ability to dissociate ends and means in our experience. It brings the ends — commodities — to the foreground of our experience, whilst ensuring that the means — technosystems — recede from view. The more these means withdraw from our immediate bodily experience, the more readily does the commodity become available. The device thus permits little or no insight into or engagement with its machinery. Its promise is to make commodities available as mere end, unencumbered by means.[32]

This notion is made clear when the typical technological process of heating our buildings — the central furnace — is examined. The central furnace has replaced the hearth as the primary source of heat; it eliminates the time-consuming, dirty, and arduous task of collecting wood or coal for fuel with the more efficient and consistent task of flicking a switch to engage the furnace. By the mere flip of a switch, the inhabitant is completely removed from the process (the means) of producing his or her desired ends (heat); this has many implications:

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[31] Davison 110.
[32] Ibid 110.

> The dissociation of means and ends through devices represents nothing less than a deformation of practice and nothing less than the disorientation of our moral experience. Through the creation and use of devices, we are building a world that would disburden and disengage us from the care of things. Our practices bifurcate into mindless labour and distracting consumption, drawing us into an increasingly careless stance toward those things that sustain us. Practices cease to be centered around world-revealing things, instead becoming centered on objects that produce what we want without our *attention, aid, or skill, and thus without our joy.*[33]

Ironically, our newly-found liberation from the arduous task of producing heat has also liberated us from the things that are good and important in life — things truly worth sustaining. Following Davison what is also "irrevocably lost is the family's careful, skilled, and cooperative maintenance of fickle, yet life-giving fire."[34] Moreover, the central furnace is "defined entirely according to the instrumental calculus of efficiency: it bears no testament to our relation of tradition, place, home, or community."[35] These qualities have not been replaced, only misplaced. They have been surrendered to process of technological efficiency, and in no way do these qualities enrich our lives — this is the true cause of unsustainability.

It is important to note that this thesis does not advocate that environmentally-sustainable architecture return to coal or wood-burning methods of heating buildings. Filling cities with the polluting smoke of a non-renewable resource is not the answer. However, it is the inhabitants' interaction with the means of producing the desired ends — the spirit of Davison's example — that this thesis *does* advocate.

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[33] Ibid 112. My Emphasis.

[34] Ibid 111.

[35] Ibid 111.

In order to transcend the limitation of contemporary environmentally-sustainable architecture, building practices must embrace and nourish qualities that enrich our lives. By placing qualities such as attention, aid, skill, and joy as primary design values, our building practices embrace the art of living well. This requires that our technological systems not exclude the user from the means, but, rather, allow the user to engage a system in which "ends and means interpenetrate and coevolve." "These are necessarily practices in which we encounter ourselves as carers of significant places, things, beings, and people." Following Davison, such practices would hold together an "appreciation of technology as a cultural project of mastery with an appreciation of technology as the forms of life in which the unquenchable ambiguity and richness of our human condition is played out."[36]

The richness of our human condition is broad and manifest in many different ways to each individual. However, surely it includes essential qualities such as the unwavering love we receive from our children and life partners; the conviviality of good food, drink, and laughter enjoyed with old friends; the tranquility of a body of water; a cooling, soothing mid-afternoon breeze; the warmth of the sun's rays in mid-winter; a good book; and even the deep smell of aged wood. "The prospects for building more sustaining worlds rest, ultimately, with a recovery of our practical experience. Sustainability is nothing less than the *craft of moral life*. The enervation of moral life is the real meaning of unsustainability."[37]

This thesis has argued that holding efficiency as our most *primal* value supports a domineering, objectifying, and unsustainable relationship with the natural environment. It has also argued that technological systems derived from such values disengage the user from the means of producing the desired ends, subsequently obscuring essential, life-enriching qualities. The two architectural precedents for this

[36] Ibid 95.
[37] Ibid 177. My Emphasis.

thesis, Glenn Murcutt's *Magney House* in New South Wales, Australia, and Peter Busby's *Currents Condominium* project in Ottawa, Ontario, exemplify the potentialities and limitations, respectively, of environmentally-sustainable architecture. Through a careful consideration and referencing of these works, this thesis will now investigate how the values discussed are manifested in two very differently-scaled works of domestic architecture.

Architectural Precedents

Peter Busby's *Currents Condominium*

The Currents is an 'environmentally-sustainable' condominium project presently under construction in Ottawa, Ontario that was designed with the goal of becoming Canada's first work of domestic architecture to receive *Leaders in Energy Efficient Design* (LEED) Gold certification.[38] This goal requires that the building meet "specific performance criteria that outperform typical standard practice"[39] as defined in LEED's prerequisites and credits. However, an issue arises because where the highest potential exists for inhabitant interaction with the technological systems — the *Energy and Atmosphere* requirements of LEED — LEED's overarching design value is *efficiency*. Subsequent to this, *The Currents'* realization of these values is antithetical to the theoretical premise of this thesis: in the pursuit of efficiency, *The Currents* employs technological systems that do not require the conscious engagement of the inhabitants.

38 Windmill Developments <http://windmilldevelopments.com/currents/lifestyle.htm>
39 Canada Green Building Council, LEED Green Building Rating System: Reference Guide for New Construction and Major Renovations LEED Canada-NC Ver. 1.0. (Ottawa: CGBC, 2004) 12.

Plate 03: Aerial view of Wellington West, Ottawa. Yellow indicates location of Currents' site.

Developed on a contaminated site at the corner of *Holland Avenue* and *Wellington Street* in Ottawa's west end (plate 03), *The Currents* is a forty-three-unit, 'environmentally-sustainable' condominium project atop the new facilities of *The Great Canadian Theatre Company* (GCTC) (plates 04 & 05). This multiuse building will showcase low volatile-organic-chemical (VOC) finishes and formaldehyde-free products; incorporate rapidly-renewable materials, such as bamboo, linoleum, and wool; provide high-efficiency fixtures and appliances, such as low-flow shower heads and energy-efficient kitchen appliances; achieve an estimated forty-five percent less energy and water use; and employ state-of-the-art, high-efficiency mechanical and electrical equipment.[40] *The Currents* intends to become Canada's first LEED Gold-certified work of domestic architecture, thus setting the precedent for similar environmentally-sustainable archetypes. Leading the endeavor to realize this unprecedented design accomplishment is Canada's most celebrated architect of environmental sustainability, Peter Busby.

In professional design circles, Peter Busby is considered the leading proponent of environmentally-sustainable architecture in Canada. His firm has designed numerous residential, commercial, and institutional environmentally-sensitive architectures, including the *Brentwood Skytrain Station* and the *Nicola Valley Institute of Technology* — each recipients of the coveted *Governor General of Canada Award of Merit for Architecture*. However, Busby's most noteworthy architectural contribution is arguably his primary role in establishing the national framework for evaluating works of environmentally-sensitive architecture, LEED. "I've been instrumental in setting up the *Canada Green Building Council* (CAGBC) and in getting LEED licensed in Canada," Busby proclaims, "so that it can become a good benchmarking tool across the country."[41] Further,

40 Windmill Developments <http://windmilldevelopments.com/currents/features.htm>
41 Penny Bondra, "Architecture as Philosophy: Peter Busby's Deeply Green Vision of Design." Interiors and Sources. (October 2003) 12 July 2005 <http://www.isdesignet.com/Magazine/03oct/cover.html>

Plate 04: View of The Currents from Wellington Street

Plate 05: Interior views of unit '3E'

every Busby employee and every architectural project produced by his firm must be LEED certified — a testament to LEED's immense influence in the design of Busby's architecture.

LEED is a voluntary, environmental-performance rating system that provides a national benchmark for the design and realization of 'environmentally-sustainable' architecture. LEED points are "earned by meeting specific performance criteria that outperform typical standard practice defined in Prerequisites and Credits."[42] These prerequisites and credits encompass sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation and design processes. "Improved building performance is certified with ratings — 'Certified', 'Silver', 'Gold', or 'Platinum'— based on total number of points earned by a project."[43] In three short years, LEED has helped create wide-spread ecological awareness and has advocated many progressive building practices and strategies that mitigate ecological degradation. Examples of such practices and strategies are as follows: promoting automobile-alternative methods of transportation; erosion and sedimentation control; redevelopment of contaminate sites; reduced heat island effect; water-efficient landscaping; renewable energy sources; reducing ozone-depleting mechanisms; encouraging recycling; encouraging building reuse; using regional materials; lowering volatile organic chemicals (VOC) in materials; monitoring carbon dioxide; and using building orientation to best suit passive heating and cooling. However, the LEED standard that is most likely to affect inhabitant interaction with the technological systems promotes efficiency.

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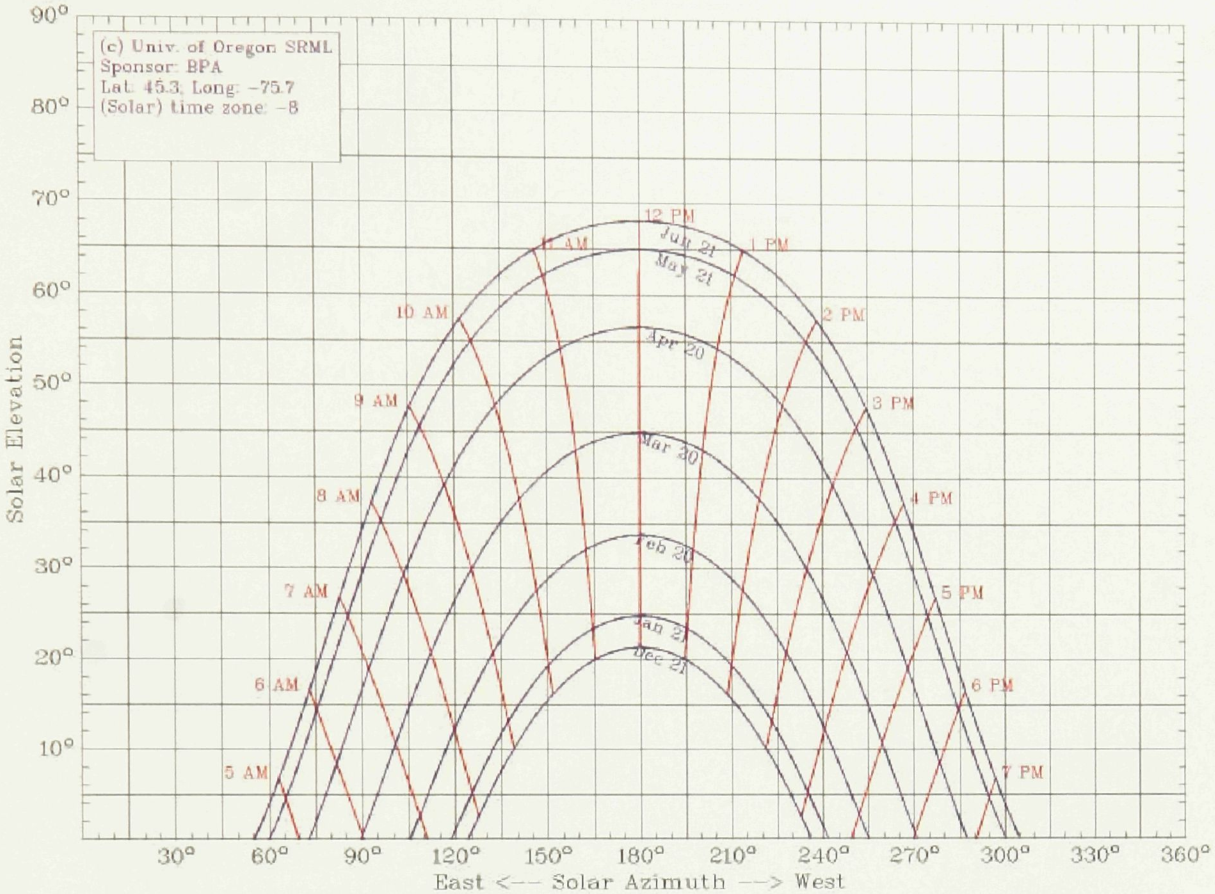
42 Canada Green Building Council 12.
43 Ibid 12.

The primary component of the *Energy and Atmosphere* section of the *LEED Reference Guide* focuses on reducing energy consumption for the base building and systems. "This prerequisite requires that the building achieve an energy efficiency level equivalent to the CBIP [*Commercial Building Incentive Program*] energy savings target. In most cases, this will require a change in the design of the building to incorporate more energy efficiency measures."[44] Moreover, the *LEED Reference Guide* further advertises that "the most important step any building developer or designer can take to create a greener building is to reduce its energy consumption."[45]

It is the *Energy and Atmosphere* LEED standard that most applies to passive heating and cooling, as these techniques reduce the energy required of mechanical systems. Moreover, passive heating and cooling techniques offer greater potential for inhabitant interaction with the technological means, in offering such options as hand-operated louver or venting systems. The main issue is that the *Energy and Atmosphere* section of LEED promotes efficiency, thus LEED-influenced works of 'environmentally-sustainable' architecture are employing the most efficient means available to achieve this required end. As a result, these systems, in their pursuit of efficiency, reduce and even obviate human interaction with the means of producing the desired ends.

The Currents realizes LEED's *Energy and Atmosphere* efficiency target by synthesizing various building techniques: solar orientation; a double-skin wall; high insulation values; fenestration location; low-e, double-glazed, thermally-broken glazing systems; balconies used as sunshading devices; energy-efficient compact fluorescent lighting and appliances; a heat-recovery ventilator; a fan coil distribution system in each suite; and a high-efficiency boiler system.

44 Canada Green Building Council 183.
45 Ibid 182.



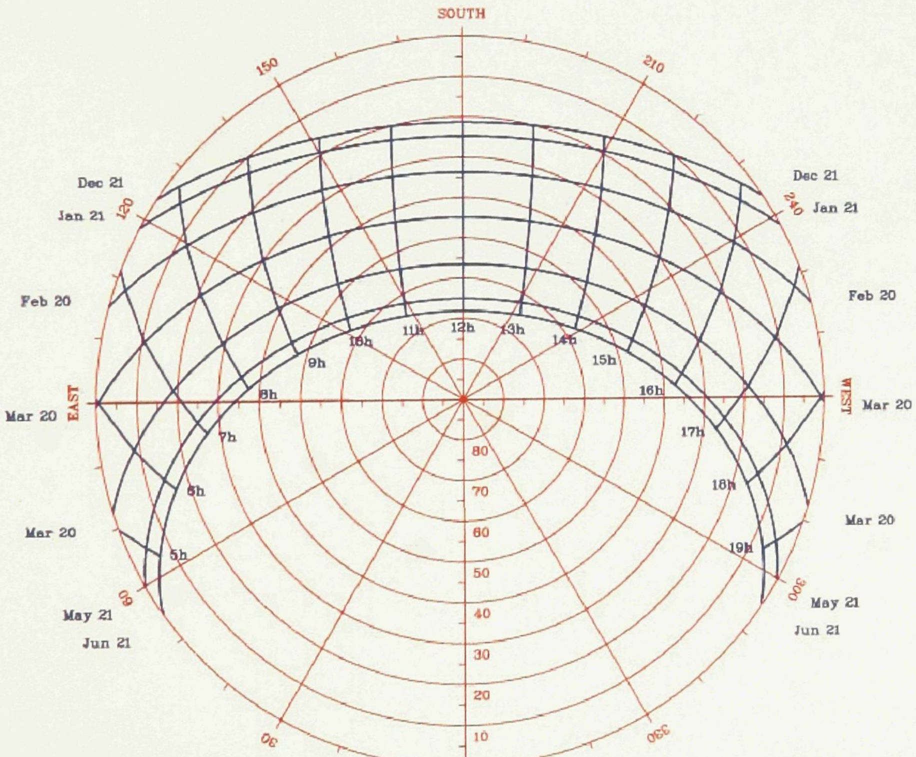


Plate 06: Solar position charts for Ottawa, Ontario (Latitude 45 19 N , Longitude 75 40 W). Charts indicate wider azimuth angle and higher altitude angle of summer sun, compared to winter sun.

Plate 07: Units 'C' and 'D' of typical floor plan. Blue indicates balconies precisely alligned to block higher-angled summer sun and permit lower-angled winter sun. Yellow indicates south-facing, double-skin wall. Note fenestrations face south. East and west exterior walls block wider azimuth angle summer sun.

Each of these techniques contributes to the overall energy efficiency of the building. The solar orientation of the building, for example, provides maximum sun exposure, thus offering optimal passive heating in winter months. Working in tandem with the building's orientation are the balcony and fenestration locations. Balconies are precisely positioned to shade the higher-angled, summer sun; the building's fenestration, primarily located on the south façade, receives the lower-angled winter sun and protects the East and West-facing walls from the wider azimuth angle of the summer sun. By limiting summer solar gain, these techniques also lessen the burden on mechanical cooling. Additionally, *The Currents* incorporates a double-skin wall to lessen the burden on the mechanical equipment. In utilizing greenhouse effect, the south-facing wall allows the sun's rays to penetrate the layer of glazing protecting the thermal mass within. Encapsulated heat within the cavity is then used as preheated air for the mechanical system. High insulation values and the low-e, double-glazed, thermally-broken glazing system also contribute to overall efficiency in that they restrict conditioned air from exiting the building. The heat-recovery ventilator maximizes conditioned air by recapturing heat radiating from the conditioned air exhausted from the building. Last, the energy-efficient appliances and high-efficiency boiler system require less energy to operate than conventional systems.

Although these synthesized techniques are successful in yielding an energy-efficient architecture, they are ultimately limited because they do not require the engagement of the inhabitant in any purposeful way. The extent of inhabitant interaction with the means of producing the desired ends — conditioning of the interior spaces in an energy-efficient manner — involves little more human interaction than the mere adjustment of a thermostat. In flipping a switch, the means have been surrendered to the process of technological efficiency, and in no way do these qualities serve to enrich the lives of the inhabitants. In an interview conducted with Jonathan Westeinde, founding partner of *Windmill Developments* (*The Currents'* developer) and member of the *Canada Green Building Council* Board of Directors, explained that this was a relationship for which they designed: "[o]ur intention was to create a sustainable living environment where the people are not aware that they are living in anything out of the ordinary. They would turn on the furnace just like any other furnace, only our furnace consumes less."[46]

Ultimately, *The Currents* has many virtues, and the realization of this building is a positive thing for both a neighbourhood saturated with hastily and poorly-built developments and the environmental-sustainability movement as a whole. First-and-foremost, *The Currents* will become the flagship residential project of LEED, drawing much-needed attention to present ecological degradation; the building will serve as an example of good passive architectural principles; the realization of this project proves that environmentally-sustainable architecture is economically profitable to real-estate developers; the project remediates a contaminated site; with the inclusion of GCTC, the project serves as a good example of multiuse architecture, which encourages walkable neighbourhoods; the residents of the building are entitled to a car-sharing program, another example of the dedication to alternative transportation methods; *The Currents* will become the first building in Ontario that uses greywater for commercial toilets, establishing a precedent for green innovation; the project uses durable, low-maintenance materials; and the building will hopefully promote subsequent architectures with similar environmental concerns. However, these benefits notwithstanding, it remains problematic that the architecture employs technological systems that do not require the active involvement of the inhabitants in any purposeful way.

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46 Jonathan Westeinde, Personal Interview. 14 October 2005.

Unlike *The Currents*, Glenn Murcutt's *Magney House*, the second architectural precedent of this thesis, requires of the inhabitants the manipulation of hand-operated environmental control mechanisms that condition and enrich the interior spaces.

Glenn Murcutt's *Magney House*

Glenn Murcutt's architecture is often characterized by hand-operated, environmental-control mechanisms, such as aluminum sunshading louvers that drape the majority of his works' façades. These mechanisms — the technological technique — require of the occupant the manipulation of the apertures through which the natural elements condition and enrich the interior spaces. This technique exemplifies the theoretical premise of this thesis: the technological system requires dwellers' participation in the means of producing the desired ends, thus allowing essential, life-enriching qualities to flourish. These technological techniques are employed because they support Murcutt's two overarching design values: a symbiotic relationship with the natural environment and an existential connection to place. Perhaps nowhere in Murcutt's work is the architectural manifestation of his design values more clearly articulated than in his seminal piece *The Magney House* (plate 16).

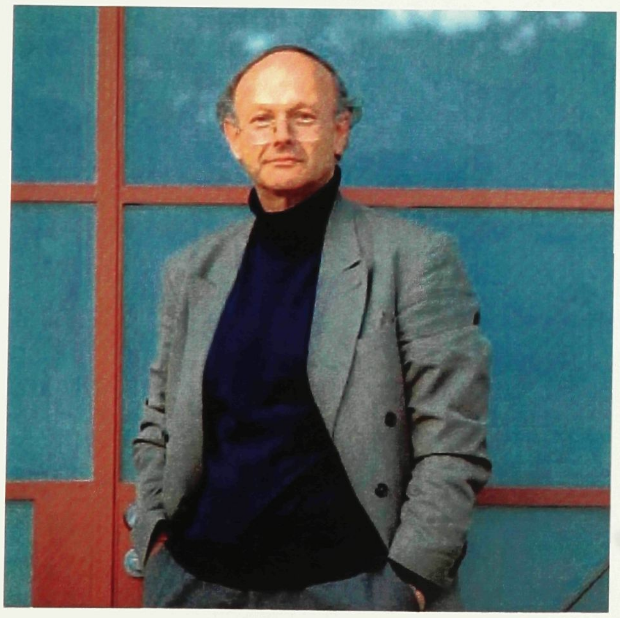

Plate 15: Glenn Murcutt

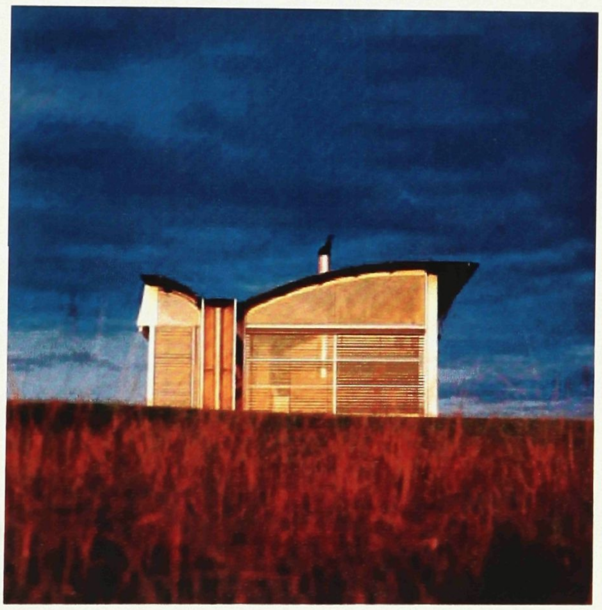

Plate 16: Magney House's east elevation

The *Magney House* is located in Bingi Bingi, New South Wales, Australia, 350 kilometers south of Sidney. Completed in 1984, on a ninety-two-acre site, the home faces the Pacific Ocean to the south, a forest-surrounded lake to the north, and headland to the east and west.[47] The site proper is rugged, bare, and treeless and endures hot and arid summer conditions and moist, cooler winter conditions — these conditions are moderate due to the site's close proximity to the ocean. While the majority of precipitation accumulates throughout the winter and early spring, "no season is entirely dry, nor is any season extremely wet."[48] These natural conditions of the site, as well as other natural and pragmatic factors such as "water tables, wind patterns, sun angles, soil types, wildlife, rainfall, humidity, material and economic exigency, not to mention programme,"[49] are integral design components of an architecture that has defined Murcutt's career.

With his receipt of the *Pritzker Prize* in 2002, Glenn Murcutt's career reached global 'star' status. Unlike every other recipient of architecture's most coveted distinction, Murcutt is a sole practitioner whose work primarily comprises environmentally-sustainable, residential architecture. Having worked exclusively in Australia throughout his entire forty-five year career, he claims that his work is undeniably influenced by Australia's indigenous people's "deep, intimate, and harmonious relationship to the land, which has spiritual, practical, social, aesthetic, and cultural dimensions,"[50] That Glenn Murcutt's work has forged a new paradigm of environmental-sustainable architecture that is adaptable to the harsh Australian landscape is its greater merit.

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47 Francoise Fromonot, Glenn Murcutt: Buildings and Projects. Trans. Alexandra Campbell (New York: Watson, 1995) 96.
48 Adam Clark, "Magney House, Bingi Point, New South Wales, Australia". (U Waterloo, 2004) 2.
49 E. M. Farrelly, Three Houses: Glenn Murcutt. (London: Phaidon, 1993) 8.
50 Beck and Cooper 133.

"Life is not about maximizing everything", Murcutt proclaims, "It's about giving something back, like light, space, form, serenity, joy. You have to give something back"[51]. This ideology speaks of the driving design *value*s of Glenn Murcutt's architecture: his architecture intimately engages the dweller with the natural elements that characterize the site —sun, rain, breezes, humidity, light, shade, flora, fauna, and topography. These qualities are embraced and nourished, or, in Murcutt's words, "contribute to one's daily existence,"[52] while simultaneously preserving the environmental capacity of the site. These design values demand an architectural and technological response that is fundamentally different from an architecture derived from values of efficiency.

51 Anne Suche, "Australian Rules." Azure: Design, Architecture, Art. (July/August 2002) 53.
52 Farrelly 7.

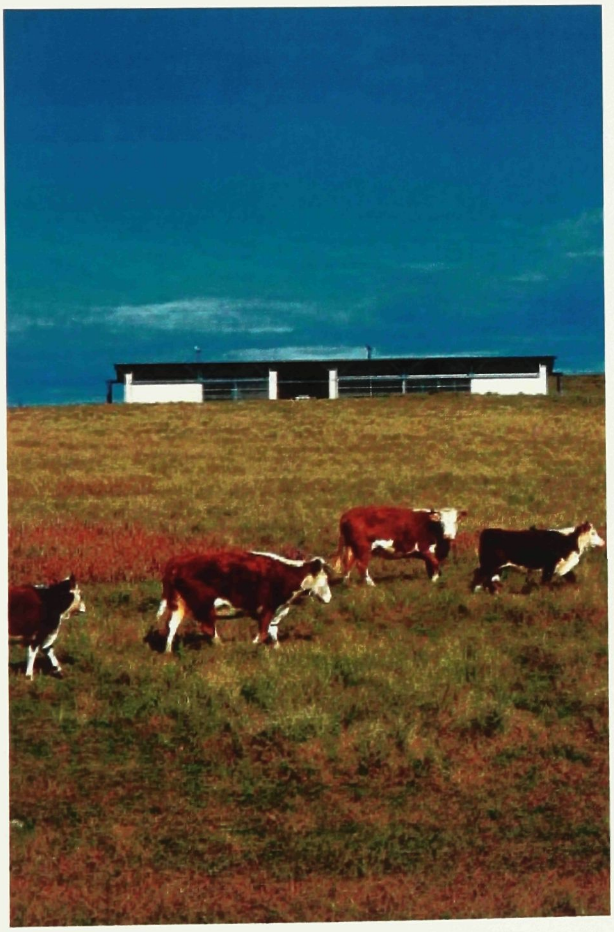

Plate 17: Magney house's rural context

Plate 18: Hand-operated sunshading louvers

The architectural manifestation of Glenn Murcutt's design values is best described in layers. First, the formal and material composition of the architecture is designed for maximum experience of and passive return on the natural elements and resources: each natural or manufactured material is refined to its minimum; for example, steel roof purlins that taper as they approach eaves; dimensions precisely calculated to yield the greatest passive energy return; or orientations that provide maximum potential for solar gain or passive cooling. In Murcutt's words, "there isn't much you could take away from this architecture."[53]

This said architectural framework is mediated by the second layer comprised of hand-operated, environmental control mechanisms. In physically adjusting these mechanisms, such as the external sunshading louvers or linear strip vents, the occupant finely tunes his/her interior conditions as desired. It is here that Murcutt's sought existential connection to place flourishes: a conscious awareness of climatic and weather conditions and the ensuing intimate experience of the natural elements permeating throughout the home as a result of the occupant's interaction.

53 Beck and Cooper 14.

Plate 21: Quality of sunlight within Living Area

Plate 22: Quality of sunlight within Bedroom

The *Magney House's* long, linear plan (plate 23) is the most important contributor to the aforementioned maximum return on the natural elements. Because the house is one-room deep, it provides every interior space full exposure to the natural elements, such as sunlight, the prevailing winds, and views of the landscape. Further, Murcutt organizes the fenestration and thermal mass locations in response to solar orientation: the north, east, and west-facing facades (reversed for the southern hemisphere) are glazed from floor to ceiling to fully accept solar penetration; alternatively, the south-facing façade is constructed of two layers of brick, providing a thermal heat-sink.

The formal and material composition of the *Magney House's* roof (plate 24) further reinforces these design intentions. The swooping profile of the roof (the formal composition), for example, realizes Murcutt's principles in several ways: first, the roof profile directs rain water to a central trough leading to a retention

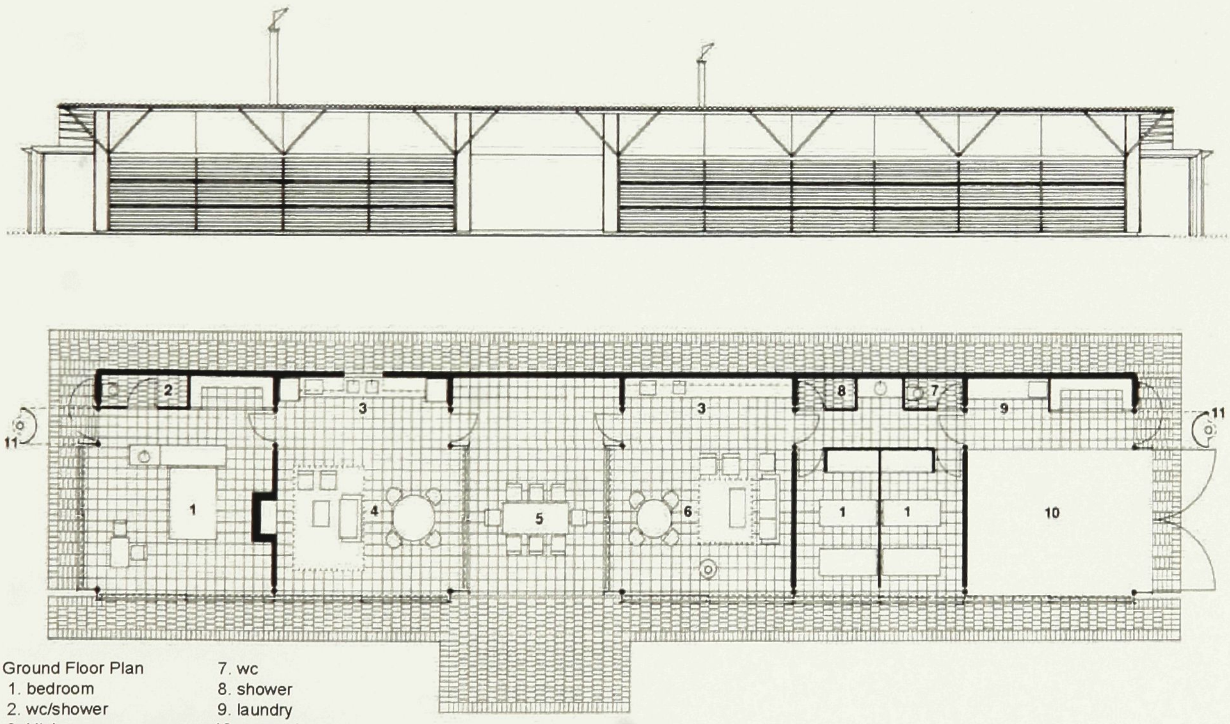

Plate 23: North elevation and floor plan

tank for domestic, irrigation, and firefighting purposes. As such, the design feature takes full advantage of the site's rainwater, reducing the need for treated water. Second, the roof profile induces air pressure differentials, thus encouraging natural, cross-ventilation. This compositional strategy exploits the cooling properties of the prevailing winds, eradicating the necessity for mechanical cooling systems that emit dangerous amounts of chloro-fluoro carbons (CFCs) into the atmosphere. Third, the convex interior ceiling profile disperses natural light throughout the home, reducing the need for electric lighting. Last, and perhaps most important, the angle of the roof struts is set precisely to the sun's equinox angle. This alignment of the roof angle allows the lower-angled winter sun to fully penetrate and warm the home, while the higher-angled, summer sun is blocked, thus offering interior shade as reprieve to the brutal exterior conditions.

Roofing materials were also selected with the same design considerations. Corrugated, galvanized metal was primarily selected for its passive cooling properties. This material is highly reflective and has a very low heat-retention capacity; these characteristics serve to reflect and dissipate unwanted heat back into the atmosphere. Moreover, corrugated galvanized metal is a local material and also has a low embodied energy coefficient.

It is important to recognize that these principles illustrate that the *Magney House does* exhibit a commitment to efficiency. As stated earlier, it would be counterproductive and naïve to argue against making a system or material more efficient as long as it did not impede the overarching values. The design strategies outlined in the preceding text illustrate that the *Magney House* is efficient in its selection and use of materials and in the productivity of the passive systems employed.

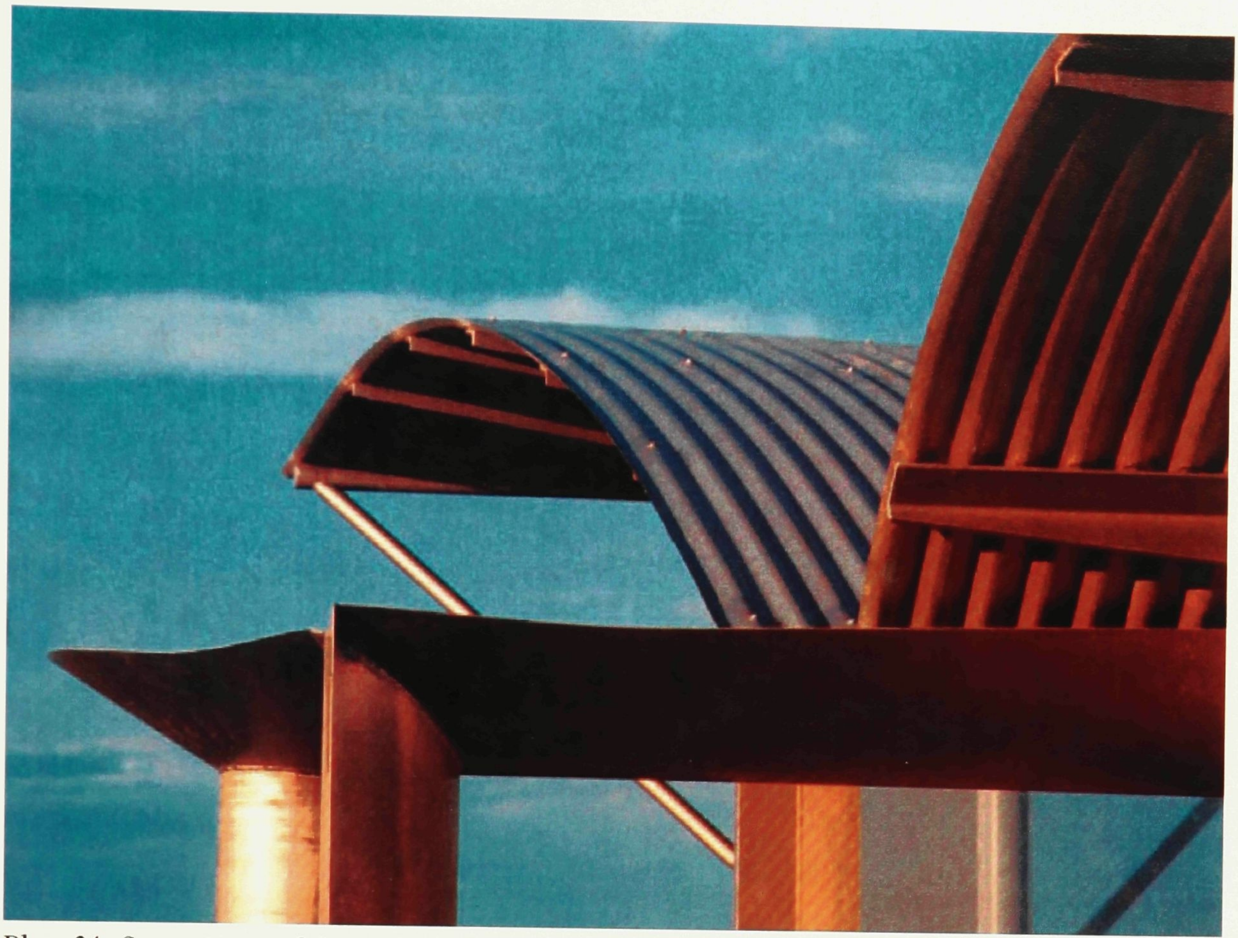

Plate 24: Swooping roof dispatching to water collection trough

Plate 25: North/East view in landscape

The *Magney house's* structural and detailing finesse underscores a commitment to material efficiency. Exposed on the interior and exterior, the steel post-and-beam structure is designed to its structural limits. The structure is so finely-tuned that it "requires gusset plates to stabilize the junctions at the pipe columns and roof beams."[54] Moreover, the structural members work in tandem: rather than additional steel braces at the eave struts, the corrugated iron roof sheets triangulate the eaves structure. The steel purlins taper as they approach the eaves' extent — minimizing material waste and reducing embodied-energy consumption.

The structure's use of steel is also a testament to efficiency. Steel, as compared to wood, requires more energy in its extraction and manufacture, but is considerably more durable and requires less maintenance over time. In this way, Murcutt argues that the value-to-energy expenditure ratio is more eco-efficient for steel than wood. In addition, the bolted connections of the structure allow for easy dismantling for recycling purposes upon demolition.

Returning to the architectural manifestation of Glenn Murcutt's design values, the hand-operated, environmental control mechanisms mediate the architecture's ideal exposure to the natural elements, such as ideal sun penetration in winter or an abundance of prevailing breeze in summer. These mechanisms — the technological technique — act as diaphragms that can be "modified to capture or reject the influence of the surrounding environment."[55] There are many examples of environmental control mechanisms in the *Magney House*, such as the ventilation systems, sunshading systems, the central hearth, or the operation of the water retention tank. Two of these are closely examined here: the ventilation and sunshading systems.

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54 Beck and Cooper 82.
55 Drew 70.

The *Magney House's* sunshading system comprises "external adjustable aluminum louvers which pull up, tilt, and drop: it's very flexible."[56] Its adjustable louver system allows the inhabitant to control the sun's conditioning of the interior space. Phillip Drew, author of *Leaves of Iron: Glenn Murcutt, Pioneer of an Australian Architectural Form,* points out, "allowing the sun in winter as a welcome guest, and keeping him at a distance in summer when he is most fierce; for the sun is like a burglar who must be stopped on the outside of the house before he has had a chance to break in."[57] The sunshading louvers drape the north, east, and west facades, which are completely glazed from floor to ceiling. These louvers drape from transom level down; above transom level is unobstructed glazing. Unobstructed glazing is important because it allows the inhabitant to "see the sky and observe the weather changes,"[58] providing necessary information for the adjustment of the exterior blinds, while the penetrating sun is blocked by the angle of the roof struts. In summer, the aluminum blinds can bounce light, without the associated heat, into the home or block out the sun entirely. In winter, conversely, they can be lifted, activating the intended passive heating or influencing the ambiance of the interior spaces. What's important to note is that the occupant has complete control of the system (the means). The occupant acknowledges the weather and light throughout the day and has the ability to respond, to engage in the process of creating the desired end.

Murcutt's approach to ventilation embodies the same values. Three separate, hand-operated venting systems within the *Magney House* work in conjunction with rotary-turbine roof vents: a linear strip vent at transom height that spans the entire length of the house on the windward façade; doorhead transom vents between each interior zone; and a sliding glazing system on the northern elevation. Each

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56 Beck and Cooper 77.
57 Drew 65.
58 Beck and Cooper 82.

system serves a distinct function and affords the inhabitants complete flexibility and control: the linear strip vent at transom height, when open, works with the rotary turbine vents to exhaust unwanted heat via stack effect; the sliding glazing system also induces stack effect or, in conjunction with the linear strip vents, induces cross ventilation; last, the doorhead transom vents dissipate heat between interior spaces. Incidentally, the rotary-turbine roof vents, which are "wind-driven air extraction units,"[59] also work with the thermal mass of the home to "modify the sometimes considerable diurnal temperature variations. The roof vents exhaust the internal volumes and minimize heat and humidity build-up inside."[60] With each 'closed-down' interior space effectively becoming an autonomous environmental zone, Murcutt points out the passive heating potential of the house when he states: "on really cold days with the vents shut down, the spaces are static air cul-de-sacs which are filled with sun."[61] Alternatively, during the summer months, the venting systems encourage an efficient air flow through the house.

59 Ibid 63.
60 Beck and Cooper 63.
61 Ibid 82

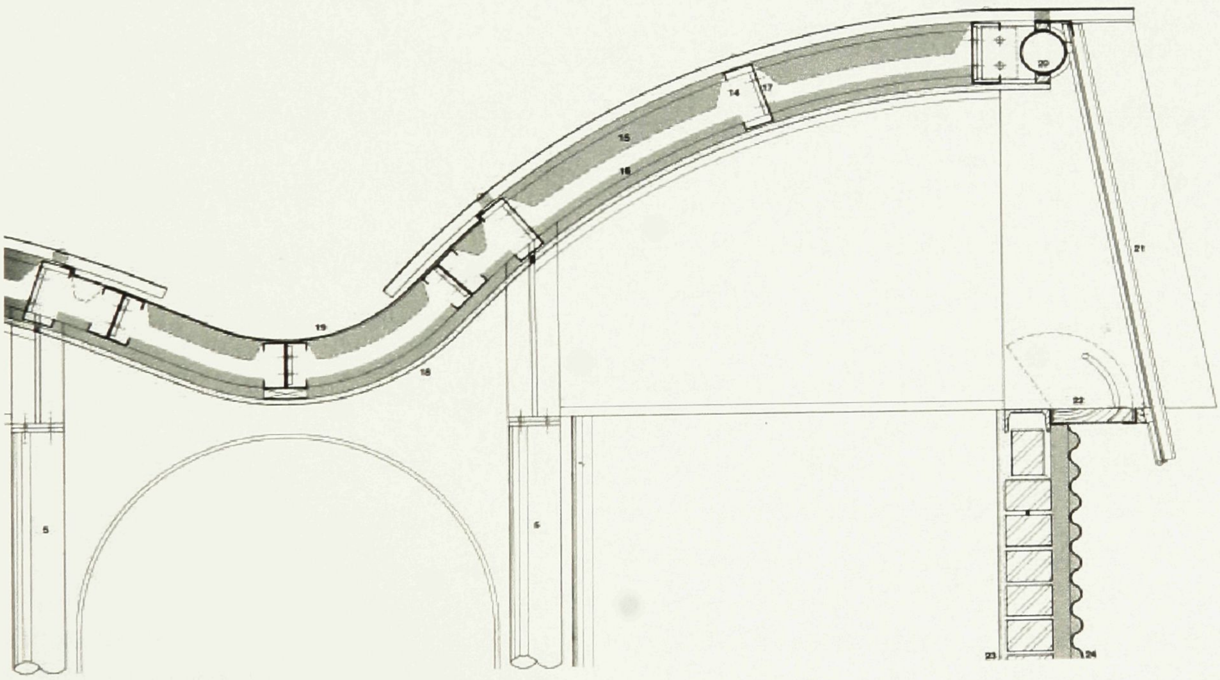

Plate 26: Roof and hand-operated vent detail; hand-operated srtip vent labeled No.22

The inhabitants of Murcutt's architecture "remain in touch with the progress of the day and the weather — indeed, with the genius loci — as they manipulate the building's environmental control mechanisms"[62] — the means — to achieve their desired interior conditions. This conscious awareness of the climatic and weather conditions, the ensuing intimate experience of the natural elements permeating throughout the house, and the lessened environmental impact as a result of passive systems effectively realize Murcutt's design values. Moreover, this engagement with the means of the technological process, unlike technologies employed to support values of efficiency, introduces "careful, skilled, and cooperative maintenance" into the technological process, further enriching the lives of the inhabitants. Before substantiating the architectural manifestation of this thesis' theoretical premise, it is necessary to describe the spatial quality of the Magney House's interior spaces, as this quality reinforces Murcutt's sought design values.

With the louvers fully retracted during winter months, the home is brought alive by the sun's presence. "In winter there is sun all day — climbing half way up the back wall — boasts a proud client — at breakfast time, in mid winter!"[63] Murcutt furthers his client's observations, adding: "[o]n a cold day you sit in front of a big fire on the southern side, with the sun from the north pouring onto your back and also lighting up the fireplace breast."[64] Radiated warmth and reflected light from the mid-winter sun is felt throughout the house, engaging the senses of the occupants; this is a quality — a value — that Murcutt intentionally sought and for which he designed. The thermal mass of the concrete slab and floor tiles, for example, are designed to slowly release the sun's warmth onto the soles of the dweller's feet: "it takes the sting out of the cold,"[65] Murcutt explains.

62 Ibid 11.
63 Farrelly 20.
64 Beck and Cooper 77.
65 Ibid 83.

With the same sensitivity, the experiential quality of the cool, prevailing breeze is captured. While every effort and calculation is made to ensure an efficient flow of air throughout the house, the experiential quality of the prevailing breeze is equally important to Murcutt. "The air can move around my buildings so I can get cooling when I want it, or shut down the building when I want it: air-conditioning is unthinkable."[66] This air movement dissipates unwanted heat while it simultaneously engages and cools the human body. In facilitating a healthy flow of air throughout the home, the building is "kept alive by its movement," telling the occupant "what kind of day it is, whether it is windy or still."[67] Moreover, the permeating fresh breeze also introduces scents from the flowering flora, the sound and smell of the ocean, and the resonance of animals and insects nearby, fostering a heightened connection to the site.

Examining the pragmatic requirements of the home, such as bathing, reveals further embodiment of these values. While showering, one can manually open the overhead light and "experience the quality of the day,"[68] enjoying the breeze, the sunlight, the smell, the sounds, and the view to the sky. This is due to both showers being located along an exterior wall and which are naturally top-lit with operable

66 Suche 53.
67 Phillip Drew, Leaves of Iron: Glenn Murcutt, Pioneer of an Australian Architectural Form. (Australia: Collins, 1985) 68.
68 Beck and Cooper 105.

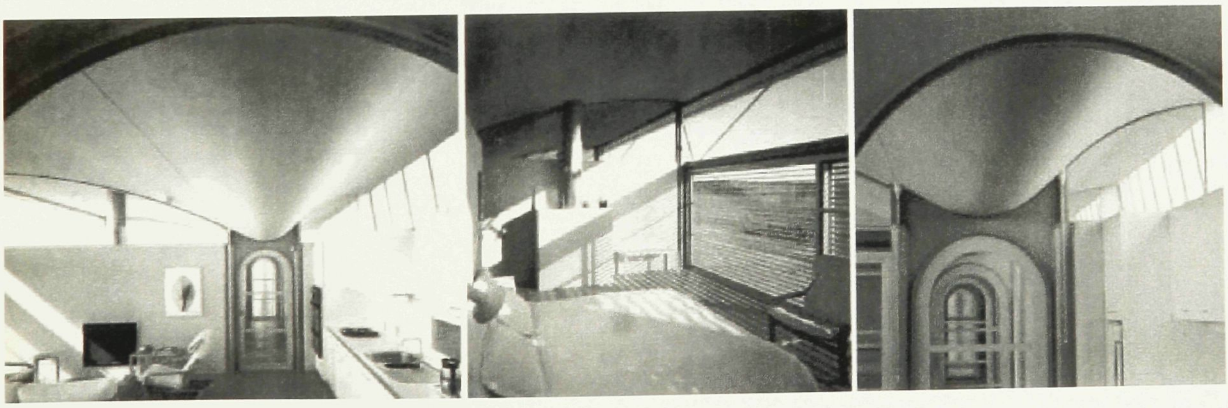

Plate 27: Convex ceiling

lights. Murcutt points out that bathing in the *Magney House* feels as though one is under "warm rain, as though he or she is under the sky. The shower is almost an exterior space."[69]

The *Magney House* also reinforces a connection to *place* in the way that it facilitates a visual and physical connection to the landscape. "The narrative route of the plan," Haig Beck and Jackie Cooper, authors of *Glenn Murcutt: A Singular Architectural Practice*, assert, "constitutes a journey of oblique revelation of both building and land, offering views and topography for contemplation."[70] But Murcutt's architecture more profoundly connects to the landscape than simply by framing views for contemplation: The *Magney House*, although its technological aesthetic is often perceived as contrasting with the landscape, is precisely tuned to merge with the natural environmental systems of the site — the architecture exists in a symbiotic relationship with the natural environment. Moreover, Murcutt explains that his architecture, in being physically and visually separated from the landscape, actually reinforces the occupants' place within the landscape: "to observe, to know about place, we have to stand apart from it. A building removes us slightly from place, yet locates us within it. It is an existential idea of sharpening awareness, exposing people to things they hadn't perceived before."[71]

Unlike technological efficiency, which becomes more optimal as the user is further removed and disengaged, the *Magney House's* technological systems require a cognitive and physical contribution from the dweller. Murcutt often likens this required engagement to that of sailing, proclaiming: "It's dynamic: you open up the windows and doors and tune the house for different conditions."[72] Haig Beck

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69 Ibid 56.
70 Ibid 10.
71 Beck and Cooper 77.
72 Ibid 49.

and Jackie Cooper propose clothing as another analogy: "the roof overhang, blinds, insect screens, and louvered windows are like layers of clothes that you can put on or remove: the blinds can be fully retracted; the adjustable louvers tilt and change the light levels."[73] What these two analogies refer to specifically is the integral relationship between the operation of the building, the spatial quality of the interior spaces, and the wellbeing of the home's inhabitants. This relationship is the architectural manifestation of this thesis's theoretical premise. Moreover, this inhabitant participation leads to an interior environment in which the quality of the space further contributes to one's *daily existence*.

Murcutt realized his architectural design values in an architecture that exists in the vast, rural landscape. The site provides the home with a full, uninhibited exposure to sunlight and prevailing winds, and the site presents no building orientation or footprint restrictions. Further, the *Magney House* is a single-family-dwelling archetype on a completely isolated site. These factors allow the home to open fully to utilize passive design principles while not compromising privacy. An urban context presents many architectural challenges that were not factors in the creation of the *Magney House*. Murcutt's own words are apt in describing an approach to the transition from a rural context to an urban context: "[i]f we understand instead why a thing looks the way it does or why it works the way it does, then we understand the principle, and that principle, not the form it produces, is transferable."[74]

73 Ibid 49.
74 Glenn Murcutt, "The Mining Museum of Broken Hill." Perspecta: The Yale Architectural Journal 27 (1992: 168-185) 174.

Architectural Proposition

Site Selection

The site for the design component of this thesis is located on Tenth Avenue, between West 14th Street and West 15th Street, straddling New York City's Chelsea and Meat-Packing Districts (plates 30 & 31). Currently, this 21,000 square-foot site is occupied by a privately-held automated carwash, small convenience store, and gas station. Sheltering these programmatic elements is the site's most distinct characteristic: the *High Line*.

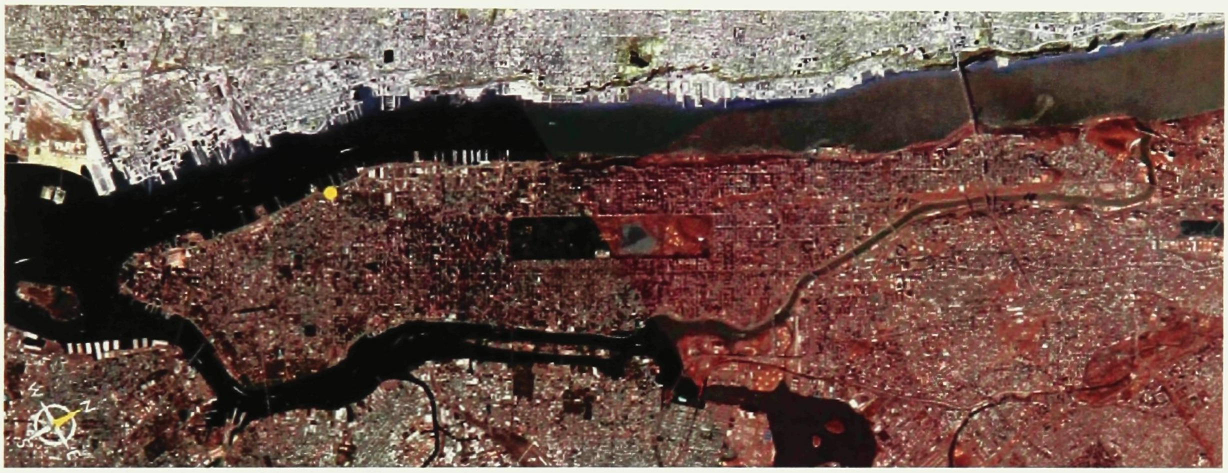


Plate 29: Aerial view of Manhattan Island. Dot indicates location of site.

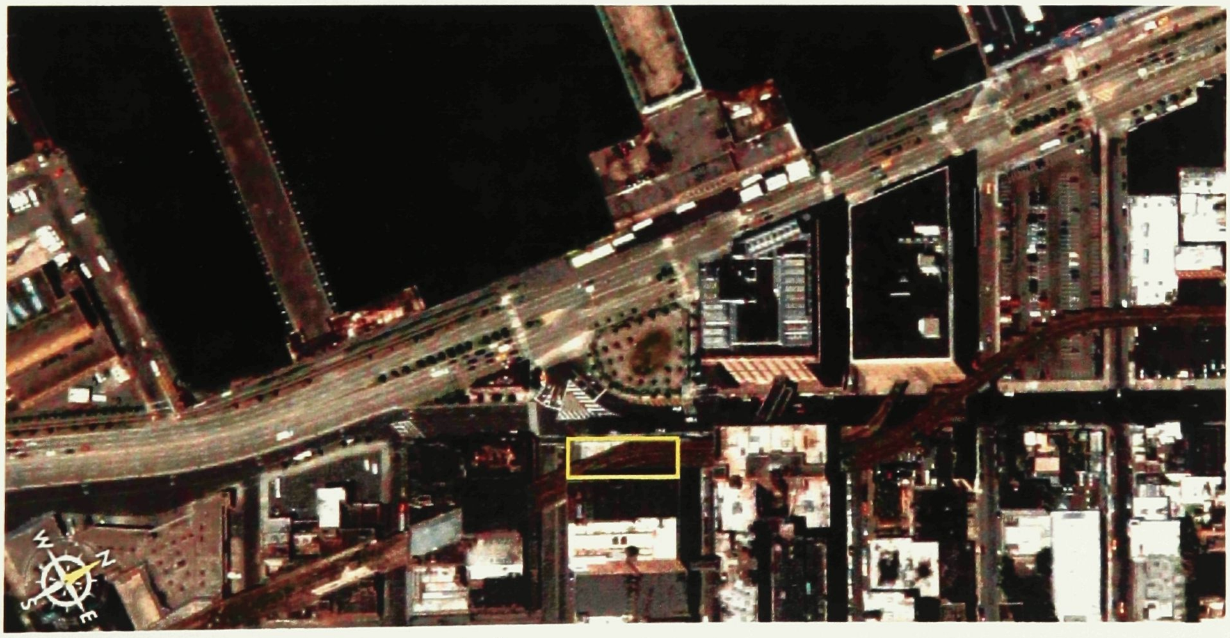
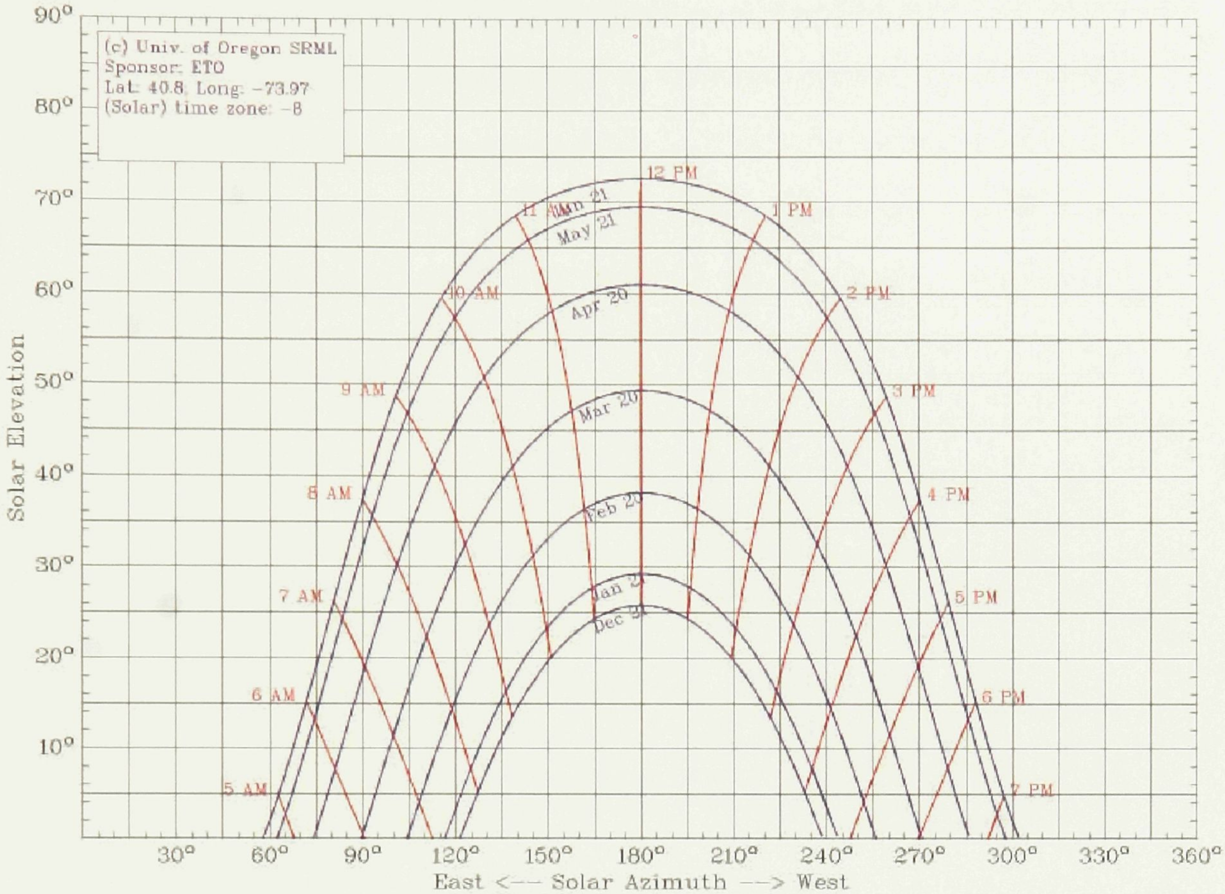


Plate 30: Aerial view of site. Rectangle demarcates site.



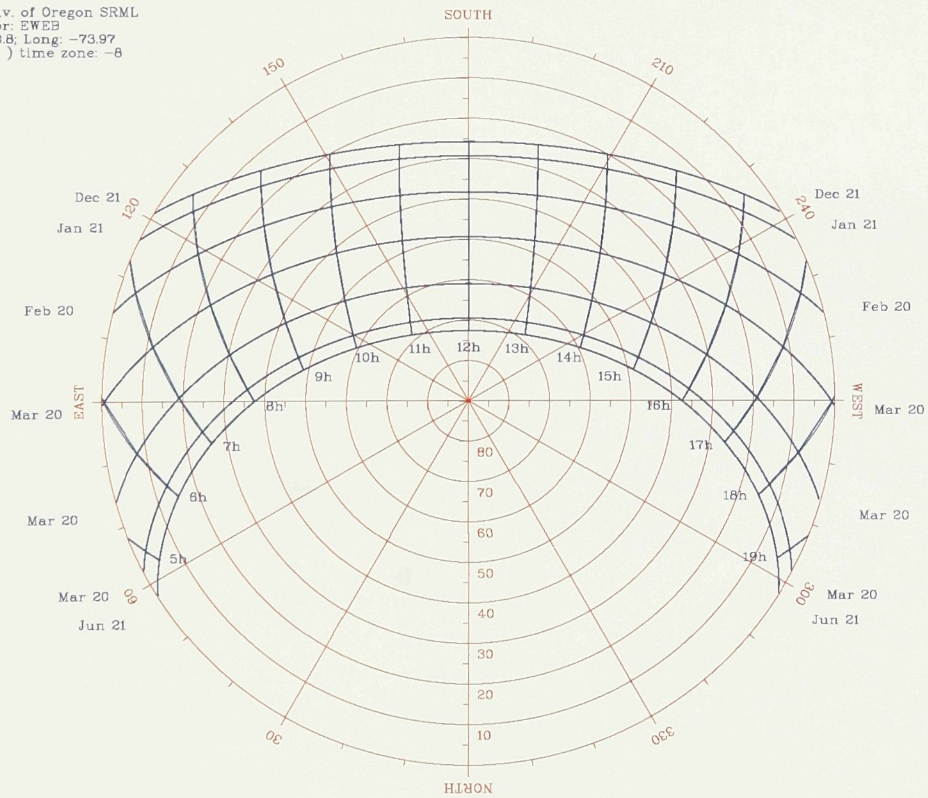


Plate 31: Solar position charts for New York City. Charts indicate wider azimuth angle and higher altitude angle of summer sun, compared to winter sun.

The *High Line* is an abandoned, elevated rail viaduct that traverses twenty-two city blocks, from West Thirty-Fourth Street to Gansevoort Street on Manhattan's lower west-side. The *High Line* was originally constructed in the early 1930s to remove dangerous locomotives from pedestrian-laden city streets, but, with the decline of rail transportation, the *High Line* has remained unused since 1980.[75] This 1.52 mile railway, which has transformed into 6.7 acres of self-seeded, elevated landscape[76], has fostered numerous world-wide design competitions. *Diller Scofidio + Renfro* in association with *Field Operations* have won the most recent and final competition with their proposal for a pedestrian thoroughfare atop the *High Line* that accentuates the various "speeds" and "resilientness" of the infrastructure, natural flora, and context. Their proposal, which includes an amphitheatre and an elevated, faux beach, is expected to commence construction in early 2006. For the purposes of placing this architectural proposition in the largest community context possible, the design assumes that the realization of their proposal has already been accomplished.

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75 Joshua David, Reclaiming the High Line. (New York: Ivy Hill, 2002) 56.
76 Ibid 17.

Plate 32: Diller Scofidio + Renfro with Field Operations proposed High Line redevelopment

Plate 33: View on top of High Line in winter

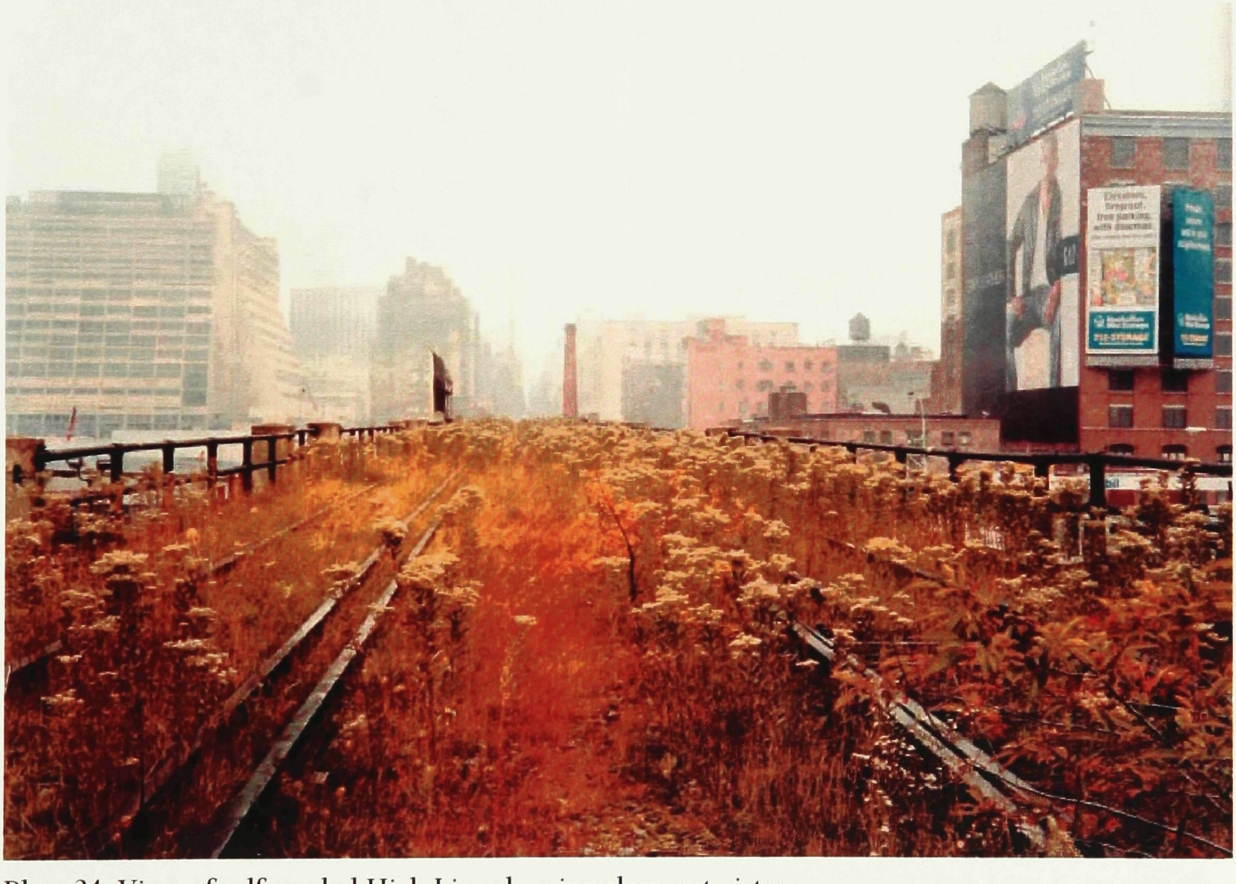

Plate 34: View of self-seeded High Line showing clear-cut vistas.

Plate 35: High Line meets site at angle to NYC grid.

Plate 36: High Line column at gas pumps

Plate 37: Underside of High Line at gas station

The site is located in one of North America's most important, dense, and influential urban contexts. As previously discussed, it is imperative that environmentally-sustainable, urban building practices be critically challenged, and this site provides an appropriate vehicle for an undertaking as such. Moreover, an urban context presents design challenges that are nonexistent in a rural context, such as constrained building orientation, relationship to a community context, and higher real-estate values that encourage particular archetypes. These issues will necessarily challenge the limits of this architectural proposition.

This site also presents an adaptive-reuse scenario. The existing infrastructural relic (*High Line*) as well as the existing architectures on the site (carwash, convenience store, and gas station) will provide the opportunity to explore how new architecture integrates with and rejuvenates existing architectures. Furthermore, the *High Line*, carwash, and gas station are symbols of technology that can be used to contrast or heighten a work of architecture that responds to the theoretical premise of this thesis.

Plate 38: View of site looking north/east. Note tall, neighbouring buildings.

Last, the site's tight architectural constraints inhibit fundamental passive design principles. For example, the tall, neighbouring buildings obstruct the amount of sunlight and prevailing breeze penetrating the site, limiting the potential for passive heating and cooling. To compound this limitation, the rectilinear proportion of the site is oriented due north/south, creating sunshading and passive heating challenges. These are design challenges typical of an urban context and impediments to which an environmentally-sustainable architecture must respond.

Plate 39: View of site and surrounding amenities. Note *High Line* enters neighbouring buildings.

Plate 40: View looking over *Hudson River* across from site

Programme Selection

The programme of this architectural proposition is a new thirty-six-unit, environmentally-sustainable condominium. The programme also encompasses the retrofit of an existing carwash, convenience store, and gas station that are currently occupying the site.

The dwelling component of the programme allows the issues discussed in this thesis to be explored within the context of everyday human activities, such as sleeping, bathing, cooking, dining, relaxing, and studying, as well as the conviviality associated with family members and friends. These activities are fundamental human practices which provide the most intimate architectural venue to explore the life-enriching capacities of the 'joy' and 'craft of moral life' that the proposed technologies yield.

As previously stated, there is an unprecedented need to reevaluate contemporary practices of environmentally-sustainable, urban dwelling. A condominium in New York City — a multi-unit, residential archetype in one of North America's largest, most dense metropolises — provides an appropriate vehicle for challenging the limitations and potentialities of these building practices. In addition, multi-unit, residential architecture presents further pragmatic challenges to these issues, such as the relation to public and privacy, communal spaces, general circulation, and strategies to accommodate passive-design principles for multiple dwelling units.

Lastly, the residential programme responds to the current land use for New York City's Chelsea and Meat-Packing Districts. A gentrification process has already introduced programmes such as art galleries, restaurants, and night clubs:

> The neighborhood through which the High Line runs is in a state of transition. During the 20 years since trains stopped running on the High Line structure, the traditional industries that once populated the area—warehouses, printers, meat-processing plants, light manufacturers— have declined, while art galleries, restaurants, and nightclubs have been on the rise.[77]

However, plate 43 indicates that the site's immediate context is comprised of no residential occupancy. It is important that these new programmes be developed in unison with residential facilities so as to create diverse, walkable neighbourhoods. Furthermore, neighbourhoods that comprise residential occupancies are kept vibrant and safe with an increase of pedestrians.

Finally, the retrofit of the existing carwash, convenience store, and gas station is an important programmatic element because in reality they are successful components of their neighbourhood and they also present an adaptive-reuse scenario to the project, a prime tenet of anti-consumption, environmental-sustainability dogma.

77 Joshua David, Reclaiming the High Line. (New York: Ivy Hill, 2002) 60.

Plate 43: Land-use map of the site's surrounding context. Note residential occupancy.

Design Proposition

This thesis proposes an environmentally-sustainable, urban architecture that embodies a symbiotic relationship with the natural environment and an intimate engagement with the natural elements that condition and enrich the interior spaces. With respect to these design values and the premise of this thesis, the design achieves three primary objectives: (a) the architectural composition yields maximum experiential and passive return on the natural elements — a challenging endeavor on an urban site that poses architectural constraints that inhibit fundamental passive design principles; (b) the design incorporates technological systems that require the conscious engagement of the inhabitants for whom the technology is employed; (c) the project celebrates the idea of 'community'.

Plate 50: Architectural proposition in context. View facing south.

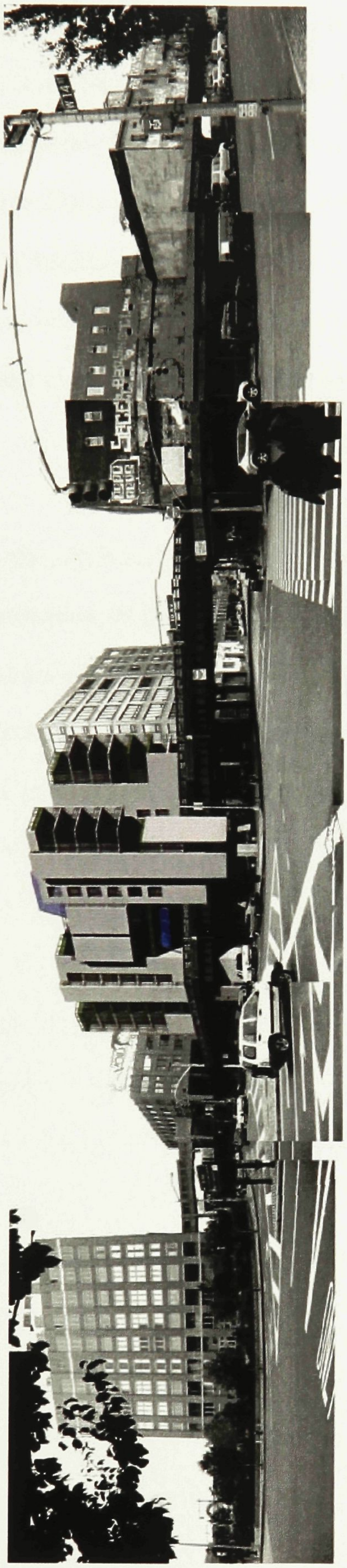

Plate 51: Photomontage of building in site. View facing north/east.

The project's site abuts a ten-storey office building to the east, and only a street separates the site from seven-storey buildings to the north and south. In response, the design incorporates two 'bars' of dwelling that are connected by a vertical circulation space. These bars, each containing two dwelling units, are liberated from the neighbouring building and each other, dividing the site into thirds. As a result, every interior space, which is at most one-room deep, benefits from an abundance of sunlight (either direct or reflected) and breezes moving throughout the site.

Oriented north/south, the site's rectilinear proportion also poses passive-design challenges. This fixed limitation of the site dictates an architecture wherein the predominant façades face east/west. The resulting issues are that the narrower azimuth angle of the winter sun is not conducive to passive heating along the building's predominant façades and the wider azimuth angle of the summer sun creates sunshading challenges throughout the summer months. The design first addresses the building's minimal southern exposure: balconies are precisely aligned to shade the higher-angled summer sun, while permitting the lower-angled winter sun to penetrate the interior spaces. Second, trombe walls extrude on the east and west façades to capture the southern, winter sun. Facing east or west, these trombe walls are an insulated, solid construction to protect against the summer sun; facing south is glazing to receive the sun. Third, the design negotiates the dilemma between conventional 'green' building practices of limiting east/west fenestration and the reality of the site's very limited north/south exposure, the desire to capture views over the *Hudson River*, and the intention to offer sunlight and ventilation to every interior space. A balance of these requirements results in the implementation of vertically-oriented, hand-operated louvers and hand-operated vents within a double-skin, glazed wall.

The building's double-skin, glazed façade is a highly-technological system which requires the conscious engagement of the inhabitants in its operation. This system uses two layers of glazing to create an interstitial cavity that moderates and controls temperature and pressure differences between the interior and exterior of the building. Enclosed within the cavity are hand-operated, adjustable louvers that arrest solar gain within the space during cooling months, slide aside to allow the sun to penetrate fully during heating months, or individually pivot to reflect light and influence the quality of the interior spaces. This system is also equipped with two types of operable openings: one to capture the conditioned air from within the cavity and one that bypasses the cavity to utilize cross ventilation. Sophisticated, automated controls and sensors monitor and adjust the pressure within the cavity, extracting heat as necessary via computer-controlled inlet and outlet throttling flaps. The double-skin system limits heat loss and captures solar gains during winter months while providing an effective method for controlling solar gain and ventilation during summer months.

Plate 52: View of design from south/west sky

This computer-augmented system not only involves, but requires the conscious engagement and participation of the inhabitants for whom it is employed. While every space is subjected to an abundance of sunlight and fresh air, it is ultimately the inhabitants' adjustment of the louvers or vents that controls the amount of infiltration, and the subsequent spatial quality and/or passive conditioning of the interior spaces. The occupant may wish to invigorate the spaces, to "bring the space alive", with the introduction of a fresh breeze and/or daylight; he or she may simply use the sun's rays to warm the interior spaces in mid winter; or the environmental control mechanisms might be used to achieve privacy. No matter the desire, this intimate relationship to the process of passive conditioning, and also the inhabitants' immersion within the enriched spaces, effectively realizes the stated design values. But equally important, the dwellers' participation in the means of the technological process realizes the theoretical premise of this thesis, further contributing to the "daily existence" of the inhabitants.

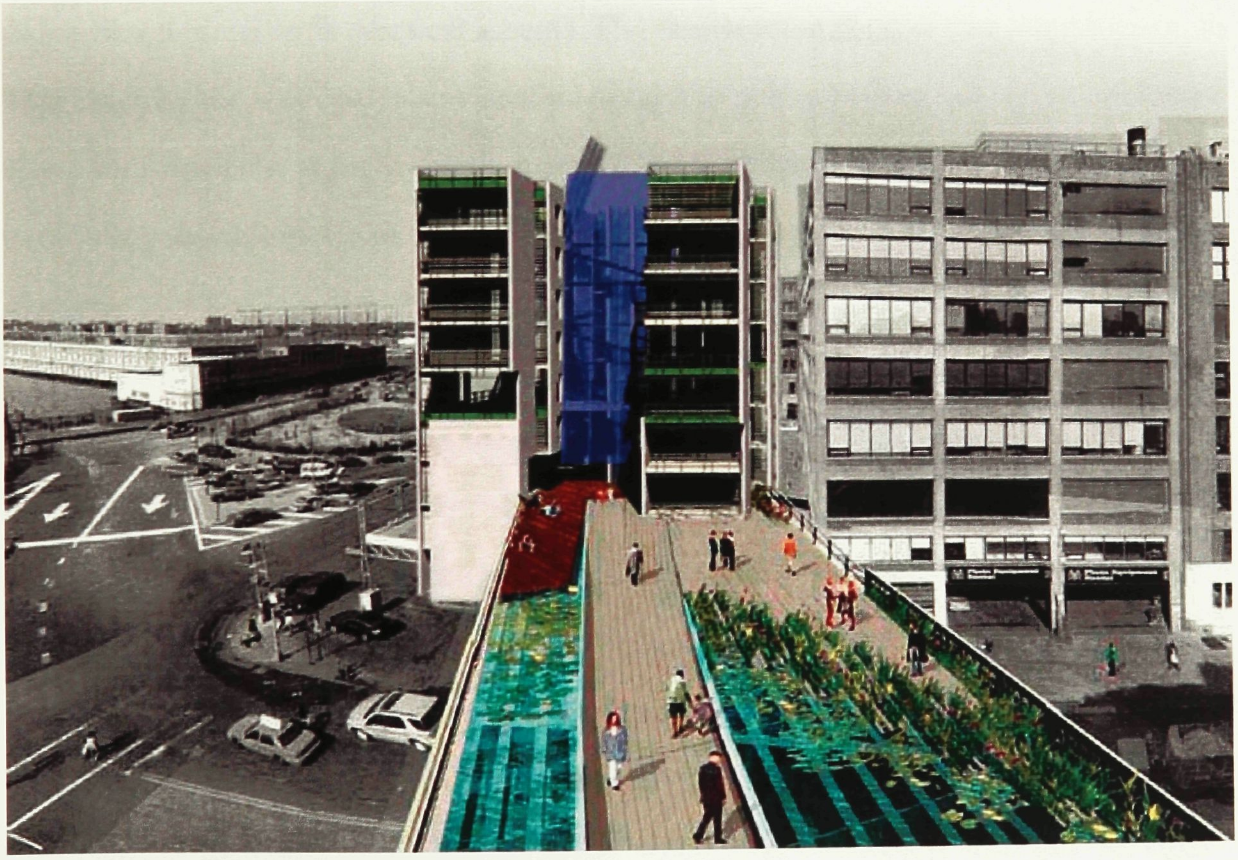

Plate 53: Building meets High Line ground plane.

It is important to acknowledge that the building's passive systems are augmented by an energy-efficient mechanical heating and cooling system. In New York City's weather climate, buildings cannot exclusively rely on passive techniques to comfortably heat and cool the interior spaces. However, the passive systems employed would significantly lessen the energy required of the mechanical systems, subsequently reducing environmental strain. Moreover, the incorporation of passive systems fosters inhabitant interaction with the means of the technological system, thereby encouraging and supporting the values discussed in this thesis.

The building's vertical circulation space architecturally embodies the stated theoretical premise of this thesis. The main feature of this glass enclosure is a meandering staircase that hovers in juxtaposition to the building's stone-clad, heavy elevator. In architecturally celebrating the staircase in contrast to the elevator, the design encourages a technology in which the user is physically engaged in the means of his/her desired ends (vertical ascent). The design intentions of this central space, as expressed by the staircase, also visually engage the public passing below the enclosure along the *High Line*; at night the illuminated space becomes a beacon, visually expressing the silhouette of the staircase along the clear-cut vistas of the elevated rail viaduct.

In addition to nurturing the qualities inherent within the means of the technological process, the design also celebrates the notion of community. An urban context, as well as a condominium archetype, provides the opportunity to cultivate relationships among the building's inhabitants, as well as relationships to the general public — relationships that are nonexistent in a rural context such as the *Magney House's*. The first level of the vertical circulation space is a community space for the occupants of the condominium. This space, which every occupant must pass through

Plate 54: View from High Line looking south

Plate 55: Vertical circulation space

Plate 56: Interior view of vertical circulation space

en route to his or her dwelling unit, provides a relaxing environment from which to gaze over the *High Line* or the *Hudson River* while conversing with fellow residents. The intention is that this space would foster camaraderie and conviviality, thereby becoming the heart of inner social activity within the building.

'Community' is also considered in the way that the design extends to the general public. The building's programme at the level of the *High Line* is intended to foster social interaction: the coffee shop and café's patios, for example, spill onto the *High Line*; the public spills into the building. Adjacent to these patios, the surface of the *High Line* steps down to create stair seating and an outdoor performance space for actors and/or musicians. The design thus brings a special amenity to the public, encouraging social interaction among the general public traversing the pedestrian park.

It is important to recognize that the proposed architecture adopts many of the successful and beneficial features of contemporary 'green' building practices. In the same way as *The Currents*, this design incorporates materials and strategies that mitigate ecological degradation, exhibit durability, and reduce the likelihood of future maintenance. The design includes bamboo flooring, a rapidly-renewable material; low-VOC interior finishes for walls and millwork; energy and water-efficient fixtures and appliances, such as dual-flush toilets and compact fluorescent lighting; local (as local as possible for New York City) light-coloured stone for the exterior façade; a heat-recovery ventilator system that takes advantage of the conditioned air within the double-skin cavity and air exhausted from the building; a sod roof, for the inherent insulation characteristics; and a high-efficiency boiler system that augments the passive systems employed.

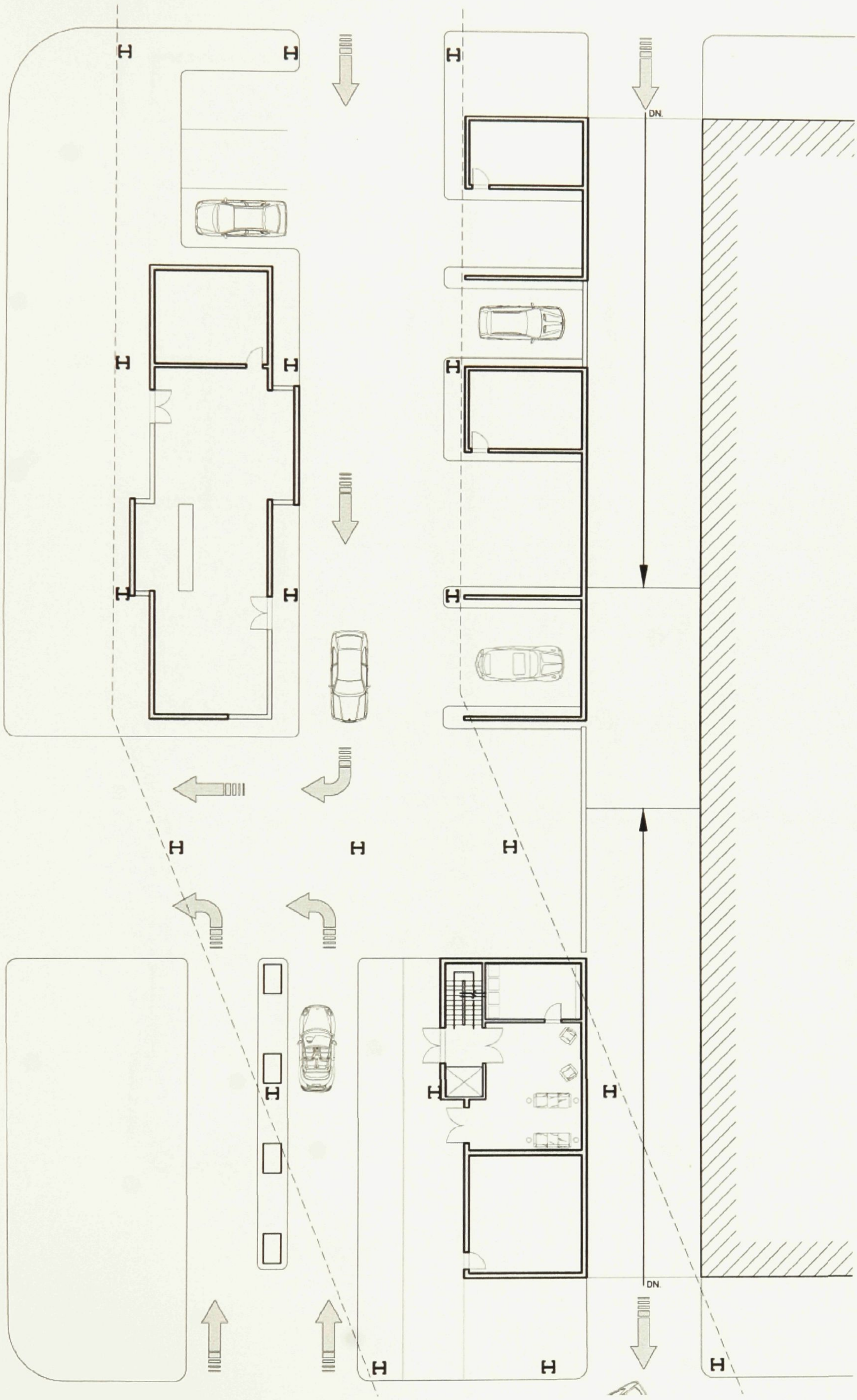

Plate 57: Plan at street level

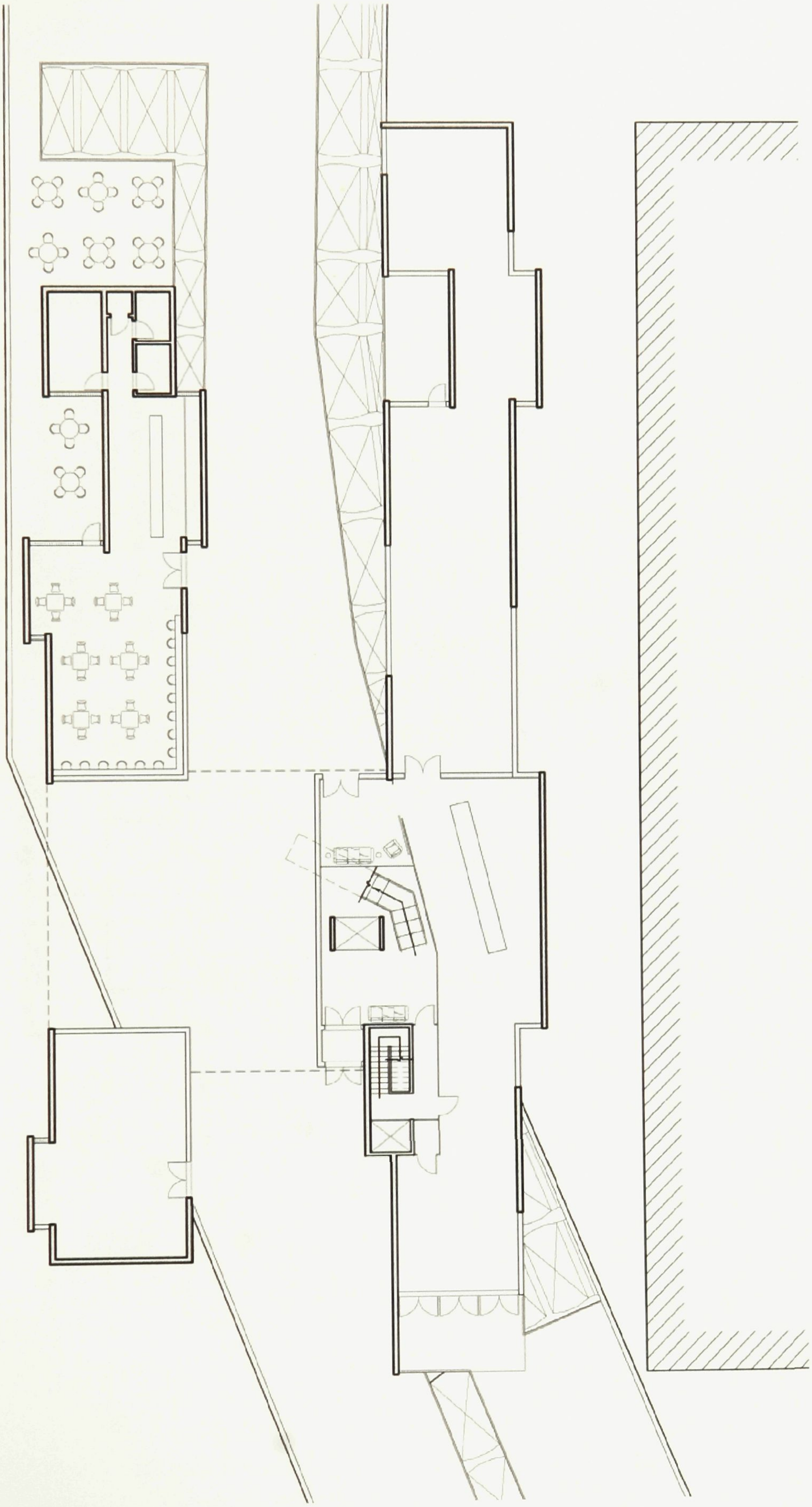

Plate 58: Plan at High Line level

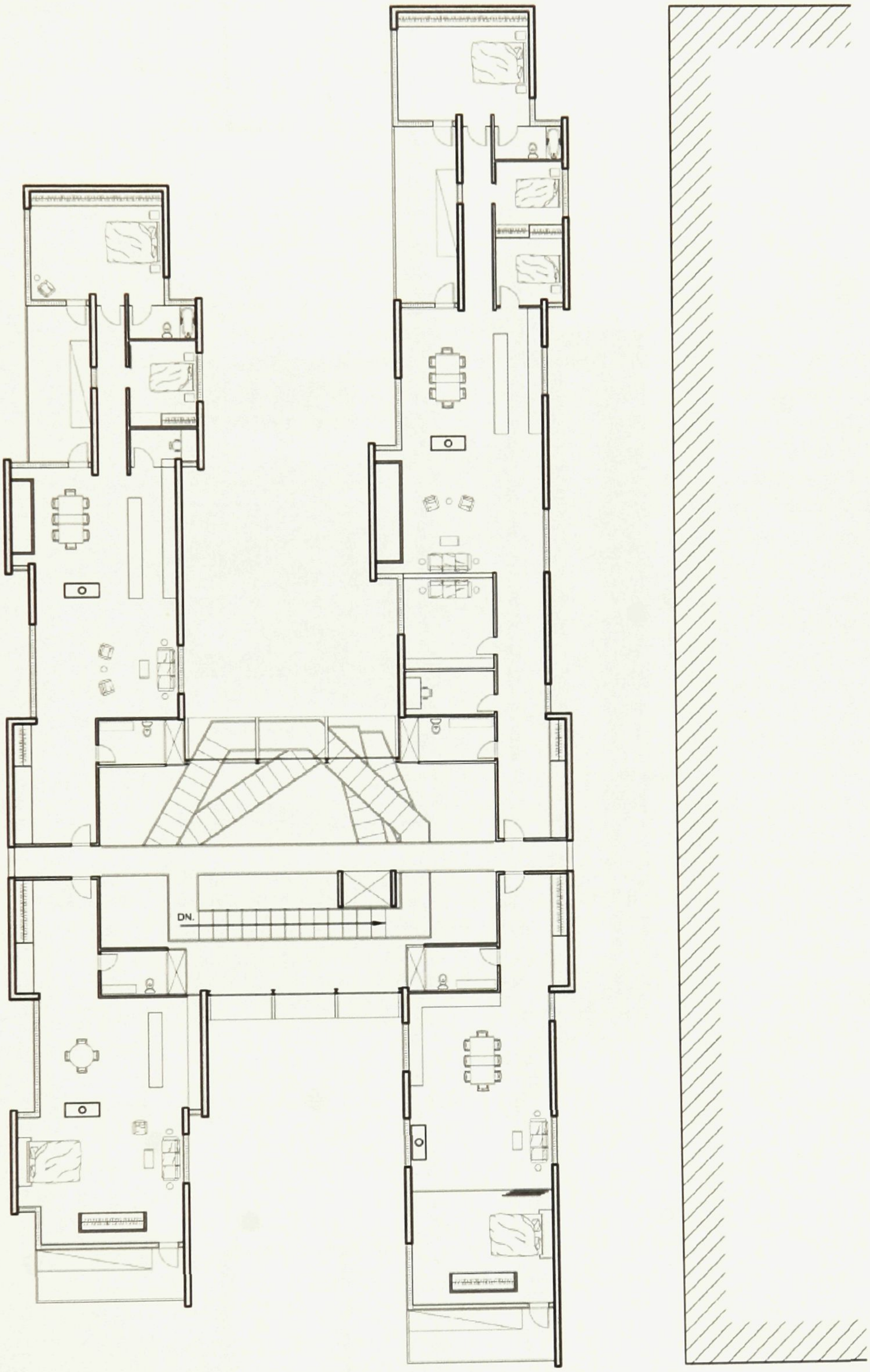

Plate 59: Plan of condo units at sixth floor

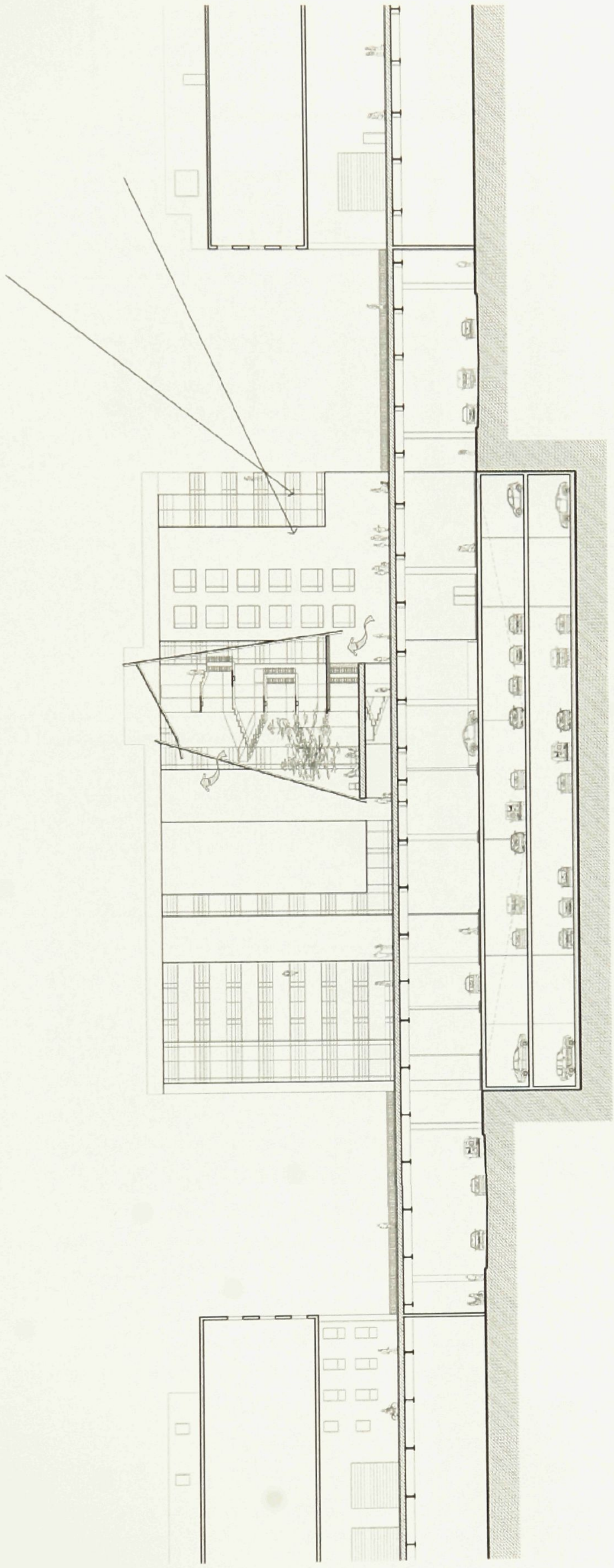

Plate 60: Longitudinal section

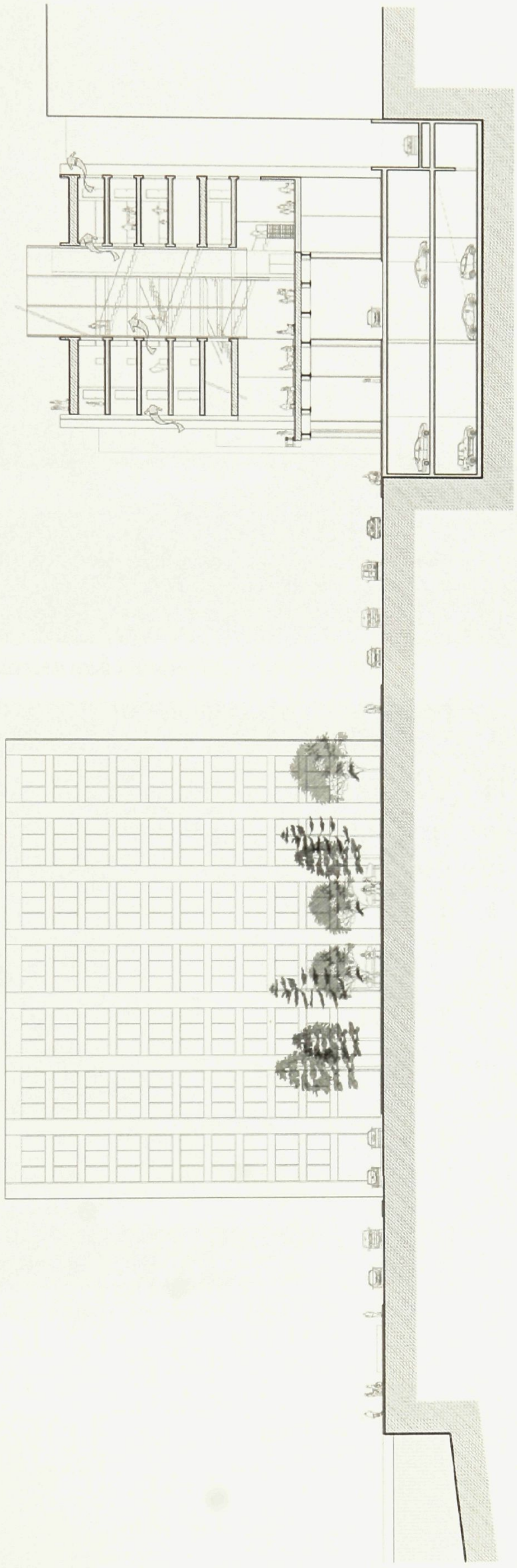

Plate 61: Cross section

Plate 62: Interior view of Kitchen and Dining Area facing north.

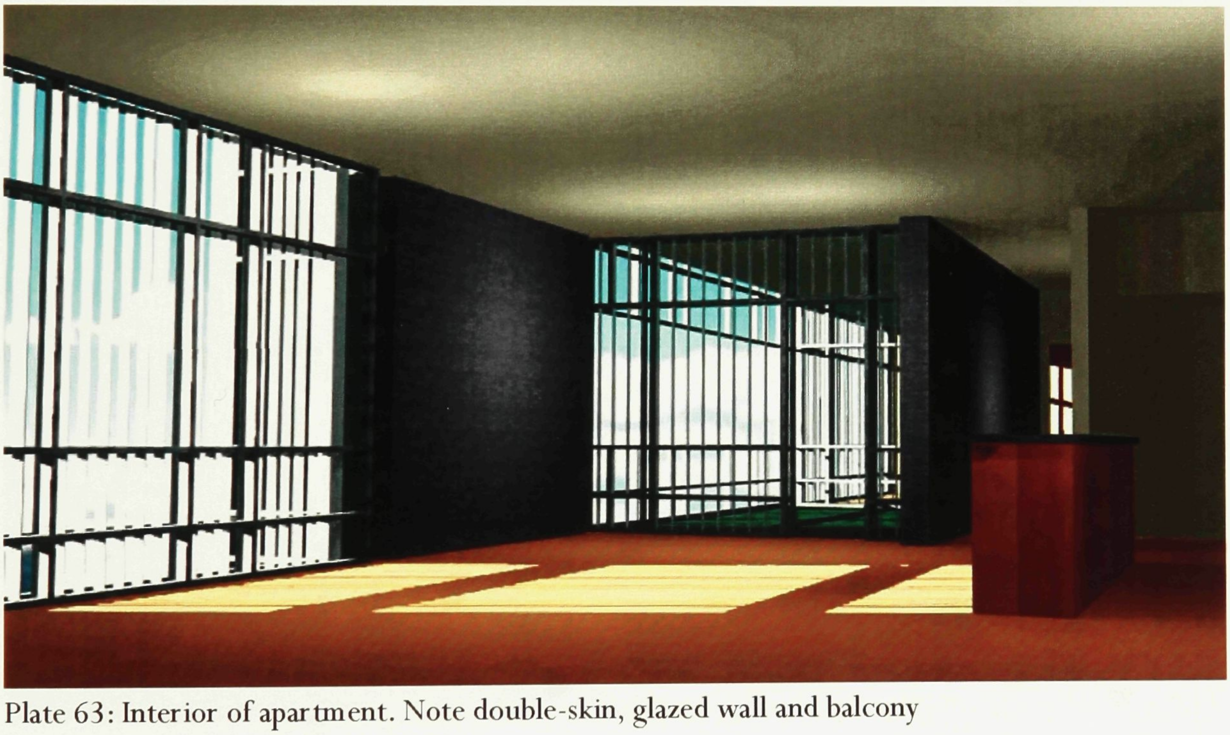

Plate 63: Interior of apartment. Note double-skin, glazed wall and balcony

Plate 64: View from Bedroom facing south/west

Plate 65: View looking over Hudson River

The project also demonstrates adaptive-reuse, incorporating the *High Line*, the carwash on site, and the existing petroleum pumps. The *High Line*, incorporated as Diller + Scofidio and Renfro's winning park proposal, becomes the public gateway into the project. In addition to the social amenities at the level of the *High Line* previously discussed, the once-slated-for-demolition rail viaduct is again made productive and vital. The design proposition of this thesis converts the automated carwash currently occupying the site to a self hand-wash carwash. The intention is to replace a completely disengaging technology — the carwash user remains in his or her automobile while the automated systems lather, rinse, and dry — with a system that engages the user with the means of producing the desired ends and, subsequently, is better for the natural environment. Lastly, the existing petroleum retention tanks now distribute biodiesel, a cleaner-burning fuel comprised of renewable resources such as vegetable oil. The design, in considering the former uses of these existing programmatic elements, introduces similar, new uses that take most advantage of the existing infrastructure while simultaneously promoting an ecological agenda. The productivity of these programmatic elements is increased, there is no additional landfill strain, and the new uses coincide harmoniously with the overall intentions of the project.

The architectural proposition of this thesis utilizes contemporary 'green' building materials and strategies that have been successfully proven to mitigate ecological depletion, such as those employed by *The Currents*. This design, however, goes further than *The Currents*, transcending its fundamental limitation: the proposed building incorporates technological systems that require the conscious participation of the inhabitant in the means of producing the desired ends, thus allowing essential, life-enriching qualities to flourish. An architecture that mitigates environmental degradation while simultaneously encouraging our "attention, aid, skill, and joy," crafting the "moral life" of its inhabitants, is derived from a building practice truly worth sustaining.

Conclusion

This thesis concludes that it is not only feasible, but imperative that environmentally-sustainable architectures employ technological systems that require the conscious engagement of the inhabitants for whom the systems are employed. A proposition as such requires primary design values that are not predicated upon efficiency, but rather values that "animate our moral lives, aspirations about what we most want to sustain in our experience."[78]

Through the investigations of this thesis, it was discovered that LEED, the national authority on environmentally-sustainable architectural design, promotes efficiency as a design value. Subsequent to this, contemporary works of eco-sensitive architecture in Canada, as evidenced by *The Currents*, incorporate non-human-engaging technological systems in their pursuit of efficiency. Although *The Currents* is successful in implementing materials and design strategies that mitigate environmental degradation, it was argued that the project as a whole is fundamentally limited because the technological systems employed do not engage the inhabitants in any purposeful way.

Examining Glenn Murcutt's *Magney House*, a rural-context, single-family home, led to the discovery of environmentally-sustainable building practices that are not predicated upon overarching values of efficiency. The Magney House requires of its occupants the adjustment of hand-operated apertures through which the natural elements condition and enrich the interior spaces, as these technologies reinforce Murcutt's design values. However, the *Magney House* is situated within the vast,

[78] Davison IX.

Australian landscape, and is not subject to the passive-design restraints imposed on urban architecture. It was determined that Murcutt's design principles, not necessarily his architectural forms, could be translated to an architecture of the city.

An environmentally-sustainable condominium in New York City is the design proposition of this thesis. Throughout the design explorations, it was discovered that the design of environmentally-sustainable, urban architecture requires balance: the degree to which an architecture delivers an intimate and ideal exposure to the natural elements and utilizes passive-design principles on an urban site is affected by the degree to which it also negotiates other pragmatic requirements, such as privacy, site constraints, economics, and relationships to existing views and amenities. The architectural form and planning strategies represent the harmonious balance of environmentally-sustainable design values and the architectural challenges of an urban site.

The design builds upon the successes of contemporary environmentally-sustainable architecture, incorporating similar eco-sensitive materials and design strategies as those exhibited in *The Currents.* However, this proposition transcends the fundamental limitation of those architectures: it employs technological systems that require its inhabitants' conscious participation with the means of producing the desired ends, thus allowing "attention, aid, skill, and joy" to flourish.

It is inevitable for technological systems to recede from our 'awareness' after familiarity with those systems develops into everyday 'habit' – the technological systems proposed by this thesis are no exception. However, the technological systems proposed allow the poetic qualities of the natural elements, the warmth of the sun's rays or the invigoration of a fresh breeze, to enrich our lives even at the subconscious level, during our most primary and fundamental activities of daily life. The joy embodied in this relationship crafts 'moral life'. "Sustainability is nothing less than the *craft of moral life.* The enervation of moral life is the real meaning of unsustainability."[79]

[79] Ibid 177. My Emphasis.

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Appendix ‘A’

LEED *Energy and Atmosphere* Prerequisite 2

SS WE EA MR EQ ID

Prerequisite 2

Required

Minimum Energy Performance

Intent

Establish the minimum level of energy efficiency for the base building and systems.

Requirements

Option 1 - New Buildings:

Reduce the design energy consumption to comply with Natural Resources Canada's Commercial Building Incentive Program (CBIP) requirement for a 25% reduction relative to the consumption of the reference building designed to the Model National Energy Code for Buildings 1997 (MNECB), including supplemental CBIP requirements. Compliance shall be demonstrated by using whole building energy simulation. The calculation of percentage energy reduction shall be in accordance with the procedures used in the CBIP program (i.e., includes "non-regulated" plug loads but excludes process equipment).

OR,

Reduce the design energy cost by 18% relative to the reference building designed to ASHRAE/IESNA 90.1-1999 (without amendments). Compliance shall be demonstrated using whole building energy simulation. The calculation of percentage energy reduction shall be in accordance with ASHRAE 90.1 procedures and excludes "non-regulated" loads.

Option 2 - Major Renovations to Existing Buildings:

Reduce the design energy consumption by 10% relative to the consumption of the reference building designed to the CBIP adaptation of the MNECB. Compliance shall be demonstrated by a whole building energy simulation. The calculation of percentage energy reduction shall be in accordance with the procedures used in the CBIP program (i.e., includes "non-regulated" plug loads but excludes process equipment).

OR,

Design the building to comply with ASHRAE/IESNA Standard 90.1-1999 (without amendments).

Option 3 - Low- and High-rise Multi-unit Residential Buildings:

EFFECTIVE UNTIL DECEMBER 31, 2006:

Design the building to comply with ASHRAE/IESNA Standard 90.1-1999 (without amendments) or 10% better than the MNECB based on energy consumption, or the local energy code, whichever is more stringent. A modeling path (not the prescriptive path) must be used to demonstrate compliance. To establish savings relative to the MNECB, the calculation of percentage energy reduction shall be in accordance with the procedures used in CBIP (i.e. includes "non-regulated" plug loads but excludes process equipment).

The project must be registered under LEED Canada-NC 1.0 on or before December 31 2006, AND a building permit must be issued within 12 months of December 31 2006 in order to be eligible for this option.

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Prerequisite 2

Required

Requirements (continued)

EFFECTIVE JANUARY 1, 2007:
The LEED Canada-NC 1.0 requirements for new and existing buildings as described in options 1 and 2 will come into effect for low- and high-rise residential buildings. Option 3 for low- and high-rise multi-unit residential projects will no longer be available.

Whichever compliance path is chosen for this Prerequisite must also be utilized for EAc1, Optimize Energy Performance, if that Credit is sought.

Computer modeling should follow the procedures in Part 8 of the MNECB 1997 for projects using CBIP compliance and the procedures described in ASHRAE/ IESNA 90.1-1999 for projects using ASHRAE compliance. All projects shall follow the modeling guidelines in the most recent version of Natural Resources Canada "Procedures for Modeling Buildings to CBIP and MNECB". Regulated loads include HVAC (heating, cooling, fans and pumps), service hot water and interior lighting. Non-regulated loads include plug loads, exterior lighting, garage ventilation, elevators (vertical transportation) and process loads.

Submittals

- ❑ Provide a LEED Letter Template signed by a licensed professional engineer or architect, stating that the building complies with the appropriate energy performance level (defined above).

AND

For CBIP Projects reviewed and approved by Natural Resources Canada:

- ❑ Provide a copy of the letter from Natural Resources Canada indicating that the building qualifies for the CBIP program, and passes LEED EAp2 requirements.

For CBIP Projects not reviewed by NRCan or ineligible CBIP Projects:

- ❑ Provide a review report by an independent CBIP Design Assessor indicating that the design meets the requirements of this Prerequisite,

OR

- ❑ Provide an electronic copy of the computer simulation files, checklist of mandatory items met and documentation supporting the claimed energy savings, including architectural, mechanical and electrical drawings and specifications in electronic form.

For ASHRAE Projects:

- ❑ Provide an electronic copy of the Energy Cost Budget and final Proposed Design computer simulation files, checklist of mandatory items met and documentation supporting the claimed energy savings, including architectural, mechanical and electrical drawings and specifications in electronic form.

SS WE EA MR EQ ID

Prerequisite 2

Required

Interpretation of Prerequisite Requirements

Summary of Reference Standards

- LEED Canada-NC 1.0 provides two options or paths to meet this Prerequisite: one based on ASHRAE 90.1-1999; and one based on the Commercial Building Incentive Program and its adaptation of the Canadian Model National Energy Code for Buildings (MNECB). Either path may be used; however, the path used for Prerequisite 2 must also be used to demonstrate performance in Energy & Atmosphere Credit 1.
- ASHRAE/IESNA 90.1-1999: Energy Standard for Buildings Except Low-Rise Residential was formulated by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE), under an American National Standards Institute (ANSI) consensus process. The Illuminating Engineering Society of North America (IESNA) is a joint sponsor of the standard. The standard, or its older, less stringent 1989 version is referenced by several provincial and municipal building codes as the minimum standard of energy efficiency. (The U.S. Energy Conservation and Production Act (ECPA) requires that each state certify that it has a commercial building code that meets or exceeds ANSI/ ASHRAE/IESNA Standard 90.1-1999.)
- The Model National Energy Code for Buildings (MNECB) was developed by the National Research Council of Canada, the organization that is responsible for the National Building Code of Canada, as a model code for adaptation or adoption by Canadian provinces and municipalities. The MNECB was developed with input from many committees and all provinces and was published in 1997, but its adoption by authorities has been poor. Both ASHRAE 90.1 and the MNECB are cited by many jurisdictions across Canada with some (e.g., Ontario) requiring that either standard be met for code compliance. A detailed study [Hepting, 2004] compared the energy performance of buildings designed to ASHRAE 90.1 and MNECB/CBIP requirements across the nation. ASHRAE 90.1-1999 was found to be more stringent than the MNECB and the differing requirements for the two paths have been set to compensate for these differences.
- Since the MNECB was based on the ASHRAE 90.1-1989 , the MNECB and ASHRAE Standard 90.1 are very similar in structure, with some modifications that reflect Canadian standards and the cost and availability of energy. Both standards establish minimum requirements for the energy-efficient design of buildings, except low-rise residential buildings. The provisions of these standards do not apply to single-family houses, multifamily structures of three habitable stories or fewer above grade, manufactured houses (mobile and modular homes), and unheated buildings. Some clauses in these standards relate to the design of parking garages associated with the building.
- The standards have three sets of requirements: Mandatory, Prescriptive, and Performance. **Mandatory Requirements** are energy efficiency measures required to be included in the design. These are typically simple prescriptive measures that are considered good building practice, such as controlling lights by light switches and low wattage exit signs. All Mandatory requirements must be met regardless of how the project demonstrates compliance.
- Both standards also have two methods of demonstrating compliance: prescriptive or performance. In the **Prescriptive approach**, the building must meet minimum

equipment efficiency and insulation levels that affect building energy use. The standards provide criteria for building envelope; heating, ventilating and air-conditioning; service water heating; power; lighting; and other equipment. While some minor trade-offs in envelope area and insulation levels are allowed, the design must meet all of the requirements.

- The other method is to demonstrate project compliance using the **Performance approach.** In the Performance approach, a computer simulation tool is used to model the building, which is used to calculate the annual energy consumption of the design, and an equivalent that is barely compliant with the Standard. Two building computer models are used in this method, a Reference (or "baseline") model that just meets the standard's Prescriptive and Mandatory requirements; and a "Proposed" model with same energy features as the design. With the Performance approach designers can trade off between Prescriptive requirements: for example, use less insulation in walls in exchange for higher efficiency heating equipment, provided the total energy use is not increased above the Reference model's. With the MNECB, it is important to understand that the Reference model has the same building orientation, massing, airtightness, hours of operation, outdoor air ventilation rates (with some limitations), thermostat setpoints and occupancy as the Proposed design. Energy savings cannot be accrued by setting these parameters different in the proposed and reference buildings (unless specifically allowed in the "Procedures for Modeling Buildings to MNECB and CBIP").

Major Renovations to Existing Buildings

- Existing buildings may be exempt from some MNECB or ASHRAE 90.1 mandatory requirements where it can be shown that meeting the requirement is technically or economically not feasible because of existing building condition or historic designation. Designated historical buildings (as defined in ASHRAE 90.1 Section 4.1.2.2) do not have to comply with the envelope thermal performance requirements of either the MNECB or ASHRAE 90.1. Furthermore, the thermal performance requirements of the Reference models' envelope would be set to the existing historic building condition. However, the mechanical and electrical systems must comply with MNECB or ASHRAE 90.1, with the exception of designated heritage lighting.
- Three conditions must be met to be considered as a major renovation to existing buildings. The building envelope (excluding windows) must be retained, the building was constructed before 1990 and the renovation consists of replacement of the HVAC and lighting systems. For projects that are a combination of major renovations and new construction, the required energy saving to meet the Prerequisite is an area-weighted average of the renovated and new construction energy saving targets. Additions to existing buildings can be considered as a LEED project, but must meet the requirement for new buildings.

Demonstrating Compliance

- Typically, for new buildings, compliance is shown using building energy computer simulation or by submitting documentation that the chosen standards' performance requirements are met (rather than actual energy bills). With ASHRAE 90.1, the Performance path is referred to as the Energy Cost Budget

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Required

method, and LEED Canada-NC 1.0 Prerequisite 1 requires that the total annual energy cost calculated for the Proposed model is at least 18% less than that of the Reference model. For major renovations of existing buildings ASHRAE 90.1's Prescriptive method may be used to demonstrate compliance.

- The MNECB option for this Prerequisite is to meet the energy consumption savings required by the Natural Resources Canada's CBIP program; that is, achieve a 25% reduction in energy consumption relative to the MNECB/CBIP Reference model. Building energy simulation is required to show that the 25% energy savings has been achieved. NRCan has also developed some prescriptive energy-saving packages that meet the CBIP 25% energy savings target.
- NRCan also has an Industrial Building Incentive Program (IBIP), aimed at buildings whose primary use is not people; buildings that meet the IBIP energy savings requirements comply with this Prerequisite.
- It is not necessary that a building receive CBIP (or IBIP) incentives or approval to meet this Prerequisite. Some buildings are not eligible for CBIP (e.g., federal government buildings) or some owners may not wish to apply for this program. However, if the MNECB method of demonstrating compliance is used, the same documentation required by CBIP is required in the projects' application for LEED certification, and the simulation should follow CBIP guidelines. For most projects, CBIP approval greatly simplifies the certification submittal and LEED review process.

Energy Simulation Requirements

- Energy simulations must be performed using a detailed hourly energy analysis program that has models for the complicated HVAC systems found in commercial buildings. CBIP requires energy simulations be done using NRCan's EE4 software. ASHRAE 90.1 energy simulations can be done with EE4, DOE 2.1 or other hourly simulation programs meeting its requirements for energy software.
- All simulations, whether for CBIP or ASHRAE 90.1, must be done in accordance with the modeling procedures defined in NRCan's "Procedures for Modeling Buildings to MNECB and CBIP". In case of contradiction between ASHRAE 90.1 modeling rules and the NRCan document, the ASHRAE rules would take precedence for the ASHRAE compliance path and the NRCan rules would take precedence for the MNECB/CBIP compliance path. See Energy & Atmosphere Credit 1 for a more complete description on energy performance modeling of buildings.

Submittal Requirements

- If the project has received CBIP (or IBIP) approval, the only required initial submittals are a copy of the approval letter from NRCan, LEED compliance form issued by CBIP, and the completed LEED Letter Template.
- If this letter is not provided, there are two submittal options. The first option is to have the energy simulations reviewed by an independent NRCan CBIP Design Assessor (see http://oee.nrcan.gc.ca/newbuildings/qualified_assessors.cfm). The independent assessor would need to certify that the design meets the CBIP requirements. This assessor must be from a firm independent of the project energy simulator and of the project design team, reporting to and paid directly by the developer.

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- The second option is to provide the electronic simulation files, checklist of mandatory requirements met and a narrative describing the major energy efficiency measures incorporated in the final Proposed design, major assumptions and parameter values used in the simulation and a summary of the simulation results.
- In the event of a LEED Canada audit of this Prerequisite, if simulations were performed, the applicant provides a complete design and energy simulation package consistent with the requirements for a CBIP submission (e.g., drawings, specifications, energy simulation files, zoning description and simulation report).
- For major renovations where the ASHRAE compliance path is used, only the LEED letter template is required. In the event of a LEED Canada audit of this Prerequisite, if the building is simulated using ASHRAE's performance path, the applicant provides a complete design and energy simulation package (e.g., drawings, specifications, energy simulation files, zoning description and simulation report) prepared to document the simulation results. If ASHRAE's prescriptive path is followed (only allowable for major renovations), worksheets similar to those available in the ASHRAE Standard 90.1 workbook should be submitted, documenting compliance with its mandatory and prescriptive requirements.

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Prerequisite 2

Credit Synergies

EA Prerequisite 1
Fundamental Building Systems Commissioning

EA Prerequisite 3
CFC Reduction in HVAC&R Equipment and Elimination of Halons

EA Credit 1
Optimize Energy Performance

EA Credit 2
Renewable Energy

EA Credit 3
Best Practice Commissioning

EA Credit 5
Measurement and Verification

MR Credit 8
Durable Building

EQ Prerequisite 1
Minimum IAQ Performance

EQ Credit 1
Carbon Dioxide (CO_2) Monitoring

EQ Credit 2
Ventilation Effectiveness

EQ Credit 6
Controllability of Systems

EQ Credit 7
Thermal Comfort

EQ Credit 8
Daylight & Views

Green Building Concerns

Traditional development paradigms that have dominated building design for the past 50 years assume off-site generation, transmission and delivery of cheap energy, ignoring upstream energy inefficiencies and environmental impacts. While a case can be made that off-site generation has enabled developers to utilize space more productively, the benefits gained have come at a high environmental cost.

Several studies have shown that the operating energy consumed by a building over its lifetime constitutes 80-90% of the total life-cycle environmental loading. [Trusty & Miel, 2000; CORRIM, 2004] The most important step any building developer or designer can take to create a greener building is to reduce its energy consumption, and shift the fuels it uses to less polluting sources, particularly to renewables.

The energy use metered at the building site, or "site energy", is only a part of the energy consumption that the building is responsible for. "Source" energy and emissions accounts for losses and inefficiencies in energy extraction, transmission and distribution systems that deliver energy to the building. For electricity, source energy and emissions may be two or more times the site energy consumed directly by the building, due to transmission and distribution resistance losses and the efficiencies of generation plants. However, calculating source energy and emissions can be difficult, especially for electricity, since regional electrical grids pool energy generated by a wide variety of plants from many different locations; and the mix available from the electrical grid changes minute by minute. LEED uses site energy or cost as a surrogate for calculating source energy and emissions, since energy costs across North America roughly correspond to environmental loadings. However, use of site energy or energy cost as an index of environmental loading is imprecise at best, and may change in future versions of LEED Canada-NC 1.0.

The evidence demonstrating that combustion of fossil fuels, with its resulting CO_2, SO_x and NO_x emissions, is linked to global warming continues to mount as we continue to extract and burn these fuels at an increasing rate. Deregulated energy markets have enabled a greater disconnection between the effects of electricity generation and electricity users, since it may be sold in regions far from the regional environmental impacts of generation. Habitat protection is becoming a critical element of power planning and allocation efforts. Nuclear power continues to be controversial due to security and environmental issues related to waste reprocessing, transportation and storage. As the side effects associated with energy use become better understood, the demand for energy efficiency, clean production and renewable energy continues to grow.

Environmental Issues

Canada has signed the Kyoto Protocol to reduce greenhouse gas emissions. As part of this commitment, the Canadian government has set a goal that by 2010, all new buildings will comply with the minimum requirements of CBIP. To encourage this market transformation, the federal department Natural Resources Canada has an incentive program to design and construct buildings that meet this target. This program, referred to as the Commercial Building Incentive Program (CBIP), requires whole building energy simulation (using EE4, a version of DOE 2.1) to show that the 25% energy savings is achieved. Most buildings wishing to achieve Canadian LEED certification will likely pursue this incentive since the program incentives can more than offset the costs for LEED design and certification.

LEED Canada-NC 1.0 Energy & Atmosphere Prerequisite 1 is more stringent than the USGBC's LEED-NC 2.1 requirements, for two reasons:

- First, Canada is a colder country than the U.S., and building energy efficiency is a more important factor in their environmental impacts.
- Second, since the government objective is to transform the market to 25% more efficient buildings, it would be regressive to set a Prerequisite that is below this target. Thus, for new buildings Prerequisite 2's requirements were raised to the CBIP target; but are unchanged for renovations to existing buildings.

These changes are supported by a comprehensive study [Hepting, 2004] undertaken to compare the energy performance of buildings designed to ASHRAE 90.1-1999 requirements, versus design to the CBIP adaptation of the MNECB. This study was then used to determine the equivalent ASHRAE 90.1 performance corresponding to CBIP's 25% energy savings target for new buildings. The study compared the relative energy performances for eight building types in seven climate zones across Canada, and found that on average a building that achieved an 18% energy cost savings relative to ASHRAE 90.1 is equivalent to a building designed to just meet CBIP.

Economic Issues

Complying with the requirements as stated in the ASHRAE 90.1–1999 standard or CBIP decreases operating costs by reducing total energy consumption as well as "time of day" or "time of season" demand charges. The reduced total energy demand for a building also may translate into reduced first costs; for example, integrated design features may allow for smaller HVAC equipment. Local utility rebate programs and incentives from provincial energy offices are available in many areas for energy-efficient design and equipment.

Fees for building energy simulation are not inexpensive, ranging from ~$7500 to $25,000 or more, depending on the features and complexity of the building design. However, CBIP incentives of up to $60,000 are available that more than offset this initial soft cost, and can contribute toward the capital costs of energy efficiency measures in the improved design.

Community Issues

Reduced dependence on fossil fuels for heating and cooling reduces air pollutant levels in urban areas, and, for most provinces, leaves more money in local communities for their use. The EPA reports that about one out of every three people in the United States is at a high risk of experiencing adverse health effects from ground-level ozone (smog), largely generated by burning of fossils fuels by vehicles and buildings.

Design Approach

This Prerequisite requires that the building achieve an energy efficiency level equivalent to the CBIP energy savings target. In most cases, this will require a change in the design of the building to incorporate more energy efficiency measures. Some possible strategies are discussed below.

Strategies

Standard 90.1-1999 and the MNECB describe minimum energy efficiency requirements, with both mandatory and prescriptive paths for five energy end uses: building envelope, HVAC systems, service water heating, lighting and process loads.

The standards address energy efficiency of the building envelope by mandating maximum assembly U-values of the various building components. (U-value is the inverse of R-value.) The U-value is calculated accounting for thermal bridging of structural and framing members and is not simply based on the insulation properties. Figure 1 shows a sample from the MNECB for Southern Ontario. These prescriptive provisions are customized for the location and climate of the project. One of the easiest ways of reducing energy use in buildings where heating outweighs cooling energy is to add additional insulation or reduce thermal bridging.

Both standards' U-value requirements for windows are based on total window performance including edge-of-glass and framing heat losses, not just centre-of-glass U-values. If the window-to-wall area exceeds 40% in the MNECB or ASHRAE 90.1, the U-value requirements are made more stringent. The energy performance of the windows can be improved by using low-e coatings, inert gas fills, warm-edge spacers and better insulated frames. In most cases keeping the window-to-wall ratio below 50% will reduce energy consumption.

The standards address heating, ventilation and air conditioning system efficiency by specifying minimum performance of all HVAC equipment. Mandated efficiency values are a function of the type and size of equipment. The standards also require control schemes that automatically shut-off or reduce system output during unoccupied hours. Energy consumption can be reduced in many ways. HVAC system type can have a major impact on building energy use. Avoid systems that require simultaneous heating and cooling to achieve comfort conditions in any given zone (e.g., terminal reheat, multi-zone). Choose systems that recover heat from waste or renewable sources (e.g., exhaust heat recovery, ground source heat pumps, water loop heat pumps) or have low fan power requirements (e.g., VAV with variable speed drives, radiant heating and cooling). Select high-efficiency equipment: condensing boilers, high efficiency scroll chillers, and packaged rooftop equipment meeting CEE standards. Ventilation heat recovery, solar air preheating, and demand controlled ventilation reduce the heating and, in some cases, cooling load for ventilation air. Large ductwork and efficient motors and drives reduce fan power.

Service Water Heating requirements include minimum tank and pipe insulation levels and water heating equipment efficiency. Water heating requirements can be reduced by installing low-flow fixtures, drainwater heat recovery, and high efficiency or solar water heaters.

MNECB and ASHRAE 90.1 have mandatory requirements for luminaire source efficacy and lighting control/ switching. The standards have maximum values for Lighting Power Densities (LPD) depending on the space function (e.g., office, retail, warehouse). Lighting design should favour efficient light sources such as T5/T8 fluorescent and HID and avoid inefficient lighting such as incandescent and halogen. The building design and lighting control