Sustainable urban dwelling – a new typology

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Sustainable architecture has long been practiced in the remote areas around the world, where man-made energy is unavailable. Yet it is in the crowded urban environment the most energy is wasted, and the most waste is produced. The priority for a green city is to create green urban housing typologies specific to each urban microclimate, and to develop standardized technologies for the common consumers.

The urban climate of Toronto creates a challenge and an urgent call for sustainable urban housing. Aside from four to six months of winter heating, most family turns on air conditioning during the summer. The pollution and urban landscape has made the climate more and more extreme and unstable. There are very few historic typologies for this polemical weather. With the improving renewable resource technologies, it is finally possible to create a self-sustaining dwelling of thermal delight in all weathers. Technology combined with principles of different historic typologies, such as nomadic tent and Mediterranean shutter skin can improve the new sustainable typologies and implement them in our urban context.

There are six architectural principles that improve the energy efficiency and interior comfort of a dwelling. They are: 1) siting and vernacular design; 2) light and shade; 3) natural ventilation; 4) earth shelter; 5) thermal inertia; and 6) air lock envelope.[1] While the basic fundamentals of passive winter heating and summer cooling are the most economic solutions for energy efficiency, a capital investment with new technologies could cover the four major self-sustaining issues in the life cycle of a building: 1) electricity; 2) winter heating and summer cooling; 3) on site water collection, treatment and recycle; 4) organic waste

[1] The principles are in reference to Robert Hotten's website, Sustainable Architecture and Urbanism

treatment and recycle. Use of local, sustainable or recycled materials is also a statement for green architecture.

There is already a new typology emerged from sustainable architecture which has been tried and discussed globally. The YMCA outdoor centre[2] at Paradise Lake is a paradigm of this new typology in Southern Ontario. The main concept surrounds the great potential of living machine as a waste treatment plant and smoking stack while offering an aesthetic and enjoyable space. This typology has been applied for community, commercial buildings and rural dwellings. With the knowledge we gained through experience, we can prove the theorem and understand its defects. The YMCA will be analyzed to form the base of a new urban typology.

Figure 1 YMCA Outdoor Centre, Paradise Lake, view from South

The Paradise Lake YMCA is an excellent case study. The 7,500 ft^2 complex considers all six architectural principals and uses many renewable resource technologies to cover the four self-sustaining issues. The YMCA has a large solarium which houses the living machine on the South side with a 45° slanted glazing wall (fig. 1). The major common space opens up to the solarium with glazed door. The Burrows (guest rooms) backs into the hill[3] and the sloping roof is planted with grass and indigenous flower. The complex features the solarium --living machine-- for biological water purification and natural ventilation, and uses composting toilets, masonry fireplace, radiant floor heating, solar water heater, photovoltaic, and wind turbine.

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2 The YMCA was completed in 1996 by Charles Simmons Architects Inc.

3 Earth sheltering would not be discussed because it's not suitable for typical urban dwelling.

The YMCA practices the common vernacular design principle in which the building complex is elongated to maximize south façade and minimized east and west facing walls. However, the building footprint and orientation is almost pre-defined in the dense city, thus the treatment of each façade according to its direction and adjacent condition is the key to a sustainable city dwelling.

Figure 2 YMCA offices

The South façade is the best location for all solar energy technologies, therefore every wall and sloping roof should be optimized with this consideration. All windows should be protected by proportional overhangs for passive solar design (fig.2). The YMCA solarium is the major feature on the south façade. It houses the living machine which is part of the grey water system. The tall triangular section induces stack effect and keeps the rest of the complex cool and ventilated (fig. 3). It also provides a delightful source of light and view.

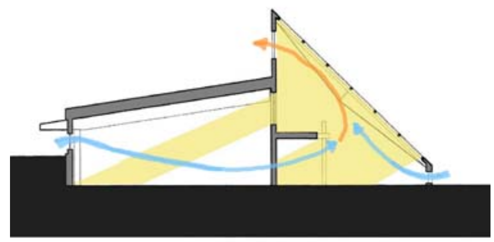


Figure 3 YMCA N-S section thru the solarium

The same concept can be well incorporated in the narrow and long city dwelling. A living machine is a perfect light-well and an all-season courtyard. Natural light brings pleasant atmosphere, yet light is also a major source of heat gain. There are several problems with the YMCA solarium. In the summer, the greenhouse is very humid and hot. First of all, the enormous space is under direct sunlight at all time. Secondly, the air intake (the mechanical louvers) is too small. We can super-impose the principle of nomadic tent to improve this condition (fig. 4). The goatskin is guyed down

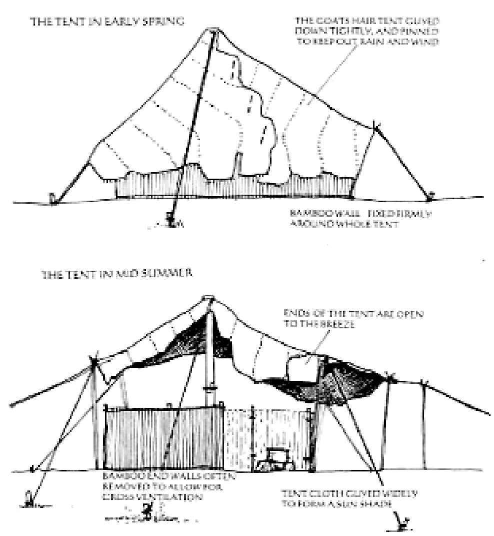


Figure 4 The black tents of the Luri tribes of Iran

tightly in the winter to keep the interior warm and it is completely opened up to form a sunshade and let in breeze. The glazing should be as operable as possible, so the living machine can be opened up and almost becomes an exterior space (fig. 5). The years of experience also proves that the living machine does not need so much direct sunlight to function. The glazed wall could be almost vertical, the roof would partially shade the greenhouse and the glass could be partially etched or patterned.

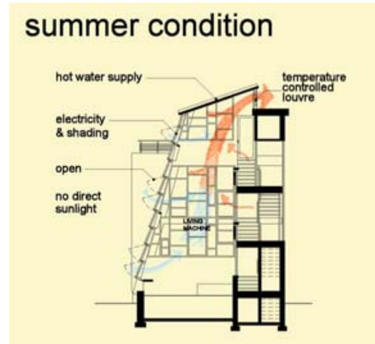


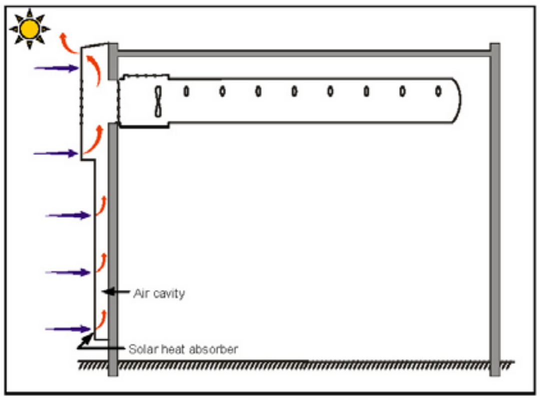
Figure 5 Living machine opened up as exterior space

On this note, we should discuss the solar technologies for it could be incorporated into a solarium. The three solar technologies that could be easily applied for typical housing are photovoltaic, solar water heaters and solar-wall. Photovoltaic could be further integrated into glass to provide shading, or privacy (fig. 6). Therefore GIPV (glass integrated photovoltaic) is the best solution for the solarium glazing wall. Photovoltaic panel or solar water heaters could become the roof of the greenhouse. There are many different technologies of solar water heater on the market. The evacuated tubular solar collector is more expensive but much more effective in cold weather (fig. 7). The hot water collected could be used for radiant floor heating in the winter.


Figure 6 Glass Integrated Photovoltaic (GIPV) provides shade for skylights.


Figure 7 Evacuated tubular solar collectors

In the summer, the excessive hot water could be used to evaporate the humidity absorbed in a desiccant wheel[4], thereby helping to cool down the building. Solar-wall is less known but it has been practiced with very good results globally[5]. Fresh air is suck into the dark-colour metal through tiny perforations and heated up within the air space (fig. 8). The heated air could go directly into the room or collected and delivered through ducts. The advantage of solar-wall is that it could easily be clad over typical Ontario construction.



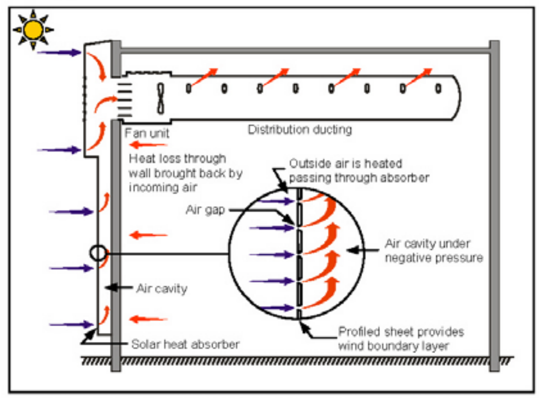


Figure 8a. (left) Summer cooling with perforated unglazed Solarwall panel

Figure 8b (right) Solarwall panel integrated into a wall and connected to an interior fan

In the winter, the YMCA solarium provides passive heating and an enjoyable space. Though there are two aspects that could be improved. The humidity in the green house is comfortable but causes water condensation on the glazing which may potentially damage the window frame. Secondly, hot air rises to the top and there is no option to use this energy. Much like that of a windshield, constant air movement alongside the glazing could avoid water condensation. SolarWall® can be placed at the base and mid-height. Fresh air would be drawn and heated before blowing upward[6]. Heated air and exhaust from the house is humidified by the plants and rise up to the top of the greenhouse. The heat air could be filtered and distributed, or passed through a heat-recovery system. (Fig. 9)

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4 A desiccant wheel cools down air by absorbing humidity and is reused after the humidity evaporates.
5 SolarWall® is the largest company that employed this solar air heating technique.
6 Temperature of air output depends on the air exchange rate and solar radiation.

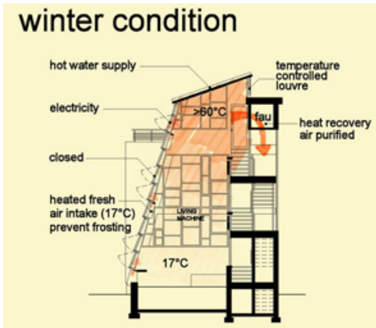

Figure 9

Heated air is accumulated and re-circulated in the winter.

Figure 10 Section through the village of Khoranaq, Yazd, showing the passage of the water from clean to dirty uses.

The living machine housed in the solarium is part of the grey water system. The concept of collecting rain water and reusing water has been part of many cultures in which fresh water supply is insufficient and precious (fig. 10). The YMCA did not collect rain water. Its living machine only treats gray water and recycles it for washroom uses, and it is somewhat oversized. It is designed to treat waste water for the high season of the YMCA facility, thus the gray water quantity and nutrient is inadequate for the low season. An ideal gray water cycle starts with planted roofs. A planted roof is great for rain water retention and purification. The water can be collected and used for all application other then the kitchen. Then, all the grey water goes to the living machine or watering the lawn. A living machine works very well in a residential situation where the amount of waste water is consistent. After the water has been biologically purified, it could be reused again[7]. The living machine can be used to treat solid waste also. However, it would expand in size and complexity, which might not be suitable in an urban dwelling. The most environmental and economical way to treat solid waste is using composting toilets as in the YMCA. The CK Choi Building for the Institute of Asian Research[8] has successfully installed waterless composting toilets on all three floors. The disadvantage of the waterless composting toilet is that it is harder to keep clean and it is not widely accepted psychologically. The

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[7] Though Charles Simmon, the architect, often proudly says that the water purified by the living machine is potable quality, it is uncommon to reuse the water for the kitchen.

[8] The C. K. Choi Building for the Institute of Asian Research is built in 1994, commissioned by University of British Columbia.

new low-water system that looks and works like a normal toilet could be used in combination with the gray water system (fig. 11)[9].

Figure 11 Decomposer and low-water composting toilet

The South wall is the most important source of light and energy. Careful design of the other three façade is crucial as well. North light is the most enjoyable light, and north breeze is important in the summer as well. With the new window technologies, north windows are no longer significant sources of heat loss. The east and west façade is the most problematic due to summer heat gain. If they are facing adjacent houses, then they need very few window openings, and they are shaded most of the day. The east-west facing houses have to have windows to the front and back for view, light, ventilation and aesthetic. The best solution is operable external shutters, which is the common language of Mediterranean architecture. The shutters should folds on a track or opens outward, so the light and view can be enjoyed at suitable time and weather.

A dwelling that employs the full potential of the living machine as a biological treatment centre, ventilator, winter heat source and beautiful courtyard while incorporates different solar and environmental technologies in its architectural language can become a successful typology in the city of Toronto. We must promote and implement such sustainable typologies to create a green urban environment.

[9] The model in Fig. 11 is the Evirolet® Low Water System.

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