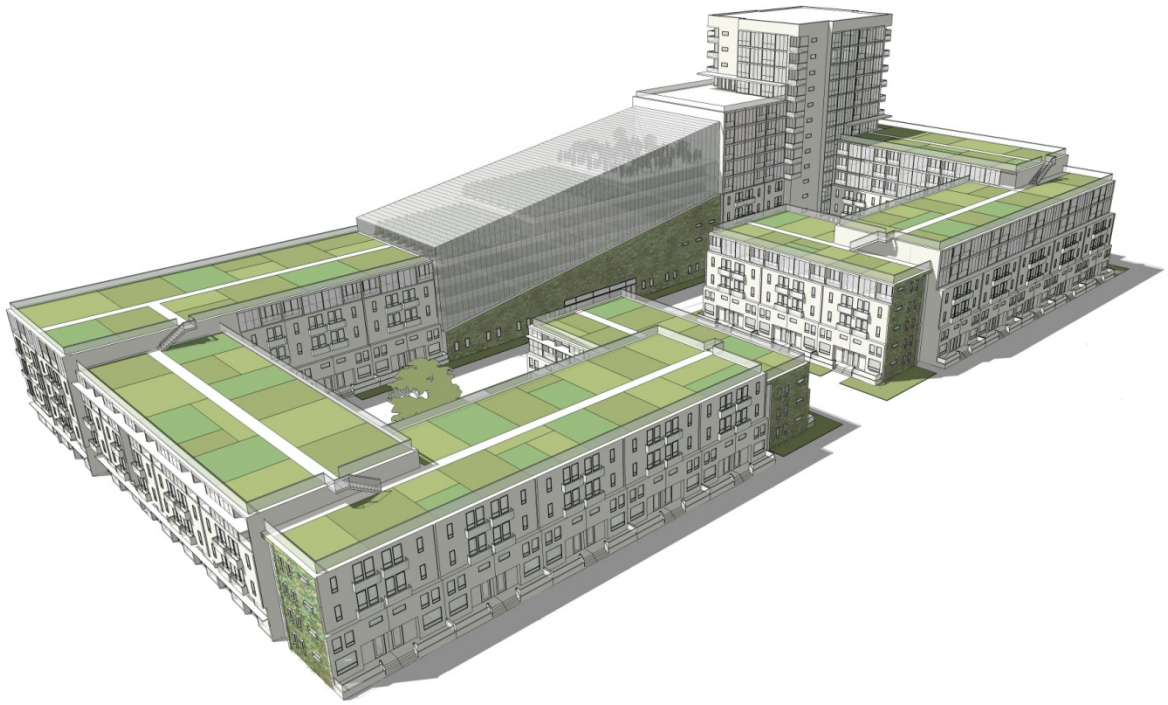
GROW Housing

By Gordon Graff



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Executive Summary

The GROW Housing project seeks to establish a new model for urban development - one which utilizes an innovative sustainable design strategy to facilitate the creation of affordable housing. The model was developed to mimic the cyclical flow of resources exhibited by the natural world. To create this system, a vertical farm, Living Machine®, and methane digester have been merged with a residential development with a population of 1,000 people.

Key Features

- The creation of rent-to-own housing for 500 residents, with an equal number of market value housing units.
- On-site growth of 100% of residents dietary needs from Vertical Farm
- On-site generation of all power needs by converting community bio-waste and farm waste into electricity via a methane digester
- Street-level commercial space on Queen and Jarvis Streets to improve the neighbourhood streetscape, stimulate the local economy and provide jobs
- Geothermal Heat Pump system provides entire site with heating and cooling needs, therein massively reducing the energy demands of the site with surplus heating and cooling needs to the neighbouring arena and community centre generating thousands of dollars in annual savings for the City of Toronto
- Geothermal Heating is extremely cost effective over the life-span of the system, providing a real financial advantage.
- A Living Machine® closes the water cycle of the project, enabling the reuse of all rainwater and waste water from the site. Solid biological waste will be filtered and directed to the methane digester for power production
- On-site processes of ALL biological waste generated by residents and farming operations.
- Creation of over 5,300 m2 of rooftop community gardens
- Bio-waste collection program allows local processing of ‘green bin’ waste, which is used to generate additional power needs via the methane digester
- The Vertical Farm, and community bio-waste collection programs would generate many low-skill jobs for the community
- Farm produce available for community purchasing through the ground floor grocery store.

Introduction

The GROW Housing project seeks to establish a new model for urban development - one which utilizes an innovative sustainable design strategy to facilitate the creation of affordable housing. Taking a cue from ecosystem dynamics, the model was developed to mimic the natural process where by waste of one entity becomes the food of another, creating an efficient cyclical flow of resources. The long-term financial gains enabled by this energy and resource efficiency enables GROW Housing to offer a financially sustainable affordable housing solution.

Presently, urban buildings require a wide array of networks to distribute the services essential to sustain human life. Without the delivery of safe drinking water, fresh food, and electricity for environmental temperature control, conventional urban buildings would be inhospitable to humans. These networks must also efficiently dispose of the waste and refuse we generate in order to preserve a healthy living environment. It is remarkable to think of the distances these materials arrive from, and are carried to, simply to facilitate urban living. Truly, modern urban buildings are strict consumers; completely dependent on the centralized distribution network for sustenance, and completely unconnected to (and unaware of) their external effect on the biosphere.

In the face of this common disposition of urban buildings, the GROW Housing project seeks to propose a new model for urban residential development. By relying less on the centralized distribution network and more on localized self-sufficiency, residents of GROW Housing will realize a more profound connection to the life-cycle of their consumed resources. Moreover, localizing the production of food, filtration of water, generation of power, and processing of waste establishes a cradle-to-cradle (or cyclical) flow of resources that greatly enhances the ecological sustainability of urban living. Fewer food imports are required, and less waste needs to be exported, meaning the development requires virtually no increase of service transportation. To lower GROW Housing's energy demands, it employs a geothermal heat pump to produce all hot water, heating, and cooling needs for its residents, as well as architectural devices that reduce the need for artificial lighting. Besides the requirement to import municipality approved potable water, GROW Housing is not only completely self-sufficient, but actually a force that lowers the ecological impact of the neighbourhood at large. Additionally, it is impossible to overstate the significance of GROW Housing's position as the first high-density residential building in a downtown core to produce 100% of its resident's food requirements on site.

Site Analysis

Located just east of Toronto's downtown core, Moss Park is bordered by Queen Street, Jarvis Street, Shuter Street, and Sherbourne Street. Undoubtedly, it is one of the most eclectic neighbourhoods in Toronto's urban tapestry. High-end stores, art galleries, and restaurants intermingle with all the illegal activities that typify economically downtrodden urban areas.

Moss Park was originally the heart of Toronto's industrial area. The tightly packed tenement houses that characterised the neighbourhood were cleared during the urban renewal programs of the 1950s and 60s, mostly replaced by large towers surrounded by green space - the infamous modern planning typology. By the 1970s, the complete de-industrialization of the area rendered the Moss Park neighbourhood as one of the poorest in Toronto. Over the years, the city's social and temporary housing initiatives slowly accumulated in the neighbourhood due to the affordable land and central location. Drugs, theft, and prostitution have become common sights around the park for decades, though recent actions taken by the residents, business owners, and Toronto Police Department have improved matters.

Mere blocks from the financial district, St. Lawrence Market, and the Eaton Centre, Moss Park is an ideally located neighbourhood. As a result, the wider community has experienced considerable gentrification over the past few decades. Properties in nearby Corktown and Cabbagetown have recently become in high demand, and former industrial structures such as the Distillery District have been converted into trendy lofts and fashionable shopping areas. The park has one of the few baseball diamonds with lights in the downtown core, as well as a heavily used hockey arena and recreational facility that generate considerable activity.

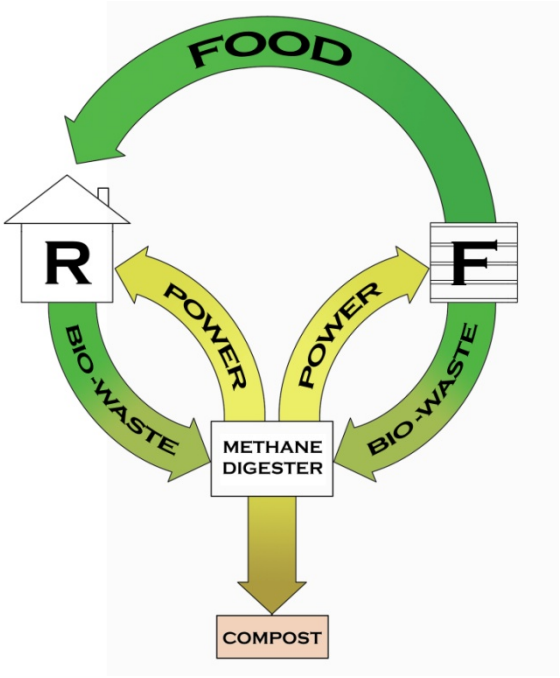
The building site, which is on the west side of the park, is currently consumed by the Moss Park Armoury. Its considerable set-back and stark facade are completely disproportioate to the human-scale, and greatly deteriorate the street life in the area. Furthermore, the prominent barb-wire fence separating its lawn from that of the park is a visual eyesore that creates the ideal setting for drug deals and gang loitering to take place. Its extreme low density completely under-utilizes the accessibility of the site, which includes being directly on

the streetcar line and a short walk from the Queen Street subway station. All-in-all, the Armoury contributes very little to a community that is in dire need of a positive intervention.

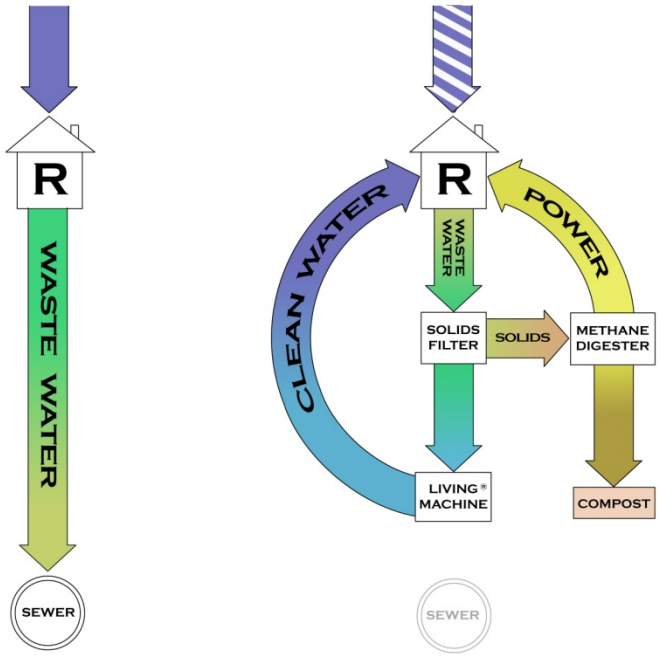
GROW Housing System

One of the great strengths of the GROW Housing model is that it does not require unproven or highly expensive technology to enable its outstanding performance. In fact, each of the project's devices are quite common, with many examples existing within the GTA region alone. Large-scale hydroponic farming has been around for decades, with many producers in southern Ontario. The Living Machine® wastewater treatment method has also been used for decades - a version of one is currently at work in the Canada Life building just a few blocks from the project site. Lastly, Methane Digesters are not an uncommon sight on farms in rural Ontario, converting the unused biological waste material into usable energy. They are relatively simple technology,

However, by combining these three devices within a residential development, the linear metabolism of resources that typifies conventional urban development can be massively restructured, enabling extremely efficient resource usage. Moreover, the on-site production of enough food to sustain the development's population, as well as the generation of all power needs from community biological waste processing, gives the Grow Housing model a miniscule ecological footprint with virtually no green house gases emitted for its perpetual operation.



This diagram shows the relationship between the methane digester, vertical farm (F), and residential buildings (R). As the farm produces food for the residential units, large amounts of bio-waste are collected from the farm's production and fed into the methane digester to produce electricity, powering the artificial lighting of the farm. Additionally, the bio-wastes from the residents' usage of the food is directed to the methane digester, producing power for their homes.



This diagram shows a comparison between the 'linear' water management of conventional buildings, and the cyclical system used in GROW Housing. The nutrients within the wastewater are processed by the methane digester to produce both power and compost, while the Living Machine® filters the water to be used for all non-potable uses, including irrigation for the hydroponic farm.

GROW Housing Components

Vertical Farm

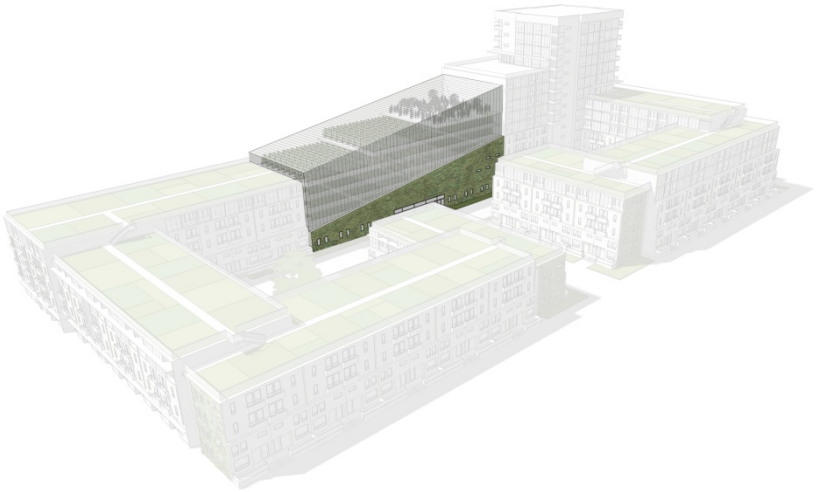
Vertical farming consists of the practice of agricultural production inside multi-storey buildings. The premise is derived from the desire to maximize agricultural production per area unit of land, effectively making agriculture 'denser' in order to reduce the land requirements necessary for food production. The density afforded by farming vertically enables these farms to be located within dense urban areas, therein bringing truly local agriculture to large city centres.

When considering agricultural production is arguably the most destructive force human beings have inflicted on the world, the logic of densifying agricultural production becomes clear. According to the World Resources Institute, over 80% of the world's forests have been destroyed by human production; most of which to clear arable land for crop production or grazing land for animals. As such, Grow Housing's production of food for 1,000 residents year-round saves hundreds of acres of land from conversion to agricultural production.

Essentially, the farm works by densely packing hydroponically grown produce within its 6 stories of space, all of which grow under artificial light. The usage of hydroponic crop production as the growing medium is a fundamental component of the vertical farm. Its minimal space requirements permit the massive densification of agricultural production to take

place, as it enables the vertical stacking of produce. Additionally, the controlled environment enables multiple harvests per year, rather than the very limited growing season available at Toronto's Latitude.

One unique benefit of having a high-density farm located within a residential development is the ability to harness the air-filtration properties of plant life to create an internal, natural ventilation system. As we all know, plants absorb carbon dioxide and expel oxygen during photosynthesis, making them natural air filters for human environments. The residential units used air can be circulated to the farm, absorbed by the plants, and then returned to the residential units with the oxygen-rich emissions of the farm. This internalized system enables a minimum of outside 'city air' to be brought into the building, which, when considering the increasing frequency of smog days in Toronto, could be a significant health benefit.



Methane Digester ***(located within basement)***

Of course, using artificial lighting to grow crops requires a large amount energy. In order to close one resource cycle, the Vertical Farm incorporates the use of a methane digester for power production. The digester consumes bio-waste to produce power, using the stems, leaves, and other inedible biological produce of the farm as fuel. Not stopping there, the methane digester can also process all of the resident's organic waste to contribute to their power production, as well as that of the neighbourhood at large. While neighbourhood residents may not benefit as directly as on-site residents, their organic waste is being disposed of in a local site, greatly reducing the transportation requirements for normal Green Bin collection.

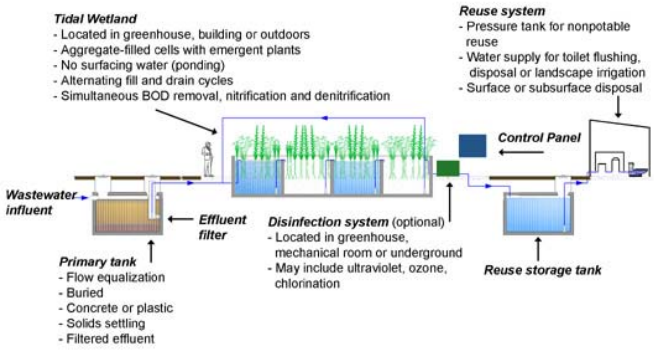
The methane digester reproduces the natural anaerobic digestion process used by bacteria to create ideal conditions for biological decomposition. Differing greatly from the aerobic digestion process used by composters, the anaerobic digestion process is more technically demanding and chemically complex than the composting process, but it requires much less

space and makes far more efficient use of the organic matter. As the organic matter decomposes, methane is released. The methane, which is 21 times more potent than carbon dioxide in causing global warming, is captured and used for the generation of electricity. After the material has decomposed sufficiently, it is then removed from the digester, for use as a natural fertilizer for the rooftop gardens.

As can be examined from the calculations on page 9 – 10, the vertical farm will produce 13,492 kg of biological waste a week. Using the model generated at Columbia University directed by Dickson Despommier, 13,492 kg of bio-waste would produce 1,123,931 kWh of electricity per year in a methane digester, well over half the vertical farm's electricity usage. With the introduction of a neighbourhood organic waste collection program to convert outside bio-waste into energy, the possibility of GROW Housing meeting 100% of its energy demands from methane digestion seem very likely. Furthermore, the collection program would introduce new, low-skilled jobs to the community.

Living Machine

Continuing the theme of natural system resource processing, GROW Housing incorporates a Living Machine® to filter collected rain water, used irrigation water from the farm, and waste water from the residential units. This natural wastewater treatment system uses a series of microorganisms, flora and aquatic life to purify the water.

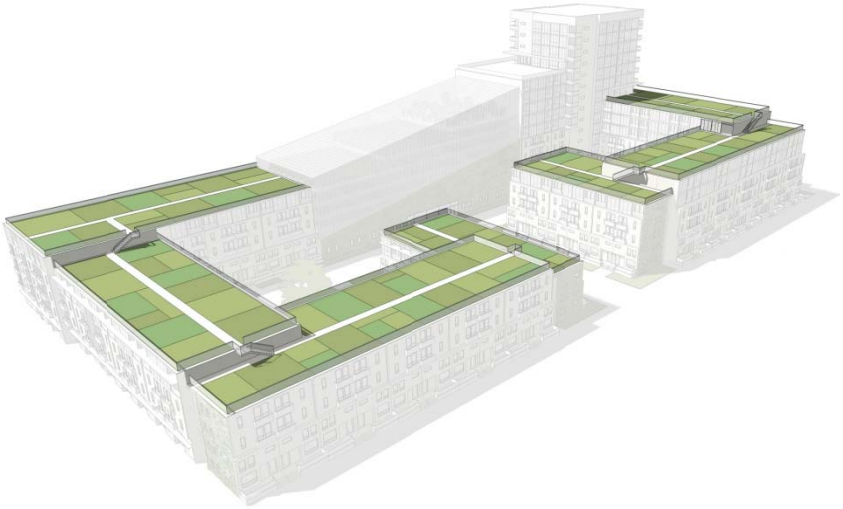


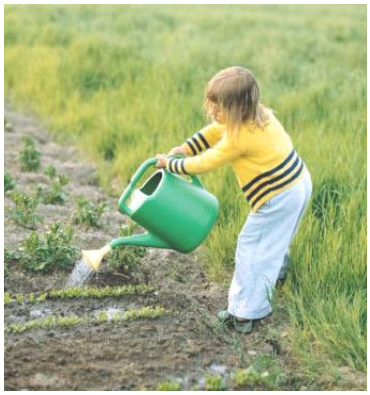
The basic Living Machine includes three stages, each with different properties and tasks. The first stage takes place in an anaerobic septic tank, the second in a closed aerobic reactor and the third stage in an open aerobic reactor. The exact number of tanks and stages included in a design depends on the context of the Living Machine®, how much water needs to be cleaned, and the quality of water output required. The Worrell Water Living Machine® used in GROW Housing is a Tidal Wetland Living Machine® with primary treatment screens. The system can produce 40,000 gallons of water per day for the farm and non-potable water uses for the residential units. The system costs approximately $1.7 million to install. Over a year, the Living Machine® provides GROW Houses with $95,656 worth of water free of charge. As such, the system has a 17 year payoff schedule.

The Living Machine® is located on the top floor of the farm, ensuring the flora have adequate sunlight, and acting as an educational amenity for the community, as it could be open to the public for tours.

Community Gardens

The roofs of GROW Housing are designed as gardens for the community's open usage. The elevated position ensures adequate light contact throughout the year, and the high quality fertilizer obtained from the methane digester ensures access to natural nutrient-rich soil. The gardens are a key component to the design, as they are an amenity the project extends to the existing community, providing a forum for social interaction, exercise, and simple enjoyment of cultivating one's own garden - which is a rare amenity in downtown Toronto.





Geothermal Heat Pump

In a measure to improve the energy efficiency of the development, GROW Housing uses a geothermal heat pump to provide all heating, cooling, and hot water for the development. Through the expansive network of closed-loop pipes bored deep into the earth below the basement slab floor, fluid transfers warm temperatures from the earth to the building units in the winter months, and extracts heat from the building in the summer to deposit into the ground. As the pipe network will already be expansive, connecting the arena and swimming pool across the park to the loop, thereby giving those city buildings free cooling and heating respectively, would be an additional benefit to the community.

The Rent-To-Own Model

Located within Toronto's social housing epicentre, on the site currently occupied by Moss Park Armoury, GROW Housing proposes a novel strategy to provide low-income earners affordable, equitable housing. The strategy was conceived to introduce home *ownership* opportunities to low-income individuals who are normally forced to the rental market. This differs significantly from the rent-geared-to-income (RGI) model used predominantly for assistance housing today, which has been criticised for propagating a system that does little to help individuals increase their financial standing.

As such, the rent-to-own (RTO) model attempts to break the rental cycle by re-directing tenants' would-be rental money into a limited mortgage. This mortgage would be administered by the non-profit GROW Housing Association, with payment schedules flexible to a qualified applicant's income. In order to ensure the RTO units stay available to low-income individuals, the units will be transferred back into the possession of GROW Housing Association when the tenant wishes to sell, for which they the tenant will receive the paid value of their unit plus the incurred inflation, and minus the building fees and taxes. Though the units are not as flexible as a free-market unit, the rent to own system does ensure low-income individuals can achieve the dignity and financial advantage synonymous with home ownership.

As GROW Housing is a mixed-use development, many different configurations of residential and commercial space are proposed. Townhouses, condominiums, and lofts of varying sizes are available, street level commercial along Queen and Jarvis Streets, and a commercial hydroponic farm are the primary land uses of the development. 50% of the residential units are free-market, while the other 50% are RTO; each interspersed to ensure an integrated social environment.

The building was designed as a modular construction, with easily recyclable materials to ensure the embodied energy of the building's materials can be swiftly metabolised for other productive uses. The aesthetics of the project were intended to be congruent with the rich historic vernacular of the community.

APPENDIX

(Table 1-3 based on research conducted at Columbia University, directed by Dickson Despommier)
http://www.verticalfarm.com/plans-2k4.htm
http://www.verticalfarm.com/plans-2k5.htm

TABLE 1: A VERTICAL FARM TO FEED 1,000 PEOPLE FOR 1 YEAR

Veg/Fruit	Tonnes/Yr	HA/Yr	m^2/Yr	Floors (1.4K m^2)	Floors (3 layers/fl)	Value (+) $ per lbs	Gross Income
Lettuce	18.2	0.0242	242	0.17	0.06	$1.49	$59,822
Cucumber	16.5	0.02	200	0.14	0.05	$1.58	$57,575
Eggplant	27.1	0.11	1,100	0.79	0.26	$1.49	$89,102
Strawberries	27.5	0.336	3,360	2.40	0.80	$2.99	$181,074
Peppers	24.8	0.0416	416	0.30	0.10	$3.95	$216,144
Carrots	42.4	0.0344	344	0.25	0.08	$0.50	$46,720
Spinach	59.6	0.54	5,400	3.86	1.29	$2.49	$327,186
Soybean	59.6	0.43	4,300	3.07	1.02	*$0.26**	$34,164
Green peas	48.0	0.099	990	0.71	0.24	*$0.25**	$26,460
Tomatoes	49.7	0.073	730	0.52	0.17	$0.99	$108,385
			17,082	12.20	4.07		$1,146,633
Chicken broilers	5126	0.43	3,149	2.25	0.75	$11.67	$10,746
Chicken layers	472	20,800 dzn	102	0.07	0.02	$2.25/dz	$46,800
Wheat	108	0.073	1,858	1.33	0.44	*$0.14**	$33,334
Potatoes	108	1.7082	1,858	1.33	0.44	$0.99	$235,718
Tilapia			113	0.08	0.03	$8.99	$24,610
			7,080	5.06	1.69		$351,208
TOTAL					**5.75**		**$1,497,841**

(+) Prices taken from downtown Toronto Lablaws - March 7, 2008
* Prices taken from Canadian Ministry of Agriculture website; actual saleable value much higher

TABLE 2: ENERGY REQUIREMENTS OF A 1,000 PERSON VERTICAL FARM

PLANTS	# of plants per year	# of plants per week	area req. per patch (m^2)	req. energy Watts/m^2	req. energy Watts / Week	req. energy Watts / Year	required kWh per year
Tomato	39,288	756	14	90	2,107,050	109,566,597	110,000
Eggplant	1,320	25	5	25	133,532	6,943,652	7,000
Peppers	7,385	142	13	25	230,640	11,993,290	12,000
Soybeans	431	8	6	25	151,408	7,873,230	7,900
Green Peas	448	9	6	25	219,045	11,390,346	12,400
Spinach	42,048	809	218	25	22,823,799	1,186,837,533	1,187,000
Carrots	194,667	3,744	22	25	607,922	31,611,926	31,700
Cucumbers	405	8	3	170	625,911	32,547,388	32,600
Wheat	406,015	7,808	60	25	1,521,619	79,124,195	79,200
Lettuce	121,576	2,338	61	27	832,154	43,272,029	43,300
Strawber.	23,292	448	42	76	9,562,841	497,267,740	497,300
Chicken Br.	5,650	109	11	13	278,208	14,466,816	14,500
Chicken Lay.	520	n/a	179	13	371,717	19,329,274	19,400
Total							**2,054,300 kWh**

TABLE 3: WASTE OUT-PUT OF A 1,000 PERSON VERTICAL FARM				
SOURCE	**Yearly Waste** (lbs)	**Weekly Waste** (lb)	**Weekly Waste** (g)	**Weekly Waste** (kg)
Tomato	109,480	2,105	955,002	955
Eggplant	119,600	2,300	1,043,280	1,043
Peppers	164,160	3,157	1,431,980	1,432
Soybeans	262,800	5,054	2,292,425	2,292
Green Peas	317,520	6,106	2,769,751	2,770
Spinach	87,600	1,685	764,142	764
Carrots	23,360	449	203,771	204
Cucumbers	72,880	1,402	635,738	636
Wheat	268,896	5,171	2,345,600	2,346
Lettuce	13,373	257	116,656	117
Strawberries	5,123	99	44,691	45
Chicken Layer Guano	-	-	`	192
Broiler Guano	-	-	-	124
Broiler Mortality+	-	-	-	99
Broiler Carcass ++	-	-	-	90
Tilapia Mortality +++	-	-	-	44
Tilapia Leftover ++++	-	-	-	105
Tilapia Excrement	-	-	-	176
TOTAL WASTE				**13,432**

(+) These are assuming a high end rate of 18% mortality and chickens weighing 5 lbs.

(++) This is the weight of each carcass after being stipped of meat and bones.

(+++) This assumes that 20% die before reaching maturity with a weight of 250 kgs

(++++) This is byproducts of gutting (60% of total weight of a 450 kg fish)