Garden vs. Exposed Roof Assemblies
Energy Usage Calculations*

*** Thermal Performance and Energy Efficiency, Institute for Research in Construction, Karen Liu, National Research Council of Canada (NRC) 2001**

Assumptions:

- Keep indoor temperature constant under both roof sections, therefore:
  - Any heat gain will be removed by cooling equipment
  - Any heat loss will be made up by heating equipment

- Consider heat flow through the roof only, ignoring other parts of the building envelope.

- Types and efficiency of heating/cooling equipment

R-20 Referenced Roof Area (exposed Modified Bitumen Roof) = 390 sq.ft.
R-20 Garden Roof Area (exposed Garden Roof) = 390 sq.ft.

$$\text{Energy Demand} = \frac{\text{Heat Gain}}{\text{Coefficient of Performance (COP)}} + \frac{\text{Heat Loss}}{\text{Heating Efficiency}}$$

		Scenario 1	Scenario 2
COP		2.06	3.53
Heating Efficiency		1	1
Electricity	kWh/m2/year	20.2	14.8
	kWh/m2/year	1.88	1.38
Cost	$/m2/year	1.62	1.18
	$/ft2/year	0.15	0.11
Equivalent CO2	tonnes/m2/y	5.6	4.1
	tonnes/m2/y	0.52	0.38

Conclusions

Thermal Performance

- The rooftop garden lowered the temperature experienced by the roofing membrane significantly.
- The rooftop garden lowered the average daily temperature fluctuations experienced by the roof membrane, most prominently in the summer
- The median of the daily membrane temperature fluctuation in the spring and summer are:
  - Reference Roof (Exposed Mod Bit): 45°C
  - Rooftop Garden: 6°C

Energy Efficiency

- The rooftop garden reduced the heat flow through the roof, thus lowering the energy demand on space conditioning.
- The garden was more efficient in reducing heat gain in the summer than heat loss in the winter, mostly due to thermal mass effects of the growing medium.
- The rooftop garden reduced the heat flow through the roof by 29.7 kWh/m2/year (2.8 kWh/ft2/year). Assuming electric heat and efficient air conditioning unit, this translates to a saving in electricity of 16.5 kWh/m2/year (1.5 kWh/ft2/year).

Energy Savings due to Garden Roofs - Scenario #1

Example: Installed 10,00 sq./ft Garden Roof Area

Energy Demand Savings = 1392 kWh

Heating: Electrical with e = 1.0
Cooling: A/C (inefficient) COP = 2.06
Electricity Cost: $0.08/KWh

2001 Heat Flow Data	Heat Gain (kWh)	Heat Loss (kWh
Referenced Roof	696	1586
Garden Roof	32	1180

Calculation:

Energy Demand (Exposed Modified Bitumen) = 696 / 2.06 + 1586/1.0 = 1924 kWh/year
Energy Demand (Garden Roof) = 32 / 2.06 + 1180/1.0 = 1196 kWh/year

Energy Demand Saving = 728 kWh/year

Normalized Energy Saving = 20.2 kWh/m2/year (1.88 kWh/ft2/year)

Normalized Energy Savings = 1.62 $/m2/year (0.15 $/ft2/year)

Therefore the Energy Demand Savings of this Consumption ** would eliminate approximately:

CO2 = 3504 kg/year
NOx = 5508 g/year
So2 = 16032 g/year

(** Data provide by Toronto Hydro – energy calculators)

How does this translate to the environment?

What is **3504 kg of CO2** similar to?
Burning **1402 liters** of gasoline.
Driving your car **11683 kilometers** (12L/100km)
That's like driving **167 times** to Toronto to Hamilton
Or driving from Steels Ave. to Lakeshore Blvd. **668 times!**

Energy Savings due to Garden Roofs - Scenario #2

Example: Installed 10,00 sq./ft Garden Roof Area

Energy Demand Savings = 1080 kWh

Heating: Electrical with e = 1.0
Cooling: A/C (efficient) COP = 3.53
Electricity Cost: $0.08/KWh

2001 Heat Flow Data	Heat Gain (kWh)	Heat Loss (kWh
Referenced Roof	696	1586
Garden Roof	32	1180

Calculation:

Energy Demand (Exposed Modified Bitumen)* = 696 / 3.53 + 1586/1.0 = 1783 kWh/year
Energy Demand (Garden Roof)* = 32 / 3.53 + 1180/1.0 = 1189 kWh/year

Energy Demand Saving = 594 kWh/year

Normalized Energy Saving = 16.5 kWh/m2/year (1.53 kWh/ft2/year)

Normalized Energy Saving = 1.62 $/m2/year (0.12 $/ft2/year)

Therefore the Energy Demand Savings of this Consumption ** would eliminate approximately:

CO2 = 2724 kg/year
NOx = 4272 g/year
So2 = 12444 g/year

(** Data provide by Toronto Hydro – energy calculators)

How does this translate to the environment?

What is **2724 Kg of CO2** similar to?
Burning **1090 liters** of gasoline.
Driving your car **9083 kilometers** (12L/100km)
That's like driving **130 times** to Toronto to Hamilton
Or Driving from Steeles Ave to Lakeshore Blvd. **519 times**!