4.2.6 Building energy and the urban heat island

The method used to determine of the impact of the urban heat island and building energy was essentially similar. Building energy has been included here as a community-wide benefit, although it might be argued that it accrues directly to the building owner. The reason for including it was that to some extent energy efficiency in buildings has been considered a societal benefit. Some impacts of energy use, such as carbon dioxide production from coal-fired plants that supply electricity for cooling buildings, accrue at community level and can be separately quantified. However, there are other impacts, such as the use depletion of resources, that benefit the society but which are not readily quantifiable. Therefore, we have used the monetary savings in the use of energy at the building level to provide a measure of the societal benefit.

We have determined the savings in annual energy and also the reduction in peak demand. Examining the avoidance cost of building power generating plants of the same capacity can value the reduction in peak demand.

The energy savings will also have an impact on the operation of power generating plants. Assuming that these power-generating plants use fossil fuels, there will be a further benefit of reducing energy in the reduction of carbon dioxide. We use the value of 0.27224 kg of carbon dioxide reduction for every kWh of energy saved.

4.2.6.1 Building energy

In order to quantify the benefits of green roofs with respect to the building energy this report relied on the modelling done at the Lawrence Berkeley Laboratory (LBL) study (Akbari et al. 2004). The LBL study determined the energy savings from applications of various heat island reduction strategies. This study reported the savings from direct measures and indirect measures.

The direct measures impact the heat flow characteristics through the building envelope by implementation of the appropriate measures. For the purpose of this study, energy savings reported in LBL's study related to cool roofing were used. Other studies have indicated that green roofing can provide as much or more energy benefit than cool roofing. Green roofs have the added advantage of benefiting from evapotranspiration during the summer months. So, use of this data should provide conservative estimates of energy savings from implementing green roofs. LBL's data identified significant savings resulting from summertime cooling. LBL data was also broken down by building types.

Data from monitoring on Eastview and the City of Toronto’s City Hall roof were also taken into account. These data overestimated the energy reduction by a factor of 4 to 5 compared to the results from LBL's study. However, these data, which provided annual energy savings, showed a fair contribution of energy savings from reduction in wintertime heating demand.

In addition, results of modelling of a typical building done by Enermodal in the FCM sponsored green roof feasibility study of the City of Waterloo were also taken into account.

The Enermodal study simulated the energy savings in a one storey building from the use of green roofs. It integrated data from work done by the National Research Council of Canada on green roofs in Ottawa. The results from this study related to cooling load were about 4 times lower than the LBL study.

Table 4.5 summarizes the potential savings in energy use in buildings resulting from the implementation of green roofs.

Table 4.5
Direct Energy savings from green roof implementation

Savings category	Amount of saving per sq. m. of green roof area
Direct energy savings	4.15 kWh/ sq. m./year
Demand Load reduction from direct energy reduction	0.0023kW/ sq. m. peak

Before the economic benefits from building energy savings can be determined it is necessary to establish the cost of energy. We have calculated the cost of electricity, which is predominantly used to run equipment that cools buildings, to be $0.1017 per kWh. Based on annual energy savings of 4.15 kWh per sq. m., the city-wide implementation of green roofs would result in savings of $21 million per year.

The demand reduction, based on peak demand reduction of 0.0023 kW per sq. m. for city-wide green roof implementation would be 114.6 MW[7]. Based on the cost of bringing in new generation capacity at $0.6 million per MW (based on a cost of bringing in 2,500 MW of new power plant estimated at $1.5 billion), the cost avoided from reduction in peak demand would be $68.7 million

The carbon dioxide mitigation from reduction in fossil fuel use at power generating stations would be 56,300 metric tonnes per year. Assuming the cost of carbon permits to be $10 per metric tonne, the cost savings from carbon dioxide mitigation would be $563,000 per year.

4.2.6.2 Urban heat island

Reduction of the urban heat island effect requires a fairly wide spread implementation of green roofs. Localized and sporadic implementation of green roofs will not result in reduction.

For the purpose of quantifying the urban heat island effect two studies were examined: the study done by the Ministry of the Environment Climate Adaptation Group and the study done by LBL.

[7] Please see the next footnote

Widespread implementation of green roofs would reduce the local ambient temperature. Such reduction in local temperature in turn would have an impact on heat flow through the buildings' walls and roofs. This impact can be determined in the same way as done for direct energy savings in section 4.2.6.1.

Based on the studies we have determined that the wide spread implementation of green roof would reduce the local ambient air temperatures in Toronto between 0.5 and 2 degrees C, depending on the time of the year.

These changes in temperature will have an impact on energy balance through the buildings' walls and roofs. Table 4.6 summarizes the energy savings from reduction in temperature due to the impact of green roofs on the urban heat island effect.

Table 4.6
Indirect energy savings from green roof implementation
(Impact of reduction in urban heat island effect in Toronto)

Savings category	Amount of saving per sq. m. of green roof area
Direct energy savings	2.37 kWh/ sq. m./year
Demand load reduction from direct energy reduction	0.00267kW/ sq. m. peak

The economic benefits from the reduction in the urban heat island effect are calculated in the same manner as the building energy benefits. Based on the annual energy savings of 2.37 kWh per sq. m., the city-wide implementation of green roofs would result in a savings of $12 million.

The demand reduction based on peak demand reduction of 0.00267 kW per sq. m. for city-wide green roof implementation would be 133 MW[8]. Based on the cost of bringing in new generation capacity at $0.6 million per MW (based on a cost of bringing in 2,500 MW of new power plant estimated at $1.5 billion) the cost avoided from reduction in peak demand would be $79.8 million.

Finally the carbon dioxide mitigation from reduction in fossil fuel use at power generating stations would be 32,200 metric tonne per year. Assuming the cost of carbon permits to be $10 per metric tonne, the cost savings from carbon dioxide mitigation would be $322,000 per year.

[8] The peak demand savings of approximately 248 MW (direct and urban heat island) resulting from 100% green roofs coverage may be considered high given the total peak demand attributed to cooling in Toronto of approximately 2.5 GW peak (as provided by Toronto Hydro during personal communications). Please refer to Section 5.4 regarding uncertainty in predicted values and sensitivity analysis.