ENERGY SIMULATIONS

The PowerDOE energy simulation program (Hirsch *et al.,* 1998) was used in this study to determine the energy consumption and cooling loads of a five-storey hypothetical commercial building with different types of roofs, with a building roof area of about 966 m^2. The simulated results indicated that the installation of plants or a soil layer would significantly reduce the energy consumption required in the five-story commercial building under Singapore's climatic condition. The simulated reductions in energy consumption due to the installation of plants and soil layer on roof are summarized in Table 2.

Table 2: Summary of simulated reductions in energy consumption required in a five-story commercial building due to plants and soil layer on roof

Thermal parameter	Range of reduction	
	Effects of plants + soil layer	Effects of soil layer only
Annual energy consumption	0.6 - 14.5	0.0 - 2.9
Space cooling load	17.0 - 79.0	2.2 - 63.8
Peak space cooling load	17.0 - 78.9	2.2 - 71.4
Sensible cooling load	17.1 - 80.6	2.2 - 63.8
Peak Roof Thermal Transfer Value	17.1 - 80.6	2.2 - 63.8

The analysis of the results of energy simulation reveals that vegetation can effectively reduce the energy consumption required in the building, and help to reduce the cooling load of air-conditioning units in buildings. The main effects of rooftop vegetation on building energy consumption are as follows:

Reduction of annual energy consumption
The reduction in annual energy consumption varies from 0.6% – 14.5%.

Reduction of space cooling load
The reduction in space cooling load varies from 17.0% – 79.0%.

Reduction of peak space cooling load
The reduction in peak space cooling load varies from 17.0% – 78.9%.

Reduction of peak RTTV
The reduction in peak RTTV varies from 17.1% – 80.6%.

The analysis of the results of energy simulations also reveals that the installation of soil layer on the roof can effectively reduce the energy consumption of the building. The main effects of a soil layer on roofs on building energy consumption are as follows:

Reduction of annual energy consumption
The reduction in annual energy consumption varies from 0% (100mm clay soil contains 40% moisture) – 2.9% (900mm dry clay soil).

Reduction of space cooling load
The reduction in space cooling load varies from 2.2% (100mm clay soil contains 40% moisture) – 63.8% (900mm dry clay soil).

Reduction of peak space cooling load
The reduction in peak space cooling load varies from 2.2% (100mm clay soil contains 40% moisture) – 71.4% (900mm dry clay soil).

Reduction of peak RTTV
The reduction in peak RTTV varies from 2.2% (100mm clay soil contains 40% moisture) – 63.8% (900mm dry clay soil).

The simulated results suggest that the optimum type of rooftop garden based on energy efficiency is rooftop garden with shrubs (300mm thick soil and shrubs). This is mainly due to the shrubs. The study showed that the moisture content of soil affects the heat gain significantly. The optimum type of soil on rooftops is dry clay soil.