1.2.4 URBAN HEAT ISLAND TECHNOLOGIES

Technology Description

Heat islands form as cities replace natural vegetation with pavement for roads, buildings, and other structures necessary to accommodate growing populations. These surfaces absorb – rather than reflect – the sun's heat, causing surface temperatures and overall ambient temperatures to rise. The displacement of trees and shrubs eliminates the natural cooling effects of shading and evapotranspiration. Measures to reduce the urban heat island effect include strategically planting shade trees, installing reflective roofs, and installing reflective pavements. Heat island mitigation measures can reduce greenhouse emissions by reducing ambient air temperatures in urban areas, thereby slowing the chemical formation of smog (ozone and precursors) and reducing demand for electricity for air-conditioning in the cooling seasons. In general, the larger the area implementing heat island reduction measures – and the longer, sunnier, and hotter the summer season – the more substantial the impacts on meteorology and air quality. Meteorological modeling can assist in understanding the effects of such measures, as well as the interactions with other factors.

System Concepts

- Reduced temperatures reduce the need for summertime cooling energy. Reduced air-conditioning reduces power plant emissions, including greenhouse gas emissions and ozone precursors.
- Reduced temperatures decrease biogenic volatile organic compounds emissions and evaporative losses.
- Trees sequester carbon (particularly urban or suburban trees, which can sequester about 18 kg of carbon annually) and precipitate particulates and other airborne pollutants.
- Reduced ambient air temperature reduces photochemical reaction rates, which may reduce ozone production.

Representative Technologies

- There are more than 200 Energy Star-labeled roof products, which include coatings and single-ply materials, tiles, shingles, and membranes. Energy savings in buildings with reflective roofs range as high as 32% during peak demand, with a summer average of 15%.
- There are several reflective pavement applications being developed, which include new pavement applications, resurfacing pavement applications, asphalt material type, concrete material type, and other material types. For example, white topping involves covering existing asphalt pavement with a layer of concrete (which has approximately 15% higher albedo than asphalt). Also, chip seals are used for maintenance and resurfacing of low-traffic streets and roads; reflective materials can be used to cover the surface. Higher albedos reduce maximum pavement temperatures by about 10°F per 0.1 increase in albedo. In turn, air temperature is reduced by about 1°F if all pavements have albedo increased by 0.2.
- Placing trees on the west-, south-, and east-facing sides of a building can significantly reduce cooling costs for a home or low-rise building during peak summertime demand. Simulations of energy savings benefits for Sacramento and Phoenix found that three mature trees around homes cut annual air-conditioning demand by 25%-40%.

Technology Status/Applications

- A few states (e.g., California, Georgia, and Florida) have incorporated reflective roofs into their state energy codes. Some states (e.g., California) and communities have reflective roof incentive programs. Reflective roofs are given credit in several environmental rating programs including the U.S. Green Building Council's LEED (Leadership in Energy and Environmental Design) rating system.
- Some communities are installing alternative pavement parking lots and alleys – mainly using porous pavement technologies. White-topping is also becoming increasingly popular.
- Nationally, there are numerous tree-planting programs. Some utilities have partnered with urban forestry groups to encourage residential shade tree planting to reduce air-conditioning energy consumption. Further, several communities have implemented shade tree ordinances (e.g., requiring parking lots shade 50% of paved areas 15 years after development).

Current Research, Development, and Demonstration
RD&D Goals • Better understand and quantify the impacts heat island reduction measures have on local meteorology, energy use and expenditures, greenhouse gas emissions, and air quality. • Develop an application based on geographic information systems that predicts heat island outcomes from different development scenarios. • Better understand the relationship between surface and air temperature. • Better understand the contribution of radiant emissions from vertical surfaces on the heat island effect. • Quantify net benefits from large-scale tree planting projects (i.e., volatile organic compound contributions, CO_2 sequestration, and removal of other pollutants). • Develop cool materials for roofs and pavements. • Assist the Cool Roof Rating Council with developing procedures to measure and rate the optical properties of the roofing materials. • Work with the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), state and Federal agencies to develop implementation plans. **RD&D Challenges** • Better understand interaction between meteorological, land surface, and emission-specific parameters in baseline and modified modeling scenarios. • Determine albedo and emissivity levels of city surfaces. **RD&D Activities** • Tulane University and a DOE laboratory are modeling the impacts of heat island reduction measures on local meteorology in seven U.S. domains. • DOE is modeling the impacts of heat island reduction measures on local meteorology, energy savings, CO_2 reductions, and air quality in several cities including Houston, Chicago, and Baton Rouge. • DOE is analyzing the urban fabric (surface composition) of several cities including Sacramento, Houston, Chicago, Salt Lake City, and Baton Rouge. • Several groups in California are examining net benefits from trees. • DOE is working with granule, pigment, and shingle manufacturers to develop cool-colored shingles. • DOE is working with the pavement industry on developing cool surfaces. • The Environmental Protection Agency (EPA) and DOE have lead efforts to organize the Cool Roof Rating Council and develop standards for the American Society for Testing and Materials (ASTM) and ASHRAE. • USDA Forest Service develops methods and models to quantify carbon storage and sequestration, building energy-use effects, and air pollution removal by urban forests at the local to national scale. • USDA Forest Service conducts analyses in numerous cities and national assessments to quantify the effects of urban forests on carbon storage and sequestration, building energy use, and air pollution removal.
Recent Progress
• EPA and DOE demonstrated the impact of cool roofs on building energy use; EPA developed the Energy Star Roof Products program. • ASTM and ASHRAE standards have been developed, and prototype cool-roofing materials have been developed. • The Cool Roof Rating Council was organized and several state and air-quality management districts have adopted heat-island-reduction measures.

Commercialization and Deployment Activities
• Reflective roofing and paving technologies may be broadly applicable to U.S. cities, but benefits will vary. • Several reflective roof programs (e.g., California's Cool Savings Program) require use of Energy Star Labeled Roof Products, thus increasing the demand and deployment of these products. **Market Context** • Heat island reduction strategies including urban reforestation, rooftop gardens, reflective roofs, and alternative pavements have been implemented in Los Angeles, Sacramento, Salt Lake City, Honolulu, Chicago, Miami, and Atlanta – and other cities are interested. • Nationally, reflective roofing materials still comprise less than 10% of the roofing market; asphalt comprises 95% of urban pavements.