Reducing Energy Use on CWU's Campus by Increasing Roof Reflectivity

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Introduction:

Often our cities experience temperature increases that are not experienced by surrounding rural areas. This is referred to as a heat island, where cities can be 2-5 degrees Celsius hotter than the more rural areas around them (Lawrence Berkeley…). Large buildings often have flat open roofs that are made with dark materials such as asphalt sheets. Heat islands are created when air passes over hot solar absorbent surfaces such as pavement or dark roofs and absorbs the heat from these surfaces. Many cities across the US have historical housing policies that put persons most at risk in areas where the heat island effect can be felt the strongest (Hoffman et al, 2020). Extreme heat is the leading cause of summertime morbidity and has been the most hazardous weather in the US for decades (Hoffman et al, 2020). The easiest way to reduce the effect of heat islands caused by solar radiation absorption is to replace dark surfaces with lighter more reflective surfaces (Lawrence Berkeley…). There are 12 buildings on CWU's campus that have been identified with flat dark roofs that could contribute to the heat island effect. The buildings with the highest priority for cool roofing are buildings with a high Energy Use Index like Science, and that have full time university staff in them all year like Jongward, Naneum, and Mitchell. Changes to CWU building and maintenance policy are being pursued to require old roofing to be replaced with new cool roofing.

Estimated Dark Roof Area on CWU's Campus:

•Using the Google Maps "measure distance" tool, I estimated the area of black roofs on CWU's campus (**Table 1**).
•I used Google Maps to find and compare the black and white roofs on CWU's campus (**Figures 1 and 2**).

Building:	Area (sqft):
Black Hall	22,300
Facilities Shed	5,216
Hebeler Hall	25,071
Jongeward	24,954
Kamola Hall	1,376
McConnell Hall	23,225
Mitchel Hall	12,514
Naneum Hall	12,393
Nicholson Pavillion	58,998
Science Hall	39,095
Sue Lombard Hall/Sue Dining	5,023
Tomlinson Concessions	2,392
Tunstall Commons	15,900
Total Area	**248,457**

Table 1: Estimated black roof area on selected CWU buildings.

Figure 1: CWU Historical District: Buildings with black roofs include Hebeler Hall, Mitchell Hall, McConnell Hall, Kamola Hall, Sue Lombard Hall, and Tunstall Commons. Buildings with white roofs include Samuelson Hall, Shaw-Smyser Hall, and Barge Hall.

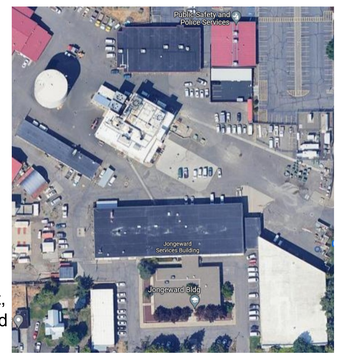

Figure 2: CWU Facilities Center: Buildings with black roofs include Naneum Hall, Facilities Shed, and the Jongeward Services Building; Buildings with white roofs include the Steam Plant, a water tower, and another facilities shed (bottom right).

Sustainable Development Goals:

11.6: "By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management."
11.a: "Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning."
11.b: "By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels."

Measured Reflectance and Temperature of Dark and Light Roofing:

•Using a Spectral Evolution spectroradiometer, I measured the spectral reflectance of different locations on selected roofs (**Figure 3**).
•The reflectance data for Samuelson Hall and Lind Hall show a reflectance of 70-85% reflectivity compared to the 5-10% reflectivity of Kamola Hall (**Figure 4**).
•While Samuelson and Lind Halls generally have high reflectance, a spectral measurement on each roof of a patch of accumulated dirt had a much lower reflectance.
•Temperature data was recorded using an infrared thermometer temperature gun for each spectral reflectance data point.
•Temperature data for the white roofs was 1-25°F (0-14°C) warmer than the 50°F (10°C) ambient temperature.
•The temperature recorded for the spots with dirt were 25°F (14°C, Lind) and 50°F (27.7°C, Samuelson) warmer than the 50°F (10°C) ambient temperature.
•Temperature data for the black roofs (including Sue Lombard) was 45-75°F (25-42°C) warmer than the 50°F (10°C) ambient temperature.

Figure 3: Measuring spectral reflectance on the roof of Sue Lombard.

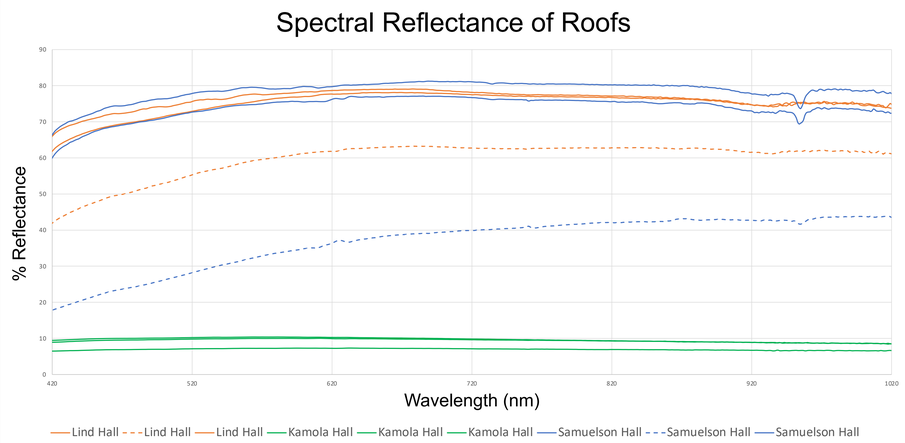

Figure 4: Spectral reflectance data contrasting white roofs (Lind Hall in Orange and Samuelson Hall in Blue) vs dark roofs (Kamola Hall in Green).

Roof Replacement in Action:

Figure 5: Dorothy-Purser Hall (left: current photo, right: recreation with the new coating) currently has an old white roof with a large rust stain from the HVAC system that is installed on the roof. This roof will be resurfaced this summer with a coating by Triton Inc. This coating is called TritoFlex 2k Rubber, and it will help seal any leaks and increase the reflectivity of the roof.

Estimated Return on Investment from Changing Dark Roofs to Light Roofs:

•I estimated the return on investment from replacing dark roofs with light roofs (**Table 2**) using the roof coating cost, electricity cost based on electricity consumption and current cost/kWh. Research indicates that white roof coatings can reduce energy consumption by 8%-30% (Lawrence Berkeley…).
•The estimated return on investment would take 30 years or longer in most scenarios.
•There are errors and limitations in these estimates. Most of the electricity consumed in these buildings are used for purposes other than cooling.
•Many of these buildings have steam heating and water cooling instead of HVAC systems. Therefore, the energy costs of building cooling is more related to the cost of natural gas used by the Steam Plant to cool buildings in the summer.

Building Name:	Coating Cost (USD):	kWh (2023):	Energy Cost (2023):	Potential ROI @8% Savings:	Potential ROI @30% Savings:
Jongeward	$249,540	365,857	$20,964	149 Years	40 Years
McConnell Hall	$232,250	346,049	$19,829	146 Years	39 Years
Mitchel Hall	$125,140	305,074	$17,481	89 Years	24 Years
Science Hall	$390,950	2,914,491	$167,001	29 Years	8 Years

Table 2: Building coating costs and potential savings.

Recommendation:

While this study did not show that coating roofs with white material would result in cost savings, it did show that the difference in reflectance and temperature is significant. This study showed that it is important to help keep the white roofs clean to prevent them from becoming less reflective and warmer. It is important to consider replacing or coating the dark roofs with reflective white material to improve the quality of life of the people working in the buildings, especially during the summer when ambient temperatures can reach 115°F (64°C). The buildings that are single story with black roofs would experience the most significant change in temperature inside the building if the roofs were replaced or coated with white reflective material. When CWU replaces or resurfaces old roofs, it should be done with reflective white material to help keep the buildings cooler and mitigate the heat island effect felt on campus.

Special Thanks:

Jeremiah Eilers: Access to information about electrical usage for multiple buildings, help with other related information, introductions to other persons who helped me get the information and access to buildings that I needed; Joe Chanes: Information on the Dorothy Purser coating project and what coating the university is going to use for future projects; Joanne Hilleman: Helping me get connected with Jeremiah Eilers; Yukon Logan: Helping me get access to the roofs for data collection; Jeff Spinner: constantly supporting me and volunteering to help with taking measurements on the roofs.

Works Cited:

Cool roofs. Cool Roofs | Heat Island Group. (n.d.). https://heatisland.lbl.gov/coolscience/cool-roofs

E814RCP co-polymer white flat roof coating: Reflect solar heat: Flexible: Waterproof. Exterior Performance Coatings. (2023, December 1). https://exteriorcoatings.com/product/e814rcp-co-polymer-white-roof-coating-solar-heat-reflective-flexible-waterproof/

Google Maps. 2024. https://www.google.com/maps

Hoffman, J. S., Shandas, V., & Pendleton, N. (2020, January 13). *The effects of historical housing policies on resident exposure to intra-urban heat: A study of 108 US urban areas*. MDPI. https://www.mdpi.com/2225-1154/8/1/12

Lawrence Berkeley National Laboratory Urban Heat Island Group. Cool Roofs and Cool Pavements Toolkit. (n.d.). https://coolrooftoolkit.org/knowledgebase/lawrence-berkeley-national-laboratory-urban-heat-island-group/

Levinson, Alhazmi, M., Becce, J., Desjarlais, A., Gilbert, H. E., Kats, G., Miller, J., Morin, E., Sailor, D. J., Schneider, S., Sun, Zhang, W., Zeng, Z., Levinson, R. M., Wei, M., Hong, T., Celniker, Chen, S. S., & Meier, A. K. (n.d.). *Cool roofs & walls*. Cool Roofs & Walls | Building Technology and Urban Systems. https://buildings.lbl.gov/cool-roofs-walls

TritoFlex 2K rubber. Triton. (2022, February 21). https://tritonwp.com/products/tritoflex-2k-rubber/

United Nations. (n.d.). *The 17 goals | sustainable development*. United Nations. https://sdgs.un.org/goals