

Cool and Green Roofs Dubuque, Iowa

Civil and Environmental
Engineering,
University of Iowa

IOWA





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Outline

Client and Site Location

Cool and Green Roofs Overview

Sustainable Components

Cool Roof Design

Integrated Design

Energy Efficiency and Production

Structural Analysis

Project Cost Estimate

Five Flags Civic Center



City of Dubuque Contacts:

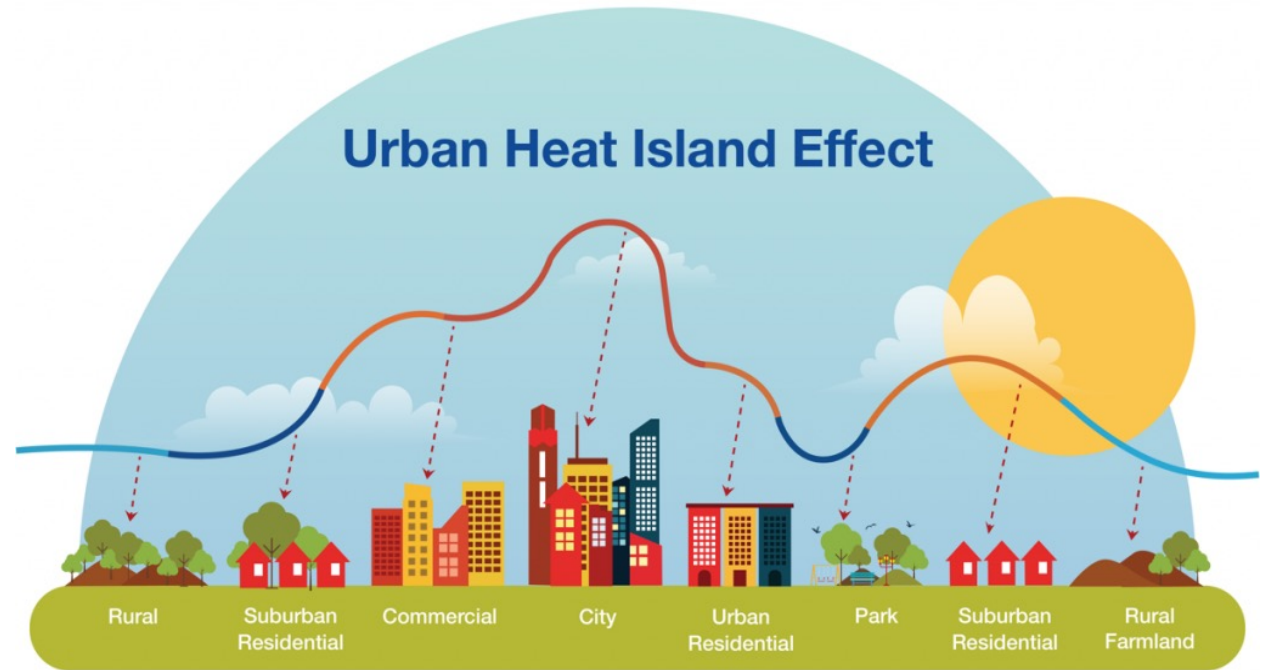
- Marie L. Ware, Leisure Services Director
- Jared Charland, Project and Facilities Manager

IOWA

Cool and Green Roofs

The Problem: Heat Island Effect

- Heat islands are urbanized areas that experience higher temperatures than outlying rural areas
- Sunlight is absorbed by dark pavements and roofs, which in turn warm the air
- Causes:
 - Urban Development
 - Human Activity
 - Urban Geometry
- Impacts:
 - Air Quality
 - Higher Energy Usage
 - Global Warming Contributions
- Mitigation Strategies:
 - Cool Roofs
 - Green Roofs
 - Urban Planning



The Solution: Cool Roofs and Green Roofs

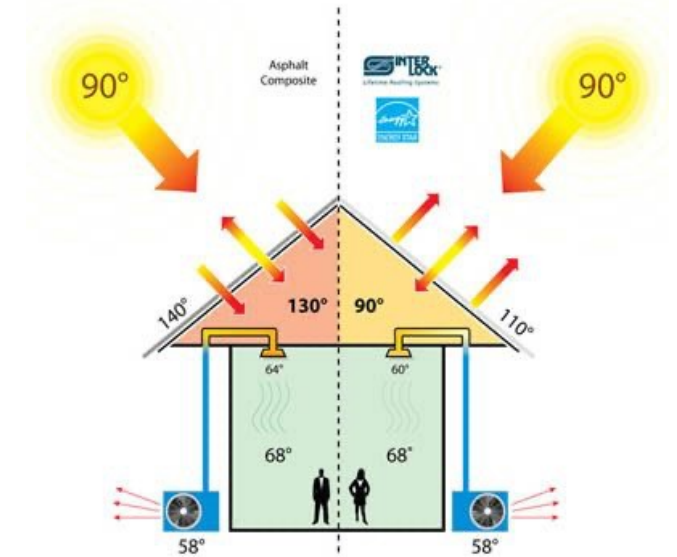
- Designed to reduce heat island effect
- Designed to reflect more sunlight than a typical roof
- Great alternatives for energy efficiency and cost savings

Cool Roofs:

- 1) lower initial cost
- 2) high reflectivity

Green Roofs:

- 1) aesthetic improvement
- 2) stormwater management
- 3) longevity



a) Traditional Roof

Surface reflectivity = 0.05



b) Cool Roof

Surface reflectivity = 0.95



c) Extensive Green Roof

prairie junegrass



→ solar radiation → water

Sustainable Components



Cool Roof

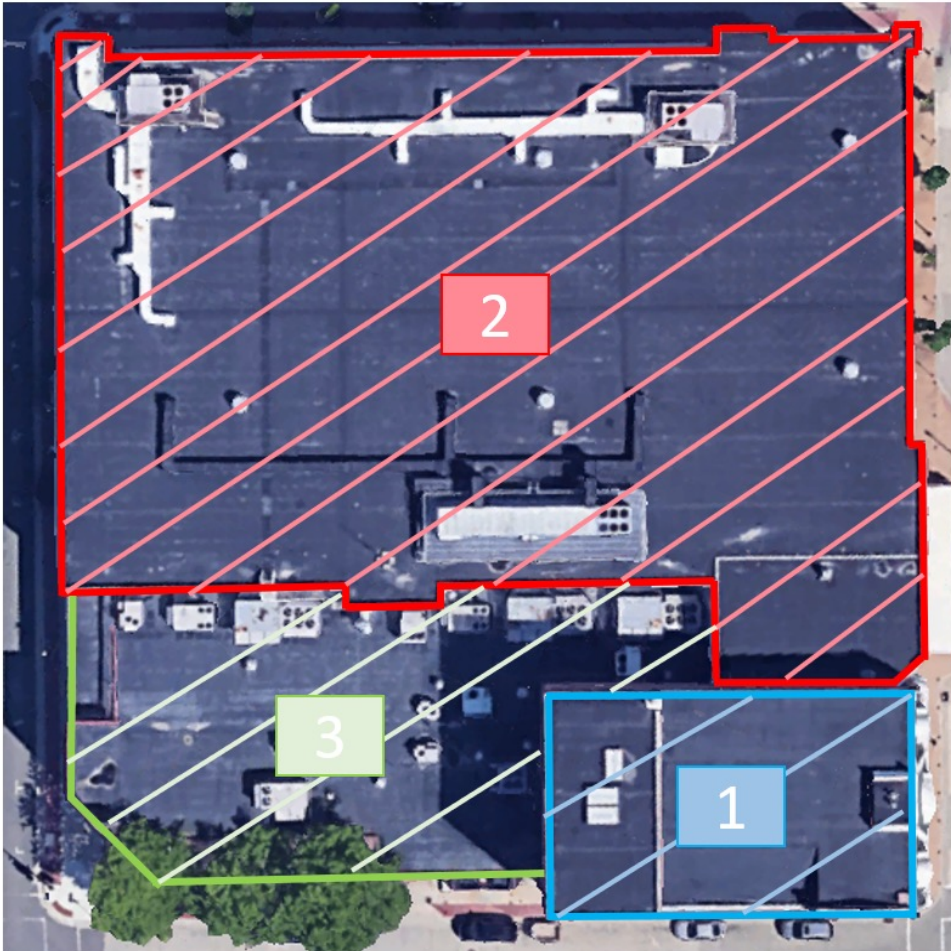


Green Roof



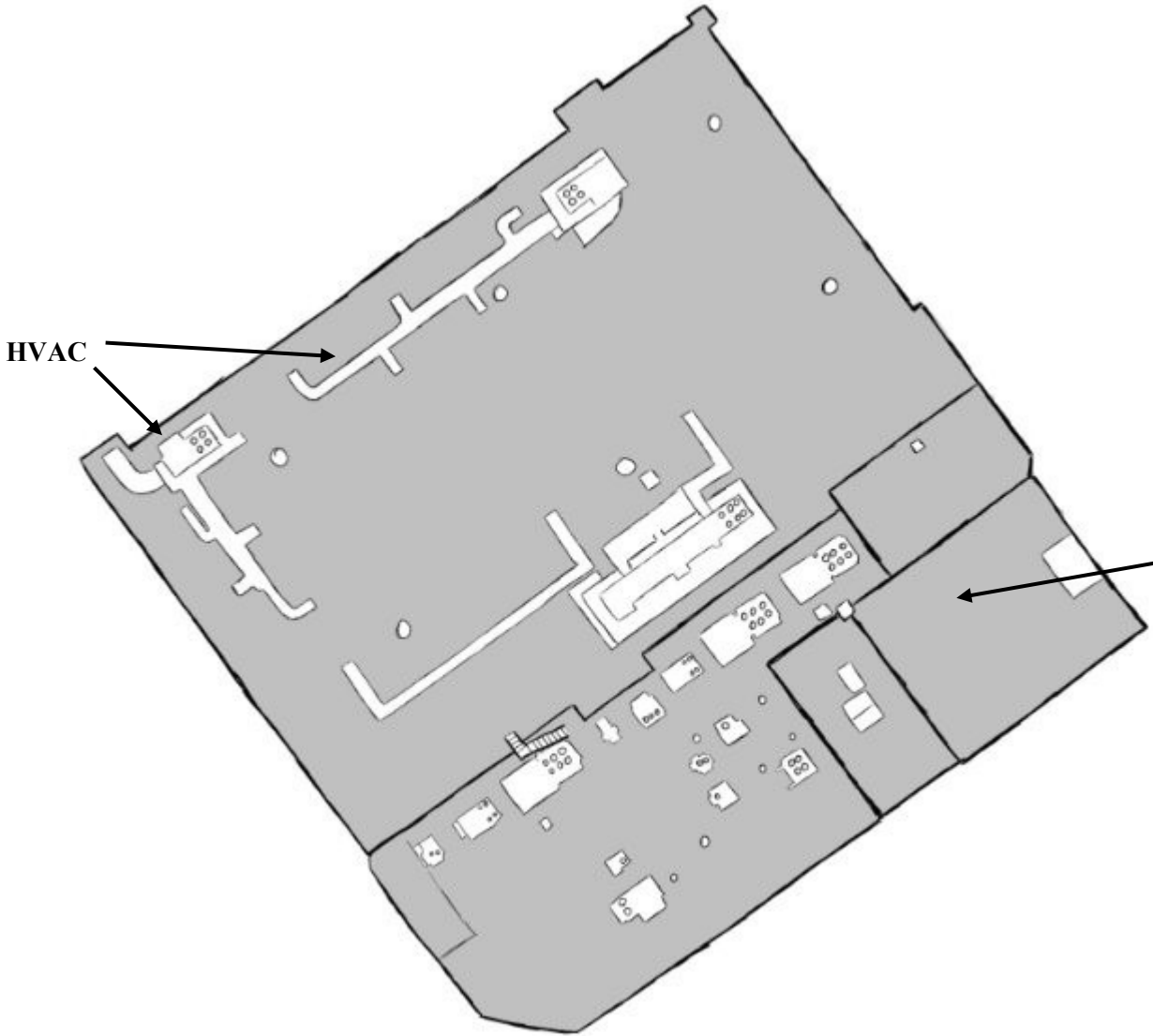
Solar Panels

Five Flags Civic Center



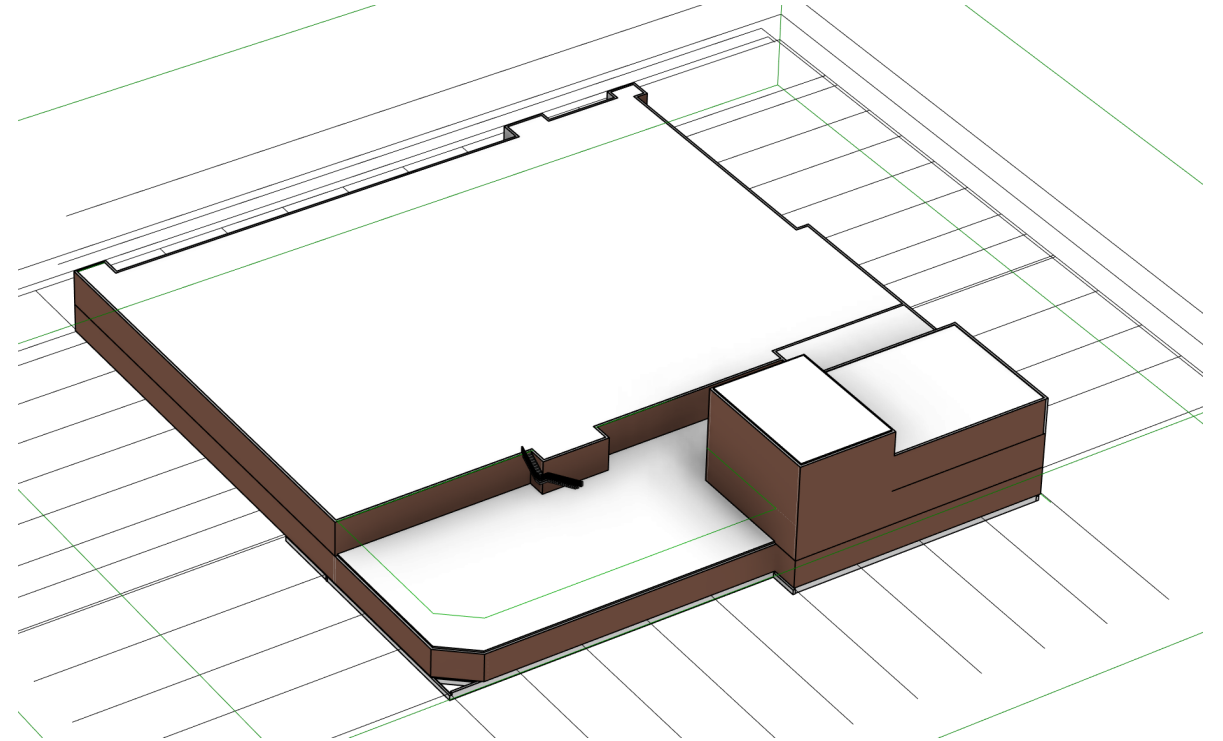
Roof Area	Use	Design 1: Cool Roof	Design 2: Integrated Roof
1	Theater	Cool Roof	Cool Roof
2	Arena	Cool Roof	Cool and Green Roof
3	Offices and Ticketing	Cool Roof	Cool Roof and Solar Panels

Design 1: Cool Roof



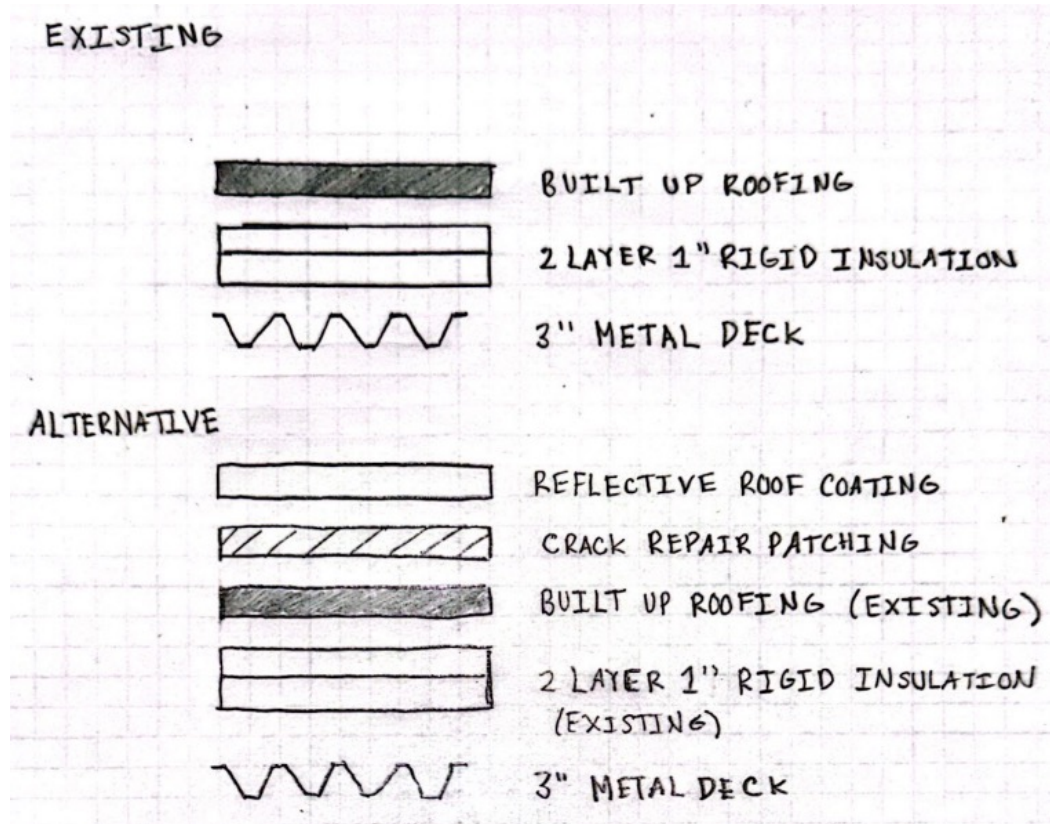
Design 1: Cool Roof

- New cool roof cover on all 71,350 square feet
- Three material options
 - Single-Ply Membrane (with polyurethane rigid foam)
 - Composite Tiling
 - Light-Colored Paint or Coating

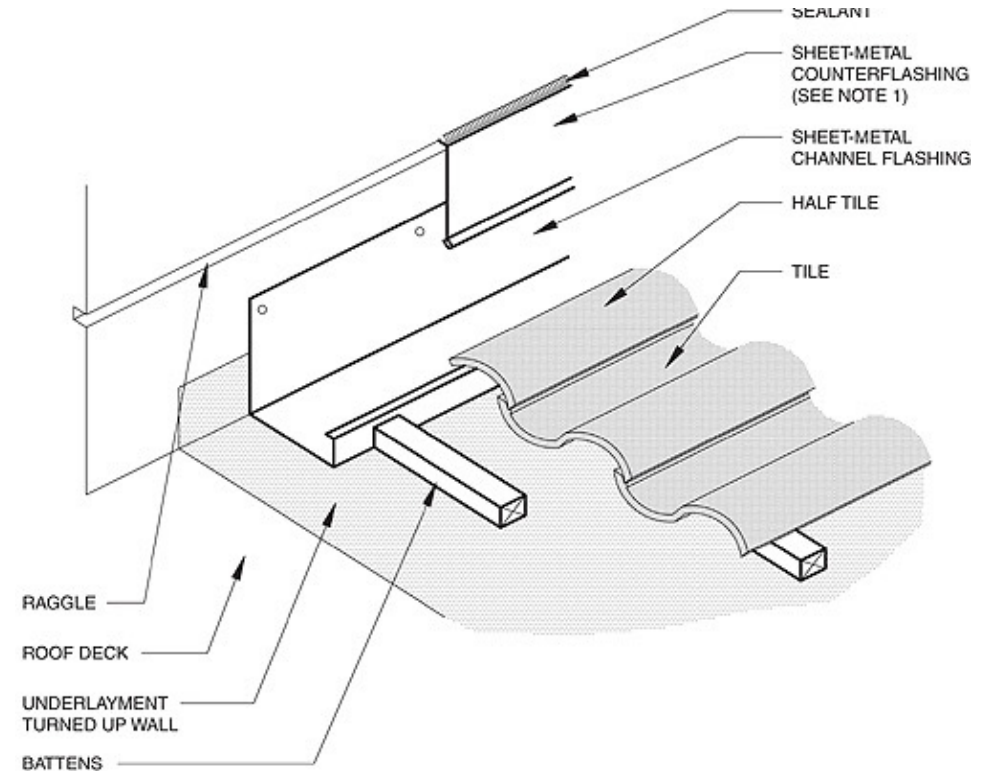


Cool Roof Material Alternatives:

Paint/Coating

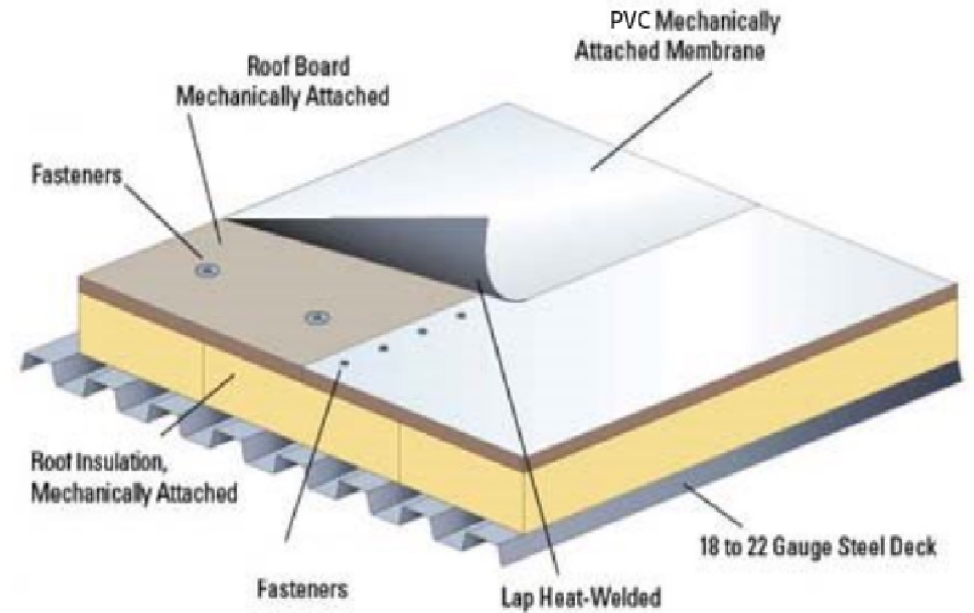


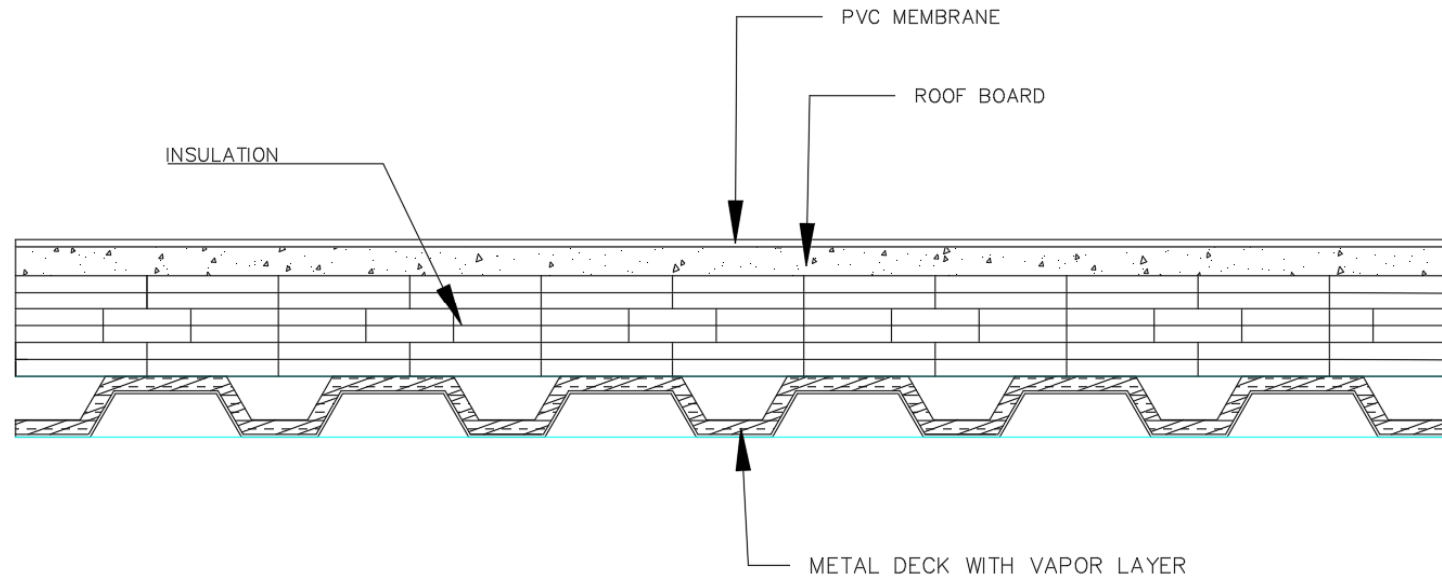
Composite Tile



Material Recommendation:

Single-Ply Membrane with Polyurethane Rigid Foam





- Insulator: Polyurethane Rigid Foam
- Cool Coat: PVC Single-Ply Membrane roll, attached with fasteners
- Lifespan: 30 years



Insulation Replacement

- Current R-value is 13
- Renovate with R-value of 30+ according to modern codes

Insulation Type	Location	Thickness	R-Value	Cost
Spray Foam	Under Roof Deck	1 inch	6.5	\$213,012
Insulation Rigid Foam Board	Above Roof Deck	3.5 inches	24	\$182,688
Waterproofing Membrane and Gypsum Board	Above Insulation Board	0.5 inch	0.5	\$65,146
Total		5 inches	31	\$460,846

Cost Estimate: Cool Roof Options

Cool Roof Type	Cost to Remove Existing	Construction Costs (includes insulation material)	Total
Composite Tile	\$64,200	\$1,229,350	\$1,319,350
Paint/Coating	NA	\$539,000	\$539,000
Single-Ply Membrane	\$64,200	\$939,200	\$1,029,200

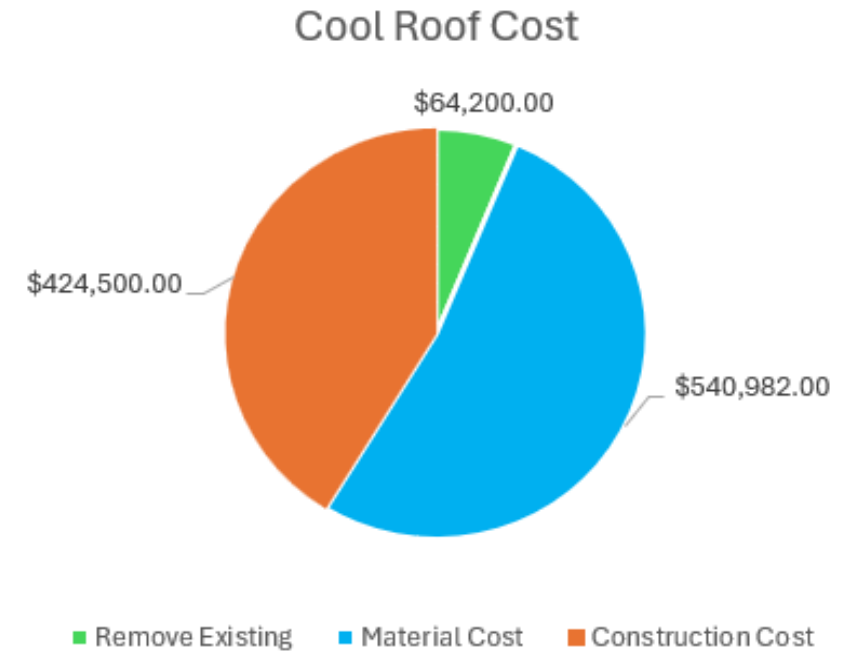
*Cost estimation does not include insulation installation costs

Estimated Return on Investment

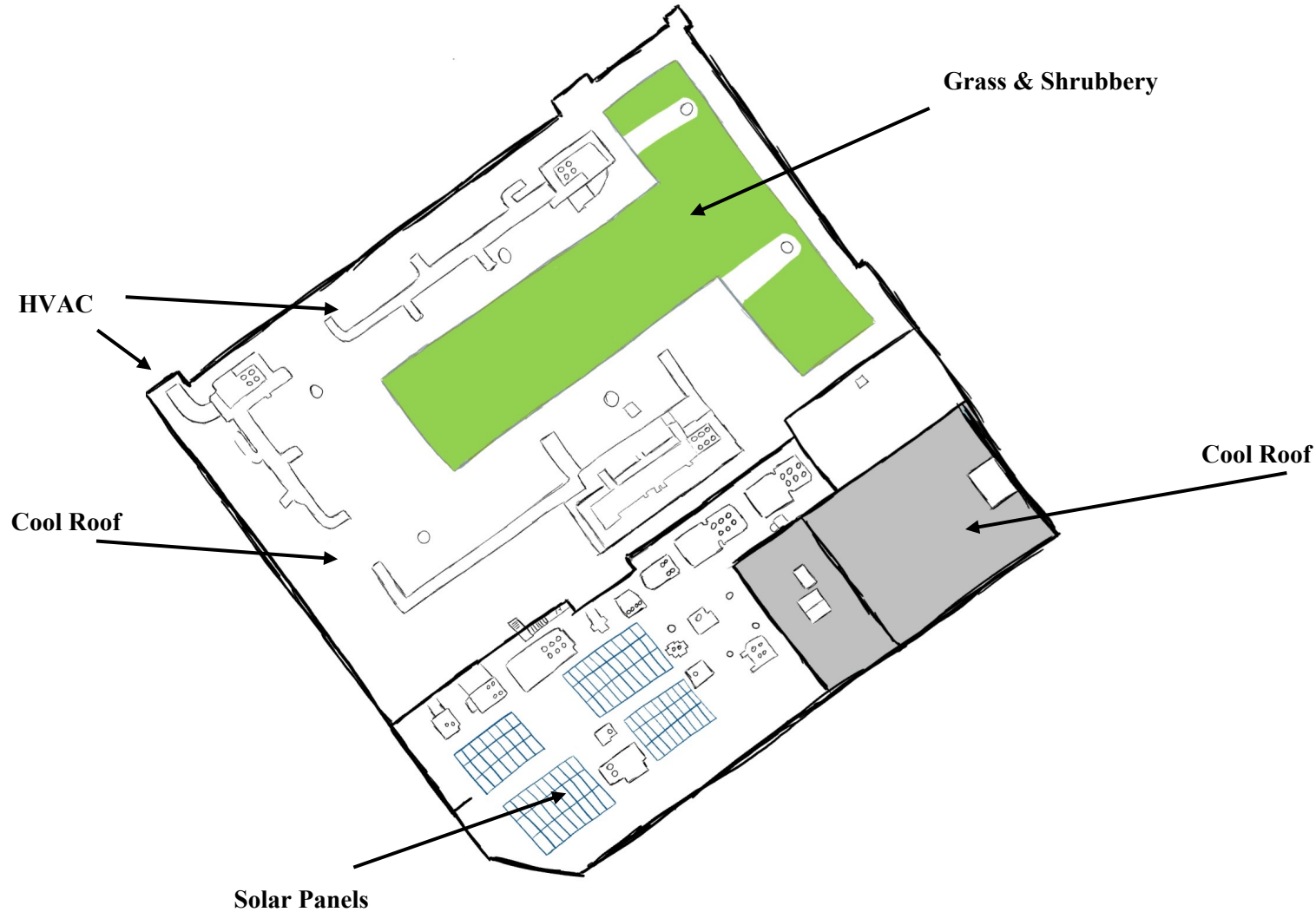
Cool Roof Type	Total Cost	Annual Savings	Payback Period
Composite Tile	\$1,319,350	\$23,550	56 years
Paint/Coating	\$539,000	\$14,270	38 years
Single-Ply Membrane	\$1,029,200	\$23,550	43 years

Cool Roof Construction Cost Estimate

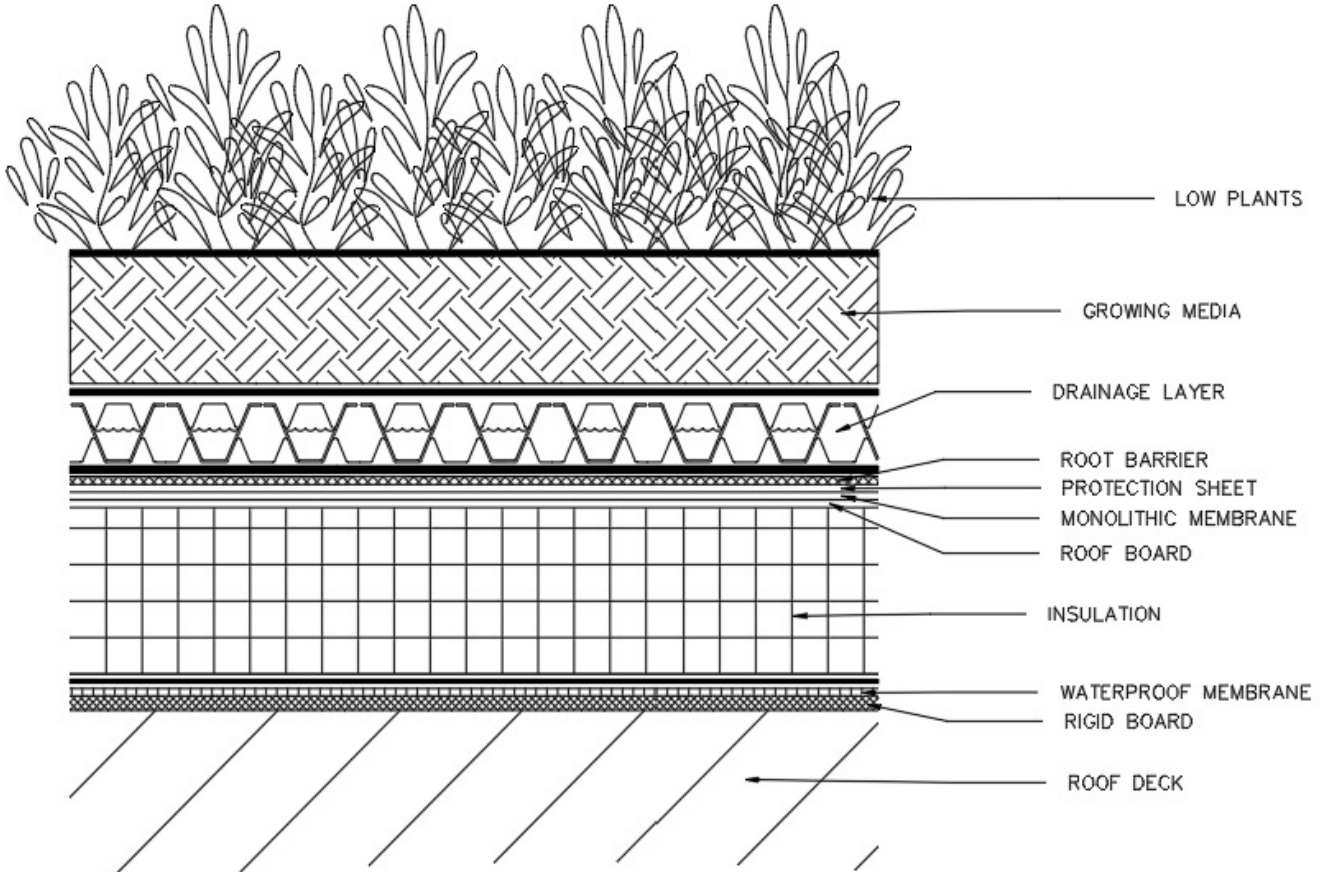
Material	Unit	Coverage	No. Units	Cost Per Unit	Total Cost (Incl. 6% tax)
Cool Roof:					
Polurethane Rigid Board Insulation	ft ²	416	172	\$ 1,000.63	\$ 182,688.00
PVC Membrane	ft ²	1000	72	\$ 1,050.00	\$ 80,136.00
Vapor Barrier	ft ²	1000	72	\$ 477.00	\$ 38,858.00
Spray Foam Insulation	ft ²	92	776	\$ 259.00	\$ 213,012.00
				Remove Existing	\$ 64,200.00
				Material Cost	\$ 540,982.00
				Construction Cost	\$ 424,500.00
Total Cost Estimation:					
				Cool Roof Cost	\$1,029,682.48
				Permit, Reviewal, Issuance, and Code fees	\$ 6,027.68
					\$1,035,710.16



Design 2: Integrated Roof



Green Roof



Energy Codes

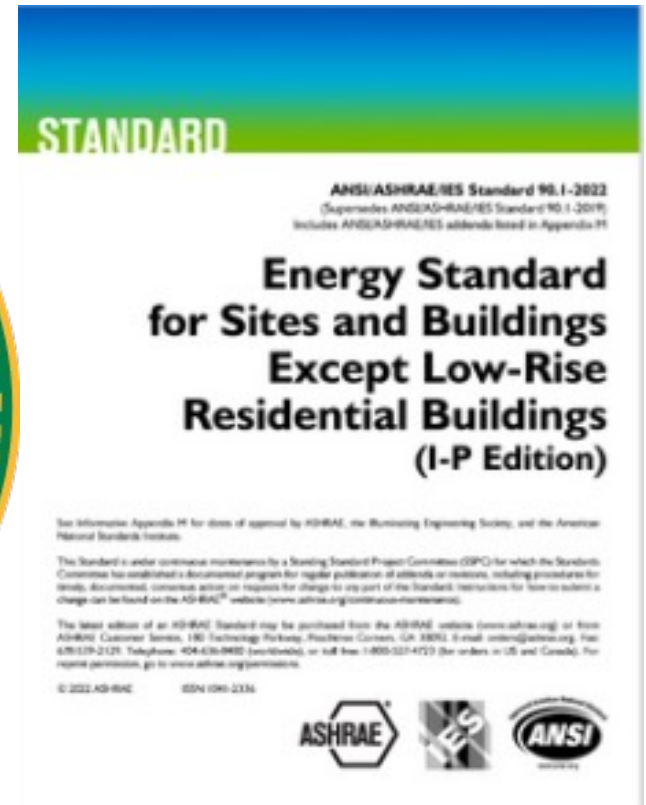
- Energy Codes Used: IECC 2021 and ASHRAE 2021
- Department of Energy (DOE) Programs estimates: \$138 Billion in cost savings implementing new standards.
- DOE has \$225 million of available funding to state and local entities

Building Codes Implementation for Efficiency and Resilience

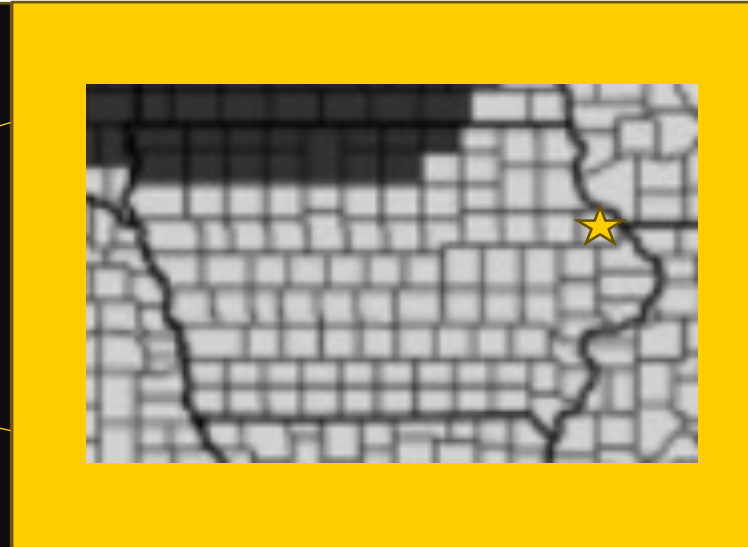
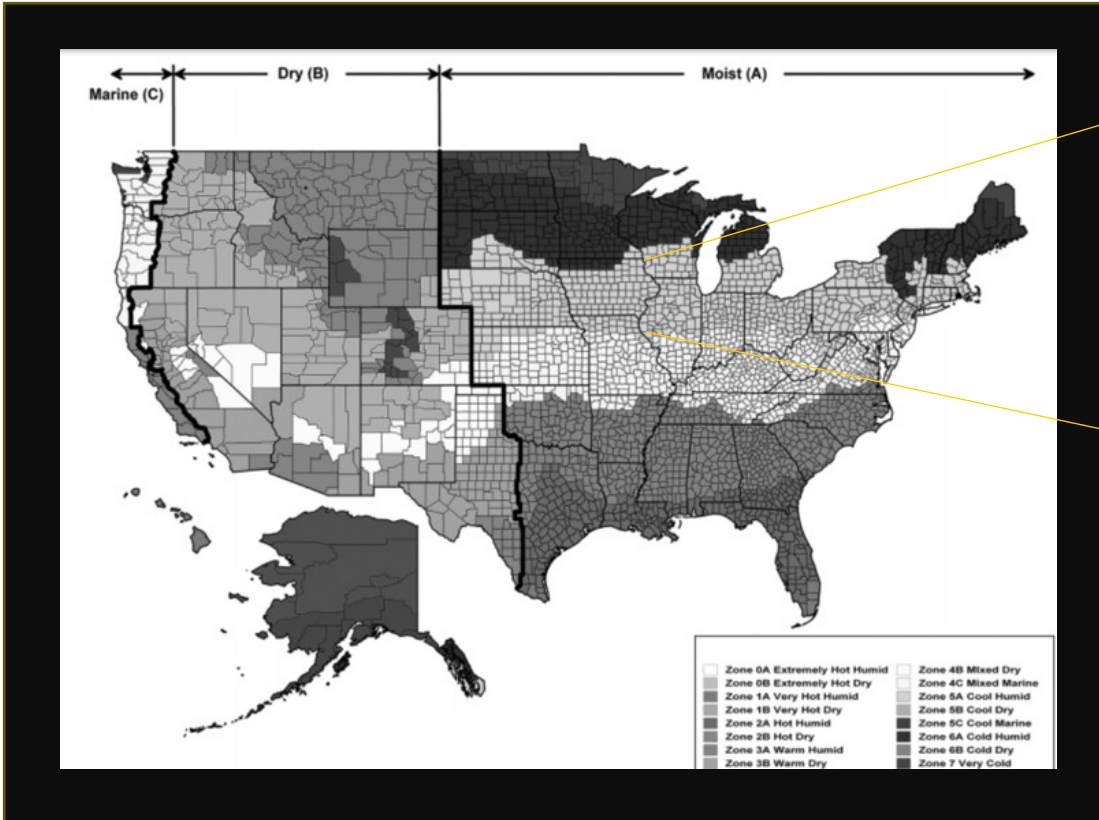
Office of Energy Efficiency & Renewable Energy



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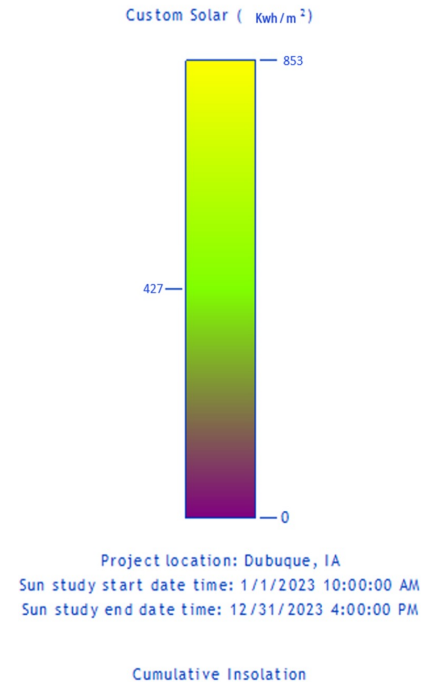
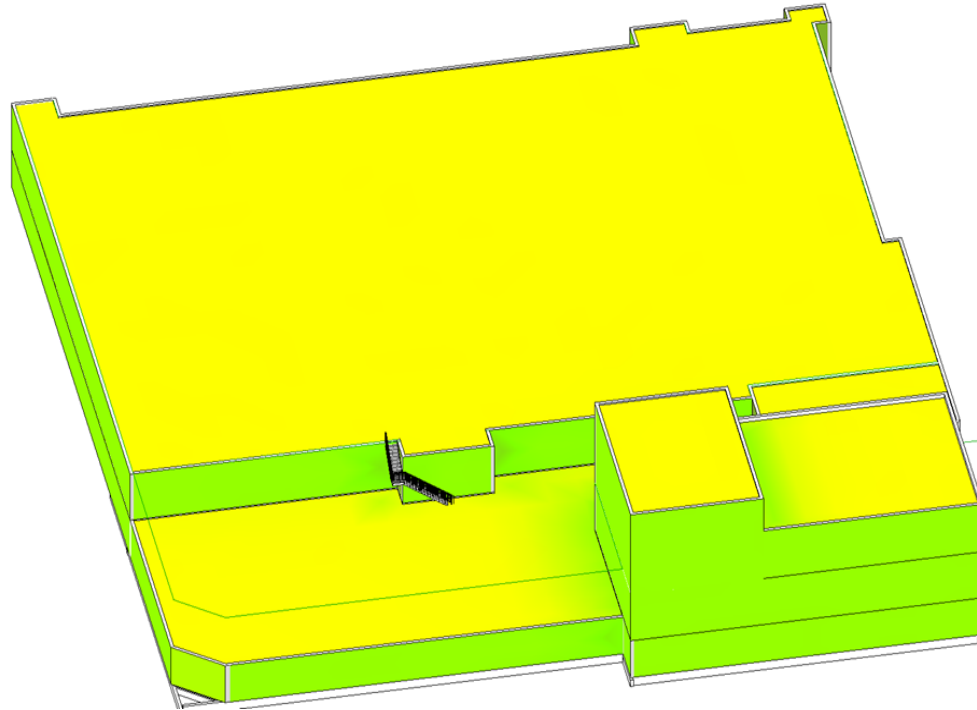


Dubuque Climate Zone



- Iowa Climate Region 6A: Cold Humid
- Climate Maps have altered this decade
- Climate Zones determine building energy requirements

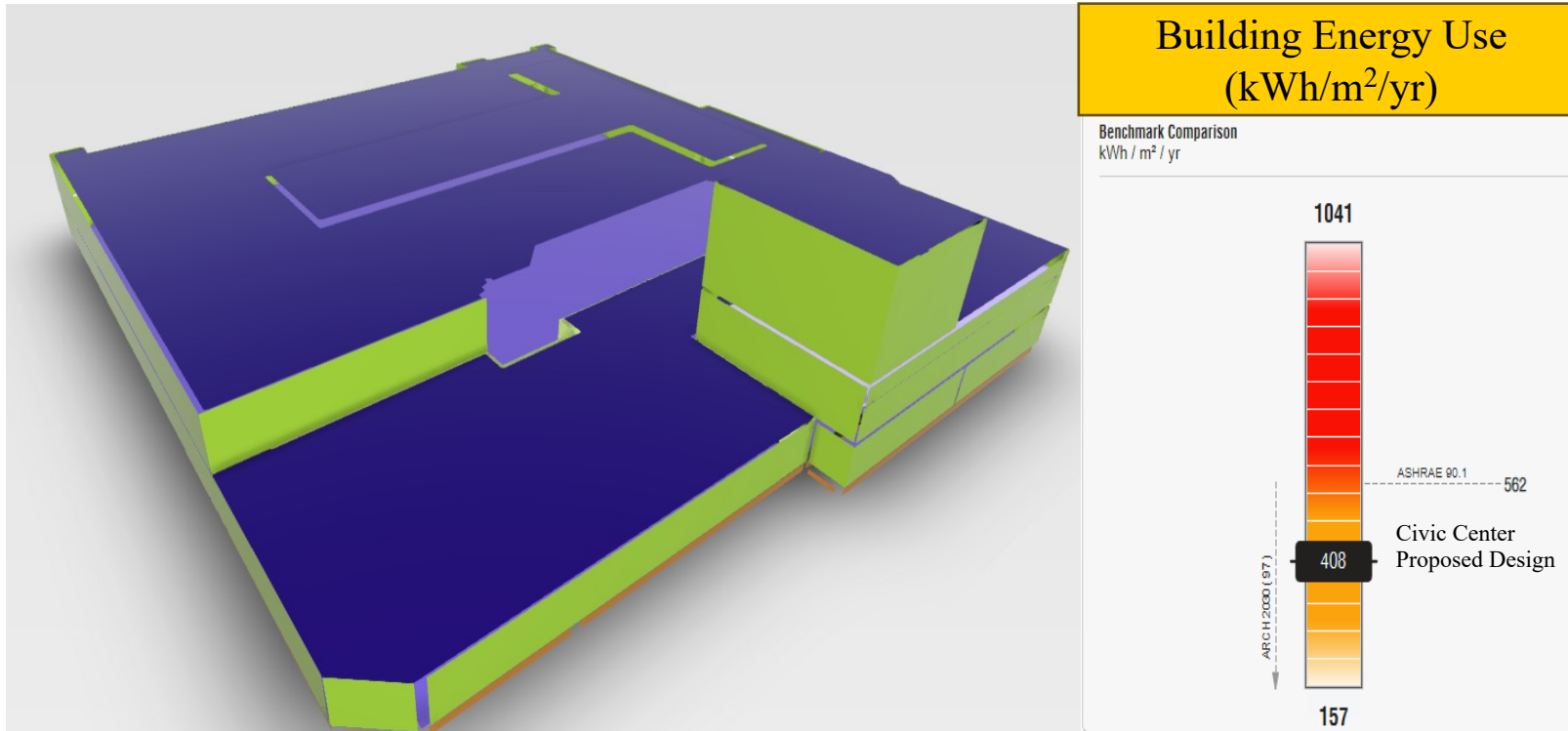
Existing Energy Efficiency



Existing Building Energy Model:

- Building Conditions- 2-in Insulation & Air-Insulated Walls
- Current Energy Exposure on Roof: 853 kWh/m²
- Greater amount of exposure, higher surface temperature

Design Energy Efficiency



Proposed Building Energy Model:

- Building Conditions- 3.5" Insulation & Air-Insulated Walls
- Simulated Exposure on Roof: 408 kWh/m²
- Overall Reduction: 52%

Solar Panels

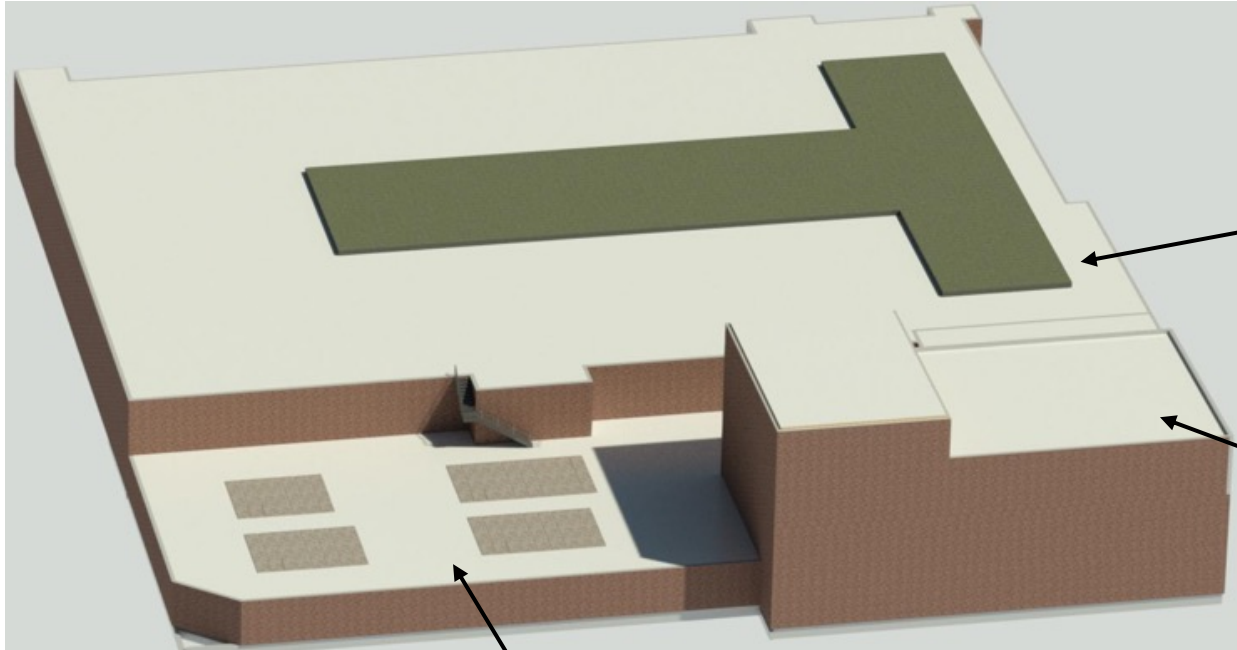


System Size	Material Costs	Installation Costs	Total	Total after 30% Tax Credit	Annual Energy Output*	Annual Savings**	Payback Period
55 kW 105 panels 2,500 sq. ft	\$158,210	\$8,702	\$166,912	\$116,838	96,588 kWh	\$13,522	8.6 years

*Estimated solar panel efficiency: 20%

**Estimated cost of 1 kWh in Iowa: \$0.14

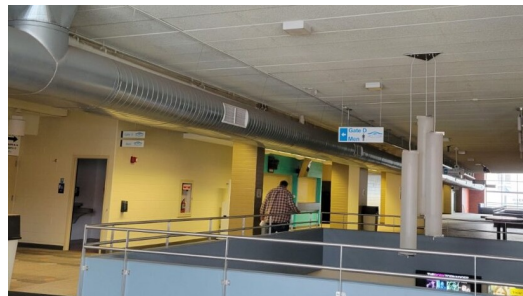
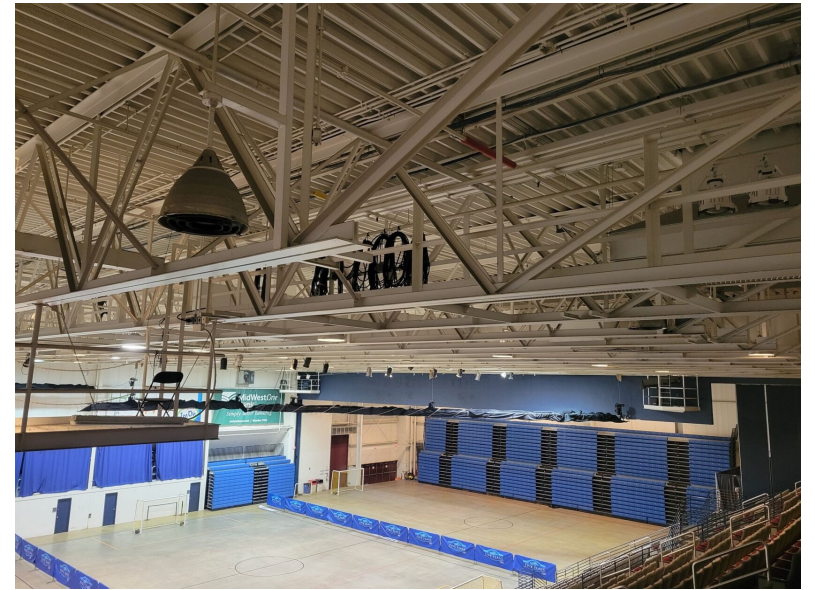
Structural Analysis



Arena

Theater

Offices and
Ticketing

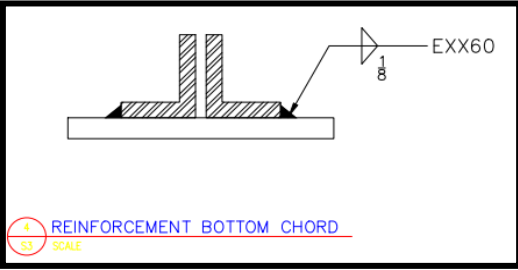
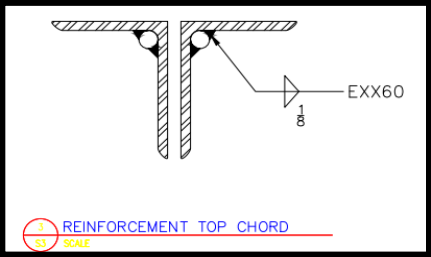


Trusses

Cool Roof
Additional Loading
1 psf

Green Roof
Additional Loading
35 psf

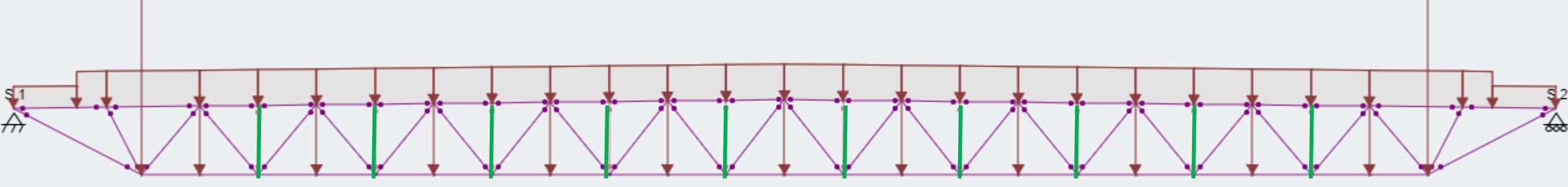
Cool Roof
Additional Loading
1 psf



Reinforcement of Truss

Green Roof

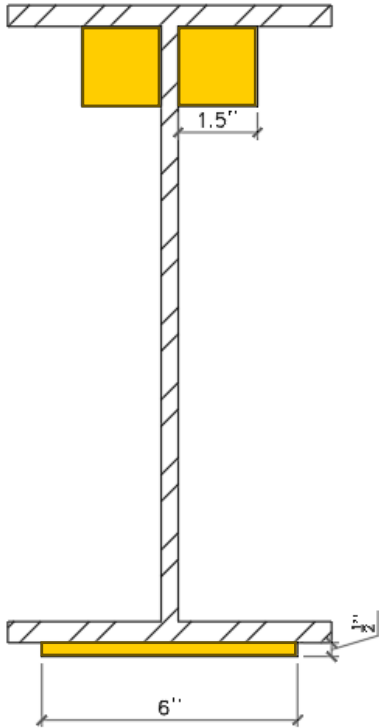
Cool Roof



Redesign of Truss 2L 6"x6"x7/8" 2L 3"x3"x1/4"



Girders and Columns



Girders

Columns

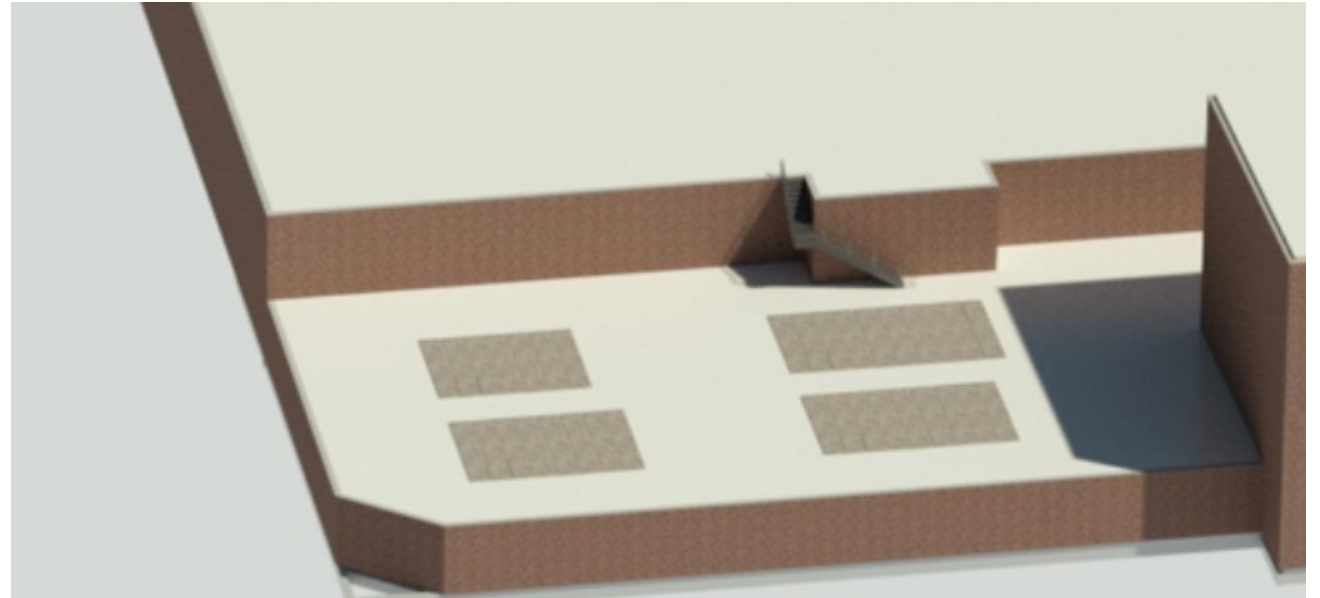


1 GIRDER REINFORCEMENT
S2 SCALE

Concrete Plank



Hollow-Core Concrete Plank



Solar Panels on Roof Area Three

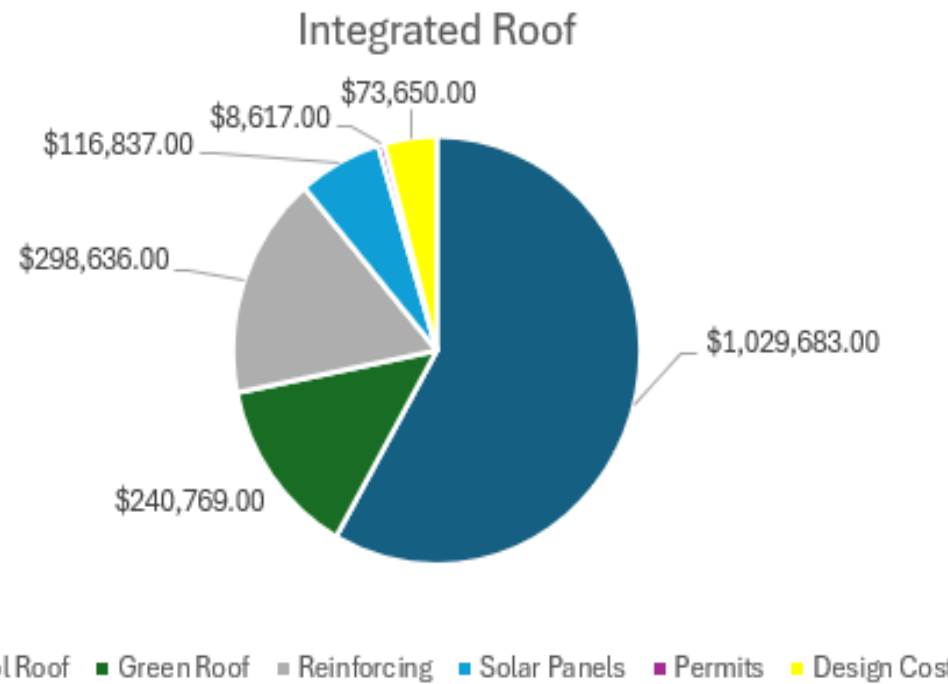
Integrated Roof Payback Period

Component	Square Footage	Total Cost	Annual Savings	Payback Period
Cool Roof	59,350 sq. ft	\$1,029,200	\$19,586	43 years
Green Roof	12,000 sq. ft	\$539,404	\$5,520	98 years
Solar Panels	2,500 sq. ft	\$116,838	\$13,522	8.6 years
Total	71,350 sq. ft	\$1,768,190*	\$38,628	46 years

*Total cost includes addition of design fees

Integrated Roof Construction Cost Estimate

Material	Unit	Coverage	No. Units	Cost Per Unit	Total Cost (Incl. 6% tax)
Cool Roof:					
Polurethane Rigid Board Insulation	ft ²	416	172	\$ 1,000.63	\$ 182,688.00
PVC Membrane	ft ²	1000	72	\$ 1,050.00	\$ 80,136.00
Vapor Barrier	ft ²	1000	72	\$ 477.00	\$ 38,858.00
Spray Foam Insulation	ft ²	92	776	\$ 259.00	\$ 213,012.00
				Remove Existing	\$ 64,200.00
				Material Cost	\$ 540,982.00
				Construction Cost	\$ 424,500.00
Green Roof:					
Soil Medium	ft ³	10	23	\$ 644.03	\$ 15,702.10
Drainage Layer Edge	lf	8	88	\$ 6.66	\$ 624.80
Drainage Layer	ft ²	36	334	\$ 2.19	\$ 27,912.51
Filter Layer	ft ²	1368.5	9	\$ 660.00	\$ 6,296.40
Root Barrier	ft ²	1218	10	\$ 657.72	\$ 6,972.00
Waterproofing Membrane	ft ²	216	56	\$ 122.95	\$ 7,296.80
Momolithic Membrane	ft ²	40.65	296	\$ 42.40	\$ 13,290.40
Weather Barrier	ft ²	32	375	\$ 25.99	\$ 10,312.50
Vapor Barrier	ft ²	1000	12	\$ 476.68	\$ 6,063.60
Gypsum Board	ft ²	32	375	\$ 11.12	\$ 4,425.00
Garden Edge Barrier	lf	40	18	\$ 831.89	\$ 15,872.40
				Material Cost	\$ 114,768.51
				Construction Cost	\$ 126,000.00
				Reinforcing Cost	\$ 298,635.47
Solar Panel:					
				Material Cost	\$ 158,208.00
				Installation Cost	\$ 8,702.00
Total Cost Estimation:					
				Cool Roof Cost	\$ 1,029,682.48
				Green Roof Cost	\$ 539,403.99
				Solar Cost	\$ 116,837.00
				Permit, Reviewal, Issuance, and Code fees	\$ 8,616.82
				Design Cost Fees	\$73,650.00
				Total	\$ 1,768,190.28



Cool and Green Roofs

Cool and Green Roof Renovation Project

