INTEGRATED DESIGN LAB

COLLEGE OF ART AND ARCHITECTURE

University of Idaho

DEDICATED TO THE EDUCATION, OUTREACH, AND TECHNICAL SUPPORT OF HIGH-PERFORMANCE ENERGY-EFFICIENT BUILDING DESIGN

University of Idaho
College of Art and Architecture

OUR TEAM MEMBERS

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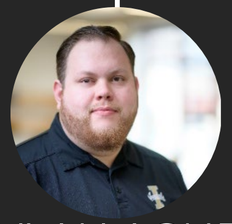
CAA Dean

RANDY TEAL
ARCH Chair

KIM OSBORNE
CAA Finance

idl



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Research Scientist II
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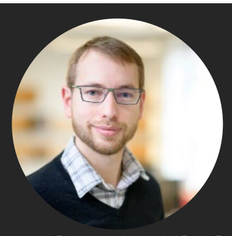

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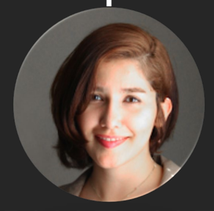
Director
Ph.D Mechanical Engineering



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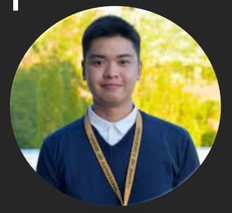

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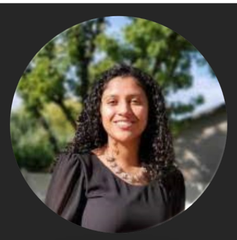
GREGORY REYES
Research Assistant
M. Architecture



NATALIE AYALA
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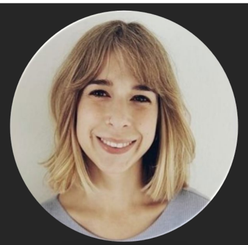
Research Assistant
M. Architecture



TAVIA DAHL
Research Assistant
M. Architecture

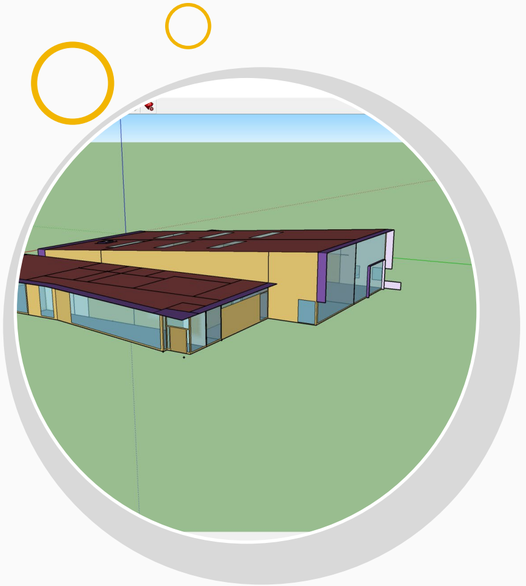
Open Position
Research Assistant

TOOLS + MEASUREMENTS

LECTURES

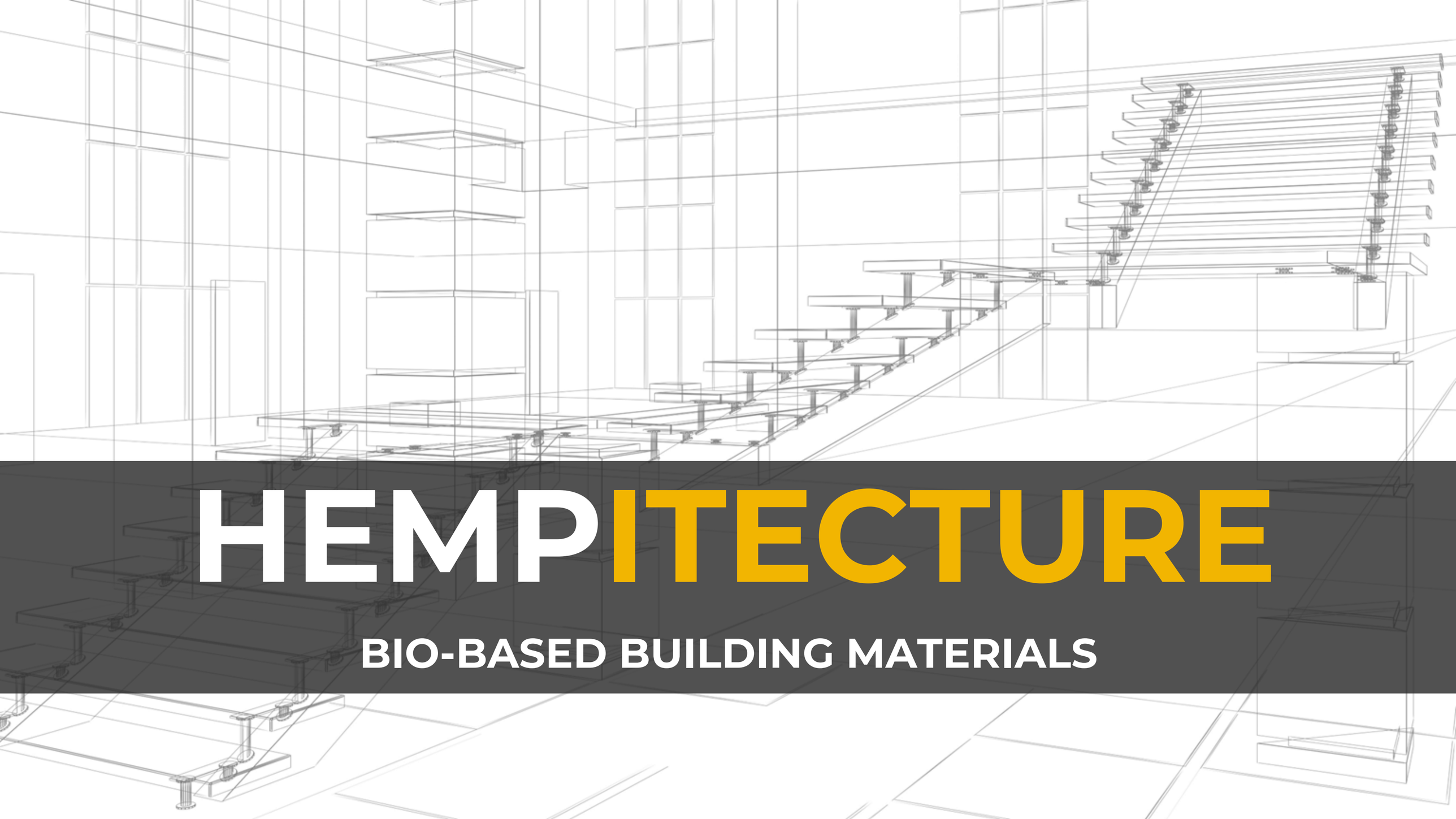
PHYSICAL

VIRTUAL



MODELING & ESTIMATES

IDL WORKFLOW



HEMPITECTURE

BIO-BASED BUILDING MATERIALS

Hempitecture IGEM Team

An Integrated Team

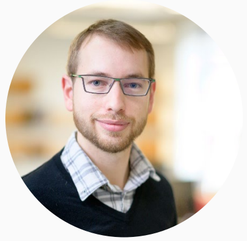
University of Idaho
Integrated Design Lab

+

hempitecture®

+

University of Idaho
College of Natural Resources



Damon Woods, Ph.D.
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Interim Director - IDL

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Hempitecture
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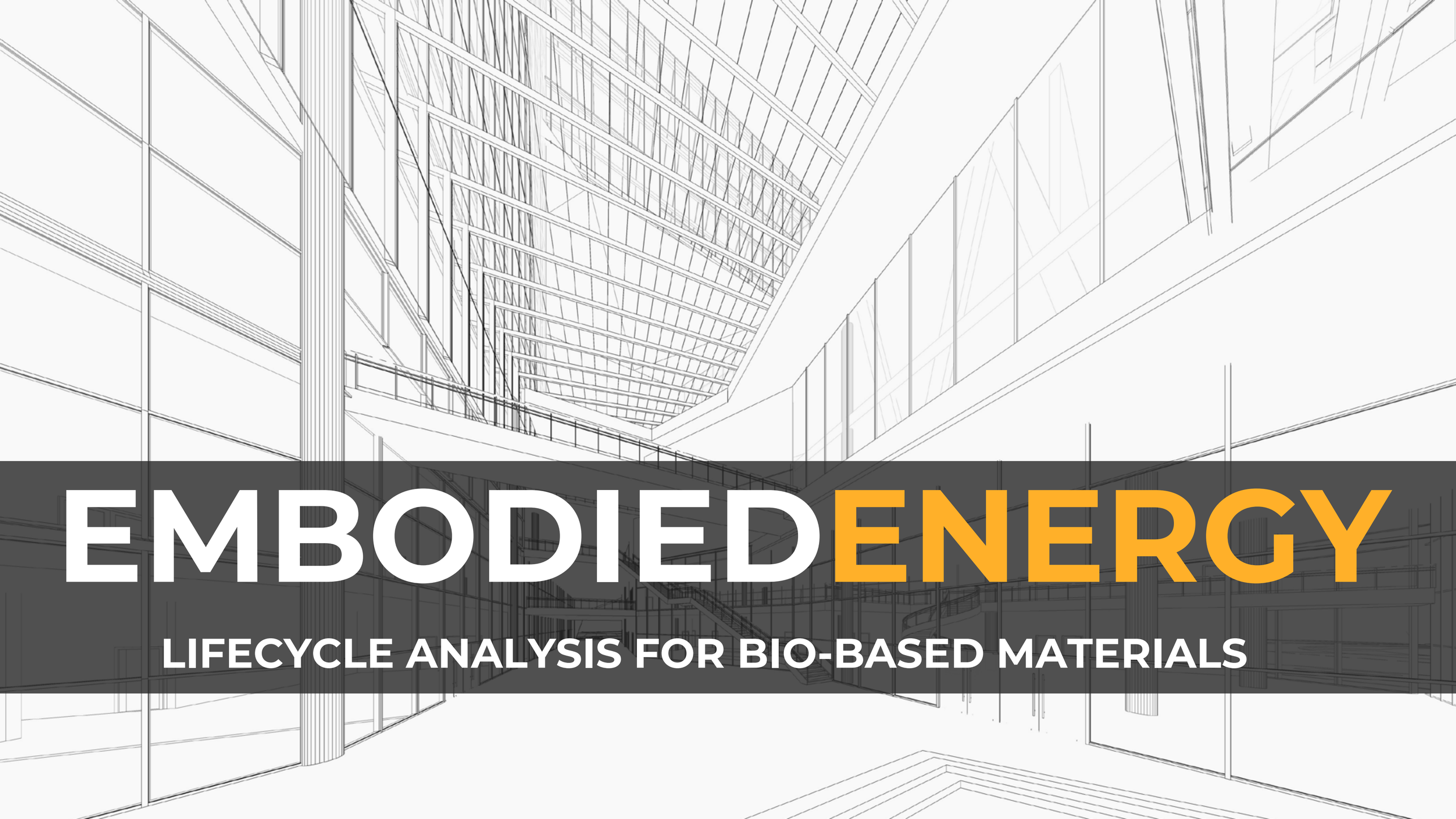
Natalie Ayala
Sophomore in Mech. Engineering

Tavia Dahl
M.Arch Research Assistant

Abdulbaset Alayat, Ph.D.
Postdoctoral Researcher - CNR

Fire and Thermal Resistance Testing

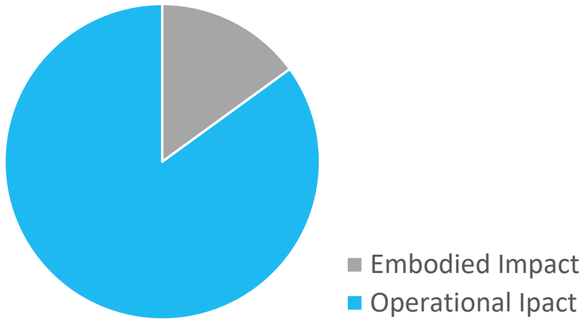
Commissioning the Manufacturing Plant:



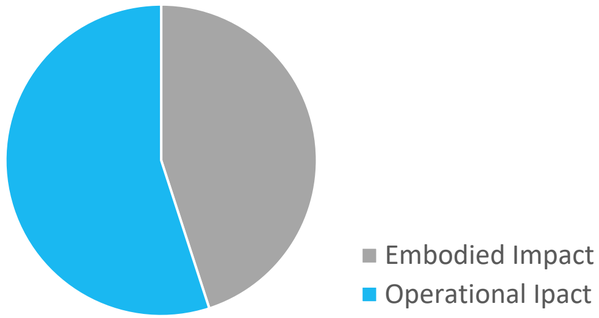
EMBODIED ENERGY

LIFECYCLE ANALYSIS FOR BIO-BASED MATERIALS

Thermal Properties and Embodied Impact of Materials: Ensuring Comprehensive Analysis

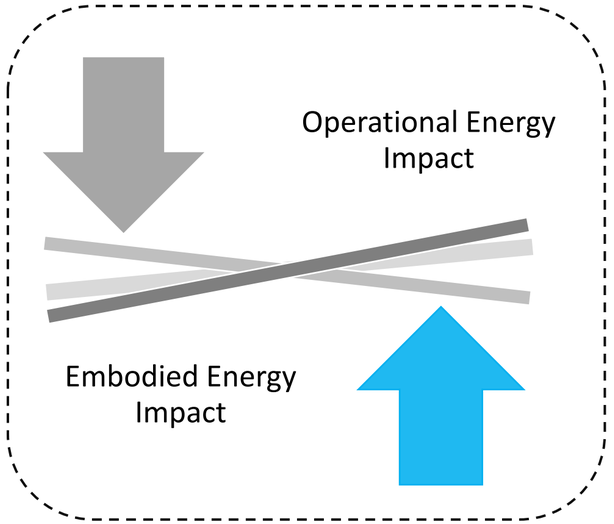


Energy Impacts over the Lifespan of 50 years (1, 2, 3)



Energy Impacts over the Lifespan of 50 years in Low-Energy Buildings (4, 5)

R-value vs. Embodied carbon



1. *T. Ramesh, R. Prakash, and K. K. Shukla, "Life cycle energy analysis of buildings: An overview," Energy Build., vol. 42, no. 10, pp. 1592–1600, Oct. 2010.*
2. *K. Adalberth, A. Almgren, and E. H. Petersen, "Life cycle assessment of four multi-family buildings," Int. J. Low Energy Sustain. Build., vol. 2, 2001.*
3. *Y. Chang, R. J. Ries, and Y. Wang, "Life-cycle energy of residential buildings in China," Energy Policy, vol. 62, pp. 656–664, Nov. 2013.*
4. *"Chastas et al. - 2016 - Embodied energy in residential buildings-towards t."*
5. *C. Thormark, "A low energy building in a life cycle—its embodied energy, energy need for operation and recycling potential," Build. Environ., vol. 37, no. 4, Apr. 2002.*

Our approach:

Literature Review

↓

Thermal Performance Tests

↓

Embodied Impact Calculation

↓

Life Cycle Impact Assessment

Image from https://i.pinimg.com/originals/1d/02/3b/1d023bfb951ccfc876453381fd861ac0.jpg

How is hemp compared to cotton?

- Cultivated for fiber production, 70-90 days after planting (1).
- lower labor-intensive production process (2).
- Higher water efficiency, requiring 38% and 84% less water for cultivation and irrigation (3).

1.A. T. M. F. Ahmed, M. Z. Islam, M. S. Mahmud, M. E. Sarker, and M. R. Islam, "Hemp as a potential raw material toward a sustainable world: A review," Heliyon, vol. 8, no. 1, Jan. 2022.

2.A. G. Duque Schumacher, S. Pequito, and J. Pazour, "Industrial hemp fiber: A sustainable and economical alternative to cotton," J. Clean. Prod., vol. 268, Sep. 2020.

3.K. Wise, E. Baziotopoulos, C. Zhang, M. Leaming, L.-H. Shen, and J. Selby-Pham, "Comparative study of water requirements and water footprints of fibre crops hemp and cotton," J. Agrometeorol., vol. 25, no. 3, Aug. 2023.

How are hemp fibers compared to hemp hurds?

- Hemp stem is composed of about 20-40% fiber and 60-80% hurds by weight (1, 2).
- Fibers: 55-72% cellulose, 8-19% hemicellulose, 2-5% lignin, <1% wax and 4% minerals (3).
- Hurds: 36-41% cellulose, 31-37% hemicellulose, and 19-21% lignin (3).

1.Thygesen, A., Daniel, G., Lilholt, H., Thomsen, A.B., 2005. Hemp fiber microstructure and use of fungal defibration to obtain fibers for composite materials J. Nat. Fibres 2, pp. 19-37.

2.Vogl, C.R., Hess J., Ströml, K.F., 1996. Die Praktische Hanffibel Informationsbroschure für den Anbau von hanf (Cannabis sativa L.) im Biologischen Landbau Universität für Bodenkultur Wien.

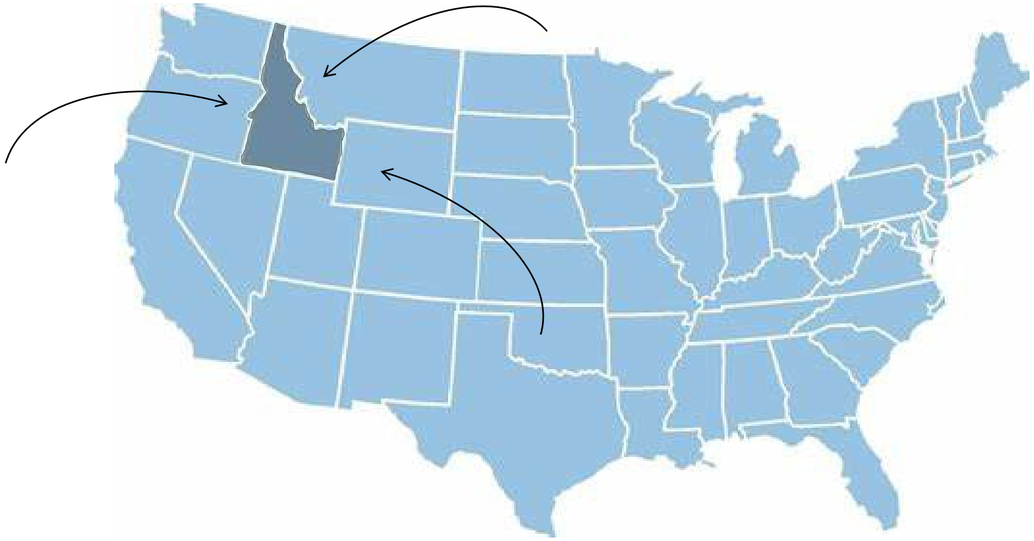
3.Thygesen, A., Thomsen, A.B., Daniel, G., Lilholt, H., 2007. Comparison of composites made from fungal defibrated hemp with composites of traditional hemp yarn. Ind. Crops Prod. 25, pp. 147-159.

Embodied Impact Calculation

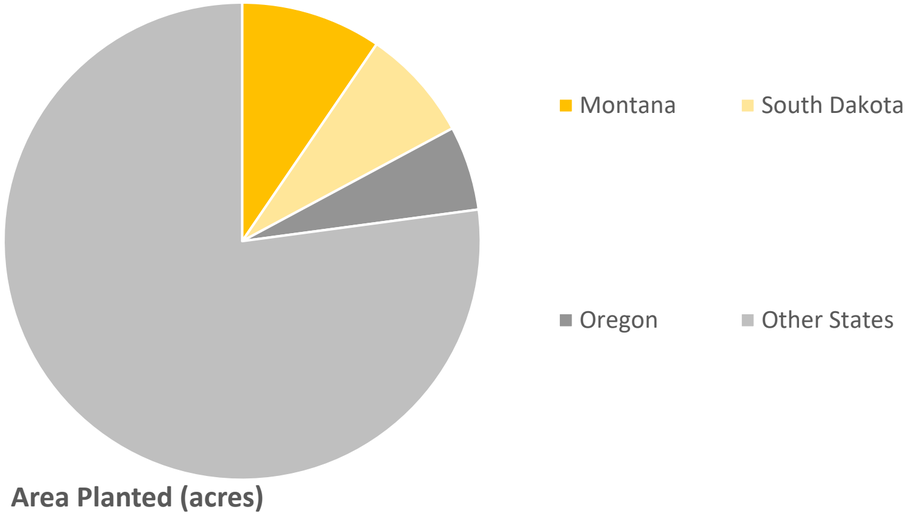
- **LCA Software Tool and Dataset**
- System Boundary
- Functional Unit

- GaBi's Education Database 2020
- Hempitecture's hemp supplier
- USDA agricultural crop data

thinkstep
GaBi



Industrial Hemp Grown in the Open Area Planted- 2022
States (Top 3) and United States



Data from National Hemp Report (April 2023) USDA, National Agricultural Statistics Service

Embodied Impact Calculation

- LCA Software Tool and Dataset
- **System Boundary :** Cradle-to-Gate
- Functional Unit

Figure from Carbon Leadership Forum (2020).

Embodied Impact Calculation

- LCA Software Tool and Dataset
- System Boundary
- **Functional Unit:** mass (kg) to provide R-SI value of 1 m^2.K/W equal to R value of 5.6786 °F·ft^2·h/BTU

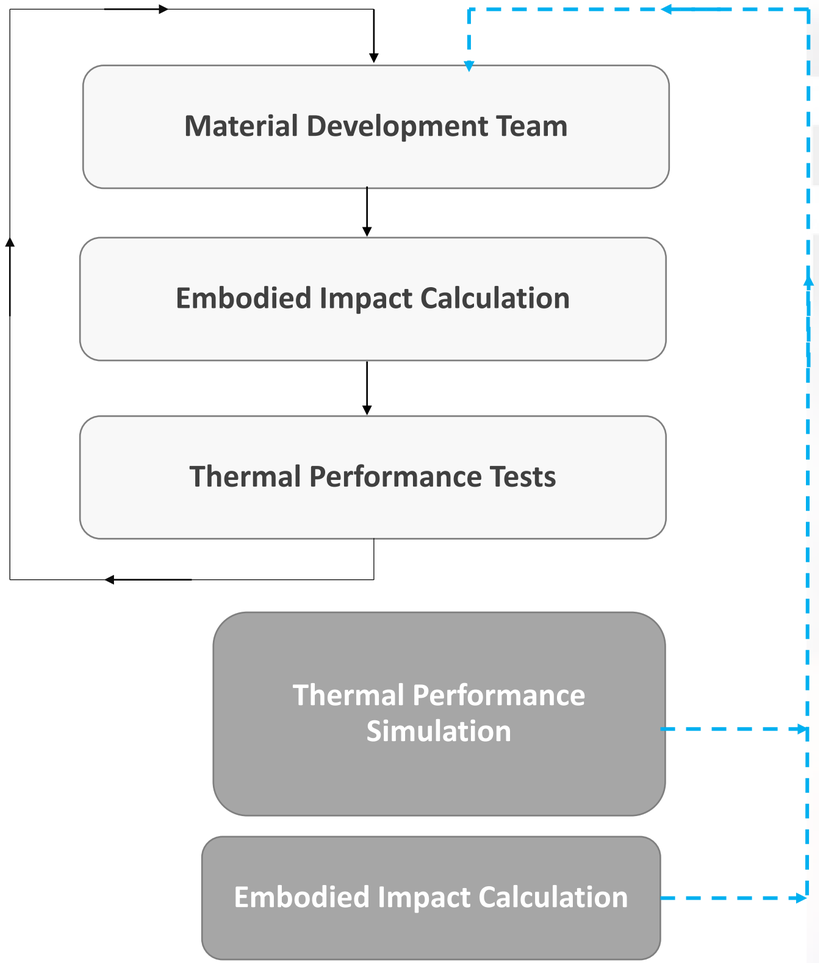
Density Kg/m^3	Thermal Conductance W/m.K	Functional Unit	System Boundary	GWP Kg CO_2 eq./FU	Reference
Hemp					
20-90	0.038-0.040	1.2-1.9 kg	Cradle-to-Grave	0.17 to 0.26	(1, 2)
38-41	0.038-0.060	2.25 kg	Cradle-to- Gate	-0.75 to -3.9	(3)

Data and EPDs Inconsistencies

Methods | System Boundary | Functional Unit | Life service | PCR

1. *S. Schiavoni, F. D'Alessandro, F. Bianchi, and F. Asdrubali, "Insulation materials for the building sector: A review and comparative analysis," Renew. Sustain. Energy Rev., vol. 62, Sep. 2016.*
2. *"Technical Dataset." [Online]. Available: http://www.maiano.it*
3. *G. Grazieschi, F. Asdrubali, and G. Thomas, "Embodied energy and carbon of building insulating materials: A critical review," Clean. Environ. Syst., vol. 2, Jun. 2021.*

Our approach:



PrinTimber

From Wood Waste to Homes

printimber.org

Funding for this project provided by the National Science Foundation Award Number: 21198099 Collaboration between The University of Idaho and Auburn University


PRINTIMBER

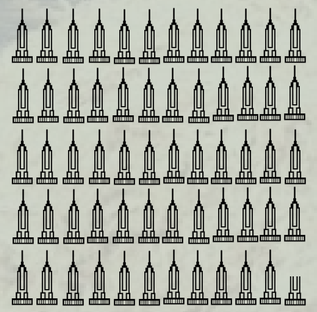
44 M TONS of WOOD RESIDUALS

50-170k tons / year at one facility

(1) 747 = 1000 tons

=

59.5



1

Non-Structural panels

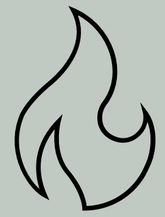
Bio-fuel

Compost

Animal Bedding

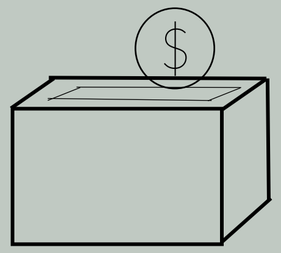
Paper Products

2



Burn

Landfill

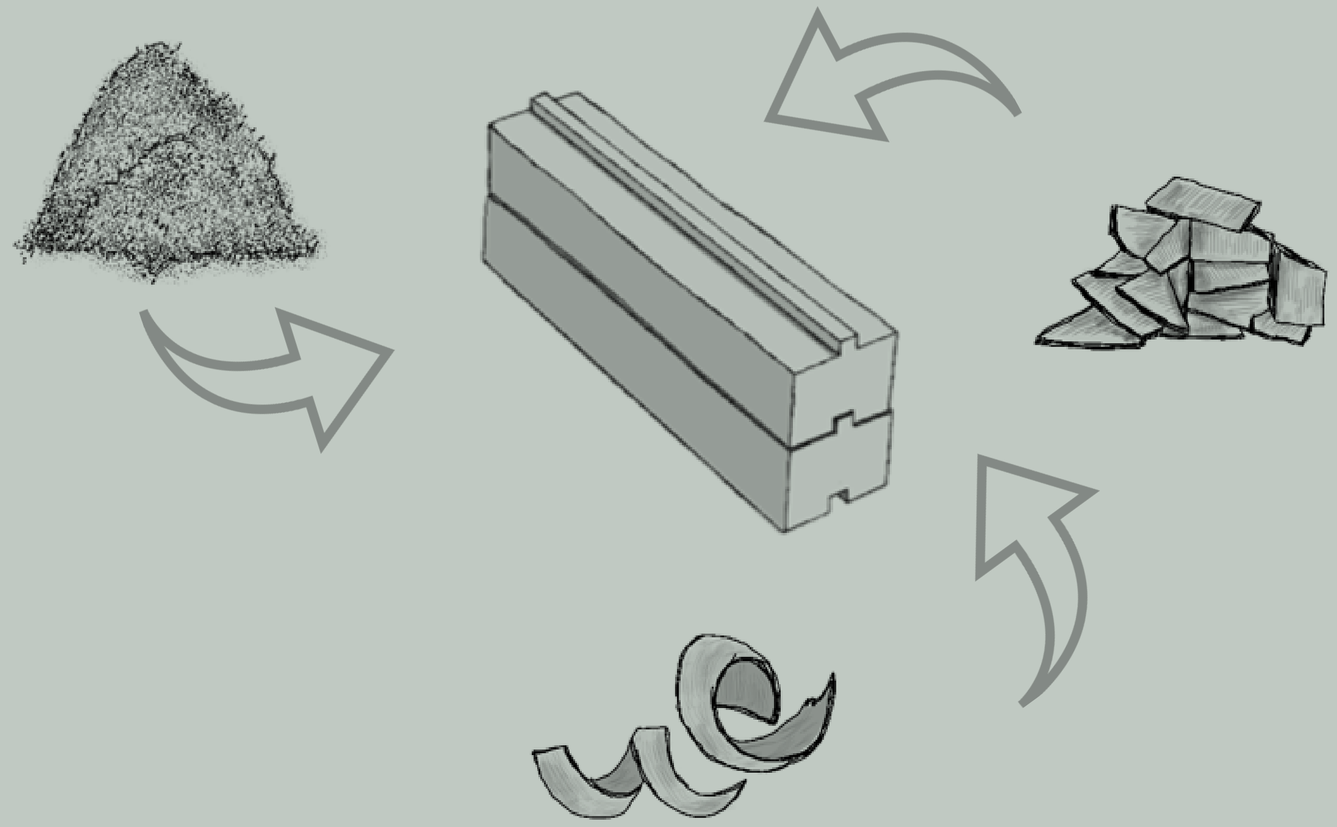


Donate

Solution: TECHNOLOG

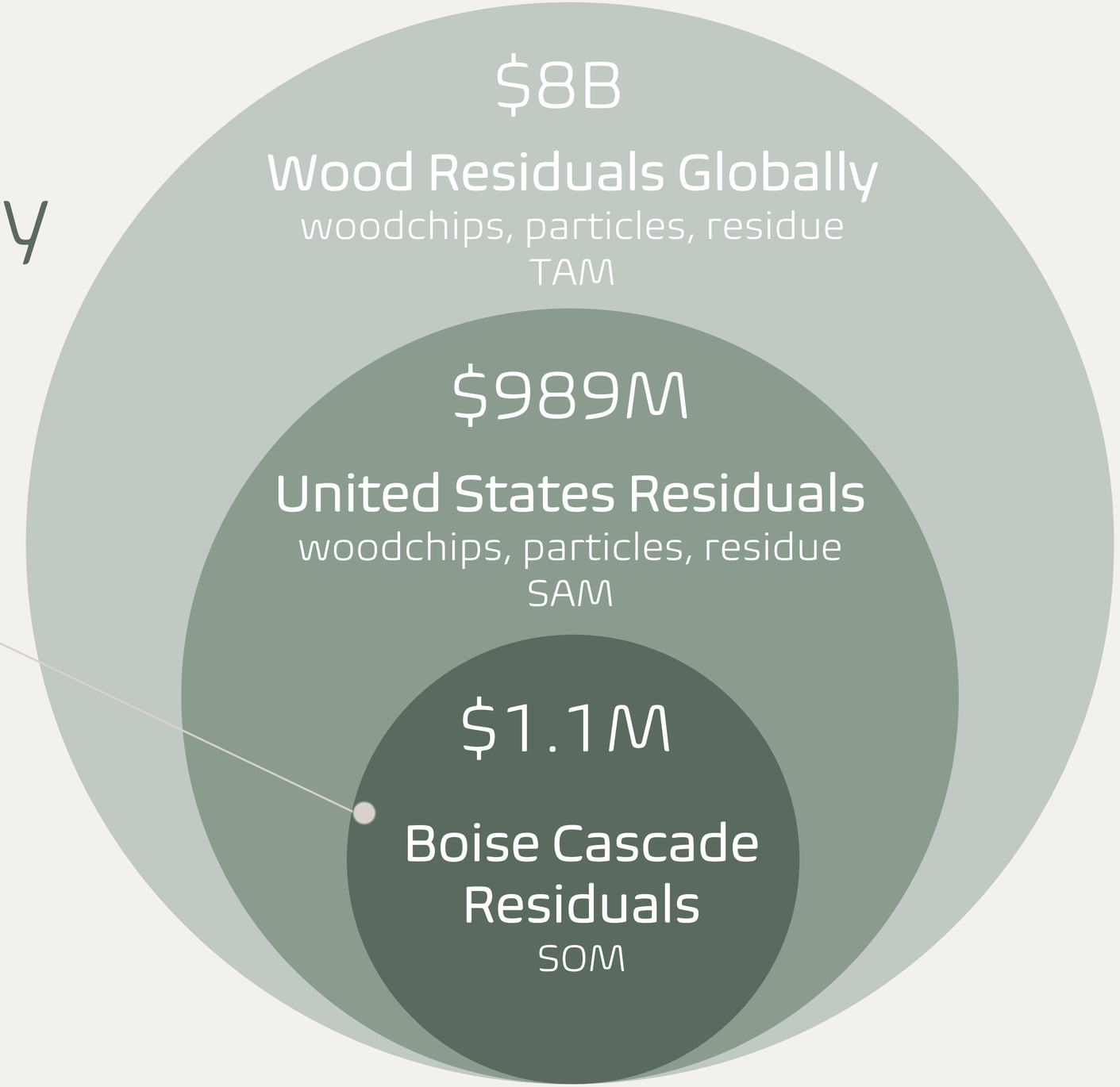
Value-Add

- Cradle-to-Cradle Construction
- Low Energy Usage
- Fewer Skilled Laborers
- Lighter Weight
- Carbon Capture



Market Opportunity

"40 truckloads per week"
(@ 24 tons/truck)



Progress to Date

First iteration: wooden box.

Second iteration: steel box.

2'6" x 8" x 8" post-compression Technolog

Technolog created in collaboration between Architecture and Mechanical Engineering students from the University of Idaho: Jim Severt, Skyler Howell, and Robert Carne

Thermal Performance Assessment

1. PrinTimber vs. Concrete
2. Insulation Fill Options
3. Cost and Embodied Energy Assessment

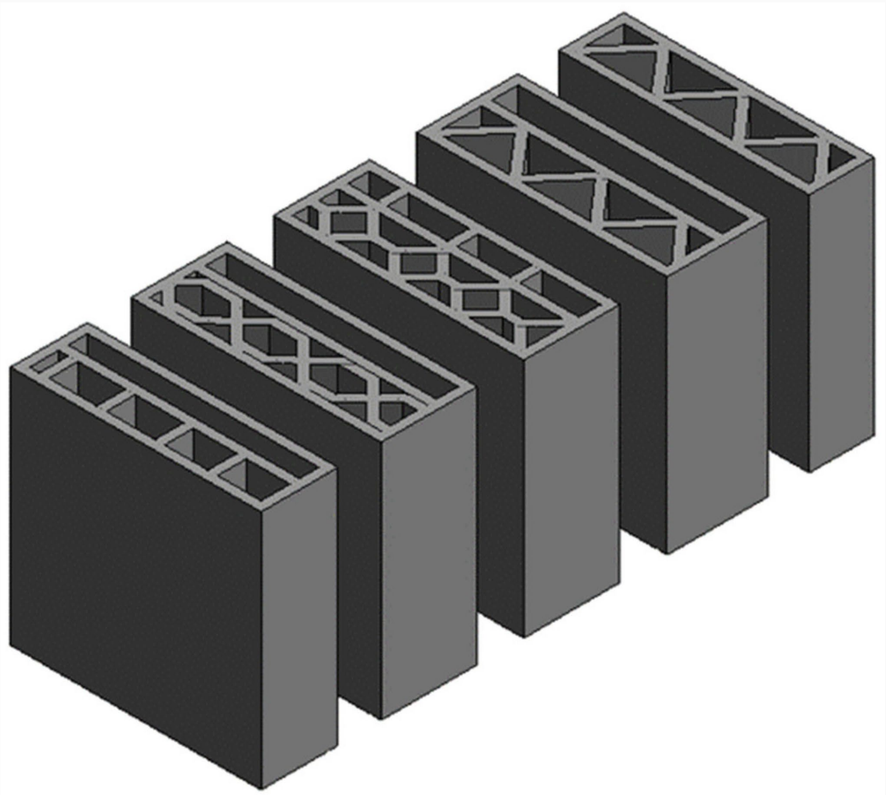


Image from *"Experimental Study on the Thermal Performance of 3D-Printed Enclosing Structures"* by Darya Nemova et. al Energies 2022 https://doi.org/10.3390/en15124230

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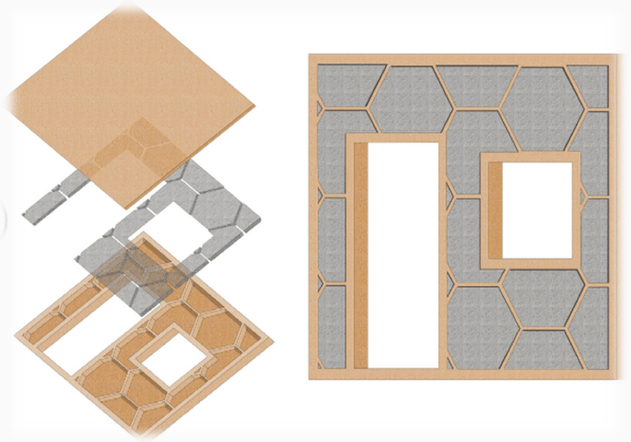
Using Bio-based Materials for the Future



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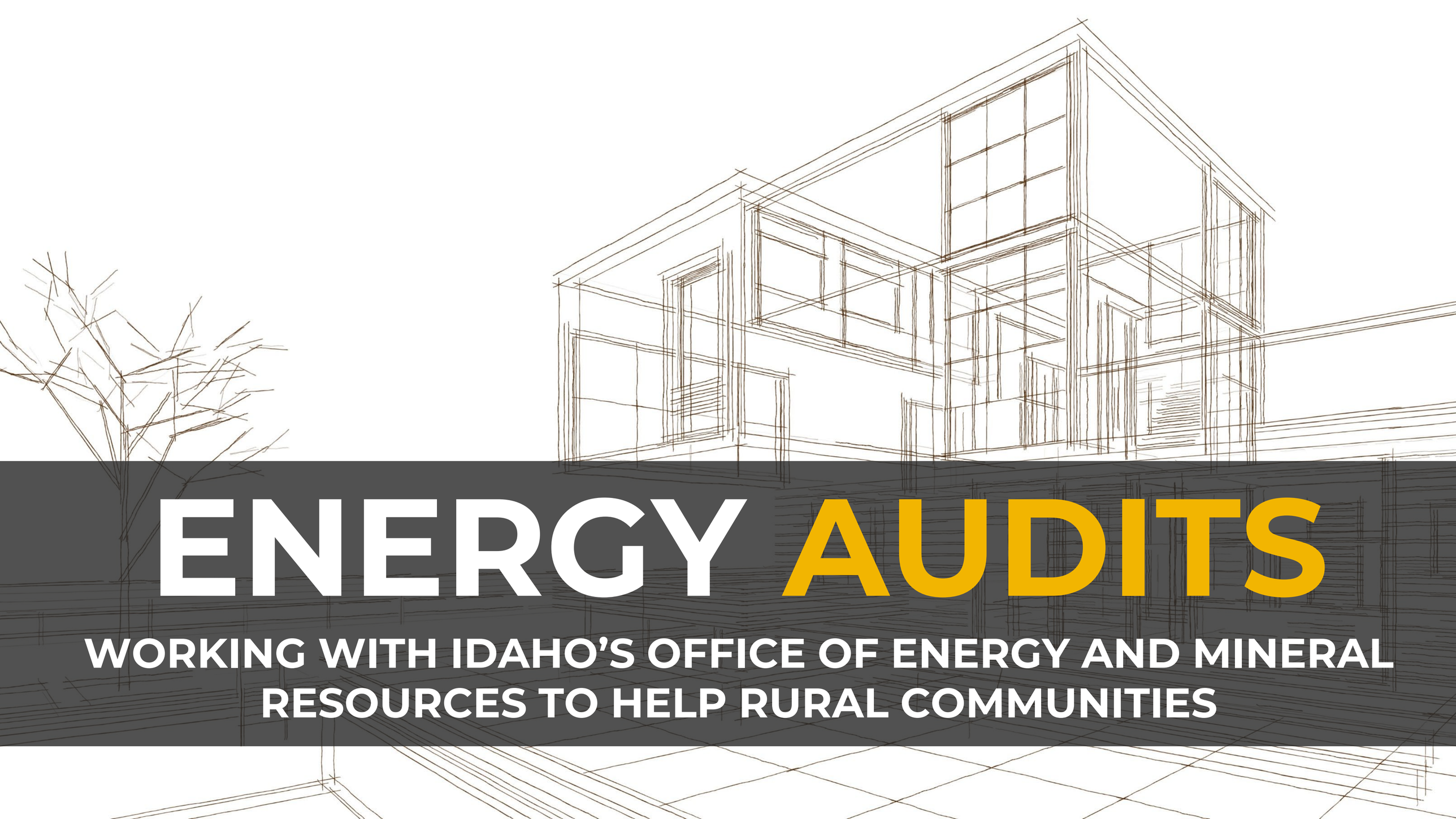
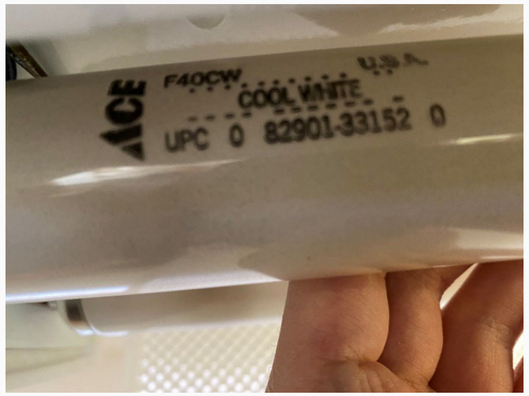


ENERGY AUDITS

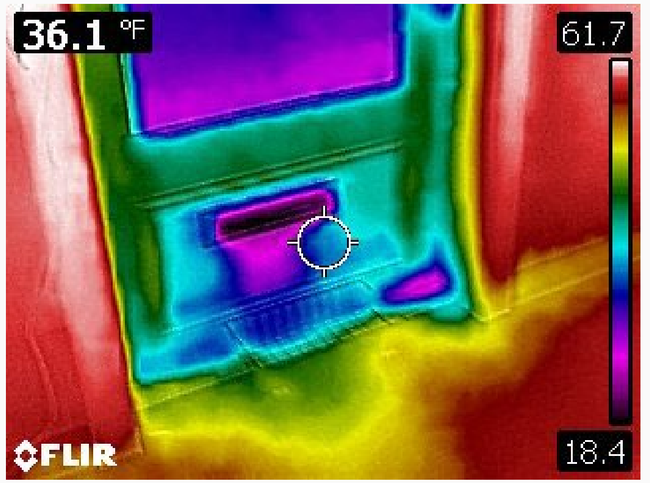
WORKING WITH IDAHO'S OFFICE OF ENERGY AND MINERAL RESOURCES TO HELP RURAL COMMUNITIES

A HISTORY TOUR OF BUILDING TECHNOLOGIES

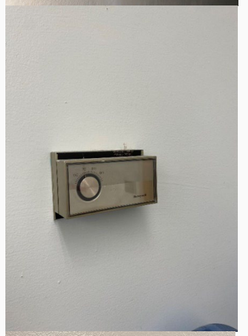
LIGHTING

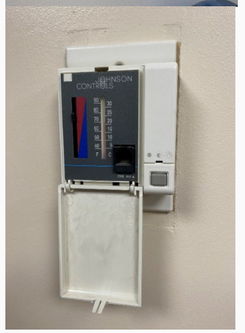


ENVELOPE



HVAC





REPORT OUTLINE

- BUILDING INFORMATION
- FACILITY DESCRIPTION
- ENERGY SNAPSHOT
- SYSTEMS DESCRIPTION
- ENERGY SAVINGS OPPORTUNITIES

1. Retrofit lighting

Description:

a. Existing Conditions:

T8 fluorescent lights are present throughout the building. There are approximately 28 fixtures and 104 bulbs that were counted on site. Most have 40-watt bulbs, and the Lighting Power Density (LPD) is estimated at 2.5 W/ft2 (about 3x the current code maximum). Estimated energy is 4,000 kWh per year. This could be reduced by 75%. Estimated savings would be about 3,000 kWh per year or $250 per year.

b. Opportunity for Change:

Update to LEDs or Luminaire Level Lighting Controls (LLLC's) for a higher incentive.

Potential benefits (energy, capital, comfort, maintenance)

Energy, maintenance, comfort

Other Considerations (implementation, conflicts between other opportunities, remodels, etc.)

Estimated costs by Retrolux vary between $1.25 - $2.00/$ft^2$

Idaho Power's most used incentives are for lighting. Incentives for this building range between $300 - $1,000 depending on the LED system chosen($0.10 - $0.29 per kWh saved).

Exit signs can also be replaced with LEDs (IPC incentive at $40/sign)

https://docs.idahopower.com/pdfs/energyefficiency/business/retrofits/StandardLightingIncentives.pdf

WHAT'S NEEDED – SPECIFIC NUMBERS ON SAVINGS

#	Utility (Electric, Gas, etc.)	Description	Capital cost (rough estimate) [$]	Utility cost savings (rough estimate) [$]	Potential Simple ROI (without incentives) [yrs]	Energy savings (rough estimate) [kBtu]	Utility Incentives (Y/N) [3]
1	Electricity, Gas	Add exterior insulation on exposed concrete walls	$1,250	$800	1.6 yrs	98,800 kBtu	Y
2	Electricity, Gas	Add central HVAC controls	$4,500	$3,400	1.3 yrs	269,100 kBtu	Y
3	Gas	Update boiler controls	$1,500+	$1,100	1.4 yrs	138,400 kBtu	Y
4	Electricity	Add SHGC film to east windows	$500	$200	2.5 yrs	7,100 kBtu	Y
5	Electricity, Gas	Update RTUs above SE Wing	$36,000+	$6,800	5.3+ yrs	538,100 kBtu	Y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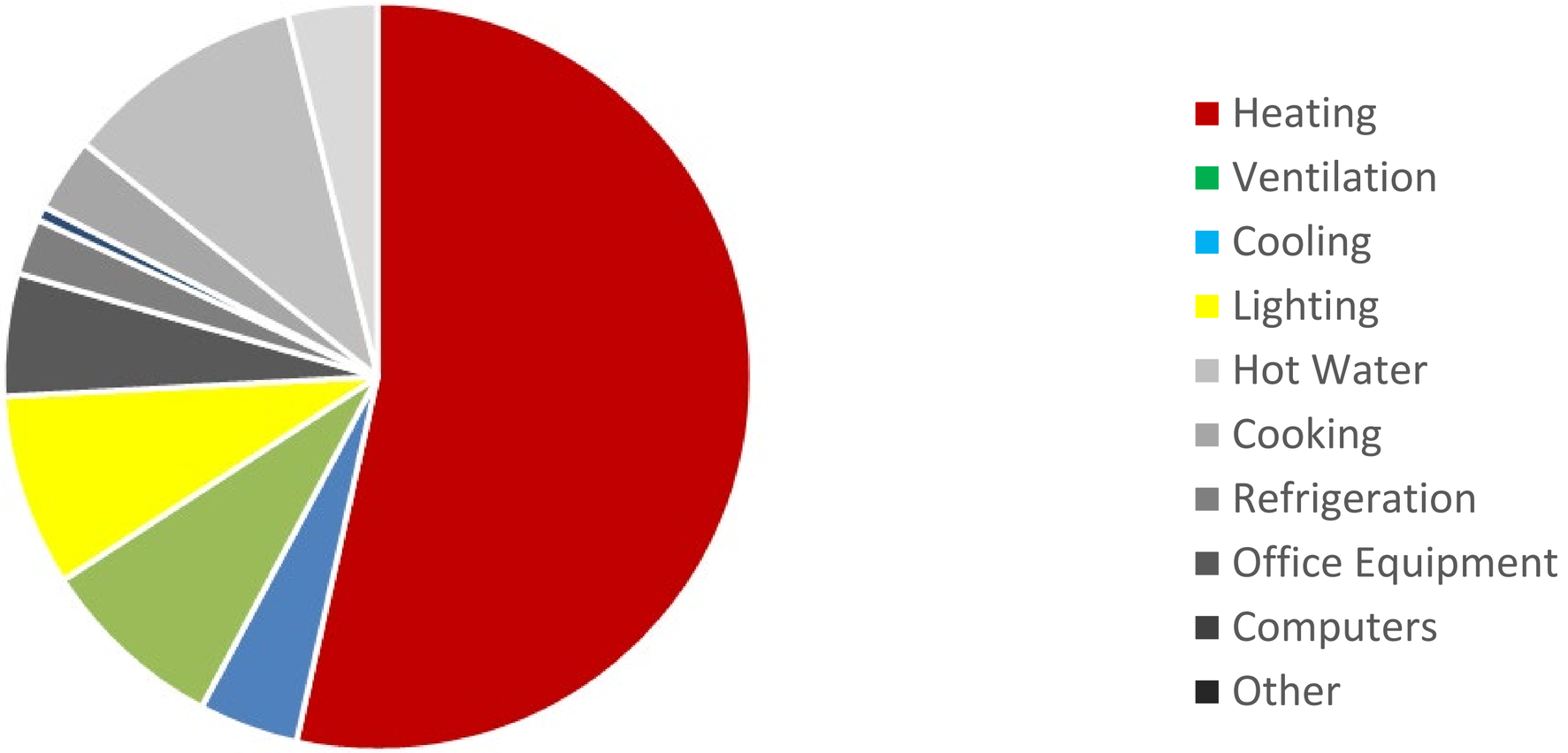
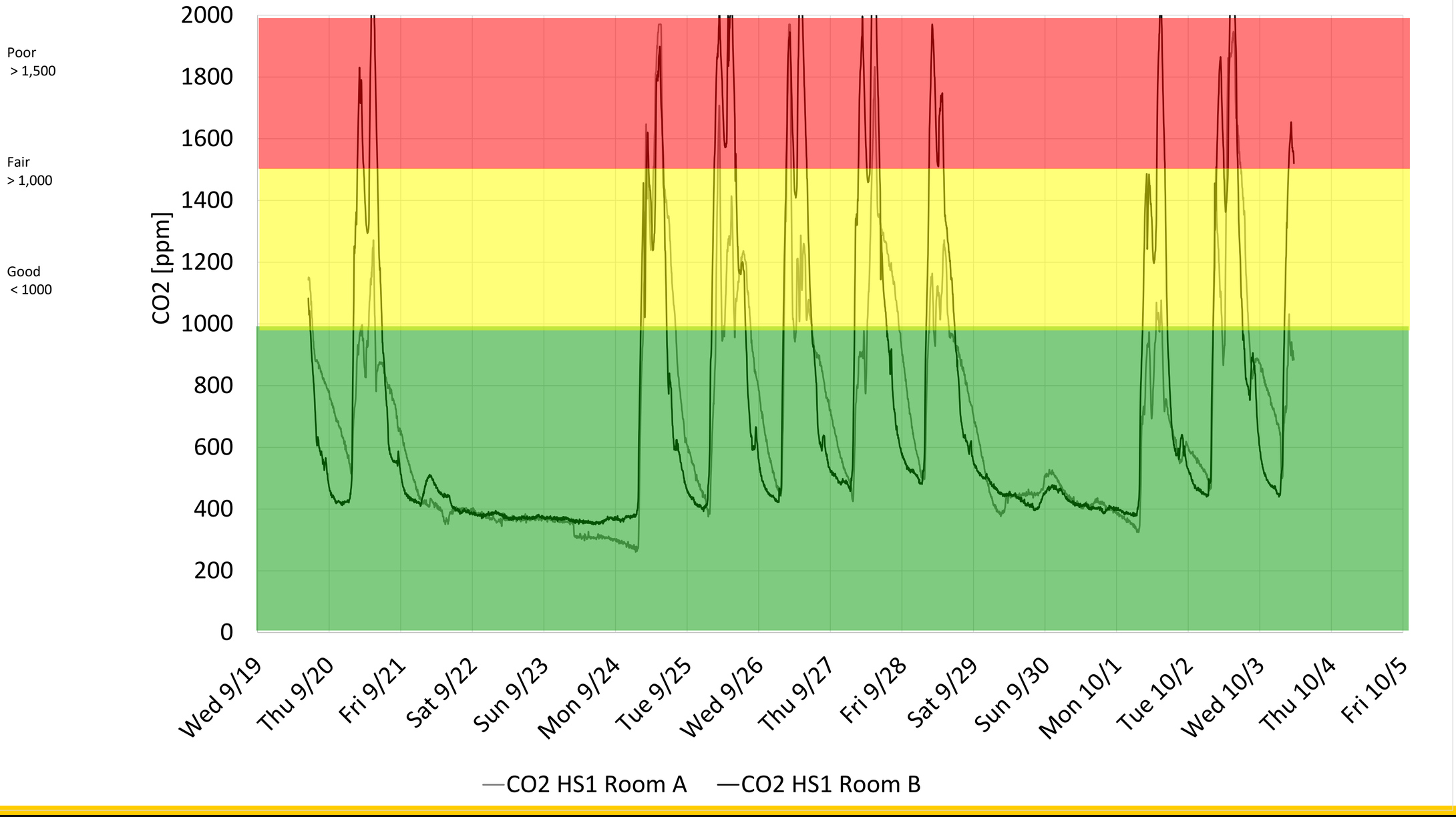
Education
Collapsing Roofs, Broken Toilets, Flooded Classrooms: Inside the Worst-Funded Schools in the Nation
by Becca Savransky, Idaho Statesman, photography by Sarah A. Miller, Idaho Statesman
April 13, 5 a.m. EDT

ENERGY USE IN SCHOOLS



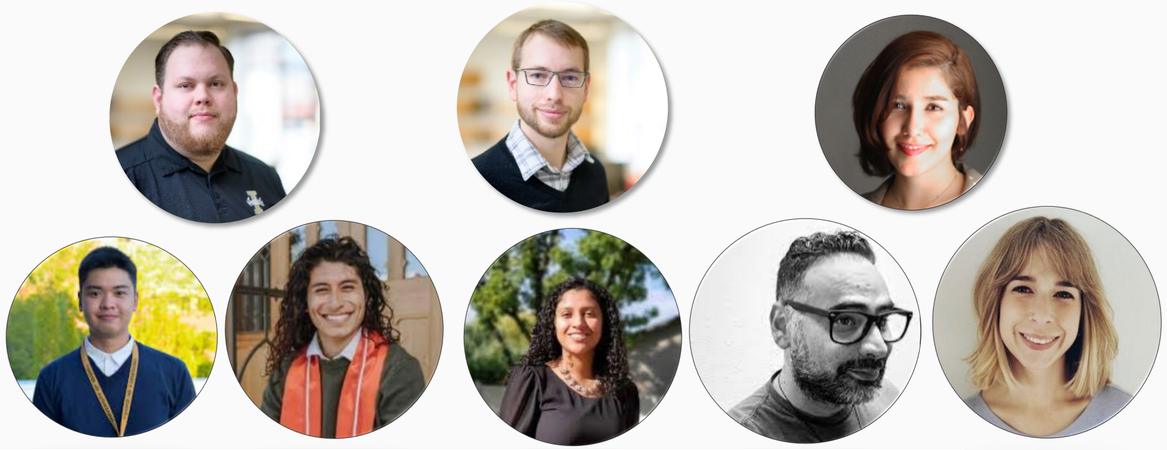
Source: EIA Commercial Building Energy Consumption Survey – Energy Consumption by End Use (Educational Facilities cool climate zones) 2018

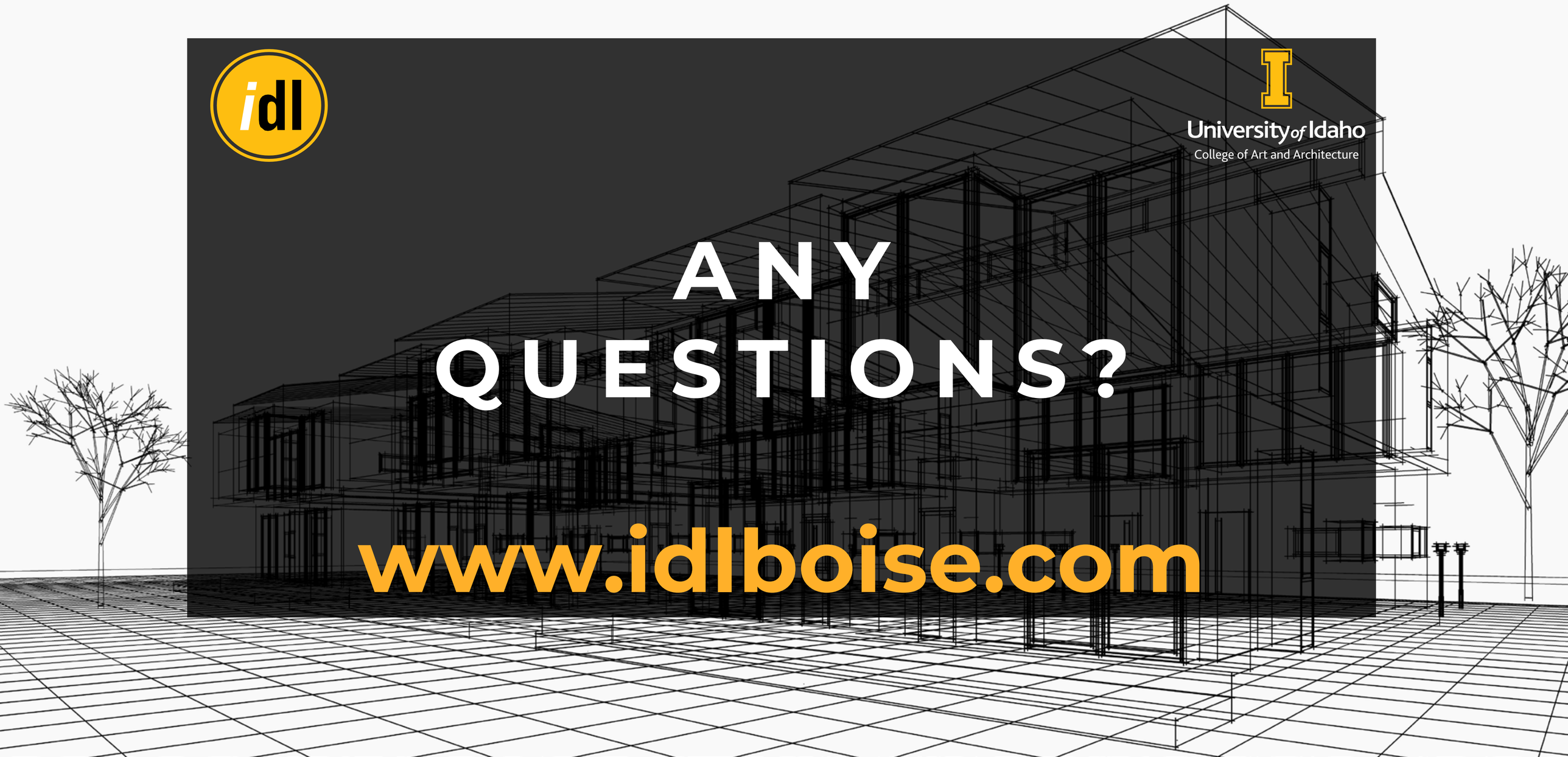
Indoor Air Quality at Idaho High School #1



Other Lab Research Areas and Funders

1. Energy Code Training (NEEA)
2. Commercial Natural Gas Consumption Survey (Intermountain Gas Co.)
3. Lunch & Learn Lecture Series (Idaho Power Co.)
4. Technical Design Assistance (Idaho Power Co.)

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