

From Gas to Grass, Passive Strawbale Home Building in the City



Homeowners /builders

- Katie Jones
 - Community Program and Policy Manager at Center for Energy and Environment
- Peter Schmitt
 - Solar Developer at US Solar



Acknowledgements – The Team

- Precipitate Architecture
- A² Design
- Andrew Morrison, Strawbale.com

Contents



Motivations



Why Straw?



Navigating Approvals



The Build



The Math



Inspiration

- Solarschiff – Freiburg, Germany (Top)
- Waldsee Biohaus in Bemidji (Left, middle)
- S-haus near Vienna, Austria (right)



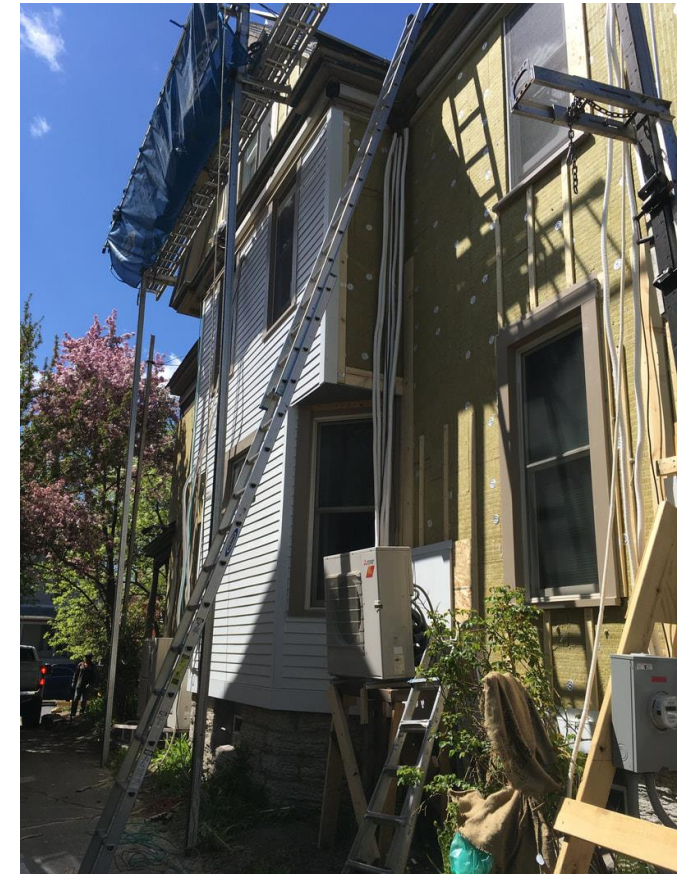


Twin Cities Inspiration

- Nordeast Nest
- Net Zero Victorian
- First Approved Strawbale Home in MN

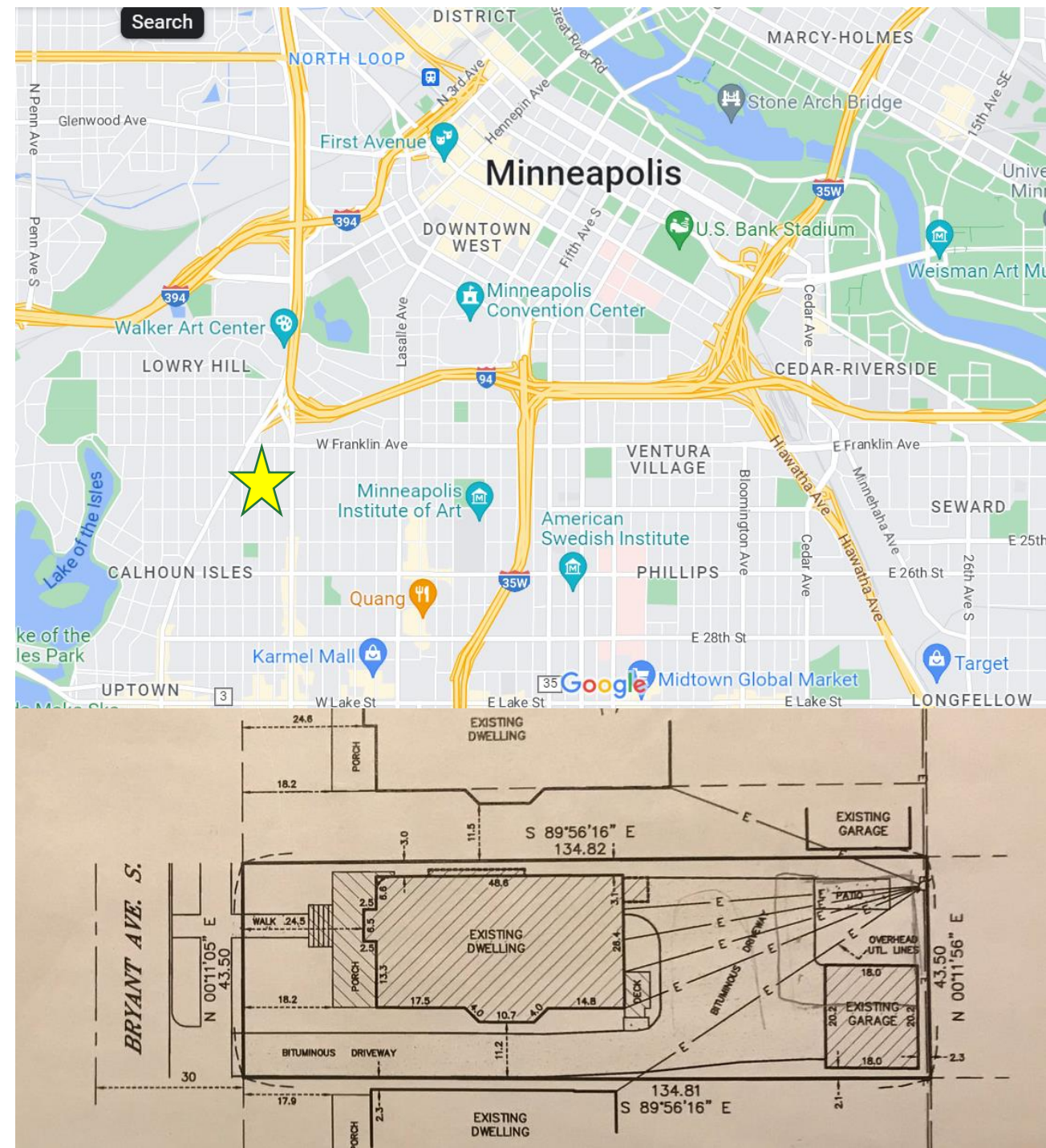
6-year Triplex Decarb

- 79% CO2 reduction
- Insulation + airsealing
- Solar
- Exterior Retrofit
- Heat pumps



Project Goals

- Small footprint
- Infill ADU/Cluster development
- Walk/bike/transit
- Low carbon materials
- Passive house
- Net zero energy construction and operation



control layers

CONTINUOUS INSULATION

AIRTIGHTNESS

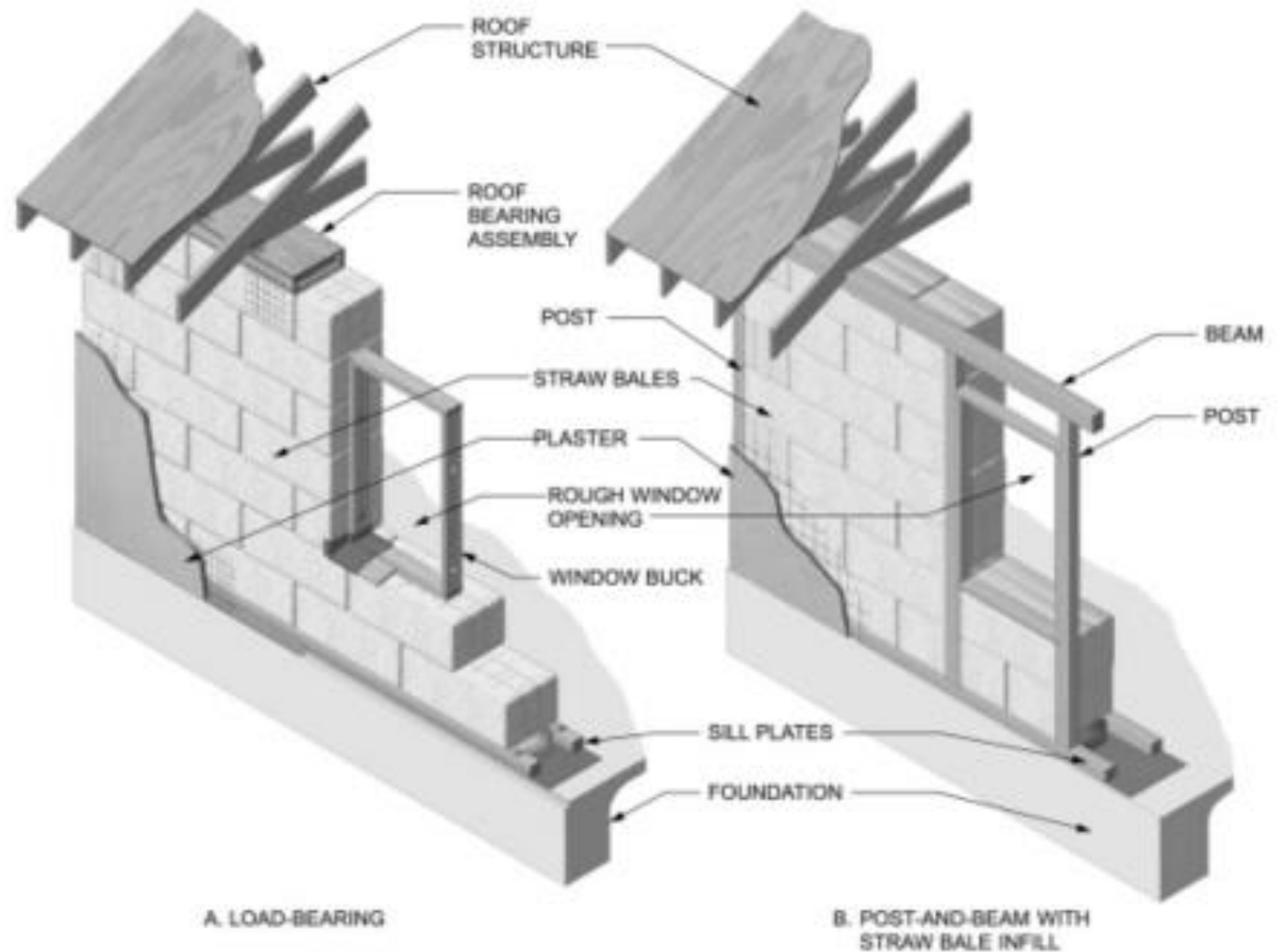




Why Straw?

Strawbale Assembly

- Plaster sandwiches the bales
- Stressed skin system + galvanized wire mesh



Appendix S

International Residential Construction Code officially recognizes strawbale construction

The screenshot displays the International Codes (ICC) Digital Codes Library website. The top navigation bar includes links for 'Search Codes', 'About premiumACCESS', 'What Are Building Codes?', a search icon, a grid icon, and a 'Sign In' button. A green sidebar on the left contains a list of code sections under the heading 'All Codes | I-Codes'. The sections listed are: 'APPENDIX S STRAWBALE CONSTRUCTION', 'SECTION AS101 GENERAL', 'SECTION AS102 DEFINITIONS', 'SECTION AS103 BALES', 'SECTION AS104 FINISHES', 'SECTION AS105 STRAWBALE WALLS—GENERAL', 'SECTION AS106 STRAWBALE WALLS—STRUCTURAL', 'SECTION AS107 FIRE RESISTANCE', and 'SECTION AS108 THERMAL INSULATION'. The main content area on the right features a header for '2018 International Residential Code' with a heart icon and the text 'First Printing: Aug 2017'. Below this is a promotional banner for 'premiumACCESS' with a 'Start Your Trial' button. The main heading for the content is 'APPENDIXS STRAWBALE CONSTRUCTION'. A disclaimer states: 'The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.' A 'User note:' section follows, containing a paragraph about the increasing use of strawbale construction since the 1980s and the prescriptive requirements provided in Appendix S.

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APPENDIXS
STRAWBALE CONSTRUCTION

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.

User note:

About this appendix: The use of strawbale construction has steadily increased since the 1980s such that there are now buildings of strawbale construction in every state in the U.S. and in more than 50 countries around the globe. Estimates are that there are over 1,000 buildings of strawbale construction in California alone, including both residential and commercial buildings. Appendix S provides prescriptive requirements for the construction of exterior and interior walls, both structural and nonstructural, in buildings that are under the scope of this code.

In field research

Strawbale.com workshop near Seattle



Benefits

1 Fire Resistance

- 2 hr fire rating @ 1850F

2 Thermal mass

- 18" bale depth; R-25 to R-30

3 Sound

- Envelop of not-stiff layers with sufficient mass
- Impeded transmission and improved energy sound absorption

Case Study #1: Sonoma



fig.1. Norrbom Road Strawbale Home - fires burned to the foundation on but not up the walls.

Benefits

4 Waste reuse

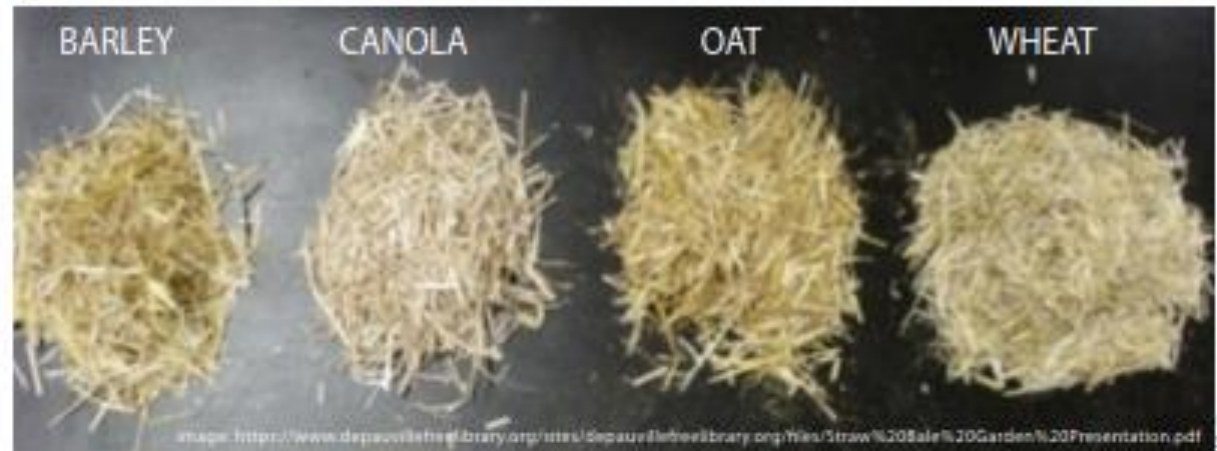
5 Low embodied energy

- Strawbale: 0.24 MJ/KG
- Cellulose: 0.45 MJ/KG
- Fiberglass: 30.3 MJ/KG
- EPS foam: 117 MJ/KG

6 Carbon Sequestration

- 26lbs carbon/bale
- The Uptown Strawhouse will sequester 9000 lbs
= 10k miles drive = 5 acres forest

7. Community building



But what about?

- Pests – sealed walls = no pests
- Electrical – direct burial of UF-B cable in bales
- Plumbing – keep to interior walls and faux walls
- Moisture – plaster allows for some vapor movement to allow for drying; design elements are also key



image: The Three Little Pigs

Strategies to combat moisture

Design

- NO vapor barrier
- Big eaves
- Bales start above snow line
- Bales sit on toe ups and gravel
- Windows sit basically flush with wall exterior

During Construction

- Bales tested for <20% moisture
- Keep out of rain during construction
- Install moisture sensors



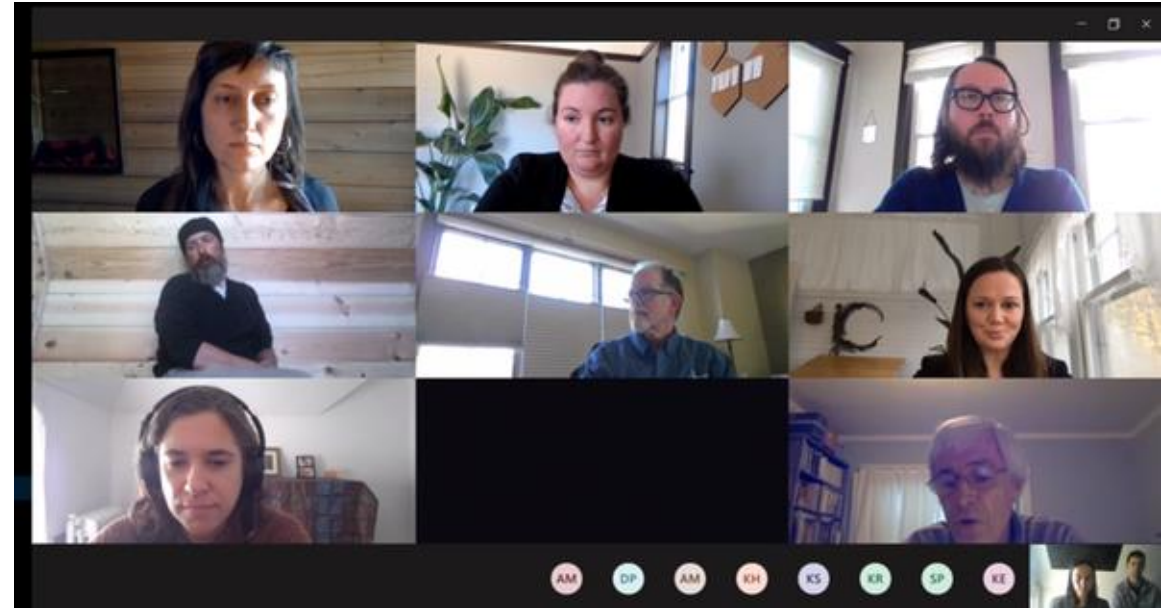
Navigating city approvals

Zoning

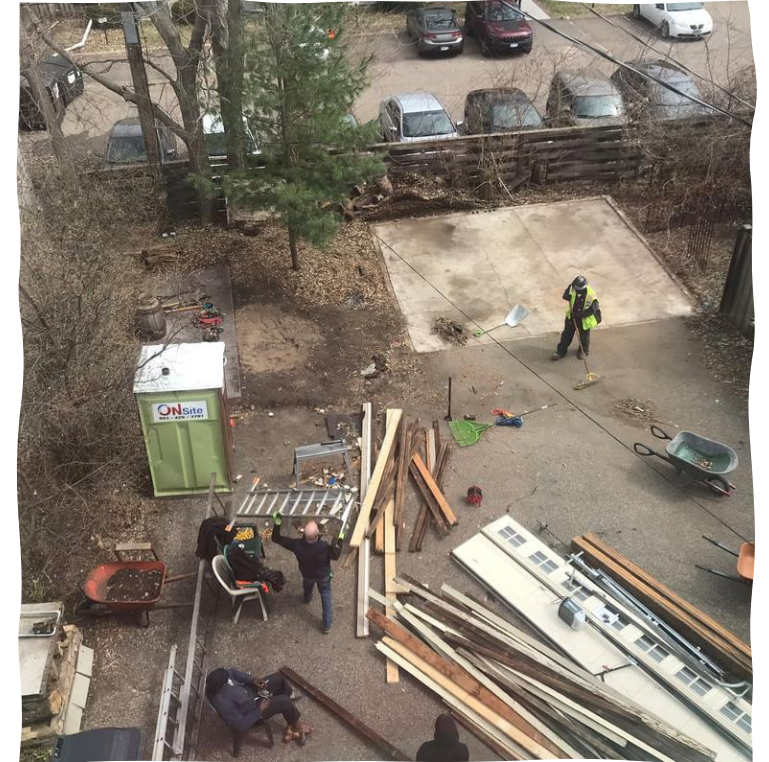
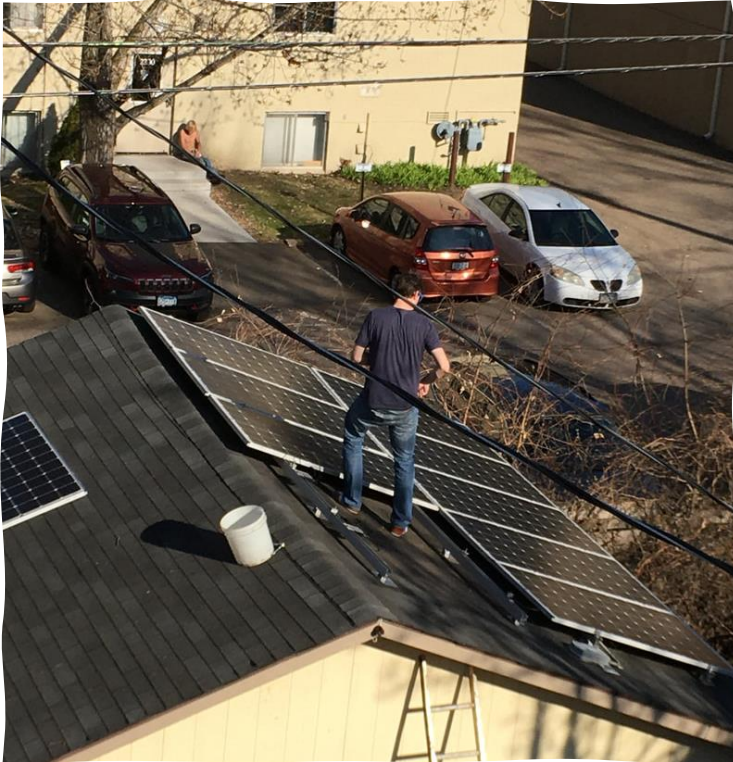
- Setback and lot coverage variances approved Feb. 2020
- Classified as cluster development
 - 4th unit to the site
 - Allowed for larger building compared to ADU

Permits

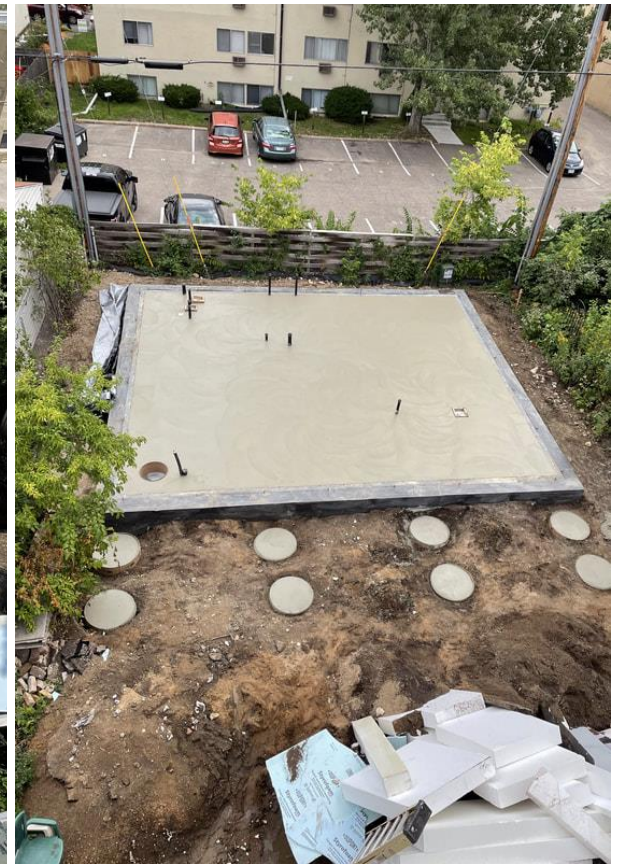
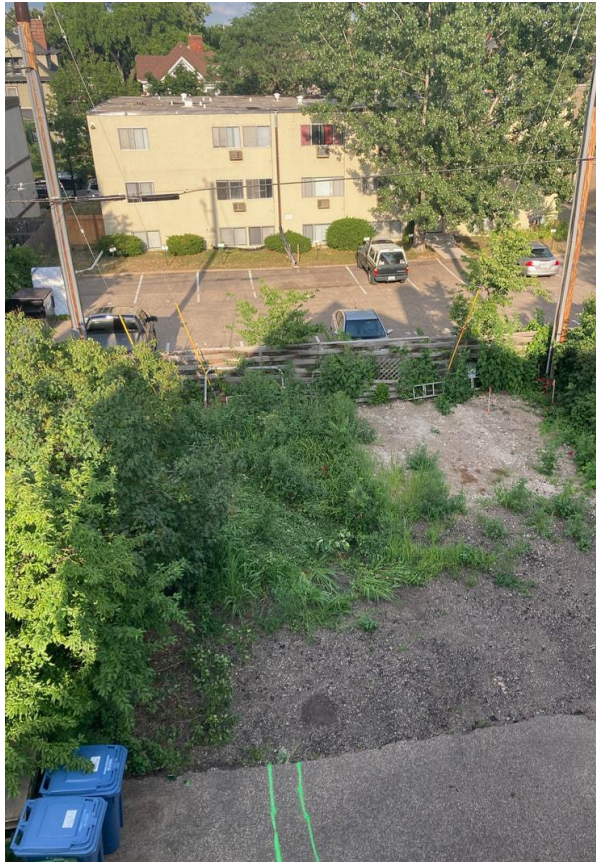
- After “no’s” and no movement for 4 months Katie organized a meeting with:
 - City council president
 - Other council aides
 - Building officials
 - Strawbale expert
 - Lead author of Appendix S



Prepping for The Build



Foundation

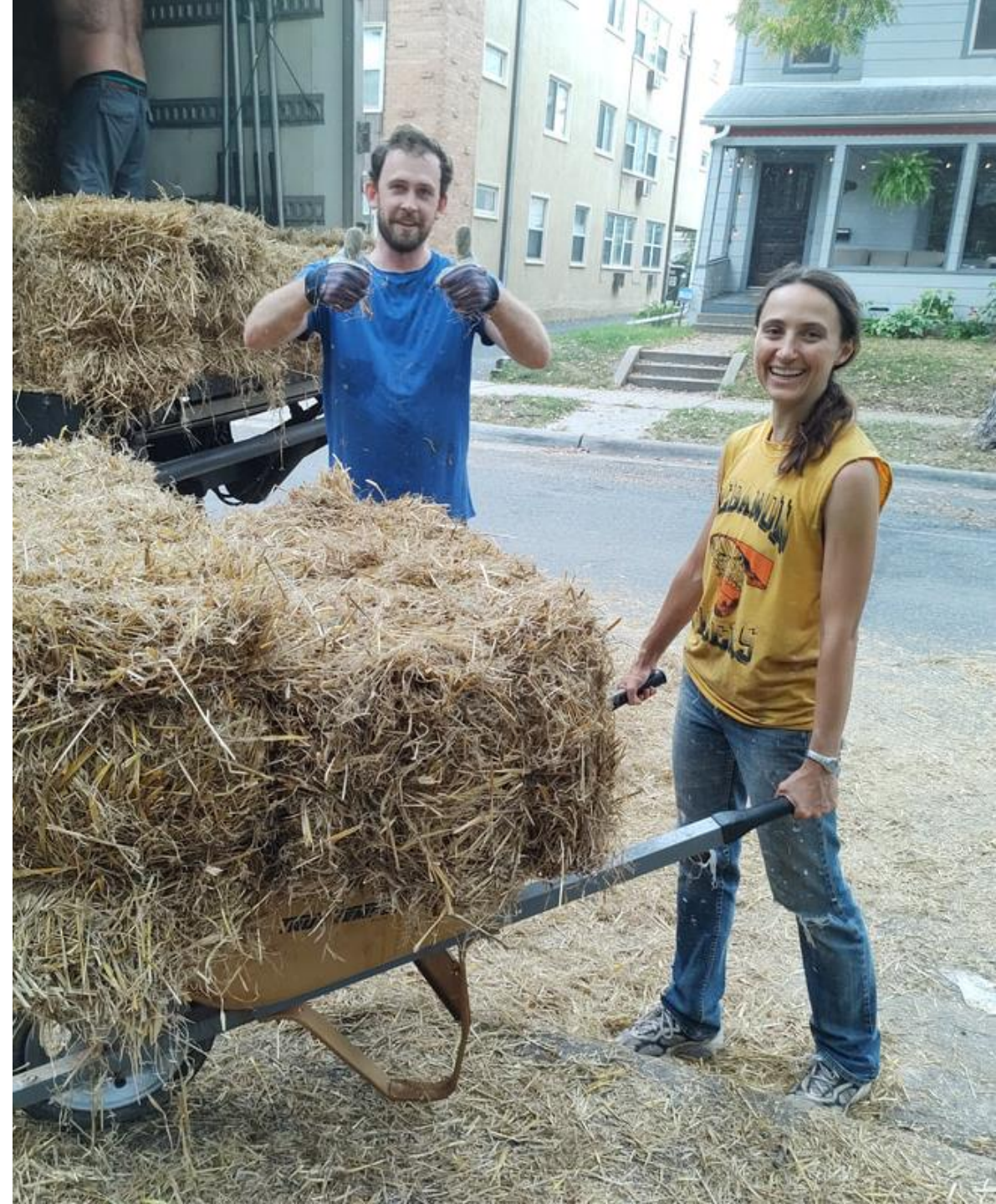


Post and Beam Structure



Moving Straw

- 650 Bales from Fredrick, WI
- Found via Facebook Marketplace
- 12 friends helped unload

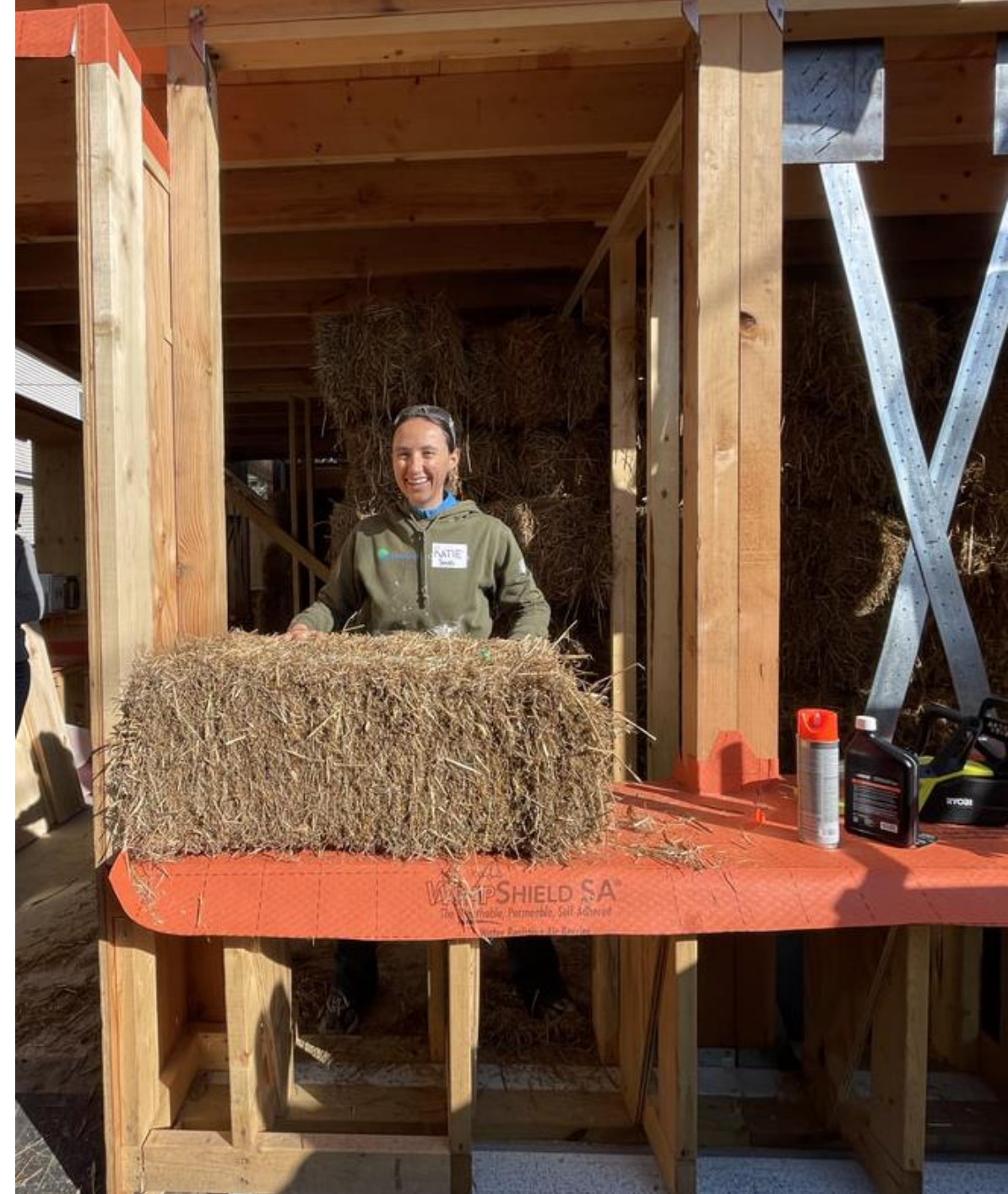




Storage + Moisture Testing

- Strawbales from floor to ceiling on both floors
- Moisture levels <20%

- First Bale!
- Lessons from Andrew



3 Main Steps of Strawbale

1. Setting bales
2. Meshing/Sewing
3. Plaster

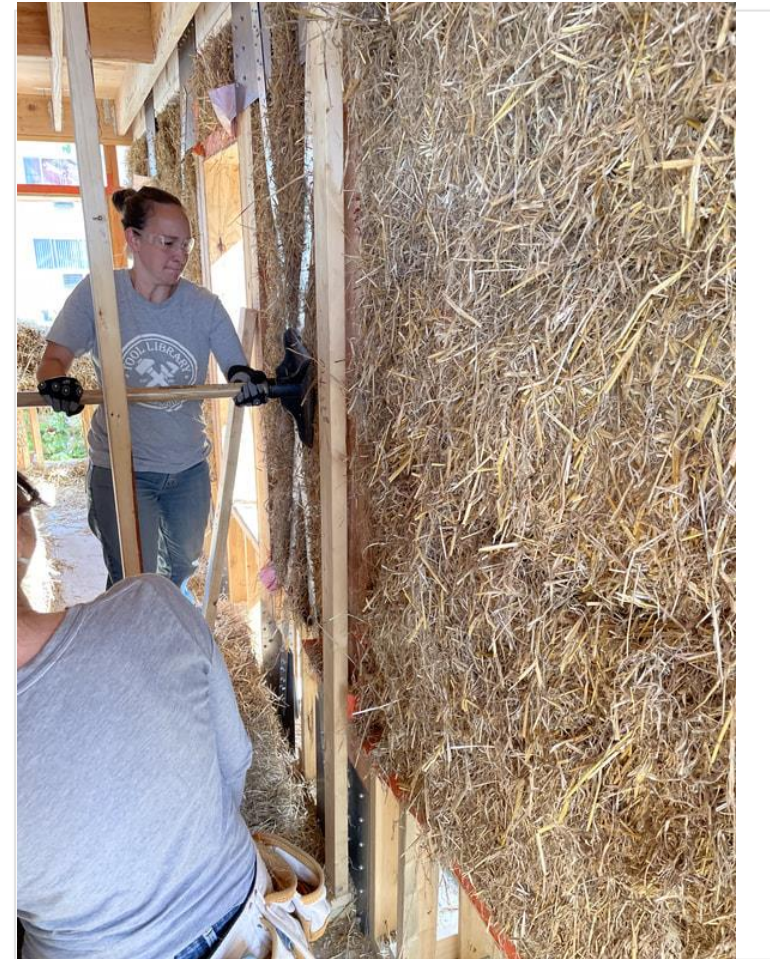




1. Baling



Depillowing, retying, tamping





Inside look



2. Meshing and Sewing

Tools and Materials:

- 2 x 2 inch wire mesh
- Twine
- 2 foot needle
- Giant tension fork



3. Plastering



Plastering



Interior plaster finish



systems

HEATING/COOLING

AIR SOURCE HEAT PUMP WITH
DUCTED AIR HANDLER

VENTILATION

DEDICATED BALANCED
VENTILATION SYSTEM WITH
ENERGY RECOVERY

DHW

(2) TANKLESS ELECTRIC HOT WATER
HEATERS



heating, cooling & dehumidification
Mitsubishi Condensing Unit - outdoor



heating, cooling & dehumidification
Mitsubishi Ducted Air Handler - indoor



Ventilation
Zehnder Q350 Comfoair



DHW*
Bosch WH17 Trosle 6000C* verify w. GC

Next steps

- Interior finishes
 - Painting
 - Flooring
 - Tile
 - Cabinets
 - Doors



The Math

How to fit it all in

- Costs
- Energy
- Carbon



COORDINATE THIS PLAN WITH STRUCTURAL, MECHANICAL, ELECTRICAL, PLUMBING AND INTERIOR FINISH PLAN. NOTIFY ARCHITECT OF ANY DISCREPANCIES.

8. REFER TO ROOM FINISH SCHEDULE FOR THE LOCATION AND FACE OF STRUCTURAL POSTS.

9. DIMENSIONS AT WINDOWS AND DOORS ARE THE RUGH-UP TO FACE OF THE FINISH MATERIALS.

10. REFER TO ROOM FINISH SCHEDULE FOR INTERIOR FINISH MATERIAL TYPES.

11. REFER TO DOOR SCHEDULE FOR INFORMATION ON DOORS AND SCHEDULES. REFER TO KEY WITH DOOR SCHEDULE. NOTIFY ARCHITECT OF ANY DISCREPANCIES.

12. LARGER SCALE DRAWINGS OF PARTS OF THIS PLAN, WHEN REQUIRED, SHALL BE SUPERSEDED BY THIS PLAN.

13. EXTERIOR WALLS SHALL BE INSULATED AND AIR SEALED. REFER TO DETAIL SHEETS FOR INSULATION, AIR AND VAPOR BARRIERS, AND FINISHES. PROVIDE JOINTS TO CONFORM TO ALL APPLICABLE CODES.

14. ALL OPENINGS CUT, PENETRATIONS MADE OR EQUIPMENT INSTALLED IN EXTERIOR WALLS, FLOORS OR CEILINGS SHALL BE PROTECTED TO MAINTAIN THE INTEGRITY AND RESISTANCE OF THE AIR SEAL TO THE FULL SATISFACTION OF THE ARCHITECT. THE GENERAL CONTRACTOR SHALL COORDINATE AND BE RESPONSIBLE FOR THIS WORK.

15. PROVIDE RECESSED SHIMS TO HOLD THE ROOM FINISH SCHEDULE AND AS NOTED ON REFLECTED CEILING PLAN.

16. REFER TO INTERIOR DETAILS FOR INFORMATION ON SHIMMERS, BOFFETS, ACCESS PANELS, WALL CAGE, ATTIC HATCH, FLOOR TRANSITIONS AND OTHER INFORMATION ABOUT INSULATION, AIR AND VAPOR BARRIERS.

17. PROVIDE BLOCKING IN WALLS FOR MOUNTING EQUIPMENT, FURNITURE, RAILINGS, AND ALL OTHER SPECIALTIES AND ACCESSORIES.

18. PROVIDE PAPER, VENT, AND CONDENS PENETRATING WALLS, FLOORS OR CEILINGS SHALL HAVE FINISHED TRIM RINGS (SCUTCHES).

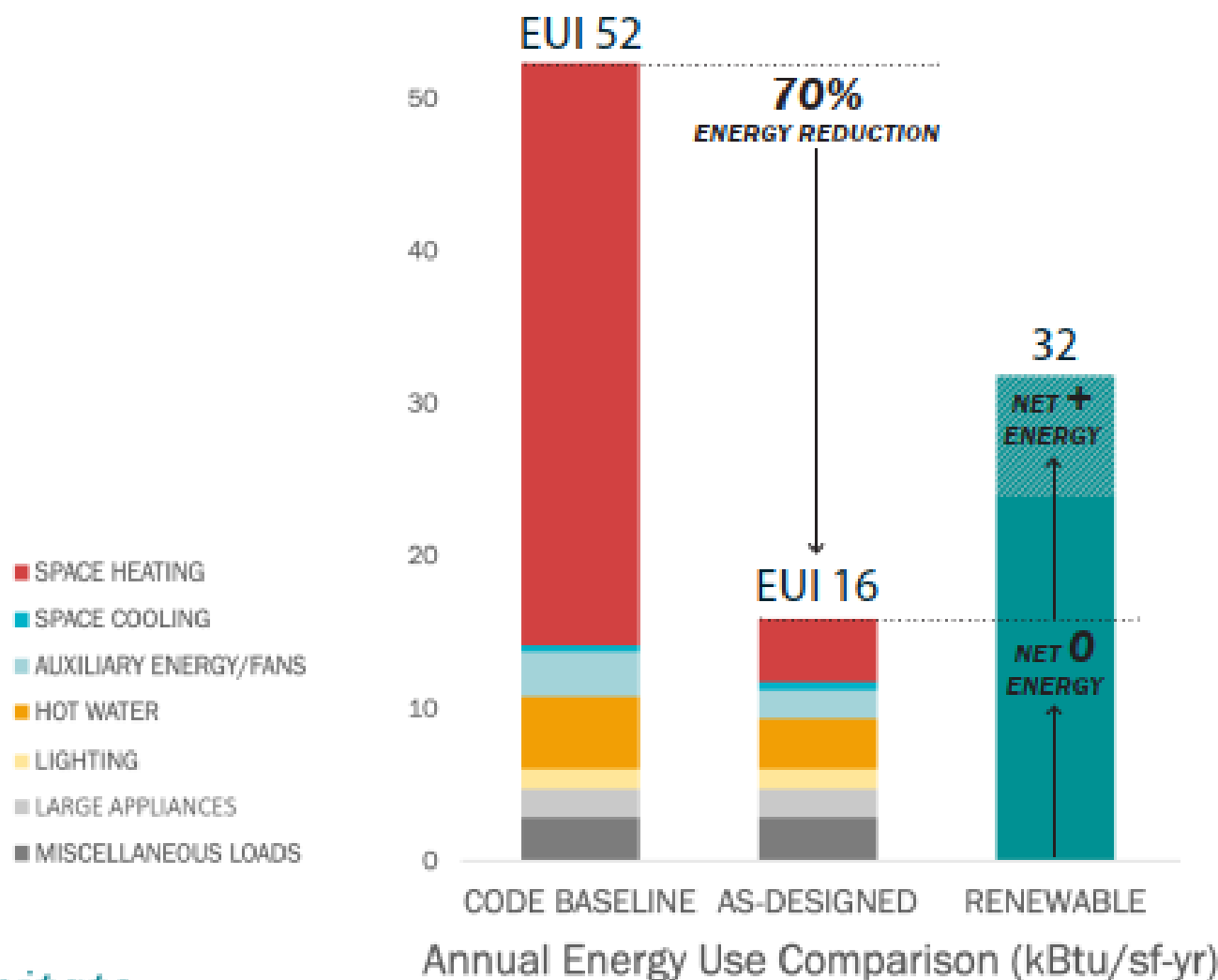
19. EXTERIOR LANDING, STOPS AND PORCHES SHALL BE FINISHED TO MATCH EXTERIOR BUILDING 14' FLOOR JOIST.

[illegible]

What about the cost?

- New material -> new learning -> more time -> more \$\$
 - Architect
 - Builder
 - Subs
 - City
- Small site
- Pandemic
 - High wood costs; supply chain issues

energy equation



CODE BASELINE

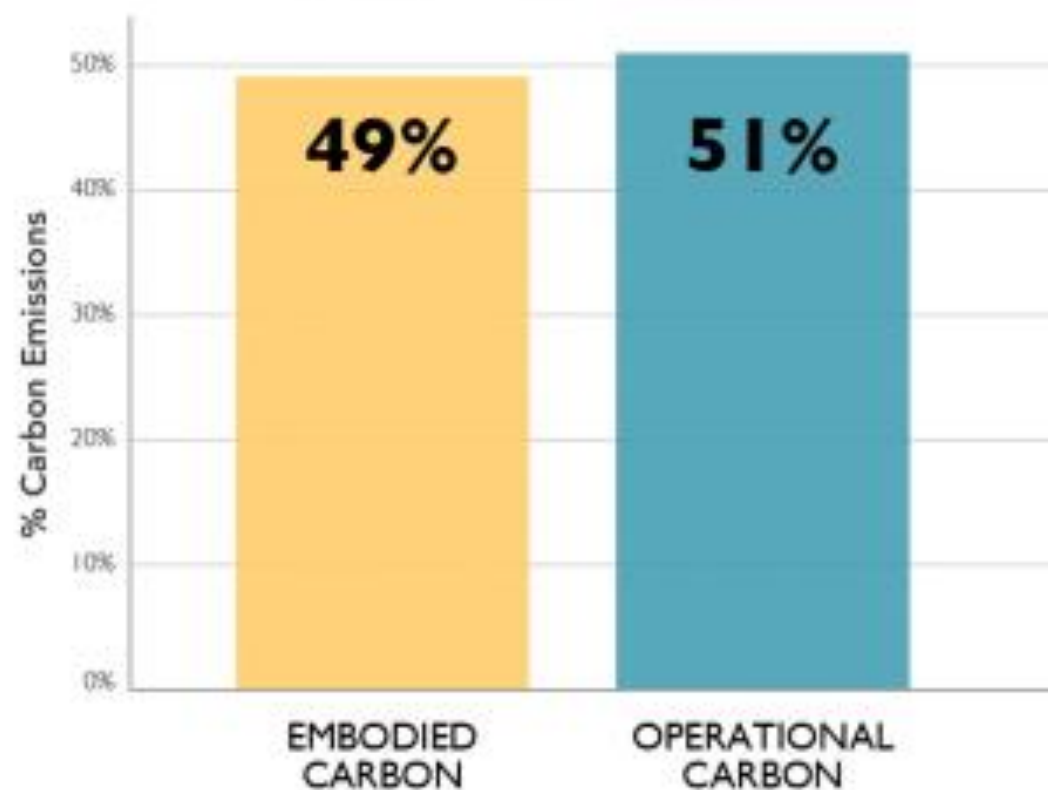
Heating demand:	47.1 kBTu/ft²yr
Cooling demand:	1.21 kBTu/ft²yr
Heating load:	23.51 Btu/hr ft²
Cooling load:	3.05 Btu/hr ft²
Source energy:	12,308 kWh/Person yr
Site energy:	65.91 kBTu/ft²yr

UPTOWN STRAWHOUSE

Heating demand:	20.89 kBTu/ft²yr
Cooling demand:	2.22 kBTu/ft²yr
Heating load:	12.86 Btu/hr ft²
Cooling load:	3.21 Btu/hr ft²
Source energy:	7,458 kWh/Person yr
Site energy:	20 kBTu/ft²yr

carbon tracking

Total Carbon Emissions of Global New Construction from 2020-2050 Business as Usual Projection



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EIA International Energy Outlook 2017

carbon equation - exterior walls

+ EMBODIED CARBON EMISSIONS

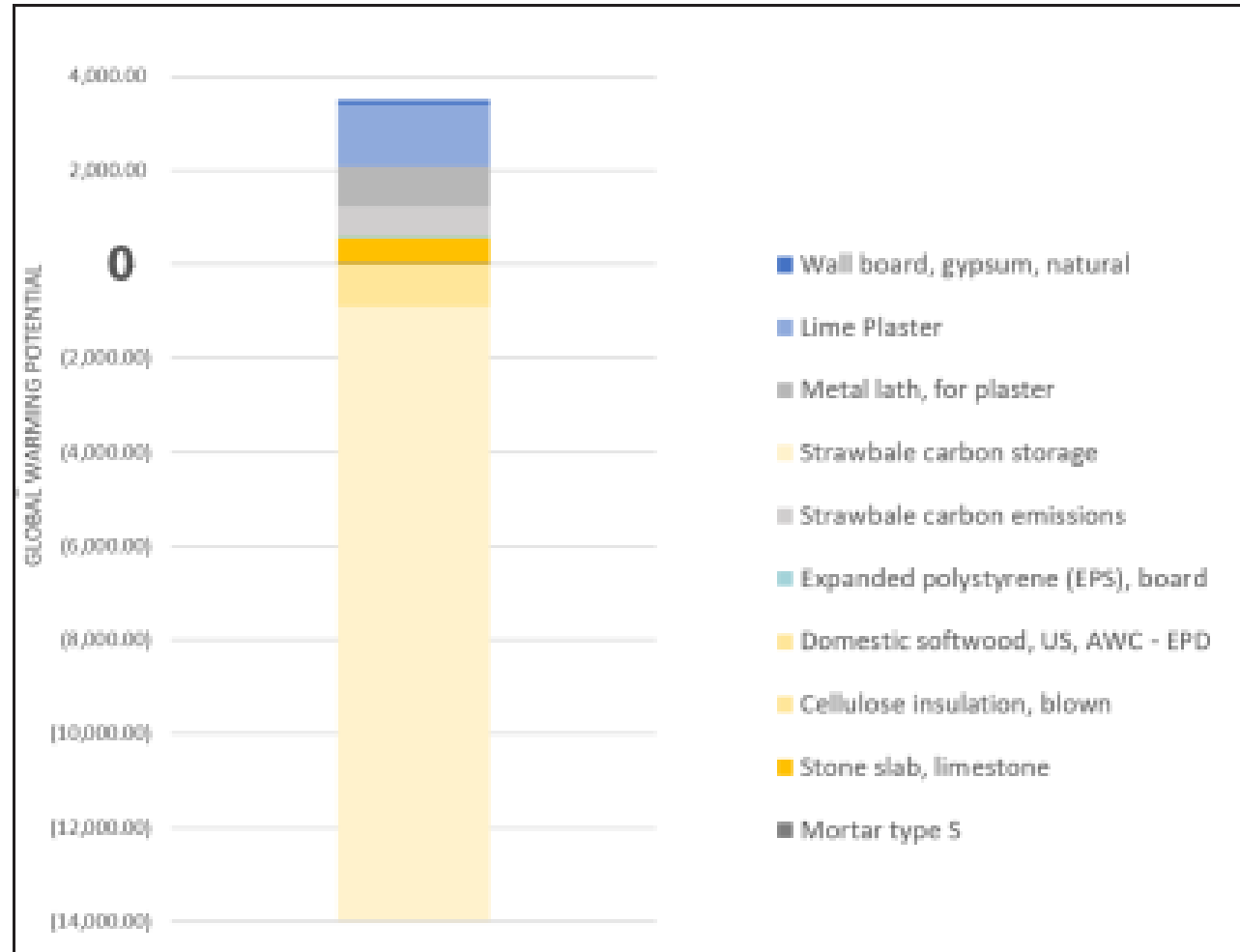


- EMBODIED CARBON STORAGE

BIOGENIC MATERIALS DRAWDOWN CARBON

*

GLOBAL WARMING POTENTIAL



Accomplishments

- Carbon negative build
- Supports climate friendly lifestyle
- Avoided LOTS of plywood (subfloor, ceiling, etc.)
- Avoided lots of glues
- Focus on “noble materials” of wood, stone, metal, straw
- Highly efficient
- 100+ volunteers exposed to natural building



Lessons Learned

- Design
 - Triple pane glazed doors are more insulative than all wood
 - Plumbing is best on interior; otherwise make 2x4 chase
- Process
 - Advocate for yourself!
 - ADU vs cluster impacts
 - Cities should consider how fronts of back buildings are treated
 - Don't use an aviation hanger engineer for a house. Result: over engineered = \$\$



Lessons Learned

Build

- Buy LONG stem straw; short straw makes for bad bales
- Do hydroscopic modeling before construction
- Hire a plaster crew

Improvement opportunities for next time

- Gravel for under foundation insulation
- Alternatives for radon mitigation?
- Natural alternatives for air sealing?
- Alternative to poly twine?



Thank you!

[Katie Jones](#)

katiemjones0@gmail.com

uptownstrawhouse.weebly.com

