Big Area Additive Manufacturing Applied To Buildings

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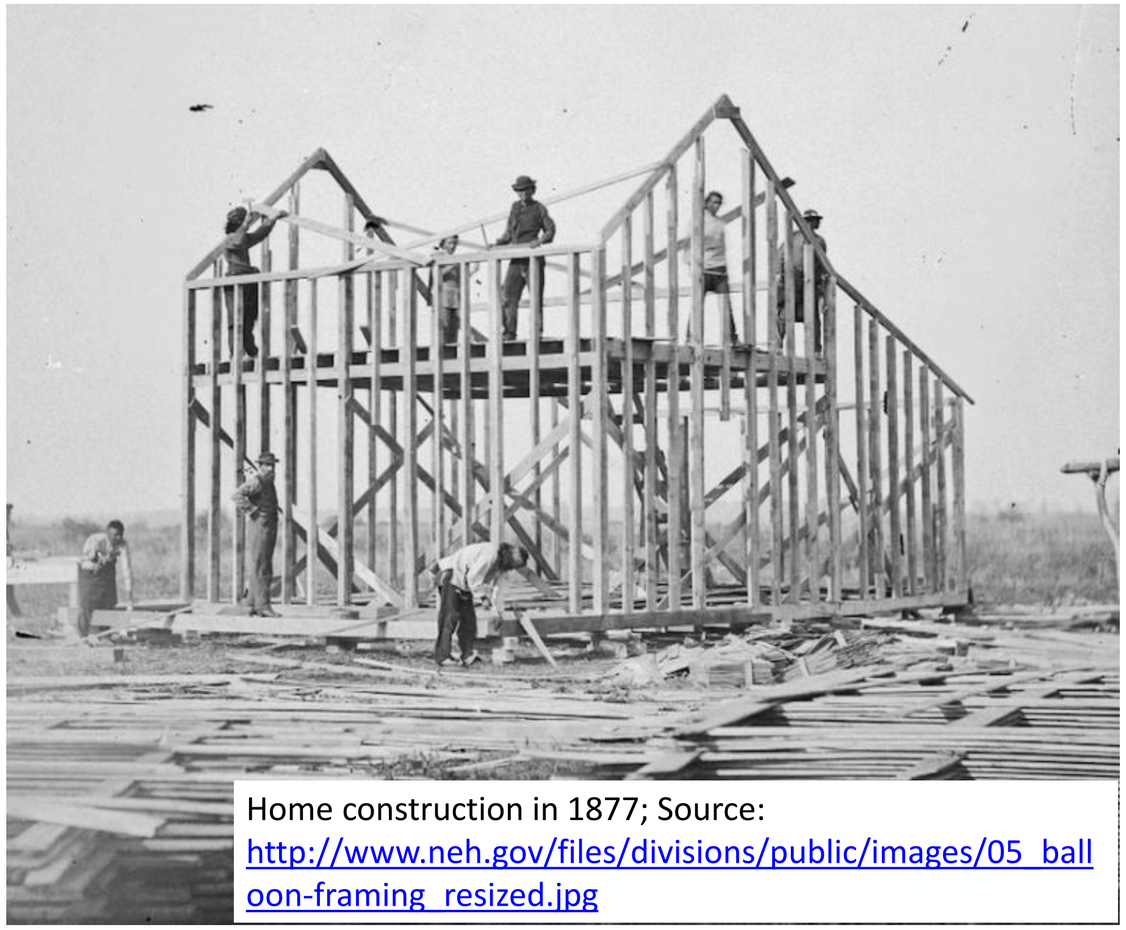
Dec 7, 2016

What if we could redesign our houses?

Source: http://mainestickbuilthomes.com/



Home construction in 1877; Source: http://www.neh.gov/files/divisions/public/images/05_balloon-framing_resized.jpg

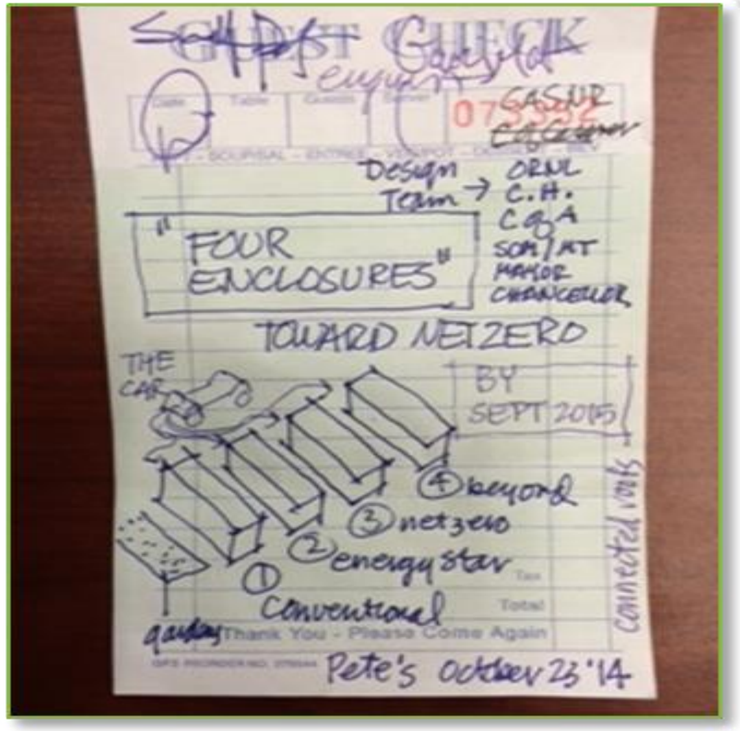
What if we could use our vehicles as power sources?

What if we could make our power systems independent and resilient?

AMIE: Redefining what's possible

Harnessing strong government-industry collaboration

October 2014



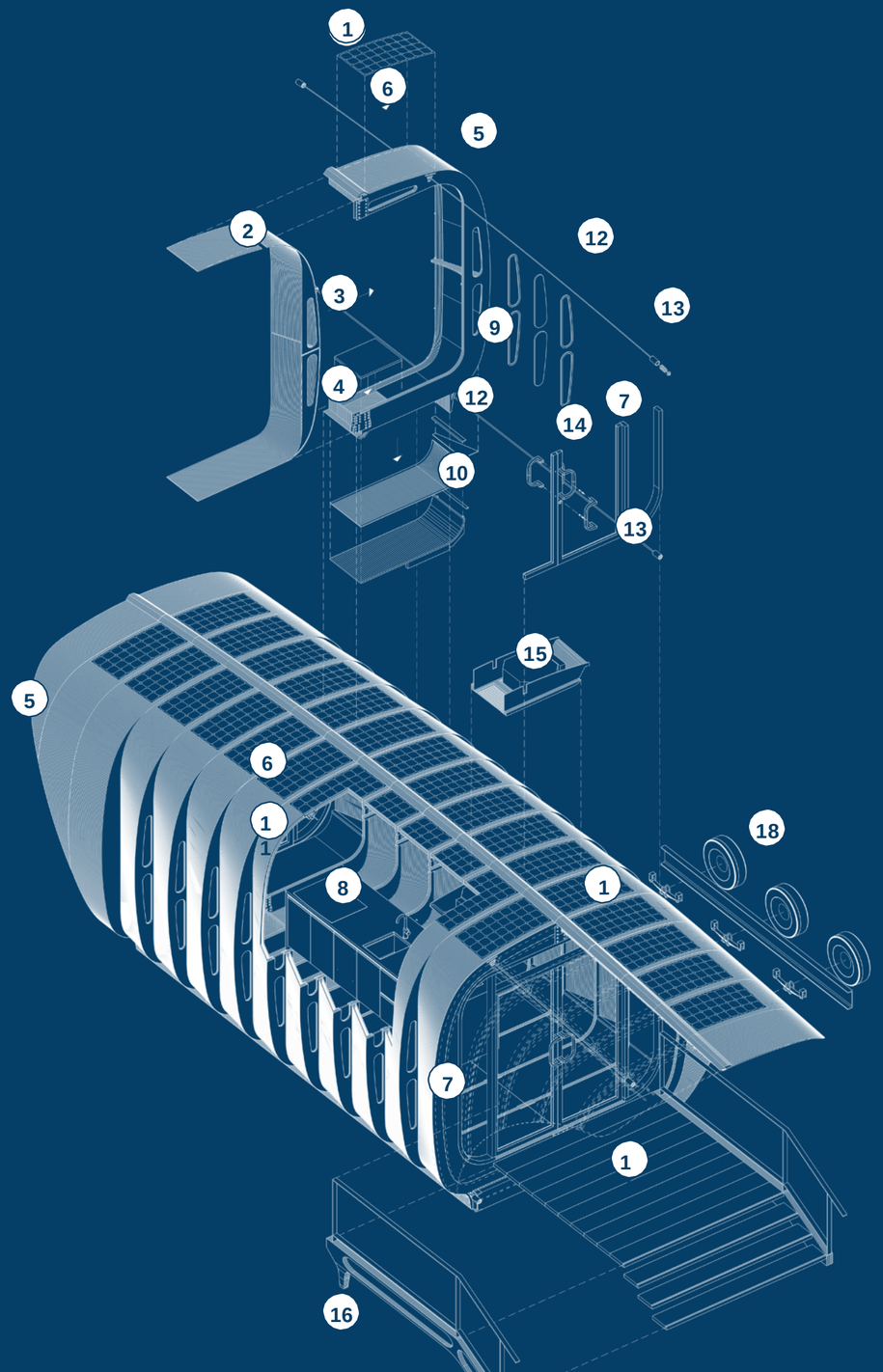
January 2015–September 2015

Novel 3D Printed Vehicle

AMIE
A First Step into the Future

AMIE is a single-room enclosure that demonstrates the unique capabilities and characteristics of additive manufacturing (3D printing), utilizes advanced insulation products, showcases innovative technology in appliances and fixtures, and is paired with a revolutionary mobile energy source.

1. **Thin film monocrystalline PV panels**
2. **Printed interior panel**
3. **Vacuum insulated panels**
4. **Steel joining plate**
5. **Printed exterior envelope and structure**
6. **Printed sleeve for tension rod & LED light**
7. **IGU storefront**
8. **Micro-kitchen**
9. **Glazing**
10. **LED light**
11. **Linoleum flooring**
12. **Steel tensioning rod in greased sleeve**
13. **Disc spring assembly**
14. **Printed door handles**
15. **Minisplit**
16. **Printed stringer**
17. **Aluminum planks**
18. **Steel chassis & removable wheels**



Designing for Zero Waste

AMIE pioneers 3D-printed panels that combine the many functions of a conventional wall system—structure, insulation, air and moisture barriers, and exterior cladding—into a single integrated system. This can lead to zero-waste construction and buildings that can be ground up and reprinted in different forms; or created using recycled materials.

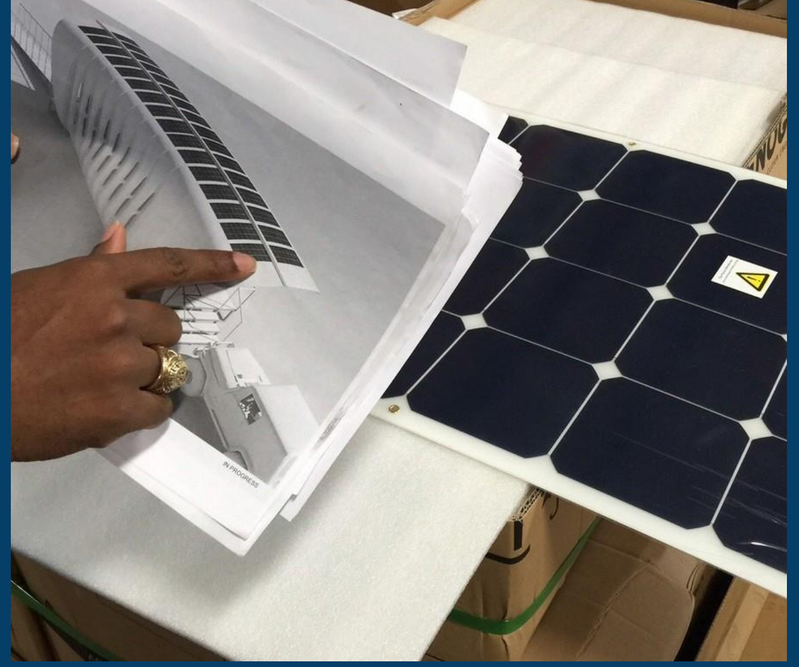
The environmental protection agency (EPA) estimated that the generation of construction and demolition debris in the United States (U.S.) to be 170 million tons in 2003, with 39% and 61% contributions from the residential and nonresidential sectors, respectively.

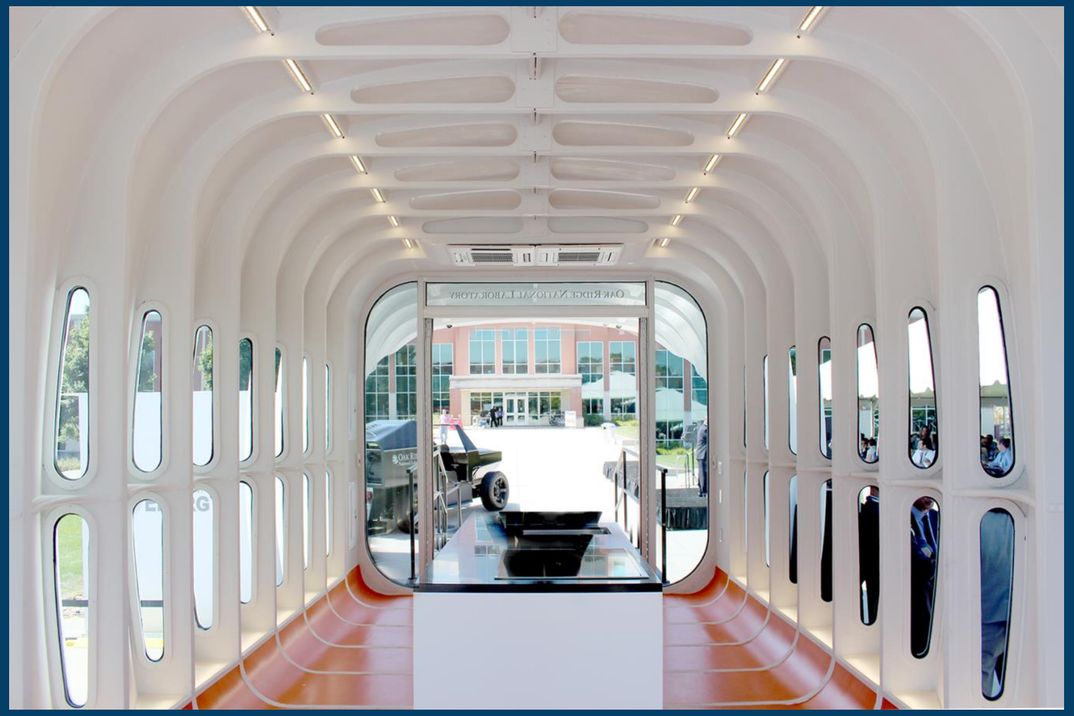
Applying Complex Geometries

Three-dimensional printing allows for complex geometries with rounded corners and curved surfaces that reduce localized stress and mitigate turbulent exterior air flow. The panels create a structural design optimized for live loads, lateral forces, and impact resistance.

Maximizing Energy Efficiency and Renewable Energy

Its high level of solid surfaces (79%) to glazed areas (21%) results in an extremely efficient energy-conserving enclosure. Photovoltaic panels are integrated into the roof surface and supplement the vehicle energy source. The panels' interior ribs are designed for vacuum insulation panels for the greatest thermal barrier in the least amount of space.

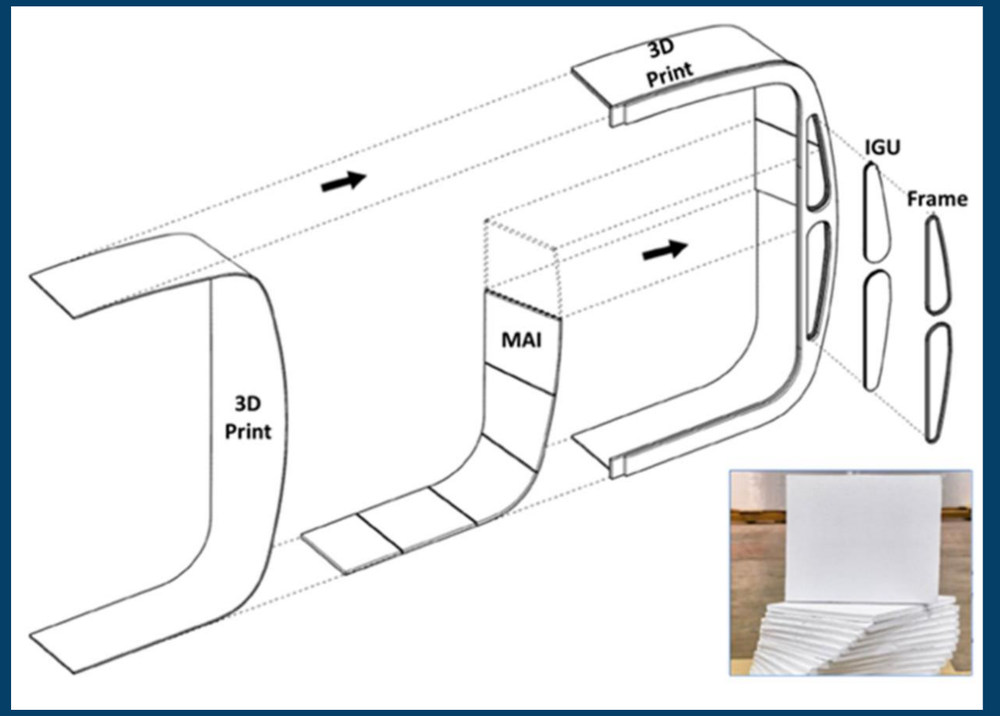




Modified Atmosphere Insulation Panels / Wall Sandwich

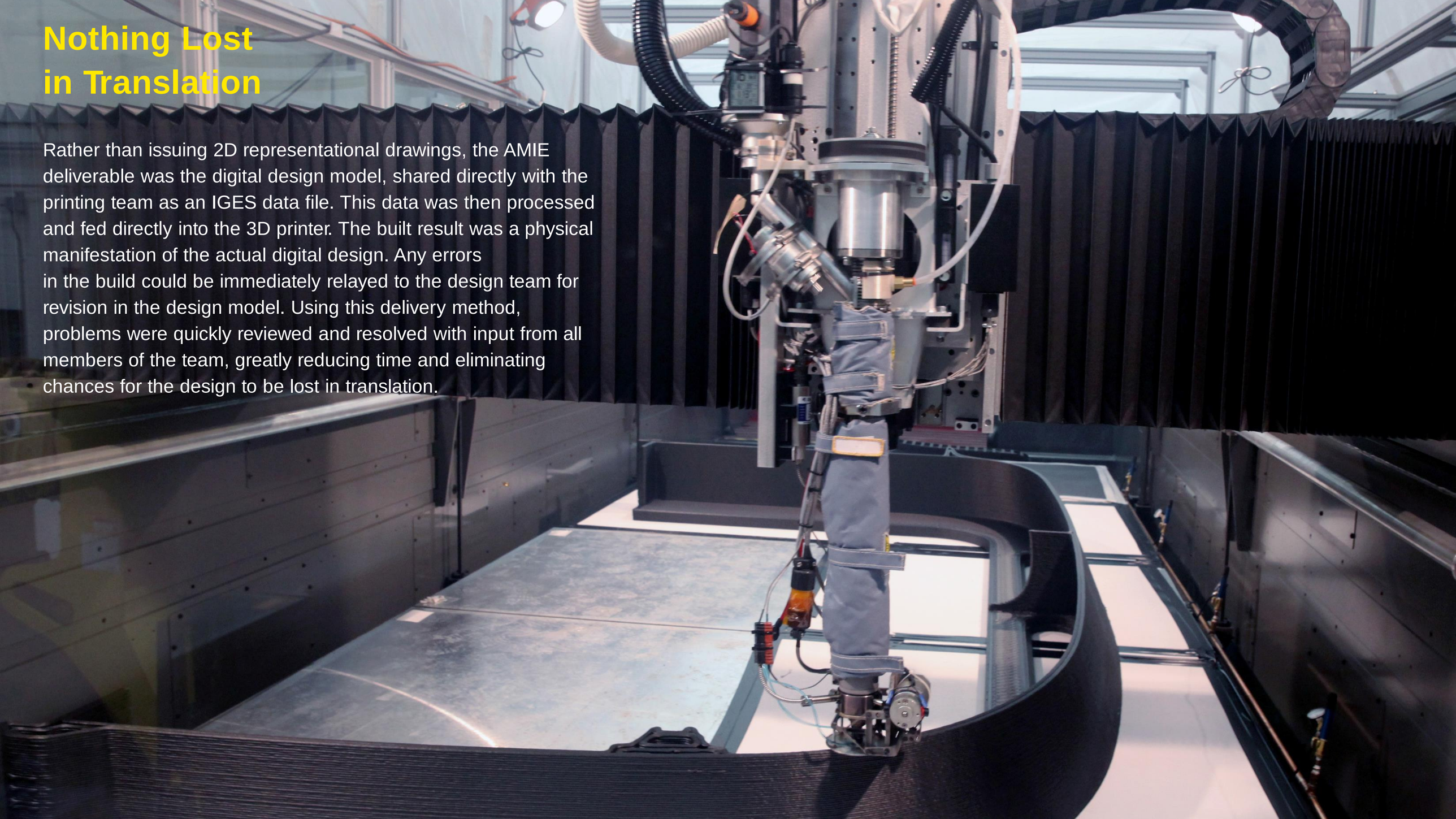
One of the energy-efficiency goals of the research was to use a new, low-cost vacuum insulation called modified atmosphere insulation panel (MAI). Early test results of the one-inch thick MAI panels yielded a thermal resistance of R-35.

By comparison, 3.5 inches of typical residential batt insulation has an R value of only R-13. The size of a MAI-panel module became a major design driver for the width of AMIE's printed C rings, each of which is lined with a single continuous loop of MAI.



Nothing Lost in Translation

Rather than issuing 2D representational drawings, the AMIE deliverable was the digital design model, shared directly with the printing team as an IGES data file. This data was then processed and fed directly into the 3D printer. The built result was a physical manifestation of the actual digital design. Any errors in the build could be immediately relayed to the design team for revision in the design model. Using this delivery method, problems were quickly reviewed and resolved with input from all members of the team, greatly reducing time and eliminating chances for the design to be lost in translation.



2015.06.30_AMIE1.0_Ring_E_Inner_L_Prt01.igs

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1H,,1H;,,                                                                       G      1
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Rings (E-F)\2015.06.30_Rings_E-F\IGES\2015.06.30_AMIE1.0_Ring_E_Inner_L_G      3
Prt01.igs,                                                                      G      4
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,                                                                               G      7
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3HSOM,                                                                          G     12
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     126      29       0       0       4       0       0       000010500D      7
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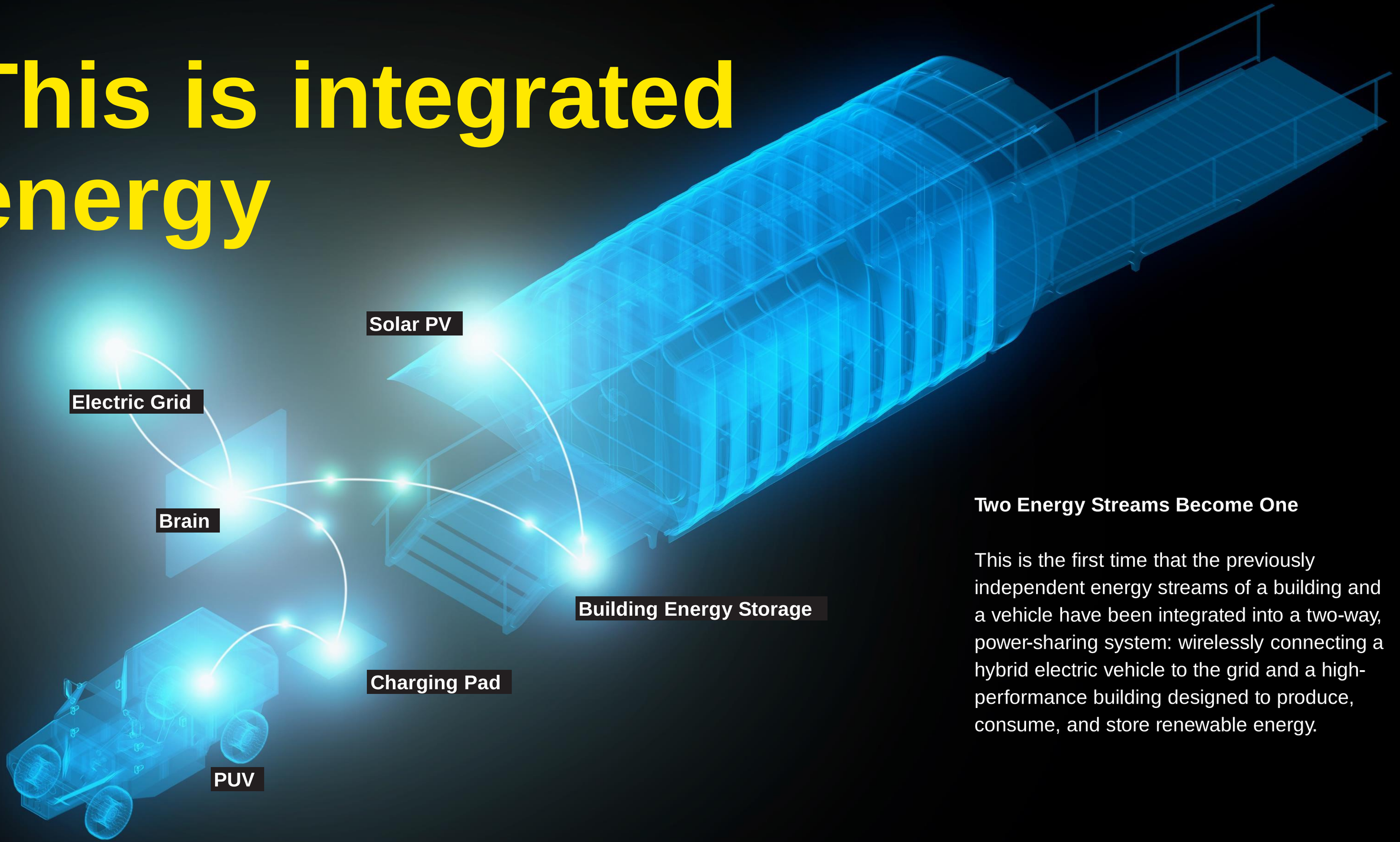
Structure

To prevent cracking in the “z” direction (perpendicular to the grain), the design used post-tensioning rods connected at the four corners with a spring assembly, ensuring structural tension during thermal movement. Correspondingly, sliding connections attached the structure’s base to its underlying steel support chassis.

Interiors

A center island incorporates micro living components for eating and sleeping. The island also includes a digital display with an interactive presentation on the integrated energy systems within AMIE. Natural daylight is supplemented with energy-saving LED lighting that is housed directly in the custom print overhead and a cove in the recycled, resilient flooring.

This is integrated energy

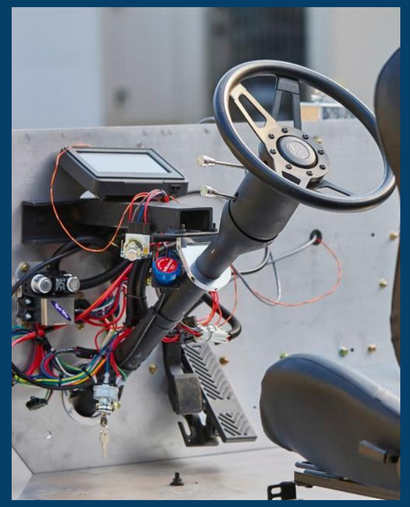


Two Energy Streams Become One

This is the first time that the previously independent energy streams of a building and a vehicle have been integrated into a two-way, power-sharing system: wirelessly connecting a hybrid electric vehicle to the grid and a high-performance building designed to produce, consume, and store renewable energy.

Printed Utility Vehicle (PUV)

AMIE was developed to address electricity supply and reliability challenges via an integrated approach to power generation, storage, and use. To offset power supply disruptions, the vehicle's engine can provide complementary power to the structure. Fitted with an advanced power control system and then scaled up, this concept could be applied to electricity needs worldwide.



Acknowledgments

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Thank you! Questions?