# Prefabricating Charles Moore: *Reinterpreted Saddlebags and Aediculae*

C. A. Debelius[1], *AIA, LEED AP*, R. C. Everhart[2], *AIA*, and J. A. Russell[3], *PhD*

[1]Dept. of Technology and Environmental Design, Appalachian State University, Katherine Harper Hall, 397 Rivers Street, Boone NC 28608-2122; PH (828) 262-6575; e-mail: debeliusca@appstate.edu
[2] Dept. of Technology and Environmental Design, Appalachian State University, Katherine Harper Hall, 397 Rivers Street, Boone NC 28608-2122; PH (828) 262-6354; e-mail: everhartrc@appstate.edu
[3] Dept. of Technology and Environmental Design, Appalachian State University, Katherine Harper Hall, 397 Rivers Street, Boone NC 28608-2122; PH (828) 262-7708; e-mail: russellja@appstate.edu

## ABSTRACT

Inspired by Charles Moore's strategy of the use of Saddlebags and Aedicule elements in residential design, this paper describes a design proposal for the retrofit of existing houses in a traditional suburban neighborhood with prefabricated Renewable Energy and/or Efficient Modules (REEMs). The conception and design of the modules is a response to two concerns:

- A 62% increase, between 1978 and 2005, in energy consumption in three of the primary components of residential energy demand: Water Heating, Air Conditioning, and Appliances and Electronics.
- The significant number of existing energy inefficient homes constructed prior to 2000.

Prefabricated Renewable Energy and/or Efficient systems are proposed as an effective means for reducing energy consumption in existing houses. These systems, comprised of (1) an array of Renewable Energy building skin systems (e.g., Solar PV, Solar Thermal, etc.) and (2) Renewable Energy and/or Efficient Modules (REEMs), are designed to decrease energy consumption—either by adding renewable energy capability and/or having more efficient energy systems. The prefabricated modules contain the equipment and components necessary to augment and/or replace the existing energy systems of the house.

The significance of the project, as distinguished from those proposals that focus on new construction, is the demonstration of a variety of design strategies for reducing residential energy consumption by retrofitting *existing* houses with mass-produced Renewable Energy and/or Efficient systems.

## PROLOGUE

*INCORPORATING FLEXIBILITY. The difference today that will enable modularization and mass production to succeed is its ability to be customizable. No longer does mass production have to produce the same repeated product; now flexible production methods allow for customization on a large scale.*

—Stephen Kieran and James Timberlake
*Refabricating Architecture: How Manufacturing Methodologies Are Poised to Transform Building Construction* (2004)

## INTRODUCTION

Rather than focusing on new construction, this paper describes a design proposal for significantly reducing energy consumption in existing single-family houses constructed between the end of WW II and the last decade of the twentieth century. The strategy calls for a building retrofit that employs the principles and techniques of *prefabricated construction* and *mass customization*.

It is the contention of the authors that this proposal not only meets a functional goal, i.e., the reduction of single-family residential energy demand, but holds the potential for significantly improving and enhancing architectural value by creating new and significant residential spaces. The argument in support of the latter point requires a brief exposition of Moore, Allen, and Lyndon's ordering device of the Saddlebag and the Aedicule in residential architectural design.

### Saddlebags and Aediculae

In their seminal work *The Place of Houses* (1974), Charles Moore, Gerald Allen, and Donlyn Lyndon describe their own version of the Vitruvian triumvirate of Firmness, Commodity and Delight, setting forth "the belief that houses must be special places within places," professing "…a special fondness for barns, which have a way of exhibiting …practical needs," and admitting an unabashed admiration for buildings that "display…the dreams and pretensions of their owners." Moore, *et al*, note that, though their clients' budgets were usually small and there was a great range in project scale and site, two essential formal ideas permeate the residential projects discussed: (1) the *Aedicule,* "a symbolic center in the midst of the specific demands of the household," and (2) Saddlebags, secondary and tertiary spaces for a specific use arranged about the central space. In the Bonham house (Santa Cruz County, California; 1961), for example, the tall central living space (with a large window with an expansive view to the surrounding redwoods) is flanked by kitchen, stairs, bathroom, and a "floating" bedroom loft. The house, small and inexpensive, "possesses great apparent size," in large measure due to the "juxtaposition of the spacious and the close" (Moore, Allen, and Lyndon, 1974).

The mutually reinforcing concepts of Aedicule and Saddlebag serve, in the present proposal, as the basis for a retrofit design strategy that improves energy efficiency while seeking to improve and enhance the architectural qualities of the houses.

## PROBLEM STATEMENT

Two disturbing facts serve as the impetus for the design proposal described here:

(1) <u>The 62% increase, between 1978 and 2005, in energy consumption in three of the primary components of residential energy demand: Water Heating, Air Conditioning, and Appliances and Electronics</u>. Recent data on changes in total energy use in U. S. homes between 1978 and 2005 indicates that a number of factors (e.g., Federal energy efficiency standards for major appliances, improved energy efficiency of heating equipment, better window design, better insulation) have led to a reduction in energy use per household of 31%. However, while the number of occupied housing units has increased by 45%, total energy use in homes has remained constant (10.58 quadrillion BTU in 1978 compared to 10.55 quadrillion BTU in 2005). Unfortunately, the dramatic 38% reduction in energy consumption for Space Heating has been largely offset by increases in consumption in three areas: Water Heating, Air Conditioning, and Appliances and Electronics. Given the increase in the number of households with dishwashers and with central air conditioning, it is not surprising that the 2005 energy consumption for Water Heating and Air Conditioning was 3.0 quadrillion BTU, an increase of 62% over 1978 energy consumption levels.

(2) <u>The significant number of existing energy *inefficient* homes constructed prior to 2000</u>. According to the 2009 American Housing Survey National Tables, there are 73M occupied single family detached housing units in the United States: in excess of 60M of those units were constructed before 2000.[i] While improvements in the construction of building envelopes, more stringent energy efficiency standards, and the development of renewable energy systems for new residential construction are laudable, it is evident that some means must be found for reducing energy use in older homes in order to reduce residential energy consumption in the decades ahead.

A reduction of 8% per annum in residential energy demand (relative to the 2005 energy demand value) equates to a reduction of approximately .93 quadrillion BTU each year: for comparative purposes, this figure is equal to the energy consumption of the U. S. military in 2009 (Karbuz, 2010).

## A DESIGN PROPOSAL

The design team recognized that, by employing the principles and techniques of *prefabricated construction* and *mass customization*, a solution could be developed that is both standardized (an energy efficiency module) and flexible: system components can be modified to respond to a multitude of criteria (e.g., owner preferences, project goals and budget, site constraints, solar orientation of the existing building, climate, building and zoning requirements). Furthermore, there are opportunities in some of the retrofit projects to provide Saddlebag spaces (e.g., bathroom, kitchen, carport) and Aediculae (e.g., an outdoor room, porch, or enclosed room) that will improve and enhance the architectural qualities of the house.

As part of the larger effort to reduce residential energy demand, the authors propose the design, construction and installation of prefabricated Renewable Energy and/or Efficient systems as an effective means for reducing energy consumption in existing houses. These systems are comprised of (a) an array of Renewable Energy building skin systems (e.g., Solar PV, Solar Thermal and even solar thermal air pre-heaters) and (b) Renewable Energy and/or Efficient Modules (REEMs) and connected to the existing building energy systems through an exterior wall). The prefabricated modules contain the equipment and components necessary to decrease energy consumption—either by adding renewable energy capability and/or substituting more efficient energy systems for the existing systems. When a southern exposure is not available, the REEMs will focus strictly on energy efficiency by using high performance tankless hot water heaters, next generation hybrid hot water heaters and fully integrated ultra-high efficiency HVAC units (both air to air and air to water units will be utilized). Regardless of whether the REEM is fitted with Renewable Energy capability, all modules will take advantage of highly efficient energy systems which are fully integrated into the module structure and require only electrical, plumbing, duct-work, and natural gas hookups. All modules, solar PV panels, and additional components will be prefabricated off-site at a single national or regional facility and shipped to a local distribution center or directly to the project site. Components will be designed to fit into 40foot high-cube shipping containers to allow for low carbon ship and rail transport in addition to the flexibility of truck transport.

An additional part of the retrofit strategy addresses energy loss related to antiquated fireplaces and chimneys. Older fireplaces are a continuous source of air infiltration. The development of highly efficient air to water heat pumps provides the thermal vehicle to remake inefficient chimneys as very efficient radiators and/or convectors that provide the functionality of thermal comfort and reinforce the understanding of hearth and living room as the symbolic center of the house (the Aedicule). The design has developed concepts that are compatible with most firebox designs which can provide both radiant and convective heat as required by the space and have the option for controlled release thermal storage using phase change materials.

Inspired by the concept of Saddlebags and Aediculae, the skin and energy module components of the system can be configured in a variety of ways:

1) As a stand-alone energy efficient module;
2) As an expanded energy efficient module with an energy and water efficient residential kitchen or bathroom [Figure 1];
3) As an energy efficient module with renewable energy capability (REEM) and a flexible array of solar photovoltaic panels (the array may be mounted to an existing roof or used to define a new outdoor room, carport, or porch); or
4) As an expanded energy efficient module with renewable energy capability (REEM), an energy and water efficient bathroom, and a flexible array of solar voltaic panels (the array may be mounted to an existing roof or used to define a new outdoor room, carport, or porch).

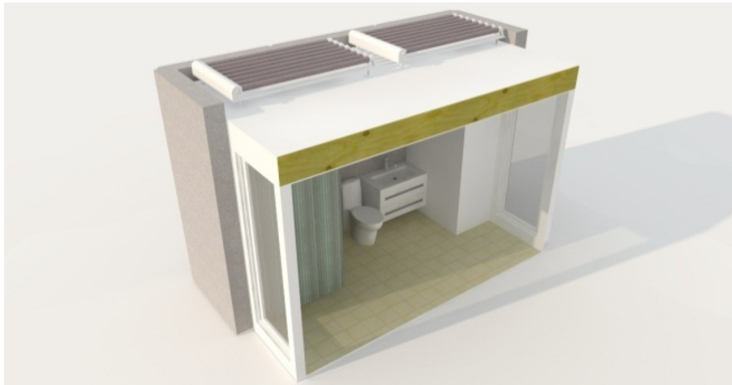

Figure 1: View of a Solar Thermal REEM as a modular component capable of being set in place with a small crane. The REEM contains a full bath that includes a vanity, toilet, and shower as well as a small mechanical room that houses the water heater and other Solar Thermal components, or can be configured as a laundry/mud room.

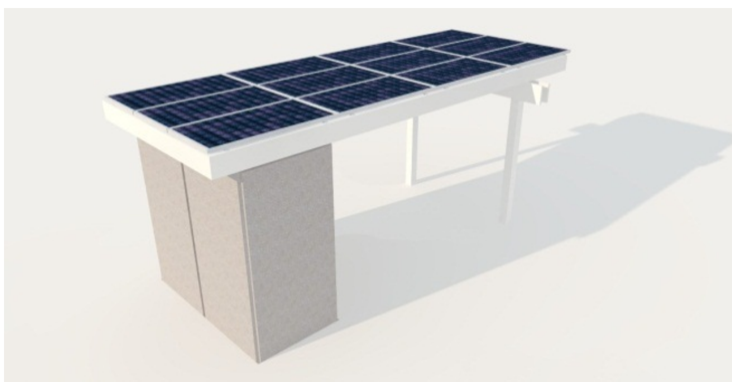

Figure 2: View of a Solar PV REEM as a modular component capable of being set in place with a small crane. The REEM contains posts, beams, a solar PV canopy, and a storage closet for PV components as well as general household items. Multiple modules of the REEM can combined to form various outdoor spaces, such as a carport or a porch.

Figure 3: View of a Solar Thermal Full Bath REEM and a Solar PV Carport REEM as modular components on a single flatbed trailer.

Figures 4 through 7 illustrate a retrofit that includes two energy modules/arrays: an expanded Solar Thermal REEM (with bathroom) and a Solar PV REEM (with an array of solar PV panels on the roof of a new carport).

Figure 4: Aerial view of a typical 3 bedroom, 1 bath ranch house facing north.

Figure 5: Aerial view of a typical 3 bedroom, 1 bath ranch house with a Solar Thermal REEM added as a full bath to the rear and a Solar PV REEM added as a carport to the side.

Figure 6: View of REEMs attached as saddlebags to a typical ranch house without obstructing the existing roofline.

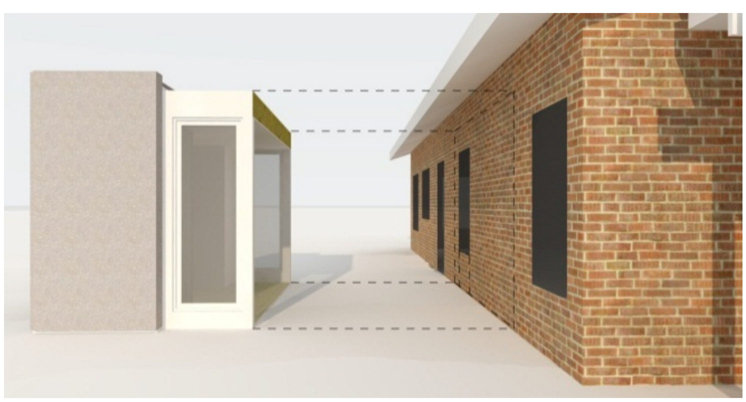

Figure 7: Exploded view of REEM-house attachment at an existing window with the sill removed to create a door to the new full bath.

Figures 8 through 11 illustrate a retrofit with two energy modules/arrays at the rear and front of the house: an expanded Solar Thermal REEM (with laundry room) at the rear and a Solar PV REEM added at the front of the house to create a new porch. The array of Solar PV panels is located on the porch roof.

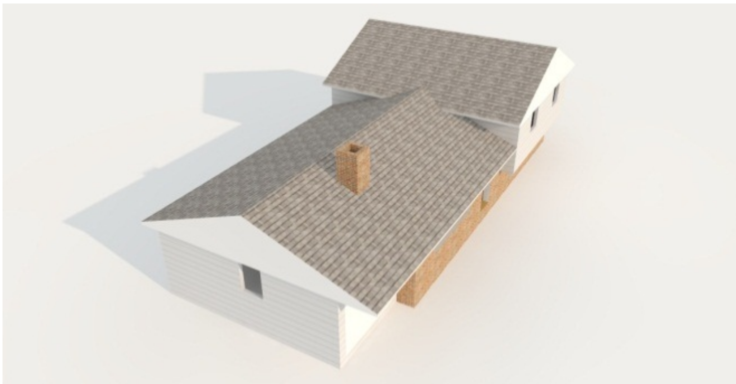

Figure 8: Aerial view of a typical 3 bedroom, 1 bath split-level house facing east.

Figure 9: Aerial view of a typical 3 bedroom, 1 bath split-level house with a Solar Thermal REEM added as a laundry room to the rear and a Solar PV REEM added as a porch to the front.

Figure 10: View of REEMs attached as saddlebags to a typical split-level house without obstructing the existing roofline.

Figure 11: View of Solar PV REEM attached to a new deck platform and overlapping the existing house roof without physical attachment.

## CONCLUSION

This paper describes a design proposal for significantly reducing energy demand in older single family residences inspired, in part, by the formal and conceptual devices of Aedicule and Saddlebag in residential design. The proposal calls for a building retrofit that employs the principles and techniques of *prefabricated construction* and *mass customization,* simultaneously exploiting the economic advantages of repetitive unit production while developing design solutions that are adapted to owner preferences, project goals and budget, site constraints, solar orientation of the existing building, climate, and building and zoning requirements.

It is the contention of the authors that the proposal not only meets a functional goal, i.e., the reduction of single-family residential energy demand, but holds the potential for significantly improving and the enhancing architectural value of the existing houses.

## REFERENCES

2009 American Housing Survey National Tables

Karbuz, L., "How Much Energy Does the U.S. Military Consume." *The Daily Energy Report*, http://www.dailyenergyreport.com/how-much-energy-does-the-u-s-military-consume/

Kieran, S., and Timberlake, J. (2004) *Refabricating Architecture: How Manufacturing Methodologies Are Poised to Transform Building Construction*, McGraw-Hill, New York.

Moore, C., Allen, G., and Lyndon, D. (1974) *The Place of Houses*, University of California Press, Berkeley, CA.