Innovation and Tradition: Eighty Years of Housing Construction in Southern Appalachia

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Abstract

This paper charts the history of advances in house construction in Southern Appalachia, beginning with the Tennessee Valley Authority's 1930s "Norris House" and wartime experimentation with demountable and "truckable" trailer housing, the post-war struggles to develop a prefabricated homes industry and their resolution in the 1970s, and concluding with a current experimental project, the New Norris House. The study demonstrates several ways in which research and experimental projects have advanced and enhanced the construction of good, affordable homes. At the centre of the study is a recurring problem in house construction: the need to balance between innovation and tradition – between the technical improvements of homes and their construction process, and the social and aesthetic value of regional and site-specific customization.

Key Words

Home Construction, Prefabrication, Tennessee Valley Authority, USA, Prototypes, Marketing

In March 1936, photographer Carl Mydans travelled through Southern Appalachia, a mountainous region in the southeast part of the United States, to document the local residents and their homes. Among his images is a photograph of a "Mountain Farmhouse" (Fig. 1), a typical example of the residential structures in this area. Originally a log cabin built on a simple stone foundation with a peaked roof and front sitting porch, the home had over time been expanded and patched. In the early twentieth century, houses in Southern Appalachia were almost invariably built by the homeowners themselves or by members of their community, and each home was adapted to its particular site and purpose. The builders used traditional building methods, some of which dated back to the European colonization of the region in the early 1800s; most houses did not have running water or electricity. Few outsiders entered these remote areas, and no commercial company invested in industrial home construction in the region. Though simple and makeshift, houses such as the "Mountain Farmhouse" were emblems of a proudly self-sufficient local culture. At the same time, they were the material manifestation of the abject poverty experienced in Southern Appalachia for generations.

A photographer following in Mydans' footsteps today would still see many traditional houses (or more likely barns) scattered throughout the region. Even more ubiquitous, however, are prefabricated homes – officially named "manufactured" homes, though still referred to as "mobile" homes (Fig. 2). Unlike the older houses, these homes are constructed off-site and are then transported into place. The location of the house and the particularities of the site play no role in their design, and they are more likely to

resemble each other than any local historical buildings. The popularity of manufactured homes in this region is hardly surprising; the centralized industrial process provides basic but dependable amenities at a relatively low price. In Southern Appalachia, where the median income is still among the lowest in the United States, price is a crucial factor, and residents often have no choice but to take advantage of the economies of scale that mass production allows. The more expensive manufactured homes keep the proportions of the original mountain homes and are adorned with elements of the local vernacular – peaked roofs, dormers and porches; but many more of the houses are long, squat and indistinguishable from each other. While some homeowners do add customized elements to the factory-made product, especially porches, a visitor could easily conclude that these repetitive homes have become the new vernacular in Southern Appalachia.

Figure 1. Mountain Farmhouse in Appalachian Mountains, Photograph by Carl Mydans, March 1935 (Source: Library of Congress Prints and Photographs Division Washington, DC 20540 USA http://hdl.loc.gov/loc.pnp/pp.print, call # LC-USF33- 000467-M4 [P&P])

Figure 2. Manufactured Home in Knox County, Tennessee (Photograph by Avigail Sachs)

The replacement of the "Mountain Farmhouse" with the manufactured varieties or, more specifically, the replacement of site-specific hand-crafted houses by standardized factory products, is hardly a unique trend, nor should it be derided: the new homes, even the most basic, offer amenities that were only dreamed of in the picturesque mountain farmhouse. At the same time, the emblematic quality of the

traditional homes is lost with the move to factory-produced anonymity. Despite its humble origins, Southern Appalachian "local expression" is, ironically, now available primarily to wealthy homeowners. No less importantly, in the process of delivering and placing the manufactured homes, the sites are usually cleared and levelled. The delicate balance between house and site, so central to the traditional "Mountain Farmhouse" and its symbolic value, is lost. In this paper we track the choices and decisions that shaped the home construction industry in this region and that led to an emphasis on the advantages of standardization over the thoughtful interpretation of local traditions, materials and sites. We find that, although the problem of balancing tradition and innovation was considered in the 1930s, the exigencies of World War II, together with the realities of marketing in a relatively unregulated economy, relegated these considerations to a secondary place. In conclusion, we report on the recent New Norris House project that has directly addressed this problem.

The New Local: The Norris Houses

The transformation of construction methods in Southern Appalachia began dramatically and decisively in the 1930s, in the context of the Great Depression and the federal programs enacted by the Roosevelt Administration. The New Deal projects, as they came to be known, were conceived with the immediate objective of providing work to the many unemployed, but they were also motivated by long-term goals of social reform, including providing better living conditions for Americans across the nation. These improvements included, among others, access to modern technologies such as electricity, dependable systems of transportation for work and recreation, and affordable, high quality homes. In 1933, the government established the Tennessee Valley Authority (TVA), with jurisdiction over the entire Tennessee River watershed which spans several states. The agency's main mandate was to provide low-cost electricity to residents through the construction of a series of dams and power stations along the river and its tributaries. The TVA also engaged in introducing new agricultural methods (such as fertilizers), supporting the region's shipping industry, and developing state parks for recreation.

The first TVA dam was designed to span the Clinch River; it was later named the Norris Dam in honour of the senator who had pushed for the legislation that instigated the entire project. The location of the dam, at a distance from any existing town, meant that housing was needed for the builders of the dam. The TVA decided to establish a new, permanent town rather than rely on temporary camps. Norris, as the town was named, was conceived as a model of progressive town planning for the region. Surveys and designs were begun in August 1933, and the town was occupied in the spring of 1935. Norris' first residents were indeed the workers who built the dam, who rented directly from the TVA, but even after construction ended applications for housing remained steady. Inhabitants included the operators and managers of the Norris Dam, employees of the other TVA divisions, and non-TVA employee families. In 1948 the town was sold in a public auction, and many long-time residents quickly bought their homes.[1]

Between 1933 and 1937, the TVA built over 200 homes in Norris, all centrally designed at the TVA headquarters in Knoxville, Tennessee. The plans were simple and repetitive and mostly similar to those used by other New Deal agencies across the country — though some of the designs incorporated local design traditions, such as screened sleeping porches and "dog-trot" hallways that traversed the entire house and provided natural ventilation.[2] The homes were considerably larger than the log cabins of the area and, more importantly, they represented modern home design: fully-equipped kitchens and bathrooms, a differentiation between living and sleeping spaces, and pre-planned storage (Fig. 3). The exteriors incorporated local materials such as wood shakes, hand-split wooden shingles and stone foundations and chimneys, based on the decision of TVA Chairman Arthur E. Morgan to use regional traditions and materials for the exterior design. TVA architects spent considerable time studying local homes as "aids for building designs".[3] Indeed, the TVA architects designed the outward appearance of

each house individually, altering the position of porches or the slope of the roof and even adjusting the house to its terrain. Earle S. Draper, the director of the TVA Division of Land Planning and Housing, boasted "There is no monotony in Norris Houses".[4]

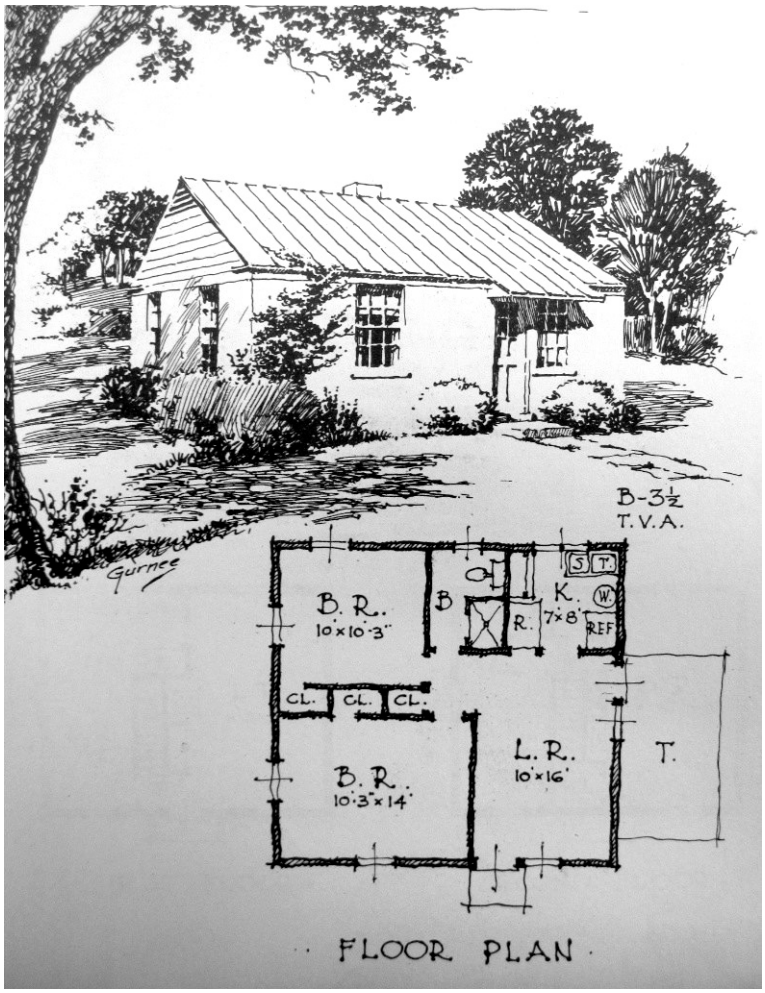

Figure 3. Plan and Sketch of a House in Norris, Tennessee (Source: TVA Archive, National Archives Building, Atlanta, GA, Collection RG 142, Box 12, Folder: TV-48514 – Geo. G. Oakley)

The houses at Norris were constructed using a highly-systematized work force, a first for this region. TVA staff managed the work directly, acting not only as designers but also as project managers and construction supervisors. While the TVA headquarters was staffed largely from outside the region, the on-site labour consisted for the most part of local contractors and builders, rather than outside relief workers. The TVA's centralized management facilitated rapid construction and reduced costs; it also allowed for changes and alterations even when work was already underway.[5] This vertical integration also required an unprecedented attention to specifications and contracts, introducing to the region a new level of construction management.[6] Unlike previous houses in the area, the houses at Norris were based on detailed, annotated construction drawings together with meticulously drawn specification drawings

(for example, an insulated metal chimney); all these drawings were carefully preserved for use in future construction sites (Fig. 4). With an eye to creating a robust construction system in Southern Appalachia, the TVA also recorded every aspect of the construction process, including the number of skilled, semi-skilled and unskilled labour hours required for each "production operation".[7]

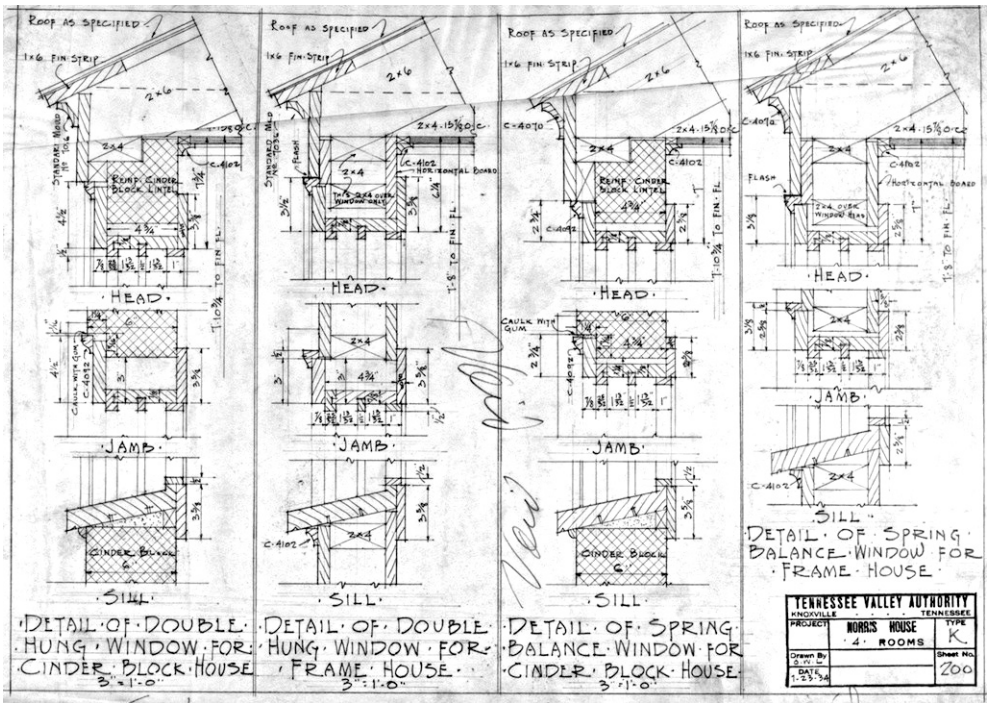

Figure 4. Details for Norris House Type K. Includes Details for Both Frame Construction and for Walls made of Cinder Blocks. (Source: TVA Archive, National Archives Building, Atlanta, GA, RPS 263)

The thorough documentation of the building process required considerable extra work, adding as much as 20 per cent to the overall costs, in time and resources. These costs were absorbed by the TVA administration, as this "theoretical inquiry" was seen as a central component of the social reform that was part of their mission.[8] The extra resources also allowed experimentation with innovative building materials and processes such as new types of frames, cladding made of brick veneers, cinderblock and stone walls, the introduction of precast-concrete floor slabs, and even the construction of an entire house made of steel. As construction progressed, the TVA team collected data on the performance of different materials providing protecting against the elements and facilitating ventilation and insulation.

The main focus of the TVA research was the integration of environmental systems into the homes, particularly electric heating, lighting and indoor plumbing. Electricity was not a new system in the United States (though it was novel in rural Appalachia), but there were still many questions surrounding its use in homes. In Norris, the TVA built 152 "electrified houses" at a cost of about a million dollars, an average of about $6,500 each, which was very high for the period (Fig. 5). The TVA personnel were especially concerned with adapting the insulation and ventilation techniques to the new technology, as reflected in a TVA memo:


Figure 5. Typical TVA Houses Using Electrical Heating in Norris, Tennessee (Source: Study of the Use of Electricity in House Heating in the Tennessee Valley TVA Archive, National Archives Building, Atlanta, GA Collection RG 142, Box 12, Folder Research – General)

> Two houses electrically heated and occupied, one insulated and one not insulated, were carefully compared and the insulation in this case was found to effect a saving of 44.75 per cent in best. Reports of these tests, among the first of their kind, served as a valuable guide for future TVA work. The results of this work were presented to the insulation industry at a meeting sponsored by the National Mineral Wool Association and have been extensively used to further the work of the industry.[9]

In the process of recording data on "electrified homes" the TVA teams developed new notation standards and also recorded the views of the houses' inhabitants to the electrified homes. In one case, residents were asked to record whether they preferred to have their bedroom doors open or closed at night. This knowledge was carefully compiled, and an initial study was published in 1938 as "Heating at Norris, Tennessee: A Study of Thermal Efficiency in Heating".[10] The findings from this and other studies informed other TVA projects, and they were made public as "Studies in the Heating of Small Houses".[11]

The Norris Houses were not the traditional "Mountain Farmhouse" but they did offer a balance between new and old, by interpreting progressive technologies and amenities in the light of local traditions and materials. More importantly, in spite of the similarities of construction, each house was individually adapted to its site. In 1975, the unique nature of these houses was recognized when the town of Norris, along with 40,000 acres of the surrounding countryside, was added to the U.S. National Register of Historic Places. The Norris Houses, however, were prototypes developed through public subsidy: they could not have been built without the financial investment of the TVA. It is interesting to speculate what might have developed had this thoughtful approach to house design and construction flourished in Southern Appalachia, through commercial enterprise. The events of the next decade, however, directed public attention, and the market, toward new challenges.

Off-Site Prefabrication: The Truckable House

At Norris, the TVA architects experimented with new materials and equipment, but the overall construction system was traditional. Materials were shipped to the site to be assembled there. By the 1930s, however, another approach – off-site prefabrication – was already gaining attention. The term covered a wide range of systems, from the use of wall panels to entire truckable trailer homes. Burnham Kelly, an authority on the topic, described these options: "There were houses of copper and of cotton; houses could be hauled down Main Street or floated down a river; and a hundred names, from 'prefabs' to 'motorized zipper housing' were bestowed upon these proposals".[12] The TVA was part of the craze. In

the early 1930s, even as the permanent homes were being built in Norris, a TVA architect named Louis Grandgent drew plans for a "truckable home". These houses, though never built, looked like the Norris Houses but "could be separated into four or five sections, each of such dimensions that it could travel safely by truck and trailer over public highways".[13] The TVA also experimented with relocating existing houses, carried by barge on the Tennessee River.

In the late 1930s the TVA began building dams in even more remote areas, and under more stringent time constraints than had been imposed in Norris. Pressed to produce appropriate housing, the Knoxville personnel took up the idea of a "truckable" and "demountable" home. Under the direction of Carroll A. Towne, then chief of the Recreation Grounds Division of the TVA's Department of Regional Studies, the agency constructed six prototype houses in Sheffield, Alabama, to be shipped to the site of the future Pickwick Dam in Tennessee. These houses, made of wood and weather-resistant fibreboard, were composed of several sections bolted together. The floor and roof were made of stressed-skin panels, with the plywood glued as well as nailed to the frame to increase its shear strength and stiffness. Each section was 7'6" long and 9'6" high (2.1 m x 2.7 m) and weighed about three tons, thus meeting highway clearance demands. Each house section was fitted with a set of wheels that allowed it to be moved along the assembly line and transported to the site. These prototypes "left the factory with all electric, heating and plumbing equipment installed, and arrived at the site completely finished even down to light bulbs and screens. Houses were finished at the site in as little as four hours by bolting together two or more sections" (Fig. 6).[14]

Figure 6. TVA Demountable Employee Housing (Source: Library of Congress Prints and Photographs Division Washington, DC 20540 USA http://hdl.loc.gov/loc.pnp/pp.print, call # LC-USW33- 015650-ZC [P&P])

After some "theoretical inquiry" – particularly feedback from potential inhabitants – the TVA produced about 150 of these truckable houses. They were much smaller and cheaper than the Norris Houses and also more "modern", but they lacked the local features and the careful variation of the Norris Houses. This was a matter of expediency rather than an aesthetic statement. As the Norris project had shown, thoughtful incorporation of local materials and traditions required more time and money than was available at Pickwick. The truckable and, even more, the demountable nature of the homes underlined their temporary nature: these houses were not intended to create a new local vernacular, but rather to solve an immediate problem. In the spirit of the time, this unadorned approach was accepted and even celebrated, and the inhabitants evidently appreciated these very basic accommodations.

Following the success of the Pickwick project, the TVA continued to produce truckable homes for other sites, such as the Fontana Dam in North Carolina. In the early 1940s, when the United States joined the fighting in World War II, the enterprise grew rapidly, spurred on by the demands of war. For strategic reasons, the American effort to develop nuclear weapons was decentralized and scattered across the country in different locations. One of these was an entirely new research facility in Oak Ridge, located north of Knoxville and 20 miles from Norris. Almost overnight the new location became home to hundreds of researchers and developers, needing accommodation for themselves and their families. The site design was prepared by the well-known firm Skidmore Owings and Merrill (SOM), and the TVA was contracted to provide most of these homes. By the end of the war the TVA architects and fabricators had designed and constructed several different types of house, with detailed plans for each. Like the first truckable homes, these houses, called "trailer homes" were designed for expediency and ease of construction rather than long-term habitation (Fig. 7).

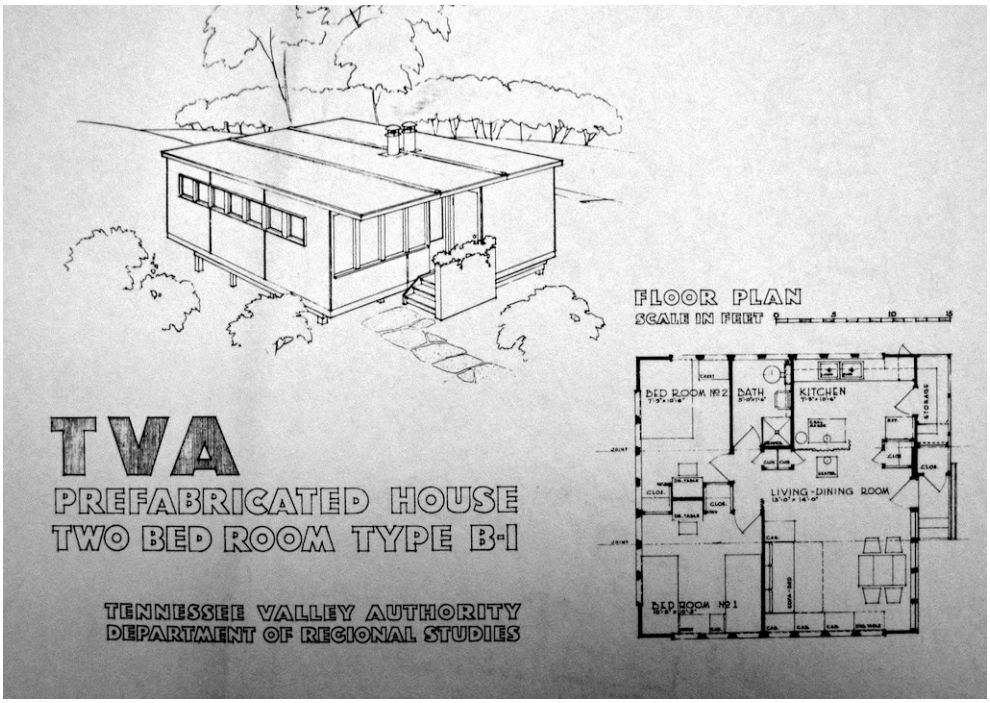

Figure 7. TVA Brochure Describing the Trailer Homes (Source: TVA Archive, National Archives Building, Atlanta, GA, Collection RG 142, Box 17)

At Oak Ridge the TVA abandoned any claim to local tradition or authenticity, although it continued to experiment with technical improvements. The designers introduced hinges for the roofs that allowed them to be transported flat and then hoisted into place. They also experimented with a system for aligning the sections on site, as on the assembly line. As at Norris, these developments were considered research and the Office of the General Manager of the TVA authorized funding for this process.[15] TVA architects also used models to simulate processes that were hard to document.[16] One of the "findings" of these experiments established a preference for using sections rather than either panels or trailer homes. As Marian Moffett explains:

> There were several advantages of sectional construction. Architects were allowed much greater freedom in design when not obligated to use a standard module, no matter how small, as the basis for construction. Even though sectional units had to be sized for highway transport, their joint locations were relatively independent of their interior arrangement. Furthermore, TVA architects felt that the time and expense required to create a workable standard panel system was better used creating varied sections designed so as to respond to a wider array of user requirements.[17]

The first truckable houses were constructed on an outdoor assembly line, set up alongside pre-cut lumber stacked ready for use. The TVA team also designed, and eventually built, an indoor prefabrication plant with twelve stations.[18] These factories underlined the difference between the prefabrication process and on-site construction. Unlike at Norris, where the materials and the construction workers were moved from house to house, here the houses travelled from one station to the next to complete each task in sequence, such as the installation of door and window subassemblies. The indoor plant also allowed a reversal of the construction sequence; for example the roof, used outdoors for protecting completed elements and further construction on site, was added only towards the end of the indoor process (Fig. 8).

Figure 8. TVA Assembly Line for the Production of "Truckable" Homes (Source: TVA Archive, National Archives Building, Atlanta, GA, Collection RG 142, Box 17)

In contrast to the Norris Houses, the wartime truckable and trailer homes were flimsy and temporary structures, but they offered affordable, basic accommodation as well as great promise for future development. Their appeal did not diminish with the return of peace. On the contrary, with the cessation of fighting, America's on-going severe housing shortage became all the more poignant and pressing with the return of veterans who could not find homes. Prefabrication became a public obsession. The ranks of prefabricators grew so rapidly that, by the end of 1946, there were 280 companies nationwide, compared to 100 just two years before.[19] Also in 1946, the federal government enacted the Veterans' Emergency Housing Act (known as the Wyatt program), which supported the increased production of homes, both by direct funding and by lending to manufacturers which, in effect, guaranteed a market for the new types of materials and prefabricated houses. In the spirit of the time, the TVA shared the plans for the truckable and trailer homes; in 1944, a complete set of plans for one house cost $8.50 and included 26 shop drawings and a description of the operations at various points in the factory.[20] Photographs, reprints and other published material were available at no cost. Firms could also "hire" a TVA staff consultant to work on their site, with the TVA covering his salary while the hiring firm paid for room and board.[21]

As the 1940s were nearing an end, the stage seemed to be set for the continued development of the innovations the TVA had instigated in Southern Appalachia. It also seemed possible to return to some of the original questions raised in the design of the homes at Norris, especially finding the appropriate balance between modern technologies and amenities and regional building traditions. The home-building industry in Southern Appalachia, however, took a different turn. The next phase in the development from "Mountain Farmhouse" to manufactured home was in the hands of private enterprise rather than government agencies; research and experimentation, which had been so crucial to earlier developments in the construction industry, were relegated to a secondary status. Like the Norris Houses before them, the TVA Trailer Homes became historical curiosities and, in 1991, were placed on the National Register of Historic Places.

From the Local to the National: Clayton Homes

In American policymaking the New Deal legislation represented a radical approach. Until the crisis of the Great Depression government intervention, especially at the federal level, had been kept to an absolute minimum to allow the free market nearly full rein. Even at the height of the crisis, many legislators objected to initiatives they considered "socialist", preferring to support private interests. In the 1950s, under two successive Republican administrations, the federal housing policies of the previous decades (including the work of the TVA) were stalled, underfunded or completely revoked. The difference between government sponsorship and free-market development in the design and construction of prefabricated homes quickly became apparent. With diminishing government contracts it became clear that the only houses that would be fabricated were those that would sell in market without subsidy and, if possible, before they had been fabricated. Unlike the TVA system, which tailored construction to the future occupants, a successful commercial industry must start with marketing, otherwise the entire system fails.[22] Manufacturers found themselves unprepared to meet these challenges, as the Architectural Forum recognized as early as 1949: "The factory-built house is here, but not the answer to the $33 million question: How to get it to market?"[23]

Part of the marketing problem, as Kelly explained, was negative public perception: "Whereas the pre-war prefabricated house may have been suspect as an interesting freak, the post-war product was often stereotyped in the public mind as a dreary shack".[24] In 1946 a Fortune poll showed that, while 70 per cent of Americans had heard of prefabricated houses, only 16 per cent were actively interested in living in them. A third of the respondents said they would buy them only if they could get nothing else.[25] A second issue was that, from levelling to finishing, site development costs money. As developer William

Levitt observed in 1949: "There is no such thing as a complete factory-engineered house – because no one has discovered how to prefabricate the land, how to prefabricate the road in front of the land, or the water main that goes into the house".[26] The additional costs involved in preparing the site often made the reduction in the cost of the home seem negligible, and bargain prices for construction were not enough of an inducement to make potential customers choose a prefabricated home. The TVA approach of thoughtful site-based adaptation was no longer tenable.

The central obstacle, however, was a legal one. To be profitable, the prefabrication industry needed to develop a national, de-localized system of production in which the economies of scale would benefit all links in the chain. Marketing and building codes in the United States, however, were inherently local — determined at the state, county and municipal levels. The existence of numerous and non-uniform building codes, many of them outdated and written in terms of specifications rather than performance, presented a prohibitive factor in the development of a prefabrication industry. In many cases, the code did not expressly allow the use of drywall (plasterboard), thus effectively prohibiting its use. In other examples, codes for framing did not take into account the technology of stressed-skin plywood construction, and they required more material be used that than such panels contained. In 1951, Kelly observed "Not infrequently the mere prospect of such obstacles was enough to dissuade the prefabricator".[27]

One sector of the prefabricated house industry that fared better than others in the post-war economy was the mobile home. Legally, these houses were defined as vehicles rather than homes, and most states did not, even into the late 1960s, distinguish between travel trailers that actually moved and mobile homes that were prefabricated off-site and then moved to a fixed location. This legal loophole allowed the manufacturers of these dwellings to evade many of the codes that plagued other types of prefabrication. In the 1950s the Mobile Home Manufacturers Association did push for the development of a national performance-based code for mobile homes (which came into effect only in 1969 in most states).[28] Even so, mobile homes were still cheap enough to be desirable for low-income buyers, including many in Southern Appalachia. Even when manufacturers did engage in creating dedicated locations (called mobile home parks), these were often in undesirable localities and included only basic amenities in order to keep their cost less than full site development. The relative success of the mobile home market did not change public opinion of prefabricated homes; in fact, it probably increased the negative perception.

The push to change this situation was, once again, the result of federally-funded research. In the 1960s the federal government — once again under Democratic control — re-engaged in research relating to housing, establishing a cabinet-level Department of Housing and Urban Development (HUD). A central project "Operation Breakthrough", attempted to harness market solutions to surmount some of the barriers to low-cost housing, including the thorny problem of local zoning codes. Harold Finger, an acting Assistant Secretary for Technology and Research, described the process: "HUD, in Operation Breakthrough, for the first time is acting like an entrepreneur. We are going through the process that most entrepreneurs go through when they develop a residential subdivision".[29] HUD also worked with the National Bureau of Standards and the National Academies of Science and Engineering to develop "a performance basis for codes".[30]

The first comprehensive set of regulation codes that were compatible with the factory production process was published in the following decade (effective in 1976). These federal standards regulate manufactured housing design and its construction, strength and durability, transportability, fire resistance, energy efficiency and quality. The HUD Codes also set performance standards for heating, plumbing, air-conditioning and electrical systems. A key change brought about by this legislation was a change in terminology. Although the term "mobile home" is still widely used, homes fabricated off-site

are now legally called either "manufactured homes" (if the chassis is part of the house structure) or "modular homes" (if it is removed after delivery). The immediate effect of the HUD Code appears counterintuitive: the standards were so challenging that sales of prefabricated homes dropped dramatically in the mid- to late-1970s. The code, however, set the stage for the development of a national industry, as imagined in the early post-war years. The industry could now offer not only the most basic mobile homes but also the more expensive variety that resembled houses constructed on-site, even though they were produced in a factory.

A second change that facilitated development of the manufactured housing industry was the "turn-key" approach to buying a home — the vertical integration of all facets of the business including building, selling, financing, leasing and insuring manufactured homes. This approach puts marketing and the customer at the centre of the process in order to provide consumers with the full support they need to buy a home. A prime representative of this changing industry, also based in Southern Appalachia, is Clayton Homes, Inc., founded by Jim Clayton in Knoxville, Tennessee in 1966. In 1974 the firm expanded into lending, establishing Vanderbilt Mortgage and Finance, Inc., and in 1984, it became a public company, trading on the New York Stock Exchange.[31] Since then, through acquisition of weaker rivals, Clayton has become the dominant U.S. maker of manufactured homes, with a market share estimated at 45 per cent.[32]

The Clayton process illustrates how the manufactured homes industry has developed since the 1970s. Like the TVA truckable houses, the manufactured homes are constructed in sections that conform to highway regulations. As a group, the homes are thus highly standardized and reaping the benefits of mass production. However, they are not built speculatively; rather, each one is customized for an individual buyer before manufacture begins. Prospective buyers can choose from different plans and finishes and can also add interior features such as vaulted ceilings, working fireplaces and state-of-the-art kitchens and baths (Fig. 9). Consumers also select home appliances, light fixtures and even curtains, all of which are installed in the factory. This customization, however, is shaped by the buyer's preferences and not by the specific characteristics of the site, as the TVA architects attempted to do in Norris. The sites are cleared and levelled before the house is delivered, thus erasing its uniqueness. Essentially, the manufactured home industry resolved the financing problem by giving consumers enough control to make the product appealing, and by learning to "prefabricate the land"[33] using heavy machinery. The process is directed by marketing agents rather than by planners and architects.

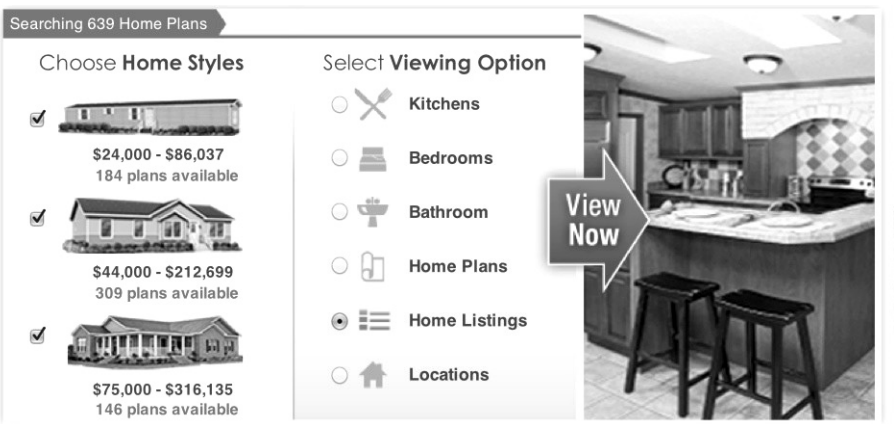

Figure 9. http: http://www.claytonhomes.com/find_homes.cfm (consulted 27th January, 2013)

The stabilization of the manufactured homes industry allowed further development in the construction process. Production engineers at Clayton Homes adapt plans created by the marketing team to the requirements of assembly line construction. Each construction element is laid out in a separate plan, which is then delivered to a station in the plant together with the materials required. Similar to the process developed by the TVA, the floor, outer walls and roof are constructed separately and assembled towards the end of the process. The house is essentially built from the inside out: bath fixtures and floor finishes, for example, are installed on the subfloor before the outer walls are put in place. This drive towards streamlining the process led directly to some significant research and innovation within the commercial setting. In 1994, for example, Clayton opened a new state-of-the-art homebuilding facility in Norris, Tennessee, with the goal of increasing the quality of the product and the choices offered to consumers, while also reducing waste. Developments in the chassis and transportation systems have allowed manufacturers to introduce two-story homes, a small fraction of the market, but an illustration of how the industry is changing. Compared to the TVA research and development, however, these research initiatives are relatively modest, and they are geared entirely towards market development rather than more fundamental scientific innovation.

Back to the Local: A New Norris House

Despite differences in mission and technology, the designers of the Norris House, the TVA truckable and trailer houses and Clayton Homes have all grappled with similar questions: What should modern housing look like? What equipment should it include? How best to construct it? Each type of home that resulted represents a resolution of particular challenges and problems, creating the context for the next round of experimentation. In the early 21st century, however, the delicate balance between innovation and tradition (the goal expressed by TVA Chairman Arthur E. Morgan) is, for the most part, ignored. Manufacturers might respond to consumer demands, but they have little leeway in adapting designs the wishes of individual clients. History shows, moreover, that the cost-intensive investigation of such a complex issue is rarely undertaken by for-profit organizations. By 2008 it was time for a new research initiative in the TVA mould, and this occurred at the University of Tennessee, Knoxville (UTK).[34]

The new research project was called a New Norris House (NNH). The goal was to design, construct and monitor the performance of an affordable single-family house for Norris, Tennessee, using current prefabrication techniques. The design of the NNH, especially in its exterior elements, takes full advantage of its site, even to the extent of reconstituting an existing trail that runs through the property leading to the centre of the town (Fig. 10). Like the original Norris Houses, the exterior was designed to be compatible with the now historic examples, while the interior offers new amenities including a large vaulted space and some "green" technologies, such as the harvesting and treatment of rainwater and high-efficiency heating and cooling (Fig 11). Also like the original Norris Houses, the NNH was intended to be a prototype; however, much work is still needed to transform it into a commercial product. Following the example of the researchers engaged in Operation Breakthrough, the UTK team undertook the role of entrepreneur and recorded each decision they made. Initiated by faculty members of the School of Architecture at UTK, the project team included students and faculty members from across the university, including the College of Engineering and the Department of Environmental Studies. The project was supported by public institutions including the federal Environmental Protection Agency, UTK's Office of Research, the Building Technologies Research Integration Centre at Oak Ridge National Laboratory, as well as by in-kind contributions from students and faculty members. Most importantly, the NNH brought designers and researchers together with both potential consumers — members of the Norris community whose opinions on building in a historic setting helped shape the design — and with representatives of Clayton Homes, Inc. In 2012 the Manufactured Housing Institute recognized the importance of the collaboration between UTK and Clayton Homes with a Design Award in New Modular Home Design.

Figure 10. A New Norris House at 143 Oak Street, Norris, Tennessee (Photograph by Ken McCown)

Figure 11. Interior of the New Norris House at 143 Oak Street, Norris, Tennessee (Photograph by Ken McCown)

Members of the Clayton Homes' engineering, manufacturing and architecture teams consulted with the UTK team, reviewing designs and making technical recommendations for adapting the standard construction method in order to advance the goals of the project. Based on this collaboration, the project team designed the house as two modules that were compatible with Clayton Home's existing fabrication methods and skills. Most of the framing, insulating, sheathing and rough-in work were completed in five days, at the company's Norris Plant. The Clayton Homes process did not, however, support all the goals of the project. To achieve a large vaulted interior space, for example, the NNH design team specified a roof detail without collar ties; they also added skylights and a dormer (Fig. 12). These structural changes complicated the calculation of design loads, as well as disrupting the standard transportation and set-up processes. Nevertheless, the industry's marketing developments had, in effect, anticipated such complications. Based on a full understanding of the customization element of the Clayton Homes process, the NNH team was able to "opt out" of the factory process and complete the construction and insulation of the roof on-site, after the modules had been delivered. This phase required collaboration with yet another expert, a roofing installer. Following the pattern of the TVA, the UTK researchers invested in this additional work since it included design details useful for future projects: the installer worked with one of the project studios to develop the shop drawings for the roof, skylights, dormer and gutter.

Figure 12. Assembly and Delivery of Prefabricated Components of the New Norris House (Photographs by Samuel A. Mortimer)

The house is now occupied and the team is continuing the research project by monitoring and recording the performance of the energy and water systems, as well as documenting the experience of those living in the house. The New Norris House, by echoing successful experimentation processes of the past, may point to construction approaches of the future.

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Biographies

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