Conquering Winter:
U.S. Consumers and the Cast-Iron Stove

Howell John Harris

Department of History

Durham University

43 N. Bailey

Durham DH1 3EX

United Kingdom

h.j.harris@dur.ac.uk

Abstract: This article explores the history of the revolution in heating and cooking technology in the United States in the first half of the nineteenth century, and the resulting transformation of the American indoor wintertime climate. It argues, *contra* William Meyer (2000, 2002), that the reasons for this massive behavioural change are traceable to an underlying demand for greater comfort, and to the complex market forces involved in the development of the technology to satisfy it and an industry to create and sell the resulting appliances, rather than simply to the increase in the price of the prevailing fuel, firewood. An attempt is made to extract 'lessons' from this history – plausible parallels with later transformations in the technology of comfort.

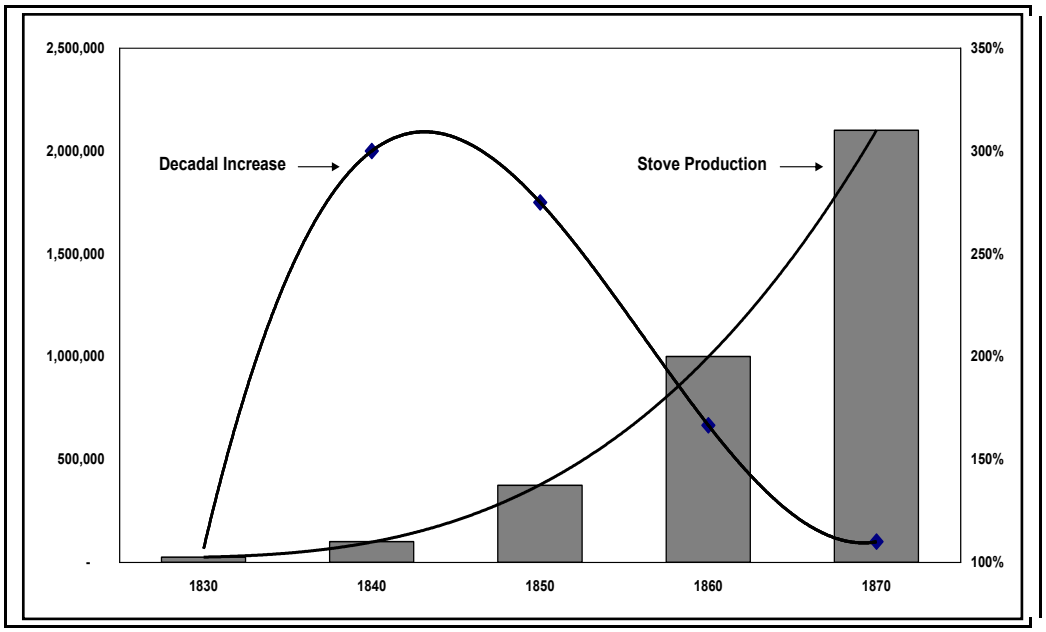
Keywords: cooking, comfort, heating, indoor environmental quality, innovation, stove, supply chains, technology diffusion, United States

Introduction

In the three decades before the Civil War, the people of the United States (particularly of the northern states) experienced a revolution in domestic technology, and the beginnings of a major fuel transition. The result was a significant rise in their expectations of comfort and convenience in everyday life, as well as an improvement in their ability economically to satisfy those rising expectations. What enabled these changes was the development of the cast-iron stove, increasingly reliant as the century progressed on coal (at first anthracite, later bituminous too) rather than wood. It was transformed over a long generation, between the 1820s and the 1850s, from an expensive item of restricted utility, and thus in limited demand, into the first consumer durable with near-universal market penetration – available, affordable, versatile, and reliable. Across the northern states, stoves for cooking and/or space- and water-heating became ubiquitous and indispensable in private houses, public accommodations (restaurants, hotels and lodging houses, steamboats and railroad carriages), places of work and of business (factories, stores, offices, banks), and public institutions (schools, churches, hospitals, asylums, prisons) alike.

Some contemporary observers were unconvinced that the new technology was better than what it displaced; in the language of architectural critic Andrew Jackson Downing, it was a "national curse," and the "favorite poison of America" was the stuffy, overheated interior climate it created (Downing, 1858, pp. 278-9 esp.). Downing may have been the "apostle of [contemporary middle-class] taste" (Schuyler, 1996), but the evidence of consumer behaviour is overwhelming: whatever reservations Americans may have harboured about the replacement of open fires by close stoves, they bought the latter by the million and reorganized their lives around them. (See Figure 1, and Garrett, 1990, esp. pp. 72, 96, 99, 101, and 183-91; Larkin, 1988, esp. pp. 51-2, 140-1; Martin, 1942, esp. pp. 113-4, 116-47; Nylander, 1993, esp. Ch. 4). As Sylvester Judd wrote in his blank-verse epic *Philo*, published in the year Downing's anti-stove tirade first appeared, his protagonist was "A man like other men" – he "hates / An air-tight stove, but cannot buy a better" (Judd, 1850, p. 125). 'Burr-Oak,' a pseudonymous reviewer who agreed with Downing, expressed the fire-worshippers' problem precisely: the cast-iron stove had become "a hopelessly necessary evil" ('Burr-Oak,' 1850, p. 125). To Henry French, editor of the *New England Farmer*, who yielded to nobody in his nostalgia for the open fire, the only important choice for most middle-class consumers by the 1850s was whether to stick with the stove or progress to the use of a basement furnace, which provided whole-house heating. All other questions could be safely left to "those who believe that the earth goes backward sometimes" (French, 1856, p. 45).

Figure 1: Estimated U.S. Stove Production, 1830-1870 (Dwyer, 1895, p. 361)



A direct result of the rapid take-up of this new domestic technology, as William Meyer (2000, pp. 32-3, 74-80, 127-8 esp., and 2002) has written, was that the American indoor climate underwent the first of its two great historic changes, with a significant increase in winter warmth (to a norm in the low to mid 70s Fahrenheit) and a reduction in the presence of, and toleration for, draughts. (The second great change took place more gradually, last century, and involved the 'conquest' of summertime heat and humidity via air conditioning – see Cooper, 1998.) Thus, one might suppose, America was early and firmly set on its high-energy-consuming path to the climate-controlled present, laying the deep cultural foundations of patterns of domestic and other architecture, ways of occupying internal space, preferences in clothing, etc., which now constitute formidable barriers in the way of movement towards a more sustainable low-carbon or renewables-based energy economy.

Meyer's is almost the only recent work on this increasingly important topic. The purpose of this article is to question, revise, and extend his explanation for the timing and origins of this great change. His argument is straightforward, and at first sight quite persuasive: what drove the transformation in heating practice was less a rising demand for domestic comfort (though this undoubtedly

existed – see Crowley, 2001) than the increasing cost and difficulty of maintaining prevailing levels of domestic discomfort (low indoor winter temperatures, abundant draughts). The price of fuelwood rose sharply in the late eighteenth and early nineteenth centuries, particularly in the long-settled, relatively densely-populated, rapidly-urbanizing regions of coastal New England and the Middle Atlantic states, where timber resources had been most severely depleted by generations of profligate use. This drove Americans in these regions to begin their fuel transition from wood to coal, and also to search for more efficient means of using an increasingly scarce, costly renewable resource, as well as its initially expensive non-renewable replacement. The devices they developed and used for this purpose (iron stoves) were not altogether new, but were so much more efficient than the open hearths they displaced that Americans were enabled to achieve and maintain higher indoor temperatures, far more economically than hitherto. Having done so, over a generation they altered their ideas of what constituted comfort, elevating "normal" indoor winter temperatures by several degrees, and thereby creating a new, distinctive, and enduring feature of the American way of life.

* * *

What, if anything, is wrong with this account? Mostly its excessive simplicity; it provides us with an explanation for change that is at most necessary and certainly very far from sufficient. One might think, reading it, that, with enough of a push from rising fuel prices, everything else followed smoothly and unproblematically. The reason why American consumers did not make this change any sooner was "not a matter of necessity but of choice" (Meyer, 2002, p. 399). Stove heat was an available option decades before it became general, "merely rare because … disliked" (Meyer, 2000, p. 33). All that stood in the way of its widespread take-up any earlier was a culturally-rooted consumer resistance.

The purpose of this article is to add in some complexity, to explain what else was needed in order to enable Americans to make a quite difficult series of behavioural changes, and to suggest that an enriched appreciation of this first transition more than a century and a half ago may be of some interest, and even

use, as we contemplate what may be required in order to begin a new transition towards a lower-carbon future.

1. The Setting: The U.S. Economy in the Early National Period

In the first quarter of the nineteenth century the (white) population of the northern United States already enjoyed one of the world's highest material standards of living. In relative terms, even if the comparators are limited to the most developed nations of Western Europe at the same time, their society was technologically advanced – highly literate, numerate, future-oriented, valuing practicality, seeing improvement in the machinery of everyday existence as a vital part of what would come to be called "The Promise of American Life." Mechanical skills were well distributed throughout the population. Entrepreneurs were hungry for new ideas to capitalize, mechanics avid for opportunities to turn their inventions into marketable goods and thus, they hoped, personal wealth. The means for making these new products and bringing them to the attention of American consumers were increasingly efficient – the northern United States not only had multiple, well-disseminated nodes of manufacturing expertise, but also the apparatus of an already quite mature commercial economy to close the gap between makers and end-users of new technologies. A large domestic market existed, at least in potential, well served by networks of wholesalers and retailers, increasingly well equipped to bring new products before one of the world's largest, richest, and most rapidly-growing pools of consumers, where the number of households was doubling every generation (see Cochran, 1981 and Meyer, 2003).

However, the United States of the early nineteenth century was at one and the same time both a relatively advanced and dynamic market economy and also a remarkably decentralized one. At the 1830 federal census, for example, New England and the Middle Atlantic states were indeed America's most highly urbanized – they contained just 43 percent of the total U.S. population, but 69 percent of its town and city dwellers. Yet the census definition of an urban place was and remained quite undemanding – a concentrated settlement with at least 2,500 people – and such towns and cities only accounted for about a seventh of

even these most developed regions' population. The national figure for the urban proportion was about one-eleventh. A generation later in 1860, after the "stove revolution" had occurred, New England and the Middle Atlantic states were more than a third urban, by the same criteria, and the United States as a whole about one-fifth (U.S. Bureau of the Census, 1970).

Thus at the end almost as much as at the beginning of this great transformation, the overwhelming majority of American consumers, even outside of the South, lived widely scattered across a vast rural hinterland. The pressures of fuelwood shortages and price increases, and the opportunities of alternative (mineral) fuels, were encountered very unevenly across these diverse communities. And yet, outside of the South, and even in regions which remained fuelwood-dependent, the conversion from open fires to stoves took place.

Evidently the fuel-price push will not do all the explanatory work required of it. It fits best the situation in and around the port cities of the eastern seaboard, where the major innovations in stove design, manufacture, and distribution were made between the 1810s and 1840s, and the early adopters of the new technology were to be found. But, even there, it encounters a basic evidence problem: the lack of consistent historical price series to provide it with an unambiguous foundation. Occasional crises in fuelwood supply, leading to localized absolute shortages, may have been more influential than gradual price inflation in driving the evolution and adoption of stove technology, and its associated fuel transition towards anthracite.

The fuel-price push idea works even less well in explaining something much more important than just the timing and location of the beginnings of change – its diffusion in less than a generation, from coast to coast and into the urban South, even into regions where fuelwood was still abundant. If stove heating had not become the norm across the rural North, one would not have been able to write in generalizing terms about a culture-wide shift towards a new internal climate; this would have remained a strictly urban and regional phenomenon, which it did not.

Unfortunately we lack good data on the proportions of households with stoves at particular times or in particular places. However, there are some good

indicators of the emergence of this new normality across the North – not just the European travellers' tales on which Meyer relies, which are most useful for urban and middle-class environments, but, for example, the evidence of legal evolution. As early as the 1820s states began to include a stove among the basic household items, essential tools of the trade, and small farmers' livestock and fodder, which were protected against seizure in settlement of personal debts (Prison Discipline Society, 1830, p. 41; McCurdy, 2001, p. 65). As Senator Rowan of Kentucky commented on Maine's 1824 statute, exempting "one swine, seven sheep, and one stove, &c. The rigor of the climate makes the warmth of wool, and of the stove, necessaries, as much so -- to the comfort of the bodies of the poor -- as the flesh of swine to their stomachs" (Register of Debates, 1826, col. 424). These laws signified that the stove had already become recognized, like his family Bible and children's schoolbooks, as a part of the ordinary citizen's decent minimum of possessions, even before its ownership had in fact become universal. But by the Civil War decade, with one stove being sold for every five households in 1860, and one for every four in 1870, a mature, indeed saturated market for these new consumer durables had been created.

* * *

Americans' dispersed patterns of settlement affected the adoption of the new technology of stove heating, and also the transition to mineral fuels, in particular because the high cost and low efficiency of most of the prevailing means of transporting goods at the start of the period meant that most potential stove consumers were in practice insulated against change by barriers of distance, time, and cost. Until the 1840s, unless consumers lived a relatively short wagon trip away from a navigable waterway, the ability of most of them to buy heavy, bulky goods, or those with a low value-to-weight ratio, from any but local makers and suppliers, was quite restricted. Similar considerations applied to the manufacture of such goods: from the 1810s through the late 1830s, for example, the making of heavy cast-iron products like stoves stayed tied to the blast furnaces providing their raw material, i.e. it was more or less confined to those locations where iron ore from mines or bogs, flux (limestone or sea-shells), and fuel (charcoal) could be sourced close to one another. Rural furnaces making stoves were scattered

through eastern Pennsylvania and southern New Jersey, conveniently close to major urban markets in Philadelphia and New York; but such producers' non-local markets were effectively limited to other port communities along the Atlantic littoral from Washington, DC to Maine, and those inland towns with good water transport links.

Communication between makers, sellers, and consumers, and the rate and diffusion of innovations, were hindered for as long as the emerging stove industry's constituent parts remained widely diffused, with slow, inefficient linkages among them. There was little technical development either in stoves themselves or in methods of making them. Small-scale manufacture of crude, heavy objects, and costly transportation, readily translated into making stoves high-priced goods which could only secure niche markets. Such niches were available, and widening – notably in the coastal towns and cities most exposed to the problems of occasional actual fuelwood shortages and chronically rising prices, and enjoying relatively cheap, efficient water-borne communications. But transforming stoves from products which some consumers in some of the country's most developed regions bought (the situation in the 1810s-early 1830s), into products which were basic to the transformed lifestyles of millions of consumers right across the United States (the situation by the end of the 1850s), required much more than the gradual inclusion of more and more households among those feeling the pinch of high fuelwood prices.

2. America's Wooden Age

There is another problem with the "high fuelwood price" argument. It seems to be based on a limited understanding of the energy economy of early nineteenth-century America. At the mid-point almost as much as at the beginning of the transition from open-fire to stove-using, the United States remained fuelwood-dependent, certainly throughout the rural heartland. Wood still provided 90 percent of the American fuel supply in 1850 – 75 percent as late as 1870, when its consumption reached an all-time peak – and 90 percent of it continued to be used for domestic purposes: "cooking, drying, smoking, and process heat for home manufactures" as well as space heating (Greenberg, 1980, pp. 34, 41). In some American energy markets, notably those of the East Coast cities, it is plausible that the high price and unreliable availability of fuelwood drove both the search for substitutes, notably Pennsylvania anthracite from the late 1820s on (Chandler, 1972, pp. 153-55; Powell, 1978, esp. Chs. 2-3), and for more efficient ways of burning the new fuel as well as the old (Silliman, 1826; Bull, 1827; Olmsted, 1837). But we also need to be able to account for the quite rapid embrace of the resulting innovations in regions not feeling the same clear stimuli of price and shortage. As Henry French explained in 1856, recalling and explaining the transition from open fires to stoves in rural New England,

> wood was reckoned of little value on the lot. But … at every respectable establishment, it was the winter's work for two men, and a team of four oxen and as many steers, to get up the years [*sic*] stock of fuel. The men and teams were off by daylight, and brought home the wood, sled-length, load after load, and rolled it up into huge piles in the door-yard, and he was considered an uncommonly forehanded farmer, who ever had a stock of seasoned wood on hand. And so they toiled all summer, to raise corn and hay and potatoes enough, to keep the men and teams through the winter, and worked all winter long, getting up wood to keep from freezing (p. 44).

We need, at the very least, to appreciate what the non-monetary cost of the old fuelwood economy was to the rural consumers dependent on it. The issue for most of them was not so much the market price of a vital commodity that was still

abundant in many localities (notably as a by-product of land clearance), and which many rural consumers provided for themselves, but the strong attraction of reducing the massive household labour inputs required to feed the voracious open hearth – felling, trimming, cutting, moving, piling, splitting and perhaps cutting again, and then yet more carrying, to the fireplace itself (Cole, 1970, esp. pp. 343-4). Greenberg (1980)'s estimate is that fuelwood preparation required more caloric inputs (in terms of human food and animal feed) than the usable heat output it generated, because of the extremely low conversion efficiency of the open hearth; and it is not clear whether her estimate includes the women's labour entailed within the home, as well as the men's in the woodlot and at the woodpile. Anything that promised to improve the balance of this equation was quite rapidly adopted by American consumers, even without the direct stimulus of market price. Knowledge of the efficiency gains possible by replacing open fires with stoves was well disseminated: improvements of eight or nine times – from a 10 to an 80-90 percent conversion ratio -- were achievable under laboratory conditions by the late 1820s, and of perhaps half that much in everyday practice. Stove makers emphasized the saving of labour alongside the saving of fuel *per se*, and the greater usable heat output. The selling points of the new technology were thus comfort, convenience, and economy – a winning combination, against which culturally-engrained preferences for the open fire provided at best feeble resistance.

But only once the choice of the new technology of controlled, more efficient combustion became effectively available to them. Note the adverb: effectively. For cash-poor rural consumers, dependent on wagon transport along inadequate roads and living far from market centres, the crude, heavy, costly devices American furnaces produced from the 1760s through the early 1830s were rarely an attractive or affordable option. When in the late 1810s and early 1820s anthracite pioneer Jacob Cist wished to grow his fuel market by encouraging stove use, he had to resort to a variety of stratagems, even in the immediate vicinity of his mines – renting stoves out as well as selling them, accepting labour services or goods instead of cash (Powell, 1978, pp. 92-3). The nature of the product and its distribution system would have to be transformed before the potential mass

market could be tapped, and millions of tired, freezing Americans would come to enjoy, and take for granted, the (redefined) comforts of home.

3. Escaping Winter: From God's House to My House

There are two more modifications to the "high fuelwood price" argument that are worth developing. The first is to question Meyer's contention that the changeover to stoves was not "driven chiefly by a desire for greater comfort" (2002, p. 398). Even if this was not the major cause, it is clear that the desire existed, and motivated much consumer behaviour, notably among the early adopters of what was at that time a very costly, imperfect appliance. Given the facts of early stoves' high price and limited utility and availability, then, even in the seaboard towns and cities, and areas of their hinterlands with comparatively efficient freight transport and prosperous market economies, they were a niche product for wealthy, go-ahead consumers – people who knew about Benjamin Franklin's and Count Rumford's innovations and arguments, and had ample means to buy the new technology of comfort. When the young Revolutionary War hero Aaron Burr set up as a lawyer in Albany, New York in the early 1780s, for example, his love-letters to his wife-to-be were surprisingly full of advice on the advantages of stoves, what type to buy, where and how to set them up, etc. Stove purchase in his case seems to have been a response to the possession of discretionary spending power, and knowledge of the comfort and status you could buy with it, rather than simply to considerations of domestic economy (Parton, 1860, pp. 134, 137). A few years later, on the frontier of settlement in upstate New York, a stove was a symbol of wealth, power, and modernity in the wilderness, as well as a bringer of comfort to visitors to the community's most powerful citizen. "The door closed, and the party were at once removed from an atmosphere that was nearly at zero, to one of sixty degrees above. In the centre of the hall stood an enormous stove, the sides of which appeared to be quivering with the heat it emitted" (Cooper, 1823, p. 74). James Fenimore Cooper's father – the lightly-fictionalized source for his wilderness patriarch -- was engaging in what one might term the conspicuous consumption of warmth, rather than attempting to cut his fuel bills. Such winter comfort was in short supply in late eighteenth and early nineteenth century

America, where the urban lower classes, in particular, lived with chronic fuel poverty (Adams, 2008), but it was evidently sought out, when and where available, by those with the power to make a choice. When Hessian troops were looking for somewhere to use as a hospital and barracks in southern New Jersey in 1778, for example, they chose the Atsion Friends' meetinghouse, because it was one of the few buildings with a stove (Sarapin, 1994, p. 153).

We do not have much quantitative data about the spread of stove purchasing and use even among prosperous east-coast consumers in the next half-century, but we do have quite powerful indirect evidence. Enough of them became used to stoves in their homes and business premises that they began to exert a strong and effective demand for the extension of a comfort they now took for granted into a kind of public space where it had rarely existed: their places of worship (Buggeln, 2003, esp. pp. 96, 202; Washburn, 1860, p. 110). Stove use in churches began to spread into New England from the 1790s on, beyond its origins among the Pennsylvania Dutch, the Moravians, and the Quakers who had adopted this one of their neighbours' sensible practices. It became normal in the 1810s and early 1820s. As the author of a version of a common apocryphal story about the first encounter of Puritan worshippers with a stove-warmed meeting house reflected, a generation after the events he recounted, "It is strange how fast any little comfort or convenience grows popular and makes its way among a people, after it first becomes known; and how soon it ceases to be a luxury, and becomes one of the necessaries of life" (Anon., 1845, p. 82).

Not, perhaps, so strange: churches were barn-like buildings, left empty and, in winter, freezing through much of the week, and neither capable of being effectively warmed by open hearths nor indeed, because of concerns about fire risk, generally equipped with them at all. Their congregations had to sit through long services and, worst of all, interminable sermons, with nothing apart from their fervour (or, for some women and the elderly, charcoal-burning individual foot-stoves) to keep them warm. They could wrap up well, stamp their feet, beseech their minister to cut his sermon short, defrost themselves between morning and afternoon services in small Sabbath-Day houses (huts in the churchyard with a cooking hearth), retreat to a smaller, less frigid building for

midwinter services, even give them up altogether until the worst was over. Or they could install stoves – as Meyer correctly argues, an available technology decades before they came into common use, but one effectively accessible, even along the north-east seaboard, only to the relatively wealthy or, in this case, to collective or institutional purchasers.

The choice became an obvious one – suffer like the poor Methodists of Cincinnati, Ohio, in 1811, who still could not afford a stove to heat their meeting-house: "on Sunday morning it being generally crowded, their breath would condense on the walls, and the water would run down and across the floor" (Finley, 1857, p. 90). Or throw away your foot-stoves, close the Sabbath-Day houses, and enter the new world of pious comfort. By the early 1820s, congregations along the eastern seaboard had discovered that they did not have to freeze through wintertime worship, and thereafter churches and meeting-houses, those most important of public spaces, were routinely heated by stoves and furnaces as part of a general move to extend domestic comforts (including carpets, cushions, and better furniture) into the house of God (see e.g. Benedict, 1860, p. 279). Something similar began to happen in Victorian Britain a little later, where it also met with some resistance (Hare 1856, Vol. 1, p. 105), but in the United States stove-heated comfort and godliness were reconciled from an early date.

When a new kind of public space – the railroad carriage – appeared in the 1830s, the gulf that had already opened up between the United States and the United Kingdom in terms of the perceived need for space heating and expectations of indoor comfort again became manifest. American railroad carriages were stove-heated almost from the outset, in the first instance with devices adapted from ordinary room-heaters, later with variants on the domestic furnace (White, 1985, pp. 379-400). British visitors remarked unfailingly upon the consequences, usually negatively -- overheated, airless, stinking carriages, intolerable temperature gradients depending on proximity to the stove (the classic cases are Dickens, 1842, Vol. 1, p. 146 and Trollope, 1862, p. 389; whenever either of these great authors came across a warm interior, he complained bitterly); but occasionally positively (Godley, 1844, Vol. 2, p. 140; Lyell, 1845, Vol. 1, pp.

140-41; Chambers, 1854, p. 26), travellers making an explicit comparison with the rigours of even first-class travel on unheated British railways in winter. Railroad stoves were an enormous fire hazard, which Americans tolerated for more than half a century as the price of the necessary, albeit imperfect, comfort that they provided (Aldrich, 2006, pp. 79-82).

The point of this discussion of what may have been two of the most important ways in which the experience of being warm in wintertime while at rest indoors was diffused beyond the relatively wealthy early adopters of stove technology to their less affluent neighbours, is that it has nothing to do with any supposed fuel-price shock in the early nineteenth century, and everything to do with the simple avoidance of discomfort. Given what we know about the exceptional severity of winters in the northern states in the late eighteenth-early nineteenth centuries, the clear inadequacy of prevailing (open fire) heating systems, and the lack even of basic "winterizing" features in American domestic architecture, then it is perverse to turn our backs on the blindingly obvious in our explanation of why ordinary people adopted the new technology for their homes too, *almost as soon as it became effectively available to them*. The pursuit of greater comfort, in a variety of settings, domestic and public, seems to have been a powerful force for behavioural change in its own right.

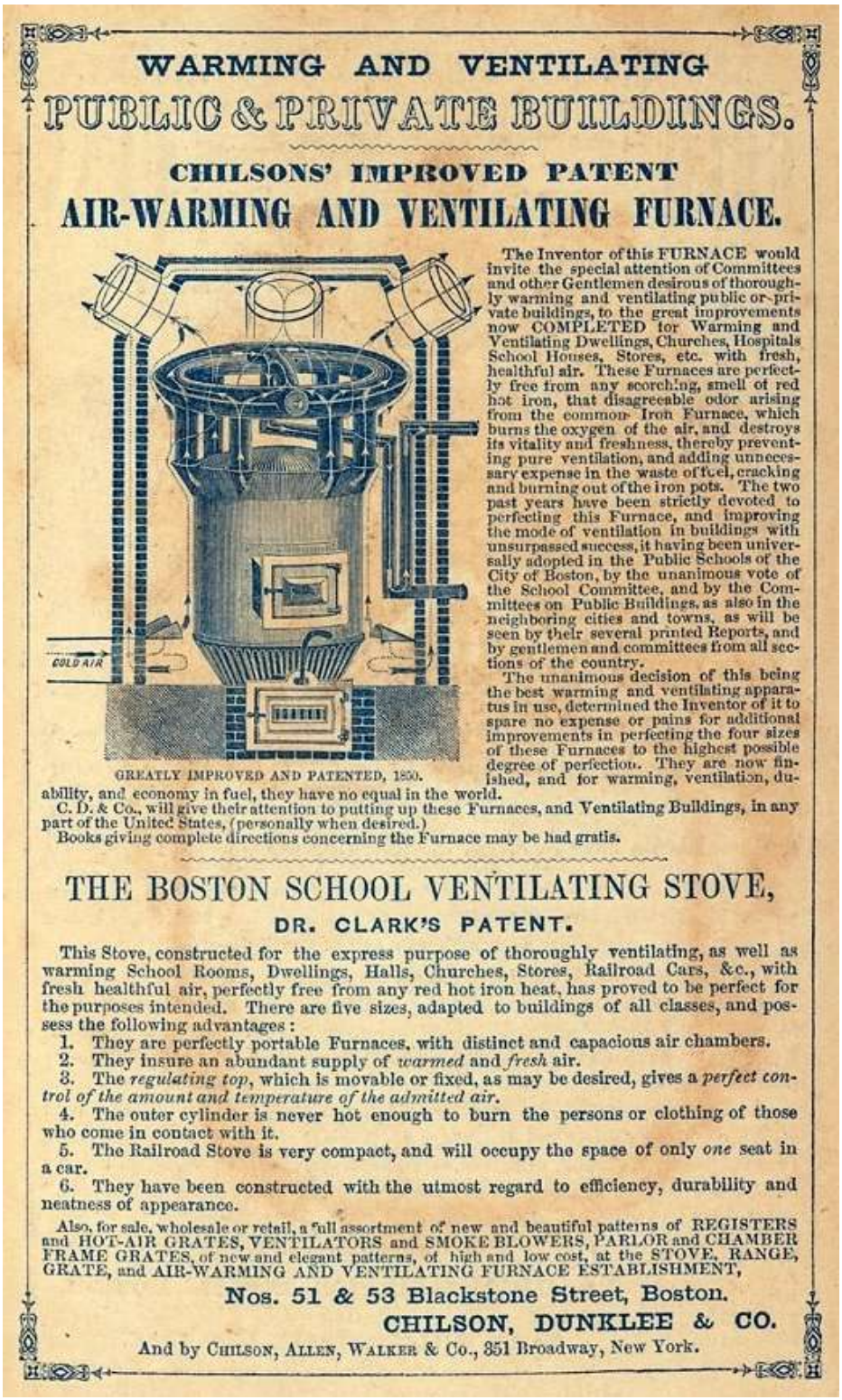
Note the above phrase: domestic and public. If we wish to understand the process by which the new technology of stove and furnace heating became ubiquitous in northern American households by mid-century, we should appreciate the important role of the challenge of heating non-household settings in driving the development of the new technology. Open fireplaces could push back the chill by a few feet at most, and create small habitable zones in the worst of winter even in the barely-insulated, draughty, single-glazed houses of the time. But in legislative assemblies, courthouses, public halls, colleges, prisons, mental asylums, hospitals, and that most common of public buildings (after churches) – schools – fireplaces were ineffective, inappropriate, or both. Lunatics and prisoners, for example, had to be kept tolerably warm for the sake of their health, but could scarcely be trusted with fires in their locked rooms or cells; and large institutional buildings with tens or even hundreds of separate inhabited spaces

were far more economically and efficiently heated from a central source than by numerous open fires (Prison Discipline Society, 1855, pp. 11-15, 620-1, 845). In crowded schoolrooms, "[a]n open fire-place is sometimes dangerous, and even fatal, to children dressed in cotton" (Woodbridge, 1832, p. 276). By the early 1830s state school laws simply considered "articles ... such as a broom, a water-pail, a stove, a wood-house, &c." as "indispensable to the comfort and health of the pupils" (Williams, 1836, p. 267). Almost all of the voluminous literature on the heating and, equally important, the ventilation of schools, prisons, asylums, hospitals, and other public buildings, poured out in the 1830s and 1840s by architects, educationists, and physicians, similarly took stove- or furnace-heating for granted, and concentrated on its improvement (see e.g. Mann, 1838, pp. 13-18; Barnard, 1850, pp. 35, 50-53; Burrowes, 1855, Ch. 6; Bell, 1848; Reid, 1858).

Historians, including Meyer, have usually written as if the domestic setting was the only place where the stove revolution took place. But the means for buying open fires' initially quite costly replacements were much more available to institutional purchasers than to most households. It would be more accurate to paint a picture of interactions among early adopters (wealthy households), the public institutions whose purchasing behaviour they influenced, and a wider consuming public likely to have encountered warm interior public space well before they could afford to extend that luxury into their own homes. The parallel with the spread of air conditioning a century later is suggestive if necessarily inexact – with movie houses and department stores, for example, helping to create the demand for cool summertime interiors decades before most American households could begin to follow suit. In the case of air conditioning, the "industrial" and domestic (room-sized) technologies were fundamentally different; but with stove and furnace heating, they were basically the same – household appliances were just smaller and cheaper versions of a single product line. (See Figure 2, illustrating space-heating stoves and furnaces.)

Figure 2: Space Heating for Public and Private Places (Chilson & Dunklee, 1850)

Gardner Chilson (1804-1877) was a pioneer inventor and manufacturer of hot-air furnaces for institutional and wealthy private users. Note the concern for indoor air quality as well as thermal efficiency.



WARMING AND VENTILATING

PUBLIC & PRIVATE BUILDINGS.

CHILSONS' IMPROVED PATENT

AIR-WARMING AND VENTILATING FURNACE.

GREATLY IMPROVED AND PATENTED, 1850.

The Inventor of this FURNACE would invite the special attention of Committees and other Gentlemen desirous of thoroughly warming and ventilating public or private buildings, to the great improvements now COMPLETED for Warming and Ventilating Dwellings, Churches, Hospitals School Houses, Stores, etc. with fresh, healthful air. These Furnaces are perfectly free from any scorching, smell of red hot iron, that disagreeable odor arising from the common Iron Furnace, which burns the oxygen of the air, and destroys its vitality and freshness, thereby preventing pure ventilation, and adding unnecessary expense in the waste of fuel, cracking and burning out of the iron pots. The two past years have been strictly devoted to perfecting this Furnace, and improving the mode of ventilation in buildings with unsurpassed success, it having been universally adopted in the Public Schools of the City of Boston, by the unanimous vote of the School Committee, and by the Committees on Public Buildings, as also in the neighboring cities and towns, as will be seen by their several printed Reports, and by gentlemen and committees from all sections of the country.

The unanimous decision of this being the best warming and ventilating apparatus in use, determined the Inventor of it to spare no expense or pains for additional improvements in perfecting the four sizes of these Furnaces to the highest possible degree of perfection. They are now finished, and for warming, ventilation, durability, and economy in fuel, they have no equal in the world.

C. D. & Co., will give their attention to putting up these Furnaces, and Ventilating Buildings, in any part of the United States, (personally when desired.)

Books giving complete directions concerning the Furnace may be had gratis.

THE BOSTON SCHOOL VENTILATING STOVE,

DR. CLARK'S PATENT.

This Stove, constructed for the express purpose of thoroughly ventilating, as well as warming School Rooms, Dwellings, Halls, Churches, Stores, Railroad Cars, &c., with fresh healthful air, perfectly free from any red hot iron heat, has proved to be perfect for the purposes intended. There are five sizes, adapted to buildings of all classes, and possess the following advantages:

1. They are perfectly portable Furnaces, with distinct and capacious air chambers.
2. They insure an abundant supply of *warmed* and *fresh* air.
3. The *regulating top*, which is movable or fixed, as may be desired, gives a *perfect control of the amount and temperature of the admitted air.*
4. The outer cylinder is never hot enough to burn the persons or clothing of those who come in contact with it.
5. The Railroad Stove is very compact, and will occupy the space of only *one* seat in a car.
6. They have been constructed with the utmost regard to efficiency, durability and neatness of appearance.

Also, for sale, wholesale or retail, a full assortment of new and beautiful patterns of REGISTERS and HOT-AIR GRATES, VENTILATORS and SMOKE BLOWERS, PARLOR and CHAMBER FRAME GRATES, of new and elegant patterns, of high and low cost, at the STOVE, RANGE, GRATE, and AIR-WARMING AND VENTILATING FURNACE ESTABLISHMENT,

Nos. 51 & 53 Blackstone Street, Boston.

CHILSON, DUNKLEE & CO.

And by CHILSON, ALLEN, WALKER & Co., 351 Broadway, New York.

4. Domesticating the Stove: the Problem of Cooking

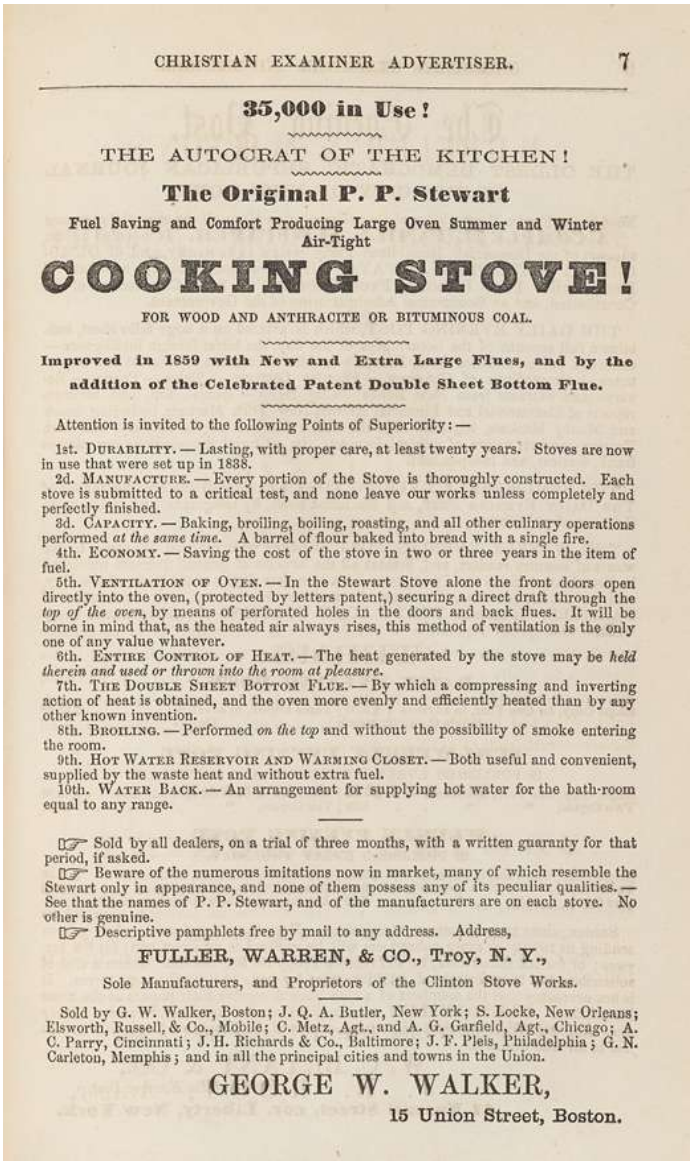
There was one final hurdle – apart from price – that had to be crossed before ordinary northern American households could afford to become dependent on stoves. It relates to what they used fire for, and how they lived in their houses (Hazen and Hazen, 1992, esp. Chs. 1, 2, 5). In most rural homes and among urban lower-class households (basically, those without servants), the kitchen was not simply the heart of the home in a sentimental sense, it was the engine-room of the domestic economy and the only room heated in winter. The kitchen fire served multiple purposes – cooking, water-heating, processing and preserving food, even producing the wood-ash for the soap supply – as well as providing space heating, which was almost a by-product; unwanted except in winter, but essential then, and unavoidable anyway.

Before the 1820s, available stove types – 6-plate box stoves, Franklins (a generic term for free-standing cast-iron devices only loosely inspired by Benjamin Franklin's original design, which could be inserted into a fireplace and allowed a view of the fire), sheet-iron "airtights," heavy "cannon" stoves, even brick-built Russian stoves working on heat-conservation principles – were quite well adapted to space heating for households and public spaces alike, though too costly for most consumers (Peirce, 1951). But they were not very useful for anything else. As early as the 1760s, stove makers had introduced a small oven into a box stove, turning it from a 6-plate into a 10-plate; but these ovens were too small for most purposes, and there were many basic cooking operations that a 10-plate stove could not perform at all (notably baking and roasting). Before stoves could become a mass-market product, and ordinary northern American households could get used to efficient fuel use and a new ability to achieve and sustain winter temperatures into the 70s more than a few feet from the hearth, they had to be transformed into effective, versatile cooking devices (Brewer, 2000; Keep, 1916; Strasser, 1982, Chs. 2-3).

As stoves of all kinds became cheaper, and households more prosperous, consumers could afford to buy more specialized appliances too – parlour stoves, furnaces – which only provided space heating (see Figure 2). But the key to building the industry a mass market was cracking the problem of cooking, not

heating (see Figure 3). Until this was achieved, households could not abandon the open hearth and, if they were relatively prosperous, the brick bake-oven alongside it, and the stove revolution (and thus the transformation of the indoor climate) could not take place.

Figure 3: The Heart of the Home – The Classic Kitchen Stove (Walker, 1861).
Philo P. Stewart (1798-1868) was one of the leading cook-stove inventors, perfecting a high-quality, versatile, economical appliance. His name turned into a brand, inspiring consumer confidence, in his lifetime.



CHRISTIAN EXAMINER ADVERTISER. 7

35,000 in Use!

THE AUTOCRAT OF THE KITCHEN!

The Original P. P. Stewart

Fuel Saving and Comfort Producing Large Oven Summer and Winter Air-Tight

COOKING STOVE!

FOR WOOD AND ANTHRACITE OR BITUMINOUS COAL.

Improved in 1859 with New and Extra Large Flues, and by the addition of the Celebrated Patent Double Sheet Bottom Flue.

Attention is invited to the following Points of Superiority:—

1st. DURABILITY. — Lasting, with proper care, at least twenty years. Stoves are now in use that were set up in 1838.

2d. MANUFACTURE. — Every portion of the Stove is thoroughly constructed. Each stove is submitted to a critical test, and none leave our works unless completely and perfectly finished.

3d. CAPACITY. — Baking, broiling, boiling, roasting, and all other culinary operations performed *at the same time*. A barrel of flour baked into bread with a single fire.

4th. ECONOMY. — Saving the cost of the stove in two or three years in the item of fuel.

5th. VENTILATION OF OVEN. — In the Stewart Stove alone the front doors open directly into the oven, (protected by letters patent,) securing a direct draft through the *top of the oven*, by means of perforated holes in the doors and back flues. It will be borne in mind that, as the heated air always rises, this method of ventilation is the only one of any value whatever.

6th. ENTIRE CONTROL OF HEAT. — The heat generated by the stove may be *held therein and used or thrown into the room at pleasure*.

7th. THE DOUBLE SHEET BOTTOM FLUE. — By which a compressing and inverting action of heat is obtained, and the oven more evenly and efficiently heated than by any other known invention.

8th. BROILING. — Performed *on the top* and without the possibility of smoke entering the room.

9th. HOT WATER RESERVOIR AND WARMING CLOSET. — Both useful and convenient, supplied by the waste heat and without extra fuel.

10th. WATER BACK. — An arrangement for supplying hot water for the bath-room equal to any range.

☞ Sold by all dealers, on a trial of three months, with a written guaranty for that period, if asked.

☞ Beware of the numerous imitations now in market, many of which resemble the Stewart only in appearance, and none of them possess any of its peculiar qualities. — See that the names of P. P. Stewart, and of the manufacturers are on each stove. No other is genuine.

☞ Descriptive pamphlets free by mail to any address. Address,

FULLER, WARREN, & CO., Troy, N. Y.,

Sole Manufacturers, and Proprietors of the Clinton Stove Works.

Sold by G. W. Walker, Boston; J. Q. A. Butler, New York; S. Locke, New Orleans; Elsworth, Russell, & Co., Mobile; C. Metz, Agt., and A. G. Garfield, Agt., Chicago; A. C. Parry, Cincinnati; J. H. Richards & Co., Baltimore; J. F. Pleis, Philadelphia; G. N. Carleton, Memphis; and in all the principal cities and towns in the Union.

GEORGE W. WALKER,

15 Union Street, Boston.

After the solution of the problems involved in burning anthracite in the 1820s and early 1830s, cooking, not heating stoves absorbed the lion's share of inventors' and entrepreneurs' attention. There is no good data on the division of the stove industry's output between cooking and heating appliances before the late nineteenth century, but there are serviceable proxies. Between 1836 and 1873, there were only about half as many invention patents for heating stoves, and one third as many for hot-air furnaces, as there were for cooking stoves and their key features (Source Translation and Optimization, 1995, Class 126). Designers concentrated on solving a number of interrelated problems, notably increasing the size of the oven and equalizing heat-distribution within it, extending the usable cooking surface, improving fuel economy and the control of combustion, and utilizing what would otherwise have been waste heat to provide abundant hot water (Gobeille, 1885). The resulting appliances became the industry's market leaders. In 1875, 60 percent of all the different stove models manufactured in Albany and Troy, the industry's focus, were cookstoves, with the rest for heating or specialized uses (e.g. tailor or laundry stoves, basically modified cookstoves), data consistent with the patent record (Anon., 1875).

The cooking stove types which were perfected by the early 1850s enabled the stove revolution to happen. They were singularly well adapted to ordinary Americans', especially rural Americans', lifestyles. They saved on construction costs and time, requiring only a sheet-iron stovepipe, not necessarily a brick or stone chimney. They were comparatively light (100 kilogrammes or even less) and portable, and could thus move house with America's exceedingly mobile population – they could even join overland wagon trains. More frequently they made a seasonal migration from indoors to a 'summer kitchen' (a lean-to providing shelter from sun and rain, but open to the air), saving housewives from the intolerable indoor temperatures otherwise unavoidable. And they had a winning combination of high thermal efficiency and great heat output, enabling wintertime survival in the temporary shacks and tents common in the early phases of settlement out on the prairies and Great Plains where fuelwood supply could be problematic, or in the California gold diggings. All told, American consumers and this distinctively American product were ideally matched with one another.

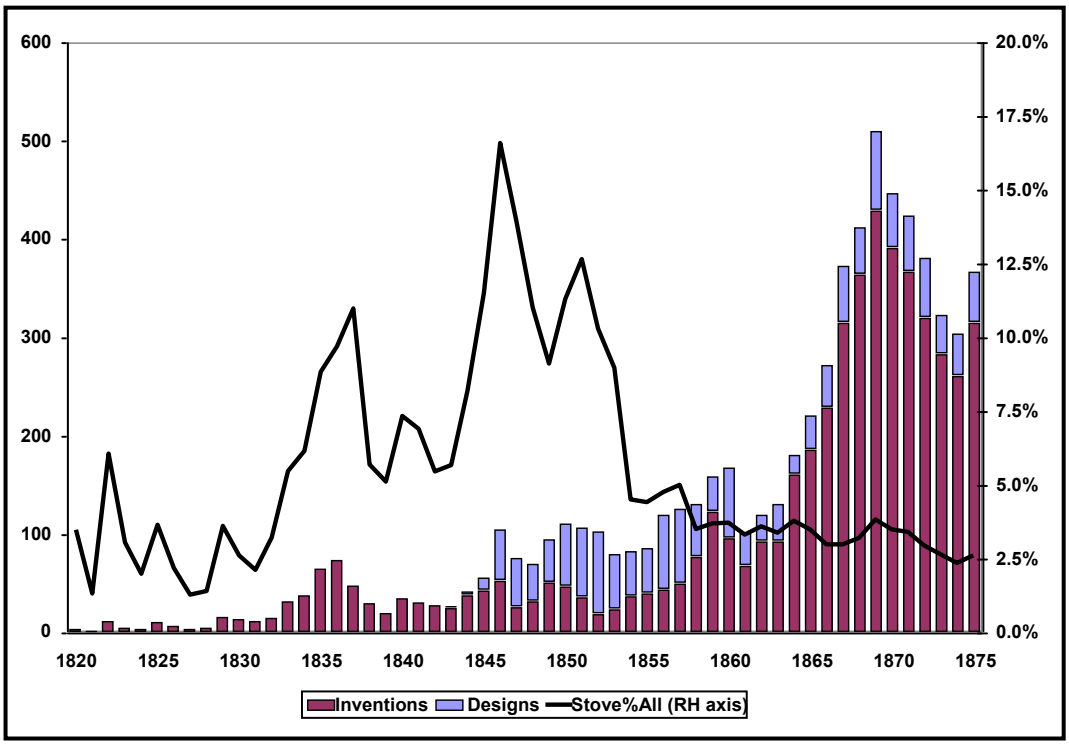
5. The Market Grows an Industry, and the Industry Grows Its Market

Between the 1810s and the late 1830s, while the demand for stoves certainly grew, and the product experienced significant development, the production system remained stubbornly unchanged. Stove plates continued to be cast at rural furnaces, mostly in Eastern Pennsylvania and Southern New Jersey but also at other locations scattered across the North – even across the Appalachian Mountains into the Ohio River valley. Some were assembled and finished where they were made, to satisfy local demand; others (in the main producing areas, most) were sent to urban stove dealers – a few tens of miles away by river and canal, or hundreds of miles by coastal shipping. The plates were put together in the dealers' "manufactories," additional ironwork was made and fixed, and then the stoves were sold – either directly to neighbouring consumers, or indirectly, wholesaled to smaller hardware and tinware dealers nearby, some of whom began to specialize in stove retailing, installation, and repair.

Between the late 1830s and the 1840s this decentralized system of production and distribution was revolutionized. Some of the larger urban dealers and "manufacturers," who had already begun to take control of the design process, commissioning castings from furnaces rather than simply contracting for deliveries of whatever styles the furnace produced, brought the entire process of designing, casting, assembling, finishing, and then wholesaling, onto a single site and under unified ownership and control. In the process, stoves turned from being a major product of the iron furnace industry into the sole product of specialized, integrated, and, for the time, large firms, concentrated in New York and Philadelphia, Boston and Baltimore, and particularly in Albany and Troy, New York – at the head of tidal navigation on the Hudson River, and the eastern terminus of the Erie Canal, the first great highway to the inland markets of the emerging Midwest. The growing market for stoves themselves had given birth to an industry dedicated to making them – and making them better, lighter, cheaper, and more generally available than ever before (Meyer, 2006, esp. pp. 131-5). Casting quality and technique improved with the movement of production from the rural furnace to the specialized urban foundry, so that the resulting products

were both more serviceable as utilitarian objects (more durable, and with better-fitting parts resulting in greater fuel economy through draught control) and more attractive as household furniture (less crude, more elaborately decorated).

Figure 4:
Inventive Activity in Heating and Cooking Appliances, 1820-1875 (Paratext™)



We have no detailed quantitative data on this period of growth and transformation, apart from the evidence of the U.S. patent record. And this is quite striking (see Figure 4). There had been a trickle of patents for heating and cooking apparatus before the 1820s, but hardly any of them are known to have been turned into saleable products, and none of them made much impact on stoves' subsequent development. From the late 1820s through the late 1830s, however -- until the Panic of 1837 interrupted the industry's growth – there was a sustained surge, until this category of products made up one-ninth of the entire volume of inventive activity recorded by the U.S. Patent Office. The Panic killed the demand for stoves and the supply of new ideas, but when the economy boomed again in the next decade, and the rate of increase in stove production

probably reached its all-time maximum (see Figure 1), stove patents once again peaked at nearly one-sixth of the U.S. total, counting patents for inventions and designs together.

This prodigious effort is evidence of the way in which a rapidly growing industry attracted entrepreneurial and other creative talents to satisfy some of the most basic needs of all American households by producing the foundation patents for generations of economical and efficient coal and wood-fired cooking and heating stoves and heating furnaces – modified and developed much further over subsequent decades, but not fundamentally transformed.[♣] In the 1850s the last great breakthrough was made – the development of the "base-burning" principle, resulting in a workable gravity-feed coal stove which enabled users to maintain a continuous fire, night and day, right through the winter season, fuel-efficiently and with far less labour than hitherto (Littlefield, 1859).

So, even before the Civil War, winter had been conquered, inside the home at least, with almost all northern households, urban and rural, enjoying a warm kitchen around a versatile cooking stove which also provided them with unprecedented amounts of cheap, easy hot water – another ingredient of the revolution in domestic comfort. For slightly wealthier consumers, parlour heating

---

[♣] Among the most significant early inventors were: the Reverend Dr Eliphalet Nott, president of both Union College, Schenectady and Rensselaer Polytechnic Institute, Troy, who made a series of breakthroughs in the design of stoves to burn anthracite, and went into business to manufacture them; Jordan Mott, a New York City fuel dealer, who both designed anthracite stoves and transformed the way they were made, turning them into mass-market products; Philo Stewart, a self-taught mechanic and social reformer, who developed an unusually economical wood-burning cook stove in Ohio and New York the 1830s, and perfected it in Troy over the next three decades (see Figure 3); Darius Buck, an itinerant mechanic and stove salesman from upstate New York, who also invented (or reinvented) a cooking stove which solved the problems of providing a large enough oven for all family needs, equalizing the temperature within it, eliminating hot spots near the fire, and making it controllable, by putting the oven beneath the fire and heating it by an arrangement of downdraft flues with dampers; and Gardner Chilson (see Figure 2), a Massachusetts pattern-maker turned stove maker who specialized in solving problems of space-heating rather than cooking. Interested readers can examine some of these men's key patents for themselves, most conveniently via Google Patents, http://www.google.com/patents -- simple word searches (e.g. Nott Stove) will produce good results.

stoves opened up more usable space within the home; and for the middle class, urban and rural, basement furnaces enabled them to warm the whole house, transforming the way they lived within it as a result of this first affordable approximation to what would later come to be known as "central heating."

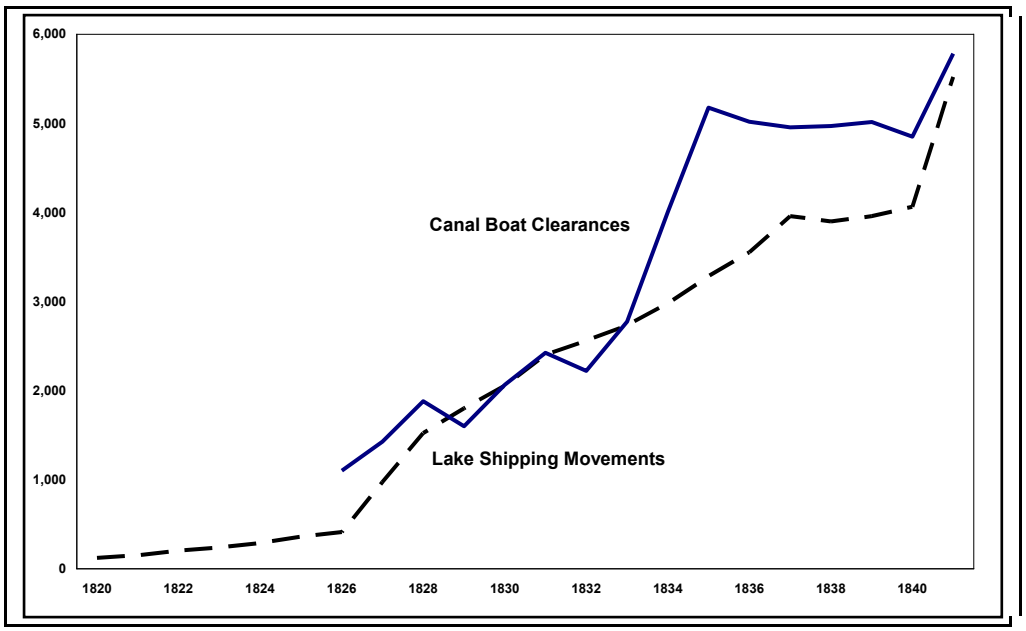
* * *

How are we to explain these two interrelated developments – the profit-seeking creative energy that poured into satisfying what was already a rapidly-growing market for stoves in the late 1820s, taking the crude and limited devices it found and radically improving their usefulness; and then the entrepreneurial inventiveness of the late 1830s-early 1840s, which transformed the way stoves were made and sold, as well as continuing the process of product development?

Given that this article has taken William Meyer to task for offering what is essentially a single-factor explanation for what was evidently a complex and protracted process, it would hardly be appropriate to offer an alternative magic bullet in place of the "high fuelwood price" argument. But it <u>is</u> tempting. Underpinning the growth of the market for stoves, the response from inventors and other entrepreneurs, and the consequent reorganization of the industry, was what U.S. economic historians call the "Transportation Revolution" (Taylor, 1951). The market for stoves into the early 1820s was effectively limited to those regions not too far away from the sea or a navigable river. Early cooking stoves might weigh as much as 500 pounds (c. 230 kilogrammes); transporting them over unimproved dirt roads or even hard-surfaced turnpikes by horse- or ox-drawn wagon was costly, difficult, and slow. And then the Erie Canal was opened, providing the first efficient highway through a gap in the mountain barrier separating the East Coast from the vast, rapidly-developing rural hinterland around the southern shores of the Great Lakes and into the Ohio River valley. The cost of freight transportation from the Hudson River to Lake Erie fell by 90 percent almost overnight, and the time was halved. (See Figure 5 for a graphic illustration of the immediate impact of the canal's opening on the number of shipping movements through Buffalo, the biggest lake port, near its western terminus.) Other canals and then railways followed, cost and time continued to

decline while speed and reliability improved, and the whole of the North was knitted together into a single market area.

Figure 5:
The Opening of the North-Western Market: The Port of Buffalo, 1820-1842 (Walker, 1842, pp. 12-13)



This is what allowed stove-making to migrate from rural furnaces to urban foundries – the ability to transport pig iron, coal, and other raw materials cheaply, and concentrate production in centres of skilled labour supply, existing demand, and good communications links with new markets. Competition in and for these markets gave stove foundries' owners a powerful incentive to learn, by experiment, imitation, and experience, how to produce better, cheaper stoves, on a far larger scale, and to develop a range of products suited to the cooking, heating, and other needs of households and institutional users big and small, rich and poor, urban and rural, wood- or coal-burning. At the other end of the distribution chain cheap, rapid postal and express freight services helped give new stove consumers the confidence to entrust the basic survival needs of heating and cooking to a new technology, by enabling the local dealers on whom they depended for installation and after-sales service to order up spare parts quickly and reliably. The number of those local retailers and thus the density of the supply and service network also

increased markedly, so that by mid-century a midwestern village with a few hundred people might have more stove stores than an East Coast city with tens of thousands a generation earlier, providing even the rural consumer with choice (Harris, 2008/9). Without a sustained, multi-layered improvement in the means for transporting information and goods around the country, the rapid development of a nationwide stove market between the 1830s and 1850s could not have taken place, and no general transformation of the American indoor climate would have occurred.

6. Conclusions

So it turns out that there is a good explanation for how the stove revolution, and its associated transformation of the indoor winter climate across the northern United States, occurred, between the 1820s and the 1850s: the interaction between an already-existing demand for greater comfort (or less discomfort) and more convenience in everyday life, on the one hand, and the complex market forces determining the effective supply of improved ways of using heat in household and institutional settings, on the other. It is not that the rising cost of fuelwood was unimportant in explaining the transformation, but that other market and non-market forces mattered at least as much.

What lessons does this chapter of history have for us nowadays, if any? Perhaps the most important is that we should understand that this revolution in consumer behaviour and expectations – for one certainly occurred – depended on the development of a technology which was superior in many respects, not just lifetime price, to that which it displaced. It could be integrated into people's existing homes and ways of life with little disruption, except of the sentimental bonds between Americans and visible, open flame as the traditional symbol of comfort and welcome (Hawthorne, 1851). Its deployment and refinement depended, more than anything else, on an efficient market economy of competitive enterprise which created from small beginnings a product range, a production system, and a distribution and service network, within about a generation. The difficult task of building a universal market for energy-efficient substitutes for carbon-intensive heating systems will certainly require nothing

less. A market of sorts exists already; but in terms of price, performance advantage, scale of production, ease of installation, and availability of reliable after-sales service, we seem to be at about the same developmental stage the American stove industry had reached by the early 1830s. The breakthrough from a niche to a mass-market product remains to be made. Perhaps all that is needed to effect it is a sustained increase in energy prices. But, if this critique of William Meyer's argument has any validity, probably not. A transformation of the supply side of the industry will be equally essential.

References

'Burr-Oak' [*pseud.*] (1850). Review of *The Horticulturist* for November. *Western Horticultural Review* **1**(3), 122-5.

Adams, S.P. (2008), Warming the Poor and Growing Consumers: Fuel Philanthropy in the Early Republic's Urban North. *Journal of American History* **95**(1), ##-##. No pagination available – not yet in page proof

Aldrich, M. (2006) *Death Rode the Rails: American Railroad Accidents and Safety 1828-1965,* Johns Hopkins University Press, Baltimore.

Anon. (1845), The Stoves: A Tale of the Imagination. *Yale Literary Magazine*, **11**(2), 82-6.

Anon. (1875), Albany and Troy Stoves: Alphabetical Index of Manufacturers, and of the Stoves Made By Them. *Metal Worker*, **3(**21), 3.

Barnard, H. (1850) *School Architecture, Or, Contributions to the Improvement of Schoolhouses in the United States*, A.S. Barnes & Co., New York.

Bell, L.V. (1848) *The Practical Methods of Ventilating Buildings: Being the Annual Address Before the Massachusetts Medical Society, May 31, 1848. With an Appendix, on Heating by Steam and Hot Water*, Damrell & Moore, Boston.

Benedict, D. (1860) *Fifty Years Among the Baptists*, Sheldon & Co., New York.

Brewer, P.J. (2000) *From Fireplace to Cookstove: Technology and the Domestic Ideal in America*, Syracuse University Press, Syracuse.

Buggeln, G.T. (2003) *Temples of Grace: The Material Transformation of Connecticut's Churches, 1790-1840*, University Press of New England, Hanover.

Bull, M. (1827) *Experiments to Determine the Comparative Value of the Principal Varieties of Fuel Used in the United States, and also in Europe. And on the Ordinary Apparatus Used for their Combustion*, Judah Dobson, Philadelphia.

Burrowes, T.H. (1855) *Pennsylvania School Architecture: A Manual of Directions and Plans for Grading, Locating, Constructing, Heating. Ventilating and Furnishing Common School Houses,* A. Boyd Hamilton, Harrisburg.

Chambers, W. (1854) *Things As They Are in America*, P.D. Orvis, New York.

Chandler, A.D., Jr (1972), Anthracite Coal and the Beginnings of the Industrial Revolution in the United States. *Business History Review*, **46**(2), 141-81.

Chilson, Dunklee & Co. (1850), Warming and Ventilating Public and Private Buildings, in Capen, N. *The Massachusetts State Record and Year Book of General Information*, Vol. 4, James French, Boston, unpaginated advertising matter.

Cochran, T.C. (1981) *Frontiers of Change: Early Industrialism in America*, Oxford University Press, New York.

Cole, A.H. (1970), The Mystery of Fuel Wood Marketing in the United States. *Business History Review*, **44**(3), 339-59.

Cooper, G. (1998) *Air-Conditioning America: Engineers and the Controlled Environment, 1900-1960*, Johns Hopkins University Press, Baltimore.

Cooper, J.F. (1823) *The Pioneers: Or, the Sources of the Susquehanna. A Descriptive Tale*, Stringer and Townsend, New York, 1856 ed., Vol. I.

Crowley, J.E. (2001) *The Invention of Comfort: Sensibilities and Design in Early Modern Britain and Early America*, Johns Hopkins University Press, Baltimore.

Dickens, C. (1842) *American Notes for General Circulation,* Chapman & Hall, London.

Downing, A.J. (1858), The Favorite Poison of America, in Downing, A.J. *Rural Essays*, Leavitt & Allen, New York, pp. 278-86. (Essay first published Nov. 1850.)

Dwyer, J. (1895) Stoves and Heating Apparatus, in C. Depew (ed): *One Hundred Years of American Commerce*, D.O. Haynes Co., New York, Vol. 2, Ch. 51.

Finley, J.B. (1857) *Sketches of Western Methodism: Biographical, Historical, and Miscellaneous. Illustrative of Pioneer Life*, J.B. Finley, Cincinnati.

French, H. (1856), How to Keep Your House Warm in the Country. *New England Farmer*, **8**(1 and 2), 44-46, 66-68.

Garrett, E.D. (1990), *At Home: The American Family 1750-1870,* H.N. Abrams, Inc., New York.

Gobeille, J.L. (1885), Engineering and Mechanical Problems in Cook's Stove Construction. *Journal of the Association of Engineering Societies,* **5**, 204-13.

Godley, J.R. (1844) *Letters from America*, John Murray, London.

Greenberg, D. (1980), Energy Flow in a Changing Economy, 1815-1880, in J.R. Frese and J. Judd (eds): *An Emerging Independent American Economy 1815-1875*, Sleepy Hollow Press, Tarrytown, pp. 29-58.

Hare, Archdeacon J.C. (1856) *Charges to the Clergy of the Archdeaconry of Lewes: Delivered at the Ordinary Visitations From the Year 1840 to 1854,* Macmillan & Co., Cambridge, England.

Harris, H.J. (2008/9) Inventing the U.S. Stove Industry, c. 1815-1875: Making and Selling the First Universal Consumer Durable, *Business History Review* forthcoming.

Hawthorne, N. (1851), Fire-Worship, in Hawthorne, N. *Mosses from an Old Manse*, G.P. Putnam, New York, pp. 128-36. (Essay first published December 1843.)

Hazen, M.H. and Hazen, R.M. (1992) *Keepers of the Flame: The Role of Fire in American Culture 1775-1925*, Princeton University Press, Princeton.

Judd, S. (1850) *Philo: An Evangeliad*, Phillips, Sampson & Co., Boston.

Keep, W.J. (1916) *History of Heating Apparatus*, unpublished manuscript, Baker Library, Harvard Business School.

Larkin, J. (1988) *The Reshaping of Everyday Life 1790-1840*, Harper & Row, New York.

Littlefield, D.G. (1859) *A History of the Improvements Applicable to the Base Burning or Horizontal Draught Stove ... by the Inventor of the Railway Coal Burner, Parlor Furnace, &c.*, C. Van Benthuysen, Albany.

Lyell, Sir C. (1845) *Travels in North America: With Geological Observations on the United States, Canada, and Nova Scotia,* John Murray, London.

Mann, H. (1838) *Report of the Secretary of the Board of Education: On the Subject of School Houses, Supplementary to His First Annual Report*, Dutton & Wentworth, Boston.

Martin, E.W. (1942) *The Standard of Living in 1860*, University of Chicago Press, Chicago.

Meyer, D.R. (2003) *The Roots of American Industrialization*, Johns Hopkins University Press, Baltimore.

Meyer, D.R. (2006) *Networked Machinists: High-Technology Industries in Antebellum America*, Johns Hopkins University Press, Baltimore.

Meyer, W.B. (2000) *Americans and their Weather: A History*, Oxford University Press, New York.

Meyer, W.B. (2002) Why Indoor Climates Change: A Case Study. *Climatic Change* **55**, 395-407.

Nylander, J.C. (1993) *Our Own Snug Fireside: Images of the New England Home 1760-1860*, Alfred A. Knopf, New York.

Olmsted, D. (1837) Observations on the Use of Anthracite Coal, in *American Almanac and Repository of Useful Knowledge for the Year 1837*, Charles Bowen, Boston, pp. 61-9.

Paratext™, *19th Century Masterfile* http://poolesplus.odyssi.com/19centWelcome.htm, viewed 27 Oct. 2007.

Parton, J. (1860) *The Life and Times of Aaron Burr*, Mason Bros., New York.

Peirce, J.H. (1951) *Fire on the Hearth: The Evolution and Romance of the Heating-Stove*, Pond-Ekberg Co., Springfield, MA.

Powell, H.B. (1978) *Philadelphia's First Fuel Crisis: Jacob Cist and the Developing Market for Pennsylvania Anthracite*, Pennsylvania State University Press, University Park.

Prison Discipline Society (1830) *Fifth Annual Report*, n.p., Boston.

Prison Discipline Society (1855) *Reports of the Prison Discipline Society, Boston, 1846-1855*, T.R. Marvin, Boston.

Reid, D.B. (1858) *Ventilation in American Dwellings*, Wiley & Halsted, New York.

Sarapin, J.K. (1994) *Old Burial Grounds of New Jersey: A Guide*, Rutgers University Press, New Brunswick.

Schuyler, D. (1996) *Apostle of Taste: Andrew Jackson Downing, 1815-1852*, Johns Hopkins University Press, Baltimore.

Silliman, B. (1826) Anthracite Coal of Rhode-Island -- Remarks upon its Properties and Economical Uses: with an additional notice of the anthracites of Pennsylvania, etc. *American Journal of Science* **11**(1), 78-100.

Source Translation and Optimization™ (1995) *Index to Manual of Classification of Patents*, http://www.ibiblio.org/patents/ [viewed 26 Feb. 2008].

Strasser, S. (1982) *Never Done: A History of American Housework*, Pantheon, New York.

Taylor, G.R. (1951) *The Transportation Revolution, 1815-1860*, Rinehart, New York.

Trollope, A. (1862) *North America*, Harper & Bros., New York.

U.S. Bureau of the Census (1970) *U.S. Census of Population, 1970*, Government Printing Office, Washington DC, Vol. I, Part 1, Section 1, Tables 8 and 18.

Walker, G.W. (1861) 35,000 in Use! In *The Christian Examiner* **70**(1), advertising section p. 7.

Walker, H.N. (1842) *Walker's Buffalo City Directory*, Steele's Press, Buffalo.

Washburn, E. (1860) *Historical Sketches of the Town of Leicester, Massachusetts, During the First Century from Its Settlement*, John Wilson & Son, Boston.

White, J.H. (1985) *The American Railroad Passenger Car*, Johns Hopkins University Press, Baltimore.

Williams, E. (1836) *The New York Annual Register for the Year of Our Lord 1836*, Author, New-York.

Woodbridge, W.C. (1832) On the Construction of School-Rooms, Appendix to *The Introductory Discourse and the Lectures Delivered before the American Institute of Instruction, in Boston, August, 1831*, Hilliard, Gray, Little & Wilkins, Boston, pp. 272-89.