The Carbon-Consuming Home: Residential Markets and Energy Transitions

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Home heating and lighting markets have played crucial and underappreciated roles in driving energy transitions. When historians have studied the adoption of fossil fuels, they have often privileged industrial actors, markets, and technologies. My analysis of the factors that stimulated the adoption of anthracite coal and petroleum during the nineteenth century reveals that homes shaped how, when, and why Americans began to use fossil fuel energy. Moreover, a brief survey of other fossil fuel transitions shows that heating and lighting markets have been critical drivers in other times and places. Reassessing the historical patterns of energy transitions offers a revised understanding of the past for historians and suggests a new set of options for policymakers seeking to encourage the use of renewable energy in the future.

Energy transitions are a pressing topic of contemporary public policy. Given the known links between fossil fuel consumption and such conditions as global warming, environmental degradation, economic inequality, and geopolitical instability, it is clear that replacing coal, oil, and natural gas with renewable energy sources will offer a wide variety of benefits. However, the magnitude of the challenge is daunting. Such a transition will most likely require hundreds of billions of dollars, decades of time, and widespread social and technological changes. It is hardly surprising, therefore, that the
subject of energy transitions has received significant attention in think tanks, universities, government agencies, and corporate boardrooms. Past, present, and future are inextricably linked in such discussions. Proposals usually begin with a goal for the future: achieving 20 percent of our electricity from renewable energy by 2020, limiting carbon in the atmosphere at 350 ppm, or reducing carbon dioxide emissions by 80 percent of 1990 levels by 2050. History is then invoked to suggest ways the future goal can be met. For example, many have recommended a Manhattan or Apollo Project for renewable energy. In other cases, people have drawn on memories of gas shortages during the 1973 Oil Crisis, the role of the Tennessee Valley Authority in spreading electrification, or the anti-nuclear movement of the 1970s. These historical examples then frame policy options in the present: large subsidies for wind and solar energy, reduced consumption by individuals, citizen mobilization, a tax on carbon, or renewable energy portfolio standards.

If the stories we tell about the past shape the ways we think about possible futures and the actions we take in the present, then historical accounts of energy transitions do not simply describe “one damn thing after another”; they provide storylines that frame plausible scenarios for what we might do next. To this end, I present a new story in this paper, one that offers a different understanding of the past and suggests an alternative set of policy possibilities. My analysis focuses on a site of fossil fuel consumption rarely associated with the momentous rise of coal and oil: the home. I argue that home heating and lighting markets played a far greater role in driving the adoption of anthracite coal and oil in America than has generally been appreciated. When historians have discussed the rise of fossil fuel consumption, they have often privileged industrial actors, markets, and technologies. The favored actors have been pioneering oil drillers such as Edwin Drake or corporate tycoons including John D. Rockefeller and Samuel Insull. The most studied markets have been factories, iron forges, steel manufacturers, steamships, and railroads. Correspondingly, the most analyzed technologies have been steam engines, furnaces, boilers, and internal combustion engines. The history of fossil fuel consumption has been tightly bound with the history of industrialization, and as a result, our stories of previous energy transitions have been biased towards the industrial sector.

And yet, a closer look at two of America’s most critical energy transitions—the adoption of anthracite coal from 1820 to 1840 and the dramatic ascendancy of petroleum beginning in 1859—reveals that both processes were driven more by residential heating and lighting markets than industrial operations. In their natural state, coal and oil were difficult to extract, expensive to transport, and unfamiliar to
consumers. Residential consumers—seen by entrepreneurs of anthracite and petroleum as the most promising initial market—enabled the growth of these trades by justifying the allocation of capital for infrastructure that rendered these energy sources cheap and abundant for the first time. The large industrial uses of coal and oil only emerged after residential markets had created a thriving trade. Industrialization was a response to the availability of cheap coal and oil, not the cause of their initial adoption. Moreover, if we examine a broad range of energy transitions, there is suggestive evidence that domestic use shaped the initial use of other energy sources as well. Put simply, residential markets have been critical forces in the past, and they belong in the stories we tell in the present about creating a new energy future.

This paper examines the role of homes in energy transitions in five sections. The first reviews the historical literature on energy transitions; the second and third analyze the adoption of anthracite coal and petroleum in America during the nineteenth century. The fourth section surveys a range of other energy transitions to assess the broader relevance of home heating and lighting markets. In the conclusion, I reflect on the implications of this story. For historians, my account offers a revised understanding of the role of the home in energy transitions, the linkages between energy and industrialization, and who we consider important energy consumers. For policymakers, I provide a new historical narrative that can support a broader range of policy measures in the present.

Homes and the Energy Transitions Literature

The phrase “energy transitions” is widely used but can be misleading. The conventional understanding of transition denotes a move from one thing to the next. In the context of energy, this suggests that once a society adopts a new energy source, older ones are abandoned. This has rarely happened. Instead, new energy sources often supplement and coexist with older ones. In many cases, as a new energy source has been introduced and absorbed a growing share of the market, the use of older energy sources has still increased in absolute terms. For example, coal consumption grew steadily during the same period that Americans were introduced to oil. Therefore, when historians discuss energy transitions, they usually mean that a new energy source has come to capture a significant fraction of market share, not that old energy sources have necessarily been abandoned.¹

¹ For a useful discussion of the concept of energy transitions, see: Melosi, “Energy Transitions.” p. 55–69.
When historians of energy transitions have directed their attention to residential markets, they have typically followed one of three approaches: analyzing the effect of energy systems on homes, studying a single energy transition, or examining multiple energy transitions comparatively. In the first case, several works have sought to understand how new energy sources influence the ways people live in their homes by exploring changing household labor patterns, the construction of residences, and domestic practices. This literature offers a number of compelling observations and insights about how energy sources shape residential life. However, these works rarely examine the reverse arrow: how homes have shaped energy systems. As a result, they have not systematically explored the importance of residential markets in stimulating energy transitions.2

Within analyses of a single energy transition, a few scholars have noted the role of homes. In particular, some works studying the early anthracite coal and petroleum trades have observed that home heating and lighting markets were important to their growth. For example, Frederick Binder devotes the first two chapters of his study of Pennsylvania coal consumption to home heating and gas lighting, noting that “the major market for [anthracite coal] during the first decade of the trade was the American home.”3 One of the most comprehensive histories of the early oil industry is aptly subtitled “the age of illumination.”4 And in his examination of the rapid development of petroleum as a source of fuel oil in the early twentieth century, Joseph Pratt notes that the development of this sector was greatly facilitated by the existence of large companies refining and marketing the illuminating oil kerosene.5 However, because these works are focused on a single energy source, they are not comparative. As a result, they have not explored whether there is a broader pattern of connections between residential markets and energy transitions.

2. Even in the compellingly titled Families and the Energy Transition, a book mostly focused on the 1980s, the editors do not develop arguments about the roles of homes in shaping historical energy transitions: Byrne, Schulz, and Sussman, Families and the Energy Transition. Other works that analyze the effects of energy on homes include: Bowers, Lengthening the Day; Brewer, From Fireplace to Cookstove; Nye, Consuming Power; Rose, Cities of Light and Heat; Schivelbusch, Disenchanted Night; and Tobey, Technology as Freedom.
3. Binder, Coal Age Empire, 5–6.
5. Pratt, “The Ascent of Oil.”
The attention to homes in studies of single energy sources has not been reflected in the literature on multiple energy transitions. The dominant trend has been to focus on the industrial applications of new energy sources and to mention residential consumption only in passing. While such accounts usually acknowledge that homes were a site of energy consumption, residential markets are most often reviewed descriptively, not analytically; the agency and importance of residential markets in driving energy transitions are not discussed explicitly. The number of pages devoted to industrial uses of fossil fuel energy far outweighs the text devoted to consumption in homes. In addition, none of these works explicitly develops the argument that residential markets were a crucial feature of multiple energy transitions. These scholars do not deny a role for residential markets, but they leave the question largely unexplored. The largest beneficiaries of fossil fuel transitions have been studied more than their first movers.

There are several reasons why the role of homes as drivers of energy transitions has been understudied. There has been a well-documented bias within histories of technology towards industrial machinery and away from the domestic sphere. As a result, the social impacts of technologies and labor in homes has been comparatively neglected. As historians including Ruth Schwartz Cowan, Susan Strasser, and Priscilla Brewer have shown, homes have long been sites of technological innovation, labor, and production. Jeanne Boydston

6. Crosby, Children of the Sun; Greenberg, “Reassessing Power Patterns”; Hunter, History of Steam Power; Landes, Unbound Prometheus; Melosi, Coping with Abundance; Schurr and Netschert, Energy in the American Economy; Sieferle, The Subterranean Forest; Smil, Energy in World History; Smil, Energy Transitions; Warde, Energy Consumption; and Wrigley, Continuity, Chance, and Change.

7. Consider, for instance, the very useful works on energy transitions by Rolf-Peter Sieferle and Vaclav Smil. While Sieferle acknowledges that much coal was consumed in homes in Britain, he focuses his attention on iron production and steam engines, devoting nearly the final thirty pages of his chapter on the adoption of coal in Britain to these topics. By contrast, the use of coal in home heating is discussed in a few pages, mostly on the subject of public resistance to coal smoke. Sieferle, The Subterranean Forest, Chapter 3. In Smil’s global overview of energy history, when he reviews the transition to coal and oil, he spends less than two paragraphs discussing home heating and lighting while devoting ten paragraphs to steam engines, two paragraphs to the use of coal in other industries, and five paragraphs to internal combustion engines. He later dedicates several pages to the analysis of energy in agriculture, industry, transportation, and information/communication technologies. When homes are discussed, it is to note the effects of energy on homes, not vice versa. Smil, Energy in World History, 158–69.

8. Horowitz, ed., Boys and Their Toys?; Horowitz and Mohun, eds., His and Hers; Lerman, Oldenziel, and Mohun, eds., Gender & Technology.

9. Brewer, From Fireplace to Cookstove; Cowan, More Work for Mother; and Strasser, Never Done.
has demonstrated that unpaid housework enabled the industrialization process by allowing families to make ends meet as men increasingly began to work for sub-subsistence wages in factories. My argument suggests that these points can be expanded even further. Work typically performed by women—tending stoves and lamps—in highly gendered spaces—kitchens and homes—was crucial to the energy transitions that underpinned American industrialization. As users, consumers, and laborers, women played essential roles in triggering the rising use of anthracite coal and petroleum.

A second explanation relates to the humble applications of energy in homes. The burning of fossil fuels to produce heat and light is a relatively simple process that is less exciting for many than the transformation of heat into motion in steam engines or automobiles. Moreover, in the short term, it is not clear that new home heating or lighting technologies constituted a major historical break: homes were warmed and illuminated before the introduction of coal and oil, and continued to be warmed and illuminated afterward. By contrast, the extensive use of steam engines, production of iron, manufacture of goods, and development of personal automobiles would have been impossible without cheap and abundant coal and oil. It has been the revolutionary, rather than the evolutionary, changes that have captured the attention of many historians. Simply put, mechanical power and its associated technologies often seem much more novel than heat and light, helping to explain why historians have focused on them.

Finally, data on energy consumption in homes is extremely limited. While those in the past often tabulated the numbers of steam engines or iron forges in a region, they rarely recorded the numbers of homes using particular types of fuels or the quantities in which they were consumed. The lack of clear data makes it a greater challenge to trace the patterns of residential consumption.

Whatever the reasons for the neglect of homes, our current understanding of the causes of several historical energy transitions is incomplete. Residential heating and lighting markets, as I’ll show in the next sections, were crucial to the development of American energy patterns.

**Anthracite Coal**

Anthracite coal, the first source of fossil fuel energy that Americans used intensively, was a critical driver for industrialization. As Alfred

Chandler has argued, anthracite coal “provided the fuel that modernized the American iron industry . . . [and] encouraged the growth of the large urban establishments in glass and paper and other industries.”\textsuperscript{11} However, despite the eventual importance of anthracite coal for factories, steam engines, and iron production, its widespread use began in homes. When anthracite pioneers sought to attract capital to invest in mining and transport facilities, they directed their focus to the residential heating market.

Coal is conventionally divided into several classes or grades based on its relative carbon content. Anthracite coal is on one end of the spectrum, with anywhere from 85 to 100 percent of its mass comprised of carbon. Bituminous, semi-bituminous, and lignite coal all have decreasing percentages of carbon. The high carbon content of anthracite means that it is much harder to ignite, but that once lit, it burns with a hotter and cleaner flame than other coals. Anthracite coal is relatively rare: most of the world’s coal reserves are bituminous, sub-bituminous, or lignite. However, in a small area in northeast Pennsylvania, huge quantities of anthracite coal are concentrated into the Schuylkill, Lehigh, and Wyoming valleys.

Anthracite coal might have been a historical side note were it not for the contingencies of geography. While America is endowed with huge coal reserves, nearly all of the nation’s deposits are located west of the Appalachian Mountains. For all practical purposes, this meant that they were unavailable to the nation’s centers of population and capital at the turn of the nineteenth century. Therefore, even though the Pennsylvania anthracite reserves were only a small fraction of the nation’s coal supply, they represented the overwhelming majority of fossil fuel energy that could reach the eastern seaboard in a pre-railroad era.\textsuperscript{12}

But getting the coal to markets was neither simple nor cheap. Pennsylvania’s anthracite coalfields may have been within a hundred miles of the eastern seaboard, but this was not considered easily accessible in the early nineteenth century. The Schuylkill, Lehigh, and Wyoming valleys were sparsely populated and the combination of mountainous terrain and rough roads meant that transporting goods to Philadelphia and New York was extremely expensive. Even though anthracite could be brought out of the ground with simple tools, shipping it to urban markets was prohibitively costly. The

\textsuperscript{11} Chandler, “Anthracite Coal,” 159.
\textsuperscript{12} There were small seams of bituminous coal along the James River near Richmond and a few outcroppings of anthracite coal in Rhode Island that were utilized in the early nineteenth century.
transport costs could be recouped on high-value products like manufactured goods, but not on a low-value bulk commodity like coal. In addition, while several rivers connected the anthracite coal regions to the eastern seaboard, they were difficult to navigate due to stretches of rapids and seasonal variations in the height and flow rate of the river waters. As a result, in 1810 it cost more to ship anthracite coal less than a hundred miles to Philadelphia than it did to deliver comparable shipments of bituminous coal three thousand miles from Britain. With the exception of a short period of time during the War of 1812 when a British blockade tripled the price of imported coal in Philadelphia, anthracite could not attract a regular market on the eastern seaboard.

The breakthrough in anthracite consumption came once entrepreneurs turned their attention to the construction of canals in the 1810s. Canal transport was much easier than overland transport due to the lower friction of water: while a pair of strong draft horses was needed to pull a cart weighing three to four tons on a road, on water a few mules could pull a boat carrying more than a hundred tons of coal. Canals, therefore, offered the potential of dramatically lowering the cost of transporting anthracite coal. On the other hand, building a canal was extremely expensive: river improvements were among the most costly projects of the early nineteenth century. In order to raise funds, boosters had to persuade state authorities to back these projects and convince investors that a compelling market existed for coal.

In their efforts to raise capital, anthracite boosters clearly identified their target market: home heating. A committee in 1813 that helped create the Schuylkill Canal argued that their river improvements would “. . . afford cheerful and comfortable fires to the residents of Reading, Philadelphia and perhaps New York.” When the company operating the Lehigh canal began selling coal in Philadelphia, it sought to develop the home heating market first. Josiah White, the company’s founder, noted disappointingly in his memoir that the company’s first shipments “proved more than en" for family supply in Philad." White persisted, however, and noted satisfactorily that

15. For more on the crucial role of transport infrastructure in creating the transition to intensive anthracite coal consumption, see Jones, “Landscape of Energy Abundance.”
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once large quantities were delivered for a few years “the public now seeing so large a stock on hand [at a uniform price], began more generally to inquire about it, as a domestic article that the supply of it seemed to be now ample, & likely to be continued.”

An 1823 pamphlet seeking to raise money in New York City for a large anthracite mining enterprise observed: “the city of New-York is principally interested in the introduction of this Coal, for its domestic uses.”

Whenever boosters sought to quantify the potential market for anthracite, they counted the numbers of homes, not the numbers of factories or steam engines. Marketers in New York argued that “this city alone, containing upwards of 20,000 dwelling houses, and a population of nearly 150,000 inhabitants, is estimated to consume yearly not less than 200 to 250,000 cords of wood, and of coal 40,000 chaldrons.” Replacing these supplies with anthracite would save New Yorkers an estimated half a million dollars, while preventing several hundred thousand dollars from being sent abroad for “the refuse of England’s coal mines.”

The promoters for the Delaware & Hudson Canal calculated that “[t]he city of New York, with its present population would require, if no other fuel were used, 221,000 tons . . . . And to this may be added the rational probability, that in twenty years, the population of the city of New York will be doubled.”

An 1821 document examining the costs of coal shipments from the Lehigh Valley estimated the annual wood consumption of eastern seaboard cities to be 900,000 cords. If only a quarter of this consumption could be displaced by coal, the author noted profits of $250,000 a year could be expected.

By appealing to the potential of the home heating market, anthracite boosters were able to raise the capital necessary to construct canals. But it is important to note that the development of the anthracite coal trade was not simply the product of free market forces: government actions figured prominently. The State of Pennsylvania stimulated the development of the anthracite trade through granting generous corporate charters giving canal boosters exclusive rights to develop rivers, allowing private investors to purchase public lands and mine the coal, and paying for geological surveys used by mining companies to increase production. Moreover, the Pennsylvania legislature also chose not to do certain things that might have restricted the trade

19. Ibid, 52.
20. A Cursory Review of Schuylkill Coal, 8. Italics are in original text.
23. Comparative Calculations on Internal Improvements.
such as installing a tax on anthracite or passing comprehensive mining safety laws. The important role of the state is illustrated clearly by comparing the Pennsylvania experience with Virginia. The conservative landowning elite of Virginia refused to allocate significant rights or resources to those seeking to develop the bituminous coalfields near Richmond, and as a result, an extensive coal trade never developed.  

Supported by the state and backed by capitalists, several canals were built in eastern Pennsylvania and New Jersey beginning in 1820. Over the next two decades, the price of anthracite dropped rapidly as its transport costs fell to as little as a dollar a ton. Whereas a ton of anthracite had cost approximately $20 wholesale in the first decade of the nineteenth century in Philadelphia, the price had fallen to $8.40 in 1820, $6.50 in 1830, and for as little as four dollars a ton after 1840.  

With a regular supply of cheap coal, boosters turned their attention to convincing families to change their domestic fuel consumption patterns. Josiah White had his wife keep an anthracite fire burning in their Philadelphia home so that potential clients could see how it worked. Scientists performed experiments that demonstrated anthracite coal offered superior heating value compared with wood. And manufacturers began to develop new models of anthracite stoves, with 329 patents for new designs awarded between 1815 and 1839.  

These efforts were crucial to the adoption of anthracite coal because it was a significant decision for many families to change heating fuels. Families first had to decide whether to purchase a stove, since anthracite coal would not burn effectively in an open hearth. This was no minor decision: stoves often cost thirty dollars or more at a time when the average laborer earned less than two dollars a day. After this, families had to learn to ignite and maintain an anthracite fire. An 1827 guide for servants reveals that this was not a trivial task: “Very few servants at first understand the method of

24. For an excellent overview of the state policies that shaped the anthracite trade in Pennsylvania during the antebellum period along with useful comparisons to Virginia, see: Adams, Old Dominion, Industrial Commonwealth.
27. Bull, Experiments on Fuel. In addition to being a scientist, Bull was also an officer of the North American Coal Company.
28. Brewer, From Fireplace to Cookstove, 64. Anthracite coal stove designs represented about 4 percent of patents during this period.
29. Adams, “Warming the Poor.”
kindling and continuing a fire of Lehigh coal, many will never learn, and many more from erroneous instructions, whilst they think they understand it, make but a bungling piece of work of it.”

The use of a stove also forced family members—typically women—to learn new techniques of cooking food with anthracite and to spend significant amounts of time cleaning the stove.

Under such conditions, the earliest adopters of anthracite were generally wealthy Philadelphians. These patrons had the money and hired help to experiment with stoves and a new fuel source. Moreover, they often had several hearths in their homes and used coal for some and wood for others. For many of these early adopters, the use of coal was tied to a broader regional boosterism: the development of the region’s coal resources, they hoped, would lead to growth for Philadelphia and Pennsylvania. The broader spread of anthracite coal to most of the population in northern cities, however, was not driven by regional boosterism or a widespread desire to emulate the heating patterns of the wealthy. Non-wealthy families faced a more practical set of considerations: was it worth the money to purchase a stove? Did they want to abandon the pleasant flame of the open hearth for a warmer home? Should they invest the time to learn how to ignite an anthracite fire and cook on an anthracite stove?

In her study of the history of American cookstoves, Priscilla Brewer analyzes why people chose to adopt coal-burning stoves. The most important factors were saving time and money along with a desire to keep the house warmer: “consumers chose heating and cooking systems based primarily on financial, not aesthetic, considerations.” Anthracite coal offered greater heating value at a lower cost, providing families more heat during the winter months. In some ways, an anthracite fire was more convenient: once started, it required less effort to maintain. Moreover, many women found it easier to cook on an anthracite stove because it produced a higher and more regular

33. There is some debate as to whether it was more desirable to heat a home with coal or wood if money was no object. Powell suggests that it was a privilege of the wealthy to burn imported coal in their homes before the introduction of anthracite. Other authors suggest that the pleasant flame of a wood fire in an open hearth produced the most desirable aesthetic. Given that compelling arguments could be made for the desirability of coal or wood fires, it does not appear that a desire to emulate the patterns of the wealthy played a particularly large role in shaping the adoption decisions of many families. Powell, Coal, Philadelphia, and the Schuylkill, 10. Brewer, “We Have Got a Very Good Cooking Stove”, 39–40.
level of heat. While men sometimes lamented the aesthetic loss of an open fire, women prized stoves that made their lives easier. “Probably because they worked with stoves less often than women,” Brewer writes, “men were especially upset by the abandonment of the fireplace.” Gendered divisions of labor within the household contributed to men and women viewing the relative benefits and drawbacks of stoves differently.34

Once the adoption of anthracite for home heating began, a feedback cycle gave it strong momentum. As more consumers purchased stoves, their prices dropped significantly over the 1830s and 1840s. Anthracite boosters sped this process up by introducing stoves costing less than ten dollars by the early 1830s, making it cheaper for people to convert.35 This justified an increase in the carrying capacity of the anthracite canals, leading to lower prices of coal to consumers, thereby further driving the rate of residential adoption. By the 1840s, nearly any resident of Philadelphia, New York, or Boston would have had friends, relatives, and neighbors using anthracite stoves, helping them to decide whether to install one themselves. The barriers to adopting anthracite were steadily lowered in a reinforcing cycle.

As a result, homes were the first and most receptive market for anthracite coal. Within ten years of the opening of the Lehigh Canal, New York City was sufficiently dependent on anthracite coal for its home heating needs that supply shortages in the winter of 1831 created widespread alarm.36 The following year, New York City consumed more than 50,000 tons of anthracite, mostly for home heating purposes.37 By 1850, approximately 90 percent of homes in the American north had stoves, suggesting that the use of anthracite was widespread.38

While entrepreneurs also hoped to develop industrial markets for anthracite, these played a small role in the revenues that gave the anthracite coal trade its foundations. The industrial uses of anthracite towards the end of the 1830s were insufficient to justify the extraordinary capital costs necessary to make coal cheap and abundant on the eastern seaboard. For example, in 1838, steam engines in Philadelphia and New York’s factories consumed only a small fraction of anthracite shipments—likely 3 to 4 percent of the

34. Brewer, From Fireplace to Cookstove, 99, 103.
36. Binder, Coal Age Empire, 17.
38. While a stove could be used to increase the efficiency of burning wood as well as coal, it was likely that anthracite was the fuel of choice for most residents of eastern cities as it was the cheapest fuel. Brewer, From Fireplace to Cookstove, 98.
The use of anthracite in steamboats was more common, but only by the late 1830s. In 1831, the Delaware & Hudson Canal Company could only count six vessels in the New York harbor powered by anthracite. By 1845, the Coal Mining Association of Schuylkill County estimated that there were thirty-five steam boats based in Philadelphia that used 45,000 tons of anthracite and that the steam vessels based in New York required 100,000 tons, “making the whole amount at these two points not less than from 150 to 160,000 tons consumed annually, for generating steam for the propulsion of vessels.” However, it should be noted that even this large quantity of coal represented less than 10 percent of all anthracite shipments that year. And practically no anthracite was used in the production of iron before 1840. Industrialists required nearly two decades to solve the technical problems of producing quality iron using anthracite coal as a smelting fuel. Most of the breakthroughs were developed in Wales where ironmasters had been attempting to use hard coal to smelt iron for several decades.

Ultimately, anthracite coal would support revolutionary advances in the industrial development of the eastern seaboard. Once ironmasters determined how to use anthracite coal to smelt pig iron, the industry expanded dramatically. By the end of the Civil War, more than two million tons of anthracite coal were being used to produce and process nearly 700,000 tons of iron. Almost 2,000 establishments

39. In 1838, there were 178 steam engines in Philadelphia with a total capacity of 1860 horsepower. Assuming that these were operated twelve hours a day and six hours a week at a coal consumption rate of 7.5 pounds per horsepower hour, we get a maximum coal consumption of 26,000 tons ((7.5 pounds of fuel × 1,860 horsepower × 12 hours per day × 309 days per year)/(2,000 pounds per ton) = 25,863 tons of coal used). There were only eighty-seven stationary steam engines reported in New York State at this time, expanding the total potential coal consumption to roughly 40,000 tons. Given that factories have frequent periods of downtime and that steam engines often required repairs, it is fair to assume that consumption was lower by at least a third. Since some steam engines were likely fueled by imported coal or wood, actual consumption was likely in the neighborhood of 25,000 tons out of total shipments that year of more than 700,000 tons. Atack, Bateman, and Weiss, “Regional Diffusion of Steam Engines,” 295; Daddow and Bannan, Coal, Iron, and Oil, 725; Secretary of the Treasury, Report on Steam Engines, 156–67, 379.
40. Binder, Coal Age Empire, 90–2.
42. Anthracite coal shipments in 1845 were over two million tons (2,013,013). Daddow and Bannan, Coal, Iron, and Oil, 725.
43. Childs, The Coal and Iron Trade.
44. Iron production using anthracite coal was 684,519 tons in 1864. Each ton of iron required at least two tons of anthracite coal. In addition, significant additional quantities of anthracite coal were used in the secondary processing to roll or puddle iron, turn it into manufactured goods, or forge steel. Bartholomew, Metz, and Bartholomew, Anthracite Iron Industry, 52–3.
in Philadelphia used steam engines to manufacture goods in 1870, consuming hundreds of thousands of tons of coal.45 When Philadelphia hosted the Centennial Exposition in 1876, anthracite coal had played an important role in causing it to be called the “Workshop of the World.”

However, these developments were in large part a response to the availability of cheap and abundant coal, not the cause of its initial use. By 1834, with only modest industrial consumption of anthracite coal, capitalists had invested almost twenty million dollars into developing the trade, a remarkable sum for the time.46 In order to serve the home heating market, boosters had created extensive mining operations, transformed the region’s rivers into coal highways, and developed large marketing organizations to sell and distribute anthracite. By choosing to adopt anthracite to heat their homes, consumers both justified these investments and subsidized the further growth of the anthracite trade. The home heating market supplied the necessary revenues to turn anthracite coal from a costly and inaccessible fuel source into a cheap and abundant commodity. The anthracite coal trade was built on home heating.

Petroleum

Residential markets were also crucial for the development of the petroleum trade. When speculators turned their attention to the seeps of oil that rose to the surface of ponds and rivers in western Pennsylvania, they were seeking to develop a cheap and abundant source of artificial light. For the first four decades of the modern oil industry, kerosene—illuminating oil refined from crude petroleum—was its animating force. And boosters had little reason to seek other markets: the global lighting market was a huge prize. John D. Rockefeller’s Standard Oil Company, one of the nation’s most powerful and reviled companies, was built upon sales to millions of homes and businesses around the world.47

47. The importance of kerosene to the early oil industry is well documented by historians. Here my goal is to bring this history into new perspective by comparing it with the development of other energy sources. On the oil industry in the nineteenth century, see: Black, Petrolia; Chernow, Titan; Johnson, “Development of American Pipelines,” Nevins, Study in Power; Tarbell, History of Standard Oil; and Williamson and Daum, The American Petroleum Industry, Vol. 1.
In the first half of the nineteenth century, and particularly during the 1840s and 1850s, a combination of urbanization and industrialization in America and Europe led to increased demands for lighting. In cities, many people worked according to the cycle of the time clock rather than the sun, lived in small urban dwellings with minimal natural light, and engaged in occupations requiring good illumination such as detail work at textile factories, accounting, or bookkeeping. Entrepreneurs in several fields sought to profit from this market. Manufactured gas companies installed miles of pipes in urban centers, ships went on multi-year journeys to hunt whales whose blubber would producing an illuminating oil, and the production of traditional lighting forms such as candles remained an important trade. In America, some turned to camphene, a foul-smelling derivative of turpentine. In addition, several manufacturers began to develop an illuminating liquid from coal in the 1850s. Despite these many innovations, artificial lighting was generally costly and limited.48

The need for good and cheap lighting was particularly acute among residential consumers. Manufactured gas provided a bright and steady light to those able to afford its high costs, most notably factories wishing to run their expensive capital equipment round the clock, cities seeking to increase public safety through street lighting, and stores hoping to grow sales by staying open into the evening. Wealthy urbanites also invested in gaslight. Most of the population, however, could not afford the expensive costs of installing pipes or the high monthly fees.49 Before the advent of the oil trade, good light was restricted to the homes of the wealthy and large municipal, commercial, and industrial establishments. Therefore, the biggest new market for illumination pioneers was in the private homes of the middle and lower classes.

It was in this context of seeking better artificial light that entrepreneurs first turned their attention to petroleum. In the hills of western Pennsylvania, small amounts of oil had been known to seep to the surface of ponds and rivers. Native Americans including the Seneca used petroleum extensively in rituals, and when European settlers moved into the region, some began to collect small amounts of oil to be sold as a patent medicine for conditions like burns and

49. For example, even in Baltimore, the city with America's first gaslight service, at most 25 percent of private households had gaslight service in 1859. The city's population in 1860 was 212,418, and there were a reported 8,200 private consumers. Assuming six residents per household, this gives an adoption rate of 23 percent. Castaneda, *Invisible Fuel*, 35.
rheumatism. Until the middle of the nineteenth century, the scale of the trade was modest: several dozen barrels could supply the market in any given year. This began to change in the 1850s as several forces converged to encourage people to reconsider the possibilities for petroleum. The most important stimulant was the burgeoning market for artificial illuminants. In addition, some began to notice the similarity between petroleum and the illuminating oil distilled from coal. Finally, there were reports from salt drillers in parts of New York and western Virginia that petroleum had seeped into some salt wells, thereby ruining the product. If oil could be found in large quantities by drilling into the ground, a few reasoned that it might meet the nation’s growing desire for light.50

To test this theory, a group of entrepreneurs sent oil samples from western Pennsylvania to Benjamin Silliman, one of the nation’s leading chemists, to analyze its commercial potential. His report noted success beyond initial expectations. Compared with candles, whale oil, camphene, and manufactured gas, the refined oil offered equal or superior light and it burned more slowly than other illuminating liquids. Silliman reported: “I have submitted the lamp burning Petroleum to the inspection of the most experienced lampists who were accessible to me, and their testimony was, that the lamp burning this fuel gave as much light as any which they had seen, that the oil was spent more economically, and the uniformity of the light was greater than in Camphene, burning for 12 hours without a sensible diminution, and without smoke.”51

With this positive report, the group of investors sent Edwin Drake to Titusville, Pennsylvania, to apply the methods of salt well drilling to petroleum production. In August of 1859, Drake and his drillers struck oil and the news spread rapidly. Thousands of speculators thronged into rural western Pennsylvania to make their fortunes in black gold. As one young company eagerly told investors: “Petroleum is bound to become the illumination of the world”52. Oil production expanded dramatically, increasing from hundreds to thousands to millions of barrels annually within a few years.

As with anthracite coal, this boom was largely financed by private capital but heavily structured by state decisions. State support for the railroad system provided much of the necessary infrastructure to deliver speculators to the western Pennsylvania and transport oil to

50. Black, Petrolia, Chapter 1.
52. The Cherry Run Petroleum Company, Venango County, PA, 23. Italics are in original text.
markets. The judicial system determined that ownership of underground oil was subject to the “rule of capture,” thereby triggering economically and environmentally disastrous boom-and-bust cycles. As critically, states took few actions to limit the growth of the oil trade, rarely levying taxes, ignoring the rise of monopoly capital, and allowing oil producers to avoid responsibility for the environmental consequences of their drilling.53

With crude oil production skyrocketing, oilmen turned to the development of markets. Homes loomed large in their imaginations. Recognizing that large establishments and wealthy consumers could afford manufactured gas or whale oil, the homes of the non-wealthy were seen as offering great potential. One company pamphlet from 1865 proudly proclaimed that kerosene would “give a good and cheap light in the houses of the poor.”54 Another author noted the promise of “an illuminator for the homes of the poor.”55 As with anthracite coal, boosters believed that residential markets were the most promising opportunity. Correspondingly, when oilmen refined petroleum—crude oil straight from the well is a mixture of water, impurities, and a variety of hydrocarbons that must be separated to create useful products—they sought to maximize the production of kerosene, much as refiners today utilize techniques that transform as much of a barrel of crude oil into gasoline as possible. Yields of illuminating oils increased from around 60 percent of a barrel of crude oil in the early 1860s to 75 percent by 1873.56 In 1901, more than forty years after Drake’s first strike, kerosene remained the industry’s main product. According to a U.S. Geological Survey report: “The average distillation of 100 gallons of crude petroleum of the Pennsylvania oil fields is estimated to yield 76 gallons of illuminating oil; 11 gallons of gasoline, benzine, and naphtha; and 3 gallons of lubricating oils, while the remaining 10 gallons represent residuum and loss.”57

Refiners maximized their production of illuminating oils because it was a large and profitable market that was easy to enter. Due to the presence of whale oil, camphene, and coal oil in the market, many people already owned lamps and knew how to fill them, trim the wicks, and maintain the flame. Moreover, lamps

suitable for burning illuminating oils could be purchased for as little as one dollar by the 1850s. It was quite simple for someone to replace whale oil or camphene with kerosene, much as one might replace an incandescent light bulb with a fluorescent bulb today. This allowed people to experiment with a new energy source without a long-term commitment, thereby further lowering the barriers to entry.

Consumers were particularly drawn to the clear and bright flame of a kerosene lamp. Commentators were quick to praise kerosene, noting its bright light and even glow: “its use is characterized by a clear, strong and steady flame that is most agreeable to the eye.” In his initial examination, Benjamin Silliman noted that the light was “pure and white without odor.” Others noted that it “surpassed all others, except gas, in brilliancy.” Kerosene was at least as effective as high-quality coal oil, whale oil, and camphene, and far superior to candles and lard oil lamps. It may not have had the intensity of manufactured gas, which was often declared “as bright as day,” but a kerosene flame was widely considered to be a compelling option.

For most consumers, though, kerosene’s main advantage was price. Common whale oil cost between thirty-four and seventy-nine cents a gallon at wholesale between 1846 and 1856 while the more highly desired sperm oil cost between eighty-eight cents and $1.62 per gallon in the same period. Camphene emitted a high-quality light but it gave off a foul smell and was prone to dangerous explosions. Moreover, it cost as much as $2.00 a gallon. By contrast, in 1865, a gallon of kerosene cost seventy-two cents (wholesale in New York), and petroleum boosters calculated that it offered anywhere from four to ten times the value of its competitors. Over the next fifteen years, kerosene would become an even better value as its price dropped to twenty-six cents in 1870 and to eight cents in 1885.

At this price, kerosene quickly came to dominate illuminating markets in the United States and beyond. Sales of kerosene increased dramatically, supplementing and largely replacing many other illuminants. The oil refining industry increased its output from six million barrels of illuminating oil in 1875 to nearly thirty million barrels in 1894. Meanwhile, the average American per capita

consumption of kerosene grew from 1.5 gallons in 1874 to 3.6 gallons in 1884 and 7.4 gallons in 1894. As a gallon of kerosene could provide about 140 hours of light, this represented an increase from 210 to 1,036 hours of light a year or from about forty minutes a day of lighting to nearly three hours.67

As with anthracite coal, kerosene became steadily cheaper for consumers because the lighting market justified the large capital expenses necessary to build the infrastructure to extract, transport, and refine crude oil. In 1860, there were almost no storage facilities at the drilling grounds, and transportation was prohibitively expensive (as much as eleven dollars to transport a barrel of oil from Titusville to the eastern seaboard) and wasteful (more than two-thirds of the oil was spilled or evaporated along the way).68 Over the next twenty years, oilmen invested in systems of iron storage tanks, pipelines, and advanced refineries that greatly lowered these costs. For example, by the 1880s a series of pipelines to the eastern seaboard reduced the expense of shipping oil to as little as five to ten cents a barrel.69 Storage and transport infrastructure were among the most capital-intensive undertakings in the oil industry. The National Transit Company, which built and operated storage tanks and pipelines for Standard Oil, was the Trust’s largest subsidiary, capitalized at nearly thirty million dollars in the 1880s.70 A positive feedback loop arose between the expansion of infrastructure, cheaper prices to consumers, and increased consumption. As infrastructure expanded, prices fell, and domestic consumption rose, leading in turn to more investment in infrastructure, lower prices, and increased use.

The adoption of oil for industrial purposes, by contrast, was far more limited during the nineteenth century. While Silliman’s 1855 report noted that oil could be refined into a variety of other products, the only one he discussed explicitly was lubricants, and this only in passing.71 Although the first efforts by refiners often resulted in lubricants that were far inferior to those produced from animal fats or coal oil, by the 1870s many of the technical problems had been addressed. Petroleum-based lubricants were literally greasing the wheels of American and European industries by the latter quarter of the nineteenth century. However, it should be noted that the lubricating market was a small fraction of petroleum

68. Ibid, 107.
69. For information on the pipeline network and comparative shipping costs, see: Jones, “Energy Landscapes,” Chapters 3, 4.
70. McElwee, National Transit Company, 38.
product sales—only 3 percent in 1880 and less than 8 percent by 1894.72 Lubricants were an important niche market for many refiners, but they only played a minor role in the early development of the oil trade.

Most of the remaining industrial applications of oil during the nineteenth century resulted from efforts to use the parts of crude oil that could not be sold as illuminants. Kerosene was too valuable to be simply burned for heat, but since at least 20 percent of crude oil could not be refined into illuminating oil or lubricants, refiners sought opportunities to earn revenues from the remaining balance.73 For example, they discovered that benzine could be used in industrial cleaning solvents and to remove oils from flax and cotton. Even in industrial applications, though, the illuminating market still loomed large: the most successful use of naphtha was for producing manufactured gas for gaslight companies. In 1869, researchers determined that naphtha could replace bituminous coal in the production of manufactured gas while lowering labor and material costs by two-thirds.74

A different set of industrial uses of petroleum emerged in the mid-1880s from the discovery of large fields of oil in western Ohio and Indiana. This oil contained a high percentage of sulfur and for many years refiners could not remove the foul smell, resulting in low quality kerosene. As a result, its price was dramatically lower than Pennsylvania crude, selling for fifteen cents a barrel during the late 1880s.75 At this cost, several manufacturers in Ohio and Chicago began to experiment with its use as fuel oil. In these instances, fuel oil was largely used as a replacement for coal in industrial processes requiring heat, such as making glass, bricks, and iron. Around the turn of the century, when large quantities of oil were found in the southwest where coal was comparatively expensive, the use of fuel oil accelerated dramatically, increasing from 2.5 percent of refinery output in 1884, to more than 15 percent in 1899.76

73. It takes more than four barrels of oil to equal the heat output of a ton of coal. If refiners could obtain five cents per gallon of kerosene, a barrel (42 gallons) of crude oil netted them at least $2.10, or more than $8.00 for the equivalent of a ton of coal which often sold for less than $2.00. Between 1880 and 1900, the average price of anthracite coal was between $1.41 and $2.01, making it a much cheaper source of heat. Price information from U.S. Geological Survey, Mineral Resources of the United States, 1901, 301.  
75. Ibid, 601.  
76. Ibid, 678.
However, the use of oil in industrial applications occurred only after illumination markets—largely domestic—had created a large and vibrant trade. Even though fuel oil use in 1899 had increased dramatically, it still represented only a small amount of America’s industrial power, less than 1 percent of the heat output of Pennsylvania coal production that year. As with anthracite coal, it was the availability of cheap and abundant oil for residential markets that drove its industrial applications, not the industrial demand for oil that made it cheap and abundant.

Residential Markets in Other Energy Transitions

Home heating and lighting were, as I have shown, crucial to the development of anthracite coal and petroleum resources in America. But do these two cases represent a pattern? Are they rules or exceptions? A brief review of transitions involving other energy sources suggests that residential markets have been important drivers in some, but not all, instances. While a comprehensive review of historical energy transitions is beyond the scope of this paper, I will explore some additional cases to place my arguments in broader perspective.

Coal use in Britain, the single most important energy transition since the development of settled agriculture, offers a compelling corroborating case. British coal consumption in the eighteenth century pioneered the Industrial Revolution and led to unprecedented economic growth for the island nation and the power to colonize large swaths of the globe. Much of the industrial growth in the rest of the world was inspired by Britain’s example. However, the roots of British coal consumption were found in the hearths of London as much as they were in industry.

As early as the 1200s, the demand for fuel was thinning the forests surrounding London. Faced with rising fuel prices, some entrepreneurs began to mine coal near the Tyne River in northern England and ship it by boat to London. Enough coal was being burnt in London by the

77. In 1900, Pennsylvania miners produced more than fifty-seven million tons of anthracite coal and nearly eighty million tons of bituminous coal. The heat output of the estimated 7.3 million barrels of fuel oil in 1899 produced less than 1 percent of this total. Schurr and Netschert, Energy in the American Economy, 93; U.S. Geological Survey, Mineral Resources of the United States, 1901.

78. On the transition to coal in Britain, see: Allen, British Industrial Revolution; Freese, Coal: A Human History, Chapter 2; Sieferle, The Subterranean Forest, Chapter 3; Warde, Energy Consumption; and Wrigley, Continuity, Chance, and Change.
1300s that there were formal complaints and bans on its use. The dramatic population losses in the next century due to the Black Death eased the constraints on the forests surrounding London and temporarily diminished the market for coal. But by the 1500s, London’s population once again was exceeding the capacity of its woodlands and coal was brought in to fill this gap. As a result, a vibrant London coal market emerged over the next two centuries. As Robert Allen has demonstrated, the evidence for this growing market can be seen by the proliferation of chimneys throughout London in the sixteenth and seventeenth centuries, a technical augmentation of homes designed to allow residents to burn coal while limiting their exposure to its noxious gases.

The home heating market absorbed much of London’s coal and many of the industrial uses lagged behind. Although coal was used early on in lime burning and salt manufacture, the various gases it contained, particularly sulfur, caused it to be shunned by other industries. For example, brewers were slower to adopt coal because the volatile gases could ruin the taste of their product. It took until the 1700s for ironmasters to develop methods for smelting iron using coal instead of charcoal. And the steam engine, perhaps the most recognized technology of the Industrial Revolution, was developed in the early eighteenth century because coal mining was so advanced that it was encountering limits to its growth. As mines were dug deeper, they began to fill with water. Originally, human and animal muscles were used to raise the water out of the mines, but this was a slow and expensive process. Thomas Newcomen realized that a modification of Thomas Savery’s steam engine might be able to pump water out using scrap coal from the mine, and in 1712, he created the first commercially successful steam engine. Due to the low efficiency of Newcomen’s design—approximately 1 percent of the energy was transformed into useful work—steam engines could only be profitably used at or near coal mines where the cost of coal was essentially free. In other words, steam engine use expanded because the British coal trade was already thriving, not vice versa. The London home heating market was essential to how, when, and why coal use began in Britain.

In Germany as well, residential markets appear to have been crucial to the development of coal consumption. In the eighteenth century, fears of wood shortages were common in many German states. In particular, state officials worried that the fuel demands of

79. Sieferle, *The Subterranean Forest*, 82; Galloway, Keene, and Murphy, “Fuelling the City.”
heating and cooking would consume wood that was needed for timber or the manufacture of goods. If people were to heat their homes with coal instead of wood, they reasoned, it would preserve wood for industrial purposes. As a result, state officials sponsored the development of a wide variety of residential coal-burning stoves and encouraged people to heat their homes with coal. In this case as well, the home market seems to have been responsible for driving coal consumption, not industrial applications.81

On the other hand, home heating was not essential everywhere. The city of Pittsburgh, for example, used bituminous coal as an industrial fuel from its earliest days. While some coal was no doubt used for home heating, industries such as glass manufacturers, brewers, and ironworkers, absorbed the lion’s share of coal in that city. Even with a relatively modest population of only six thousand residents in 1807, Pittsburgh already had more than 250 factories.82 Because bituminous coal was so widespread and rarely delivered long distances in the nineteenth century, its patterns of use varied enormously from place to place: most generalizations about its use are unlikely to withstand scrutiny. Further analysis about its adoption is likely to reveal cases where home heating was an important driver as well as examples where industrial applications played a more active role.

The use of natural gas in America followed a somewhat different trajectory than coal or oil. Whereas boosters devoted great attention to finding and extracting coal and oil resources, natural gas was mostly discovered by accident while drilling for oil. While “burning springs” had been known to exist for a very long time and pockets of gas were occasionally discovered when drilling salt wells, natural gas was rarely used commercially. Most of it was simply allowed to escape or flared off because drillers had little way to store or transport the gas. In many cases, natural gas was considered more of a nuisance than a benefit.

Given the difficulty of storing or transporting natural gas, it was initially used in isolated cases for home heating and lighting as well as industrial applications. In 1821, a small well was tapped in Fredonia, New York, to provide gas lighting in a few buildings, and over the next decades natural gas was used in isolated instances for home heating and lighting, glass and iron manufacture, and the production of carbon black, a raw material used in lubricants, pigments, and rubber production.83 Farmers in Ohio and Pennsylvania

were known to drill gas wells to heat and light their homes in the nineteenth century—345 of Pennsylvania’s 819 natural gas producers in 1906 were solely for private use. However, because these examples were relatively isolated and most use was local, they did not constitute an energy transition.

It was only with the development of better pipelines in the early twentieth century that natural gas began to be used in larger amounts and across greater geographic regions. Home heating and lighting markets played an important, but not exclusive, role in this transition. Urban gas companies sponsored the development of many long pipelines so that they could deliver natural gas to their customers for heat and light. The bulk of natural gas, however, most likely was used for industrial applications, in large part for “field use”: drilling for oil, powering pipeline pumps, and refining petroleum. Residential consumption did not exceed 30 percent of total consumption in the first half of the twentieth century. However, home heating and lighting provided a much greater share of the trade’s revenues than the absolute level of consumption would indicate. Because pipelines required large fixed costs, achieving an even flow of natural gas was extremely important to their profitable operation. To ensure regular consumption of natural gas, suppliers often gave deep discounts to manufacturers if they agreed to have their service interrupted during peak periods of domestic consumption such as the heart of winter. Therefore, homes provided a much greater percentage of the natural gas trade’s revenues than total consumption because they paid higher rates than industrial consumers.

Lighting markets also shaped the spread of electrification in America. Since the 1850s, cities had been experimenting with new ways to light their streets, both in the interest of public safety and as a conspicuous means of advertising their municipalities’ grandeur. Arc lighting, a system in which an electrical charge produced illumination when it flowed between carbon electrodes, came into favor during the 1870s. However, the electrodes burned down and required regular maintenance, the light was often considered overly bright for some streets, and many thought it was too dangerous to be

86. Ibid, 69.
used indoors. The development of the incandescent light bulb in 1876 by Thomas Edison and his opening of the first commercial generating station in Manhattan six years later were crucial steps in the spread of electricity. Edison and his financial backer J. P. Morgan knew that indoor lighting could be a highly profitable business. The development of electrification, like the petroleum trade, was pursued with the initial goal of profiting from illumination markets.

However, residential markets did not play as important of a role in driving the growth of electricity as they did with other energy sources. City governments and stores were the primary early adopters of electric lighting. Cities purchased electricity to light streets and municipal buildings and business owners quickly discovered that electric lighting drew consumers to their stores and helped increase sales. Individual homes, by contrast, absorbed a much smaller percentage of electrical output due to its high initial cost. Only the wealthy could afford to wire their houses until the 1910s and as in the natural gas industry, residential consumers were charged as much as four times the cost for electricity as industrial consumers. While lighting was essential to the development of the electric industry, by and large the main customers were cities and stores, not homes.

This review of other energy transitions provides enough evidence to suggest that residential markets have been important in cases other than anthracite coal and petroleum, but that no single pattern can be expected to hold across time and space. These sketches, admittedly brief and exclusive to America and Europe, suggest that there is good reason to study the role of heating and lighting markets more broadly.

Conclusions

I began this paper by noting that discussions of energy transitions link the past, present, and future. In concluding, I would like to return to this theme by drawing out some lessons for historians and policymakers. I have argued throughout that we should revise our historical understanding of previous energy transitions to acknowledge a more central role for homes in stimulating the rise of new energy sources. Residential heating and lighting markets were

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90. Ibid., 31.
91. In 1917, the average rate for lighting was 5.5 cents per kilowatt-hour while the average rate for power was 1.2 cents per kilowatt-hour. The distinction between lighting and power is closely correlated with the distinction between residential and industrial electricity consumption. U.S. Bureau of the Census, Census of Electrical Industries, 1917, 118.
far more important than has previously been acknowledged. Without the potential of large profits from urban residents, anthracite coal and petroleum pioneers would have had much greater difficulty raising the capital needed to build the infrastructure that rendered these energy sources cheap and abundant. Residential markets shaped how, when, where, and why Americans began to use large quantities of anthracite coal and oil and were important for the adoption of energy sources in other times and places as well.

An implication of my argument is that we should rethink the chain of causality linking fossil fuel use to industrialization. As several studies analyzing the links between energy, economy, and environment have made clear, the concentrated energy found in fossil fuels was an essential input for industrialization. Moreover, industrial applications have accounted for the great bulk of fossil fuel energy consumption over the last few hundred years. However, the symbiotic relationship between fossil fuel energy and industrialization does not explain the timing and shape of the onset of the anthracite and petroleum trades. The industrial consumption of energy was, to a great measure, a response to cheap and abundant coal and oil, not the cause of their initial widespread use. Industrial growth may have been the result of fossil fuel consumption, but it was not always the cause of its adoption.

My study also suggests that we reconsider how we study the history of energy consumption. We should pay greater attention to a class of people that is rarely discussed in energy histories: domestic consumers of heat and light. Historians have rarely analyzed these agents, as Sean Adams has demonstrated in his recent study of 19th century heating. They were not cultural or financial elites, they left few records, most were of modest means, and many were women. Even though they often had humble goals—supplying their residences with heat and light within the constraints of the household budget—their collective actions had much greater ramifications. As a result, the history of fossil fuel consumption is far more linked to the domestic sphere than we have typically acknowledged. We have analyzed men, steam engines, and factories in great depth; it is time to focus more attention on women, stoves, and lamps.

Of course, consumers of heat and light did not make their choices in a vacuum, which suggests that we should pay attention to the convergence between individual choice and the structuring power of


93. Adams, “Warming the Poor.”
corporate and government decisions. This is a point at which the past and present can meet. There was no “free market” for anthracite coal or oil in the nineteenth century. Instead, the prevailing prices were heavily influenced by government actions such as granting private corporations extensive rights to land and minerals and funding surveys that helped companies increase production. Just as importantly, state authorities chose not to pursue policies that might slow the growth of coal or oil production or increase the cost to consumers. When brought to the attention of government bodies, issues of worker safety in these trades were rarely addressed with legislation. The environmental consequences of resource extraction were externalized. Tax policies were geared for cheap energy, not to further social equity. In short, the reasons that millions of consumers found coal and oil to be desirable had much to do with the policies governing their development.

The same is true today. Contemporary prices of fossil fuel and renewable energy reflect a wide range of government actions. Different policies can alter what consumers find to be cost-effective and convenient. They can affect the potential trajectories of an energy transition to renewable sources.

It is here that I would like to return to the power of historical narratives to shape policy decisions. This account suggests an important domain where we should look to develop new policies. A recurring issue in policy circles is how to strike a balance between measures that are directed at a few centralized organizations (top-down) and those designed to spur change from below (bottom-up). Many current energy policy measures focus on the former, as is illustrated in discussions of carbon taxation, cap-and-trade systems, offshore drilling regulations, CO₂ sequestration at coal-fired power plants, higher fuel efficiency standards, and subsidies for research into renewable energy technology. In part, these policies reflect historical accounts of energy transitions that have focused on the industrial sector and the power of large economic actors. My analysis suggests there is good reason to pay more attention to the small consumers. If homes have been critical to energy transitions in the past, it stands to reason that we should give more critical attention to bottom-up policies directed toward residential markets.

Developing such policies will require creative approaches. One of the reason top-down policies are so popular is that they appear easier to implement and manage. Policies aimed at residential markets face

94. On the general linkages between history and policy, see Zelizer, “Clio’s Lost Tribe.” For a recent account analyzing the history of technology and energy policy, see Hirsh, “Historians of Technology in the Real World.”
many of the same challenges represented by the regulation of non-point pollution sources such as the run-off of soil, pesticides, and fertilizers into rivers from the agricultural sector. The activities are decentralized and the decision-making processes of users are shaped by many factors, which can make it difficult to design and measure the effectiveness of policy measures. But the mere fact that such an approach is a challenge should not dissuade us. If we believe that many little things can add up to something big, as I have argued happened in the past, then it is worth the effort to expand our policy imagination in the present.  

Some bottom-up programs already exist—such as tax incentives for efficient appliances, rebates for the installation of solar panels, and grants to improve the insulation of homes—or have been tried in the past. But these policies are easily viewed as incremental steps and not worth funding aggressively. By linking such policies to a historical narrative emphasizing the agency of residential markets in previous energy transitions, policymakers might be empowered to expand these programs and implement multi-pronged strategies that more effectively encourage the use of renewable energy. In other words, policy designs are not simply econometric cost-based analyses; they are narrative accounts whose storylines must be seen as compelling to be enacted. By emphasizing the agency of residential markets in the past, policymakers can better sell bottom-up policies to elected officials and publics in order to garner votes and funding.

This is not to suggest that history will simply repeat itself or that we should ignore the potential contributions of industrial users or the value of top-down approaches. We now live in a world where industrial applications for energy are well developed and residential markets absorb a smaller percentage of the total energy supply. Unlike anthracite coal or oil in the nineteenth century, renewable energy sources are trying to gain market share despite being more costly than fossil fuels. Moreover, people are actively trying to direct an energy transition in a way that exceeds the ambitions of most anthracite and petroleum boosters, who were focused on turning a tidy profit, not revolutionizing their society’s energy base. These factors suggest that a transition to renewable energy sources will look quite different from the adoption of anthracite coal and oil. On the other hand, homes continue to be important sites of energy consumption that could play an active role in the transition to a renewable energy regime. In America, residential markets use

approximately 22 percent of the nation’s total energy supply today, which indicates that they have enough market power to influence the course of our energy system. Even though the ability of single individuals to shape the broader energy system is profoundly limited—alone, any one of us has little agency—the accumulation of millions (and now billions) of individual decisions will affect the path of our energy future. Residential consumers, through the power of aggregation, have the agency to help pioneer a new energy transition.

Ultimately, no one knows how or when a transition to renewable energy will occur. But we know that our actions in the present will shape the eventual outcome. It is in this context that the historical accounts we relate matter so much: they are resources we can use to guide actions and imagine new futures. Paying attention to small consumers and humble energy applications not only provides a more accurate account of the past but also offers a greater range of options for policymakers in the present. In a world in which our use of fossil fuel energy is so problematic, our stories of past transitions are crucial to how we can create a better future.

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