Long Run Trends in Energy Services, 1300-2000

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January 2005

Abstract

Over the last five centuries, industrialised societies have experienced major technological innovation, mass production of equipment, expansion of energy infrastructures and networks and falling costs of fuels. This has meant cheaper heating, power, transport and lighting. This paper presents evidence on the decline in the cost of these energy services and the associated rise in energy service use, from the fourteenth century to the present day, in what was to become the United Kingdom.

For most of the services (i.e. heat, power, transport and lighting), there was an upward trend in average energy prices during the second-half of the nineteenth century and much of the twentieth century. During the period, energy systems were dramatically altered with large scale substitution towards more expensive but higher 'quality' fuels. From the beginning of the nineteenth century on, though, the average efficiency for energy services always improves. This means that, since 1750, apart from a brief period of stagnation in the first half of the nineteenth for power and transport, Britain experienced consistently declining prices of energy services. We also found that, since the Industrial Revolution, demand for power, transport and to a less extent lighting appear to be inelastic. However, in the last fifty years, power and transport demand have become far more sensitive to declining prices and rising income levels.

I. Introduction

Over the last five centuries, industrialised societies have experienced dramatic transformations. They have been freed from dependence on land and wood for heating, humans and horses for power and transport, and sun and moonlight for illumination. Technological innovation, mass production of equipment, expansion of energy infrastructures and networks, falling costs of fuels, rising incomes and social and cultural change have revolutionised our desire and ability to heat, move and illuminate. Important economic and social welfare, resource and environmental consequences have resulted from these changes in energy services.

The purpose of this paper is to present evidence on the decline in the cost of energy services and the associated rise in energy service use, from the fourteenth century to the present day, in what was to become the United Kingdom. An investigation into the economic and technological history of energy services identifies valuable lessons for our understanding of energy markets: by analysing the consumption, costs and quality of energy *services*, rather than energy; and it also helps us to understand how energy markets and market institutions are born, grow and decline, how innovations are developed and diffused, and how governments play their parts in service provision and market regulation.

There have been previous long run indicators of the cost of fuel and light in the United Kingdom (including the detail in Phelps-Brown and Hopkins 1956, Feinstein 1972, or Fouquet and Pearson 2003). However, these series do not take into account the efficiency with which energy consuming technologies use and convert the energy flows. Thus, they measure the price of energy, not the price of the energy service. William Nordhaus (1997) addressed this failure by estimating the efficiencies of lighting technologies, and then combining them with the price of the energy source, to create a ‘true’ price of light series for the U.S., which was dramatically different from the conventional light price index. Fouquet and Pearson (2006a) built on Nordhaus’s pioneering approach, created a much more detailed study of the technological changes and their impact on the price of lighting services, and focussed on the United Kingdom. It also extended Nordhaus’s paper by incorporating consumption data, and, therefore, identifying a relationship between the price of illumination, economic development and the consumption of lighting services. The current paper extends this analysis for a series of energy services: heat, power, transport and light.

There is also a wider context in which the evolution of energy service markets should be understood: climate change scenarios often draw on carbon dioxide emissions projections that are based on extrapolated trends in the relationship between fossil energy use, GDP growth, and fuel prices. But better insights about future fuel use and emissions might come from understanding the two-stage relationships between: (i) energy use, energy technologies and delivered energy services; (ii) and between energy service consumption, GDP growth and the costs and prices of energy services. As yet, however, both the impact of innovation on energy service provision and costs and the evolution of demand over waves of socio-technical development are poorly understood. Here, we aim to contribute to this understanding by investigating the separate trends in heat, power, transport and light in the United Kingdom.

At the same time, as economists, we are not trying to provide a formal historical analysis of energy services. The richness and complexity of treatment that this would deserve is beyond our scope and skills (Church 1993, Hatcher 1993, Flinn 1984, Williams 1981, Hannah 1979, O'Dea 1956, Schivelbusch 1988, Smil 1993). This paper seeks to pull together a lot of exciting and disparate information in order to present the dramatic transformations that have occurred in the cost and provision of energy services over the last seven hundred years.

In the next section, we briefly explain the market for energy services and the main energy systems that have existed over the last seven centuries. The following section points the reader towards the secondary and original sources for the data and briefly explains the methodology for estimating energy service costs and consumption. The subsequent sections present the data in the following sequence: the price of energy sources for heating, power, transport and light; the related energy technologies; the price of the four energy services; and the consumption of these energy services. The final section makes a few comments about the trends.

II. The Market for Energy Services

Economic activity involves transformations. Without energy - be it in the form of muscles, wind, water or solar power, or organic, fossil or nuclear fuels – these transformations could not happen. E.F. Schumacher (1979) said that "energy is for the mechanical world, what consciousness is for the human world. If energy fails, everything fails."

The demand for energy results from the needs for energy services, such as heat, power, transport and light. To provide these services, it is necessary to combine energy with the appropriate equipment, be it a hammer with muscular strength, a harness with horse power, sails with the wind, or a train with steam, diesel or electricity. So, energy is an input into the production process for firms and households along with physical and human capital, labour, materials and land.

Each market for energy services reflects the complex interactions of energy resources, technological development and institutions created to produce, trade and regulate energy. These interactions make-up the system within which demand and supply meet, prices are set, and energy is produced and consumed.

In the last thousand years of history, there have been (broadly speaking) two main energy systems, the organic and the mineral energy systems, as Wrigley (1988) outlined. Each system had very different resource limitations, market structures and institutional structures. Yet, in both systems, the evolution of energy service consumption through time for a whole economy depended on (and interacted with) economic, social, demographic and technological activities and resource constraints. So, for example, increased economic activity in growing urban areas required additional quantities of energy services; the adoption of new technology, discoveries of new resources or depletion of old resources alter the means and costs of production. Long run adjustments to changes in output, income, prices, technology or climate can only be made gradually as qualitatively and quantitatively new appliance stocks are accumulated and used.

We will try to present and discuss the broad trends in energy service prices and consumption over roughly the last seven hundred years. This presentation will enable us to explore and improve our understanding of the transition from a completely organic energy system to a full mineral-based economy.

III. Data

Identifying trends in evolution of the cost and use of energy services requires statistical information on prices and consumption of heating, power, transport and lighting fuels, on energy technologies and their efficiencies, and on variables that help to explain service consumption patterns, including population and income. Details about the principal sources and methods used to assemble the data series associated with fuels, prices, consumption and technologies can be found in detail in Fouquet and Pearson (1998, 2003, 2006a, 2006b).

It is worth, however, pointing-out the general sources of the data. There is a considerable amount of annual or periodic information on the history of energy services in Britain, collected from markets, schools, colleges, hospitals and government departments around the country, going back many centuries. Just to mention the most frequently used source, they are Rogers (1886), Beveridge (1926), and Mitchell (1988). However, despite their relative richness, it is necessary to stress that the data presented and discussed below should be interpreted with caution. Especially for the early centuries, the data are often drawn from the records of one or a few institutions that bought fuel for lighting in the South of England, and so are not representative of Britain as a whole. In some other cases, the data are interpolations based on information for previous and later years. In particular, while 'annual' data for 'the United Kingdom' are shown, there are considerable margins of error and data gaps, notably before the mid-nineteenth century. Hence, it is wiser to focus on the broader trends and the orders of magnitude differences over several decades or one technological revolution and the next, rather than on individual year-on-year changes.

The conversion of the price and consumption of fuels into their equivalents in energy services requires combining them with energy efficiency of the equipment used for each service. For example, in the eighteenth century, a tonne of coal could be placed in a traditional fireplace and burnt, generating around ten percent of a tonne of coal in useful heat (Fouquet and Pearson 2006b). With this information, and the price of one tonne of coal (in 2000 money) being equal to £145, we can estimate the price of one tonne of coal equivalent of useful heat – about £1,450. Tables 1, 2 and 3, which will be discussed in more detail later, present the three variables (price of energy, technological efficiency and the price of energy efficiency) involved in the calculation. It should be noted, however, that the calculation presented above for a coal-burning fireplace are not the same as those presented in Table 1, 2 and 3 for 1700 heating. Many households did use coal in fireplaces (i.e. with chimneys); but, some households still burnt woodfuel in both traditional fireplaces and open hearths. Thus, the tables represent average estimates for the range of energy sources and technologies.

Throughout the paper, prices are quoted in *real terms* (i.e. in £(2000) money). The retail price index is from Officer (2004). Thus, our costs of using different fuels and of producing services are broadly comparable across time.

IV. The Price of Energy for Different Services

Prices provide an indication of a fuel's relative scarcity and value. There has been considerable debate about the expected trends in energy prices. In a sense, a non-renewable resource might be expected to become scarcer as the stock is used-up. There has been a large literature on the study of long-term trends in non-renewable resource and energy prices. The evidence is inconclusive, yet there is little sign of growing scarcity (Krautkraemer 1998).

Fouquet and Pearson (2003) also presented trends in individual fuel and average energy prices. A prominent feature of those trends was the dramatic declines in prices in the early expansion phase of the associated industries, such as the coal, gas, petroleum and electricity. The second phase tended to be associated with more gradually declining prices. In the third phase, where resources might begin to hit limits of availability and consumers might substitute away from these fuels (as in the case of woodfuels from the seventeenth century, coal from the nineteenth century, and petroleum from the end of the twentieth century), there was little evidence of systematic or substantial rises in prices.

Another important observation was the absence of a clear rising trend in the weighted average 'energy' price series over five centuries. However, the second half of the nineteenth century and the early years of the twentieth century were characterised by an increase in the real average ‘energy’ price. During the period, energy systems were dramatically altered with large scale substitution towards more expensive but higher ‘quality’ fuels. It was reflected in the growing share of petroleum, gas and ultimately electricity in final user expenditure on energy over the period. So, a possible explanation for this price increase, rather than being associated with rising scarcity, reflected growing value consumers placed on the energy being consumed.

Breaking-down the average energy price (and examining energy services later on) helps understand this argument. Table 1 presents average energy prices for the specific services over seven centuries.

While the data hides considerable volatility, the evidence supports the arguments proposed above. Energy prices for heating and lighting fuels tended to drop before the sixteenth century, rise until the mid-eighteenth century, and fall with the beginning of the Industrial Revolution. For most of the services, there is an upward trend in average energy prices during the second-half of the nineteenth century and much of the twentieth century.

Table 1. Long-Run Trends in the Price of Energy Sources, 1300-2000

	1300	1500	1700	1750	1800	1850	1900	1950	2000
P(Heating Fuels)a	150	140	145	160	70	50	90	160	90
P(Power Fuels)b			3.4	3.4	11	37	68	52	100
P(Transport Fuels)c					10	25	50	590	900
P(Lighting Fuels)d	38	26	38	40	25	20	6	10	4

a - £(2000) per tonne of coal equivalent (for households); 1300 value is actually for 1441.
b – £(2000) per tonne of oil equivalent; energy cost of wind and water assumed to be zero.
c – £(2000) per tonne of oil equivalent (passenger); 1800 value is actually for 1837 horse fodder.
d – p(2000)/kilowatt-hour

There is a lot to discuss about the nature of individual trends, and this is not the place to go into much detail. We direct the reader towards Fouquet and Pearson (1998, 2003, 2006b). Nevertheless, some brief points can be made.

For instance, the price of heating fuels in households (which is represented in Table 1) rose from the sixteenth to the mid-eighteenth century. There was indeed a shift towards coal and away from woodfuels. Still, the rising price of woodfuels appears to impose a rising average price – coal prices were relatively constant (in real terms) for those centuries. By the beginning of the nineteenth century, virtually all households have shifted towards coal. Then, from the end of the nineteenth century, the more valuable and expensive commodities enter the market for heating. First, gas is used in heating, then eventually electricity, to be dominated today by gas in central heating systems.

The fuels for power and transport are quite similar until the twentieth century. Humans and mostly animals provided power until the steam engine arrived. Consequently, horse fodder (e.g. oats, maize and hay) was the price of fuelling power before the nineteenth century. For stationary sources, wind and water also generated considerable power – here, the price of these energy sources is assumed to be zero. Then, coal began to provide the heat that powered the steam. Coal was relatively expensive compared with horse fodder and free wind and water. The rising average price of power and transport in the nineteenth century is represented by the growing share coal takes. The introduction of electricity for stationary power also used coal for generating the power. At the end of the twentieth century, more expensive and effective natural gas begins to be used, alongside coal, driving-up the average price of power fuels. For transport, the growing use of coal in trains from the mid-nineteenth century increases the average price. Then, the share of the more expensive petroleum products for buses and cars increases; by the end of the twentieth century, they dominate the market for transport and, therefore, reflect the dramatically higher average price of transport fuels.

Before the nineteenth century, most illumination results from fires and tallow candles from animal fat. It fluctuated through the centuries, rising somewhat in the mid-nineteenth century. Animal fat (per unit of energy) was an expensive source of illumination. A hundred years later, gas was used widely and kerosene (or paraffin) was starting to light poorer homes. Although expensive in their first years of use, these new fuels soon became cheaper than fat. In the same way, the introduction of electricity drove-up the average price of lighting fuels, because it was initially very expensive. By the end of the twentieth century, electricity had taken-over the whole market for lighting sources and its price had fallen considerably[1].

V. Improvements in Energy Technologies

Table 2 presents the trends in energy technologies. As might be expected, through time, equipment uses the energy more efficiently. From the beginning of the nineteenth century on, the average efficiency for a particular service always improves.

The improvement in the efficiency of heating in the last two hundred years is substantial – from 11% to almost 90%, when we moved from the simple coal-burning fireplace to the gas central-heating system. The early steam engines were quite poor, but they improved forty-fold in two hundred years after the beginning of the Industrial Revolution. For transport the improvements are far more dramatic. Though animal fodder was relatively cheap, a horse converts its oats into travelled distance in a very inefficient way. The steam engine was far more efficient, and the internal combustion engine more so. A two thousand-fold improvement in the efficiency in which prime movers used their energy was experienced in the last two hundred years. In those same two hundred, the shift from tallow to gas to electricity (especially with today's compact fluorescent lighting) has enabled humanity to generate nearly one thousand times more light per unit of energy.

Table 2. Long-Run Trends in the Energy Technologies, 1300-2000

	1300	1500	1700	1750	1800	1850	1900	1950	2000
T(Heating)a	13%	13.5%	11.2%	11%	11%	13.5%	21%	41%	86%
T(Power)b				0.5%	4.6%	10%	15%	20%	
T(Transport)c					10	24	36	11,700	20,000
T(Lighting)d	19	22	27	29	36	190	500	11,600	25,000

a - % of energy converted into heat
b – % of thermal efficiency from Smil (2003) p.145.
c – passenger-kilometre per tonne of oil equivalent
d – lumen-hours per kilowatt-hour

Innovations build on past experience and knowledge. Developments may direct changes in the technology in a way that leads to a less efficient use of energy. But, in

[1] In estimating the price of the fuels for different services, there might seem to be an inconsistency. For power, coal (and then natural gas) was considered the fuel for generating electricity; where as, for lighting, electricity is the energy source in the twentieth century. However, power is used for lighting, just like heating is used for power. Thus, coal is the fuel for power, and electricity the fuel for lighting.

the case of heat, power, transport and light, the cost of energy was a major part of the overall expenditure on the service. Consequently, efforts to reduce the cost of the service would lead towards reducing the amount of energy required to generate a unit of heat, power, transport or light.

Possibly the most interesting case is when efficiency worsened. This is due to the shift from the open hearth to the fireplace. This appears to be a retrograde move, as the chimney, especially in its early years, was quite inefficient. It required more fuel to generate the same amount of heat. Yet, there are several clear reasons for the shift in technology. A crucial reason was that the chimney enabled the smoke associated with fuel combustion to leave the room or hall. Burning wood in an open hearth created a smoky room, with considerable health effects. This was undesirable. Using coal in an open hearth would have been a deeply unpleasant experience. Thus, when the chimney began to be adopted on a large scale in Britain from the sixteenth century, it was the only way to burn coal, which was a far cheaper fuel than wood (even considering the modest loss in efficiency for producing heat, discussed in section VI). The chimney also reflected a certain status in society and became fashionable then – it distinguished the middle classes from the labourers (Crowley 2004). Thus, the fireplace, though less efficient, provided additional attributes of value to the user: social status and externalising the costs of smoke.

It is also probable that the conversion of energy was worsened when steam power (for stationary or moving purposes) replaced water power (for stationary power) and wind (for transportation). Reliability of service provision was improved – water and wind power were intermittent, where as steam could be created whenever a stoker had coal. There were, therefore, important characteristics of the technology that make it desirable. There have, therefore, been examples of worsening efficiency. But, they mostly done to improve the quality of service provided.

V. The Price of Energy Services

In terms of the service generated, the trends are quite clear. Before the Industrial Revolution, there are fluctuations in the prices of energy services. Once the scientific, engineering and marketing skills are allowed to flourish, the price of energy services always falls (See Table 3). Thus, since 1750, apart from a brief period of stagnation in the first half of the nineteenth for power and transport, Britain experienced consistently declining prices of energy services.

In those last two hundred and fifty years, the cost of generating useful heat has fallen more than 10-fold. To generate a unit of power costs 50 time less. To travel one kilometre is 150 times cheaper. To produce the same quantity of light, it costs us 8,000 times less.

Table 3. Long-Run Trends in the Price of Energy Services, 1300-2000

	1300	1500	1700	1750	1800	1850	1900	1950	2000
P(Heat)a	1,250	1,000	1,250	1,400	700	500	460	380	130
P(Power)b				140	35	35	20	4	2.5
P(Transport)c			20	15	5	1	0.38	0.16	0.10
P(Lighting)d	19,875	11,140	13,050	13,690	6,630	1,175	276	10	1.7

a - £(2000) per tonne of coal equivalent of effective heat
b – p/kilowatt-hour
c – p per passenger-kilometre
d – £/million of lumen-hour

Throughout history, the price of energy services has rarely risen. In the case of heating, it did before the full switch to coal and the diffusion of the more efficient Rumford fireplace. Families still using woodfuels experienced substantial price rises; some of them were burning the wood in highly inefficient old chimneys.

Another interesting example is the rise in the price of transport services during the seventeenth century. The evidence is based on the series for freight transport, which stretches back to thirteenth century, rather than passenger transport presented in Table 3, which only goes back to the mid-seventeenth century. The explanation for the dramatic price rise appears to be associated with the growing use of roads of worsening quality. Transport services depend on a network of roads. The church was responsible for looking after the roads, before its dissolution under King Henry VIII. For a long period, there was no clear body responsible for maintaining roads, and they were left to local communities. It appears that they failed to provide an adequate service. The introduction of turnpikes in the seventeenth century was a reflection of the desperate need for institutions to provide these public goods – in this case, in private hands. Once turnpikes became widespread in the eighteenth century, the price of transport services improved substantially (Jackman 1960).

Another example of rising prices was for lighting in the eighteenth century. In 1696, lovers of natural light faced the introduction of the Window Tax. It was intended to reflect the wealth of the inhabitants, as proxied by the number of windows in the house, but inevitably, it "operat[ed] as a tax on light, and a cause of deformity in buildings" (Mill 1909 p.3.27). At the beginning of the eighteenth century, a tax on candles (and other articles of general consumption) was introduced to help fund the war of Spanish Succession. A duty of four pence per pound was placed on wax candles and one half penny on tallow candles, equivalent to a tax of about £1,000 for a million lumen-hours, or a 10% increase. This fed through into the (ten-year) average real price, which rose by nearly 50% between 1700 and the mid-1740s (Fouquet and Pearson 2006a).

VI. Consumption of Energy Services

The declining price of energy services will have led to an increase the consumption of energy services, both for reasons of substitution and of income effect.

Again, focusing on the last two hundred and fifty years, consumption has risen dramatically. At present, estimates of the quantity of heating generated were not available. For power, use increased more than 200-fold. In terms of transport services, 1,000 times more passenger-kilometres are travelled today than then. Finally, the increase in lighting is 150,000-fold.

Table 4. Long-Run Trends in the Energy Service Use, 1300-2000

	1300	1500	1700	1750	1800	1850	1900	1950	2000
Q(Heating)a									NA
Q(Power)b	0.14	0.11	0.40	0.57	1	4	20	28	120
Q(Transport)c			0.6	0.8	1.9	5	29	190	735
Q(Lighting)d			0.005	0.008	0.05	0.35	11	250	1,270

a – Not available
b – Terawatt-hours of power
c – billion passenger kilometres (i.e. only passenger transport); 1700 value is actually for 1715.
d – trillion (i.e. one million-million) lumen-hours

To compare these figures, it is first worth take account of the growth in population. Population has quadrupled, from roughly 15 to 60 million people. This means each person uses 50 times more power, 250 more passenger kilometres and nearly 40,000 more lighting than in 1750.

Given the quality of the data, it is more appropriate to provide changes in orders of magnitude rather than marginal changes in behaviour. Thus, econometric analysis was not attempted on the data. Nevertheless, comparing changes in price, income and consumption provide some valuable information.

We will compare the changes in consumption with changes that would result if demand was price and income elasticity was equal to one. Income rose by nearly 20-fold in these two hundred and fifty years. If demand was price and income elastic, then per capita consumption would have risen:

- For power: 1,000-fold (rather than the actual 50 times)
- For transport: 3,000-fold (rather than the actual 250 times)
- For lighting: 160,000-fold (rather than the actual 40,000 times).

We cannot say whether it is more price or income elastic, but we can say that power is 20 times less, transport is 12 times less, and lighting is 4 times less than unit elasticity. In other words, the demand for power is highly inelastic, transport inelastic and lighting moderately elastic.

Just to repeat the exercise over the last 50 years, we can gather some evidence about the trend in elasticities. Population has only increased by twenty percent in that period, while income rose by nearly 4-fold. If demand was price and income elastic, then per capita consumption would have risen:

- For power: 6-fold (rather than the actual 4 times)
- For transport: 6-fold (rather than the actual 4 times)
- For lighting: 24-fold (rather than the actual 5 times).

Again, we can say little about price and income elastic individually, but it would appear that power is two-thirds less, transport is two-thirds less, and lighting is one-fifth less than unit elasticity. In other words, the demand for power is highly inelastic, transport inelastic and lighting moderately elastic.

This suggests that in the last fifty years, the demand for power and transport services have become far more elastic, while lighting demand has become slightly less elastic. While it is not the place to provide explanations, we can speculate about the reasons.

Perhaps lighting demand is starting to get saturated, while power and transport demand has found new 'leases of live'. It might be to do with the nature of marketing techniques and success in convincing customers to generate more energy services. Or, it might be associated with other features of the services. The power and transport services have become privately-owned in the last fifty to one hundred years. The private ability to generate power and transport is an additional characteristic that places greater value on the service.

VII. Conclusion

The purpose of this paper was to present evidence on the decline in the price of energy services and the resulting increase in the consumption heat, power, transport and lighting, from the fourteenth century to the present day, in what was to become the United Kingdom.

Despite the existence of considerable volatility in the original data series, the evidence presented shows that energy prices for heating and lighting fuels tended to drop before the sixteenth century, rise until the mid-eighteenth century, and fall with the beginning of the Industrial Revolution. For most of the services, however, there was an upward trend in average energy prices during the second-half of the nineteenth century and much of the twentieth century.

During that period, energy systems were dramatically altered with large scale substitution towards more expensive but higher 'quality' fuels. From the beginning of the nineteenth century on, the average efficiency for energy services always improves. This means that, since 1750, apart from a brief period of stagnation in the first half of the nineteenth for power and transport, Britain experienced consistently declining prices of energy services.

In this paper, we do not seek to over-interpret the results. It is nevertheless worth drawing a few conclusions. The first lesson is that focussing exclusively on energy prices (as economists have tended to do, due to a lack of data) risks ignoring the actual processes at work in the market. For instance, deducing that rising energy prices are the result of increased scarcity might be correct, as in the case of some woodfuel in the eighteenth century, but it might also be misleading. At the end of the nineteenth and in the early twentieth century, higher prices reflected more valuable energy sources, using more efficient technologies, generating far greater energy services.

Similarly, the second lesson is that focussing exclusively on the trends in efficiency of technologies (as engineers and historians of technology might do, again due to a lack of evidence) might ignore the nature of the fuels being used, their prices and the systems within which they operate. The rare declines in efficiency, as in the switch to the fireplace or the steam engine, reflect characteristics of the technology and fuels they use.

So, looking at the services that consumers seek to produce tells a different story. As Nordhaus (1997) highlighted, the fall in the price of services is far greater than that indicated by the price of the fuel. The welfare improvements are far greater than expected.

The paper also provides some indications about the response of consumers to the declining prices of energy services. Econometric analysis did not seem appropriate for data that is appropriate more providing orders of magnitude than marginal changes. Yet, a comparison of changes in prices and consumption can yield some information. We found that, since the Industrial Revolution, demand for power, transport and to a less extent lighting were inelastic. However, in the last fifty years, power and transport demand have become far more sensitive to declining prices and rising income levels.

Returning to the second lesson, about characteristics of a good, it can be a reason for being careful to not to over-interpret the trends in the price of energy services, even if they do provide more information about the costs to consumers of generating the services they are interested in. Market forces seek to find ways to heat or light homes or move cars in cheaper ways. Yet, sometimes, the consumer or society benefits from a way that causes less smoke or reduces the risk of burning the house down (as was the case with candles), or even indicates the social status of the owner.

And, when considering future trends in the price of energy services, we might be aware that the for certain of these services - especially lighting, but increasingly the other services - the expenditure on energy is not so important. Other characteristics may be more crucial to what drives demand and the adoption of a new technology. Thus, trying to anticipate these future trends, analysts should consider what attributes are important for improving consumers' value of the heating, power, transport or lighting experience.

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