

The switchover from coal gas to electricity in Spanish cities, 1880s-1936

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Introduction

Studies on the history of technology show that technical changes (i.e., since industrialisation) went hand in hand with an increasing use of energy, particularly in the growth of lighting consumption. The switchover from gas to electricity is one of the stages in the increase of artificial light which occurred over the last 150 years, approximately, transforming our way of life (Fouquet and Pearson, 2007).

This particular history is related to change. This is a story which has become repeated over time, albeit in ever decreasing cycles, with the accelerated level of societies' development. One of our protagonists, gas, has been both the executioner and the victim; the other, electricity, was the final victor of this narrative since it became an economically viable and technological industry in the final quarter of the 19th century.

The exact aim of the paper will be the gradual substitution of one source of energy by the other, applied in this case to Spanish cities, from approximately the final quarter of the 19th century to the Civil War.

Gas from its origins to the competition from electricity

The introduction of gas was a progressive process which entailed a significant innovation in developed countries. The implementation sequence varied in European cities. Towards the first quarter of the 19th century, it was notably extended in the United Kingdom (Tomory, 2014). Its establishment was somewhat slower on the continent. But there is no doubt that significant cities within urban hierarchy in each county had started to adopt gas as a street lighting system, standardising this in a few decades (Martínez and Mirás, 2012: 125-126). German, Swiss, Austro-Hungarian, Italian, and Spanish cities belong to the second wave of diffusion which occurred in the 1840s and 1850s (Paquier, 2011: 171).

During the 1850s and 1860s, gas was exclusively used in street lighting. This was the demand segment which experienced the most noticeable growth, doing so uninterruptedly as it was less affected by economic cycles than the industrial sector (Ward, 1988: 7). Conversely, the private market developed with less urgency. At first (as regards individual consumption), businesses and leisure establishments predominated (cafes, theatres). Industrial consumption had to wait until the 1870s-1880s for a series of technological innovations to enable the

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application of gas as a driving force, increasing the productivity of certain productive processes (Arroyo, 2002: 86).

It was only in the advanced phase that gas for street lighting began to spread to homes (Foreman-Peck and Millward, 1994: 130), although it still continued to be a luxury item in other types of domestic uses. The spread of gas ovens, heaters and stoves eased its way into the domestic sphere, a phenomenon which began in the last quarter of the 19th century in developed countries.

Values related to prestige were a high priority in the authorities' decisions to install gas. The new technology, especially in its version of public street lighting, was related to the emulation effect by local elites. However, old sources of energy did not immediately disappear. Moreover, initially, gas only arrived in central areas. This meant that for decades, these continued to be used in suburban areas which contributed to accentuating the processes of urban segregation.

In Spain, almost every city had some kind of public lighting. In some cases, this was from the end of the 18th century (although most had to wait until the first third of the 19th century for oil lighting to be installed). Later petroleum was incorporated, replacing it or being used alongside it.

There is evidence of early gas street lighting testing in Spain. A certain pressure existed to substitute the old elements of street lighting. For this, they reported to campaigns which attempted to influence the opinions of citizens and municipal authorities, creating an environment concerned with high prices and poor quality of old methods. Nevertheless, in comparison with other countries the process of diffusion was rather late, slow and modest (Sudrià, 1983: 97).

The usual evolutionary pattern was firstly street lighting using oil, then (coinciding with the latter), petroleum from the 1860s although this was not always present in Spanish cities and later, gas and finally electricity. Nevertheless in various cities, the energy transition passed directly from traditional systems to electricity (Arroyo, 2013a: 3). In some cases it was not implemented because there were no serious and viable installation offers. In others, they did not yield results due to other various circumstances: doubts about the viability of projects, conservatism or opposition from the city councils, mistrust on savings the new street lighting system would bring to municipal budgets, a high operational cost etc. There were also cases when early experiments with electric bulbs were carried out although the time for this energy had not yet arrived.

City councils understood that the new technology surpassed knowledge and resources, thus they turned to concessions. In turn, companies were aware of the difficulties that councils usually faced when dealing with payment for street lighting (including oil and petroleum). This led to some doubts which increased almost on a daily basis. Despite this, gas companies used public lighting licences as a way of showing the advantages of the new system (which would also occur later with electricity companies) (Arroyo, 2013b: 160), with a strategy to get to know and attract future clients following an actual model of countries with poor manufacturing development (Fernández Paradas, 2009a: 22).

In this stage, gas and electricity maintained "calm" relations due to the lack of competitiveness shown by the latter in its first operational years. In any case, gas providing companies and gas distributors tried from the start and in various ways to discredit the new

energy. But whereas electricity did not turn out to be a significant rival, actions were isolated and of little importance, although progressively scientific explanations were used which contradicted its virtues.

Competition and “peaceful” coexistence between gas and electricity, 1885-1900/1905

When electricity began to consolidate at the end of the 19th century, it was immediately serious competition for gas. Electricity played a fundamental role in the economic modernisation and spatial transformation of cities. However, although the transition of gas to electricity in many western cities began in the 1880s, it was neither abrupt nor total nor was it the result of a uniform or linear process. On the contrary, gas consolidated further, actually experiencing significant growth over the following decades. Various technological innovations then helped so it was sustained during the final years of the 19th century and the beginning of the 20th century (Castaneda, 1999: xvii). But, gradually, it started to lose its hegemonic status so had to reconsider its position in the market, redesigning its strategies to capture other segments which could replace the foreseeable loss of demand predicted with the competitive development of electricity: the industrial sector and above all domestic consumption (Arroyo, 2003: 5).

Until the 20th century had well and truly begun, it was common for gas and electricity to co-exist simultaneously in the western world (albeit with different degrees of serenity). Electricity gained ground at a growing speed and gas decreased its presence in street lighting but the process occurred gradually, accelerating when electricity became clearly dominant at the start of the 20th century (Sudrià, 1984: 88).

But for networked services, technology represents a critical variable and this period witnessed some changes which determined the acceleration of technical modernisation in the electrical sector (Arroyo, 2005: 547). Production was then mainly of thermal origin. The inauguration by Thomas A. Edison of the first electricity power plant in Pearl Street, New York (1882), was a challenge. In all developed countries, companies set up in places where they had to provide their supply as there was no technology which facilitated long-distance transmission.

A general feeling began to extend that energy transition was inevitable as authorities and the public mainly felt that sooner or later street lighting would end up being monopolised by electricity. Towards 1885, the plan was that gas would be reserved for domestic consumption and that electrical lighting would have its market, the private one, which was still one of luxury (Bartolomé, 2007: 39-40).

The tests which were occasionally carried out before the first installations suggested that the new system was far more effective and that the lighting was of a higher quality. Later, having corrected the initial understandable shortcomings of all innovation and in a time of accelerated technological change, the brightness of the new lights fascinated some citizens who were eager to replace a system which they considered old-fashioned with one which symbolised modernity (Cordularck, 2005).

Initially, electricity was an essentially urban phenomenon (Hausman, Hertner and Wilkins, 2008: 18). American cities were the first scenario whereby, at the start of the 1880s, the battle to dominate lighting by electricity was triggered (Shiman, 1993: 318), arriving a few years later in Europe (Bowers, 1998). From then onwards, it began to capture the market (Foreman-Peck and Millward, 1994: 202). The result was that, with the turn of the new century, the change of the energy system consolidated in street lighting (MacAvoy, 2001: 10).

In Spain, the process occurred later although the gap was lower than what had been in its day with the mainstream use of gas. Electricity arrived in our country at a relatively early date (1874) (Fernández Paradas, 2009a: 75). Just like in Europe, the leisure sector was one of the first to benefit from this innovation as, in 1884, the first installations of electrical street lighting were inaugurated in the country's theatres.

This is the experimental phase (1875-1881) (Maluquer, 2006: 54), which preceded the industrial generation (towards 1885). It would not be until the end of the 1880s when electric street lighting with electrical current spread in the main cities (Antolín, 1999: 418), immediately following the tendering of public lighting after the very first, Girona (1886). The demand of this market would be helped by small businesses created from local initiatives, of reduced dimensions and limited supply capacity which installed thermal electricity production generators using steam machines to generate a constant current and supplied fluid to very few clients at prices which were furthermore high (Maluquer, 2006: 60). These are the pioneer, or first generation businesses.

In this sense, Spain shows similarities with other countries characterised by a greater provision of coal where the first electrification had a strong bias towards thermoelectricity. During this initial phase, the first hydroelectric power stations were installed, often using old reconverted installations (water mills, fulling mills and mills). In regions with a favourable provision of hydraulic resources, used in industrial installations since the middle of the 19th century (Catalonia), reconversion reached greater proportions (Arroyo, 2013a: 2).

In the 1890s, electricity started to be applied to productive processes in Spain, relatively early if one considers that various European cities had begun to adopt electrical traction at the end of the previous decade. But the most significant factor was the arrival of a new client which spurred electricity production onwards, the trams, whose electrification accelerated at the end of this decade and the beginning of the 20th century (Martínez, 2012). In street lighting, once Edison's light bulb had been perfected, electricity took the leap from public lighting to private lighting (Antolín, 1999: 419), although this was still excessively costly (Bartolomé, 2007: 40). The result was a noticeable increase in the number of public street lighting companies¹.

The change of the century involved the start of a path of definitive change (Maluquer, 2006: 61). The urban growth which had occurred since the 1890s and which accelerated in the first third of the 20th century was probably partly responsible. In this period, more particularly in 1901, the first high tension line was inaugurated in Spain, practically in parallel with its application in the developed world, so that in a few years the transport of long distance current made rapid progress.

But the escalation of electricity was not a simple matter due to the resistance of some gas companies which tried to create all kinds of obstacles for electricity companies, a common strategy, conversely, in the sector where companies attempted to block the competition of electricity in public street lighting. These types of situation reoccurred when there was a

¹ In 1890, 30 provincial capitals had electric street lighting installed or underway. In 1893, there were already 88 small power stations in the country. A little afterwards, the 1901 statistics registered 859 electricity factories, of which 648 were of public service and 211 produced for their own consumption (Núñez, 1995: 42; Maluquer, 2006: 57).

critical technological innovation and when the precedent could face its competitor by adopting improvements to extend the technology cycle.

The process was not imitative as it enabled gas to supplant the old energy sources for lighting and this is related to the latter's dimensions. To understand this, some economists speak of situations which generate a high capacity of social takeover of a certain technology (Abramovitz, 1986), which is related to cultural, social, political and institutional factors, to name but a few, linked to interpretative currents like that of the *Social Construction of Technology* (Pinch and Bijker, 1987).

In reality, the modernisation which accompanied the western economic development ran parallel to the electrification process. But this did not represent a mere technological innovation. It was more an active agent of global change (social, cultural, ideological, etc.) (Platt, 1991: 281) which was generating and, simultaneously, the result of various economic, technical and cultural factors, etc. which would fully disembark in the first third of the 20th century (Nye, 1990).

Going back to Spain, gas companies relied on a decisive legal tool, monopolistic licences obtained from city halls, generally for long periods of time (twenty years or more). Despite this, on numerous occasions, after the initial rejection, electricity was incorporated years later by some of these companies, what can often be explained by the successive increase in raw materials and the change of scale of electricity production, similar to what occurred in European gas companies.

The change of century was significant as the gas situation began to deteriorate dramatically. Until then, Fábregas (2003: 128) notes that gas companies had experienced a "basically calm" existence in the market and their main concern was to ensure that councils paid for the gas of public lighting. But thanks to improvement in the electricity production and transport systems, the situation began to alter radically.

Likewise, contracts with city councils in many Spanish cities began to expire over these years. In some cases they were renewed, generally for shorter periods than in the original contracts, although there were exceptions. But in the vast majority, new contracts were signed with electricity companies (Martínez and Mirás, 2012: 136).

The definitive transformation of the energy model, 1905-1936

The turn of the century meant a substantial modification in the energy model. But the electricity boom went back to the First World War with quite intense growth from 1910 when it made the transit from thermoelectricity to hydroelectricity in Spain (Aubanell, 2011: 1). The rise depended on the resolution of problems linked to long distance transmission of energy which led to the construction of large hydraulic dams with the subsequent decrease of costs and the increase of the volume of supply². This therefore was the pivotal spring which allowed, at world level, the country's definitive energy transition (Devine, 1983: 372).

² Between 1907 and 1913, the main Spanish cities began to be supplied by plants with power installed around 5,000 kW (Bartolomé, 2007: 49-52, 71). The total power installed in electricity power stations went from 50,000 CV in 1904 to 700,000 CV in 1918, whilst production increased between 1913 and 1920 from 62.5 to 228.4 million kW-hour (Fábregas, 2003: 125-126).

The electricity sector and the energy structure underwent great transformation (Amigo, 1991: 212). From the initial state of reduced and isolated local markets, firstly regional electricity markets were formed where the first territorial dissociation between production and consumption was produced. Later there was a move towards an integrated energy management system (Amigo, 1992: 123-127).

The lights went off in the gas industry. Technological innovation (spurred on by developments in the electricity sector) had rescued the sector (the most relevant being Aüer's burner), to facilitate improvements in lighting systems and significant cost reduction. But the insufficient implementation of gas in the country left the road clear to penetrate electrical companies. Some companies understood that cooperation could be an excellent way of stemming competition but this strategy was a minority in Spanish cities.

On the other hand, the possibility of resisting the spread of electricity was extraordinarily reduced because the panorama was substantially different to that of solo cohabitation with thermoelectricity. The strategy of entering the electricity sector or taking control of rising electricity companies (as had occurred in the last twenty years of the 19th century) was unviable due to the different productive scale of hydroelectricity and the high volume of capital needed. Conversely, after the European war, companies which produced and distributed electricity took over gas companies, which were condemned by the definitive triumph of this energy option.

Many companies maintained licences in this period but, despite this, the global volume of production reduced. Gas manufacturers could not claim that these contracts involved a monopoly on street lighting as Spanish legislation was against monopolies (Del Guayo, 1992: 26). The 1877 municipal law implied a *coup de grâce*, which prevented city councils from granting a monopoly to the lighting service (Fernández Paradas, 2015: 115). The introduction of diverse technical advances in the electricity sector did the rest (Fernández Paradas, 2009b: 149-150).

On the other hand in the electrical sector, two realities lived side by side. On one hand, the dominant scenario in Spanish cities whereby previously established companies appeared to have consolidated a stable position and, as a result of this, had achieved a certain monopoly which gave them regular functioning, thus ensuring their possibilities of mid to long term survival. By specialising in small sized markets which were not attractive for the new large electricity firms, most of these businesses did not have to compete with them (Fernández Paradas, 2008: 254). They understood that their possibilities of survival in a competitive war were few and far between but they counted favourably on a safe market and on the local distribution market.

In other cities, on the other hand, a progressive disappearance of primitive companies was seen, substituted by those of the second generation, which arose to supply centres of greater consumption, as well as intermediary cases (the most prominent, Madrid and Barcelona, characterised by a more complex panorama) (Núñez, 1995: 44-45, 56-57). In both cases, they started to produce processes of business concentration, which had exacerbated since the First World War.

The conflict had a very negative impact on the gas industry both in Europe and in Spain. The result was that after the war, electricity increased its power to the detriment of gas (Goodall, 1993: 553). In Spain, the difficulties in supplying coal and its exorbitant cost affected gas and electricity of thermal origin. The strong and growing increase of its price (higher than that of

electricity of hydraulic origin) meant that the gas industry underwent a strong decline. Some factories suspended production and others were forced to close (as did many thermal electricity stations), leading to a noticeable reduction of production and the number of companies. This, in turn, led to a greater level of oligopolisation of the sector.

Conversely, hydroelectric energy underwent extraordinary advances, as a consequence of the expansion of the Spanish economy, whilst its costs did not vary significantly (Sudrià, 1984: 88-89). A decisive factor was that, protected by the industrial growth of the country during the war cycle, production for power, rather behind that of industrialised Europe, overtook that of lighting (Bartolomé, 2007: 75).

At international level, the inter-war period saw a deceleration of the growth rhythm of the gas industry, although it continued to expand. However, for Spain, the 1920s were a turning point as they symbolised the flagging of the sector. The number of companies significantly reduced and, on the other hand, the weight of gas in the productive structure of gas supplying companies was increasingly less significant.

Gas lost its competitiveness. The fight to control street lighting finally opted in favour of electricity companies. Gas companies which resisted the war crisis had to diversify their businesses, investing to improve their efficiency and capture (from this decade onwards) new markets in the domestic sector in order to survive: heating for homes as well as in cooking and to obtain hot water (Arroyo, 2002: 86). At the other extreme, in the 1920s and 1930s, the electricity sector received a high volume of investments, which is the other aspect of the huge acquisitions by electricity companies and the subsequent processes of business concentration in the sector, headed by hydroelectric companies mainly formed before the War (Bartolomé, 2007: 72).

Conclusions

The transition of gas to electricity was an inevitable process, the result of a technical change which usually replaces technologies when a series of variables merge which “recommend” its substitution. In our particular case, the most significant were the greater economy or saving of costs and prices, the greater efficiency, the higher quality of power, the less risks inherent to functioning, various environmental questions or simply social, cultural or political factors linked to a particular group’s desire to transform the energy model.

The chosen area, Spanish cities, makes up a heterogeneous conglomerate. The rhythms and intensities of the phenomenon vary considerably although common elements can be identified. The process was not linear as many populations continued to maintain traditional systems of street lighting for decades, extending its survival in various cases until the 20th century. And, likewise, there was coexistence with modern street lighting systems.

The most common sequence was that of oil lighting from the first third of the 19th century, which was then successively replaced by gas. In pioneering cases, from the 1850s to 1860s. Sometimes they even shared street lighting with petroleum. There are other quite frequent cases where gas arrived late (between the 1870s and 1890s), whereby its life cycle was cut as it entered into direct competition with the birth of thermal electricity. There is no doubt that in those cities with a gas factory with a long-term licence, the entry of electric light was slowed down. But where its introduction came later, licences were given for shorter periods, soon entering into a tough dispute with electricity. Despite this, old lighting continued to offer a service until practically the 20th century, although from the First World War its role was practically testimonial.

The following substitution, gas by electricity, had two well-defined periods. Whilst electricity generation was thermal, its competitive capacity was reduced, due to high costs, a narrow business scale, reduced installed power and the difficulties of long distance energy transmission etc. Furthermore, it was overtaken by a rival which could rely on large licences over time, with well-established companies which, moreover, relied on a strong debt contracted by city councils which would be used as an element of pressure. Where competition involved traditional lighting means, the entry into the market was indeed far simpler.

The second period, the one of hydroelectricity, started to become a reality at the turn of the century, and is the chronicle of an announced death. As well as the factors related to “illusion” of new technology, which stimulated social agents towards innovation, the advantages in terms of costs, scale economies etc. finally led to the substitution of gas by electricity between the first decade of the 20th century and the 1930s.

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