

URBAN GAS AND ELECTRICITY NETWORKS IN PORTUGAL: COMPETITION AND COLLABORATION (1850–1926)

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In the last decades of the nineteenth century, even though the decision to create urban infrastructures for gas was one of the responsibilities of local councils, from the very beginning the concession for gas distribution was granted to private businesses. In an attempt to attract private capital, the concessions granted by the municipal councils were for extended periods of time in order to allow for the recovery of the fixed capital investment. Thus, at the beginning of the twentieth century, the introduction of electricity was hampered by those extended contracts established by municipal councils with gas companies to supply gas for public lighting. This situation explains why electricity was often introduced earlier in cities that were not district capitals and did not have gas lighting.

In some Portuguese cities, different companies in competition with each other held concessions for the exploitation of gas and electricity. In other cities, however, the same company had the concession for the distribution of gas and electricity for both public lighting and private consumption. In these cases the company searched for parallel markets for each of these energy sources and tried to diversify the gas applications.

This study traces the diffusion of urban gas networks in Portugal in comparison with those of electricity, as well as analysing some situations of competition or cooperation in the creation and exploitation of gas and electricity networks.

1.-The spread of urban gas networks in Portugal.

1.1.- The first concessions for the exploitation of gas.

The introduction of gaslight in the streets of Portugal dates from 1848, when the Lisbon City Council awarded the concession for gas lighting to the

Companhia Lisbonense de Iluminação da Gás (CLIG)¹.

Gaslight was also introduced in Oporto in 1855 and subsequently in Coimbra in 1856. The monopoly of the gas supply in each given city was associated with the contract to provide public lighting. As the start-up investment to create an infrastructure of gas required large financial assets, this contract was a crucial step in order to ensure a prior basis of consumption, before the use of gas for domestic and industrial purposes became widespread. Nonetheless, the companies that invested in the creation of gas infrastructures expected to conquer the domestic consumer market, which is one of the reasons why gaslight was introduced first in the more populated cities. The existence of greater economic activity and the location of the cities closer to the coast also contributed to this early introduction of gaslight. In the cases of Lisbon and Oporto, factories were located near the rivers (the Tagus and the Douro) in order to assure the supply of imported coal².

Cities	Population in 1864	Date of the competition for awarding gas-based public lighting
Aveiro	6.395	1889
Braga	18.831	1856
Coimbra	12.727	1856
Covilhã	7.177	1889
Elvas	10.271	1887
Evora	11.518	1890
Leiria	2.922	1890
Lisboa	163.763	1848
P. Varzim	9.623	1888
Oporto	73.325	1855
Santarém	6.207	1887
Setúbal	12.747	1859
V. Castelo	9.263	1887

Source: *Estatística de Portugal, Censo da População no 1º de Janeiro de 1864*, Lisboa, Imprensa Nacional, 1868, VIII.

- 1 Among those interested in obtaining Lisbon's lighting concession there was Samuel Clegg, who had been Murdock's assistant, and had worked at Boulton & Watt's, a company he left in 1805 in order to create his own business. Until 1812, when it specialized only in the production of steam machinery, Boulton & Watt was devoted to the gas industry and made fixtures for gas lighting in several factories. In 1813 Samuel Clegg was appointed engineer at the Gas Light & Coke Company. GOODALL, Francis (1999) *Burning to Serve. Selling Gas in Competitive Markets*, Ashbourne, Landmark Publishing, 21-23.
- 2 Portuguese coal was of low calorific value, and as such inadequate for the production of gas. Besides, the extraction of coal in Portugal was not sufficient to supply the needs of industry.

However, the existence of larger populations, their location along the coast or the presence of industries was not enough to assure the supply of gaslight. In the case of Braga, the concession of which was awarded to Jacques Robert Mesnier³, who transferred it to the Companhia Barcareense de Melhoramentos Materiais da Província do Minho, the concentration of the population in the city and the importance of the textile industry in the region were not enough to assure the success of this initiative. In the case of Setúbal, a harbour located to the South of Lisbon, the concession was awarded to Louis Lougé, Felix Canier, and Pedro Leré, French citizens, who conceded it to the Companhia Setubalense de Iluminação a Gás, but the company dissolved in 1859 without having brought gaslight to the city.

In the cities where the installation of gas infrastructures did take place, such as Lisbon, Oporto, and Coimbra, companies had to face several difficulties in the supply of gas due to the need to build their factories away from the city centres, where most of the population lived⁴, and also due to the topographical characteristics of the cities themselves. All of these three cities are characterized by the existence of hills; Lisbon is even known as the “city of seven hills”. These hills prevented stable gas pressure from being maintained in different areas of the city, and the fact that the residential district was spread over a wide area meant that a large network had to be constructed.

Another difficulty that companies faced was the need to create large extensions of pipelines with an uneven distribution of streetlamps sparsely scattered and with no private consumers, or with a small number of private users spread along the network of pipelines⁵.

1.2. – The creation of gas infrastructures from the 1880s.

During the 1880s, schemes to introduce gaslight into urban centres that still remained unlit intensified. The high number of proposals presented

3 French by nationality, he settled in the city of Braga with his family.

4 Regarding Lisbon, MATOS, Ana Cardoso de (2009) “Gas industry and urban modernisation: Lisbon in the 19th and 20th centuries”, *TST, Transportes, Servicios y Telecomunicaciones*, num. 16, 65–68 and 71–72; and regarding Porto, MATOS Ana Cardoso de; MENDES, Fátima; FARIA, Fernando (2003) *O Porto e a Electricidade*, Lisboa, EDP: Chapter 1 - Do gás à electricidade, 19-62.

5 In Oporto, the Companhia was forced to build a factory outside of the city, which compelled it to create a long pipeline to reach the city centre. In Lisbon, the city’s many hills and the fact that the residential district was spread over a wide area involved the construction of a large network.

when municipal councils opened up competitions for the concession for the public lighting demonstrates the interest of Portuguese and foreign corporations in the exploitation of urban networks of gas and electricity.

Even though the construction of a gas factory and a network of pipelines demanded substantial start-up capital, the profits obtained by other companies running this kind of concession in several European cities had already demonstrated that the investment soon translated into substantial profits. In Portugal the Companhia Lisbonense de Iluminação a Gás, the company that since 1848 had assured the supply of gas to the city of Lisbon, provided an example of the kind of profits that could be obtained with this kind of investment. Although during the first few years of the exploitation of the contract for gas supply in Lisbon the investments necessary for the creation of the factory and pipelines had made it impossible to distribute dividends among stockholders, a few years later the situation had dramatically altered and investing in the gas Companhia became highly rewarding⁶.

During the 1880s, the proposals in which, as stated above, both Portuguese and foreign businessmen were involved, correspond to a phase of internationalization of gas and electricity corporations⁷. These companies were interested in investing in countries in which such ventures had not yet been undertaken or which demanded technological modernization⁸.

When several cities opened up public competitions for the concession for public lighting by gas, some entrepreneurs, Portuguese businessmen, presented proposals and even managed to win the contest, but they encountered difficulties in obtaining the capital required to build a gas factory and to establish pipelines. As a consequence, they were unable to meet the deadlines

6 Indeed, as early as 1851 they managed to distribute a dividend of 6%, which the following year increased to 7.5%. In 1853, the dividends were back to 6%, and remained at that level until the 1870s. From then on we see a tendency for dividends to rise. During the 1880s, they rose as high as 25%, which allowed shareholders to recover the capital they had invested in just a few years. For more details see, MATOS, Ana Cardoso de (2003) "A indústria do gás em Lisboa - uma área de confluência de várias abordagens temáticas", *Penélope: revista de história e ciências sociais*, 20, 109-120.

7 On this subject, PAQUIER, Serge & WILLIOT, Jean-Pierre (dirs.) (2005) *L'industrie du gaz en Europe aux XIXe et XXe siècles. L'innovation entre marchés et collectivités publiques*, Bruxelles, Editions Peter Lang.

8 Foreign investment was also made in other sectors, such as railways and later electricity, and "The creation of foreign firms in these sectors internalized financial capital markets and technological capabilities". Cf MATOS, Ana Cardoso de; SILVA, Álvaro Ferreira da (2008) "Foreign capital and problems of agency: the Companhias Reunidas de Gás e Electricidade in Lisbon (1890-1920)", *TST - Transportes, Servicios y Telecomunicaciones*, num. 14, 142-161.

stipulated by the contracts they signed with the city councils to initiate the supply of gas, and they lost their concessions. For example, we may mention the case of Figueira da Foz: in 1885, a contract was signed with Francisco Borges da Cunha, but he did not manage to assemble the necessary funds to build the factory and the network within eighteen months, and his contract was annulled. Two years later the concession was granted to other businessmen.

Thus, we find that several schemes for the introduction of gas in the 1880s were awarded to foreign companies, which not only had greater facilities for obtaining the necessary funds, but also the technical and organizational knowledge necessary for success of this kind of enterprise⁹, having already been active in this business in other countries. In addition to these advantages, they also employed technical personnel accustomed to circulating among the different textile businesses owned by these companies in different countries¹⁰. Nevertheless, despite such advantages, the company that won the contest often transferred the concession to a new company that it created with many of the other companies that had also submitted their proposals in the contest. This was a practice that was applied, for instance, in Lisbon.

In 1887, when the Lisbon Municipal Council started a new competition for the city's lighting, several national and foreign companies submitted their proposals. The concession for public lighting was awarded to the Sociedade Anonyme d'Eclairage du Centre, from Brussels, which created the Companhia do Gás de Lisboa together with the other foreign companies that had presented tenders for the gas lighting concession: the Compagnie Générale pour l'Eclairage et le Chauffage par le Gaz, also from Brussels, Khon Reinach & C^a, and P. M. Oppenheim¹¹.

A similar situation occurred in the city of Oporto in 1889, when the Municipal Council started a competition to award the concession of public lighting by gas. Twelve proposals were presented, some from foreign companies that already operated gas networks in several European cities, such as the Imperial Continental Gas Association¹² or the Belgian Compagnie du

9 MATOS; SILVA (2008).

10 MATOS, Ana Cardoso de (2006) "Les ingénieurs et la création des réseaux de gaz et d'électricité au Portugal: transferts et adoption de technologies (1850-1920)". In: MERGER, Michèle (dir) *Les transferts technologiques en Méditerranée*, Paris, PUPS, 185-205.

11 MARTINS, Alice M. Campos; COELHO, Adriano Pinto (1998) "A Fábrica de Gás de Belém: os projectos e os processos de produção no final do séc. XIX", *Arqueologia & Indústria*, num. 1, 24.

12 The Company was formed 1824, commenced operations distributing gas in Hannover in 1825 and provided gas lighting in Berlin in 1826. During the course of the 19th century, it

Gas¹³. On one hand, some of the companies that competed for the Oporto concession were already involved in activities related to the supply of gas to Portuguese cities. In the same year, the Sociedade Dalhaise, Magerman & Van Hulle signed a contract with the Companhia Geral de Iluminação a Gás, which held the concession for gaslight in the city of Évora; in the terms of this contract it took charge of setting up the gas factory and running it for 25 years¹⁴. On the other hand, the Usines à Gaz du Centre company, which had competed in this contest through its engineer León Somzée¹⁵, also presented a project in the competition for the concession of public lighting by gas in Lisbon that was held in 1887 and was won by the Sociedade Eclairage du Centre from Belgium. This latter company transferred the concession to the Companhia Gás de Lisboa, a company created at that time and in which it held a share, as did León Somzée¹⁶.

Businesses/businessmen who participated in the 1889 competition for the concession of gas lighting in the city of Oporto

Proponent/Business	Nationality	Other contests in which they participated	Other concession contracts in Portugal
Imperial Continental Gas Association	English (London)		
Fernand Delhaise & B. Margermon	Belgian		Contract with the Companhia Geral de Iluminação a Gás – Évora
Charles Georgi	French		Also involved in the Company of Lisbon
León Somzée – Gaz du Centre (Belgian)	Belgian (Brussels)	Contest for gas lighting in Lisbon 1887	Also involved in the Companhia Gás de Lisboa

established gas works in Antwerp, Brussels, Berlin and Vienna.

13 In 1869 this Company had eight gas factories in Italy, two in Germany and three in Belgium, while in 1887 it also obtained a concession in Carcassonne. « Du fait qu'elle contrôlait plusieurs usines, la Compagnie out réaliser d'importantes économies d'échelle, par exemple en passant des contrats avantageux pour l'achat de charbon en grosses quantités ». BRION, René ; MOREAU, Jean-Louis (2005) « La Compagnie générale pour l'éclairage et le chauffage par le gaz (1862-1929) ». In PAQUIER, S. ; WILLIOT, Jean-Pierre (dir) *L'Industrie du gaz en Europe aux XIXe et XXe siècles. L'innovation entre marchés privés et collectivités publiques*, Bruxelles, Ed Peter Lang, 227- 228.

14 MATOS, Ana Cardoso de (2001) "Aspectos técnicos, empresariais e sociais do abastecimento de gás e electricidade à cidade de Évora (1890 -1942)", *A Cidade de Évora*, II série, nº 5.

15 León Somzée was the chief engineer of the Gaz Belge company from 1867.

16 MARTINS; COELHO (1998), 27-30.

Companhia Portuense de Iluminação a Gás Portuguesa	Portuguese (Oporto)		Contract with the Municipal Council of Évora
Companhia Gás de Lisboa	Portuguese		Contract with the Municipal Council of Lisbon in 1887 for gas distribution to the city
Henrique Carlos de Meirelles Kendall	Portuguese (Oporto)		
António Queirós Montenegro	Portuguese (Oporto)		
Joaquim António Ferreira da Silva	Portuguese (Oporto)		
João Eduardo Sotto Maior da Silva	Portuguese		
José Ribeiro Vieira de Castro	Portuguese		
Luís Venâncio Torres Leão	Portuguese		

Source: AHMP – Casa do Infante. Série vereações, livro 132, fols. 38 a 39v.

The other Portuguese companies that were interested in the concession of public lighting in the city of Oporto were also involved in public lighting concessions in other Portuguese cities. The Companhia Portuense de Iluminação a Gás, which was based in Oporto and involved several Portuguese and foreign businessmen living in the northern part of the country, such as António José da Silva Cunha, resident of Gaia, Edmond Compton, resident of Oporto, Percy Miller Stears, residing in the council of Bouças, and Arnaldo de Novais Guedes Rebelo, inhabitant of Oporto, obtained the concession for the city of Évora.

The competition held by Oporto Municipal Council also seemed like a good investment for businessmen from Oporto linked to other industrial sectors. Such was the case of José Ribeiro Vieira de Castro, who had invested a fortune acquired in Brazil in the purchase of the Companhia Industrial de Fafe and in the later funding of Fafe's Companhia de Fiação e Tecidos, a business venture in which several other *brasileiros* took part¹⁷. Interest in

17 Jorge Fernandes Alves, *Os brasileiros. Emigração e retorno no Porto Oitocentista*, Porto, 1994, 308. José Ribeiro Vieira de Castro was a member of Oporto's Industrial Association (*Associação Industrial Portuense*), being elected vice president in 1891.

the public lighting concession for the city of Oporto, expressed by men such as the businessman Henrique Carlos de Meirelles Kendall, stockholder of Viana do Castelo's Banco Mercantil and member and president of Oporto's Commercial Association¹⁸, made itself evident in the strategy followed by the "business leaders of the Oporto marketplace", who tried to determine the investment of the *brasileiros'* capital. Since the 1870s, the "*brasileiros*"¹⁹ had invested more and more in large corporations²⁰, which is what justified the interest expressed by representatives of Viana do Castelo's Banco Mercantil and of Oporto's Associação Comercial in obtaining the concession for gas lighting – a concession they would exploit through a newly created company to which they expected to "attract" the investment of the "*brasileiros*".

On 18 February 1889 several proposals submitted to the Oporto Municipal Council were appraised, and the concession was awarded to Charles Georgi, who created the Companhia do Gás do Porto (a private corporation with limited liability). When he took over the gas factory, it was badly rundown and the process of gas production required extensive technical improvements so as to assure the quality of the gas distributed to consumers. In order to implement these improvements, the Companhia was obliged to turn to national and foreign funds over the next few years. Its efforts to gather investment were rewarded by the Companhias Reunidas de Gás e Electricidade (CRGE), a company created in 1891 that operated the gas supply in the city of Lisbon. This company benefited from important foreign shareholders, among which was the *Companie Générale pour l'Eclairage et le Chauffage par le Gaz*²¹. The CRGE granted the Companhia Gás do Porto the necessary capital by the purchase of shares. In 1897 the CRGE bought more shares and became the largest shareholder of the Companhia Gás do Porto.

Some of the companies interested in this sector tried to obtain concessions for gaslight in several of the country's cities, even when they were geographi-

18 CRUZ, Antonieta (1999) *Os Burgueses do Porto na Segunda metade do século XIX*, Porto, Fundação Eng. António de Almeida, 643.

19 "*Brasileiros*" were Portuguese people who migrated to Brazil and came back to Portugal after making their fortune.

20 ALVES, Jorge Fernandes (1994) *Os brasileiros. Emigração e retorno no Porto Oitocentista*, Porto, FLUP, 354-366.

21 The percentage of shares belonging to foreigners represented 41% in 1891, and by 1914, when with the purchase of new shares SOFINA had become the largest shareholder, it had risen to 68.7%. For this reason, the CRGE was a free-standing company. For further details see, MATOS; SILVA (2008), 142-161

cally distant. The Companhia Geral de Iluminação a Gás, based in Oporto, competed for the public lighting of cities such as Santarém (1889), Évora (1889), Aveiro (1889) and Leiria (1890). Its interest in exploiting the supply of gas in cities located in regions so far apart can be explained by an attempt to obtain economies of scale.

City	Date of the concession	Company	Nationality
Elvas	1887	Emile Pitsch and António Barbosa representing Alfredo Harrison and Diogo Souto	English
Figueira da Foz	1887	Thomas Nesham Hirkham, Thomás Carlos Hersey (civil engineers)	English
Santarém	1887	Diogo Souto representing Alfredo Harrison	English
V. Castelo	1887	Augusto Lavereé	French
Matosinhos	1888	António Augusto Cogorno Oliveira	Portuguese
P. Varzim	1888	Percy Miller Street representing Alfredo Harrison	English
Aveiro	1889	Diogo Souto representing Alfredo Harrison	English
Covilhã	1889	Diogo Souto representing Alfredo Harrison	English
Leiria	1890	Diogo Souto representing Alfredo Harrison	English
Evora	1890	Diogo Souto representing Alfredo Harrison	English

1.3. – The significant increase in gas consumption.

From 1848 to 1888 gas consumption increased significantly in Lisbon, almost doubling every ten years²². Starting in the 1880s, we see an accelerating increase in the consumption of gas, which in the case of Lisbon is directly related to an increase in residential building²³ and to the reduction in the

22 Regarding the evolution of the consumption of gas in Lisbon, ARROYO, Mercedes; MATOS, Ana Cardoso de (2009) "La modernización de dos ciudades: las redes de gas de Barcelona y Lisboa, siglos XIX y XX", *Scripta Nova. Revista Electrónica de Geografía y Ciencias sociales*, vol. XII, núm. 296 (6); MATOS, Ana Cardoso de (2009) "Gas industry and urban modernisation: Lisbon in the 19th and 20th centuries", *revista TST- Transportes, Servicios y Telecomunicaciones*, num. 16, 62-80.

23 As Álvaro Ferreira da Silva remarks on the granting of building licences in Lisbon, a phase began in 1878 which ended "in 1896, thereby completing a cycle of intense and rapid growth

price of gas (70 réis from 1848 to 1870, and 22.5 réis in 1890).

From the end of the nineteenth century to the early twentieth century, the newly recorded progress in gas-driven engines favoured their greater usage in the country's most important industrial centres, even though these industries did not always use the gas that was distributed by the companies running the urban networks.

In Lisbon, in 1892–93, the CRGE supplied gas to 140 engines (representing 400 c/v). At that time, in order to foster the installation of gas-driven engines, the company intended to create a special service for paying for the purchase of these devices in installments. In 1905, due to the increase in both domestic and industrial gas consumption, the CRGE installed a new gasometer with a capacity of 20,000 m³²⁴.

In the case of Oporto, during the first few years private individuals showed no great interest in adopting gaslight in their houses, and the Companhia Portuguesa de Iluminação a Gás, the company in charge of providing this service, dug up whole streets in order to put in pipelines “without finding a single private consumer”²⁵. When private individuals interested in signing a contract started to appear, it was necessary to extend the pipelines to the entrance of their buildings; while some cases this involved no great expense because of the proximity of the house to the pipes already installed, in other cases the extension of those pipes was extremely costly, and with no guarantee that the amount spent in the gas consumed would compensate for the company's outlay.

Even so, gas consumption gradually spread throughout the city of Oporto, and with the increase in the numbers of private consumers it became necessary to stipulate under what conditions the contracts they signed with the Companhia Portuguesa de Iluminação a Gás should be established. According to the terms of the 1874 policies, the Companhia was required to supply consumers at the gas meter outlet with all the gas necessary for their lighting needs from sunset to sunrise. The fact that domestic supply only covered the time period from sunset to sunrise demonstrates that gas usage was predominately for lighting purposes²⁶.

in the issuance of licences”. SILVA, Álvaro Ferreira da (1998) *Crescimento Urbano, Regulação e Oportunidades Empresariais, Lisboa 1860-1930*, Florence. Phd thesis, vol. I, 140.

24 CRGE, Relatórios da Administração referentes aos anos de 1892–93 e 1904–05.

25 *O Commercio do Porto*, XI Ano, n.º 39, 19 de Fevereiro de 1864, 1.

26 The price per lamp was inversely proportional to the number of lights. Thus, while a meter

From the late nineteenth century, Oporto registered an increase in industrial gas consumption; however, the industrial crisis the city experienced at the beginning of the twentieth century limited this increase. In 1901, “if the sale of gas does not increase it is due to the industrial crisis now happening in that city, and that is revealed by the gas consumed in the factories”²⁷. Nevertheless, throughout the following years, the endorsement of the use of gas by entrepreneurs became more significant, and gas-driven motors came into use, mostly by small industries in Oporto and the surrounding areas²⁸. In 1905, in the first *Circunscrição dos Serviços Técnicos e de Indústria*, there were 171 of these engines with an approximate power of 960 c/v, and during the course of that year 14 new motors were examined. These engines, which did not exceed a power of 30 c/v, were installed in industries ranging from typography to shoemaking and locksmiths’ workshops. As the number of engines increased, so did their power. The increase in the private consumption of gas in the city of Oporto led to the construction of a new gasometer around 1908–1909. At that time, a large part of the increase was due to the installation of gas meters in private dwellings, but gas consumption in the industries was taking on a growing importance.

2. - Negative “images” of gas and electricity as an alternative to public lighting and domestic and industrial consumption.

Industrialization spawned a wide variety of pollution problems in urban spaces particularly endemic to cities – directly through smoke, industrial waste, and water pollution, and indirectly through urban growth and congestion²⁹. All these problems were particularly pressing in production by

for two-lamps led to a monthly payment of 150 *reis* (or 1\$800 *reis* per year), a meter for 50 lights rose only to 600 *reis* (or 7\$200 *reis* yearly). *Apólice de contrato ente a Câmara Municipal e a Companhia Portuense de Iluminação a Gás relativamente aos consumidores, a que se refere a condição 20ª art.4º do contrato Geral de 22 de Janeiro de 1874*. AHCMP. Documentos Originais - Obras Públicas, vol. 9, 1874, doc. 1.

27 Arquivo EDP, Actas do Conselho de Administração 1900-1907, 47.

28 VISCONDE DE VILARINHO DE S. ROMÃO (1906) *Relatório dos Serviços da 1ª Circunscrição dos Serviços Technicos de Industria no anno de 1905*, Lisboa, Imprensa Nacional, 8.

29 The problems created by industrializations were particularly endemic to cities. Regarding this matter, among others, see: TARR, Joel A. (1996) *The Search for the Ultimate Sink: Urban Pollution in Historical Perspective*, Akron, University of Akron Press; MELLOSI; Martin V. (2001) *Effluent America, cities, industry, energy, and environment*, Pittsburgh, University of Pittsburgh Press.

the gas industry. The construction of gas plants and the development of the gas industry in different cities contributed to changing the natural aspect of the cities and created environmental problems, namely as a result of the construction of gasometers and the implantation of gas pipes throughout the city streets.

Following an increase in the concern for public health, together with the notion that industrial pollution was indeed a factor in the increase of diseases, governments tried to control the urban environment through new legislation. This movement, which occurred in most European countries, was also noticeable in Portugal. In 1837, it was determined that tanning factories should be removed from the cities (Ordinance of 20 September 1837). In 1855 industries were classified according to their level of salubrity. Those factories considered unhealthy or hazardous to public safety (like gas or chemical plants) could only be allowed into the cities after having been approved by a group of experts. These experts investigated aspects such as: the factory's blueprint; the characteristics of the land on which the factory would be built; the exposure to the winds; the production processes, and the consequences that the factory might have for public health (*Instruções especiais*, 21 February 1856). This legislation was reinforced in 1860 and 1863. The Decree of 21 October 1863 established that no factory classified as insalubrious, hazardous or noxious could be founded without prior licensing. An Order of 23 November 1865 charged administrative and sanitary authorities with the responsibility of imposing on such industries the conditions required to "preserve public health and the convenience of citizens, without concerning themselves with the costs that such conditions might occasion".

The construction of a gas network brought into the cities a new factor of environmental contamination. The gas factories contributed to pollution of the atmosphere, land and water. The construction of a gas network for public and private lighting spread this pollution to the rest of the city. For these reasons the gas companies were regularly considered responsible for diseases. In 1856–57, when Lisbon suffered an epidemic of yellow fever, the smoke from this plant was considered to be one of the causes of this disease.

In order to prevent pollution caused by gas, factories and gasometers were built on the outskirts of cities, in sparsely inhabited zones. As a matter of fact, gas factories were classified as insalubrious or dangerous to public health, and that is why they could not be built in the city centre. As previously stated, Lisbon's gas factory was built in the eastern region of the town and

the contract between the municipality of Oporto and Hardy Hislop specified that the gas plant should be constructed beyond the city limits, in a location with few inhabitants.

The strong odour emanating from the gas factories also contributed to the fact that the inhabitants of the cities where such plants were located attributed to them the cause of several diseases. Thus the inhabitants created a negative image of the gas industry, and this was one of the reasons why in many cases factories were “hidden” behind building façades. That is what happened in Lisbon in 1875/76³⁰.

3.- Competition between gas and electricity.

The development of electricity as a means for public and private lighting registered during the second half of the nineteenth century, and the negative “image” people had of gas lighting, contributed to the fact that electricity slowly emerged as an alternative to gas.

Thus, in 1870, when the contract between the Companhia Lisbonense de Iluminação a Gás, the company that operated Lisbon’s street lighting by gas, and the Municipal Council was renewed, the new contract stipulated that the municipality could adopt another system of lighting, providing it had already been used in either Paris or London. A few years later, the Companhia still believed that “despite the glow from that type of light, there are, among others, several essential doubts experts still consider difficult to resolve: the economic question; the question of divisibility as far as private lighting is concerned”³¹. Even so, notwithstanding the doubts still held by the Companhia Lisbonense in relation to this new source of lighting, times were changing and electricity was steadily becoming an alternative to gas³².

The upturn in electricity was the first Electricity Exhibition held in Paris in 1881³³. Over the next few years, several other exhibitions devoted to electrici-

30 MATOS (2009), 65-66.

31 *Relatório da Companhia Lisbonense de Iluminação a Gás de 1878*.

32 MATOS, Ana Cardoso de (2005) “Perspectives of analysis of Gas Industry in Portugal. The Case of Lisbon in 19th Century”. In: PAQUIER, S. ; WILLIOT, Jean-Pierre (dir) *L’Industrie du gaz en Europe aux XIXe et XXe siècles. L’innovation entre marchés privés et collectivités publiques*, Bruxelles, Ed Peter Lang, 567.

33 According to Alain Beltran and Patrice A. Carré, this exhibition was « Séquence majeure dans l’histoire des techniques, séquence inaugural de l’histoire des applications de l’électri-

ty were held in different European cities in which the uses of electricity were presented. Simultaneously congresses were organized that contributed to the circulation of technical and scientific progress. That is what happened in 1881, when a congress with an attendance of 256 engineers from 28 countries was held, among which there were 3 Portuguese nationals.

During the 1880s several companies were also created in Portugal that were able to supply and assemble electric installations. Some of these companies were Portuguese while others belonged to foreign businesses³⁴.

From the late nineteenth to the early twentieth century, several Portuguese cities adopted electricity as a form of lighting. In some cases the initiative came from municipal councils and in others from private individuals³⁵. With the exception of cities in which the same company exploited both gas and electricity, such as Lisbon, in which both networks were exploited by the Empresa Companhias Reunidas Gás e Electricidade (CRGE), in cities that had chosen to adopt gas for public lighting a few decades previously, the extended terms of the concessions that had been awarded to private companies delayed the introduction of electricity in public lighting. However, this situation did not prevent the fact that in some cities schemes arose to produce and distribute electricity to private consumers. This was the case of Oporto, for example, where in 1888 the Companhia Luz Eléctrica was created for that end³⁶. An identical situation could be found in the city of Évora, where since

cité ». BELTRAN, Alain ; CARRÉ, Patrice A. (1991) *La fée et la servante. La société française face à l'électricité XIXe-XXe siècle*, Paris, Belin, 64. According to André Grelon e Girolamo Ramuni, « cette année 1881 marque la frontière entre deux étapes du développement industriel de l'électricité », GRELON, André ; RAMUNI, Girolamo (1997) « Ingénieur, vecteur de la science électrique ». In *La naissance de l'ingénieur-électricien. Origines et développement des formations nationales électrotechniques*, Paris PUF, 8.

34 This was the case of the *Companhia Portuguesa de Electricidade* founded in Lisbon, or the *Companhia de Luz Eléctrica* and the *Société Emílio Biel*, located in Oporto, MATOS (2006).

35 For further details, see: MARIANO, Mário (1993) *História da Electricidade*, Lisboa, EDP, 100–104; SIMÕES, Mariz (1997) *Pioneiros da Electricidade em Portugal*, Lisboa, EDP, 163–210; FERREIRA, Jaime Alberto do Couto; FIGUEIRA, João José Monteiro (2001) *A electrificação do centro de Portugal no século XX*, Lisboa, EDP- distribuição; MATOS, Ana Cardoso de et al. (2004) *A electricidade em Portugal. Dos primórdios à 2ª Guerra Mundial*, Lisboa, EDP, 106–114; SILVA, Álvaro Ferreira da; MATOS, Ana Cardoso de; CORDEIRO, Bruno (2004) “Ciência, técnica e Indústria nos primórdios da electricidade». In HEITOR, Manuel et al. *Momentos de Inovação e Engenharia em Portugal no século XX*, vol. 2, Lisboa, D. Quixote, 64–65.

36 This company, created in 1887 on the initiative of a medical doctor named Tito Fontes, bought from *Empresa Luz Eléctrica* the power plant it had built on Rua Passos Manuel, which had started to function a few years before. MATOS, Ana Cardoso de (coord), MENDES, Fátima; FARIA, Fernando (2003) *O Porto e a Electricidade*, Lisboa, EDP, 76.

the early twentieth century there had been attempts to create a company that would assure the distribution of electricity to private consumers.

So, when we try to recreate the process of implementation of electrical networks in several Portuguese cities, we have to take into consideration the pre-existence of the earlier gaslight networks. On one hand, because the concession of the monopoly for public lighting by gas for extended periods of time restricted initiatives for the creation of an electricity network solely for private usage, the market was uncertain, and insufficient to justify for the high investments needed for the construction of an electrical power plant and a distribution network. On the other hand, even if contracts allowed for gas companies to substitute that kind of lighting for electric light, the truth is that the investments gas companies had made in the construction of factories and in setting up pipelines for distribution were amounts that could not be recovered if the company altered its production. Hence the gas companies that won the concessions for the supply of electricity for public lighting delayed the start of their production.

This was the situation in Lisbon and in Oporto. When the new gas franchise contract was signed in 1887, electricity in Lisbon was already a potential competitor for street lighting. Therefore, the municipality pledged not to launch any other technology for lighting during the next 10 years, in order to secure the investments the company had to make in order to modernize the gas network. After the experience of lighting the Avenida da Liberdade, the Companhia, grantee of the gas concession³⁷, delayed the building of a new power plant and the extension of the network for electricity distribution; it kept gaslight for public illumination in a substantial part of the city for an extended period of time. The fact that in the city of Lisbon the electricity network was run by the same company that supplied gas favoured this kind of situation, and was responsible for the fact that competition among those different systems of lighting was not very intense. Only in 1903 did CRGE finish construction of a new electric power plant, the Central de Boavista, and only in 1905 did CRGE sign a contract with Lisbon's Municipal Council compelling it to replace 177 streetlights meant for gas with electric streetlights³⁸. Three years later, the number of electric streetlights for public

37 The Companhia Gás Lisboa, which in 1891 joined with the Companhia Lisbonense de iluminação a gás to become the Companhia Empresas Reunidas de Gás e Electricidade CRGE.

38 Câmara Municipal de Lisboa, *Contracto para a Nova Iluminação a Luz Eléctrica de diversas ruas, praças e avenidas celebrado com a Sociedade Companhias Reunidas de Gaz e Electricidade em 25 de*

lighting amounted to 293³⁹. During the early years of the twentieth century, the number of electricity consumers tended to increase, but that growth was accompanied by a similar tendency among gas consumers. The situation was the same in other European cities, such as Paris, where despite the creation of electricity firms, from 1889 to 1900 the number of gas consumers doubled⁴⁰.

In the case of Oporto, where since 1887 there had been a small electric power plant belonging to the Companhia Luz Eléctrica, supplying electricity to a small number of private consumers, the Companhia do Gas tried to obtain the concession for the distribution of electricity for the city's public and private consumption. However, it only started the production of electricity after being urged repeatedly to do so by the Municipal Council. Indeed, the contract signed in 1889 by the Municipal Council and the Companhia do Gás do Porto allowed the Companhia do Gás to supply electric energy as well. However, in order to guarantee the financial return of the investments needed to build gas pipelines and the factory, the Municipal Council solemnly promised not to employ another system of public lighting for the following 15 years. Once that period had passed, if the council members decided that the city should be "illuminated by electric light, or by any other system", it would grant the concessionary preference if equal circumstances were met⁴¹. The substantial investments the company needed in order to update the gas factory compelled the Companhia to resort to both national and foreign capital, and in 1893 in an attempt to amortize the invested capital, it asked the Council to extend its contract for a further 25 years, which would then cover a total of 50 years⁴². Following this request, on 7 February 1894 a new contract was signed between the Council and the Companhia do Gás, extending the term of the concession for the city's public lighting by gaslight until 1939. However, this contract reinforced the Companhia do Gás, obligation gradu-

Fevereiro de 1905, Lisboa, 1911, page without number.

39 Câmara Municipal de Lisboa, *Contracto de 28 de Novembro de 1908 com a Sociedade Companhias Reunidas de Gaz e Electricidade*, Lisboa, 1911, 5.

40 BELTRAN, Alain (2002) *La Ville - Lumière et la Fée Électricité. L'énergie électrique dans la région parisienne: service public et entreprise privée*, Paris, Éd. Rive droite, 46–47.

41 *Programa do Concurso para a iluminação a Gaz da cidade do Porto*, 1888.

42 This request was analyzed by a technical committee, which confirmed that the Companhia was in no financial condition to meet interest rates and capital amortization, nor the expenses related to the exploitation of the concession, upon the deadline initially stipulated by contract. "Parecer da Comissão Municipal sobre o pedido da Companhia do Gaz para prorroga do seu contracto por mais 25 anos". In: *Documentos relativos à Iluminação a Gaz e Eléctrica da cidade do Porto. Publicados por ordem da Exm^a Camara Municipal do Porto*, Porto, 1910, 56.

ally to replace gaslight with electrical lighting.

In order to implement this supply a new corporation was therefore created, the Sociedade Energia Eléctrica, from which it retained a large amount of shares⁴³. Although the Companhia do Gás operated the old power plant that used to belong to the Companhia Luz Eléctrica, located on Rua Passos Manuel, this plant only supplied a relatively small number of private consumers, and its electricity supply neither corresponded to the numbers stipulated in the contract nor was able to respond to any increase in the number of consumers. Therefore, given the increasing number of private consumers in the following years, the Municipal Council kept pressuring the Companhia do Gás to start electric light distribution for both public and private lighting. Unable to implement the installation of an electrical network, on 11 December 1907 it transferred the concession for electricity to the Sociedade Energia Eléctrica do Porto, which took over all the rights and obligations towards the Council formerly stipulated in the contracts. By 1909, the construction of the Central do Ouro power plant was completed and the electricity supply for public and private consumption also started; this was exploited by the Sociedade Energia Eléctrica until 1917, when the service was taken over by the municipality. By 1912, the number of consumers reached 1,250. Of these consumers, 100 used electricity as a source of industrial power and for lighting.

Cities (District capitals)	Date of introduction of gas street lighting	Date of introduction of electricity	Electric Lighting Companies
Aveiro	1889	1921	Empresa Electro-Oceânica
Beja		1926	Municipal Council
Braga		1893	Sociedade Electricidade do Norte de Portugal
Bragança		1907	??
Castelo Branco		1905	Companhia Eléctrica de Portugal
Coimbra	1856	1914	Municipal Council
Evora	1890	1908	Companhia Eborense de Electricidade (only private consumption)
Faro		1911	Companhia de Electricidade de Faro

43 For more details, see: MATOS (coord.) (2003).

Guarda		1899	Empresa de luz Eléctrica da Guarda
Leiria	1890	1910	Empresa Luz Eléctrica de Leiria
Lisbon	1848	1889 (a)	Gás Lisboa – (from 1891 CRGE)
Portalegre		1901	Emilio Bueno and Cruz Samanugo Perera (Badajoz, Spain)
Oporto	1855	1888 1908	Companhia Luz Eléctrica – Only for private consumption Sociedade Energia Eléctrica
Santarém	1887	1924	Municipal Council
Viana do Castelo	1887	1915	Empresa Hidroelectrica do Coura
Vila Real		1894	Empresa de Luz Eléctrica
Viseu		1907	Paradinas & C ^a

(a) Restricted to a small area of the city.

Sources: *Diários do Governo*; SIMÕES (1997); FERREIRA; FIGUEIRA (2001).

In those cities where no public lighting network by gas had been established by the last decade of the nineteenth century, the option would be electricity. In this case we can say that this delay in modernizing the lighting systems in these cities turned out to be an asset, because the fact that there were no pre-existing contracts preventing the Municipal Councils from choosing this solution paved the way for the introduction of electric lighting. On the contrary, cities that introduced gaslight at a later date found consumers to be less receptive, and the city's lighting was the target of criticism, often based on a comparison with cities already lit by electricity. At the end of the nineteenth century, some cities, such as Vila Real, Braga and Lisbon, had decided to adopt electric public lighting. In the early twentieth century, electricity was introduced in several towns on the initiative of industrial firms that started using power engines with the aim of maximizing profits by producing electricity for public lighting. This was the case of Elvas, Reguengos de Monsaraz, Estremoz, Penalva do Castelo and Famalicão, where the use of electricity for industrial purposes was later extended to lighting. By supplying electricity for public lighting, companies tried to make a profit on the investments they had already made to introduce electricity into their factories. A somewhat paradoxical situation emerged: small towns, sometimes located very far away

from larger cities and with low levels of per capita income, benefited from an early introduction of electricity.

In the early 1920s a new surge in electricity supply to several cities took place, with successive competitions opening up for the concession of electricity supply services, although many of these were not immediately implemented.

Number of municipalities with electricity

Years	Municipalities	% of municipalities
1918	41	14.9
1923	146	53.2
1933	214	78.8

Source: Apolinário (1918), Estatísticas das Instalações Eléctricas

The appearance of the first regional firms for the use of hydroelectric energy, such as the União Eléctrica Nacional (1919), which exploited a power plant situated in the Douro region, enabled several municipalities in that region to be supplied with electricity. When we look at the percentage of municipalities that already had electricity by 1923, we can verify that this constituted a significant jump, even though the First World War had a negative effect on the supply of coal to electrical power plants. The truth is that the increase in production and distribution of electricity that continued to grow even more during the following ten years was closely linked to the increase in hydroelectricity.

While the creation of gas and electricity networks were capital-intensive ventures, in the short term the investments made in the companies exploiting these services were extremely rewarding. Given the fact that those ventures were based on new technologies, which many times triggered fear in some populations, it was not possible to determine beforehand how the use of gas or electricity would be received by urban dwellers. Therefore, the pre-existence of the gas-lighting concession hindered the introduction of electricity, and in Portugal several of the smaller towns that were “late” in adopting gaslight ended up by profiting from this fact, since they had been the first to

introduce electricity.

Obtaining concessions for public illumination in Portuguese cities was essential for national or foreign entrepreneurs seeking to invest in the creation of a gas network. Only by obtaining the concession could they guarantee a fixed level of consumption, although at prices that were normally lower and therefore less rewarding than those that applied to private individuals.

Investment by foreign companies in Portugal from the 1880s onwards corresponded to a period of internationalization of the gas and electricity industries that were already doing business in several European cities. They found in Portugal a market to which to extend their business, which had proven to be extremely rewarding financially. While investing in Portugal, these corporations were able to benefit from both their technical and administrative knowledge in a business area that had its own characteristics; economies of scale, namely in contracts for the acquisition of coal, and technicians who had acquired specific training by working in their many factories. By investing in many different countries, these corporations contributed to creating technical norms and procedures, and thereby dissolved the frontiers of technological transfer.

When we analyse the companies that exploited, or expressed an interest in exploiting, urban gas and electricity networks, we notice that the same names crop up every time; an indication of the complexity of the relationship between them. This complex relationship extended beyond national borders. On the other hand, it is also noteworthy that several of these corporations' shareholders were also involved in other industrial branches. In the case of Oporto, we can see the relationship that existed between the Companhia do Gás do Porto, Oporto's Sociedade Energia Eléctrica and Lisbon's CRGE, a relationship that also involved the private interests of men such as Charles Georgi, who were shareholders in several corporations. It is also possible to detect interest by leading tradesmen and industrialists from other fields in participating in these industrial ventures, in which the money of the *brasileiros* seems to have played an important role, even though it is not possible to ascertain the amount.

4.- Conclusion.

Although the creation of networks of gas and electricity were capital-intensive ventures, in the short term the investments made in the companies exploiting these services were extremely rewarding. Given the fact that these businesses were based on new technologies, which many times prompted fear in local populations, it was not possible to determine beforehand how the use of gas or electricity would be received by city dwellers. Thus, the pre-existence of lighting concessions for gaslight hindered the introduction of electricity, and in Portugal several of the smaller cities that were “late” in installing gaslight ended up by benefiting from this fact and were among the first to introduce electric lighting.

Obtaining concessions for public lighting in Portuguese cities was essential for businessmen, either national or foreign, who sought to invest in the creation of gas networks. Only by these means could they guarantee a fixed level of consumption, although at normally lower and therefore less rewarding prices than those obtained from private consumers.

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It is likewise noticeable that the early interest in electricity was closely linked not only to its characteristics and to the spread of its several applications, but also to the fear people had of the effects that gas might have on the health and security of the urban population.