History Dispatch 1. The Business of Reliability
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Paper (Draft)

"If we want a continuous and reliable electric light, something that will not fail us on occasions; if we want a light that people can always have at command when they want it, like gas light, there's nothing like the steam engine." *-E.P. Roberts, "Description of a Large Secondary Battery Plant for General Commercial Distribution,"* 1885. [1]

From the start of the industry, power company managers and engineers treated reliability as a business concern, not a matter of public duty. As Cleveland engineer, E.P. Roberts adroitly expressed, a power company in competition with a gas-lighting company had to offer a continuous and reliable service to attract customers. But in 1885, competition was precisely the issue. Depending on the area, proponents of electric lighting networks could compete against networked gas companies for control over street-lighting franchises or against a wide variety of noncontinuous and modular stand-alone systems. Electric lighting and motive power were novelties, and in the United States public use of electricity varied widely by geography, population density, and local economies. With access to electricity limited and expensive at the outset, potential customers had other choices. For example, a homeowner might prefer candles, kerosene lamps, or gaslight over electric lighting.

In this context, power company engineers and executives described reliability as a tool to build the business, a consideration when weighing investment costs, and a requirement for certain classes of customers. Indeed, discussion of reliability in the professional literature often addressed whether the physical bits and pieces of power stations and distribution lines could be counted on to function, and what it would cost the company to fix them. Between 1880 and 1900, electrical experts debated investment in duplicate equipment, the benefits of storage batteries, and eventually the opportunity to link to another system for backup power as methods to minimize losses if equipment failed.[2] In other words, companies generating and delivering power did not yet face expectations of making usable electric service available to any customer at any scale and over any given time.

Unlike other types of products and services, electricity is usable and marketable only if it can meet instantaneous demand. Stored inventory and delayed delivery have simply not been

[1] E. P. Roberts, "Description of a Large Secondary Battery Plant for General Commercial Distribution," *Transactions of the American Institute of Electrical Engineers* II, no. 1 (1885), https://doi.org/10.1109/T-AIEE.1885.5570484.
[2] Richard H. Schallenberg, "The Anomalous Storage Battery: An American Lag in Early Electrical Engineering " *Technology and Culture* 22, no. 4 (October 1981). Thomas Edison reportedly opposed the use of storage batteries in central stations, following unsatisfactory experiences in the early 1880s. In the United States, particularly after 1895, electric companies began to use lead-acid batteries for a variety of purposes, from leveling the load to off-peak electrification to smoothing the electrical current for more steady lighting to energy storage for use during breakdowns. Though more often used on systems generating direct current electricity, some alternating current systems also used storage batteries.

options.[3] If the electricity stopped, the electric company had nothing to sell, and if the electric company wanted to succeed, it had to keep the lights on. As J.A. Powers, of Troy New York, explained, "The most disastrous calamity which can befall an electric lighting business, is the destruction of its central station."[4] In the same vein, the lighting offered had to match or beat the alternatives in quality, stability, safety, cost, and continuity. In this first History Dispatch, we will discover that *reliability*, understood to mean the dependability of equipment and the ability to provide uninterrupted electrical service to a limited number of customers, was primarily a business concern for participants in a newborn industry.

The Competition

"I had familiarized myself with the balance sheets of gas companies, and I knew I was up against stiff competition … The whole question was in my mind one of economy and reliability, for I knew the system would operate satisfactorily." – Thomas Edison, Interview in *Electrical World*, 1922."[5]

Early electrification focused on light. To develop his concept of central generation, lighting homes and businesses with incandescent bulbs, inventor and entrepreneur Thomas Edison competed primarily with two forms of networked lighting: electric arc-light and lamps with manufactured gas. Both had drawbacks. The brightness and harshness of the electric arc lamp severely limited its usefulness as indoor lighting. After seeing the much-celebrated electric arc lamp at the Paris Opera House, author Robert Louis Stevenson offered this description: "A new sort of urban star now shines out nightly, horrible, unearthly obnoxious to the human eye; a lamp for a nightmare! Such a light as this should shine forth only on murders and public crime, or, the corridors of lunatic asylums, a horror to heighten horror. To look at it only once is to fall in love with gas …"[6] In addition, Edison, himself, did not think much of gas lighting. "(i)t was a nasty, yellow light, too, and far removed from the color of natural light" with the "nauseous, dim flicker of gas, often subdued and debilitated by grim and uncleanly globes."[7] Poet and author Edgar Allen Poe echoed Edison's perspective "Gas is totally inadmissible within doors. It's harsh, unsteady light offends. No one having both brains and eyes will use it."[8]

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[3] This is changing in the twenty-first century. With the evolution of battery technology, storage and delayed delivery are becoming options. Storage battery capacity in the United States increased from 43 MW in 2003 to 8,827 MW in 2023. U.S. Energy and Information Agency, "Battery Storage in the United States: An Update on Market Trends," release date: July 24, 2023, accessed November 17, 2023.

[4] J. A. Powers, "Central Station Construction," *Transactions of the American Institute of Electrical Engineers* IV, no. 1 (1886), https://doi.org/10.1109/T-AIEE.1886.5570426.

[5] L. W. W. Morrow, "An Interview with The Father of the Central-Station Industry," *Electrical World* 80, no. 11 (September 9 1922): 529.

[6] Stevenson, Robert Louis, "Virginibus Puertisque" cited in King, Thomas "Consolidated of Baltimore 1816-1950: A history of Consolidated Gas Electric Light and Power Company of Baltimore, published by the Company, Baltimore, December 1950. Pg. 95

[7] Baldwin, Neil Edison: Inventing the Century, pg. 137.Hyperion Press, 1995.

[8] Poe, Edgar Allen "Philosophy of Furniture" cited in cited in King, Thomas "Consolidated of Baltimore 1816-1950: A history of Consolidated Gas Electric Light and Power Company of Baltimore, published by the Company, Baltimore, December 1950. Pg. 95

Entrepreneurs and inventors had been competing to provide new and improved forms of light to Americans throughout most of the nineteenth century. By the time Thomas Edison introduced his central station system in 1882, not only did manufactured gas companies operate networked gas lighting systems and the Charles Brush company provide centrally linked arc lighting systems, but for outdoor settings, companies such as Penn Globe sold and serviced free-standing gas lights, and a few lamplighters kept stand-alone whale oil lamps aflame.[9] In other words, new competitors like Edison faced a wide array of lighting systems. Thus, to build a viable business, Edison had to prove to investors, consumers, and municipalities that his system was better than the others. Edison's reflections above, after 40 years of electrification, underscored the need for both economy and reliability to compete successfully, especially with manufactured gas companies. As his biographers have noted, his specific objective in developing central station electric light service was to imitate in every way the efficacy of networked, manufactured gas lighting.[10]

Networked gas lighting company executives touted safe, clean, bright, and continuous lighting as their selling points, and in 1881 some deemed electric light "unreliable."[11] When electric lights on Broadway in New York City went out, C. Warren Dresser, editor of The American Gas Lighting Journal, noted that gas lights in shop windows kept the sidewalks illuminated.[12] He explained, "the gas, which has a peculiarity of always being ready and good-natured enough to help the electric light out of its difficulties and mishaps, was on hand ready for work, and maintained its reputation for reliability and cheerfulness." Manufactured gas lighting had one advantage, it was reliable and controllable. It was delivered through a system of pipes to a home or business that was able to turn it on and off at will.

To counter this, Edison echoed several of gas's advantages in his own marketing materials and publications, stating his electric lighting system offered convenience, reliability, and ease of control.[13] His company's marketing materials delineated these qualities, for a universal system:

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[9] Joel A. Tarr, "Illuminating the streets, alleys, parks and suburbs of the American City: non-networked technologies, 1870-1920," *History and Technology (online)* (May 22 2020), https://doi.org/https://doi.org/10.1080/07341512.2020.1739816.; "Charles F. Brush," Engineering and Technology History Wiki, https://ethw.org/Charles_F._Brush. last edited February 19, 2020, accessed November 17, 2023.

[10] Baldwin, Neil Edison: Inventing the Century, pg. 137.Hyperion Press, 1995. Edison, Thomas, "Notebook, Volume 184," cited in Silverberg, Robert, *Light for the World: Edison and the Power Industry*, D Van Nostrand, New York. 88. Edison quoted in Jones, F.A., "Thomas Alva Edison: Sixty Years of An Inventors Life." Hodder and Stroughton, London 1907. Pp 119-120).

[11] A.H. Renton, "The Oxyhydrogen Lime-Light," *The American Gas-LIght Journal* 1, no. 9 (March 1 1860): 182, https://archive.org/details/sim_pipeline-gas-journal_1860-03-01_1_9/page/182/mode/1up?q=continuous+light&view=theater.

[12] "Partial Darkness in New York," *The American Gas-Light Journal* 34, no. 12 (June 16 1881), https://ia802303.us.archive.org/4/items/sim_pipeline-gas-journal_1881-06-16_34_12/sim_pipeline-gas-journal_1881-06-16_34_12.pdf.

[13] *A Warning from the Edison Electric Light Company*, (New York: 1887).

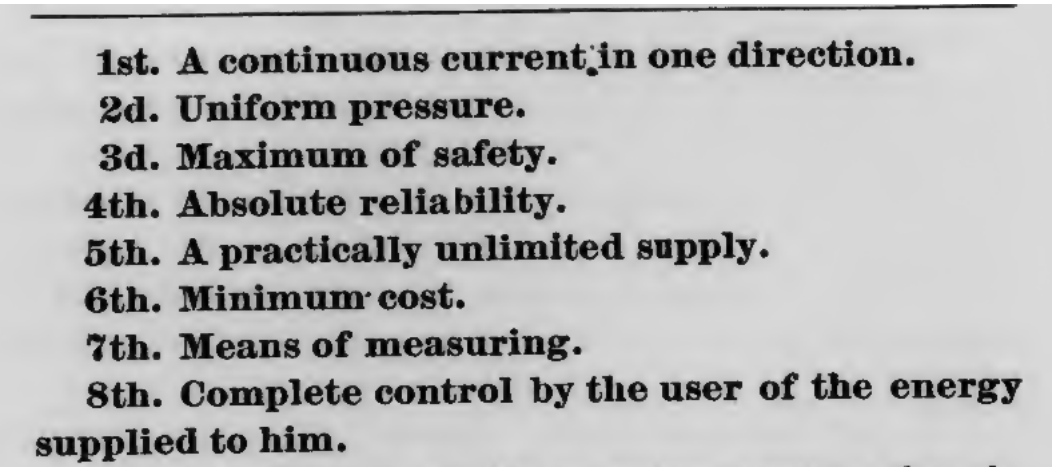
1st. A continuous current in one direction.
2d. Uniform pressure.
3d. Maximum of safety.
4th. Absolute reliability.
5th. A practically unlimited supply.
6th. Minimum cost.
7th. Means of measuring.
8th. Complete control by the user of the energy supplied to him.

Figure 1. Source: A Warning from the Edison Electric Light Company, 1887, cover and p. 18

As other entrepreneurs developed franchises, sold equipment, and operated electrical stations, they shared Edison's concerns. In 1888, Boston engineering consultant W. Lee Church reminded his colleagues at the seventh meeting of the National Electric Light Association that "The electric light company contracts to supply the demands of a diverse and exacting public, and that public expects to find its light on tap at every moment in the year."[14] He continued with a lengthy discussion of the importance of investment in multiple dynamos at a central station, lest equipment break – as it had recently at a large station, "shutting down six thousand lights," causing related damage, and endangering employees.[15] He compared electric lighting service to editing a daily newspaper, "in that time lost can never be regained."[16] Church went on to describe the other essential elements of a successful plant – fuel economy, flexibility of equipment, maintenance, first cost, record-keeping, and so forth. Church's presentation illustrated several key points about reliability in the late nineteenth century: it was essential to gaining and retaining business; it depended on functional equipment – much of which was relatively new in both design and manufacture; and it mattered to those who could afford the service, which for this "large" station was still a relatively small number of customers. He also, notably, forecast a definition of reliability as it is understood today – "light on tap at every moment of the year."[17]

Building Business

For the business of new central station lighting systems in the late 1800s, growth happened fast, but it was a tough business, and financial success was not assured. The number of central stations documented by the U.S. Census Bureau grew from eight in 1881 to 3,620 in early 1902, as shown in figure 2 below.[18] At the same time, industrial manufacturers began to switch from

[14] "Seventh Meeting of the National Electric Light Association," *Electrical World* 11, no. 9 (March 3 1888): 108.
[15] Prior to effective metering, electric companies sold power based on the number of lamps in use.
[16] "Seventh Meeting of the National Electric Light Association," 108.
[17] "Seventh Meeting of the National Electric Light Association," 108.
[18] *Central electric light and power stations, 1902*, (Washington: Government Printing Office, 1905), 7.

steam engines, gas engines, and waterwheels to electric energy for power. In 1890, almost 2 percent of the 355,415 establishments reporting used electricity, and in 1900, well over 5 percent used electricity.[19] These establishments tended to use in-house generating facilities. But many electric companies failed, and even by 1900, most Americans did not use electricity in their daily lives. Business historians William J. Hausman and John L. Neufeld explain, "The raw numbers representing the diffusion of the invention conceal the fact that 20 years after Pearl Street [*referring to Edison's first station in New York City*] the industry remained small-scale, limited in scope, highly competitive, politically challenged, and with very uncertain prospects for the future."[20]

TABLE 2.—*Number of central electric stations beginning operations during each year.*

YEAR.	Total.	Private stations.	Municipal stations.
Total	**3,620**	**2,805**	**815**
1902 (January 1 to June 1)	**146**	**106**	**40**
1901	**250**	**185**	**65**
1900	**213**	**152**	**61**
1899	**237**	**178**	**59**
1898	**277**	**195**	**82**
1897	**228**	**170**	**58**
1896	**193**	**129**	**64**
1895	**239**	**166**	**73**
1894	**191**	**144**	**47**
1893	**192**	**161**	**31**
1892	**247**	**190**	**57**
1891	**198**	**157**	**41**
1890	**227**	**198**	**29**
1889	**208**	**168**	**40**
1888	**160**	**142**	**18**
1887	**147**	**127**	**20**
1886	**100**	**86**	**14**
1885	**55**	**49**	**6**
1884	**47**	**43**	**4**
1883	**27**	**25**	**2**
1882	**30**	**27**	**3**
1881	**8**	**7**	**1**

Figure 2. New central electric stations reported in Central Electric Light and Power Stations, 1902, p. 7.

[19] Twelfth Census of the United States Taken in the Year 1900: Manufactures, Part I, United States by Industries, William R. Merriam, Director, (Washington, DC: Government Printing Office, 1902). https://usa.ipums.org/usa/resources/voliii/pubdocs/1900/Vol7/05457254v7ch04.pdf p. cccxvi.

[20] William J. Hausman and John L. Neufeld, "The structure and profitablity of the US Electric Utility Industry at the Turn of the Century," *Business History* 32, no. 2 (1990): 225, https://doi.org/http://www.tandfonline.com/action/showCitFormats?doi=10.1080/00076799000000047.

Electric lighting companies faced stiff competition, as exemplified by all types of street lighting enterprises.[22] In 1890 a total of 323 cities with an aggregate population of almost 17 million possessed more than 300,000 streetlights. Of these, nearly two thirds were manufactured gas streetlights; only 19 percent were electric and of those the vast majority (four fifths) were arc light systems, not Edison-style incandescent light systems.[23] By 1900, the numbers had shifted significantly. For example, 59,130 arc lamps were in use, while the total number of incandescent lamps was 3,315,445 (these are not distinguished by location or purpose).[24]

The intensity of competition for street lighting franchises, and later wiring franchises, increased with each decade. Overhead telephone, telegraph and electrical wires lined the streets while companies dug trenches for underground wiring, often along the same routes, and frequently without adequate conduit protection to prevent damage to lighting equipment.[25] Maintaining operable equipment while defeating the offerings of other companies, or avoiding interference from parallel, yet unrelated services became additional sources of challenge to reliable electrification.

(Image something like this):

[22] Joel A. Tarr, "Lighting the Streets, Alleys, and Parks of the Smoky City, 1816–1930," *Pennsylvania History: A Journal of Mid-Atlantic Studies* 86, no. 3 (Summer 2019), muse.jhu.edu/article/729367.
[23] Tarr, "Illuminating the streets, alleys, parks and suburbs of the American City: non-networked technologies, 1870-1920," 3, 16 fn. 17.
[24] Abstract of the twelfth census of the United States 1900, 408 (Washington, DC: Government Printing Office, 1904).
[25] "Seventh Meeting of the National Electric Light Association," 115-16; "Eigth Meeting of the National Electric Light Association," *Electrical World* 12, no. 10 (September 8 1888): 121-22.

Main Street of Houston, 1884

Figure 3. Example of competing lines on a city street. {get high-definition image/permission from Lisa Struthers, San Jacinto Museum – info in JAC email)

While a power company might obtain a franchise agreement in a city, the franchise did not serve as insurance against a hostile race with another company to provide electrical service. Starting, operating, and – in the case of the investor-owned companies – profiting from electrical service depended on many factors, including reliability.

Central station operators had to prove to customers that electric service would be superior in every way to centralized gas service, and to in-house power generation of any type. In 1892, Westinghouse engineer Charles P. Scott explained that a transmission line in Telluride, Colorado, during its first 10 months of operation, ran continuously 6-7 days per week, with occasional interruptions resulting in actual lost time of less than 48 hours, or about nine minutes per day.[26] Scott couched this as the "stamp of commercial success."[27] As another engineer explained in 1895 "we all of us know how it is of the utmost importance that the service from an electric central station shall be perfectly reliable, and that the light shall be perfectly uniform."[28] Louis

[26] Charles P. Scott worked for Westinghouse Electric and Manufacturing Company, where he collaborated with Nikola Tesla, later taught at Yale University, and served as president of the American Institute for Electrical Engineers at the turn of the century (1902-3).

[27] C. F. Scott, "Long Distance Transmission for Lighting and Power," *Transactions of the American Institute of Electrical Engineers* IX, no. 1 (1892): 438, https://doi.org/10.1109/T-AIEE.1892.5570456.

[28] C. L. Edgar, "Practical Experience with Storage Batteries in Central Stations," *Transactions of the American Institute of Electrical Engineers* XII (1895), https://doi.org/10.1109/T-AIEE.1895.4763896; E. P. Roberts, "Storage

Duncan, president of the American Institute of Electrical Engineers (AIEE), told his colleagues in 1896 that while both economy and safety imposed limits, consideration of *reliability* [emphasis added] had not been sufficiently stressed. He described this as a commercial question affecting the growth of the industry.[29]

The first power stations represented true experiments in real time. The equipment was newfangled, the operators had little experience, the investors were nervous, and the customers really didn't know what to expect. In 1897, Samuel Insull, president at the time of Chicago Edison, celebrated a recently established lamp testing bureau that would result in lamps made to specification, hence improved service, hence savings for central station companies.[30] "It should be borne in mind," he said," that faulty apparatus, from one cause or another resulting in a stoppage of the service of one or more customers, is, in the mind of the user of electricity, set down to the *unreliability* of the system as a whole [*emphasis added*]."[31] This concern encompassed equipment from the power company's generators to the fuses, wiring, and lamp fixtures at the customer end of the line.

From the Customer Perspective

Who was the customer in the late nineteenth century and what kind of service did this customer expect? From the power company's perspective, customers came in many varieties, and were relatively limited geographically and socioeconomically. A central station customer might be a well-to-do homeowner, a department store, an office building, an industrial manufacturer, a streetcar company, a California farmer, or an entire city. And each different type of customer posed a different set of reliability demands. Provision of continuous electrical service over a 24-hour period was relatively rare. As the US Census Bureau reported in 1902, "In many of the stations the apparatus is in full operation during only a small part of the day, on average, and a great deal of it stands idle for some hours." Samuel Insull explained to his colleagues that many customers in Chicago used electricity for a mere 100 hours per year, hence there was no need to worry about making power available continuously to those customers.[32] By contrast, in another part of the country with different types of customers, a

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Batteries in Practice," *Transactions of the American Institute of Electrical Engineers* IV, no. 1 (1886), https://doi.org/10.1109/T-AIEE.1886.5570421.

[29] L. Duncan, "Present Status of the Transmission and Distribution of Electrical Energy," *Transactions of the American Institute of Electrical Engineers* XIII (1896): 309, https://doi.org/10.1109/T-AIEE.1896.4763936.

[30] Samuel Insull and William Eugene Keily, *Central-station electric service; its commercial development and economic significance as set forth in the public addresses (1897-1914) of Samuel Insull* (Chicago,: Priv. Print., 1915), 5. Samuel Edison built Chicago Edison into one of the world's largest utility holding companies, Midwest Utilities, and often served as spokesperson and leader for the electric utility industry. For more about Insull: Forrest McDonald, *Insull* (Chicago: University of Chicago Press, 1962); Harold L. Platt, *The electric city: energy and the growth of the Chicago area, 1880-1930* (Chicago: University of Chicago Press, 1991).

[31] Insull and Keily, *Central-station electric service; its commercial development and economic significance as set forth in the public addresses (1897-1914) of Samuel Insull*, 38.

[32] Insull and Keily, *Central-station electric service; its commercial development and economic significance as set forth in the public addresses (1897-1914) of Samuel Insull*, 28.

one-day breakdown would mean "an enormous pecuniary loss to the community."[33] In other words, company managers and system engineers well understood that the electrical business was like no other. Electric companies could not effectively store electricity and create the types of inventories used in other industries, and the correct amount of electricity had to be available at the instant. When there was no demand, there was no business, and if there was no power to sell at the moment of demand, there was no business.

For customers, the experience of a new lighting regime was both exciting and daunting, as the realities of its costs and the challenges of its delivery quickly became evident. Many early observers remarked how the electric lights had yet to provide the kind of service that gas lighting could offer, commensurate with the prices being asked. An 1883 Lancaster, Pennsylvania newspaper editorial reflects these sentiments, stating that the city's councils "would not accept the electric light as long as the lamps were unreliable in their illumination," and calling them "spasmodic and irregular." [34] They warned electric companies that for their products to "be a success," the light must be "reliable," "steady," and "constant." Though they acknowledged that other cities had different lighting systems with varying levels of satisfaction, they concluded that "no city dependent on electric lighting is safe from sudden darkness."[35]

At the same time, customers observed that electric companies did not always meet the expectations and standards they advertised.[36] As quoted in the New York Times in 1887, Henry Morton, a respected scientist and the first president of the Stevens Institute of Technology, stated "It has been customary ever since the first introduction of electric lighting for electric companies to call their ordinary street lights '2,000 candle power lights,' though they have not possessed any such actual efficiency."[37] This reality worried electric industry insiders as well. Roderick Williams wrote in the Electrical World in 1893 that he believed customers would continue renewing their gas contracts because gas companies, at the least, delivered what they promised.[38] Williams asked, "What chance has the seller of current against the seller of gas when the latter can show that he will furnish a good 24-candle light under all circumstances, and can generally find a good instance nearby of the poor light from incandescent lamps which have been allowed to burn beyond their proper term of usefulness…[?]"[39]

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[33] Duncan, "Present Status of the Transmission and Distribution of Electrical Energy," 309. With this 1986 comment, forecast metrics that might define reliability for a much later generation of power system experts.
[34] "The Electric Lights" In the Lancaster daily intelligencer. Lancaster, PA. (December 14, 1883): 2. Chronicling America: Historic American Newspapers. Lib. of Congress. https://chroniclingamerica.loc.gov/lccn/sn83032300/1883-12-14/ed-1/seq-2/
[35] Ibid.
[36] V. Jacome, ""Killing Complaints with Courtesy": The Role of Relationship Building in the Success of Central Power Stations (1890-1938)," Forthcoming.
[37] "Power of Electric Light" in the New York Times. New York, NY. (February 11, 1887): 3. New York Times Time Machine. https://nyti.ms/3QkXV0Y
[38] See, W. Roderick, "Economy of Incandescent Lamps." *Electrical World* 22, no. 26 (December 23, 1893): 474.
[39] Ibid.

For their part, gas advocates openly positioned themselves against "the unreliability of electric light."[40] These competitive statements echoed the sentiments of customers during these early years of service delivery when electric lighting failed to live up to expectations. As the *Evening Capital* remarked on August 15, 1892, when the Annapolis, MD, fish market was "left in total darkness," again, "that those who use [electric lights], are thinking very serious [*sic*]of going back to gas or oil lamps.[41] Customers themselves recognized the challenges of electric lighting and its competition with other lighting sources. For these potential electricity users, quality and reliability of service were of paramount importance.

Conclusion

"An electric motor run from an Edison station is the most convenient, most reliable, and most easily controlled source of power imaginable. Always ready, it can be started or stopped by turning a switch; it is only necessary to oil two bearings and all is ready, and on turning the switch there is at once a steady power, doing its work quietly, cleanly and well, and requiring little if any attention." – A Warning from the Edison Electric Light Company, p. 74[42]

Edison and his competitors sought to persuade customers that they wanted and needed a convenient, reliable, and easily operable source of light and power. In the earliest years, reliability was a keystone of building a market, for without it, the companies had nothing to offer. In the years before large-scale networked operations, before government regulation, and before a widespread and demanding customer base, central station managers weighed the cost of their equipment against the likelihood that different types of customers would use and depend on their product. The role of electrification in the late nineteenth century economy was sufficiently modest and it did not yet embrace a duty to serve the public. But in just a few short years, electricity would become essential to urban economies, defense manufacturing, and commercial success. Electricity transitioned from a luxury to a necessity, power companies acquiesced to state regulation for a variety of economic and political reasons, and power system experts began to balance their obligations to investors and stockholders against new expectations for reliability. Watch for History Dispatch 2.

[40] "Some Revelation on Heating and Lighting" in The Anaconda standard. [volume] (Anaconda, Mont.), 26 June 1898. Chronicling America: Historic American Newspapers. Lib. of Congress. <https://chroniclingamerica.loc.gov/lccn/sn84036012/1898-06-26/ed-1/seq-18/>

[41] "Left in Darkness" in Evening capital. (Annapolis, Md.), 15 Aug. 1892. Chronicling America: Historic American Newspapers. Lib. of Congress. <https://chroniclingamerica.loc.gov/lccn/sn88065721/1892-08-15/ed-1/seq-3/>

[42] *A Warning from the Edison Electric Light Company*, 74.

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