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The Laws of the Markets

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The making of an industry: electricity in the United States

Mark Granovetter and Patrick McGuire

1 Introduction: economic sociology and the sociology of industry

Although economic sociology has enjoyed a strong resurgence in recent years, it has focused on relatively low or high levels of aggregation. One central concern has been what determines the actions of individuals and firms, and another the role of government and large-scale interest groups in the governance and evolution of the economy. With some notable exceptions (eg, Hirsch, 1972; Campbell, Lindberg and Hollingsworth, 1992; Dobbin, 1994; Roy, 1997), few have paid close attention to middle levels of aggregation such as industries. Problems of industrial organization have largely been left to economists, who treat industry boundaries as resulting unproblematically from the nature of the product, the state of technology at a given time (as summed up by production functions), consumer demand, and the attempt to reduce production and transaction costs.

Sociologists have reacted to some general arguments on the subject of organizational form, especially those of Chandler (1962, 1975, 1990) and Williamson (1975, 1985), and to some of the other standard assumptions. But these critiques, whatever their merits, have been largely defensive; they have followed and responded to economic arguments rather than setting the agenda with a distinctively sociological position about industry and organizational form. A substantial sociology of industry must be a persuasive alternative based on serious research about particular industries and their evolution, rooted in a coherent view of how people and organizations form and co-operate in such a way as to produce those goods and services that consumers demand.

We do not dispute the convenience of defining industries as sets of firms that produce the same or related products. But we argue that such classifications are deceptively simple and not obvious at the outset; instead it is up for grabs, early on, exactly which products will fall inside and outside an industry's boundaries, and even what will be defined as a product. To understand the outcome, one must analyse socio-economic and institutional links among self-designated competitors, since an industry only becomes a social reality when firms are similarly structured, occupational categories are standardized and extra-organizational structures are created to manage competition and articulate common goals (cf. White, 1981). Thus, which firms are considered to be involved in 'related activities' is a social construction that evolves in ways that cannot be understood only in technical terms, but requires also attention to social processes and interactions among firms.

We stress the role of human agency and social structure in determining which firms become associated into an industry and in defining the scope and structure of the resulting collectivity. Standard economic discussions of industrial organization neglect human agency since they assume that industrial structure is an inevitable and efficient consequence of existing technology and market conditions. At the opposite extreme from this functionalism, in which the activity of individuals is irrelevant because outcomes automatically meet the needs of the economic system, is the argument that certain industries take the form they do on account of the activity of a few 'great' men or women. Such a position is taken by some philosophers and historians (eg, Hook, 1943; McDonald, 1962). We argue that human agency is vastly underestimated in the former argument but overestimated in the latter and that individual and collective action, while critical, operate only within sharply defined historical and structural constraints.

A sociology of industry ought to account for the social structure of an industry, in which we include: 1) the internal structure of organizations comprising the industry; 2) the structuring of relations between firms and their upstream and downstream trading partners, where 'upstream' means not only suppliers of equipment and raw materials, but also of inputs such as labour and capital—eg, unions, professional groups, agencies creating accreditation standards, and financial institutions; 3) relations among industry firms (including formal and informal relations, cross-stockholding and interlocking directorates, trade associations and vertical relations such as those expressed in holding companies); 4) relations between the industry firms and outside institutions or groups that play crucial auxiliary roles—such as political parties, voluntary associations

(eg, the National Civic Federation) and, in the case of electricity, the crucial role of the electrical engineering profession; 5) relations between the industry and government at all levels.

The present chapter is part of a larger project on the history of electricity as an industry in the United States, which will attempt to cover all these bases from the beginning of the industry in about 1880 to its stable form, around 1925.

We believe that the way the electricity industry developed was only one of several possible outcomes and not necessarily the most technically or economically efficient. Its particular form arose because a set of powerful actors accessed certain techniques and applied them in a highly visible and profitable way. Those techniques resulted from the shared personal understandings, social connections, organizational conditions and historical opportunities available to these actors. The instruments of this success, in turn, used their personal and organizational resources to trigger pressures for uniformity across regions, even when this excluded viable alternative technologies and organizational forms. By the 1920s, the diversity of organizational and technological forms was much lower than one might expect, given the highly heterogeneous environments in which electricity was produced. We believe that this suppression of diversity hampered the adaptability of the industry in ways that became clear only in the late 20th century.

We attempt to identify the forces that moved the industry in certain directions, and the advantages that those directions achieved simply by being in place; these advantages then helped perpetuate forms that might not have been abstractly optimal, while excluding possibilities that had previously seemed entirely plausible. These new forms then themselves modified the environment in ways compatible with their needs. Later observers, who look only at a snapshot of technology and organization, may note the fit between industry and environment and conclude that the industry has arisen in its present form *in order* to meet environmental needs. Only a dynamic, historical account can break through the functionalist misconceptions resulting from confining analysis to comparative statics. Our argument resembles that made by economists Paul David and Brian Arthur on the 'lock-in' of inefficient technologies (such as the QWERTY keyboard on which this paper is typed—more slowly than it would be on one of better and well-known design), but draws on the sociology of knowledge and of social structure, leading to a generalization from the case of technology to that of institutional and organizational form.

One implication of our approach is that at several historical junctures, quite different outcomes might have emerged and had this occurred it would likely have been argued, as it has for actual outcomes, that *those* were the most economically or technically efficient. Our goal is systematically to analyse the particular conditions within each historical setting and consider the options and factors influencing path selection at each point of decision-making. This method allows us to differentiate between selected and avoided opportunities, between intentional and unintentional outcomes, to provide a more nuanced and realistic depiction of how economic institutions are formed. It removes the need to infer the intentions of firm leaders from known outcomes, or to rely on teleological categories such as technical and economic efficiency to explain all outcomes.

2 Electricity: the initial boundaries of an industry

In 1880 Thomas Edison had only begun to develop the incandescent electric light, and most homes and factories were lit by natural gas. On-site electric lighting systems had been sold and installed as early as 1878 and by 1885 were a booming business involving over 1,500 arc and incandescent systems, operating in homes and factories (American Electrical Directory, 1886). Alongside these 'isolated plants' (as these systems were known), a fledgling industry of privately-owned central electric stations blossomed from less than two dozen firms in 1882 to almost 500 in 1885 and almost 2,000 independent local firms by 1891, using different technologies and organizational structures.[1] These firms were hobbled by local governments and large equipment manufacturers, and wracked by destructive competition. Yet by 1929, isolated generation was receding in importance, and the industry was dominated by a few large holding companies overseeing central station firms using standardized methods of production, sales, and marketing, common organizational structures, and protected by government agencies that regulated them, guaranteeing profits under the concept that electricity provision was a 'natural monopoly' (Bonbright and Means, 1969; Rudolph and Ridley, 1986; FTC, 1935; McGuire, 1986: 526–529; American Electrical Directory, 1892).

We have reviewed the histories of 80 central station firms and the careers of over 200 one-time employees of Thomas Edison, analysed the participation of 1,500 executives in for-profit firms in industry trade associations, and studied several hundred other secondary and archival sources. We find that the boundaries, composition, and dynamics of the U.S. electric utility industry were constructed by identifiable social networks. We will use the content of several industry contests to demonstrate how and why these networks acted to construct and shape industry development and boundaries in particular ways, and not in others of apparently equal viability.

Central station electric systems were a major commitment for Thomas Edison, who mobilized his personal financial and patent-based resources and those of his subordinate co-workers and their families to create and manage the Edison (later General Electric) electrical equipment manufacturing firms (McGuire, Granovetter, and Schwartz, 1993). He strongly argued that electricity should be the primary commodity, and that electric equipment should be built for and sold to central stations, rather than to each building owner who would generate his own electricity (in a process similar to systems producing heat for a single building).[2] Edison also mobilized long-standing associates to sell and/or invest in several central station firms. They secured funding for several additional central station firms by exploiting antagonisms and fears among financiers. And by exchanging equipment for securities of local firms, Edison created shared ownership between the patent-owners, equipment manufacturing firms, and central station firms.

Edison was establishing the initial boundaries among electric industries. Again drawing upon the collective resources of himself and associates and their families, and upon a production monopoly secured by exclusive contracts, they separated electric light current business from the manufacture of electric devices, electric trolleys, electro-plating, telephone, etc. each of which preceded the incandescent lighting system and involved millions in invested capital and sales by 1881 (Bright, 1972:33). Edison also worked to retain the separation between incandescent lighting (mostly indoor) systems such as his own, and the well-established arc lighting (mostly street and public spaces) systems, keeping them separate industries and markets.

Through 1884 Edison also argued the need to differentiate between firms selling electric current for lighting and those supplying it for motors (Conot, 1979:207), given his own lack of personal investment in devices run by electric power, and his strained personal relations with innovators of such applications (Conot, 1979:Ch. 18).[3] But for a series of reasons, he was unsuccessful at and soon drew back from insisting on this separation. First, some of his friends and investors in his manufacturing and central station firms came to own crucial patents related to power, tailored the equipment derived from these patents so as to operate on his central station system, and signed exclusive production contracts with the Edison manufacturing firms (Passer, 1962, 1953:238–239, McGuire, 1990, McGuire, Granovetter, and Schwartz, 1993). As a result, many local utilities began to simultaneously serve both arc and incandescent lighting systems as well as power customers. Given the different but compatible applications of these technologies, and the technical possibility of serving all customers from common equipment, it became difficult for Edison to argue that separation was efficient.

Moreover, Edison was preoccupied with struggles against his own financiers for the control of his firms and patents, and was distracted from this issue. Thus, in this period, friendships, family connections, personal fears, mobilized collective knowledge and resources, scarcity of capital as well as vested interests and technical possibilities, all shaped the inclusion of various proto-industries within what became the electric utility industry.

While Edison had created the basis for central station firms, it was not inevitable that they would survive or become the dominant form of electric service. Isolated systems (in individual homes and factories) were viable and would be the most common supplier of electricity to consumers through 1915 in most cities (cf. Platt, 1991:209). While economic arguments were mounted on behalf of each type of service, it appears that isolated systems in a factory or apartment building were at least as viable as other decentralized amenities, including home furnaces, water wells, and personal automobiles, each of which became a norm (Gilchrist, 1940:I, 21–32; Adams, 1900). Isolated systems had significant first mover advantages: thousands had been sold before Edison ever opened his first central station—(Brush, 1882, Stout, 1909) and they had the support of major financial houses, such as that of J.P. Morgan. We even found examples of co-ordinated distribution systems involving many isolated stations (Marvin, 1988:170).[4]

Two other industry boundaries—the selection of the preferred form of current, and the standardization of current frequency at 25 and 60 cycles (for power and light, respectively)—also resulted from personal insights, compound historical accidents, longstanding friendships, and corporate interlocks (McGuire, 1990). AC and DC current each had advantages and disadvantages (Passer 1953:

164–166) but neither was intrinsically preferable or dominant. AC became the principal U.S. current form because both General Electric and Westinghouse, the two major manufacturers, had AC equipment and their leaders had no personal stake in promoting an exclusively DC system, and because J.P. Morgan had a lingering antagonism toward Edison who held and could have reaped a handsome profit from continued use of crucial DC patents (David, 1987).

There was no overwhelming technical or economic imperative driving the selection of AC or of 25 and 60 cycles as the industry norm. The 'rotary converter' that transformed AC into DC current also worked in reverse. Systems in which current was generated and transmitted in AC and then converted to DC for distribution were feasible, and indeed were typical in Europe through most of the 20th century and in most U.S. central city areas through the 1920s. Motors and appliances for each current type were manufactured and sold here, and so each current type could have had its own niche. Further, the initial selection of two frequencies of current as a norm (rather than one as occurred in Germany and in parts of Britain and of California—Hughes 1983:129) embedded a technical and economic inefficiency that lingered generally through 1950 when most of the remaining 25 cycle engines were rewired at utility expense (McAfee, 1947:19, Bush, 1973:501).[5] Social factors including involvement of decision-makers in multiple firms (corporate interlocks), personal friendships and animosities guided these decisions and helped to lock in these technical and economic inefficiencies.

3 The stabilization of boundaries and practices in private central station firms

Through 1890 the definition of the electricity industry included both the equipment manufacturing firms and all the local operating utilities. In 1885 the owners of non-Edison electric current sales firms met and formed a trade association, the National Electric Light Association (NELA). The NELA included firms making, selling, operating, and repairing (especially arc) light and power systems. By 1888, it was dominated by the leaders of the Electric Club, a New York organization with a national roster (Nye, 1990:173, NELA, 1888) that constituted a primarily non-Edison social network. In response, Samuel Insull, secretary to Thomas Edison and an executive who helped Edison sell and open central station firms, formed the Association of Edison Illuminating

Companies (AEIC) in 1885. Early AEIC members were mostly personal friends of Edison and/or Insull who were also executives of small Edison central station incandescent lighting systems.

Beginning in about 1890 both trade associations began to redefine the boundaries of the electricity industry by denouncing city-owned electric firms, even though such firms used the same equipment, sold the same commodity, and operated in a similar way (NELA, 1890:164–179, 1898, 1900: 1:412, Rudolph and Ridley, 1896:23–34, and Toledo Edison 2:83 2/14/1897). The associations tried to exclude them from their organizational meetings, proposed boycotts of manufacturers who supplied them, and mobilized to oppose and impede their creation. They also sought and secured state legislation that limited not-for-profit systems to street lights in some cities, such as Detroit (Wilcox, 1908). This new industry boundary was being built based on form of ownership, contrary to the logic of the Bureau of the Census and its SIC codes which officially define industries (McGuire, 1986).

A second boundary was being constructed simultaneously during the early 1890s as local utilities sought to separate themselves from the electric equipment manufacturing firms. NELA members included firms selling and operating all types of electric devices involving several proto-industries, such as electric arc light and electro-plating, telephone, electrical medicine, and electric motor devices. In fact the first major electric light company in Chicago—Chicago Arc Light—emerged from a combination of electric medicine and central station service (Platt, 1991:268). Many of these industries were in place and had millions of dollars in investments and/or sales before Edison even invented the incandescent light bulb (Bright, 1972:33). The NELA's concept of electric light service (and by extension the composition of the industry) involved vertically integrated firm components, including manufacturers, operating utilities, contractors, and repairmen, similar to Bell Telephone.[6]

AEIC membership was limited to people from the Edison-affiliated central station electric lighting firms and their associated Edison manufacturing firms (first Edison Manufacturing, then Edison General Electric). Through 1893 the AEIC promoted a limited notion of industry involving a two-level vertically integrated industry of equipment manufacturers (GE) and Edison incandescent central station firms. The central stations had exclusive contracts with the manufacturing firms, and depended on them for financing, supplies, and innovations, factors that in effect left them as subordinate cheerleaders in the AEIC. This changed when, in

1892, J.P. Morgan and his allies wrested full control of Edison General Electric from Edison and his supporters, in a leveraged buyout through competitor Thomson-Houston; the resulting firm was renamed General Electric. Beginning in 1893, the owners of early but small Edison central station firms became less prominent in the AEIC, and the organization was increasingly dominated by a small group of former Edison employees. Samuel Insull left General Electric after the buyout to become a utility executive in Chicago; he and other urban executives mobilized to counterpoise their central station firm interests to those of General Electric, redefining the electric utility industry boundary to exclude manufacturers.

There were numerous conflicts of interest between the equipment suppliers and the central stations. Exclusive contracts locked the central stations into purchase from one supplier. In return, the suppliers were supposed to refrain from selling isolated generation equipment within the franchised territory of the utility companies. That they often ignored this provision is evidenced by sharp exchanges at AEIC meetings. Rival central station firms still operated within the same areas, and expected their suppliers to pursue patent infringement suits against other such firms using different equipment; but this was a low priority for the manufacturers. The exclusivity of contracts gave equipment suppliers market power which they used to keep prices higher than seemed reasonable to central stations. Service issues, such as delivery time, were frequent bones of contention. Manufacturers, for their part, considered the central stations unreliable customers, whose often strained financial condition made them delay payment for equipment or issue new securities, to meet this obligation, which might then be drastically devalued in the next recession.

Personal distrust between these groups, in part resulting from past history of conflict and resulting animosity between the J.P. Morgan interests who dominated General Electric after 1892 and the Edison/Insull group, might, in a transaction-cost account, have presented a need for vertical integration between manufacturers and central stations, so as to achieve consummate rather than perfunctory co-operation (Williamson, 1985). But central station executives were pulling forcefully in the opposite direction, to preserve their independence and assert their own interests, through collective action.

The crucial group in this emerging industry is what we will call the 'Insull circle', consisting initially of men who had worked in the drafting room of the Edison Electric Light Company's Goerck

Street (Manhattan, New York) equipment manufacturing plant between 1882 and 1885, at a time when Samuel Insull was Edison's most trusted confidant and head of the Edison manufacturing operations (cf. McDonald, 1962). While hundreds of others worked for Edison during this era, a small group of four who had both worked in the Goerck Street plant in the early 1880s, and had attended special classes together, were especially influential. They had also been among the men sent out by Insull and Edison to help set up and initially operate central station light systems. The four were Samuel Insull, John Lieb, Charles Edgar, and Louis Ferguson. They, along with another set of—gradually shifting but probably never larger than eight—close associates of Samuel Insull, would become the key to industry development for the next 40 years. One of their first efforts was to distance themselves from GE domination in the AEIC, and to create a certifying board—the Electrical Testing Laboratory—to assure GE quality and innovation—and in effect assert their (and central station in general) control over the AEIC. The board of ETL consisted of Lieb, Edgar, Insull and William Barstow, who began working for the Edison manufacturing operations after they moved to Schenectady in 1887.

We refer to this as the Insull circle because of its domination by Insull, and in our ongoing research, we examine Insull's company, Chicago Edison and detail his access to U.S. and European capital. We explain how his personal knowledge, his connections to the European technical and financial community, and a group of very talented friends and associates created both autonomy and innovative opportunity for Chicago Edison.

Insull brought European innovations (including the Wright rate system, load building, and turbines) to the U.S., and actively promoted emulation of and adoption of these techniques and devices among the other principal firms within the AEIC (Hughes, 1983:217–233). His circle identified, deliberated upon, and mobilized to promote these and other technical and organizational changes among AEIC members and then the rest of the central station utility industry. The over-arching theme linking their efforts was the pursuit of what we have called a 'growth dynamic' approach—scrap and replace old technology with new, create and expand a territorial monopoly, increase total and per capita load and establish load balance—as an industry-wide development strategy.[7] They used their personal and trade organization relationships to promote adoption of this strategy and associated technology. As we will detail, alternatives that involved more decentralized and

smaller-scale provision of electricity, separation of generation, transmission and distribution, provision combined with the production and sale of other products (such as heat in co-generation arrangements), or provision by not-for-profit companies, were effectively attacked and discouraged by the Insull group.

Crucial to the embedding of their collective template of industry development was domination of the AEIC as a method of transferring technical and organizational norms. Insull's circle held over 90 per cent of the AEIC officer and committee positions, and from 1892 to 1897, in combination with the technical experts from what we will call the 'Six Cities' firms they led (New York, Philadelphia, Brooklyn, Detroit, Boston, and Chicago Edison) delivered almost all the paper presentations at AEIC annual meetings. Leaders of firms in other large cities—Buffalo, Providence, St. Louis, Baltimore, and Pittsburgh—did not participate in the AEIC leadership, despite their having large populations and loads. Regardless of firm or load size, we find that through 1910 most firms only joined and/or became active in the AEIC after hiring other former Goerck St. employees and/or family members of the inner circle's executives.

Our analysis of the composition of AEIC committees from 1897 to 1910 shows that personal networks and firm domination of the AEIC became institutionalized as executives from Insull's circle were replaced. Twenty-three out of 28 times that one of these left a committee position, he was replaced by a subordinate executive from his own firm, an 80 per cent rate of re-constitution of 'broken ties' (cf. Palmer, 1983). Men from the Six Cities firms occupied 275 of the 287 committee positions on AEIC committees and presented 71 per cent of all papers between 1901 and 1910. Direct, almost monolithic, control over the AEIC by this group continued, albeit through firm subordinates.

But important as the AEIC was on its own it was not sufficient to dominate the industry; it was a highly self-selected group associated with large urban firms and it worked closely with General Electric. The other industry trade association, the National Electric Light Association (NELA) was broader, bringing together many smaller firms, those not dependent on General Electric equipment, and in close contact with contractors, jobbers and workers. It held the potential for industry dominance that could not be assured from an AEIC base.

Correspondingly, an informal system of industry-wide self-governance emerged after several Six Cities firms joined the NELA. While several AEIC firms joined the NELA in the early 1890s, they were rarely involved in the NELA leadership before 1896. However in 1897 Insull's circle, aided by leaders from a few other long-standing AEIC firms, became a major bloc in the NELA. Rather than having a straightforward system of unilateral domination as in the AEIC, their *modus operandi* in this trade association was different.

Analysts such as McMahon (1985) and McDonald (1962) have suggested that the AEIC acted as the directing and co-ordinating committee for the remainder of the industry. A brief examination of the committee assignments of the NELA from 1901 to 1910 supports that insight. Insull's circle, their firm subordinates, and executives of other urban firms involved in the AEIC, occupied a majority of seats in two-thirds of the 75 NELA committees existing during the 1901–1910 period.

However, something much more significant was occurring beneath this process. Samuel Insull (President of both the AEIC and NELA in 1898), and his circle gained a substantial minority (13 of 40 positions 1901–1910) in the NELA officerships and executive committees. They, their firm subordinates, and long-standing AEIC supporters together occupied 32 of the 40 seats. In effect they established an important system of significant and strategic influence over the NELA, rather than overt domination.

These leaders, their subordinates and those AEIC firms that had long-standing membership and a former Goerck Street employee as a top executive were a majority in only 19 of the 75 committees (six to ten per year) operating between 1901 and 1910. While rare, those majorities were important, occurring mostly when the committee was new or when its policy focus was initially being established. After policy was initially set, the inner circle and its supporters left the committee, leaving behind a significant minority presence of their subordinate Six Cities executives. In effect, they and their long-standing AEIC supporters created precedent. Afterward, they used their subordinates to scan or monitor the committee deliberations for continued compliance with their initial policy precedents (consistent with the theory of Useem, 1985). When the standing NELA committees did stray from the original policy decisions, committee membership changed soon after and several AEIC associates returned to that committee, re-establishing AEIC-supported policy.[8] Following-up upon this initial insight, Chi-nien Chung (1997) has developed a social network analysis that supports these deduced patterns, showing the high centrality of Insull's circle in the AEIC and their emergence in the NELA after 1895.

Consequently, preferred technologies—including turbines, meters, organizational entities (such as the Contract, Statistical, and Appliance Departments—Insull, 1934: 51; Gilchrist, 1940:8–18; Platt, 1991:89) organizational relations, strategic goals, and even dirty tricks (Gilchrist, 1940: 14–16, 50, 32), were identified, implemented, promoted, and transferred uniformly throughout the industry. Acting through their informal/formal governance structures, the inner circle mobilized their own firms to adopt similar technology, organizational format, or goal (Gilchrist, 1927:472–473). They and/or their Six Cities executive experts then promoted this before the AEIC (Gilchrist, 1940:18; AEIC, 1901:197–209), and in turn they (and/or other AEIC members) did the same before the NELA (NELA, 1905:116–135). They invited executives from other cities to their facilities and taught them about new technologies (Flynn, 1932b:36). They loaned their firm executives (NELA, 1900:412–413; Seymour, 1935:126–127) and consultants[9] to smaller firms so as to enable them to reproduce these policies and/or install new technologies. These efforts and outcomes were then trumpeted in the trade association papers and discussions as trends or rational necessities and subsequently adopted by other central station firms. Significantly, this emerging isomorphism coincided with a decline in industry earnings through 1907 (USDCL, 1910:50). This is not surprising since Insull and other industry leaders acknowledged that their expansion crated some diseconomies (Platt, 1991:178, 342 ft. #37).

This system of industry self-governance had been actively constructed based on friendships, family relations, and social network participation, which were subsequently augmented by actions of formal organizations. Such relations and decisions reverberated throughout the industry via the medium of existing formal organizations that came to be dominated by the inner circle's social network supported by their firm subordinates and former Goerck Street associates. Elements of the preferred template of industry relations became institutionally-embedded through replacement by firm subordinates and/or leaders of other AEIC firms who supported both the organizational and technical policies of the leaders and the system of industry self-governance.

4 Deflecting alternatives to the preferred template of industry development

The success of industry self-governance under the leadership of Insull's circle was most apparent in the containment of alternative forms. There were several viable alternatives to the dominance by urban central station systems and to the 'growth dynamic' strategy during the 1890–1910 era. Isolated systems in individual apartment buildings and/or factories continued to grow in size and in number until by 1902 they produced half of all the horsepower from electricity in the U.S. (USDCL, 1905:3, 1910:14). They were so successful that more U.S. customers (homes and factories) were served by isolated than by central station systems through 1918 (Gould, 1946:21). As late as 1912, more than half of all electricity produced and distributed in the United States was attributable to industry rather than to electric utilities (DuBoff, 1979:41, 219). Even in an urban centre such as Chicago central stations only produced 70 per cent of the electricity consumed in 1922 (Platt, 1991:213). In much of rural America, isolated stations were the only form of electric service available before 1930 (Nye, 1990:296–297).

There were also neighbourhood systems serving small geographic territories. Some were dedicated co-generation systems supplying a neighbourhood with both electricity and steam for heat. Entrepreneur Homer Yaryan, for example, built and operated dedicated steam and electric neighbourhood plants in 35 cities stretching from Cleveland to LaCrosse Wisconsin, including Chicago, Detroit, Toledo, and Fremont Ohio (Scribner, 1910; Cyclopedia of American Biography; Meyer, 1972: 102–103; Porter, 1986). Prominent financier and electricity/natural gas magnate Henry Doherty argued that these multi-use systems involving steam were the hardest to displace because of their efficiency: waste heat from electricity generation could be cycled back into the heating operation, rather than requiring additional energy for cooling the equipment as in traditional generation (cf. Hirsh, 1989), or being dissipated into streams and thus upsetting the local ecosystem by raising temperatures. Investor-owned utilities were in fact so determined to dispose of this competition that they often built otherwise unneeded steam plants to meet the full need of the customer, and ran them at a loss, just to eliminate the competition for electricity (Doherty, 1923:I, 125, 140).

Other neighbourhood systems originated in a 'base' factory, hotel, or trolley firm, and then sold 'surplus' current to other nearby customers (Greer, 1952:14). Some of these were dedicated electric systems while others involved selling electricity in combination with ice, irrigation, pneumatic air, water pumping, and trolleys. For example, 47.4 per cent of all electricity sold to the U.S. public in 1902 and 44.9 per cent in 1907, were sold by 251 and 330 street railroads respectively (USDCL, 1910:14). Such multi-purpose and/or

decentralized systems were common in the U.S. through 1910 and they became the norm in Scandinavia, Canada and most of northern Europe and Russia (Nye, 1990: 384; Armstrong and Nelles, 1986:101–104; USDCL, 1910:13–27.

Some such systems sold off current continuously and others sold surplus current during off-peak periods. This type of firm was especially common in areas with hydro-electric potential and/or geographically diffused, energy-intensive factories such as the Carolinas, Georgia, the Rockies, New York, Minnesota, and Michigan. Through the 1920s these factories served their own needs and after normal closing time, when the electrical equipment would have otherwise been idle, they sold their spare current to utilities that engaged only in transmission and distribution. This practice, revived in the late 20th century under the rubric of wholesale 'wheeling', promoted more efficient capital utilization and load balance.

Another common decentralized schema during this era involved separation of the functions of the typical vertically-integrated central station firms. Generation, transmission, and distribution activity could each (or in combinations of two) be performed by distinct firms and by extension could be distinct industries. For example, Niagara, Lockport and Ontario Electric Company in New York State was only a transmission firm (USDCL, 1910:103). The factory-based generation systems noted above sold to a separate (but often co-owned) electric firm that re-sold current during the evening (Horn, 1973). There are even examples of a city-owned generating and transmitting firm that sold current only to street railroads and factories during this early period (BOC, 1912:198). Bulk sales (ie, of current from one utility to another, some of which were sales among integrated firms and others of which were sales to and/or from non-integrated firms) became so common that by 1907 they were described as 'a special branch of the electric industry' (USDCL, 1910:84). Similar separations between generating, transmitting, and distribution firms in various combinations developed subsequently among U.S. Rural Electrification Administration co-ops from 1930 to now, and in Canada and Britain (Doyle and Reinemer, 1979:253–263, Nelles and Armstrong, 1986; Hannah, 1979). Most equipment sales to these 'alternative' neighbourhood, railroads, and city-owned firms between 1895 and 1906 were by Westinghouse rather than by General Electric (Westinghouse, 1898, 1906: 15–16, Coffin, 1909).

The technical merits and limits of such alternative constructs are variable, locally-specific, and debatable. In some cases they were technically- and energy-efficient (especially if combined with new investment in generating technology) and, given sunk capital costs, were often cost-effective.[10] In fact, Moody's (1995) and Sparks (1995) recently predicted that only firms that unbundle their generation from a transmission and/or distribution firm, and firms that co-generate and sell to dedicated transmission/distribution firms, will survive deregulation.

Yet by 1915 most of these decentralized and multi-purpose firms were subsumed, or undermined by technical licenses and patent monopolies (Passer, 1953:56–57, 158–168; Bright, 1972:82–89) and these alternative constructs for the boundaries of the electric current industries had begun to wither. A cross-licensing agreement between General Electric and Westinghouse, for example, severely limited competition in electrical equipment, leading to their 1911 prosecution for anti-trust violations (Bright, 1972:103). Moreover, regulatory bodies weighed in against these decentralized alternatives with prejudicial rulings. The Massachusetts Gas and Electric Commission, for example, prohibited firms from sending current across streets or alleys unless they were regulated utilities; this prevented neighbourhood or surplus sales.

If technology and organizational form actually followed from efficiency considerations, we should have seen considerable variation by area, since what was efficient varied dramatically according to local circumstances. One key puzzle we seek to explain is how such variation was suppressed in favour of a uniform set of technologies and organizational forms. It appears that the usual mode of suppression and homogenization was that the inner circle mobilized its own firms (as exemplars), discussed the 'problem' at the AEIC and after reaching consensus presented their opinion to the NELA. For example, 72 per cent of NELA papers presented between 1901 and 1910 were from Six Cities firms and 4 per cent by other AEIC central station firms. The leaders used their control of the NELA conference paper topics and committees to marginalize advocates of and information about decentralized energy systems. After dominating NELA presentations from 1890–1896, Westinghouse and other decentralized advocates occupied only two officer and three executive committee positions (of 40 and 80 respectively) between 1901 and 1910, presented only 15 per cent of all papers, and only once for one year had two of their advocates on a committee (public policy committee, 1906). Even in this later case they did not hold a majority. They were joined by three men whose firms were AEIC members—one from a Big Six urban firm and the other two long-time supporters of Insull's policies and agenda.

Insull's circle, their firm associates, and their AEIC supporters presented papers advocating the elimination of isolated systems and the integration, centralization and state-level regulation of production. They influenced the content, agenda, and goals of (both sets of) trade association committees toward load building and balancing and other 'growth dynamic' attributes. They also actively promoted the reconfiguration of suppliers and dependent downstream constituencies to match those 'emerging trends'.

Our research identifies friendships, family connections, shared travel, co-authorship, and site visits among the executives of the inner circle affecting the timing and selection of the various elements of this preferred template of industry development. Absence of individuals not affiliated with them on trade association committees and paper presentations might be argued to be merely a matter of friends selecting other friends for committee assignments. But our review and analysis demonstrates instead that their omission corresponds also to a conspicuous absence of voices advocating alternative (decentralized) paths of firm and industry development, despite the continued and increasing material success of such alternative systems (USDCL, 1910:13; Gould, 1946:21; Bergman, 1982:67 table #7, 68 table #9).[11]

Many of the more energy and cost-efficient technologies introduced in the 1890–1910 era by central station firms could have rendered comparable advantages to non-central station systems, as for example did the installation of turbines in neighbourhood and rail-based systems. (Indeed, the average size of an isolated generator quadrupled between 1904–1914 as they sought and gained economy of scale advantages—USDCL, 195:36). Yet discussions of such alternatives are essentially absent from trade association discussions and publications; similarly omitted was the strong growth, and increasing importance of municipally-owned firms (USDCL, 1910, 1915).

Critics could argue that the dominant market position of the inner circle, which included their leadership of six large urban firms, was the key factor motivating convergence of the industry and standardization of technology. But in fact, isolated systems purchased from 35 per cent to 50 per cent of all electrical equipment, and were thus hardly a negligible market factor. Of the remaining electric production for public sale, railroad firms produced over 45 per cent of all electric current in the U.S. and thus were major purchasers of generating equipment roughly equal to the combined purchases of all investor-owned electric firms (USDCL, 1910:14). The six largest urban central station electric firms in the U.S. (two of which were not among Big Six firms) constituted only 20 per cent of the central station equipment purchases (itself less than half of public sales—a category involving barely more than half of all electric sales) and generated 25 per cent of all central station profits (USDCL 1905:10–11). In fact, the largest 73 central station firms held only 56 per cent of installed central station capacity (USDCL, 1910:67–68). Thus the market position of the Six Cities firms was important but it certainly did not represent an overwhelming portion of customer demand for equipment such that it could result in their having leverage on manufacturers for this reason alone.

5 Restructuring the market: institutionalizing the growth dynamic model

Insull's circle often had to mobilize and re-organize the market to help lock in their preferred template. We detail how they altered the internal dynamics, standards and content of the trade press, unions, college officials, and professional associations. We repeatedly find that several of them were also officers in these groups, and/or that individuals from the larger Goerck Street group, and/or AEIC committees were the principal advocates of change in the direction of a growth dynamic, and/or sat on committees charged with securing such change. These extra-industry groups and others including suppliers and organized customer groups (again often involving Goerck Street *alumni*) typically established legal/contractual obligations and created vested interests that influenced firms involved in sales of electric current.

Groups also emerged that promoted organizational and occupation-related changes among relatively autonomous and diffused industry firms. These included NELA sub-groups, occupational/fraternal clubs (that included initiation, parades, and picnics), corporate welfare and employee clubs (that promoted loyalty through ritual social activity), and/or professional associations (with annual conferences emphasizing social and professional obligation). Here again we note the participation and leadership of the inner circle and of AEIC -associated firms.

In one case, four key figures (Lieb, Edgar, Insull and Barstow) constituted the board of a collectively-owned lab, the Electric Testing Laboratory, that created the technical criterion and standards for production of bulbs and other end-use devices (cf.

McMahon, 1985:17–20). This allowed them to monitor, license (nor not), and potentially to discipline major manufacturers including GE. It also allowed them physically to create the basis for technical continuity and integration among the central station firms of the industry. Their friendships with GE manufacturing executives and important consulting firms (several members of whom had also been at Goerck St.), their personal and/or firms' subsequent ownership of smaller investor-owned firms after 1905, and their long-established and institutionalized policy of loaning of executives to other firms (often through the aegis of the NELA), helped to promote the transfer of preferred policies that rendered disproportionate benefit to their capital-rich, integrated, urban central station firms.

The most important external issue was the passage of state regulation as a method for diffusing the growing challenge of public takeover and ownership of central station urban electric firms. Unable to mobilize support among industry firms for state regulation, or to impose it through informal governance or social peer pressure, Insull's circle turned to friends outside the industry with whom they shared membership in men's clubs, business groups, and/or corporate interlocks.

Several of the circle, Board members from their Six Cities firms, and General Electric, encouraged the National Civic Federation to study this issue and individuals including Samuel Insull and Charles Edgar became members of the study committee. After the introduction of multiple anti-public ownership biases into the study process, and despite mixed findings generally more favourable to public- than privately-owned firms, the NCF adopted the specific provisions that had been proposed by Insull and promoted by his circle for almost a decade—provisions favouring state regulation that protected investors and (to some limited extent) the public specifically by rewarding the pursuit of a 'growth dynamic' strategy and not decentralized alternatives, and rewarded firms with the greatest access to investment capital. These provisions transformed bankers (dependent upon the knowledge of and often sharing interlocks with Insull's circle) and holding company executives (which included several of the circle, and others of whom were former Goerck St. employees) into agents of industry standardization. The bankers and the NELA policy committee (dominated by Insull's circle) then secured support from other investor-owned electric firms for state regulation that had previously been resisted (McGuire, 1989).

The NCF promoted 'its' plan to state governments, several of which were directly lobbied by Insull's circle. Analyses then and now uniformly show that regulation, in the form adopted, promoted merger and rewarded urban, capital-rich IOUs, while disadvantaging publicly-owned firms by locking in their territorial limitations and prohibiting their operating rules. As a result, the Wisconsin utility commission approved 50 of 52 IOU rate increases, while denying 28 of 39 rate reductions sought by public firms between 1908–1914 (Jones, 1914). These criteria also impinged upon the operations of decentralized systems, creating bureaucratic and other conditions that burdened their profitability.

Critics of our argument might perceive Insull's circle as Chandler-esque (1977) characters—uniformly insightful, proactively exercising initiative, pursuing efficiency, and achieving rational outcomes. In fact, technical, organizational and/or economic inefficiencies were created and often locked in due to their efforts. We find that they were overwhelmingly reactive in their efforts: reactive to the potential alternative systems, to public ownership and to challenges to specific elements of the growth dynamic strategy. They were backing into the future as much as or more than striding into it.

Acting through informal governance processes, for example, they had pressured firms to select inefficient paths (such as boycotting Nernst and fluorescent bulbs, over-extending their territories, ignoring street light service, investing in DC equipment, and entering the stand-alone steam heating business) and repeatedly to select the less efficient between two paths of potential development. For example, because of the threat of electric railroads as sellers of surplus current, industry firms sought contracts to supply electricity and/or merger with trolleys, which in fact were in decline and would actually force numerous central station companies into bankruptcy between 1915 and 1935. Correspondingly, after 1902 they essentially ignored electric cars (then 60 per cent of all cars in operation—Volti, 1990), that drew almost all their current at night and could have drastically improved the IOUs load balance. The making of policy through defensive reaction was so pervasive that several of Insull's circle even ignored their personal investments in electric car companies while pursuing trolley loads, hurting their industry, their firms, and themselves.

6 Summary: the social construction of the Electricity industry

We conclude that the electric utility industry was born not of Benthamite Equations or optimizing rationality, but longstanding

friendships, similar experiences, common dependencies, corporate interlocks, and active creation of new social relations. Samuel Insull and his circle of collaborators socially constructed their firms in similar ways, and then promoted a system of industry governance and template diffusion. They drew upon their local and national contacts to re-frame the market and the political system in ways that pressured utility firms toward technical, organizational, economic, and legal conformity. Yet, isomorphism among firms was never fully achieved because this was a system of influence and not of direct control, and because of the varying resources and market attributes in each firm's locale.

This study directly examines only one industry, and one with an unusual combination of highly diffused production and highly intensive capitalization. The largest firms did not directly compete, and there are virtually no international market or trade concerns. Further, we have only examined industry development occurring from 1880 to 1925. These attributes limit generalization of our findings to other industries. Nevertheless, most major industries are similar in having important trade associations, interacting with government and regulatory bodies, and seeking capital from bankers and the public through debt and equity markets. More specialized aspects of electricity have commonalities with the products of other important industries; telephone, telecommunications, transportation and computing service firms, for example, face comparable issues of peak-load pricing, load-balancing, and issues of expansion in relation to optimal utilization of capital. Communications, transportation and entertainment industries are similar in having highly decentralized consumers, and are currently going through consolidations reminiscent of those in the early period of electricity.

More generally, we believe our approach allows us to identify industries whose outcomes are typically attributed to economic and technical rationality, individual achievement and omniscience. When the case is carefully examined within its historical context, all these may turn out to be socially constructed by the mobilization of resources and influence through social networks. Industries are constantly re-negotiated, re-framed, and re-mobilized in response to their environment.

Finally, our story, is empirically and theoretically incomplete. While we find a tight web of friendship, shared experience, club activity, and domination through an industry governance structure in the process of industry formation, we do not believe that such concentrated patterns necessarily continue indefinitely; a fuller theory of industry would specify under what conditions all this shifting of boundaries would solidify. Were we to follow the industry past its formative years chronicled here, we would find that processes and relationships once shaped by individuals became institutionalized in more formal organizations, institutional alliances, standardized practices, and industry norms. As in other industries, we argue, such patterns become embedded as norms, unless and until an industry-wide crisis occurs.[12] At that point, a new social network of firm leaders has the potential to re-define and re-construct a new industry based upon various elements of the old.

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Notes

1 Of the central station firms existing in 1882, only a handful powered incandescent lights, the rest providing arc lighting for outdoor illumination, or for hotels, factories or large public buildings. The first incandescent station was brought on line by Edison himself, on October 1, at Pearl Street, in New York's financial district; it served no more than about a square mile. Arc lighting stations existed from 1879 on, but it was only incandescent stations that provided residential service and which eventually displaced arc lighting stations entirely. Thus it is common, if not literally correct, to describe Pearl Street as the 'first' central station installation.

In the early period of the industry, arc and incandescent systems ran on different cycles and frequencies, and each product line or system of lighting had its own distinctive current and frequency for operating its devices.

2 Ironically, however, in this period, an Edison firm was also the main provider of generators to homes and businesses. Despite Edison's distaste for this option, its substantial profits and consequent approval by investors discouraged him from curbing it.

3 The first central stations were oriented almost entirely to lighting, and Edison, like most others, underestimated the subsequent demand for current used to power motors. The capacity of central stations in the 1880s was rated by the number of lamps they could support.

4 In fact, until the early 20th century, it was not even inevitable that electricity would displace natural gas as the dominant lighting medium for home use. Many homes in which electricity was installed through 1900, had dual systems: using gas for daily light and the more expensive option, electricity, only when entertaining guests (Platt, 1991:80,154–155).

5 Inefficiencies continue. For example, Toledo (Ohio) Edison, until 1996, operated a generator producing 25 cycle current in an otherwise abandoned power plant in order to serve a single customer, which, consequently, did not have to rewire its motors (Sharp, 1995).

6 One NELA member—Western Electric—manufactured telephones and sold them to Bell as its main business, but also produced, installed, and repaired electric arc and incandescent equipment (Smith, 1985).

7 By 'growth dynamic' we mean something essentially similar to what Richard Hirsh (1989), in his important account of the impact of technology on the utility industry, calls the 'grow-and-build' strategy.

8 A good example of this is the NELA Public Policy Committee, 1904–8.

9 Many of these consultants were themselves Goerck St. alumni such as Frederick Sargent, (Sargent and Lundy, 1961:15–18; Toledo Edison, 1:19 9/10/1894) or members of Insull's own circle, such as William Barstow (1900–1905 *National Cyclopedia of Biography*).

10 A good indicator of viability of cogeneration is found in the success of such systems in the aftermath of the 1978 PURPA Act which required central station firms to purchase current from such producers at a rate equal to their own (low) production costs. It spurred the rise of over 3,000 independent power generators—many of them co-generators. This has accounted for over half of all new privately-owned electrical generation in the U.S. since 1986 (Hoffman, 1994:10–13). Also, most of the 1,900 public firms in the U.S.A are transmission and distribution, or distribution-only firms: 91 per cent buy part and 75 per cent buy all of their power from generating and/or transmitting firms.

11 Indeed before the advocates of the growth dynamic had won decisively, the differences could even lead to public quarrels. In 1902, Henry Doherty, then president of NELA, and a sceptic about the virtues of unlimited growth, physically tussled on the dais of the meeting with the vice-president, Insull's deputy, Louis Ferguson from Chicago Edison, about who would have the chalk and chalkboard and who would assume the (silent) Chair role at the meeting. Doherty (1924:III, 136–137) had hard feelings for years afterward, and complained about Ferguson's constant promotion of his agenda.

12 Hirsh (1989) provides an excellent account of what precipitated such a crisis for the electricity industry in the 1960s and 1970s: combination of technical stasis—the industry having reached some basic physical limitations in increased economies of scale, inflation, supply shocks for fuel, and a changing political climate that reduced tolerance for pollution while increasing consumers' resistance to rate increases.

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