

Light Switch: Towards a History of the Second Enlightenment

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Article abstract

This paper attempts to answer the question how and why did planet Earth begin to glow in the dark over the long twentieth century? It begins with a survey of the contemporary global distribution of light followed by an excursion into the history of night, early efforts at interior and exterior illumination, and the global diffusion of light and power companies aided by foreign investment. The spread of the automobile vastly expanded the market for nocturnal illumination just as the economies of scale associated with electricity generation drove down the unit cost of lumens. The paper concludes by emphasizing light as a form of human cultural expression by stressing the importance of social systems, political and cultural factors in turning the lights on, and off.

Light Switch: Towards a History of the Second Enlightenment

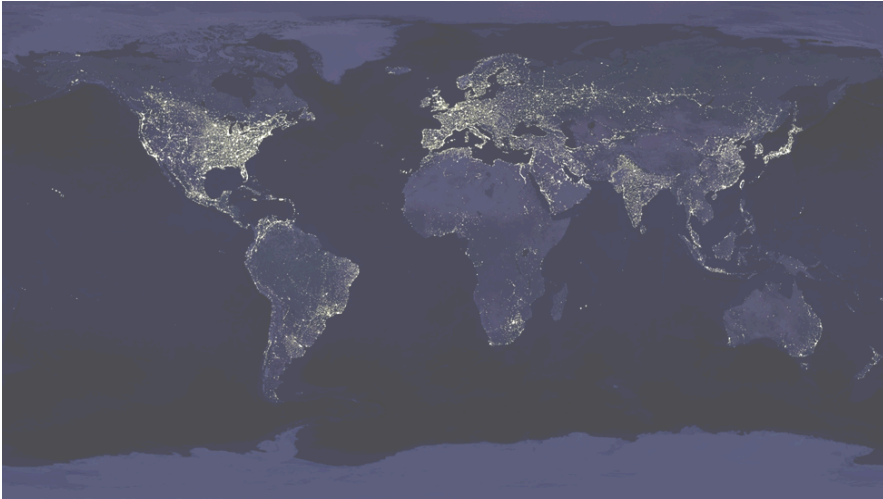
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Abstract : This paper attempts to answer the question how and why did planet Earth begin to glow in the dark over the long twentieth century? It begins with a survey of the contemporary global distribution of light followed by an excursion into the history of night, early efforts at interior and exterior illumination, and the global diffusion of light and power companies aided by foreign investment. The spread of the automobile vastly expanded the market for nocturnal illumination just as the economies of scale associated with electricity generation drove down the unit cost of lumens. The paper concludes by emphasizing light as a form of human cultural expression by stressing the importance of social systems, political and cultural factors in turning the lights on, and off.

Résumé : Cet article tente de comprendre comment et pourquoi la planète Terre a commencé à briller dans l'obscurité tout au long du vingtième siècle. L'article commence par un survol de la distribution mondiale actuelle de l'éclairage suivie d'une excursion dans l'histoire de la nuit, des premiers efforts d'éclairage intérieur et extérieur et de l'expansion mondiale des compagnies d'éclairage et d'électricité soutenue par des investissements étrangers. La diffusion de l'automobile a grandement contribué à l'extension du marché de l'éclairage nocturne, alors que les économies d'échelles associées à la génération d'électricité ont mené à la baisse du coût unitaire de production des lumens. En conclusion, l'article insiste sur la prise en compte de la lumière comme une forme d'expression culturelle et souligne l'importance des systèmes sociaux et des facteurs politiques et culturels dans la présence ou non de l'éclairage.

Figure 1 : Earth at Night (1996)



Source: http://nssdc.gsfc.nasa.gov/planetary/image/earth_night.jpg, accessed 26 January 2010.

Getting a Glow On

This image from space purports to show the Earth at night circa 1996. It is not a photograph, thank goodness, or we would all be dead. This would be a day the sun did not rise. It's also a world without an atmosphere. Rather this is a mosaic; thousands of remote sensing images taken over a period of time stitched together to give a systematic and plausible representation of what the dark side of the world looks like as it turns in space. As an image it says many things, but certainly the one obvious message it delivers is that humanity at the end of the twentieth century gave off a tremendous amount of light.

But historians looking at this image would immediately respond that that has not always been so. And secondly we would observe that light - even in 1996 - is not universal. There are some important variations across the globe in its production.

Let's begin with the second issue, the distribution of light. Extraterrestrial observers would notice that light is unevenly produced across the globe, but with our knowledge we can see - as they perhaps cannot - that light is not precisely correlated with population. Some of the most densely populated areas of the Earth do not give off very much light: for example much of Africa, Haiti, Bangladesh, India, and North Korea. Light intensity, or rather the reverse, dimness, appears to be highly correlated with poverty - though not perfectly. Egypt is brighter and Vermont is darker than light emissions would predict compared with recorded income levels. On the other hand some locations with relatively

few people give off huge quantities of light: North Sea oil platforms, fishing fleets off Argentina and in the South China Sea. And in some parts of the world light sources combine in a blinding glare: North-Eastern United States, the lower Great Lakes and the West coast, Western Europe and England, the Rio-Sao Paulo conurbation in Brazil, and Japan. Bright light has an economic, social, and ultimately a political source.

Without a coordinated strategy, or even much thought, the world has been turned into a colossal light bulb. There is a dark side to this: light pollution as it has been called. A clear night sky is as important to humanity as clean water, fresh air, and healthy soil. We have enveloped ourselves in a luminous nocturnal fog. *The World Atlas of the Artificial Night Sky Brightness* estimates that two thirds of the world population and 99% of the US population "...have already lost naked eye visibility of the Milky Way."¹ The geophysicists in their laconic way point to some of the unintended consequences of this over-lighting: "...the night sky, which constitutes the panorama of the surrounding Universe, has always had a strong influence on human thought and culture, from philosophy to religion, from art to literature and science."² We have sacrificed a view of the universe to live instead in a state comparable to a permanent full moon.

In historical terms the lighting of the world is a relatively recent phenomenon. It is as if in the recent past a global light switch got turned on. Up until about 150 years ago an extraterrestrial observer would have gazed upon a dark planet. Well not completely dark. Light is not entirely dependent upon human sources. The world is, and always has been, on fire, as Stephen Pyne persistently reminds us. A ring of fire around the equator, moving north and south with the seasons, would have given off considerable light - as it still does.³ The human-set fires of swidden agriculture and aboriginal clearance would have contributed as well, as would volcanoes, lightening storms, and meteors. But until near the end of

1. P. Cinzano, F. Falchi and C.D. Elvidge, "The First World Atlas of the Artificial Night Sky Brightness," *Monthly Notes. Royal Astronomical Society*, 328, 3 (2001): 689-707. See also the website: <http://www.lightpollution.it/worldatlas/pages/fig1.htm>, accessed 8 February 2010; P. Cinzano, F. Falchi and C. Elvidge, "Moonlight Without the Moon," *Earth, Moon and Planets*, 8, 13 (2001): 517-22; K.J. Narvan and R.J. Nelson, "The Dark Side of Light at Night: Physiological, Epidemiological, and Ecological Consequences," *Journal of Pineal Research*, 43, 3 (2007): 215-21; C. Rich and T. Longcore, eds., *Ecological Consequences of Artificial Night Lighting* (Washington, DC: Island Press, 2006).

2. P. Cinzano, F. Falchi and C.D. Elvidge, "The First World Atlas of the Artificial Night Sky Brightness," 689.

3. Stephen Pyne, *Vestal Fire: An Environmental History, Told through Fire, of Europe and Europe's Encounter with the World* (Seattle: University of Washington Press, 1997); Stephen Pyne, *World Fire: The Culture of Fire on Earth* (New York: Holt, 1995).

the nineteenth century the human habitation of the Earth would not have given off much light, certainly not enough to be seen from space.

An extraterrestrial observation of the Earth over time would have documented the gradual illumination of the planet from darkness in 1850 to the present gleaming orb. Those looking on from space would have to infer the meaning and process of all this light emission from an apparently intelligent source able to sustain it, from the emerging pattern alone.

This uneven and in some cases excessive illumination of the planet has not been much studied. But this Second Enlightenment has a history. Where does light come from? How does it spread? Why is it so intense in some places and not others? Does light mean the same thing everywhere? What are the implications of marginalizing night? Can darkness return? We know the Earth to be a highly differentiated space geographically and culturally. Light has to propagate itself through quite different social and economic systems as it colonizes the earth. Lights go on, but they also go off. Some historical work has been done on these and related questions, but I think it would be fair to say that in the broad academic study of the human condition relatively little attention has been paid to the fact that over the last century or so we have come to glow in the dark.

Good Night

Once upon a time night ruled. Everyone who could sought shelter indoors at nightfall. Thereafter whatever had to be done took place in the dark. And those abroad in the dark were usually up to no good. Before the modern era there was nothing for most people to do at night except try to sleep, huddled together for warmth and security. In the pitch blackness night noises stoked primordial fears: moaning winds, howling wolves, trees crashing in the forest, distant thunder, the shrieks of prey, the triumphal cry of predators, the cracking and grinding of ice in the river, baying dogs, shouts in the street, closer in the scurrying of mice and the gnawing of rats. In the dark the human psyche turned anxieties into terrifying legends of werewolves, night prowlers, strange visitors, vampires, child-snatchers, hobgoblins, sprites, will o' the wisps, bogymen and trolls. At the close of the day witches went abroad to commune with Satan. In towns and cities vandals, footpads, thieves, arsonists, grave robbers and murderers plied their grim trades. Revellers rioted. Under the cope of darkness chaos and misrule, the deviant and the illicit were unleashed.

Yet night was also a time of enchantment. The heavens sparkled with deeper mysteries. Here too the human imagination, projecting itself upon eternity, animated the sky with Twins, Bulls, Archers, Dippers, Centaurs, Scorpions, a Milky Way, and Bears. The bemused Man in the Moon peered down and meteors briefly blazed. Moonlight and lightning cast

familiar landscapes in a strange, surreal glow.⁴ For most of human history the Dominion of the Night ushered in a time of confinement, torment, dreams and nightmares, until the cock's crow and Dawn brought a return of the certainties of the day.

Perhaps not surprisingly the search for a source of light to hold night at bay has been a universal human quest throughout the ages, driven not only by functional considerations but also deep psychological needs. Similarly the possession of light, like the control of water, has historically been a reflection of wealth and power. It does come as something of a surprise, therefore, to reflect that the discovery and diffusion of a reliable source of light is a relatively recent human achievement.

Until the 1880's humans inhabited a world lit only by fire, to borrow William Manchester's title.⁵ For millennia rushes and wooden torches, augmented by pitch, resins, tar grease and other flammable materials were the only means of illumination.⁶ Later lamps fuelled by locally available materials - vegetable oils, animal and fish fats - provided feeble light indoors. Wicks drew the fuel up onto a brighter flame, and later candles made from beeswax and tallow were added to the armoury of light. Over the centuries a great deal of human ingenuity was spent coaxing more light from candles and oil lamps but with only slight improvements. For all that they remained dim, flickering, short-lived, foul smelling, dangerous, needing constant tending - wicks trimmed, oils replenished - and also expensive.⁷

Gaslight, developed to lengthen the working day in textile mills at the beginning of the nineteenth century, entered domestic service only after mid-century with the installation of effective central production and underground supply systems modelled on water distribution works. Gaslight represented a quantum improvement in brightness, reliability and variability of application, though it remained smelly, hot humid, sooty and dangerous. In Europe and America theatres naturally led the way experimenting with gaslight; hotels, stores and other commercial

4. Roger Ekirch, *At Day's Close: Night in Times Past* (New York: Norton, 2005); Wolfgang Schivelbusch, *Disenchanted Night: The Industrialisation of Light on the Nineteenth Century* (Oxford: Berg, 1988); Jean Verdon, *Night in the Middle Ages* (Notre Dame: Notre Dame University Press, 2002).

5. William Manchester, *A World Lit By Fire. The Medieval Mind and the Renaissance: Portrait of an Age* (Boston: Little and Brown, 1993).

6. A vestigial memory recently ritually re-enacted with the mass participation relay of the Olympic Flame.

7. Schivelbusch, *Disenchanted Night*, 4-14; Leroy Thwing, *Flickering Flame: A History of Domestic Lightning through Ages* (Rutland: Charles Tuttle Publishing, 1958), for a comprehensive introduction to the history of domestic lighting; Brian Bowers, *Lengthening the Day: A History of Lightning Technology* (Oxford: Oxford University Press, 1998); Maureen Dillon, *Artificial Sunshine: A Social History of Domestic Lightning* (London: The National Trust, 2002).

establishments quickly followed.⁸ Leisure, amusement and commerce were the vanguard of the light revolution. The simultaneous development of lanterns and petroleum-fuelled lamps with adjustable wicks extended the reach of the new light into domestic spaces. The world's whales, for a brief but unforgettable literary moment, bore the brunt of the headlong quest for light. More advanced lamps combined with the discovery of oil in Canada and the United States and the development of mass production, transportation and distribution of kerosene, made light even more widely available. Rockefeller, it will be remembered, made his first fortune with Standard Oil before the automobile refining and marketing illuminating fluids.⁹

Technological and organizational breakthroughs in the second half of the nineteenth century in Europe and America that dramatically reduced the cost of light effectively began the process whereby humans began to assert control over darkness. The economist William Nordhaus, in a famous paper, calculated that for 1,000 lumen hours the cost of light in human labour fell from 41 hours in Babylonian times, to between 5 and 6 hours for early nineteenth century candles and lamps, and then plummeted to about 0.3 hours for gaslight in the 1870's and 0.2 hours for a kerosene lamp at about the same time.¹⁰

The advent of electricity eventually broke the connection between light and fire. Thomas Edison developed an entire system of illumination based upon a new form of energy, electricity, and a carbon filament that glowed in a vacuum rather than burned. His combined system of generation, transmission, distribution and lighting apparatus in the form of wiring, switches and the incandescent bulbs, had distinct advantages over gaslight and oil lamps that led to its diffusion and eventual triumph. Edison initially modelled his centralized system on the gas industry and priced his electric light on gaslight; nevertheless incandescent light caught on because it was brighter, more reliable, steadier, cooler, cleaner, safer to

8. Schivelbusch, *Disenchanted Night*, 137-153.

9. Harold F. Williamson, *The American Petroleum Industry* (Evanston: Northwestern University Press, 1959); Alfred D. Chandler, *The Visible Hand: The Managerial Revolution in American Business* (Cambridge: Harvard University Press, 1997); Schivelbusch, *Disenchanted Night*, 9-49.

10. William D. Nordhaus, "Do Real-Output and Real Wage Measures Capture Reality? The History of Lighting Suggests Not," in T.F. Bresnahan and Robert J. Gordon, eds., *The Economics of New Goods. NBER Studies in Income and Wealth, Vol. 58* (Chicago: University of Chicago Press, 1997), 29-66. This exercise in estimating the cost of light over thousands of years was intended mainly as a critique of traditional historical price and wage indexes that measure the cost of inputs (fuel, equipment etc) without taking into account the changing quality of the service (how much light). Nordhaus argues that such an approach mis-measures the welfare gains of new technologies which change the qualitative dimensions of consumption - in the case of light by somewhere between 40 and 190 times traditional estimates! The paper was sufficiently striking to warrant a full page in *The Economist*, "The Price of Light", 22 October 1994, 84.

use, more adaptable and eventually even much cheaper. In time the cost of 1,000 lumens in electric light also fell from about 0.2 hours of labour in 1900 (about 12 minutes) to an insignificant 0.01 in 1920 (about 30 seconds).¹¹ In the nineteenth century the revolution in illumination effectively extended the working day by several hours, carried light more widely across the social scale, opened up a new evening domestic life in the homes of even the relatively poor, enhanced leisure activities, created mass public nightlife and stimulated reading.

But the lights recorded by satellites in space do not for the most part emanate from houses. Domestic lighting may contribute to the ambient glow, but the phosphorescence of the planet results primarily from outdoor lighting. Why did human beings in so many different parts of the globe decide to illuminate exterior spaces in the 20th century?

For centuries architecture alone afforded protection against the real and imagined perils of the night. High walls, shutters, sturdy doors, bolts, latches, locks, barred windows were the traditional means of keeping those indoors safe from sunset till dawn. Residents sometimes identified their houses by putting out a light; in some cases residents were ordered to do so by the authorities. But for the most part public safety depended upon curfews, torch bearers (linkmen) armed escorts, and a fitful night watch. Street lighting was an innovation of the absolutist state for surveillance purposes at the end of the seventeenth century. The Sun King insisted upon shining at night to identify suspicious characters moving about under the cover of darkness. By royal decree Paris police maintained a system of lanterns suspended across main streets or on lamp posts. In the eighteenth century the idea was firmly planted that lighting streets and public places heightened surveillance capability and to that extent curbed unauthorized activity, criminal and seditious. Competitions and prizes spurred French inventors to develop distinctive multi-wick, multi-reflector lamps (*réverbères*) to brighten the night streets. Other major cities, London and Berlin for example, followed the Parisian example but where state power and the fear of sedition were weaker, the street lights were correspondingly dimmer and less overtly political. The fact that residents of Paris were taxed to support this surveillance system rendered street lighting system a symbolic representation of royal tyranny during the French Revolution. Militants targeted this surveillance system, systematically destroyed the lanterns, and revolutionaries used the suspension system and lamp standards to string up their enemies. The verb “lanterner” acquired a sinister new meaning. The French Revolution

11. Nordhaus, 52-53. In addition to Schivelbusch, Bowers, and Dillon cited above, see David E. Nye, *Electrifying America: Social Meanings of a New Technology 1880-1940* (Cambridge: MIT Press, 1992), 1-28, 238-338.

unfolded in darkness.¹² Light, by contrast, expressed state power. With the restoration of monarchies and empires in the nineteenth century Paris again became famous as The City of Light.

Light had no intrinsic ideology. It could be monarchist or republication. It had popular, bourgeois, civic origins as well. The quest for brighter light ignited Ben Franklin's ingenuity. Apart from his near fatal attempt to call electricity down from the sky, Franklin also invented a vastly improved oil lamp. The cities of the new republic were if anything brighter than the monarchies of Europe. At the beginning of the nineteenth century the streets of New York, Boston and Philadelphia fairly glowed with democratic light under thousands of oil lamps.¹³

Night light also created night life. Well lit streets increased public safety, made pedestrian traffic after sundown possible. Lights in the night also enhanced pleasure as entertainment entrepreneurs quickly discovered. The Jardins Tivoli on the site of an ancient Roman Bath in Paris, became a popular summer venue for strolling, dining, assignations, music, and theatricals.¹⁴ In London the Vauxhall, Marylebone and Ranelagh Gardens set the fashion in this entertainment genre.¹⁵ Evening illuminations, hanging lanterns, reflecting pools, fountains, fanciful pagodas, orientalist and Moorish architecture lent an air of dreamy enchantment to these magical places. Light meant rejoicing. Illuminations and fireworks celebrated victories, welcomed royalty, and expressed the pride of guilds and municipal corporations. Light then shone from a multitude of sources.

The long eighteenth century witnessed a nocturnal revolution that has not received the attention of other contemporaneous insurrections. The revolt against "The Reign of the Night" lengthened the day; people regularly ventured out of doors after dark for amusement, sociability and public gatherings. Work, domestic affairs and entertainment stretched far into the evening. "It would be difficult to exaggerate the importance of this remarkable transformation in urban life," noted A. Roger Ekirch near

12. Schnivelbusch, *Disenchanted Night*, 79-106.

13. John A. Jakle, *City Lights: Illuminating the American Night* (Baltimore: Johns Hopkins, 2001), 19-24.

14. On the history of this park see:

http://www.faget-benard.com/petit_bout_du_monde/textes/chap2/tivoli.html, accessed 23 February 2010.

15. For the best treatment of the cultural and social life at Vauxhall, Marlebone and Ranelagh Gardens, see John Brewer, *The Pleasures of the Imagination: English Culture in the Eighteenth Century* (New York: Farrar, Straus Giroux, 1997), Chapter 2; Schivelbusch, *Disenchanted Night*, 140-43, who terms these places "commercial imitations of courtly festive culture." See also the website maintained by the Vauxhall Gardens Historical Society. See: http://www.vauxhallgardens.com/vauxhall_gardens_briefhistory_page.html, accessed February 23, 2010.

the end of his splendid history of night. “Especially for the middle classes, hours once dominated by darkness became familiar. The public spaces that people shared were larger and more crowded. Just as coaches and pedestrians filled major avenues, so did squares and plazas become hubs of commotion and activity. Time and again, observers commented on the liveliness of the city streets at night.”¹⁶

Gas considerably enhanced the ability of societies to light in public spaces. Projects on Pall Mall in London (1807) and the Champs Elysees (1828) demonstrated the greater brilliance, range and lower cost of gaslight compared to oil lamps and lanterns. Observers marvelled at the soft brilliance of this new form of outdoor illumination. Within a few years gas companies, modelled upon the engineering of contemporaneous waterworks, spread gas street lighting throughout Europe and the Americas. Baltimore, New York and Philadelphia led the way in the Americas. In 1827 hundreds of gaslights blazed along Broadway. Within a decade almost 6,000 gas lamps illuminated the major commercial and residential avenues of New York.¹⁷ By mid-century more than 1,000 gas companies operated in Britain alone. Even in far off colonies gaslight shone. In 1846 the Montreal Gas Light Company began illuminating the main streets; the Toronto Gas Light and Water Company commenced operations a year later.¹⁸

The technology and the corporate form of organization travelled rapidly through commercial networks, driven in part by the fear (as expressed by a Montreal historian) that “Darkness is a friend of vice,” and the desire on the part of aspiring cities to appear progressive and up to date. Metropolitan examples set the pattern; European and US manufacturers exported the equipment and know how around the world. For example, French businessmen built a gaslight system in St. Petersburg in 1835; the British-owned Hong Kong and China Gas Company went into service in 1862 and the Sao Paulo Gas Company in 1869.¹⁹

The development of electric lighting in the later nineteenth century completed the process of turning night into day. Just as people marvelled at the quantum improvement of gaslight over oil lamps and lanterns, electric light cast gaslight in a shadow. Indeed the first widely used electric illumination - arc lights - were actually too bright. Their blinding

16. Ekirch, *At Day's Close*, 324-325.

17. *Ibid.*, 30-40, 114-15; Jakle, *City Lights*, 27-31.

18. C. Armstrong and H.V. Nelles, *Monopoly's Moment: The Organization and Regulation of Canadian Utilities 1830-1930* (Philadelphia: Temple University Press, 1986), 20-33. Private gas companies, supplying gaslight to the municipal corporation, provided similar services almost simultaneously in St. John, Quebec City, Ottawa, Kingston, Hamilton and London.

19. Jonathan Coopersmith, *The Electrification of Russia 1880-1926* (Ithaca: Cornell University Press, 1992), 49; Duncan McDowall, *The Light: Brazilian Traction, Light and Power Company Limited, 1899-1945* (Toronto: University of Toronto Press, 1988), 22.

blaze, closely approximating sunlight, cast an unsettling, ghostly white light. Electric arc lights made their first public appearance in Philadelphia at the Centennial Exposition in 1876, at a Sheffield football stadium in 1878, and in Paris on the Place de l'Opéra and the Paris Exposition Universelle in 1881. Futurists of the time imagined that centrally located arc lights could illuminate entire cities. In 1886 the Eiffel Tower project narrowly defeated a bid to build a gigantic Sun Town near the Pont Neuf, an electric lighthouse intended to light all of Paris. At about the same time the Charles F. Brush company, among others, installed street lighting systems not only in major US cities (such as Cleveland, 1879, a demonstration system), but also in response to demand from smaller centres such as Wabash Illinois where he built the first municipal plant. Arc lights worked best in large public spaces; they were too bright however for most purposes. The light from Edison's incandescent bulb was purposefully intended to be much less intense, less harsh, and warmer in hue.²⁰

At the end of the nineteenth century electric companies, following in the wake of and competing with gas companies, spread incandescent light throughout Europe and America and across the world. Electricity as an intermediate good is not desired in and of itself. It is valued for its applications, light being foremost among them. For that reason the first electric companies frequently identified themselves by that capability: the Edison Electric Light Company; the Toronto Electric Light Company; Tokyo Electric Light Company, China Light. In Sao Paulo the electric utility in popular parlance went simply by the name "The Light."

The familiar story of the development of incandescent electric light and the rise of the electric utility industry need not be retold.²¹ But a few

20. Schivelbusch, *Disenchanted Night*, 50-57, 128-34; Jakle, *City Lights*, 38-58.

21. Brian Bowers, *A History of Electric Light and Power* (London: Peter Peregrinus, 1982); Thomas Hughes, *Networks of Power: Electrification in Western Society 1880-1930* (Baltimore: Johns Hopkins University Press, 1983); Harold C. Passer, *The Electrical Manufacturers, 1875-1900: A Study in Competition, Entrepreneurship, Technical Change, and Economic Growth* (Cambridge: Harvard University Press, 1953); Robert D. Freidel, Paul Israel and Bernard S. Finn, *Edison's Electric Light: Biography of an Invention* (New Brunswick: Rutgers University Press, 1987); André Millard, *Edison and the Business of Invention* (Baltimore: Johns Hopkins University Press, 1990); C. Armstrong and H.V. Nelles, *Monopoly's Moment*; I.C.R. Byatt, *The British Electrical Industry, 1875-1914: The Economic Returns to a New Technology* (Oxford: Oxford University Press, 1979); Leslie Hannah, *Electricity Before Nationalisation: A Study of the Development of the Electricity Supply Industry in Britain to 1948* (Baltimore: Johns Hopkins University Press, 1979); François Caron et Fabienne Cardot, eds., *Histoire de l'Électricité en France 1881-1918* (Paris: Fayard, 1991); McDowall, *The Light*; C. Armstrong and H.V. Nelles, *Southern Exposure: Canadian Promoters in Latin America and the Caribbean, 1896-1930* (Toronto: University of Toronto Press, 1988) and for a popular account Jill Jonnes, *Empires of Light: Edison, Tesla, Westinghouse, and the Race to Electrify the World* (New York: Random House, 2003). The best history of the electrification of a major city is Harold Platt, *The*

words need to be said about the manner in which electric light was sold. For the demand for light was not merely functional; rather light came to serve a multiple of purposes and a variety of psychological needs. Electric light was not simply put to the same uses as candles and oil lamps; this new more manipulable form light came to be applied to entirely new purposes and accordingly came to be produced in infinitely greater quantities. These uses had to be taught.

The Theatre of Science at the end of the nineteenth century cultivated a taste for an overabundance of and new uses of light. Brightly lit theatres and hotels drew crowds and made fashionable impressions. The new department stores deployed light, mirrors and goods to create "dream worlds" and "lands of desire" to tempt customers into the new habit of shopping.²² At night billboards and storefronts came alive with animated, colourful advertisements. Spotlights piercing the sky drew crowds to exhibitions, shows and gaudily illuminated amusement parks. The Great White Way of Broadway and the blazing billboards of Time Square awed visitors.²³ International expositions the purveyors of light put on dazzling light shows to introduce new applications, inspire emulation and of course greater consumption. The White City of Chicago's World's Columbian Exposition in 1893 also gleamed at night with silhouette lighting outlining the facades of the main buildings. At the Exposition Universelle in Paris, 1900, a cascade of light poured out of the Palais de l'Électricité looking for the entire world like an oversize jewel box. The Electric Tower at the Buffalo Exposition in 1901 introduced flood lighting, colour and the selective illumination of architectural detail.²⁴ These techniques taught and learned at world's fairs and expositions, once transferred to public buildings and monuments, inspired pride, confidence and respect glowing

Electric City: Energy and the Growth of the Chicago Area (Chicago: University of Chicago Press, 1991).

22. Rosalind Williams, *Dream Worlds: Mass Consumption in Late Nineteenth Century France* (Berkeley: University of California Press, 1982), 84-90, for the "Electric Fairyland"; William R. Leach, *Land of Desire: Merchants, Power and the Rise of a New American Culture* (New York: Pantheon, 1993), 39-70, for the uses of colour, glass and light in the department stores.

23. Nye, *Electrifying America*, 29-84; Jakle, *City Lights*, 93-142. For a recent history of the night and night life in northeastern United States, see Peter C. Baldwin's elegant monograph *In the Watches of the Night: Life in the Nocturnal City, 1820-1930* (Chicago: University of Chicago Press, 2013).

24. Nye, *Electrifying America*; Jakle, *City Lights*, 143-68; Robert Rydell, *All the World's a Fair: America's International Expositions, 1876-1916* (Chicago: University of Chicago Press, 1984); Caron et Cardot, eds., *Histoire de l'Électricité en France*, 18-33; David F. Burg, *Chicago's White City of 1893* (Lexington: University of Kentucky Press, 1976); Richard Mandell, *Paris 1900: The Great World's Fair* (Toronto: University of Toronto Press, 1967); S.W. Cordulack, "A Franco-American Battle of Beams: Electricity and the Selling of Modernity", *Journal of Design History*, 18, 2 (2005): 147-66.

against the night sky. Light lengthened the day and added to life's chores, but it also kindled dreams and new forms of cultural expression.

Through these demonstrations light acquired powerful symbolic meanings. Light spread a sense of security and ensured public safety to be sure. But it also asserted power, proclaimed wealth. Light was up to date, modern. Light provided assurance of progressiveness. Moving light and coloured light drew attention and burned brand names into memories. Night light posited an ideal world against the mundane. The city at night was an idealized place, sleek, outlined, highlighted, and emerging from the drab greyness of the day. City lights drew hopeful migrants like moths from the rural darkness. Dimly lit towns and cities yearned to be alive with light. The demand for light sprang from many quite divergent social and psychological sources. It is important to note that we give off light not just out of the duties of production and consumption, but also to express ourselves.

By the late nineteenth century the planet seen from space at night would have begun to have a faint glow. Here and there across the surface of the sphere pinpoints of light would pierce the night sky rising from the major cities and towns of Europe and America. Light too would radiate from the world's main commercial cities scattered across the globe, Sao Paulo, Rio de Janeiro and Buenos Aires in South America, Hong Kong and Shanghai in China, Bombay, Calcutta and other port cities in India. With the coming of electricity at the end of the nineteenth and the beginning of the twentieth century the global light switch from oil and gas to electricity was well under way. And a switch had been turned on which, over the next century, would lead to a quantum increase in the light pouring over and out of our planet.

Caught in the Headlights

Throughout the twentieth century the earth at night grew brighter and the light spread more widely over its surface. The economics of electricity production would have much to do with this, as would the increasing efficiency of lighting technology. But the most powerful propagator of outdoor illumination would be an unrelated technology that also became central to urban industrial life, the automobile.

For most of the twentieth century electricity production was an industry characterized by increasing returns to scale. Larger generating stations, whether thermal or hydro-electricity could produce power at lower unit costs. Falling prices, stimulated demand, in turn supporting ever larger facilities and output, a classic virtuous circle. Light was also needed at night, when other electricity demand slackened off, thus providing essential off peak loads to the capital intensive electric industry. All other

things being equal the cost per unit of electricity, and thus per unit of light, fell dramatically.²⁵

But all things were not equal. If there were economies of scale at the generation and transmission side of the business, relentless innovation and technological change managed to wring ever greater quantities of light out of units of electricity. Tungsten filaments increased the brightness and efficiency of incandescent bulbs. Fluorescent and gas vapour bulbs released much more light per unit of electricity input than incandescents. Riding down the cost of electricity curve, and soaring up the lumen efficiency curve, light became, as we have seen, incredibly cheaper in the twentieth century. Corporations, municipalities and other public authorities could combine to push back the night wielding an ever cheaper and more effective lighting system.²⁶

This conjuncture arrived at a propitious time, just as a new light demanding technology entered the marketplace. Initially street lighting responded to demands for identification, security and then for pedestrian and horse drawn mobility. The higher speed and greater danger posed by heavy automobiles and trucks navigating at night led to public lighting systems of much more comprehensive and brighter standards. The machines themselves had headlights, but this immediate illumination was not adequate alone for nocturnal driving. Faster speed required light affording greater depth of field definition, much greater distance ahead, and ample scope to illuminate intersections, pedestrians and traffic merging from the sides. Lighting engineering emerging in the early twentieth century as subfield of civil engineering, developed elaborate lighting protocols for the hierarchy of streets (central commercial, high volume arteries, secondary roads, residential streets) and developed different kinds of light and light fixtures for specialized circumstances (intersections, highways, urban streets). Of course traffic itself came to be controlled by light, traffic lights. As the cars and truck grew larger and faster, as their numbers grew, and as social and economic life demanded

25. On the economics, see P.J. Garfield and W.F. Lovejoy, *Public Utility Economics* (Englewood Cliffs: Prentice-Hall, 1964). Two electrical entrepreneurs, Samuel Insull and Adam Beck, one in the private sector in Chicago and the other a public ownership promoter here in Ontario, quickly grasped the organizational implications of increasing returns to scale, building two public utilities empires among the largest in the world in the 1920's. See Forrest McDonald, *Insull: The Rise and Fall of a Billionaire Utility Tycoon* (Frederick, MD: Beard Books, 2004); Harold L. Platt, *Electric City*; Thomas Hughes, *Networks of Power*; Nelles, *The Politics of Development*.

26. For a brief introduction to improved lighting efficiency, see Vaclav Smil, *Energy in World History* (Boulder: Westview Press, 1994), 251, and V. Smil, *Energy in Nature and Society: General Energetics of Complex Systems* (Cambridge: MIT Press, 2008), 267; Jakle, *City Lights*, 77-122 deals in greater detail with the economics of lighting (falling costs) and the improvements in street lighting technology.

more night transportation, the lighting standards for Europe and North America brightened and pushed outdoor light ever further into the realm of the night.

Urbanization and auto-mobilization (and the dynamic interaction between the two) largely drove the remarkable brightening of the planet during the twentieth century. Cities grew bigger, spread over much larger spaces, and the cars and trucks, to work effectively at all hours, required specialized brightly illuminated facilities. Besides roads - wider and more brightly lit - the symbiotic urban/auto relationship also created entirely new brightly lit urban environments, commercial strips, malls, clover leaves, parking lots. On the margins cities and conurbations grew into one another making a continuous radiance of light.

But the trend was not continuous. The lights could go off, or at least dim. Power outages created localized and sometimes regional blackouts - and the return of night. Human beings could bring night upon themselves. As Earl Grey famously observed on the eve of WWI, the lamps would go out across Europe - and they did - but they came back on in the 1920's - well within his lifetime (1862-1933). In the United States as well, during WWI, to conserve coal, lighting was restricted. As was noted at the time this conservation of illumination led to an unexpected rise in the crime rate and a dreadful increase in automobile accidents. During the Depression of the 1930's cash strapped municipalities turned off non-essential lights,²⁷ and again during WWII east coast cities lowered their visibility to airborne assault with self imposed blackouts and brownouts to divert electricity to war industries.²⁸ At that time Europe, Britain and Japan, of course, reverted to a fearsome night, illuminated only by aircraft searchlights, exploding bombs and burning cities.

It should be remembered that even in metropolitan societies large proportions of the population went without electricity and light well into the 20th century. In the United States in the 1930's, for example, 30% of the population, mainly in rural parts of the country, were without electric light. In Canada and Germany the numbers were 32% and 21% respectively. By contrast at the same time 65% of Greeks and 78% of Mexicans lacked electric light.²⁹ During the Great Depression the US government launched ambitious rural electrification programmes subsidizing local public or private companies to service heretofore

27. "In our current fiscal crisis the street lights are being switched off once again", *The Globe and Mail*, 8 February 2010, A10 reports that city of Colorado Springs will shut down 33% of its 24,000 street lights to save money.

28. Jakle, *City Lights*, 11; Matthew Evenden, "Lights Out: Conserving Electricity for War in the Canadian City, 1939-1945," *Urban History Review*, 34, 1 (2005): 88-99.

29. William Hausman, Peter Hertner and Mira Wilkins, *Global Electrification: Multinational Enterprise and International Finance in the History of Light and Power, 1878-2007* (Cambridge: Cambridge University Press, 2008), 27-28.

neglected and darker regions of the US. The Rural Electrification Administration with its subsidies brought electricity into the farmhouses of America. The light was a revelation. As one middle-aged farm wife reported: "We just turned on the light and looked at each other - it was the first time I'd seen Pa after dark in thirty years."³⁰

Light would return with even greater intensity in the postwar era as automobile ownership rates, suburban expansion, the construction of high speed motorways, autobahns, and superhighways created high speed transportation webs. The automobile was not alone in giving off more light. Other forms of transportation, industry, entertainment and round the clock construction also contributed to the brighter glow. Ports, canals, rail yards, airports and truck depots required specialized high intensity lighting systems to function safely at night. In a globalizing economy at the end of the 20th century more and more commerce operated 24 hours a day. Advertising became even more gaudy and animated and commercial lighting much more widespread. Skyscrapers, businesses, apartment buildings, monuments and public buildings became more brilliantly illuminated out of both pride and security concerns. Outdoor mass amusements - especially sports - led to illuminated stadiums and night games. Even community playgrounds and sports fields and ski hills were lit up for night use. All of this economic and recreational activity drew more people into the streets at night, increasingly in their automobiles, which fed the upward demand for more and brighter light.³¹

Wired and Wireless Networks

Light is not a commodity that can be imported or exported. A shipment of light bulbs alone will not glow in the dark. Light is also a collective product; it is a manifestation of the existence of a system. Light on this scale depends not upon individuals but rather upon organizations. To be turned on, sustained and maintained, light requires a web of complex

30. Quoted in Brian Q. Conon, "Power Relations: Western Rural Electric Co-operatives and the New Deal," *Western Historical Quarterly*, 31, 2, (Summer 2000): 133-34. Audra Wolfe argues for a more restrained and selective adoption of electricity on the farm, "'How Not to Electrocute the Farmer: Assessing Attitudes toward electrification on American Farms,'" *Agricultural History*, 74, 2 (Spring 2000): 515-29. For examples of other state sponsored rural electrification programmes, see Maurice Lévy-Leboyer and Henri Morsel, eds, *Histoire de l'électricité en France, Tome 2. L'interconnexion et le marché, 1919-1946* (Paris: Fayard, 1994), 1198-1232; H. Morsel, ed., *Histoire de l'électricité en France, Tome 3, 1946-1987* (Paris: Fayard, 1996), 168-182, 614-20. For Canadian examples, see Keith Fleming, *Power at Cost: Ontario Hydro and Rural Electrification, 1911-1958* (Montreal-Kingston: McGill Queens University Press, 1992) and Clinton O. White, *Power For a Province: A History of Saskatchewan Power* (Regina: Canadian Plains Research Centre, 1976), 265-94.

31. Jakle, *City Lights*, 123-255.

interconnected networks, some material and visible, others imaginary and socially constructed. A world wired for light also requires essential unwired support systems.

Surprisingly electricity itself is rarely exported. Less than 3% of electrical production crosses borders. Global electrification and the concomitant illumination of the planet depended upon the spread of localized interconnected systems, first and foremost the electrical systems themselves and less obviously the support systems they require. The development of these undergirding systems presents a fruitful area for comparative historical study. How does light-making establish itself across many different cultures and economies? The answer, one suspects from the history of the industrial west, must surely go beyond purely functional explanations.

Light and its energy source, electricity, can be produced and distributed in many different ways - as the multiplicity of plugs required for international travel regularly reminds us. It can be produced from water, coal, oil and gas, wind, the sun and even garbage. It knows no one particular ideology: communist, fascist, and the several capitalist regimes all give off light. But sustained light measurable from space cannot be produced by anarchists. Light on a grand scale everywhere requires organization. Light depends upon order, and when turned on, also helps to maintain order. The successful spread of light depended upon the establishment and interconnection of a web of technological, but also cultural, economic, social and political systems.

Very briefly the systems that must be brought into some harmonious alignment to produce sustained light include Energy (a source of power), Capital (to finance, provide banking, exchange and reinvestment flows); Technology (generators, transmission lines, transformer stations, distribution networks and light fixtures); Technique (the technical education, engineering, management and skilled labour required to build, operate and maintain the system); Demand (sufficient personal income, social organization, economic activity, urbanization, a state to purchase electricity and light); and Governance (state agents to provide licenses and franchises, legal systems to enforce contracts and protect sunk capital, security from theft, vandalism and confiscation for extensive and exposed physical plant, and reasonable certainty that bills will be paid and/or taxes gathered to repay the investment). The global spread of light is not just the story of technology transfer. The spread of sustained light across jurisdictions and cultures illuminates these underlying requirements that must also obtain to a minimum degree. In the absence or collapse of any of these elements, the light fails, or does not come on in the first place. Notwithstanding the brilliant glow from all around the world, it is important to remember that about 1.4 billion people - a quarter of

humanity - still live without electricity and light.³² They remain in the grip of night, in dark countries and continents, because these necessary independent systems could not or would not be hooked up satisfactorily.

The lighting up of the earth, especially during the second half of the twentieth century, was a global phenomenon. Scholars have written extensively about the electrification and illumination of Europe, Britain, the Americas and some selected early industrializing countries. A good deal of this writing - with some notable exceptions - concerns itself with the production side of the equation in metropolitan countries: the electric equipment industries and the development of electric utilities. The focus to date has been upon the wiring of the world than the underlying requirements and subsequent social implications of technological change in this sector.

On the demand side we do not know much about the ways in which light was embodied into and adapted by different cultures. How did different cultures apply light? How do we account for variations in adaptation? How did light change social relations? Artificial light had to be legitimized for the local population and affordable to spread. We need not think in technological determinist terms: there were many ways light and electricity could be incorporated into social organizations. But once demand had been inculcated, light supply had needs that required organized and sustained attention. Stable contractual relations had to be established between providers and users. The openly exposed physical plant of the electricity network had to be secured and maintained. End use equipment - in this case fixtures and bulbs - and electricians had to be available. Education at different levels had to adapt to the new technology and its accompanying techniques. Banks and financial institutions had to service the different needs of the light industry from commercial credit to long term debt. We need not think in technological determinist terms: there were many ways light and electricity could be incorporated into social organizations. But once demand had been inculcated, supply had needs that required attention. In turn societies had to respond to those needs as light served current functions and created unanticipated opportunities for social change. Nor must the entire society respond at once. Light could penetrate niches and social strata, establish itself, and then spread.

32. International Energy Agency, Energy and Development; http://www.iea.org/speech/2004/WEO2004_Energy_Development.pdf; http://www.iea.org/weo/database_electricity/electricity_access_database_files/sheet002.htm, accessed February 10, 2010. Note: This information is now compiled annually in the IEA publication *World Energy Outlook*. In round numbers 60% of Africans and 22% of Asians make do without electric light.

How do we account for variations in adaptation? For example in Tuscany at the turn of the century the provinces of Florence and Livorno were much brighter than the rest, while the cities of Siena and Grosseto lacked electricity. In some societies - Norway and Finland, for example - the light, power and heat needs of large industries drove the process of electrification ahead of the commercial, municipal and domestic demand for light. Industries - mills and mines - also seem to have initiated electricity and light production in Japan. In Korea the Emperor Kojong promoted artificial lighting and electrification generally by illuminating his palace.³³ In China mercantile entrepôts, such as Shanghai, were the first and most brightly lit cities. The French naval base in Algeria deployed the first large scale lighting system in that country. Civic leadership, industry, dynastic authority, commerce and colonialism all spread light.³⁴

Light changed social relations. In South Africa dock workers protested against night work in the newly illuminated port of Durban for religious reasons. When they became habituated to the light they were then - out of fear - subjected to a curfew by the white authorities. Light enhanced the output of small workshops and food suppliers, the main clients of the privately owned electric company in Dakar early in the twentieth century. The textile industries in Bombay were the principal customers for light, a demand that inspired a major hydro-electric development controlled by the entrepreneurial Tata family. This project in turn lit and powered the extraordinary urbanization and economic growth of Bombay and consolidated the industrial fortunes of the Tata family on a new technological platform.³⁵

On the supply side Hausman, Hertner, Wilkins and company have made the first sustained attempt to explain the course of global electrification and the role of multi-national corporations and international finance in that process.³⁶ The complexity and variation they have uncovered do not

33. Yun-Hee Kim, "The Establishment of Seoul Electric during Korea's Imperial Era," *Journal of the Korean History of Science Society*, 19 (1997): 87-121 (Historical Abstracts); and Moon-Hyon Nam, "The Early History of Korean Electric Light and Power Development," *Transactions of the Asian Royal Society – Korea Branch*, 86 (2011): 41-59.

34. The examples cited, with the exception of those relating to Korea, are taken from essays in Monique Trédé, ed. *Électricité et électrification dans le monde, 1880-1980* (Paris: Presses Universitaires de France, 1992).

35. These and many other examples of the alteration of social relations with light and electricity can be found in Dominique Barjot, Arnaud Berthonnet, Daniel Lefeuvre and Sophie Coeuré, eds., *L'Électrification outre-mer de la fin du XIXe Siècle aux premières décolonisations* (Paris: Publications de la Société française d'histoire d'outre-mer et Fondation EDF, 2002).

36. In addition to the main authors, the research team included Dominique Barjot, Jonathan Coopersmith, Kenneth Jackson, Pierre Lanthier, H.V. Nelles, John L. Neufeld, Harm Shröter and Luciano Segreto.

lend themselves to easy generalization but some patterns do emerge. The capital intensive nature of the electric utility business, its technological complexity, the operating skill sets required at first created severe barriers to entry for many cities and countries. Small isolated lighting plants might be attempted, but system development on a large scale could not be contemplated as efficient scale increased. Local demand could not therefore be met from one or all of local capital, business acumen, or labour pools.

Thus a major first step in the global diffusion of electricity and light involved foreigners providing an varying proportions the money, equipment, engineering, management and skilled labour. Some countries could assemble all of these elements internally: United States, France, Great Britain, Germany, for example. Some countries imported some or all of the components through the process of foreign investment to differing degrees. In the 1930's, for example, foreign investment accounted for approximately 34% of electric production in Canada, 85% in Greece, 27% in Spain, 60% in China, 90% in Argentina, 80% in Brazil, and virtually 100% of all African production except for 65% in South Africa. Some countries were both investors in electricity companies abroad and recipients of foreign investment in the electricity sector, Canada being a notable example, a curiosity that turned out to have been a fairly common experience.³⁷

However the spread of electricity and light did not follow the pattern of foreign investment established in the commercial and manufacturing sectors. During the early phases electric utilities firmly established in metropolitan markets did not establish subsidiaries in foreign countries. Rather the electric equipment manufacturers, by way of building markets for their products, played a major role in promoting, financing, and for a time operating foreign enterprises. Secondly "free standing companies," organized in one jurisdiction to do business in another, played an unusually important role in the spread of electrical technology by building integrated systems abroad. Thirdly these independent foreign owned operating companies were often bundled into the portfolio of holding companies operating in several different markets with different degrees of risk which provided centralized financial engineering and managerial services. Finally foreign-owned manufacturing, milling, smelting, electrolytic refining, and mining companies, with their own high electricity demands, could sometimes spin off electric utility subsidiaries to service local markets with their excess capacity. Some countries were self-sufficient, importing equipment alone and developing systems of their own - Japan would be a good example of this kind of light autarchy. Japan

37. Hausman, Hertner and Wilkins, *Global Electrification*, 31-33.

completely embodied the new technology under state promotion and protection. The first and largest electrical engineering schools in the world provided one of the pillars upon which self-sufficiency in electric technology would be based and high technology electrical equipment exports would eventually be built.³⁸ However Japanese style self-sufficiency was exceptional: lighting technology spread across the face of the earth in large measure through capitalist, foreign enterprise through these four organizational conduits: manufacturer's satellites, free standing companies, holdings, and enclave enterprises.

Foreign investment was, however, an "obsolescing bargain."³⁹ Private companies - especially foreign owned ones - could not entirely satisfy the demand for service at prices deemed fair. The demand for light and power always exceeded the profitable capability of private companies to supply. Secondly, the perceived inadequate service combined with seemingly excessive monopoly profits stimulated populist resentments against foreigners which could be easily channelled into political forms. This raised political risk factors. But the fundamental problem faced by foreign investors is that the differential factor endowments that made foreign investment possible in the first place diminished over time. Whatever the foreign investors initially brought to the table - capital, technology, technique - the host countries gradually developed these attributes themselves over time. The production of light and power could thus be "domesticated," i.e. controlled and managed by local agents.⁴⁰

Sometimes this took the form of local buyouts: the replacement of foreign owners and managers by nationals - the cases of Italy and Spain would be typical examples as would the sale of the British Columbia Electric Railway and Shawinigan Light and Power to Canadian investors. However more frequently the state - either the national or regional order of government - became the agent of transformation. Before WWII in many countries, the state had acted as a permissive facilitator of private development, supplying the energy, fiscal stability and governance required. After the Keynesian revolution and the rise of development economics, states at all levels - municipal, regional and national - became much more interventionist as electrifiers in the name of progress. With greater access to capital (through taxation and/or borrowing) and active

38. H. Ushida, "The Transfer of electrical technologies from the US and Europe to Japan, 1869-1914," in David J. Jeremy, ed., *International Technology Transfer: Europe, Japan and the USA, 1700-1914* (Aldershot: Edward Elgar, 1991), 219-41. For the development of electrical engineering education in the US, Britain and Germany see Hughes, *Networks of Power*, 140-174.

39. The phrase is from Raymond Vernon, *Sovereignty at Bay: The Multinational Spread of U.S. Enterprises* (New York: Basic Books, 1971).

40. For a detailed discussion of relations between foreign investors and host countries see Armstrong and Nelles, *Southern Exposure*; McDowall, *The Light*.

social policies in the postwar era, the state could modernize systems and expand into underserved and frequently uneconomic areas in the interest of social and economic development.⁴¹ International agencies frequently noted the correlations between access to light and consumption of electricity per capita and levels of economic development.⁴² Thus states were encouraged and provided with large loans to expand state owned electric systems and electricity became an agent of social change. State borrowing on a grand scale on international capital markets and through agencies such as the International Monetary Fund, the Asian Development Bank and the World Bank replaced the much more limited earlier flows of private investment across borders.

This transition from private sector to public sector promotion of electrification had to some extent already occurred in some of the metropolitan countries in the postwar era. Soon after WWII European governments nationalized their electric industries with a view to improving social welfare and promoting reconstruction and economic growth. These large state-owned systems would in time create national grids which drew the full benefits of economies of scale and load balancing. Britain and France with The British Electricity Authority (1948) and Électricité de France (1946) respectively were the models of this form.⁴³

In this context it should be noted that this pattern of state owned electric enterprise with social and economic development objectives could be said to have started on a large scale in Ontario. The Hydro-Electric Power Commission of Ontario, founded in 1907, began operations a century ago in October 1910, with a mission to provide “Power at Cost” to the municipally-owned distribution systems of the province.⁴⁴ It grew into one of the most dynamic, large scale, regional or superpower systems and its success in social and economic development provided a practical though somewhat controversial model for the TVA in the US. In the postwar era many Canadian provinces adopted this provincial hydro model of economic development, most notably Hydro Quebec and BC Hydro. At about the same time state agencies in Brazil, Mexico, Argentina and many other countries took control of electrification with a mandate to promote social and economic development. Foreign direct investment and

41. For a detailed discussion of this historical process Hausman, Hertner and Wilkins, *Global Electrification*, 233-61.

42. For a detailed analysis of the correlations between GDP growth and electricity consumption in the U.S., see *Electricity and Economic Growth: A Report*, Prepared by the Committee on Electricity and Economic Growth, Energy Engineering Board, Commission on Engineering and Technical Systems, National Research Council (Washington: National Academy Press, 1986).

43. Hannah, *Electricity Before Nationalisation*, 329-56; Henri Morsel, ed., *Histoire de l'électricité en France*, Tome 3, 35-96.

44. Nelles, *Politics of Development*, 215-306.

domestic investment - public and private - spread the light before WWII. In the post-war era of economic expansion and international development public debt largely replaced foreign direct investment as state enterprises borrowed at home and abroad to promote mass electrification.

Eventually a countervailing reaction set in not against the brightening lights, but rather against the massive public debt being built up and the perceived inefficiencies of the integrated monopoly form of industrial organization. A wave of neo-conservatism aimed at reducing the size of the state, privatization of parts of the public sector, and deregulation has to some degree disentangled the vertical monopolies on the supply side. Privatization once again opened the door to foreign investment, though not on such a large scale as before. In some jurisdictions the functions of electricity supply have been unbundled. Competitive markets have been created in electricity generation and sales but not transmission and distribution. But this era of industrial re-organization, currently somewhat faltering, has not yet dimmed the lights although, as light has become more costly that may be one of the consequences.

Thus at the end of the twentieth century it could be said that the state and the automobile conspired to significantly brighten the night sky over many parts of the world. Where states are weak and/or automobiles scarce, the night continued to rule. Light, in turn, enhanced state power and authority.

Conclusion

Questions relating to what is now called light pollution and the future of light profligacy in an era of rising energy costs can be left for another day. For present purposes I hope that this brief meditation on the Second Enlightenment opens up some avenues for comparative historical investigation, especially with respect to the development of the demand for light, the social networks upon which steady light depends, and the mutual interdependence of technological and social systems.

Night is in some respects a thing of the past. Under a luminous sky, in dwellings where light can be turned on and off, we have replaced night with sleep. We close our curtains, draw our blinds and shut off our lights indoors to replicate night. And most of us do this at roughly the same time as our pre-modern ancestors. But while we sleep the global and local economies hum along uninterrupted under lights as bright as day. That is a bit of a puzzle too, when the light we create allows so many other options. This has happened without historians taking much notice. But the Robins have. Biologists tell us they've begun to sing much earlier in the morning.⁴⁵

45. Mark W. Miller, "Apparent Effects of Light Pollution on Singing Behaviour of American Robins," *The Condor*, 108, 1 (2006): 130-39.

I cannot help but think as I ponder this remarkably recent outpouring of illumination that we are by nature light emitting humanoids. To understand this Second Enlightenment we must think about light not simply in functionalist terms - for purposes of identification, security and mobility. We produce far more light than we need to serve those purposes. Light is also a form of art. We express ourselves with light. It is as much a part of our creative life as architecture. Our light is to mark our place and to say something about who we are and what we hope. We have turned on the lights as much out of pride as need. In the course of this burst of illuminated expressionism our planet glows in space.