POWER, OF LINES AND MAN: AN EXPLORATION OF OPPOSITION

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Human societies are defined by social behaviors and interactions, particularly those in those areas deemed to be in the commons. Limitations are often necessary to prevent destruction or overuse of these commons, as 19th Century Economist William F. Lloyd famously described (Clerke, 2012). In the modern era the dueling and overlapping commons of the local, technology, and the global have grown in noteriety. In the technical work, a solution to the overlapping uses of a communal space was constructed to ameliorate some of these duels. By contrast, in recent years these duels have become increasingly apparent in power transmission. In both the American West and Maine projects to decrease dependence on fossil fuels by transmitting renewable power to urban centers have faced concerted local opposition in the rural areas the lines pass through. Desires of many to move towards renewable power such as Quebec Hydro or Wyoming Wind, are conflicting with those who have high power transmission lines pass through their locality causing impacts on their natural systems and other existing features (Roth, 2022) (Sharp, 2022).

This Science and Technology in Society (STS) research thesis explores the historical contexts of electrification and high power transmission lines, present conditions, and thought concerning opposition to such lines in a North American context, looking broadly and at the particular instances of California, the region around the Niagara River in Ontario and New York, and the American Midwest. The loosely coupled technical work concerned the design and implementation of a networked display easing communication and scheduling in multi-use spaces. The STS research examines changes in social attitudes amid the changing contexts of the past century using Actor Network Theory and Social Construction of Technology (Bijker, 1987) (Serres, 1995).

The interactions between these competing interests can be broken down in many ways, for the purposes of this paper two will be used, Actor-Network Theory (ANT) and Social Construction Of Technology (SCOT). Actor-Network Theory is a method for analysis wherein the constituent persons or groups in a system are rendered as *actors* working within a *network* or *networks* ultimately creating or shaping the overall system (Serres, 1995). Social Construction of Technology by contrast is a method of analysis wherein technology is viewed as the product of a broader sociological forces cooperating to construct a technological system, described as to include common norms or bureaucracy around it (Bijker, 1987).

A BRIEF HISTORY OF ELECTRIFICATION

ELECTRIFICATION IN DIFFERING JURISDICTIONS

In analysing the context of and opposition to high speed transmission lines, it is helpful to look at electrification and the manner in which electricity originally became a common fixture in modern life. To this end the cases of electrification in California, and the creation of generation and transmission capacity around Niagara on the US-Canadian Border will be explored.

In the Californian case, electrification took place relatively early compared to other regions and was highly developed even within rural areas (Williams, 1998, p. 13). This development was facilitated by readily accessible hydropower, and high connection and utilization rates even within rural and agrarian regions (Williams, 1998, p. 14). Williams (1998) also directs us towards one of the most fundamental parts of electrification, commercial benefits from newfound business applications (pp. 15-18). These applications varied, but included warming crops and enabled a revolution in the poultry industry with greater yields of breeding chicks (pp. 16-17). In California electrifiction was seen by farmers as a boon making the

"arduous task of agricultural endeavor mere child's play" (Williams, 1998, p. 13) . Though this perspective would come to change, the overwhelmingly positive view the farmers of California had to initial electrification is vital to understanding later rural inhabitants attitudes towards power infrastructure.

When analyzing the Niagaran power generation case, context is key, both in the trans-national nature of the power generation of that mighty river and of the circumstances in the surrounding area at the time of said generation's construction. Spinak (2020) informs us of the early recognition in the late 19th century of the power generation capabilities of the Niagara river, feeding the famous falls of the same name, and the potential development that it could spark the relatively unindustrialized areas of southern Ontario (pp. 76 – 79). The Niagaran case contrasts between public ownership oriented Canada, and private service oriented New York. Ontario, driven by internal desire for energy independence and freedom from corporate monopolies, moved towards an "at-cost" system of pricing from a state-operated utility, Ontario Hydro (Spinak, 2020, pp. 76-81). In doing so the Ontarians created a system that was more directly accountable and therefore one more devoted to broad rural adoption, implementing systems like flat rates. By contrast the American system was one of regulation of private power monopolies (Spinak, 2020, pp. 85-88). This lead to higher costs and lower utilization amongst un-subsidized rural consumers (Spinak, 2020, p. 82)

SETTING LINES ACROSS OTHERS

In examining the context of power distribution and its history interconnects play a central role. Interconnects, connections between power grids, have been central to addressing growing electrical demand in addition to acting as nexuses of systems where the demands of communities

and their needs differ, as in the case of the Pennsylvania New Jersey Interconnect (Singer, 1988, p. 20). The Pennsylvania New Jersey Interconnect (PNJ Interconnect) was the first high voltage transmission line between different companies, builtin the 1920s between the states of Pennsylvania and New Jersey, and centered about the city of Philadelphia (Sanger, 1988, p. 20). Devised to enable the sale of power, much of which being hydropower, between several privately held utilities, the PNJ was built over the ashes of several previous attempts in the 20s at a power interconnect that failed for a number of reasons both technical and bureaucratic (pp. 23-25). These prior initiatives ran into several issues, two of which were dominant in their failure and a third that foreshadowed future circumstances.

The first issue lay in the multi-jurisdictional nature of interconnects. As inter-state transmission lines the interconnects were subject to federal regulation in addition to the local and state regulation that the companies were accustomed to (Singer, 1988, pp. 20-22). Competing interests amongst lobby groups and federal regulators themselves, particularly as pertaining to adminstrative frameworks, would stall out proposals and prevent action from being taken (Singer, 1988, pp. 20-22). This lack of a clear regulatory framework hampered technial development and implementation, and is important to remember in the context of the physicality of power transmission infrastructure.

The second issue lay within the competitive nature of interconnects between private corporations. Several separate companies, or groups of companies, sought to construct interconnects or analagous systems (Singer, 1988, pp. 23-26). Though the competition would normally be welcome, physical and financial constraints made competition detrimental to actual construction of a system and caused these groups to actively sabotage one anothers efforts (Singer, 1988, pp. 23-26). This internal fighting due to selfish motives amongst groups otherwise

in favor of interconnects is vital to understanding competition amongst power producers as well as the views that power generators and transmitters take towards their own infrastructure.

The third, less prominent, issue was linked to environmental concerns. Though such concerns did not play a central role in the death of several of these would-be interconnects, the hostility of a Pennsylvanian governor and conservationist towards hydropower's destruction of the environment in addition to the monopolies held by these power companies (Singer, 1988, p. 22). Though this hostility was not solely grounded in environmental concerns, it would indicate that such concerns were increasingly common to see in the halls of power, and such complaints would be able to find fertile ground in the future.

Regulatory Status

In addition to the historical context of interconnects, it is valuable to examine the present regulatory conditions regarding power. Gardner (2015) examines these regulatory conditions in the context of wind power and found a number of measures need be taken to centralize authorities and improve coordination and evaluation of power infrastructure (pp. 279-285). Existing regulations and understandings are insufficient, and often result in repeated efforts due to multiple overlapping layers of regulation, particularly concerning the siting of power transmission lines (Gardner, 2015, pp. 281-282). This fact is magnified by the inflexibility of existing grid systems, and the anticipated need for greater flexibility and transmission capability to accommodate wind power (Gardner, 2013, p. 250).

TECHNICAL CONCERNS

GENERATION POTENTIALS

In analyzing the concerns surrounding contemporary power transmission and its infrastructure the relevant technical concerns in implementation must be examined. At a fundamental level the core issue of the contemporary era is the mismatch between the places where people are and where power generation capabilities are the greatest (Brooks, 2022, p. 23). A notable example of this can be seen in Figure 1, wherein the areas of greatest wind power potential are in the low density states of the Plains, Mountain West, and Southwest, largely away from significant population centers.

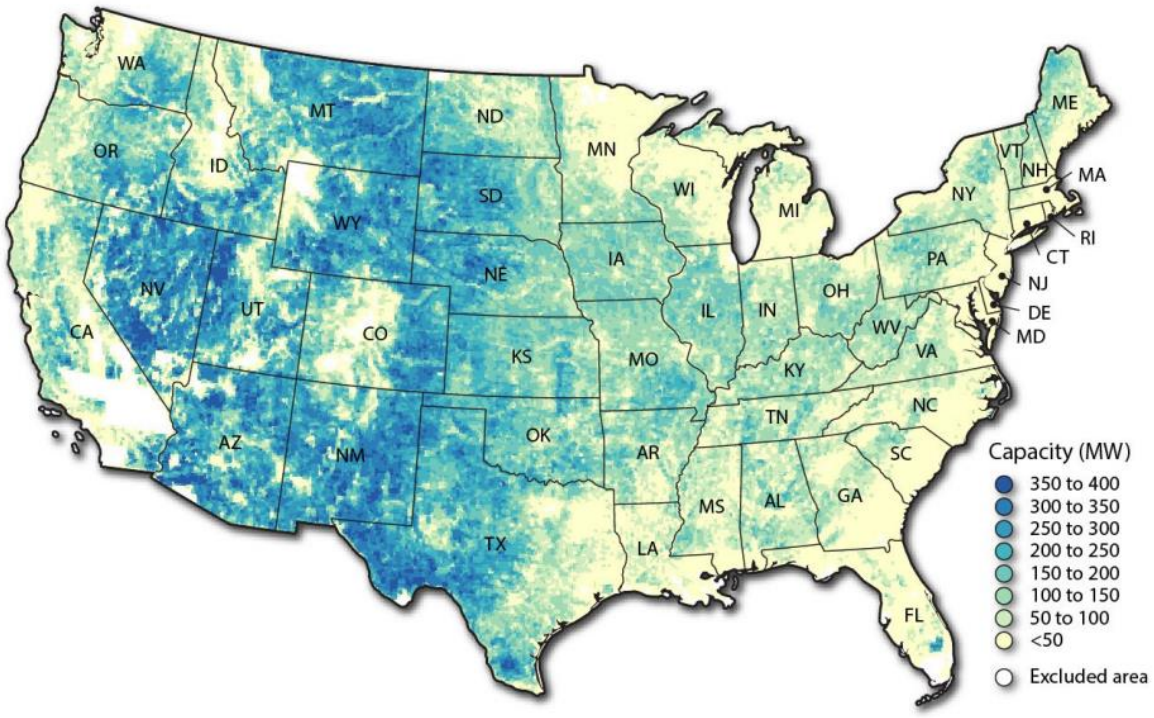

Figure 1: Technical Capacity for Land Based Wind. The engineer negotiates and balances the interests of the groups. (Brooks, 2022, p. 23)

The massive potential of renewable energy within the United States, 434,000 Terrawatt-hours, an over 100 fold increase over the 2021 national energy production of 4,000 Terrawatt-hours cannot be understated (Brooks, 2022, p. 3). Increased availability of power at low cost has been behind human advancement for centuries, and clean abundant power allows the elision of a number of economic concerns. This incredible potential poses a key issue, how to get this energy from the areas where it is generated, often low density rural expanses, to the places where it can be used, urban population centers. As noted in Brooks (2022), "developing such renewable energy resources … together with an identification of any barriers to providing adequate transmission for remote sources of renewable energy resources to current and emerging markets, recommendations for removing or addressing such barriers, and ways to provide access to the grid" (p. iii).

THE FORM OF OPPOSITIONS

The First Fights

Early modern opposition to power transmission infrastructure is best exemplified in the Rural Revolts of the 1970's against high power transmission lines. These revolts were novel for a number of reasons, an environmentalist character, a rural base, and broad mobilization on regional bases (Tate, 2021, pp. 2-4). The revolts were against high power transmission lines specifically, though the purposes of such lines varied depending on circumstance (Tate, 2021, p. 4). This opposition was descendant of historical rural opposition to new technologies, like the telegraph several generations prior or electricity generally in the previous generation, but with a newfound environmentalist character in part attributable to the activism of the late 60s and early 70s (Tate, 2021, pp. 4-7). This activism broadened protesters reasoning as Tate (2021) explains, "What may have once started as [Not In My Back Yard] concerns about the siting of the powerline soon evolved into broader political critiques of the 'energy system'" (p. 5).

More than mere opposition for its own sake the rural revolts generated their own cohesive philosophy for opposition to power trasmission lines. Broadly grouped under the label "Alternative Technology Beliefs" there was a general skepticism of large corporations, a desire to preserve land as it was, a belief that projects need to benefit all they impact, and a desire for technology "with a human face" (Tate, 2021, pp. 5-7). These protestors opposed high tech power lines incomprehensible to the layman being built by large external groups that would impact their localities without providing economic or other benefits. As a general guideline these groups saw small as better, and challenged conceptions of large infrastructure projects as inherently modern (Tate, 2021, pp. 16-18).

This rural opposition was not abstracted by itself however, and did encounter and interact with engineers and managers from the power companies. This interaction demonstrated a clear chasm in conceptions of technology between the groups with management prioritizing efficiency, cost, and interconnectedness. With local groups viewing pricing and their environment as primary concerns (Tate, 2021, pp. 10-16). The two groups had irreconciliable conceptions of what the purpose of power utilities was, and how best to achieve it, with rural groups favoring greater regulation of utilities while management viewed infrastructural projects as vital to their core business of providing power. It is this difference that is examined when looking at competing interests surrounding power transmission infrastructure, and the values of the rural revolters, often called "bolt weevils" for their promises to sabotage infrastructure, are the clearest antecedents to modern opposition (Tate, 2021, p. 2).

Reasoing of Modern Opposition

Beyond the historical opposition of the rural revolts, there are a number of causes of modern opposition to power transmission lines including aesthetic, ecological, and justice. As regarding aesthetic concerns Oosterlaken (2014) proposes the use of value sensitive design (VSD) as it pertains to wind farms and their accompanying transmission infrastructure to reduce opposition (pp. 359-360). Value sensitive design is a design philosophy focused on the manner in which objects are reflective of societal values. Oosterlaken (2014) takes this stance as an advocate against the common characterization of opposition to wind farms as NIMBY (not in my back yard), arguing that rather than participatory processes being needed to help integrate opposition's concerns, "VSD may be helpful to achieve a responsible, socially acceptable implementation of wind energy" (p. 360). Oosterlaken's approach here is useful in considering how the implementation of power infrastructure is a values judgement, and much of the

opposition comes from a percieved conflict in values. Much like neighborhoods where pastel siding is considered beyond the pale, aesthetic concerns many alleged NIMBYs concerns about wind power are grounded in local norms.

Wuebben (2017) explores the trade offs of the visiblity of power lines and the impact of burying or otherwise removing them (pp. 55-56). In a personally conducted study concerning a park proximate to a substation, and entailing transmission lines, comments and attitudes were solicited about aboveground lines, and though a majority accepted existing lines their appearance inspired an intolerant attitude in a number of respondents moved to comment further (Wuebben, 2017, pp. 56-58). Wuebben's work is useful for displaying the varying attitudes towards power lines in communities, particularly of begruding toleration, as well as the depth of opposition that such lines can inspire.

Hess, McKane, and Pietzryk explore environmental justice concerns, and broader reasoning for opposing power transmission lines (Hess, McKane, and Pietzryk, 2022, p. 663-664). Of particular note is a breakdown of reasons for opposition with impacts to property and health and safety at the forefront, 73% and 71% of respondents respectively (Hess, McKane, and Pietzryk, 2022, p. 674). In addition Hess, McKane, and Pietzryk (2022) approach oppostion from the perspective of justice, a broad term here construed to mean just outcomes in the near term (pp. 666-669). This framework is useful in drawing antecedents to the rural revolts and conceptions of fair treatment and equal participation.

CONSIDERATIONS

When designing infrastructure it is important not only to consider local opinions, but also those of expert technologists. Ribeiro (2012) examines the potential future of grid infrastructure, particularly "smart grids" and how to best both implement them while addressing external

concerns (p. 35-39). In combining grids into greater overarching systems there are concerns of complexity, likely to be addressed technologically, and there are concerns of society whcich must be addressed more personably and actively (Ribeiro, 2012, p. 42). Infrastructural design is not merely technical, and though the Values Sensitive approach favored by Oosterlaken (2014) has merits it has yet to reach common use.

Likewise, Gardner (2013) raises points about regulatory isolation of communities from broader grids due to improper incentives as in distance sensitive rate-setting (pp. 267-268). This is an important factor in analyzing the demands of end users of electricity, as cost is often a driving factor in complaints towards electrical infrastructure and its providers. Furthermore, it reminds of the interplay that seemingly inactive groups like regulators can provide in the contextualization and construction of technologies.

ANALYZING INTERACTIONS

In analyzing competing interests over power transmission with SCOT, it is helpful to use a diagram to break down the system into several parts all of which contribute to and are impacted by the ultimate technological system. In this instance Figure 2 depicts this social construction, with engineers here acting as a stand-in for the general designers of the power transmission system being interacted with by four primary stakeholders (Dolan 2022 *SCOT Model*). The four stakeholders, power generators, power utilities, end users, and local populations, best shaping the overall power transmission system. The goal of the whole power transmission infrastructure is to transpower electricity from the generators to the end user, the population local to that infrastructure and the electrical utility also play key roles.

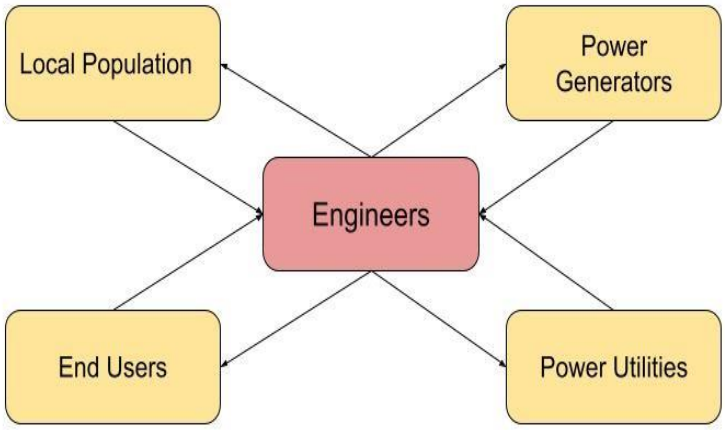

Figure 2: Power Transmission Line SCOT model. The engineer negotiates and balances the interests of the groups. (Adapted by Dolan (2022) from Carlson 2009)

Analyzing competing interests with Actor Network Theory requires a different understanding of the overal system. Rather than a hub and spoke, as in SCOT, ANT is perhaps better understood as a web. In Figure 3 below such a web is depicted between the actors all

centered about the creators of the technology, here abstracted to “Engineers” (Dolan, 2022 *ANT Model*).

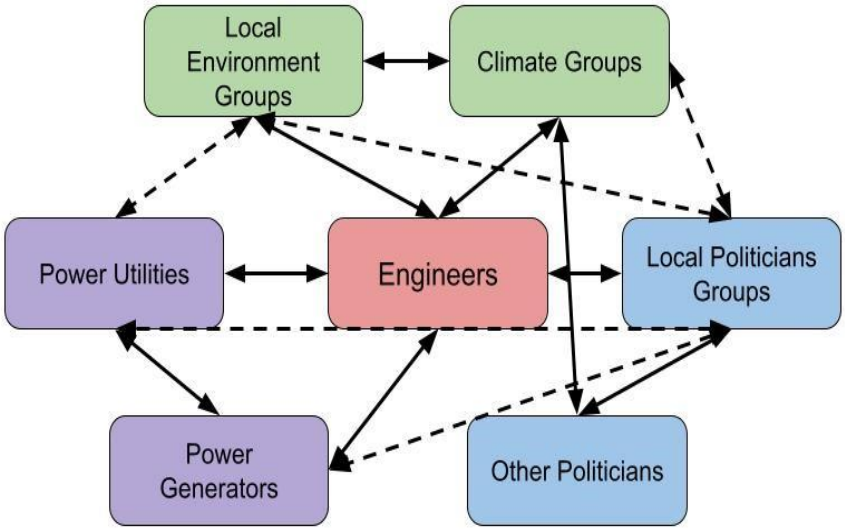

Figure 3: Power Transmission Line ANT model. A network of groups interacts regarding a technology. (Adapted by Dolan (2022) from Carlson, 2009)

Such a model is useful because the interactions between groups outside of the context of power lines can be futher modeled. In this instance the interactions between rural groups and their power utilities prior to the revolts of the 1970s allow us to be given greater context as to why the two behaved during as they did during those revolts. Likewise in a broader context environmental groups and local groups interacted with common language, with different areas of percieved responsibility and interactions with political figures. As a complex web, ANT allows the viewer to see the manner in which historical actions between groups, amiable or otherwise,

influence their perspectives on shared points of contact such as how power generators and utilities will have slightly varying views on power transmission lines.

WHERE WE ARE GOING

Examining the motives of various groups concerning power transmission infrastructure, seeing the evolving stances of local groups stances towards said infrastructure is vital as their direct relationship pivots about it. Early, within the Californian context, power lines were appreciated as bringers of modernity. This changed as lines increased in scale and decreased in direct local benefit with the rural revolts of the 1970s growing out of the activist impulse of that same decade. These changing views have been slowly adapted to with systems such as value sensitive design, but technologists and utilities have been slow and ill equipped to respond forcefully and eloquently to their detractors. Local opposition to power lines centers about local environmental, aesthetic, and justice concerns.

While several systems to address the concerns have developed from the academic value sensitive design to the money focused solution of payment seen in Wyoming (Roth, 2022), none have yet been adopted as industrial best practice. From the perspective of the technologist, solutions to address opposition are very specific to individual cases or landholders. Though local groups often view the construction of power transmission lines as a matter of justice, engineers and corporations have yet to come up with a systemic manner of creating a just outcome. Though a great deal of information on these cases can be found in journalistic writings, there is relatively little currently examining these circumstances within the academy. Overall this is a largely unexplored field, with even industry journals of the IEEE largely devoid of content concerning the contentious nature of the 1970s rural revolts, let alone more modern events. The dearth of

such literature does not indicate a lack of forethought, or ideological work, on the behalf of opposition groups, but rather an ongoing misapprehension of the societal impact of their work on the part of engineers and utilities.

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