Infrastructure and the Energy System: Historical Perspectives on the Tide-Water Pipeline

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Abstract

System lock-in and inertia constrain social energy choices. We know that continued use of oil and coal exacerbates climate change, geo-political instability, and unequal distributions of wealth, and yet we continue to increase our consumption. Why are we so addicted to fossil fuels? An extremely significant—and poorly understood—reason is the technological infrastructure of energy. We use fossil fuels because billions of dollars and decades of effort have been devoted to making coal, oil, and natural gas cheap, reliable, and widely available. At the same time, society has not chosen to invest in infrastructure for renewable energy sources, thereby creating a system where these technologies are not considered viable alternatives. To overcome the strong incentives favoring fossil fuels, society must create technological infrastructure that will encourage the use of renewable energy resources.

This paper explores the role of energy infrastructure in society by theoretical discussion of infrastructure as a particular type of technology with a case study drawn from the history of oil—the building of the Tide-Water pipeline. The conclusion integrates these sections and suggests ways of thinking about energy infrastructure that will be helpful in making human-directed changes to our energy system.

Introduction

The theme of this conference is “Transforming the Energy System.” In support of this ambitious and admirable goal, I would like to use my paper to direct our attention to the importance of infrastructure in perpetuating existing energy usage patterns. It has been my experience that the role of infrastructure has been underappreciated by scholars, political actors, and citizens in debates over our energy future. Drawing on my historical research, this paper raises critical questions about the nature of energy infrastructure and its relevance to this conference’s theme.

This paper is broken into three sections. The first explores critical issues in understanding infrastructure and its relationships to our energy system. The second section grounds this analysis in a historical case study—the building of the world's first long-distance oil pipeline. The final section contains a discussion integrating the first two sections and suggesting ways to move forward.

Some Characteristics of Infrastructure

Infrastructure should be understood as a particular class of technology. Although it is similar to many other technologies that historians of technology and STS scholars have analyzed, it has some of its own features that are distinctive and worth noting. I will sketch out a few of these features in this section, including its relatively invisibility, its durability, and its enabling power.

Before identifying the features of infrastructure that are distinctive, it is important to note that these are socio-technical systems, just like any other technology. As historians and sociologists of science have demonstrated repeatedly, technologies are more than just their physical parts. They involve a variety of people, such as engineers, capitalists, politicians, citizens, and users. Technologies involve organizations, including corporations, regulatory agencies, industry associations, and consumer groups. They are embedded in a social system involving laws, norms, and market structures. All of these factors apply to infrastructure as well.

However, infrastructure is not just like any other technology. One reason is the relative invisibility of infrastructure. These projects are typically massive, involve huge expenditures of capital, materials, and expertise, and transform the built environment. Our daily lives are dependent upon the smooth operations of these systems, whether it is the transportation networks that enable the flows of people and goods, sewage systems that remove and process our waste, or electrical grids that power everything from laptops to household appliances to security systems. Life as we know it could not exist without infrastructure.

Such considerations would make it seem likely that scholars, politicians, and citizens would be acutely aware of infrastructure and its social importance. Yet this is not the case (at least in America). While times of crisis—such as the electrical blackout that left New York City and much of the north-east without power for a couple days in the summer of 2003—may temporarily raise the public perception of infrastructure, the attention disappears once the next big news story strikes. This pattern makes infrastructure a peculiar beast—its social importance is not matched by corresponding social attention. One of the primary characteristics of infrastructure is its relative invisibility.

This claim of invisibility is, of course, relative. I am basing this on anecdotal knowledge of American political and academic culture. I also do not mean to imply that no groups are aware of the importance of infrastructure. There are exceptions to the rule, including certain people in business, government, and the university. Urban planners may be the group most aware of the impact of infrastructure, as they must deal with the constraints infrastructure places on their designs everyday. Despite these caveats, the overall attention that infrastructure receives is far less than its social importance should warrant.

Infrastructure is also distinctive because of its durability. Infrastructure is built to last a long time—often 50 to 100 years or more. This means it is not only significant at the time of its construction, but through the course of its useful life. For example, building a coal-fired power plant today means that at least a thirty-five year supply of coal will be required. Our current decisions about coal usage are still being shaped by decisions several decades ago to invest in coal-fired power plants. Future transportation patterns are heavily structured by past decisions about where to build roads and rails. In other words, infrastructure matters not just at its time of construction, but through its entire lifetime (including when it becomes obsolete). Having a thorough understanding of infrastructure, therefore, requires paying attention to the full life-cycle of these technologies.

The durability of infrastructure raises a number of analytical and methodological challenges that must be addressed if we are to properly understand infrastructure in society. First, as scholars, we tend to study things that are new. After all, new is sexy, and sex sells, even (perhaps especially?) in academia. Second, STS and history of technology also have methodological tools to study new technologies, namely social constructivist models derived from the Social Construction of Technology (Bijker, Hughes & Pinch eds. 1987, Bijker & Law, eds. 1992). Both of these factors, I believe, help explain the fact that the majority of technology studies performed within STS and history of technology study the design and development of technologies, versus their ongoing social impacts over time. A similar point has been raised by David Edgerton in his recent book *The Shock of the Old* (Edgerton, 2007).

Another characteristic of infrastructure is that it encourages certain types of activity. At the most basic level, infrastructure makes certain things easier to do. Bruno Latour offers a few straightforward examples of this phenomenon in an article that describes the ways technologies alter human behaviors (Latour, 1992). He notes, for example, that people have a tendency to leave doors open or drive without seatbelts. While one way of changing these behaviors would involve educating people and trying to change their approach to doors and seatbelts, this would obviously involve a lot of effort. On the other hand, designing technologies that make it difficult to engage in these behaviors can be a lot easier. Self-closing doors and automatic seatbelts can alter this behavior much more simply, because it means it takes a person more effort not to shut the door or put on a seat belt. One point of his paper is to suggest that people tend to take the path of least resistance, and that technologies can make things easy or hard. Infrastructure operates in this way, only at a much bigger scale. A network of highways makes it easy for goods and people to travel between certain cities. Oil pipelines make it easier to transport oil across the globe. Mass transportation networks make it easy to live without a car. Electricity transmission wires make it easier to build centralized power stations.

The enabling nature of infrastructure may seem obvious, but it brings with it a host of unintended consequences. Making certain things easier to do makes other things relatively more difficult. If you build an oil pipeline it lowers the cost of transporting oil. This means that alternative energy sources such as wind and solar power are economically disadvantaged because they become more expensive *in relation* to oil. A choice to do things one way is also a choice *not* to do things other ways. When studying infrastructure, therefore, we must ask questions about how doing things a certain way disadvantages alternative approaches. Second, making things easier to do can create a feedback loop reinforcing the original behavior. Historically, the result of every increase of energy availability since the Industrial Revolution has had the unintended consequence of increasing demand. Whenever new amounts of energy have been supplied, people have found new applications for the energy, which leads to increased demand. Therefore, energy infrastructure that supplies energy has the unintended consequence of leading to increased demand. Building energy infrastructure, therefore, involves a commitment to continually expanding the system.

Putting all of these factors together, we see that infrastructure are socially constructed technologies that shape people's behaviors for long periods of time in a fairly invisible manner. Seen from this perspective, technologies like pipes and wires take on a much greater significance than we are accustomed to giving them.

Historical Example—The Tide-Water Pipeline

Theoretical discussions of infrastructure's characteristics are useful, but we should also ground these discussions in the complexities of the real world. In this section, I will relate a brief history of the building of the world's first long-distance oil pipeline. The building of the Tide-Water pipeline in 1879 marked a significant moment in the history of the oil industry and is a fascinating tale of business struggle and technological development. It also marked the beginning of the transportation of oil via pipelines, a transition which continues to enable society's addiction to petroleum.

Let me begin by indicating the role of transportation in the early oil industry. Simply put, the transportation of oil has always been about far more than the movement of liquid. Control over transportation has always given certain groups disproportionate power within the industry. When oil production began in 1859, storing and transporting oil quickly became central problems. The teamsters were the first group to obtain control within the industry, using horse-drawn wagons and barges to transport barrels of oil to market. The teamsters were widely reviled within the oil regions because of their exorbitant charges and propensity for drinking and fighting. However, because there was no other way to transport oil, their presence was tolerated. The next revolution in the transportation of oil arrived with the introduction of gathering pipelines and railroads in the mid-1860s. Gathering pipelines were short, small-diameter pipelines that shipped oil from the well-head to railroad depots. Railroads then shipped the oil to markets in Pittsburgh, Cleveland, Philadelphia, and New York. These technologies replaced the teamsters and ushered in a short period of relatively open competition within the oil industry.

This balance was soon overturned by the rise of Standard Oil. John D. Rockefeller's company became a monopoly player in the refining of oil using control over transportation to reinforce and strengthen his position. Beginning in the early 1870s, Standard Oil began a two-pronged approach that gave it control over oil's transportation. First, it began purchasing all the gathering pipeline companies. Second, it negotiated deals with the major railroads ensuring that it received spectacular discounts on its oil shipments. Rockefeller was able to achieve these discounts based on the volume of his oil shipments, his control over the gathering pipeline network, his negotiating prowess, and his ability to end rate wars on oil between the railroads. The savings that Standard Oil gained on transportation filled its treasury enabling it to either purchase competitive refineries or bury them through rate wars. By 1878, Standard controlled an estimated 90% of the nation's refining capacity. At this time, a typical barrel of oil would be pumped by an independent producer and sent into a Standard-controlled gathering pipeline to be stored in a Standard-controlled iron tank then shipped to a Standard-controlled refinery via a Standard-controlled railroad and sold to consumers through a Standard-controlled marketing group.

Independent oilmen—the majority of producers and the few remaining refiners—protested this state of affairs through a variety of mechanisms including political lobbying, lawsuits, organizing campaigns, and technological innovations. A long-distance pipeline was a persistent hope of oil producers as long as it was not controlled by Standard Oil. Several efforts to build such a pipeline had been undertaken in the 1870s, but all had failed as a result of insufficient capital and competitive pressures. Therefore, when a group of men led by Byron Benson proposed a new pipeline in the fall of 1878, they received a skeptical response. The plan was to build a pipeline from Coryville, at the edge of the prolific Bradford field, to Williamsport, where the Reading Railroad would ship the oil to independent refineries in Philadelphia and New York. Because the tracks of the Reading Railroad did not extend to western Pennsylvania, the company had not entered the oil trade and was therefore not in cahoots with Standard Oil.[1] In return for the opportunity to obtain lucrative oil shipments, the Reading Railroad supplied half the capital as well as its significant political clout. In November of 1878, the Tide-Water Pipe Company was incorporated and began raising funds. Construction began in February of 1879.

The building of the pipeline was an epic endeavor, combining geographic, technical, and competitive pitfalls. The physical landscape proved a major challenge as the pipeline would need to lift oil over 1100 feet to cross the Allegheny Mountains while winding up and down cliffs and valleys. Construction supplies had to be carted by wagons several miles through dense forests on primitive roads. An especially harsh winter generated snow banks five feet deep. Many technological challenges had to be faced as well. New pumps had to be developed in order to power the oil over the mountains without exceeding the pressure limits of the wrought iron pipes. Because no one had worked with such long and heavy pipe lengths before, new tools such as pipe tongs had to be invented to complete the work. The company also faced a variety of competitive pressures. The greatest challenge was obtaining rights-of-way all the way to Williamsport.[2] Standard Oil sought to buy a north-south blocking path that would bisect the east-west pipeline, but Tide-Water secured a narrow path through clever legal strategies and the use of false surveying teams to hide the true path of the pipeline. Competing railroads offered any resistance they could by delaying shipments of supplies and attempting to block the pipes from being laid under their tracks. The combination of these challenges led many in the oil regions to dub the project "Benson's Folly."

Despite the many challenges, the pipeline was completed by May of 1879. The pumps were started on May 28th and oil arrived in Williamsport on June 4th. It was a great success for the Tide-Water company and proved the feasibility of shipping oil via pipelines. It signaled the beginning of the end for railroads in oil transportation and opened the door for a new age in the industry. However, the fact that the pipeline could ship oil over the mountains did not guarantee that the Tide-Water company would be able to profit from its pioneering efforts. As soon as the pipeline was completed, the company faced a renewed onslaught of competitive challenges. The railroads slashed their rates on oil shipments in an attempt to force the company into bankruptcy. At the same time, Standard Oil bought the remaining few independent refineries in New York City that had agreed to buy oil from Tide-Water. These pressures forced the company to operate at a loss for its first six months and to take out heavy loans in order to construct its own refineries. The railroads eventually relented in their rate war when they realized the Tide-Water company would not fold, and a partnership agreement was reached allocating a set share of the oil traffic to the pipeline.

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[1] The railroads that dominated the oil trade in collaboration with Standard Oil were the Pennsylvania Railroad, the Erie Railroad, the New York Central Railroad, and the Baltimore & Ohio Railroad.

[2] Pipelines, unlike railroads, did not have eminent domain rights at this date.

With the ending of the railroad rate war and the building of its own refineries, the Tide-Water company established itself as a significant player in the oil industry, and the main challenger to Standard Oil's dominance. Tide-Water began expanding its operations and extended its pipeline further east in the winter of 1881-1882. Paying its competitor the highest form of flattery, Standard Oil began the construction of its own network of pipelines connecting its refineries in Cleveland, Pittsburgh, New York, Philadelphia, and Baltimore to the oil regions. Within five years, Standard Oil owned more than a thousand miles of long-distance pipelines. At the same time, Standard continued to attack its competitor. Two cases involving the management of the company—one in 1882 that accused the company of fraud at a time it was raising money and another in 1883 that involved an illegal coup by a group of minority stockholders—had strong ties to Standard Oil and required legal intervention to protect the original directors.

The independent struggle of the Tide-Water company ended in late 1883. For a variety of reasons, the company's directors decided to end their struggle against Standard Oil and enter a pooling arrangement. Under the terms of the agreement, Tide-Water would receive 11.5% of the shipments from the oil regions—a number roughly equal to the pipe's capacity—but agreed not to expand its operations. This agreement guaranteed that the Tide-Water company would go on to profit handsomely in the future but would never again be a competitive threat that might undermine Standard's control of the industry.

There are several important features of the Tide-Water pipeline worth noting. The Tide-Water pipeline's history reveals the social power dynamics that shape the development of many energy transportation technologies. The introduction of a long-distance pipeline was not simply part of a quest for cheaper ways of transporting oil. It was the centerpiece of an assault on Standard Oil intended to alter the competitive dynamics of the industry.[3] The Tide-Water company took advantage of the new pipeline technology to carve a space for itself within the industry. Standard Oil recognized the profound threat pipelines represented to its interests and moved quickly to appropriate the new technology by attacking Tide-Water and developing its own network. The railroads did not adapt to the new technology and lost their role in the oil trade. Similar dynamics are present in the industry today. Pipelines remain a source of power, and choices about ownership, routes, and government regulation still have cascading effects through society. The Tide-Water pipeline example enables us to see many of the issues involved and suggests helpful questions we might ask about pipelines currently under consideration.

This case study also reveals the important role played by governments in structuring market conditions. Pipelines were at a distinct legal disadvantage vis-à-vis railroads because they lacked eminent domain privileges. As a result, a company wishing to build a pipeline had to purchase unbroken rights-of-way for many miles, leaving them subject to being blocked by competitors, harassed by railroads, and extorted by local landowners charging obscene fees for the use of small pieces of land. Legal efforts to achieve such rights were consistently defeated by the combined strength of Standard Oil and the railroads, which saw proposed measures as a threat to their interests. Standard Oil and the railroads were able to parlay their financial strength and monopoly positions into legislative influence that would help ensure the status quo. As a result, the actions of the Pennsylvania state legislature—by giving eminent domain privileges to railroads and not to pipelines—structured market conditions in favor of entrenched interests.

[3] In this manner, it can be understood as an example of a disruptive technology as described by Clayton Christensen (Christensen, 1997).

We must pay attention to the role governments play in encouraging certain types of energy infrastructure and thereby discouraging alternative possibilities.

However, the most significant effect of the Tide-Water pipeline was the fact that it initiated a revolution in the transportation of oil that still influences our world today. Its construction spurred Standard Oil to create its own network of pipes and abandon railroads as transporters of crude. Within five years of the building of the Tide-Water pipeline, three-quarters of the oil transported from western Pennsylvania flowed through pipes. In today's world, almost all of the overland transportation of oil continues to flow through pipes, a direct legacy of the Tide-Water pipeline.

There have been many long-term effects of this transition, although it is often difficult to trace direct connections. This is an area of my research that I am just beginning, and I would greatly appreciate suggestions. Let me mention a few angles of analysis I am thinking of pursing. One effect of the pipeline transition was to lower the price of transporting oil. I believe this has been especially important in the twentieth century as oil has been discovered in increasingly remote regions. My hypothesis is that oil fields in places like Alaska and the Middle East have been developed much more quickly because pipelines have reduced the economic significance of geographical distance. Another idea is that by lowering the cost of transportation, pipelines have made oil cheaper for consumers. This has resulted in increased use of oil and a search for new ways to use it, such as in motors and as fuel oil. Perhaps as a result of both these factors, one of the unintended consequences has been to make oil *too easy* to use. Until recently, this was seen as a good thing. However, with the clear linkages between oil and global climate change and undesirable geo-political relationships, easy oil has become a problem, not a benefit.

Discussion

The history of the Tide Water pipeline is a rich case study that can contribute to our present understanding of the energy system and how we might transform it. I will conclude this paper by suggesting a set of critical questions to apply to future infrastructure projects, examining current pipeline developments, and discussing the possibilities and constraints infrastructure offers for transforming our energy systems.

Historical study never leads directly to current-day policy recommendations. However, it can lead to a much more reasoned and informed debate that leads to socially desirable outcomes. One of the main ways it can accomplish this goal is through suggesting questions that should be asked. Based on my research, here are a set of questions that are worth asking about any future infrastructure developments: Who pays for it? Who profits from it? How is it likely to affect the structure of the industry? Who will receive energy and who will not? How long will the infrastructure commit society to using a particular type of energy? What are the alternative energy sources that will be disadvantaged by the project? Will the infrastructure be a social benefit or detriment in 50 or 100 years?

We can also apply some of these issues more directly to the oil pipelines that remain a vital component of our current energy system. The Tide Water was the most ambitious and technologically complex pipeline of its day. It can be compared with the recently completed Baku-Tbilisi-Ceyhan pipeline from the Caspian Sea to the Mediterranean or the proposed Nord Stream Gas pipeline. Remembering the history of the Tide Water pipeline, one of the first questions we should ask about these pipelines concern the power dynamics in their construction. As one of the most contentious issues is the route of the lines and which countries they pass through, we should examine the ramification of these decisions for geo-politics. In addition to the financial incentives certain nations receive for land rights, we should also be attentive to the power a country gains or loses politically by having the pipeline cross its boundaries. We should also be aware of the negative environmental costs for these nations. At the economic level, we should also pay attention to the perceived impacts of the pipeline on the oil industry. Will it reinforce the dominance of the major companies or will it create a more level playing field? We should also examine the potential long-term impacts of the pipeline. Will it be able to satisfy existing demand or will it simply lead to an increased dependence on oil?

Finally, if there is one thing you take away from this paper, I would like it to be an appreciation for the ways energy infrastructure shapes our energy system, for better and worse. People have a strong tendency to do whatever is easy, and infrastructure goes a long ways towards determining what is easy to do. Right now, it is easy to burn fossil fuels because we have an incredibly advanced and complex technological infrastructure for moving coal, oil, and electricity around the world. If we want to shift away from fossil fuels towards renewable energy sources, we need to design infrastructure that makes it easy for this transition to occur. At the most basic level, this would involve ceasing to build infrastructure that enables fossil fuels and starting to build infrastructure for renewables. Governments should take the lead on projects such as building photo-voltaic cell factories, research laboratories to enhance battery technology, and mass transportation networks. Infrastructure decisions, therefore, offer a particularly attractive site where positive transformations to our energy system can be made.

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