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Forest City: A Nexus of the Digital, Built, and Natural Environments

Tucked away in the foothills of the Appalachians, a quiet town of around 7,000 seems like just another small rural community in western North Carolina. Forest City, however, is a place where “the Cloud” descends into the real world: it’s home to one of around 15 data centers in the United States that Meta (formerly Facebook) owns. With a name like “Forest City,” and calling the servers and information stored across the internet “the Cloud,” it’s easy to neglect the environmental impact of this data center and the information technology sphere it represents. Examining the Forest City data center and Facebook’s relationship with the town more attentively affords an insightful look into how the seemingly intangible internet interacts with the physical environment; how infrastructure is a key component in the relationship between transnational tech companies and small rural communities; and how sustainability compares to other values in the software development sphere today.

The Cloud gives an ethereal name to what can be thought of as the vast majority of the internet that most of us do not see or understand, but interact with every day. The internet is perhaps the paragon of the invisibility of infrastructure, a key dimension of infrastructural systems as outlined by Star and Ruhleder (1996). The term “the Cloud” has a sense of intangibility, inclining internet users to disregard its environmental impacts, and a sense of naturalness, distancing internet technology and the information economy from the industrial economy it succeeded (Ensmenger, 2018). To deconstruct the notion of the intangibility of the Cloud, we must first draw back the curtain on to see what the Cloud actually is and understand the internet as an infrastructure system. Internet users have devices like laptops, smartphones, and tablets, that send requests for and receive data. Personal devices directly communicate these requests and data, called messages, with a modem. A modem is a device that connects a home or office to the broader internet. When one "connect to Wi-Fi," they are connecting their personal device to a modem (perhaps via a router with antennae that broadcasts a radio signal). A modem connects a home network of devices to an Internet Service Provider's network of devices. Some common Internet Service Providers (ISPs) are Spectrum, Xfinity, and Verizon, although there are many local-scale ISPs as well. An ISP hosts a network of routers that can send a message closer to the destination of its request. Routers are simply computers that communicate with each other and know where to send a data request or response. An ISP's routers communicate with a larger network of routers, which is the actual network that we think of as the crux of the "internet," A message will eventually find its destination, which is often a server, a computer designed to store data and process messages requesting these data. Everything stored in the cloud can be found physically saved in a server somewhere. Data centers, like the one in Forest City, are buildings that store servers–on the order of tens or hundreds of thousands of them (HP, 2019).

Underlying all these points of interest that make up the internet are physical connections. With the exception of Wi-Fi utilizing radio waves for communication between personal devices and modems, the vast majority of information sent between parts of the internet travel by physical cable. DSL, cable, and fiber are the three primary forms of connection. DSL utilizes copper telephone cables to send internet messages, while cable connections, the most common, use TV cables to communicate. All of these connections are "broadband" meaning that multiple communications can happen on a wire at the same time, so internet, TV, and phone communications don't interfere with each other. Fiber is the newer, faster form of wired communication that is intended primarily for internet connections, although it isn't quite as widespread as DSL and cable yet (Ryan, 2018). The fact that the vast majority of internet connections piggyback on existing wire infrastructure is the perfect example of what Ensmenger and Slayton (2017) call "underlying technologies that make the cloud possible…simply a reconfigured network of industrial-era physical infrastructures” (p. 298). Not only are the Cloud and internet much more wired than they are widely perceived to be, but they also may not be as post-industrial as they seem either. It is clear that the internet is also built upon preexisting infrastructures, another dimension of Star and Ruhleder’s (1996).

An illustration of this infrastructural building on top of a preexisting base is found when looking at the Forest City data center. The site where the facility stands was home to a textile mill that left. Town and county officials partnered to acquire and refurbish the spot, recognizing its potential as an industrial park for some new company. The site had a neighboring highway and existing industrial-level water and energy infrastructure, and the town had excess utility capacity now that the spot was inactive. The combination of these factors and the potential for state tax breaks made this an attractive spot for companies looking to expand and build a new facility (Here We Grow, 2021). Facebook also was attracted to this location by a unique meteorological phenomenon known as an isothermal belt. An isothermal belt forms as a result of topography affecting air movement. At night, warmth that was absorbed by the ground during the day radiates back out into the air. As shown in Figure 1, in a region with mountainous contours, cool air above this sinks along the slopes and pools underneath this warm air. This creates a layer of this warm air, a thermal belt (Polk County Government, 2013). In North Carolina, this phenomenon creates more consistent weather throughout the year, which is advantageous for agriculture and data storage. Facebook sought to leverage this phenomenon as a way to maximize server cooling efficiency at its data center facility. This is not the only example of climate impacting data center location. atNorth is an Icelandic data center colocation company that boasts unparalleled sustainability by taking advantage of geothermal energy

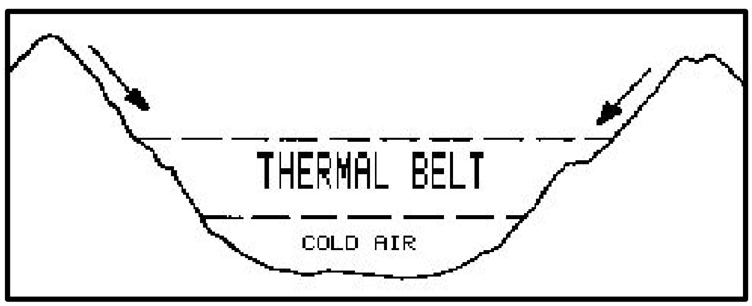

Figure 1. An isothermal belt (Polk County, 2013)

sources and open-air cooling in the cold Nordic environment. Especially as data centers grow in number and scale, climate and data storage will be thermodynamically intertwined. Facebook entered negotiations with Forest City officials and broke ground in 2010, with the data center going live in 2012. It is Facebook's second-oldest data center in the United States, so its relatively rich history gives good insight into the interplay between sustainability, infrastructure, and data centers.

According to Facebook's 2020 sustainability report, the Forest City data center (like all of its other data centers) is "supported by 100% renewable energy." Facebook buys renewable energy from Duke Energy, the utility company that powers the Forest City area and much of the state of North Carolina. This doesn't mean that all of the energy actually powering the data center comes from renewable sources; instead, it means that Facebook buys energy, often at a higher price, in the form of Renewable Energy Certificates that legally links that energy consumption at the data center to a renewable source somewhere on the electrical grid (Duke Energy, 2021). This system incentivizes these utility companies to invest in more renewable energy projects. It also delocalizes the environmental benefits of renewable energy generation from the locales of the Renewable Energy Certificate buyers; that is to say, while the Forest City data center is supported by renewable energy, the actual environmental benefits are commuted elsewhere. In addition to buying Renewable Energy Certificates, Facebook actively invests in and partners with local utilities to build more renewable energy projects. In association with their Forest City facility, Facebook has helped fund the addition of 410 megawatts of solar energy to the North Carolina grid. However, all of these projects are in the eastern part of the state, over 150 miles away (see Figure 2 on the next page).

Figure 2. Forest City data center (orange) and Facebook-supported solar projects (yellow). (Facebook, 2021)

Sustainability is a priority at the Forest City data center because of the level of natural resource consumption necessary for large-scale data storage. According to a Facebook-commissioned report in 2016, when Facebook had 4 domestic data centers, these facilities consumed 1,000 gigawatt-hour (GWh) of energy (Oliver et al, 2018), giving an estimate of 250 GWh for the Forest City data center. As the size and number of Facebook's data centers have increased, Facebook's total energy footprint eclipsed 7,000 GWh in 2020, rising significantly each year in that period. 7,000 GWh is more than Luxembourg is estimated to consume yearly. If the Forest City data center consumes 250 GWh, that would be on par with Andorra (CIA, 2021). Rutherford County, home of Forest City, also boasts the 4th highest per capita rate of pollution associated with electricity generation (Garcia, 2021). This shows not only the massive energy necessary to store this large amount of data but the pressing need for sustainable improvements to Rutherford County's energy infrastructure.

Water is also a key resource in data center operation. Facebook's data centers withdrew over 1 billion gallons of water in 2020, consuming 600 million of those gallons (Facebook, 2020). Facebook also reports that by sourcing its energy use via Renewable Energy Certificates to renewable projects, it averted over 360 billion gallons of water being consumed. This is because traditional energy generation methods with fossil fuels are very water-intensive due to steam or cooling needs. Solar and wind energy, Facebook's primary sources of renewable energy, do not require water at this scale. Again, because of the geographic disjunction between the Forest City data center and Facebook's renewable energy project in North Carolina, the hydrological benefits of averting massive water consumption are not felt in the local ecosystem of Forest City.

To report on their sustainability, Facebook utilizes the measurements Power Usage Effectiveness (PUE) and Water Usage Effectiveness (WUE). PUE is the ratio of energy used directly by the data server operations over the total energy consumption of the facility. It effectively measures how energy-efficient a data center's cooling system is. PUE values that approach 1.0 are best; Facebook's facilities hover around 1.1, while the industry average is around 1.5. They are at the cutting edge in terms of PUE. WUE is calculated by dividing water consumption by total data server energy consumption, intending to measure the water efficiency of a data center's cooling system and humidification system. The idea is that less water usage means a lower WUE value. Facebook reports around a 0.2 WUE for their data centers, while stating the industry average is 1.8 (Facebook, 2020).

However, some experts critique the effectiveness of these measurements. Ipsen (2018) states that PUE is essentially worthless as a measure of overall environmental impact because it doesn't report the amount of water or energy consumed overall. She follows by suggesting that the significant environmental impact of these data centers is being normalized, or worse, forgotten because of the popularity of the PUE metric. She also questions the value of WUE because of its similar inability to communicate net impact, as well as its capability as an industry standard because it isn't as widely used as PUE. Moreover, since energy consumption is the denominator for this metric, a wastefully energy-intensive data center might have a lower WUE than one that is actually more water-efficient. The critiques surrounding these measurements are tied to a larger debate in sustainability: the conflict between focusing on efficiency and overall impact when discussing the values in sustainability. Proponents of emphasizing the importance of total impact, eschewing efficiency, often cite the Jevons Paradox: throughout history, in multiple societies, gains in natural resource use efficiency, especially energy efficiency, perplexingly coincided with an overall increase in total use of that natural resource (York & McGee, 2015). It could be suggested as an example that although data centers today are more efficient than 10 years ago, there are many more and they are often larger, and thus data centers overall consume more energy than 10 years ago. What is unclear about the Jevons Paradox is whether these efficiency gains directly cause the total usage increase. It could be argued either way in our data centers example; perhaps the efficiency gains and increased prevalence were caused by an underlying economic growth of tech companies, or perhaps increased efficiency while keeping utility contracts the same has increased the server capacity of data centers. Regardless, especially when considering the near certainty that Facebook will grow as a platform, it is paramount to consider whether efficiency gains alone will reduce the environmental impact of the Forest City data center and Facebook's operations as a whole.

Another notable environmental impact of the Forest City Data Center is the minerals and metals in the electronics that make up servers. Facebook builds its own barebones servers, opting for the lower cost of buying parts in bulk over the reliability of premade servers (Schneider & Hardy, 2011). These skeleton-build servers use materials whose environmental background is more difficult to trace than ubiquitous utilities like water and electricity. Several rare earth metals are crucial to the construction of computer hard drives, a couple of which are solely mined in China. Some experts note that China may try to leverage this geographic reality to get American companies to invest in projects in China. Tin is also important for the soldering of electronics, and much of the world's tin comes from an unregulated market in Indonesia, where rainforests, reefs, and low-wage workers alike are being incredibly harmed by this industry (Ensmenger, 2018). Several uncommon minerals are necessary parts of modern electronics, and their scarcity sometimes leads to environmental degradation and worker endangerment in areas lacking a comprehensive regulatory framework for these extractive industries.

When understanding why rural communities like Forest City hope to attract companies like Facebook, it's critical to contrast the environmental impacts with the social and economic gains. Since they broke ground in 2010, Facebook has invested over 3 million dollars in Forest City and Rutherford County, supporting local schools, computer labs, teacher education programs, and COVID-19 relief grants for small businesses (Facebook, 2021). Another Facebook-commissioned report (Oliver, 2014) found that from 2011 to 2013, Facebook's investments in their Forest City data center brought over 5000 jobs across the state. However, this number does not represent the local economic benefit seen in Forest City. About half of these 5000 jobs were "indirectly created" or "induced" by Facebook investment, meaning new hires in other companies in other parts of the supply chain, or new jobs created via economic demand as Facebook investments trickle into local economies. It's a stretch for Facebook to claim these jobs as a part of the economic impact of Facebook investments. Moreover, the vast majority of those "directly created" jobs were temporary construction jobs, some in Rutherford County as Facebook expanded their data center facilities, and many in other parts of the state as a part of Facebook-funded renewable energy projects. Only around 300 people work at the data center today (Facebook, 2021).

Facebook's monetary investment in its Forest City facility rivals that of the great textile mills that it succeeds in western North Carolina, but the workforce it generates is a fraction of those of the past. This is due to the nature of what goes on at the facility; most of the work that goes on is done by computers. Not only is all of the data being stored on servers, but many of the service and maintenance tasks are also carried out by automated scripts (Forest City Data Center, 2012). In other words, computers tackle many of the daily problems that pop up in Forest City. Humans are no longer as critical to the processing, and by extension, the economic growth that goes on in these facilities as they used to be. Although Facebook has certainly been a boon to Forest City, it doesn’t bring the same economic prosperity that a new textile mill coming to town would have brought fifty years ago. Might it be that computers and automation reduce the benefit these tech companies bring to their local communities? In a Washington Post article (Frankel, 2018) that interviewed residents of Forest City about data privacy concerns in the wake of the Facebook-Cambridge Analytica scandal, almost all residents seemed to define their relationship with Facebook not as benefactors of Facebook’s presence in the town, but merely as typical Facebook users. This is interesting to compare to the increase in work-from-home jobs seen with the COVID-19 pandemic. Consider a lucrative tech company with workers all over the world working remotely, with data centers that employ relatively few. It would be hard to pinpoint which local economies are being benefited by the economic prosperity of this company. As the world becomes more connected, especially through internet technologies, perhaps economic growth associated with corporations will become less localized. This is at least the case with Facebook and Forest City, where corporate investments have spanned the state rather than staying in Rutherford County.

Regardless of localization, as industrial companies are shifting operations overseas for cheaper labor, our domestic economy has become more service-oriented, which includes tech companies like Facebook. Carnevale and Rose (2015) report that this transition has made post-secondary education more valuable. For rural communities like Rutherford County, where only 17.8% of adults have a college degree (nearly half the national average) (U. S Census Bureau, 2020), is this post-industrial transition leaving them behind? While Facebook coming has been an economic boon for Forest City, has it left something to be desired for those looking for economic growth? And perhaps more chillingly, as data centers build on sites where textile mills once stood, does Facebook’s benevolent arrival in Forest City represent a more sinister transition of the economy for rural communities?

Infrastructure is also a critical thread in the relationship between Facebook and western North Carolina. Facebook is partnering with a local non-profit to expand fiber-optic infrastructure (MCNC, 2020). MCNC is a non-profit in North Carolina that manages a fiber-optic network that connects government offices, educational institutions, public healthcare facilities, and other community anchor points. Facebook will finance a project to install around 100 miles of fiber to MCNC's network. See Figure 3 for a map showing the new connection as a purple line; Forest City is at the south terminus of the line. This project will link the data center there to another data center that Facebook operates in western Virginia. This development shows another chapter in the intertwining of infrastructure and development. It was infrastructure investments in the textile mill site by local officials that helped bring Facebook to Forest City, and now Facebook's arrival has brought about this new infrastructure project (not to mention the renewable energy projects in the eastern part of the state). It's even conceivable that this new fiberoptic cable might sway Facebook or some other company looking for a data center site to invest and build in another small town along the new connection. In this instance at least, there is a feedback loop of infrastructure expansion; infrastructure promises economic prosperity, which in turn increases both funding and incentive for infrastructure as operations using those infrastructures expand.

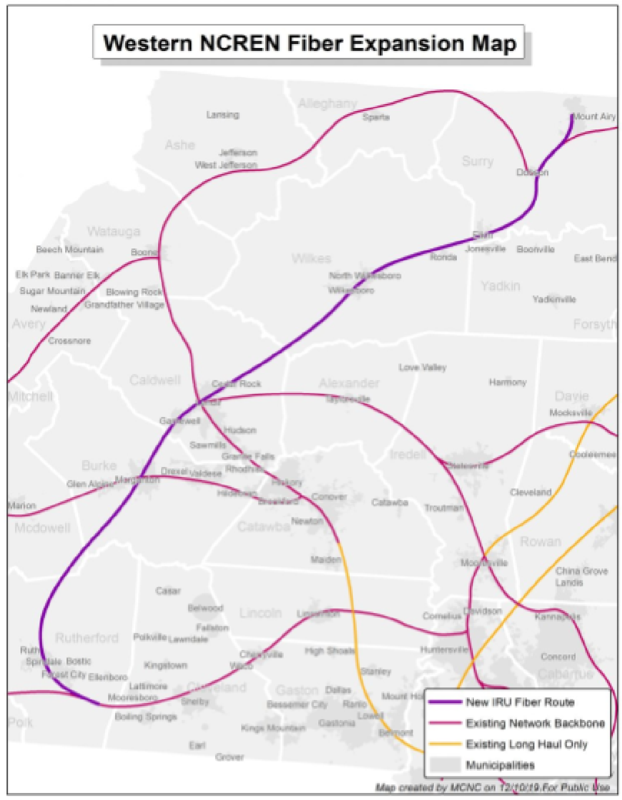

Figure 3. Facebook's Fiber Investment. (MCNC, 2020)

Facebook purports that sustainability is a priority for the company; but how does it compare to other priorities in their software development ideology? Reliability, or the idea that your Facebook app should work the same every time you use it, is important to software engineers like those at Facebook. If a data center goes offline, this impacts reliability; and as a result, many data centers invest in expansive backup generators that may not be as clear as their primary energy source. To further combat blackouts, tech companies value Redundancy, storing data in multiple places so requests can be rerouted and fulfilled during an offline period. This clearly increases the number of servers needed by a company. Low-latency is another key priority to review through an energy-use lens. Facebook wants data to be available to users all day, every day; to do this, they must keep servers up and running all day, every day, even when many of their users may be asleep or inactive. The New York Times (Glanz, 2012) even found that as much as 90% of a data center's energy consumption is just to keep servers idle, not for actual data retrieval. The precedent of these always-on, always-available services has expanded the environmental impact of services like Facebook (Hogan, 2013). It's clear that many of the goals and expectations that tech companies that Facebook have for products are at odds with sustainability, and are often prioritized over it. An interesting further research topic would be to investigate environmental critiques of current software design philosophies and proposed green software development ideologies.

Relationships between small towns, large companies, infrastructure, and the environment are extremely complex, and a lot of questions arise in the process of analyzing these relationships. A common thread seen with internet infrastructure and the Forest City data center site is that while the internet seems like cutting edge and new and separate from industrial legacies in this country, it is very much built on top of pre-existing infrastructure, in the same way that telephone lines follow railroads and ditches go alongside roads. Being built on top of these infrastructures grounds the environmental impact of the internet technology ecosystem and allows us to examine it. The importance of infrastructure is seen in this technological march of progress in infrastructure, and also in the infrastructure feedback loops like the one seen in western North Carolina. The ethereal, futuristic image of IT and companies like Facebook is just that; an image. They have an impact, even as their products seem less and less material. This transition of the American economy from material, industrial companies to service-oriented businesses like Facebook also perhaps bodes ill for rural communities like Forest City, increasing the prevalence of white-collar jobs and the delocalization of economic benefits that companies bring. In this analysis of Forest City, we also find a conflict of values between sustainability and other design priorities for IT companies. Analyzing these competing ideologies critically is important for companies like Facebook and users of internet technologies like us.

The questions and concerns raised in this case study will only be more important to consider in the future. In 2016, 7% of emissions were from the information-communication technology ecosystem (Cook, 2017). That number likely has risen since then and will continue to do so. As climate change and other ecological disasters become more and more glaring, we all must ground the internet’s impacts if we seek to understand and mitigate them.

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