

ECFiber: Building a Fiber-to-Premises Network in the Rural United States¹

George Sadowsky²

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Background

Nestled in the northeastern part of the United States is the small state of Vermont, the 14th State to join the United States in 1789. Its name comes from the French, in which 'vert montagne' means 'green mountain.' and it is known as the Green Mountain state. With only about 625,000 inhabitants, it is the 45th state out of 50 in size, and 49th of 50 in number of people, even less populated than Alaska. Its earlier existence was as a rural agricultural state, and it used to be claimed that more cows than people lived in Vermont.

Vermont is a rural state. Founded by the early colonial settlers in the 1700s, it soon became a farming state, while industrialization in New England developed further south where the climate was somewhat milder, water power was more available, and access to larger markets was easier. The largest city is Burlington, with about 42,000 people in a metropolitan area of about 220,000, followed by Rutland with only 13,000 inhabitants. It is among the most politically liberal states, and it cherishes its rural and early American roots. Unlike most other states, it governs its towns through annual town meetings held during the first week of March, in which all inhabitants are invited to participate to set the budget and agenda for the coming year. Such a model of participatory democracy must have seemed more effective to implement because of the state's rural structure of small towns and its relatively sparse population.

Vermonters have generally been in favor of tight environmental standards, with strong zoning laws that discourage urban sprawl and support preservation of its rural, unspoiled beauty. That beauty, including its rolling hills and gentle mountains, cool summers, good skiing in winter, a brilliant 'leaf season' in autumn and the sense of a traditional simplified life style, support one of Vermont's major industries: tourism.

However, as in many countries, people tend to migrate to urban areas, and rural areas are becoming less populated on a relative basis. Vermont may be seen as a good place for vacations and leisure activities, but from the point of view of participating in leading industries and economic opportunities offered by the digital revolution, it has not been as good a place to work. For farmers, artisans, writers, retirees, and the like it offers a good environment, but for others who need to be involved in cutting edge technology projects and need widespread communication, it has been weak in providing essential infrastructure.

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² George Sadowsky has been involved in computing and networking nationally and internationally since 1973. During 2013-2019 he represented Woodstock as a member of the.

In particular, the pleasant rolling hills and mountains and the lack of crowds of people puts Vermont at a distinct disadvantage with respect to communication. Historically the implementation of electric power lines and land line telephone communication was slow because of the low population density. Often the capital investment in right of way, poles, and lines was not easily justified because the limited number of premises per mile was insufficient to justify a business case for the investment and costs of providing the service. With the introduction of mobile telephony, Vermonters continued to be at a disadvantage because the topography of the state worked against them. Vermont's hills and mountains are not very high, and many of the premises in the state are located in narrow north-south valleys that were created by retreating glaciers at the end of the ice age. As a result, cell towers in many areas of the state have limited catchment areas, resulting again in higher costs needed to service customers. Backhaul capacity was also more expensive for the same reasons. Today it can still be difficult to obtain consistent mobile phone service in some parts of the state.

Vermonters concerned with economic development perceived that the Internet could be a major force in attracting more people to Vermont who would be able to participate in their profession and in the economy via the Internet and yet enjoy the relaxed life style that Vermont offers. Indeed, as bandwidth costs have come down and capacity has risen, even before the onset of the Covid-19 pandemic, telecommuting was becoming a viable alternative for workers in some professions. In addition, Vermonters saw telecommuters as being above average in education and income, and therefore as likely to contribute to a vital and diverse economy. However, initial deployment of the Internet was subject to the same factors that had slowed previous communication technologies: higher costs and less reliable service for connectivity via mobile carriers, long run lengths over older category 3 copper telephone lines to most rural premises, high per subscriber costs of installing coaxial cable or fiber lines, and a population with lower than average income to pay for it all.

In 2008, the situation on the ground was not encouraging. There were a number of dial-up Internet service providers (ISPs), and with the exception of winter storms, they provided reliable albeit low bandwidth access to the Internet. Several tier 1 ISPs had coaxial cable and some fiber running through the state on major highways, of which there are few, and reasonably good connectivity although at a higher cost. Service was available for premises that were within a short distance, about one third of a mile, of those highways. This served the few built-up areas reasonably well, but it essentially eliminated the possibility of higher bandwidth connectivity for the vast majority of the rural residents who comprised a significant majority of the state's population. Some Internet users installed satellite dishes for downloads, using a split path topology that used terrestrial telephone circuits for the return path. The local CLECs supported such access.

Formation of ECFiber: the Early Days

Early in 2008, a group of people living in east central Vermont, who understood the importance of the Internet to economic development, decided to act independently. They formed ECFiber, the EC standing for East-Central Vermont, a 501(c)3 not-for-profit corporation with the goal of

providing fiber access to every premises in 23 contiguous towns and one municipality in central Vermont. ECFiber would be chartered and owned by the towns, and any excess revenues that might accrue when it reached its steady state operation would be given to the towns in accordance with the number of ECFiber subscribers in the town. Governance would be provided by a Board of Governors consisting of one representative and alternates from each member town, formally designated by the town's Selectboard, or governing body.

In 2008, the U.S. equity market was reaching an all-time high, and funds for investment were available relatively easily. ECFiber entered into negotiations with a large leading financial investment bank to provide eventually USD\$80 million for the entire Internet buildout in the 23 towns and the municipality. Negotiations progressed smoothly until September, when equity markets crashed and the US government scrambled to prevent a meltdown of the financial system. The financial institution with which ECFiber was negotiating perished, and the organization was left with a vision and a goal, but no cash for moving forward. The investment climate had quickly reversed itself, and there was no significant financing to be had from any source. Worse, the governing structure of the state was not helpful. Towns were prevented by state law from investing in communications services, so there was no help coming from that direction.

Finally, about US\$1 million dollars in seed financing was secured from insiders who were dedicated to building a network in their areas of Vermont. The seed financing was sufficient to establish an office and technical hub in South Royalton and to build a 20 mile pilot network in Barnard, one of the neighboring towns. Local notes were then offered to members of the community in amounts of US\$2,500, and were purchased primarily by local investors in the towns to be serviced. By 2015, ECFiber had received about US\$7 million from about 500 investors, and the network was being built, albeit slowly, using these funds. It was clear that while the effort was likely viable, it would take a lifetime or more to meet the goal of the project, given the slow pace of investment.

ECFiber as established was purely an administrative and governance organization, having no staff. Early on therefore, it established a partnership with a like-minded organization, ValleyNet, also a not-for-profit organization, that had as an ISP previously offered dial-up service and was interested in moving further into the Internet space. ValleyNet had some technical experience and entered into an agreement to be the implementing arm of ECFiber's network. The cooperation exists to this day, and Valley Net has begun to serve other groups like ECFiber that are forming both in Vermont and in the neighboring State of New Hampshire.

During this early period, compromises were required in view of the reduced financing possibilities. ECFiber's original plan was to use a 'home run' fiber topology in which each premises would have its fiber go back to a central station located in the town, thus pushing any sharing of media with other subscribers to further upstream. This idea was dropped. In addition, the original plan called for Internet, IP-telephone, and video content services to be offered. To simplify the offering to what could be delivered most easily, video content services were eliminated from the plan.

Financial Breakthrough

During its early years, ECFiber worked to establish and maintain constructive relationships with Vermont State officials, and it was awarded occasional grants for piecemeal extensions of the growing network. In 2016 a breakthrough was achieved. One of the members of the ECFiber Governing Board was also the representative of his town in the State Legislature. The importance of Internet was by then increasingly recognized, and the member used this to successfully shepherd into law a category of organization called a Communications Union District. Districts could be established for the purpose of improving communications in their jurisdiction, and would have the status of municipalities of the state. In homage to Vermont's rural dairy history, they bore the appropriate acronym of CUDs.

The importance of this change was that municipalities had bonding authority, and although the State of Vermont had no liability to the bondholders in the case of default, just the designation of municipal status was sufficient to imply that the State had done due diligence and was morally if not financially in support of the organization. And while a CUD could not by law issue general obligation bonds, it could issue revenue bonds, using funds from its current revenue stream to satisfy interest and principal repayment obligations

At the beginning of 2016, ECFiber formed the first CUD, the East Central Vermont Telecommunications District, in Vermont. A financial plan was put into place for four rounds of financing over four years, totaling about US\$40 million in the aggregate over four years that would allow the completion of the great majority of the network. The post 2016 business plan had to assure that revenue generation was sufficient to cover scheduled interest payments as well as assist with principal repayment. ECFiber's bonding authority did not obligate the State in any way as they were not general obligation bonds; rather, they were revenue bonds, and interest payments depended upon the ability of ECFiber to maintain sufficient earnings to meet interest payments. Fortunately, by 2016 the network had sufficient fiber installed, servicing enough subscribers to cover the anticipated cost of covering a first bond offering.

After the formation of its CUD, ECFiber promptly went to the capital markets and sold a US\$14.5 million allotment of long-term revenue bonds. Part of the proceeds were used to retire the old debt, including the initial US\$1 million loans by the initial inside investors, resulting immediately in reduced interest repayment costs. The other part of the proceeds was used to continue extending the network. Subsequently ECFiber returned to the capital markets almost yearly and has raised to date a total about US\$41 million in long term revenue bonds, experiencing growing acceptance and lower interest rates in each tranche.

Lessons Learned

Layer 0. One of the specific difficulties of the implementation of the ECFiber network was that much of the effort and the delay was related to layer zero of the protocol stack. Layer zero is where you put layer 1, the medium through which the signals travel. Layer zero could be a

physical conduit or a set of above ground poles, or it could be a piece of the electromagnetic spectrum using satellite communication for wide area networks or 802.11 for local area networks.

In urban and developed environments, layer 0 is often taken for granted, since there is already a great deal of communications infrastructure already installed. Buildings have a telecom distribution infrastructure consisting of risers and floor distribution systems. Towns and cities have below ground conduits that carry wires, fiber and coaxial cable for distributing telephone, video, and public service systems. Longer distance connectivity is often provided through statewide fiber links, microwave and other wireless technologies and satellite systems.

Little of that infrastructure was present in 2008 when ECFiber was formed. A few towns had conduit systems in their downtown areas, but those systems were owned by whoever installed them. In Vermont's case the installers were the initial cable TV operators, and there was no legal requirement that their conduits had to be shared. Most communication in the State depended upon wires attached to poles. The poles were generally owned by ECFiber's competitors, and while the Public Utility Commission did have a mandate to enforce pole sharing (with appropriate rents being paid), often existing wiring attached to the pole had to be relocated to provide room for new entrants and in some cases taller poles were required to provide additional mounting capacity. Poles were owned by the electric power company and by several telephone companies. Making each individual pole ready generally required coordination between owners and existing pole renters with little incentive to do this work. Delays were amplified by a state regulatory agency that initially was not zealous in its enforcement of time limits established legally for responses and actions by the pole owners. Given that ECFiber's geographic area contained over half a million poles, this "make ready" activity to secure a usable layer 0 often resulted in many months of delays.

Economics of rural Internetworking. Rural areas have lagged in introducing Internet services primarily because they do not exhibit the economics of scale possible in more densely populated areas. The true 'death of distance' is only possible when internet connectivity exists. In rural areas, geographic distance is the enemy when it comes to building sustainable networks and the physical infrastructure that is required to enable it.

ECFiber initially estimated that, taking into account all costs incurred, the cost of installing fiber along a Vermont roadside was about US\$25,000 per mile. In order to be economically viable, it needed a 'take up rate' on average of 4-5 subscribers per mile. While commercial ISPs can use such considerations as a way of choosing which roads they should invest in, ECFiber's goal of networking all roads and premises required that it successfully subscribe an average of 4-5 premises per mile across all roads in its towns, not just those where density and demand combined to provide economic success.

Competition. Competition for ECFiber came from several sources. The area CLEC, currently Consolidated Communications, which passed through several ownerships during the period of ECFiber's build, had offered DSL service for some time. However, the low population density

worked against them in that they had to trade off the location and number of base stations in a rural area against the bandwidth that they could offer to deliver. In village centers, they were somewhat effective, but along a significant percentage of rural routes their bandwidth was no more than 128Kbps, effectively double the speed of dial-up. In the mid-2010s a major CLEC in the southern part of the state received a large federal grant to establish a wireless 'Internet canopy', based upon large towers across the entire state, so that all regional areas would be served. That canopy has yet to materialize. The various mobile carriers in the state all offer mobile Internet using a mixture of 3G and 4G technologies. However, they are equally hampered in service delivery by the topography of the state, where even the availability of their voice service can be spotty and unreliable in areas.

Marketing the Internet. In 2008 when ECFiber was created, the demand for broadband Internet service was moderate and geographically scattered. As a socially traditional state, it prized its way of life. Information technology was represented by a large VLSI chip fabrication plant in Winooski more than by Silicon Valley types of activities. There were a number of dialup ISPs, and the local CLEC was offering moderate speed DSL services in some towns. The Internet was considered adequate for email, community bulletin boards, and some access to the World Wide Web. ECFiber had an uphill battle to convince inhabitants that broadband was not only useful, but that it would be essential in their future.

External pressures built up in the intervening decade. Schools became pressured to strengthen their STEM curricula, including computer science. The rapidly growing body of information available via the Internet caused teachers to need Internet access both for themselves and for their students. State educational testing moved to the Internet. The local major hospital started to experiment with telemedicine applications. Tourist facilities began to understand the importance of connectivity for advertising and for operating their businesses. Vermonters woke up to the importance of the Internet for many aspects of their daily existence.

During the past year, the Covid-19 pandemic provided a serious operational stress test of the quality of people's lives, including the contribution of Internet access to their welfare. Without doubt, the Internet has been a major factor in allowing societies and economies to continue functioning, offering working, meeting, schooling and communicating at home to millions who would otherwise have lost those abilities. These lessons will not be lost on Vermonters, and this bodes well for the continuing success of ECFiber and similar organizations in the rural United States. The Internet's fight for relevance and utility has now been largely won.

Moving the Goal Posts: Edge cases. The original goal of ECFiber, extending the possibility of Internet to every premises in 23 towns and one municipality, was stated as a concrete goal. Over the course of implementation, it became clear that there were limited exceptions — edge cases — that would make achieving the last 1% of that goal inordinately expensive.

First, in a few towns early cable TV companies had installed underground conduit for their coaxial cable infrastructure in the core center of the town. In at least one of those towns, once the conduit was installed and the underground infrastructure provisioned, above ground poles

were declared illegal and taken down in order to contribute to the look of an early Vermont village. To reach those areas, ECFiber would have had to install new underground conduit to reach a limited set of premises that were already being served by a commercial ISP.

Second, some residences in towns on the border of ECFiber's territory could not be reached without going through towns external to the area. In Vermont, as in most of New England, every part of the state is in a town. The boundaries of towns were established in the 1700s when North America was still subject to Great Britain's rule, and they are defined for the most part by two sets of parallel lines, almost orthogonal, forming a grid that does not respect any topographic features of the geography. It is not unusual to find dead end segments of roads in towns that can only be reached by going through other towns.

Third, the one municipality in the original members of ECFiber, Montpelier, is the state's capital. Conduit had been installed in a part of the city, which already had service from a commercial ISP when ECFiber was established. Over time, it became clear that ECFiber's focus of interest was in rural areas, and that provisioning Montpelier would result in duplicating a commercial infrastructure that was already serving much of the town. As a result, Montpelier lost enthusiasm for participating in ECFiber's efforts that focused upon rural connectivity, and it withdrew from membership in the organization.

Current Status

At the end of 2020, almost all of the roads in the original 23 towns have been provisioned with fiber. The network extends over 1400 miles of roads, allowing approximately 18,000 premises to connect. As of late 2020, the number of subscribers was in excess of 5,200. Bandwidth offered includes 25/25 Mbps, 100/100 Mbps, 300/300 Mbps, and 800/800 Mbps. All service is symmetric, with equal upload and download capacities. Prices range from US\$25 per month for basic 25/25 Mbps service to US\$164 for 800/800 Mbps service, all with no data caps. Continental IP-based telephone services without limit are available for an additional US\$25 per month. Bandwidth prices are periodically reduced as the economics of the organization improve.

ECFiber is now seen as a success story in Vermont. Recently ECFiber voted to admit eight new towns into its organization for a total of 31 member towns, and it has just completed successfully another round of additional funding of about US\$11 million to, among other things, extend its network to these newcomers. Pole data have been collected for the new entrants, design of the network is currently underway, and network implementation will start in the summer of 2021.

The economic future of ECFiber seems to be secure. Of the almost 18,000 business and residential premises in the original 23 town area, there are already about 5,300 customers, an established 'take rate' of about 30% at present and growing, with another 2,500+ premises currently indicating interest in becoming customers. The addition of the eight new towns will add about 15,000 premises to ECFiber's service area. This has allowed ECFiber to generate a

revenue stream considerably surpassing its requirements for interest payments and debt renewal to its bond holders.

The Board believes that the wake-up call sounded by the Covid-19 pandemic, combined with the expanding migration of government, education and medical services from in-person service to remote delivery via the Internet, is highly likely to generate substantial additional interest in subscribing to the Internet service. They estimate that by 2024, they are likely to have about 12,000 customers and will also be identifying ways to reduce drop cost and complexity.

The idea of the Communications Union District has grown in popularity, and ECFiber has been active in evangelizing its model. At the end of 2020, eight additional such CUDs have been formed for the purpose of extending the Internet to their respective towns, and the state has approved a basic loan program that can be used by them for initial startup costs.

In its early years, an informal saying among ECFiber Board members was, “ECFiber: Built for Vermonters by Vermonters.” ECFiber has succeeded in that objective. With the help of local volunteers, town and state governments that understood the transformative nature of the Internet, an advancing technology, and some serendipity, ECFiber is now making a significant part of Vermont ready to participate in a digital future, as well as leading the way in helping its neighbors and their CUDs to follow in its footsteps.

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