Leduc County

Regional Broadband Strategy

May 2021

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Report Objective

Recognizing both the opportunity and challenges associated with facilitating advanced broadband infrastructure and services throughout the commercial-industrial and rural areas of the County, Leduc County commissioned this study to provide and quantify the options available to enhance broadband service availability and to examine the partnership options available to help make it so.

With a specific emphasis on Nisku, this report completes the study and:

- Provides a review of the County's current state;
- Outlines the desired future state based on extensive stakeholder consultation;
- Provides options to close connectivity gaps;
- Updates earlier infrastructure studies to estimate capital/operational costs to close the gap.
- Quantitatively evaluates and compares the business case financials and operational trade-offs associated with the options of most interest to the County;
- Reviews the partnership options available to assist the County execute; and
- Outlines recommendations and next steps to provide guidance to the County going forward.

Recommendation

Nisku

Given the urban industrial nature of the Nisku area, the varied requirements for broadband services, smart city and connected vehicle support, security issues, and the excellent likelihood of attracting multiple service providers, the open access, wholesale, lit-network utility option is recommended. Further, as a number of national and international businesses in the area likely need to connect to secure corporate networks that depend on services from a corporately anointed carrier, those businesses require the option to go with their carrier of choice, an option not available should a single incumbent move to deploy fibre in the area. With this option, the County would enable a fully competitive broadband services environment that would support high availability services up to and beyond 40 Gb/s, maintain some control over the infrastructure and services, and receive a new revenue stream. The network could be fully implemented and operational within three years.

While the business case for the Nisku area is sound from a cashflow perspective, it is challenging with respect to achieving the target returns private providers and investors may be looking for. The County has a variety of options to support execution. While they could undertake the effort in-house, they would be best served to concurrently minimize County funding and effort by either pursuing conversations for financing assistance with Agentis/DIF and Crown Capital or, for both financing and a more hands-off, integrated, turn-key approach, with DIG, DUC, Rock Networks, and/or Valo.

With the latter set of options, financial, technical, deployment, and operational risk would be managed via the terms of the partnership. This still leaves residual market risk and to effectively manage this risk, all required service-related partnership agreements should be executed prior to implementation, and detailed market surveys and pre-sales activities leveraged to ensure adequate demand and revenue.

Rural Areas

While fostering competition is a worthy aim, it can be counter-productive in rural areas with market failure. Open-access models increase operational costs and splitting the small potential revenue amongst numerous competitive players simply exacerbates the problem. Based on both this and superior financials, an integrated retail, hybrid fibre-wireless option is recommended.

If a capable ISP can be found to handle the overall deployment and operation of the network for the County, that would be ideal. As fibre can be considered critical long-term infrastructure, our recommendation is that the County at least retain ownership of the lit fibre infrastructure and leave the wireless components to the ISP. As the ISP's operations would depend on the fibre, longer-term arrangements, say an IRU on the fibre they require to maintain their wireless operations, would be required.

To accomplish this, the County would negotiate with the ISP to deploy and light the fibre network based on a County specified design – or to also design it, but to County specifications. All fibre network-related central office equipment would be housed in County facilities. The ISP would then be contracted to operate the network on behalf of the County for a five-year period and use it to feed their version of a gig-wireless solution in all selected rural subdivisions. A longer-term service agreement would ensure continuity of fibre services to the ISP for at least a ten-year period. At five-years, the County would have the option to renew the fibre network operations contract with the ISP, internalize the operations, or award the contract to another player. After an agreed-to non-compete term, the County would have the option to extend its fibre network to individual premises.

With this option, the County would significantly enhance broadband services available throughout its rural footprint, deploy and control critical infrastructure, and ensure scalability commensurate with that in urban areas. To be successful, the agreements required would need to ensure the ISP's success as well. The network could be fully implemented and operational with three-years.

Introduction

Project Background

As the world transitions to more complex economic systems built around knowledge, access to information and communications technology (ICT) becomes critical to sustainable economic development in virtually every community and society on the planet. Moving forward, the required connectivity infrastructure is no longer about simply moving data around, it is about enabling a fundamental societal transformation. High-speed broadband services now provide critical infrastructure for community prosperity, resiliency, and quality of life – not unlike roads, electricity, water and wastewater, and other essential utilities that support economic activity and community life. In fact, according to the recently released EMRB Broadband Situation Analysis, Leduc County could experience an $11.6 million per year GDP uplift through the deployment of capable broadband infrastructure.

Leduc County recognized the fundamental importance of broadband infrastructure and set out to create a collaborative regional strategy to guide the development of infrastructure and support the shift in the local economy towards global connectivity. High-capacity broadband network infrastructure will support economic development in the rural parts of the County most affected by the transition away from coal-fired electrical generation and the increased demand arising from the COVID pandemic, drive the redevelopment of the Nisku Business Park, and enable implementation of the County's economic development priorities surrounding the Edmonton International Airport. In order to achieve these objectives, the County, commissioned this report to provide a set of detailed options for the development of a high-capacity broadband network throughout Leduc County. The impact of this Plan and the program surrounding it will be transformative for the economy in the County.

In conducting this review, Leduc County seeks to revisit and update its existing broadband studies to align with their refined visions for broadband connectivity, specifically in Nisku, and outline potential partnership models for infrastructure deployment. TaylorWarwick and RSM were commissioned to assist the County in developing this Regional Broadband Strategy. This report documents the results of this engagement and includes the following:

- A review of the County's current state;
- The desired state, as developed through consultation;
- An array of options to close connectivity gaps;
- Considerations and potential directions with regard to the associated infrastructure, business, operational, and partnership models which are of most interest to the County; and
- An update of the earlier infrastructure studies to estimate capital/operational costs to close the gap.

In lieu of proceeding with the second portion of the engagement, which was to focus on finalizing an appropriate governance model and engaging other communities within the County to potentially develop a coalition with which to move forward, the County elected to pursue direct negotiations with private providers such as TELUS and the Digital Infrastructure Group.

Project Approach

The project plan follows a three-phased project approach which is outlined below.

Phase 0 – Mobilize

In the preliminary phase, TaylorWarwick and RSM kicked-off the project with identified Project Team members to review and understand the strategic goals and objectives of the project, identify primary contacts and key stakeholders, determine communication and reporting protocols, and validate the project approach, methodology, and workplan. The Project Charter and Communication Plan were delivered as a part of this phase. In addition, the TaylorWarwick and RSM team and the County identified existing documentation relevant to the project for review.

Phase I – Update 2010/11 Regional Broadband Studies

In Phase I of the project, TaylorWarwick and RSM conducted extensive consultation to assist the County to determine the infrastructure, deployment, business, and operational models that best align with delivering on the County's vision. The main output of Phase I was the development of this report, which includes conceptual level infrastructure design for a fibre and hybrid fibre-wireless network for the Nisku and rural areas of the County, respectively, along with business cases and financials for potential broadband models. In addition, TaylorWarwick and RSM outlined partnership models for broadband deployment for the County to determine the path forward.

Phase II – Confirm Governance Model

While in the third and final phase of the project, TaylorWarwick and RSM were originally responsible to further refine the recommendations for a broadband governance model for the County, draft accompanying policies, and hold workshops with the six municipalities in the County, partly based on the results of Phase I. However, the County elected to pursue direct negotiations with private providers such as TELUS and TaylorWarwick and RSM were not required to undertake this effort.

Current and Desired State Analysis

The Current and Desired State Analyses captures an up-to-date view of broadband in the County and captures future state needs. It includes an understanding of the current and expected requirements for broadband over the next 10 years for County staff, businesses, developers, Internet service providers (ISPs), and other key stakeholders such as the Edmonton International Airport (EIA).

Approach

A key objective of Phase 1 of the Regional Broadband Strategy Project was to assess the current state of broadband in Leduc County and to conceptualize the future state. This was completed through the following engagements:

Collaboration with the County's Internet Service Providers (ISPs) to map currently deployed broadband infrastructure. This foundational element provided the basis for determining current infrastructure gaps and the development of future state infrastructure designs.

Business and Resident Access and Speed surveys were released across the County to understand overall satisfaction with current Internet services, understand current speed levels and costs, and to understand future state needs. The surveys were released to the public from June 23rd to July 26th, 2020 which resulted in 455 resident responses and 46 business responses.

Workshops with 8 Leduc County Directors and Managers were held to discuss current state pain points and future state connectivity needs of County administration. In addition, two workshops were held with Leduc County Council to better understand the future state direction they would like to explore.

A workshop was held with the EIA as they represent the focal point of the Aerotropolis and a central hub of economic activity for the Nisku industrial area. The discussion was centered around their current state of connectivity, deployment plans for the future, and potential partnership opportunities with the County.

Interviews with the Builder and Developer Communities were held to gather insight into their broadband infrastructure deployment needs in the areas that they develop, and to understand their appetite for the introduction of broadband engineering and development guidelines and, possibly, a County-based network.

The findings from these various engagements are summarized in the following Current State and Desired State sections. First, the Current State focuses on providing an updated view and understanding of the broadband infrastructure deployed in the County and the current service levels the infrastructure provides. Then, the Desired State section provides a summary of future state needs of the various stakeholder groups that were engaged.

Current State

Infrastructure

As a main component of the Regional Broadband Strategy, it is imperative to understand the infrastructure that is currently available in the County today to understand if it can be leveraged to enhance connectivity and to also understand where the greatest issues with service availability are. In discussing with ISPs and referencing other reputable sources, the following infrastructure was reviewed and documented:

- Fibre Backhaul;
- Fibre-to-the-Premise (FTTP);
- Fixed Wireless Access (FWA);
- Small-cell Wireless (LTE and 5G);
- Satellite; and
- Open Wi-Fi.

The following sections provide a brief introduction into each of these connectivity technologies and provides an up-to-date view of the current state of deployment in the County. For more information on these technologies, their advantages, and disadvantages, please refer to Appendix A: Telecommunications Technology.

Fibre Backhaul

As shown in Figure 1, three components are required to establish a regional or sub-regional network:

- local, lit access network which provides premise access connections,
- backhaul/transit connection to connect the local network to an Internet Exchange, and
- Internet gateway at the exchange to enable backhaul traffic to be exchanged with that on the global Internet.

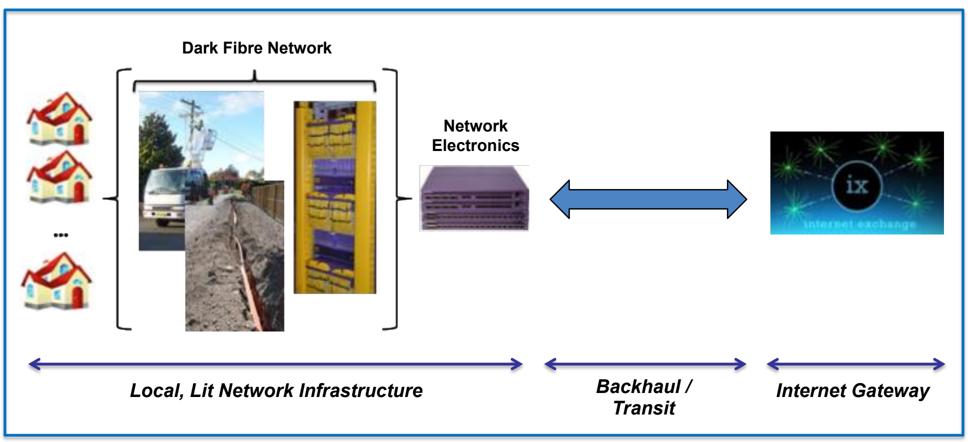

Figure 1. Local, backhaul, and gateway components

Gathering data on local, lit-network infrastructure is often quite difficult as this information is key to ISPs competitive advantages. As such, in the next section, commentary is provided on the extent of FTTP deployment in the County gathered through anecdotal evidence from interviews and reviewing service offerings from key ISPs.

Information on the Backhaul Fibre available in the County was more readily availably and data was gathered from Bell, Shaw, and SuperNet. TELUS does not disclose this information publicly.

Through the data gathered, it was found that backhaul fibre and SuperNet POPs are available in all cities, towns, and villages as well as in 2 of the County's 8 hamlets.

Excluding TELUS assets, the backhaul fibre available in the County, is shown in Figure 2. The colour code is as follows:

- **Bell:** red and orange
- **Shaw:** magenta
- **SuperNet:** red and blue
- **SuperNet POPs**: red squares

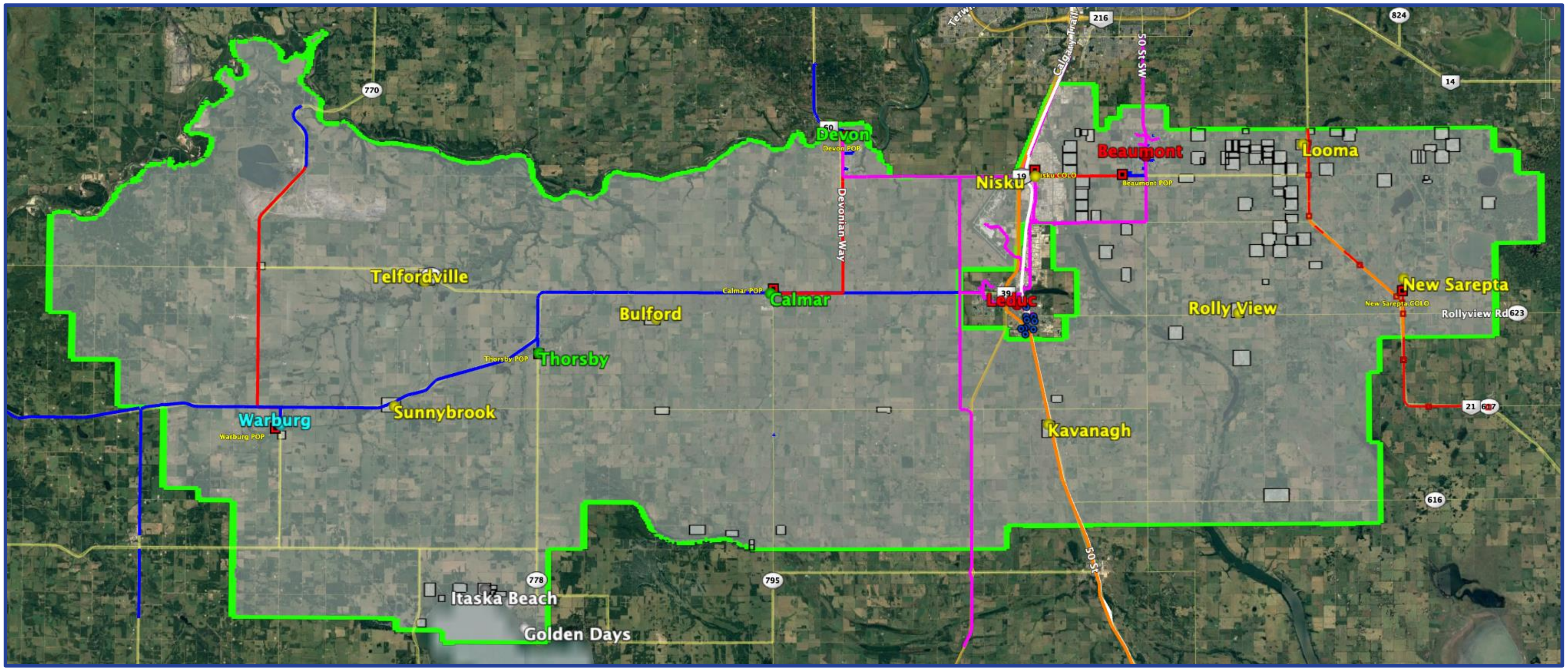

Figure 2. Leduc County backhaul infrastructure

Fibre-to-the-Premise Deployment

Fibre-to-the-premise deployment is the 'gold-standard' for "last mile" connections. FTTP is specifically addressed in this report as it can theoretically support connection speeds up to 2,800 Gb/s at 1.55 microns (μm) and, as current access systems operate at only 80 Gb/s, deployed fibre capacity can be increased 35-fold before its limits are reached. Though it is expensive to deploy due to the civil works involved, with essentially unlimited capacity, it can be considered to be a 40-year asset. Once fibre is in place, capacity can be increased by simply upgrading the network's opto-electronics.

Although the extent of FTTP deployment in the County is difficult to gather due to ISPs reluctance to provide such competitive information, evidence from ISP websites, survey results, and information from stakeholder interviews can be used to understand where fibre may be deployed in the County.

FTTP Offerings in Leduc County

When looking at ISPs that offer FTTP services in the Edmonton Metropolitan Region, TELUS is the only provider that offers fibre services with symmetrical upload and download speeds – their offerings provide a maximum of 1 Gb/s download and 1 Gb/s upload. Shaw has a Fibre+ offering which relies on their fibre backhaul network, with connection to the premise provided through coaxial cable. As premises are connected through coaxial cable, Shaw's Fibre+ service does not offer symmetrical speeds and while maximum download speeds reach 1 Gb/s, upload speeds do not typically exceed 35 Mb/s.

When looking at offerings in the Leduc County area, though TELUS has yet to generally deploy its PureFibre offering, it did acquire Axia's FTTP infrastructure in Thorsby. As for Shaw's Fibre+ offering, this is highly prevalent in the dense population centers across the County, with offerings in Nisku, Beaumont, Leduc, and Devon. However, according to survey results from resident and business surveys, only 3.9% of residents and 13.0% of businesses are subscribing to services beyond 150 Mb/s download speeds and only 3.4% of residents and 8.7% of businesses are subscribing to services with greater than 50 Mb/s upload speeds. This is telling of the lack of FTTP availability across the County.

Although there is a lack of FTTP penetration across the Leduc County area, there are areas where fibre is being deployed, namely in new developments and at the Edmonton International Airport.

Deployment in New Developments

When speaking to the Canadian Home Builders Association and the Urban Development Institute to understand the business and developer community's involvement in deploying broadband, it was found that they are consistently ensuring that fibre is being deployed in new developments.

Developers partner with ISPs such as TELUS and Shaw to assist with the deployment of broadband infrastructure. Typically, developers pay for the infrastructure deployment and allow ISPs to retain ownership. This is due to a recognition that broadband connectivity is fundamental to communities and that businesses and residents alike no longer choose to purchase property where capable Internet connections are not available. This shift and focus that purchasers have in ensuring reliable Internet connections exist has occurred over the past decade and it was not previously as important as it is today.

It is important to note that although there is a focus on ensuring fibre or broadband infrastructure is deployed in new developments, residents are less concerned with the type of infrastructure that provides them connectivity, whereas industrial and commercial customers put much more significance on connectivity through fibre infrastructure.

Edmonton International Airport (EIA)

The EIA has deployed their own broadband infrastructure and have developed a 144-strand fibre loop that is connected to gateway services through TELUS and Shaw backhaul networks. The fibre loop provides robust connections for the airport and the businesses on the EIA property. It was noted that their decision to deploy fibre infrastructure on their own was to ensure that they had an open network for which they could solicit services from multiple providers.

Despite their success in deploying fibre infrastructure, they have found the ongoing management of the infrastructure to be difficult as revenue is small and, when combined with their older copper-based infrastructure, the mixed network is expensive to maintain. As such, they expressed the need for a review of their telecom infrastructure and its operation.

Fixed Wireless Access

Fixed Wireless Access (FWA) technology represents another method of providing "last mile" connectivity and is often used in rural areas where the population is less dense.

As illustrated in Figure 3, fixed wireless or wireless point-to-multipoint (PMP) access networks use a central access point (AP) that is connected to a backhaul network to provide services to premises in the area surrounding the AP. Coverage areas depend on the height of the AP, local terrain, and foliage. With a 100m tower and near line-of-sight (LOS), signals in the 2 and 3.5 GHz bands can provide services up to 25-30 km away. If the AP has a backhaul link capacity of 100 Mb/s, this is typically split to say 75 Mb/s for downstream and 25 Mb/s for upstream services. These speeds are then shared amongst however many subscribers are concurrently online and utilizing the system. If 100 premises are so doing, then each would see services of only 750 x 25 kb/s. In FWA networks, each premise requires a subscriber antenna to receive signals from the AP and to transmit their data back.

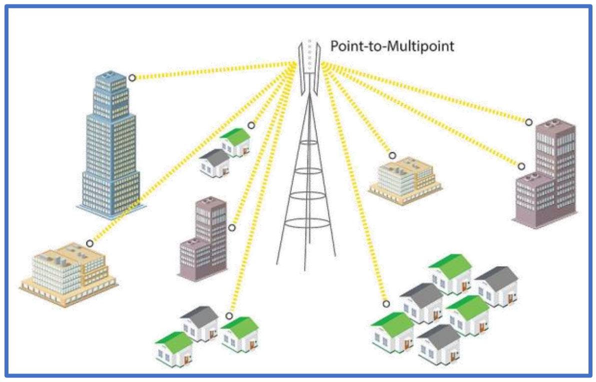

Figure 3. Point-to-multipoint FWA networks

In Leduc County, these services are mainly provided by Big Wi-Fi, Broadband Surfer, Clearwave, LABBAIR, MSCNet, Syban Wireless, and Xplornet (now including CCI), with 72% of subscribers paying for 30 Mb/s download services, as indicated in resident and business surveys. Wireless services are also available via business grade point-to-point (PTP) links from Switch and TeraGo and through the mobility network via the TELUS Smart Hub.

Internet services to rural residents are largely provided by seven wireless ISPs using some 31 fixed wireless towers – as shown by the balloons in Figure 4. The white balloon depicts a tower that is at capacity and would benefit from a fibre connection and red are those that will not need fibre for a few years yet. That a tower does not currently require fibre does not necessarily mean that service in the area meets the Canadian Radio-television and Telecommunications Commission's (CRTC's) Universal Service Objective (USO) of 50 Mb/s download by 10 Mb/s upload. Indeed, low premise density together with heavy tree cover and or terrain issues may restrict service to premises in the area and thereby limit the load on the tower.

The circles in Figure 4 show idealized coverage off the FWA towers and premise locations are shown by white dots. As the County is well covered, service level issues have more to do with capacity of the wireless equipment than they do with coverage. With so many ISPs serving the same low-density market, it is likely that none of them have sufficient market-share to justify upgrading their equipment.

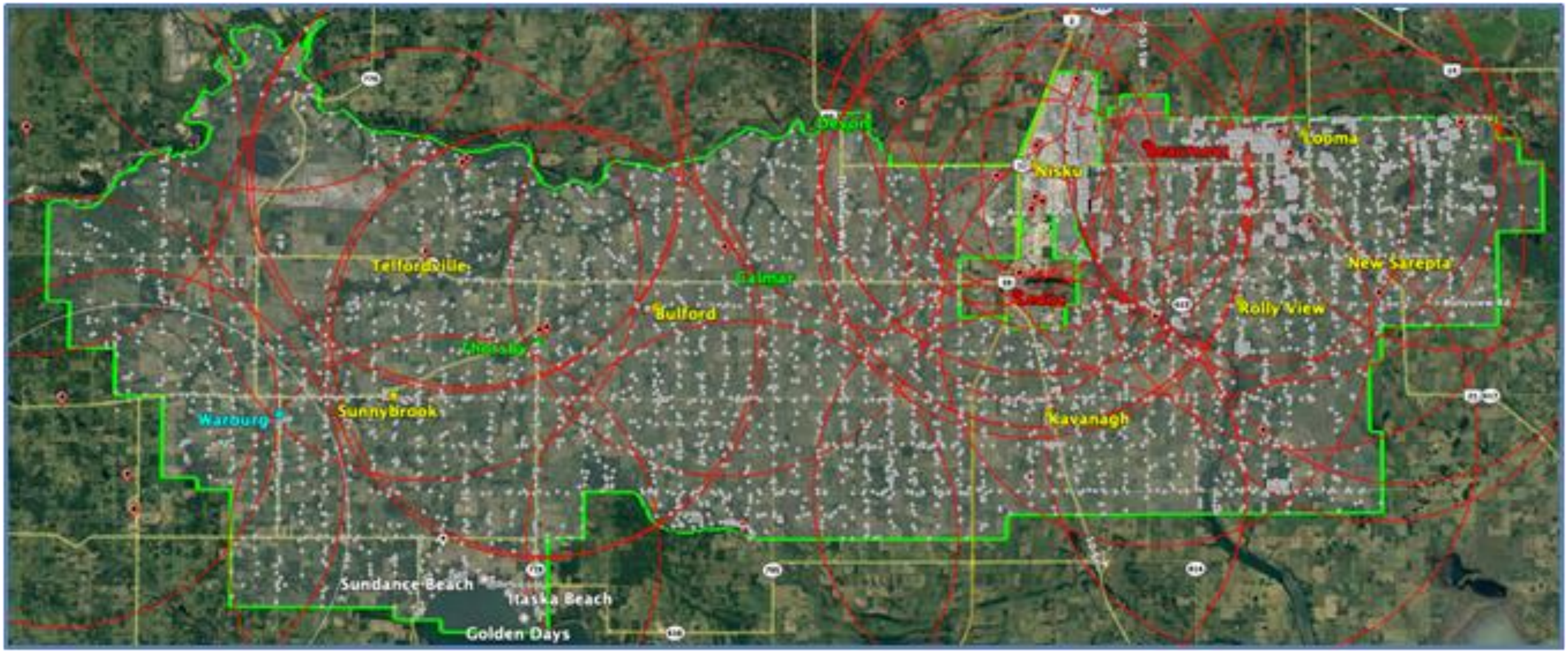

Figure 4. FWA coverage in Leduc County

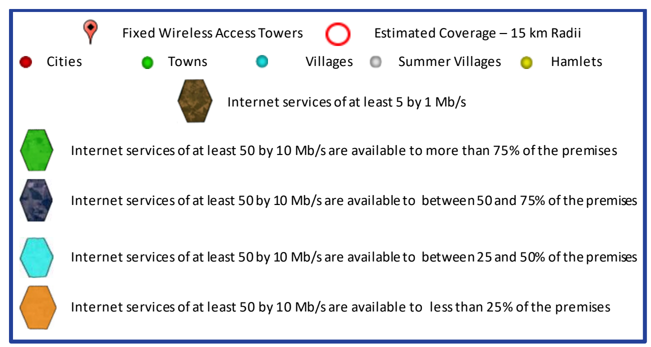

Figure 5. FWA Coverage Map Legend

Cellular Networks

Cellular coverage in the County is provided by 4 providers using the 41 towers shown in Figure 6. According to Innovation, Science, and Economic Development Canada (ISED), all areas of the County have LTE coverage. In most cases, LTE and 3G cellular coverage are limited by data caps that make it difficult and expensive to use cellular networks as an alternative to broadband network connectivity.

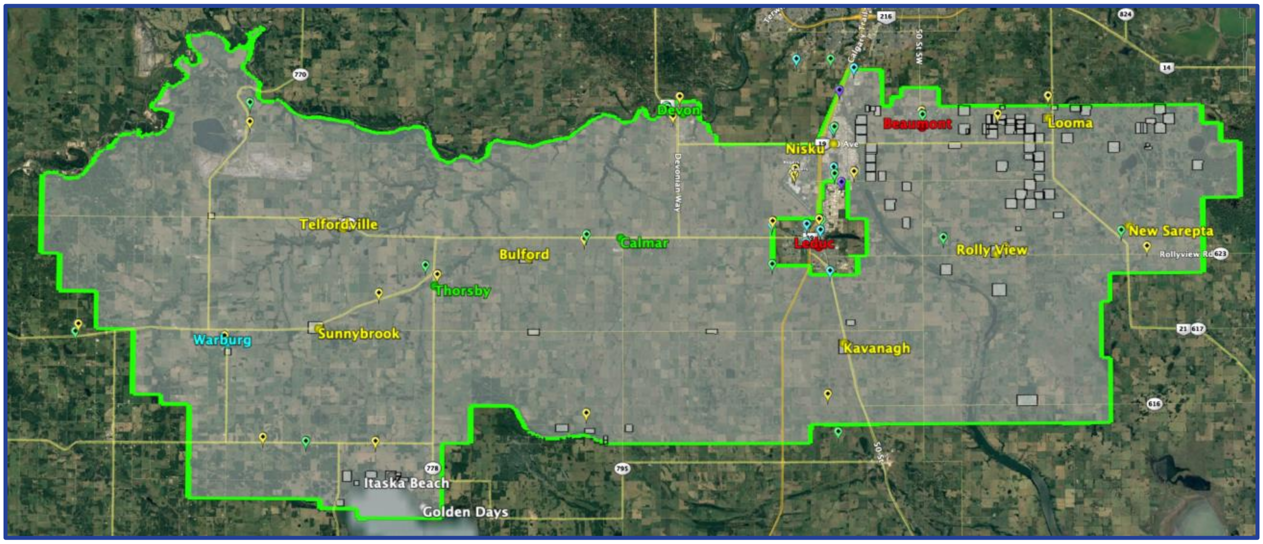

Figure 6. Cellular infrastructure in Leduc County

5G Considerations

As advances in 5G will benefit the cellular, fixed-wireless and satellite markets and vice-versa, the capability-to-cost ratio with wireless equipment is improving rapidly. FWA versions of 5G cellular systems are becoming available and some, such as that being developed by Starry[1] and Cambium are being targeted as a replacement to last-mile fibre connections.

To achieve the aggressive capability targets set for 5G systems, all aspects of the radio technology are being exploited, from software-defined radio technology to more complex modulation, signal processing, and antenna (beamforming) technologies, among others. Of these, beamforming is especially key, as much for its capabilities as its price-tag. Beamforming refers to the ability of an antenna to generate multiple '*spot*' beams within its coverage area and coordinate the frequency re-use much more efficiently than that possible with fixed coverage antennas – together this increases the effective capacity of the system significantly. In effect, they create many mini-cells within the macro-cell associated with the fixed antenna equivalent – simultaneously increasing both signal strength and bandwidth.

A concern with technology development dependent on multi-dimensional improvements is that compromises are often required – leading to the analogy of the duck: while a duck can swim, walk, and fly, it doesn't do any of them overly well. It may take a while for 5G systems to truly reach their potential and deliver on the hype.

Small Cell Wireless

[1] https://starry.com

With the advances in wireless technologies that will underpin 5G, providers such as Cambium, Ericsson, and Nokia are providing pre-5G 'small-cell' APs that can bridge the gap between the traditional FWA and wi-fi options outlined above. Indeed, it was the Nokia version that ATCO was looking to deploy as it evaluated the opportunity to assist communities with broadband access. Along these lines, a number of traditional FWA suppliers are now making small-cell options available that mesh well with their larger (macro) cell traditional FWA equipment – thereby enabling a more flexible evolution of the networks they support.

Interestingly, the developing 5G standards include a capability termed 'network slicing' which permits network capacity to be sliced, or subdivided, into independent sub-networks. Leveraging this capability, the County could look to deploy a backbone network and leverage it to deploy one 5G network, including all the required APs, and make the sub-networks available to different providers – thus obviating the need for duplicate or triplicate 5G infrastructure. Unfortunately, the spectrum issues associated with this approach have yet to be resolved and true 5G equipment will not be available for another year or two.

Converged Access

The world is going wireless, but wireless is going fixed. – Nokia

As application requirements and the bandwidth needed to support them increases – whether mobile or fixed as illustrated in Figure 7 – so does the need for fibre. As per Nokia's quote, the more the world goes wireless, the more wireless goes fixed, as fibre to the wireless APs becomes increasingly mandatory. There is an increasing array of both wireless and fixed sites that will require fibre connections. Network design is therefore moving toward optimized 'converged' fibre and wireless designs to concurrently maximize flexibility and minimize deployment costs going forward. With this approach, *fibre to the most economical point* becomes a key consideration and small-cell wireless is typically assumed for initial premise connections. Only when requirements increase is the fibre extended to individual premises.

Figure 7. Both mobile and fixed applications will require access to substantial bandwidth

Satellite Networks

Traditional broadcast and communication satellites are located in geo-synchronous orbit, sometimes referred to as the Clarke Belt – Figure 8. Satellites in this orbit, which lies in the plane of the equator some 22,300 miles / 36,000 km above the earth's surface, appear to be stationary with respect to earth-bound observers. These large and expensive satellites tend to be capacity-limited from an Internet perspective as each may have millions of devices within its footprint. There is also a delay problem – due to the round-trip time from the surface to the satellite and back, signals are delayed by a minimum of 240 ms, or about a quarter of a second. In broadcast applications this is irrelevant, but in two-way communication, it degrades services from a voice and video perspective, and renders the system unusable for applications dependent on voice and video.

These traditional satellites are what provide coverage for Leduc County today, with 27.4% of resident and business survey respondents indicating they access Internet services through Xplornet's satellite network, which currently operates off of two satellites.

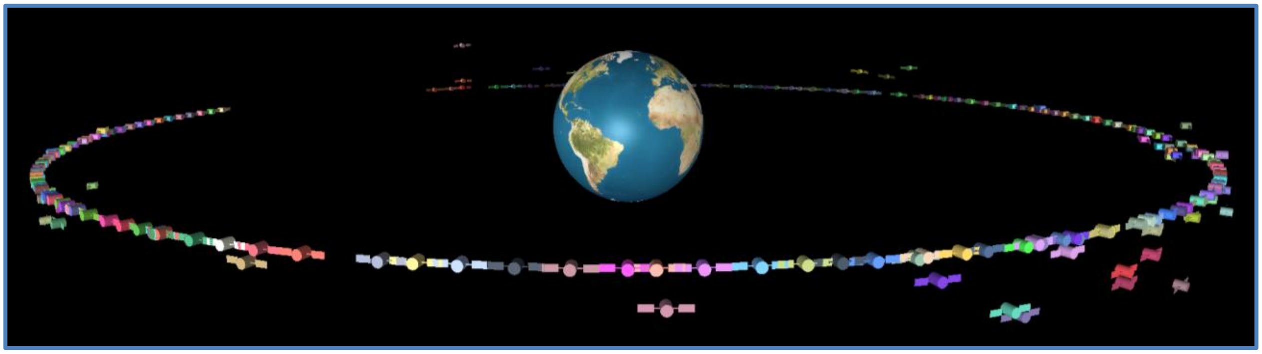

Figure 8. Geosynchronous orbit

To get around both capacity and delay issues, current plans to provide space-based global Internet services involve placing thousands of satellites in low earth orbit as illustrated in Figure 9. Compared to the geosynchronous satellites, these would be small enough that many, 60 in the case of StarLink, can be launched at once. For further information on the advancement of satellite technology, please refer to Appendix A.

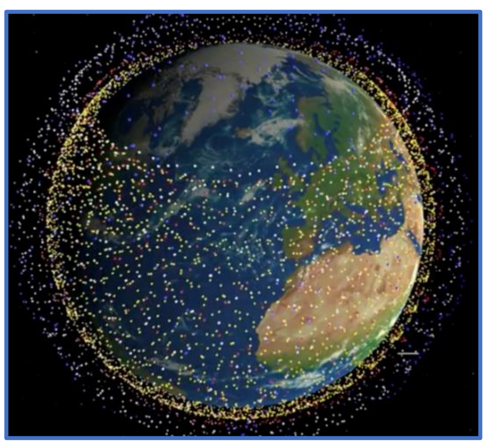

Figure 9. Proposed StarLink LEOS constellation

Open Wi-Fi Networks

In urban centres, wi-fi services are typically available in commercial establishments like grocery stores and coffee shops, are widely available from large providers such as TELUS and Shaw which leverage their existing networks to provide service, and can be made available by municipalities themselves (the City of Edmonton and Olds are examples of municipalities with publicly deployed wi-fi networks).

As typical coverage off individual wi-fi APs is quite limited – typically under 200m – many devices and an underlying network are needed to provide ubiquitous coverage. While a connectivity network could be designed to service such a deployment, with fibre going to every block, the cost savings over a full FTTP play are limited.

In Leduc County, Wi-Fi networks are provided in some commercial establishments and are more widely available through Shaw and TELUS, as depicted in Figures 10 and 11.

Figure 10. Shaw Go Wi-Fi coverage

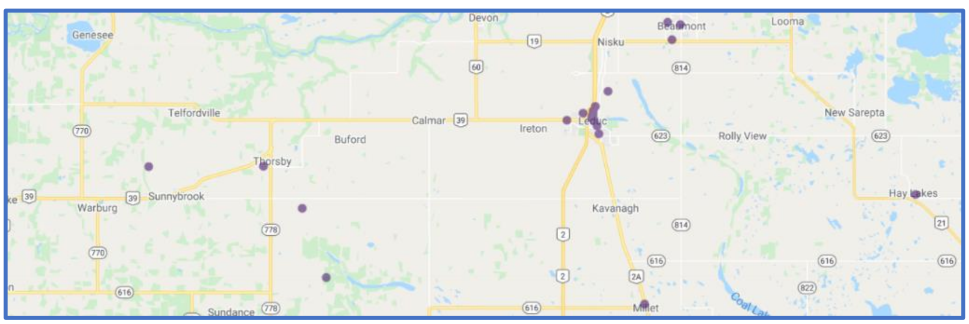

Figure 11. TELUS Wi-Fi Coverage

Service Levels

Current service levels are analyzed in this section through various means. Firstly, commentary is provided on overall satisfaction with current service levels through a summary of information gathered through resident and business surveys and departmental workshops. This is followed by three alternate views on the service levels available in the County today which have been provided through data gathered from surveys, the Canadian Internet Registration Authority (CIRA), and the Government of Canada (CRTC and ISED).

Overall Satisfaction

Resident and Business Surveys

95% of residents and 98% of businesses have indicated that broadband connectivity is extremely important to them. However, their satisfaction with current connectivity levels are fairly low. Furthermore, when analyzing the data, it was found that there is a significant difference in satisfaction between rural and urban areas. The charts In Figures 12 through 15 show the comparison.

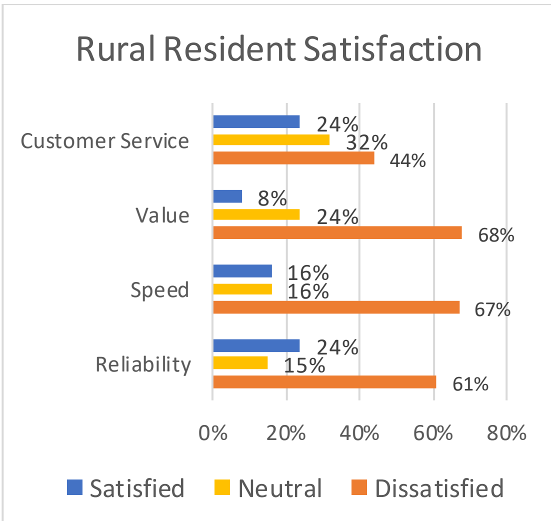

Figure 12. Rural resident satisfaction

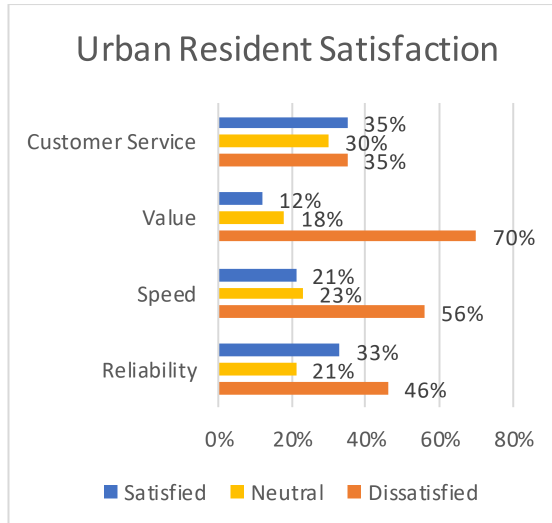

Figure 13. Urban resident satisfaction

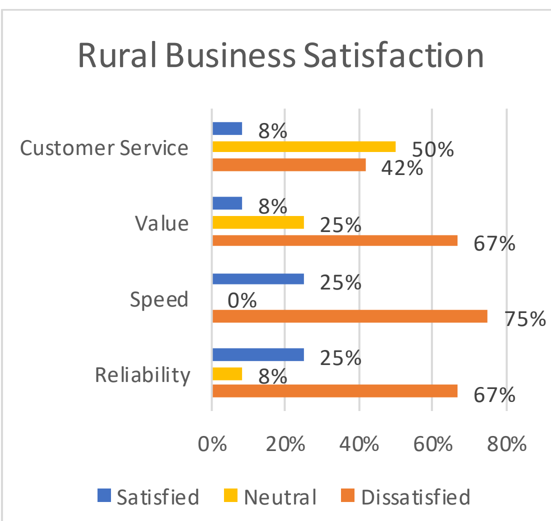

Figure 14. Rural business satisfaction

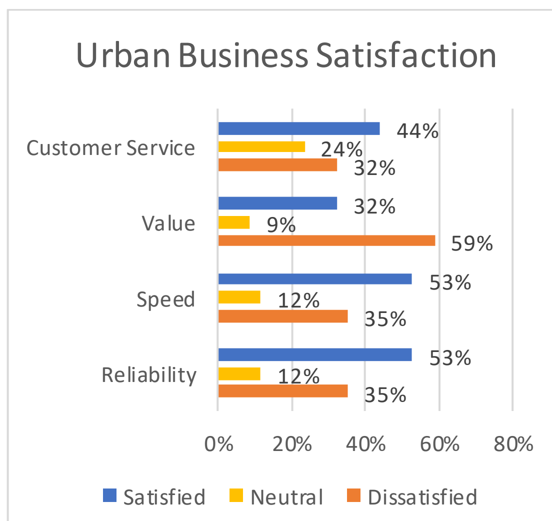

Figure 15. Urban business satisfaction

The results shown above indicate that there is dissatisfaction with service levels across the board, and that there is greater dissatisfaction with Internet reliability and speed in rural areas. This dissatisfaction likely arises due to a greater percentage of rural residents and businesses accessing the Internet through wireless technology, as shown in Figures 16 and 17.

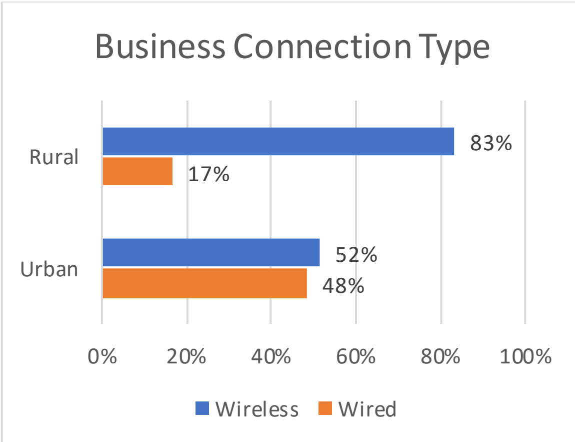

Figure 16. Business connection type

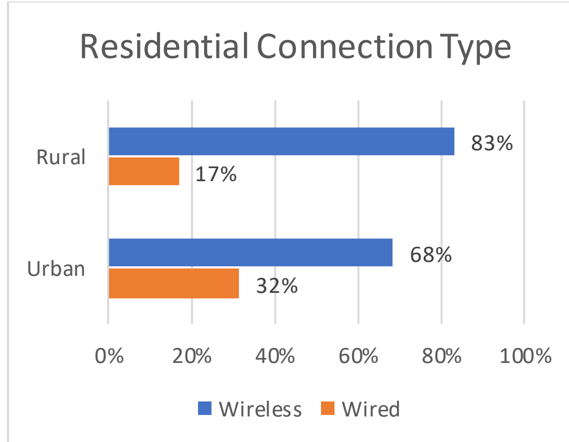

Figure 17. Residential connection type

Internal County Stakeholders

When speaking to internal County stakeholders, much of the dissatisfaction seen in survey results was echoed. In particular, it was noted that connectivity issues negatively impact investment attractiveness in the Nisku business park, that County buildings have poor connectivity (some of which are also located in Nisku), and that Leduc County employees that live in the County experience connectivity issues when working from home.

These issues were brought forth in each County workshop and the consequences for this lack of connectivity are highlighted by two key examples:

- All Emergency Operations Centres (EOC's) are seen as having poor connections, and the EOC in Nisku, which was at the center of the County's COVID response had connectivity issues during the pandemic response.
- Lack of broadband connectivity has also been seen to have a negative impact on security, which is exemplified by break-ins to Waste Transfer Stations and the St. Francis Radio Towers. These break-ins were noted to have occurred partly as a result of the lack of remote monitoring at these sites.

These key data points collected through surveys and workshops clearly indicate that broadband connectivity is extremely important to residents, businesses, and County administration, and that there is a need to enhance current service levels.

Advertised Speeds

Resident and Business Surveys

According to data collected through resident and business surveys and shown in Figures 18 and 19, the majority of residents and businesses do not have Internet service that meets the 50/10 Mb/s CRTC USO. A key factor in this may be that 76% of residents and 59% of businesses are connected via cellular, fixed wireless, or satellite technologies.

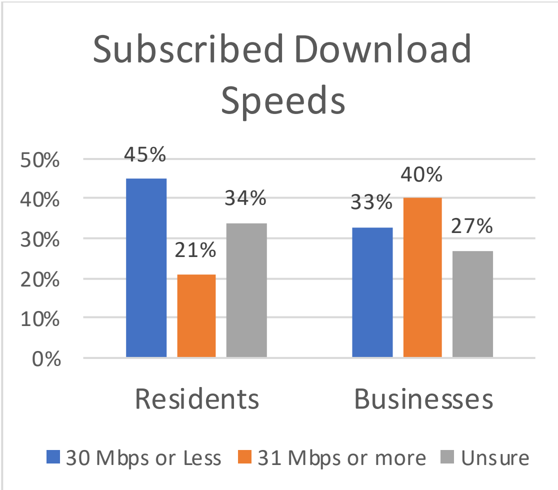

Figure 18. Subscribed download speeds

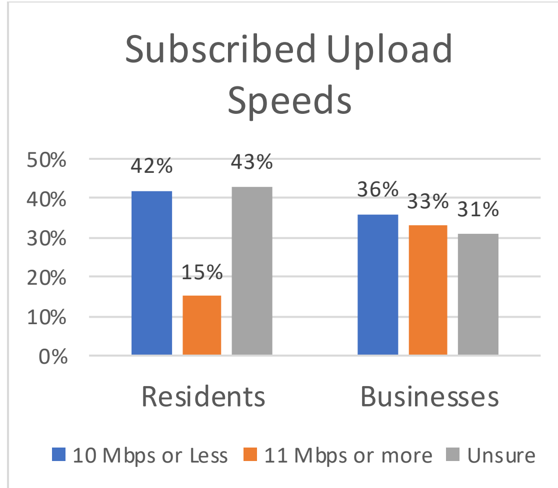

Figure 19. Subscribed upload speeds

The data gathered through surveys is further supported by current CRTC and ISED data that is utilized to determine eligibility for Federal broadband funding.

ISED and CRTC

The updated ISED/CRTC data for Leduc County is shown in Figure 20[2]. As can be seen, the best services are available in the north central area and then gradually decrease to the east and west. Premise locations are shown by white dots.

Coverage areas should be regarded as indicative only. First, the maps were largely assembled off suppliers' advertised service levels and coverage areas which, for marketing purposes, are often either over-stated or covered off with the prefix '*up to*'. While a client may see services up to, say, 10 Mb/s in the middle of the night, during peak usage periods, service levels may be less. Second, wireless coverage is significantly impacted by terrain and ground cover. As many areas in rural Leduc County have dense tree cover, wireless service levels in these areas are problematic.

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[2] https://www.ic.gc.ca/app/sitt/bbmap/hm.html?lang=eng

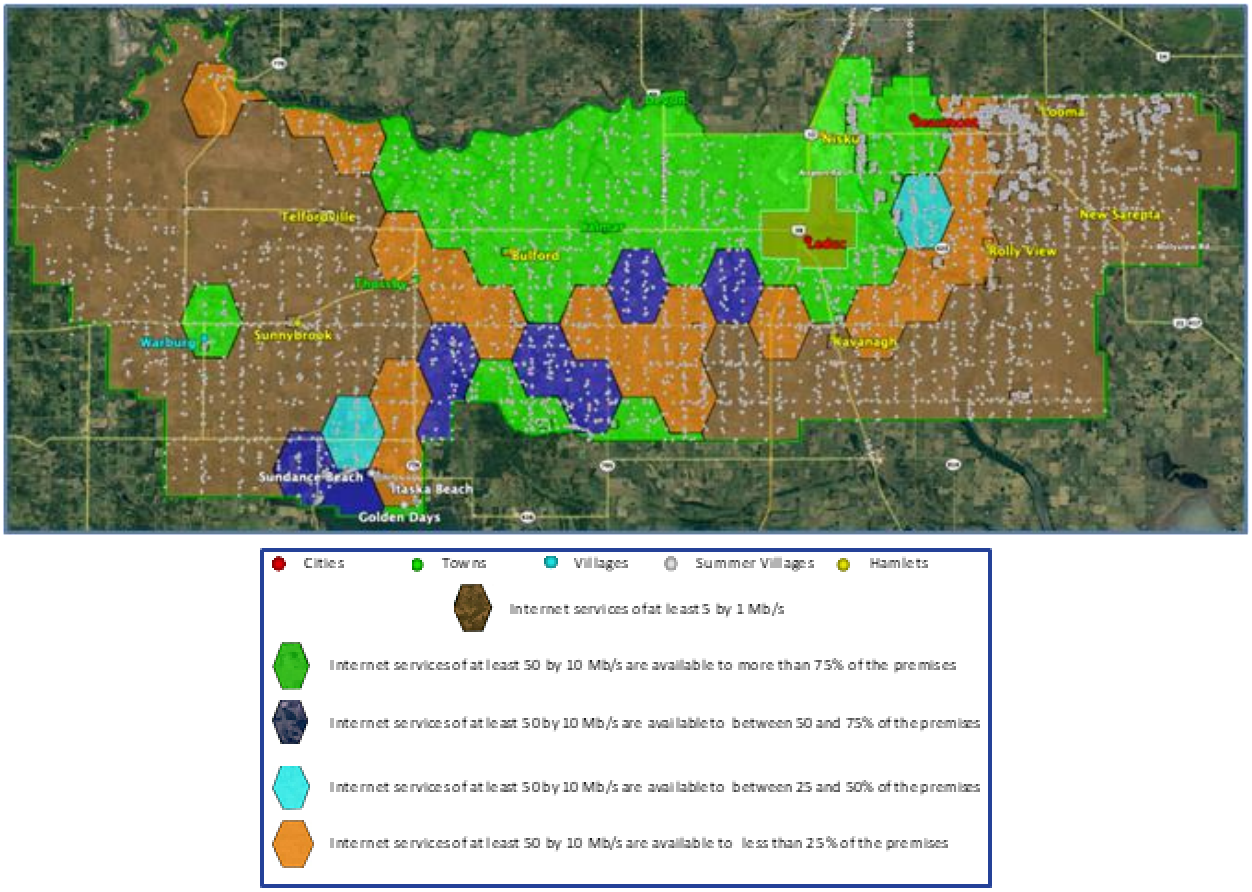

Figure 20. Availability of Internet services meeting the CRTC's 50/10 objective

In addition to the hexagonal map that has been utilized by the CRTC to determine funding eligibility in the past, ISED, in partnership with the CRTC, has created a more granular view of the advertised speeds across Canada. ISED's National Broadband Internet Service Availability Map, shown in Figure 21[3], looks at advertised service levels across the country in relation to 250m segment roadways. The data displayed in the National Broadband map largely matches the information available in the hexagonal maps.

[3] National Broadband Internet Service Availability Map

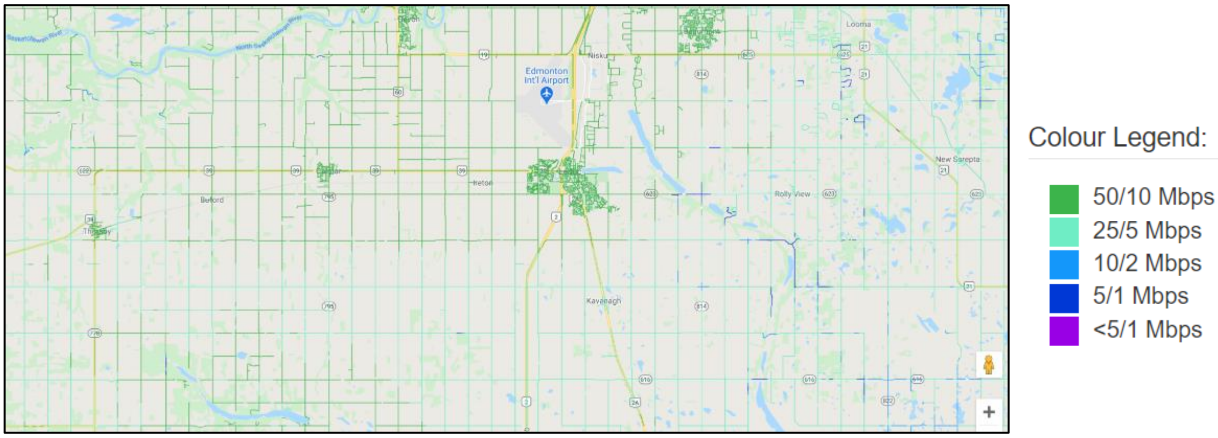

Figure 21. National Broadband Internet Service Availability Map

Actual Speeds

Often times, residents and businesses find that the advertised speeds they are paying for are not always what they experience. As such, the County made arrangements for residents and businesses to access the unbiassed Canadian Internet Registration Authority (CIRA) performance testing program. The County encouraged those within the County to run the tests on their various device's multiple times – on different days of the week and at different times of the day. As of September 28, 2020, 1,119 tests have been run and the speed results are shown in Figure 22. An overview map showing the test results is available at: https://performance.cira.ca .

In these charts, the urban results refer to all tests run within Electoral Division 3 north of the City of Leduc [4]– the Nisku area, while the rural results are those for tests run everywhere else. A map of the Electoral Divisions appears in Figure 23.

Though initially surprising, the minimal differences between the urban and rural services apparent in Figure 22 can be explained by considering that the primary broadband services infrastructure in Nisku has largely not been updated and does not differ substantially from that in the rural areas – older generation copper and fixed wireless.

[4] That is, north of 53°18'31.4" N.

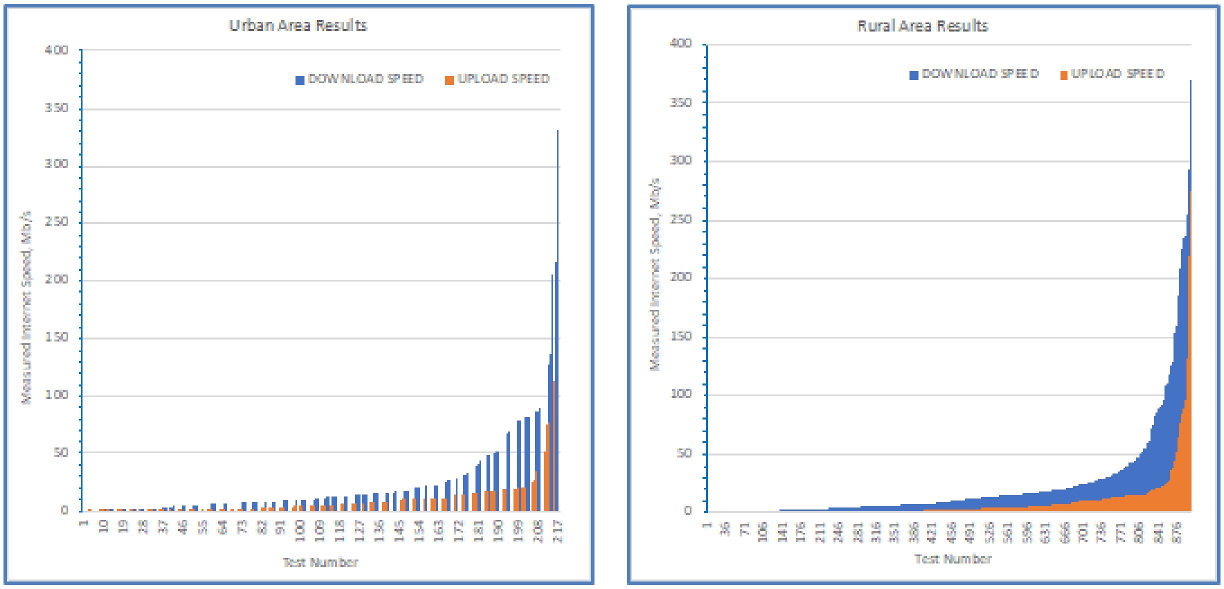

Figure 22. Urban and rural CIRA speed test results for Leduc County

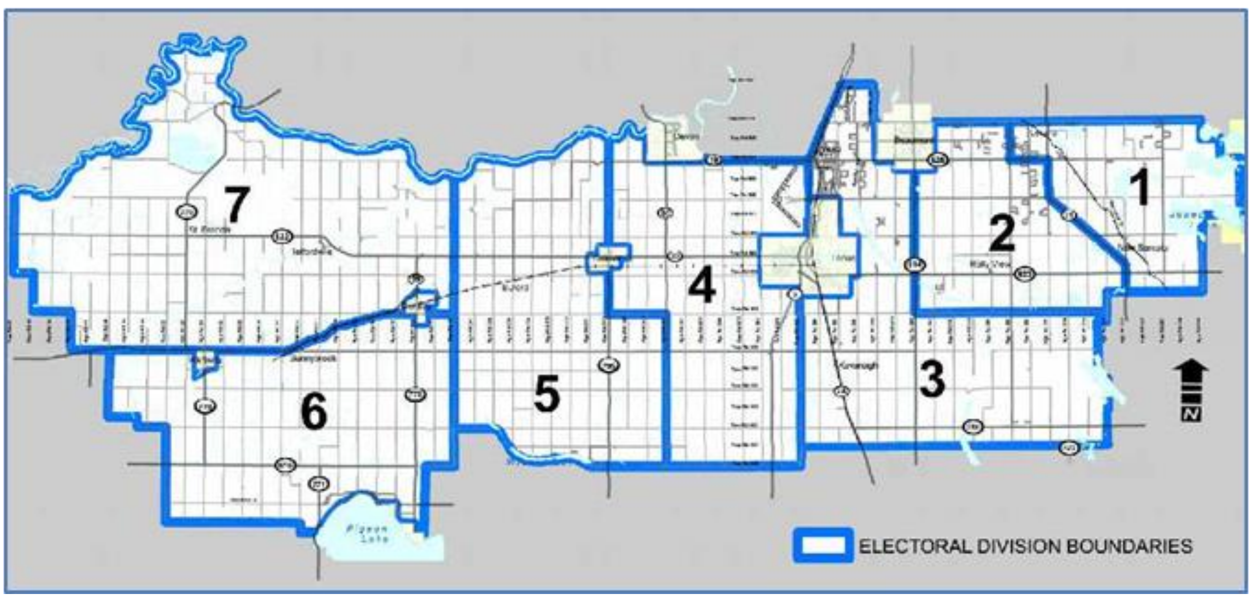

Figure 23. Electoral Divisions in Leduc County

A more quantitative view of the broadband measurement results is provided by the so-called box and whisker plot in Figure 25. As shown in Figure 24[5], box plots divide the results into four quartiles, wherein each quartile represents 25% of the results. The box, then, represents the results falling within the 2nd and 3rd quartiles, or those results representing the middle 50% of the results collected – also referred to as the interquartile range. The median result marks the mid-point of the data – so 50% of the speeds collected fall below the median, while the remaining 50% lie above. The average result is shown by an 'X'.

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[5] Figure is taken from: https://www.simplypsychology.org/boxplots.html

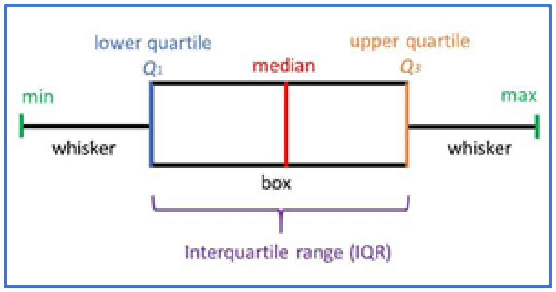

Figure 24. Box-plot representations

Table 1. Speed test statistics

	Download		Upload	
	Urban	Rural	Urban	Rural
Maximum	52.64	48.24	24.82	19.84
Q3	24.62	21.70	11.03	8.64
Average	25.36	24.68	12.09	9.34
Median	10.97	9.34	4.67	2.77
Q2	5.39	4.00	0.79	0.95
Minimum	0.00	0.02	0.00	0.04

Before calculating the box-plot shown in Figure 25, Excel removes 'outliers', which are those results which are over 1.5 times the interquartile range above the Q3 boundary – the outliers are shown by dots and likely represent tests from locations in which the business owners have arranged for custom service. Though the outlier results extend to ~400 Mb/s as shown in Figure 22, for clarity, the vertical scale has been limited to 100 Mb/s.

The statistics associated with the box plot in Figure 25 are summarized in Table 1. Relative to the CRTC's 50/10 objectives, the median urban/rural, download/upload speeds found are 10.97 by 4.67 and 9.34 by 2.77 Mb/s. Based on these results, 75% of Nisku businesses see download and upload speeds less than 24.62 and 11.03 Mb/s, respectively. Similarly, 75% of rural premises see download and upload speeds less than 21.70 and 8.64 Mb/s second, respectively.

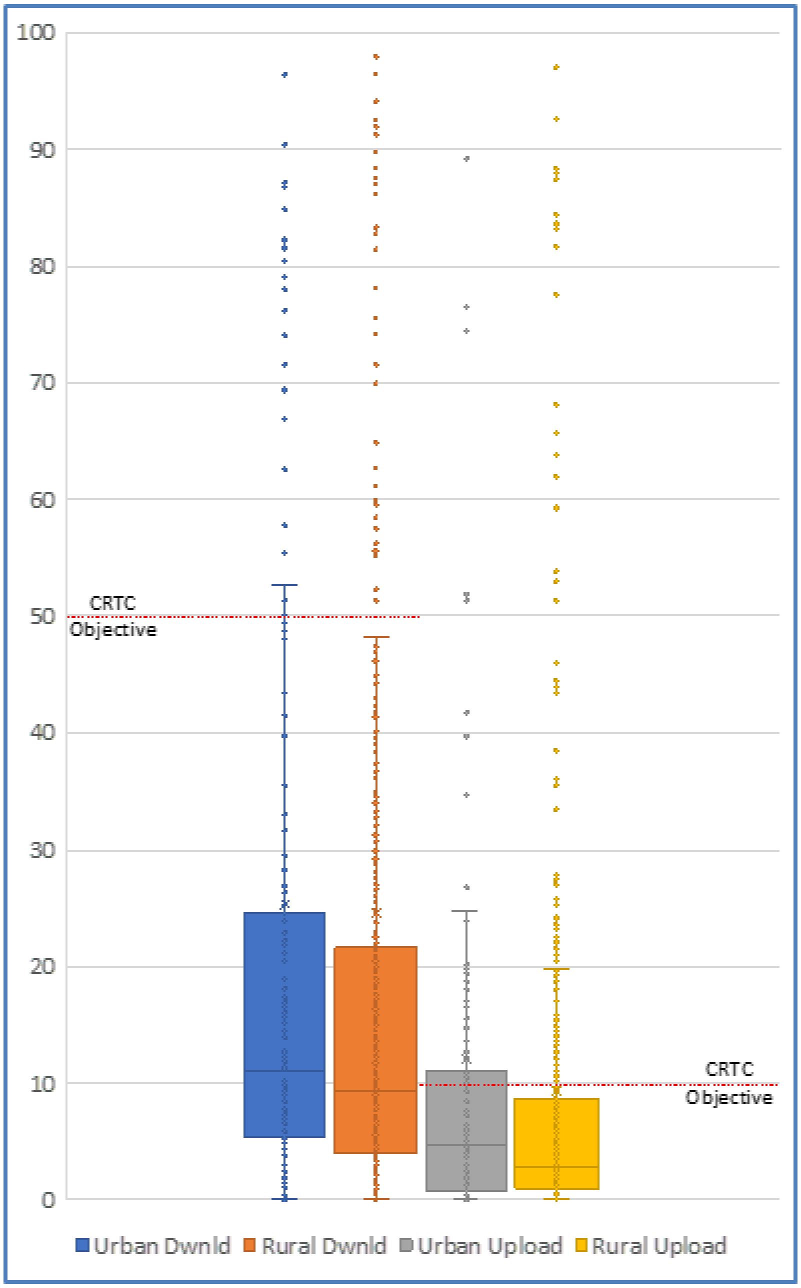

Figure 25. Speed test results

Desired State

The desired state of connectivity was expressed through resident and business surveys, internal County workshops, and conversations with the EIA. This section provides a summary of future state needs that were expressed in the aforementioned engagements.

Residents and Businesses

Survey results have made it clear that enhanced connectivity is needed today, will be needed even more into the future, and that businesses and citizens want the County to take ownership of the issue and resolve it. Comments left by residents and businesses have highlighted the need for this further:

- One business owner in Nisku has stated they will move their business back to Edmonton if the problem is not resolved within the next two years.
- Citizens have called out that high-speed connectivity is no longer a luxury but is a utility that is needed. This has been highlighted by the COVID pandemic, as it has been stated that Internet services have gotten worse.

Moving into the future, residents have indicated that they see their use of the Internet increasing in the 3, 5, and 10-year period. They believe the remote working environment will continue and increase into the future, that their children will be utilizing the Internet more as they grow, and, in general, that they will continue to acquire additional connected devices.

For businesses, 40% feel 50 Mb/s download speeds would meet all business requirements with an additional 30% who feel 100 Mb/s would meet their requirements. In addition, 50% of businesses require 50 Mb/s upload speeds. These requirements will continue to increase into the future as more and more businesses subscribe to cloud service offerings and new digital ways of working.

In addition, and as mentioned, both residents and businesses would like to see the County take a more active role in the enhancement of high-speed broadband infrastructure. As shown in Figure 26, 61% of residents and 78% of businesses would like the County to have medium to high involvement in ensuring the County's future Internet needs are met. For clarity, the following were the options that respondents chose from to answer this question:

- No involvement; the County should not be involved in the Internet needs of its residents and businesses.
- Low to medium involvement; the County should encourage and/or support the private sector, possibly with municipal investment.
- Medium involvement; the County should look at investing in Internet infrastructure and providing it on a utility basis (like roads and water) for all Internet service providers to use.
- High involvement; the County should provide Internet infrastructure and services to ensure county-wide access and quality of service to all county residents and businesses.

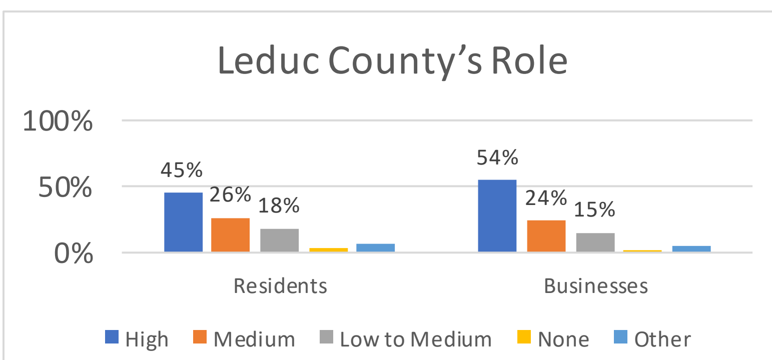

Figure 26. Leduc County's role

Internal County Stakeholders

When conducting workshops with internal County stakeholders, discussion occurred around the future state connectivity needs of the County and the potential involvement they would like to see administration play in enhancing broadband infrastructure. Key considerations around smart city infrastructure, internal County broadband governance, and the County's role in future deployments were brought forth.

Development of the County's Smart City infrastructure and services were top of mind as the benefits of real-time data analysis and automation of services is seen to enhance business and citizen experience. Smart City examples discussed during workshops included smart traffic signaling, Next Generation 911, use of unmanned aerial vehicles (UAV's) for emergency response, and e-government services, to name a few. If harnessed, the County could realize significant benefits from these currently developing innovations.

In discussing internal County governance of broadband development, it was generally agreed that a committee made up of stakeholders from various departments would be required to appropriately manage all aspects of broadband development. The task often involves expertise and collaboration across various departments, such as Information Management & Technology, Engineering and Utilities, Planning and Development, Road Operations and Agriculture, and potentially other stakeholders from across departments. As such, it was seen that no one department would be able to perform the task on their own.

Furthermore, it was also generally agreed upon that a partnership model that includes the private industry would be required, as operational capacity does not exist within the County to manage either the deployment or operational aspects of broadband infrastructure.

Edmonton International Airport

As the EIA looks to the future, they see a need for enhanced connectivity across the airport area, which includes enhanced wired connectivity and enhanced connectivity through 5G. The demand for greater bandwidth comes from both passengers and airport operations, with passengers looking to gain access to entertainment mediums that often require streaming of video, and the EIA operational team looking to enhance real-time management of their airport via a "connected cockpit" that connects all camera, airline/airplane, and passenger information.

In addition, and perhaps most importantly, the EIA expressed an interest in collaborating with the County to enhance broadband connectivity. As mentioned previously, they are currently managing their own telecom infrastructure, are looking for options to continue to enhance it, and are exploring options available to manage operations in a more sustainable manner.

Municipal Options to Close the Gap

Municipalities have a range of options available to realize their vision and close the gap between their current and desired states. Given the foundational nature of the required underlying connectivity infrastructure and that Canada has yet to develop meaningful related technology policy, a key question municipalities face is whether the required connectivity infrastructure is best provided by traditional incumbents with a profit motive or on an inclusive, affordable, utility basis for the benefit of all. Whereas an incumbent that provides fibre infrastructure in Nisku or the rural areas of the County would restrict use to its own services and limit bandwidths to what can be competitively monetized, a regional utility could focus on providing fibre inclusively and affordably throughout the surrounding region, provide equal access to all service providers, and maximize the bandwidths delivered.

The impact of the differences in these two approaches is significant. Under the private sector facilities-based model prevalent in Canada, Canada now ranks 14th in Broadband and in Innovation and at most locations in Canada, one has the option of two wireline providers (each with their own infrastructure). With shared, utility network infrastructure in Europe, in cities such as Västerås, Sweden, choices number over 30.[6] As the choice will impact life and work in County for the next forty-plus years, the stakes are high.

Based on the financials developed in the Business Case section later in this report, a comparative summary of the two options before the County for Nisku is provided in Table 2. The differences are significant, and which is better will depend on both the County and its vision going forward.

Table 2. Public vs Private Options for Nisku

	County	Incumbent
Service levels	1 – 10 Gb/s 40 Gb/s if needed	0.15 Gb/s
Business model	Wholesale, open	Retail, closed[1] – monopoly
Services-based competition	Yes	No
Local control[2]	Yes	No
Smart infrastructure support	Yes	No
Support to rural neighbours	Yes	No
Required capital[3]	$13,728,373	$0.00
Annualized net proceeds[3]	$949,280	$0.00
25-yr NPV[4]	$5,902,303	$0.00

[1] While the CRTC does mandate wholesale access to Incumbent fibre access networks, issues remain.

[2] Including service levels, affordability, security, access for IoT devices, etc.

[3] These financials assume reserve financing (see Table 10).

[4] Based on wholesale services only – no off-balance sheet benefits are included.

Regardless of the comparative advantages, though, municipalities may defer to the 'safe' incumbent solution. Given the choice will materially the community's future, based on both the cost and limitations associated with the incumbent option, 'safe' may not be the correct term. This is particularly true due to the often-compounding impacts of the factors presented. Non-competitive service levels, for instance, impact corporate decisions on where to locate businesses, which then impacts property values and the community's workforce and tax base. A lack of support for smart infrastructure increases community operational costs and service levels which then impacts the quality of life. A lack of support to one's rural neighbours, some

[6] Lafleur, B. et al; How Canada Performs – A Report Card on Canada's Innovation Performance; Conference Board of Canada; 2013-04.

of whom are part of the community's workforce, fosters a digital divide and creates an imbalance in the delivery of online education and health services.

In terms of complexity, deploying a conduit/fibre network is arguably no more complex than running water or gas lines – and, like water, fibre doesn't blow-up. With the state-of-the-art opto-electronics quoted, operational complexity is significantly less than what the County's information technology (IT) folks deal with on a day-to-day basis. As the equipment is unencumbered by legacy equipment and operational support systems, in spite of significantly increased state-of-the-art functionality, the operational costs will be much less than those faced by traditional operators.

Including the incumbent option, six potential approaches to enhance broadband within the County, together with examples of communities pursuing each, are illustrated in Figure 27. These range from electing to stay with the status quo and leaving things to private providers (1) to deploying a fibre network (5) to developing a retail services portfolio much like an incumbent or ISP (6). As one moves from left to right in the figure, the options require increasing levels of community involvement, investment, and risk. In return, the options afford the communities increased levels of control and benefit.

Communities often choose to offset the risk associated with the more aggressive options (3 to 6) by partnering with private enterprise. Typically, such partnerships leverage the deployment and operational expertise of private enterprise with the longer-term capital available to the municipalities. Partnership structures can range from simple contracts to joint ventures to public-private-partnerships.

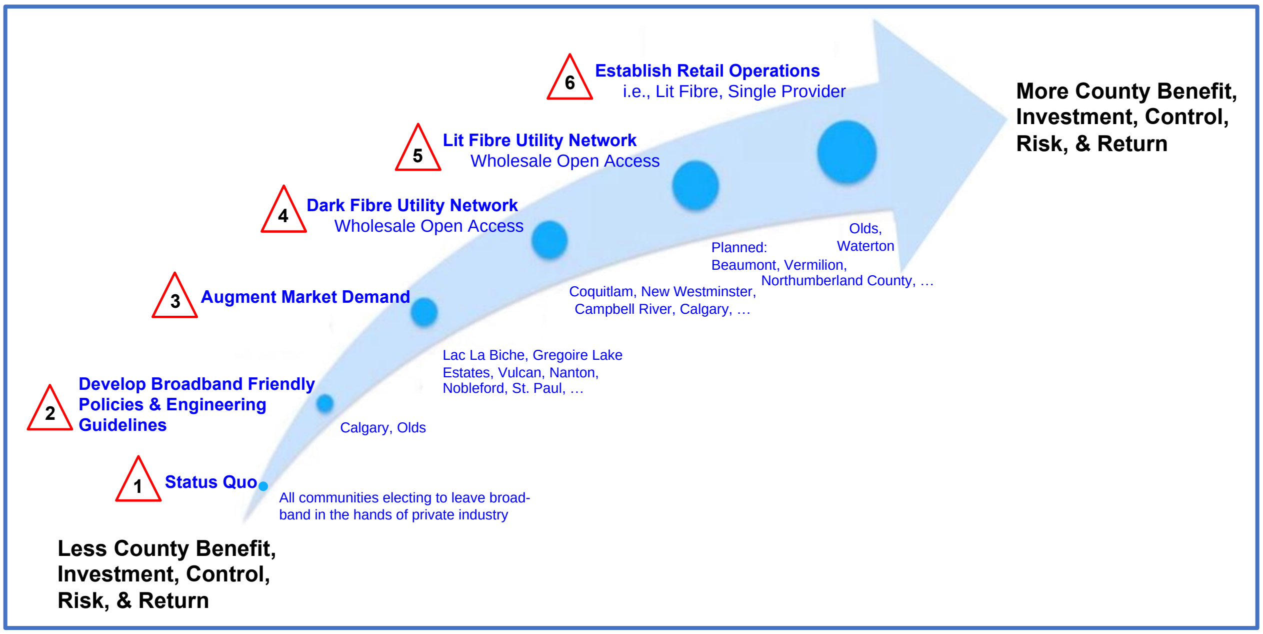

Figure 27. A range of available options.

As Leduc County expressed most interest in the deployment and implementation options (4), (5), and (6), those are the options for which capital and financial estimates were completed.

Network Infrastructure Analysis and Capital Estimates

Context

Recognizing both the opportunity and challenges associated with facilitating advanced broadband infrastructure and services within Leduc County, in 2010, the County undertook an initial study largely focused on enhancing the wireless infrastructure in the rural areas. While Nisku was included, the focus there was on speed tests to determine baseline existing service levels on which to base a strategy[7]. In rural areas, detailed radio-frequency analyses of the existing FWA infrastructure were undertaken and coverage gaps identified. To improve services in the rural areas, the report recommended additional tower infrastructure and equipment upgrades.

As shown by the idealized coverage circles in Figure 4, the issue is no longer a coverage issue – the County is well covered – it is one of capacity. The underlying issue is that residential and commercial usage of the Internet doubles every couple of years and to meet the ever-growing demand, the infrastructure must scale, and beyond a certain point, wireless technology does not scale well. Unlike fibre, which has essentially unlimited capacity and so scales by simply upgrading the equipment on either end of it, scaling a wireless network involves upgrading the radio equipment on existing towers, increasing the tower density, and enhancing the backhaul capacity to the tower.

This point was made clear in the cashflow projections associated with the needed growth in the wireless infrastructure provided in the 2010 report and reproduced in Figure 28.

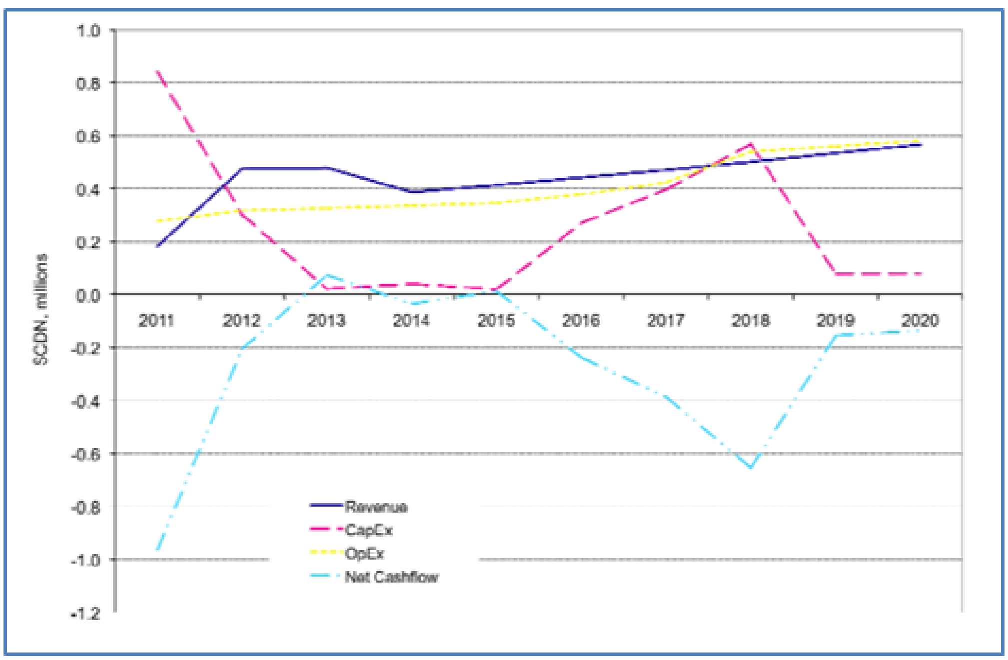

Figure 28. Cash flow results for wireless broadband infrastructure (2010)

[7] Bly, A. & Dobson, C.; Leduc County Regional Broadband Feasibility Study; ViTel Consulting & Taylor Warwick; 2010-06-03.

In the figure, the capital expenditures required to scale the network, together with net cashflow, are shown by the dotted magenta and dotted blue lines respectively. While the initially deployed infrastructure is good for the first 5-6 years, the capital required to grow capacity beyond that results in significant losses to the ISP. If only one ISP is serving an area, there may be enough clients to support the enhanced infrastructure. With several ISPs serving the same area, however, market-failure results and none may have the capacity to scale their networks as needed.

To ground the analyses required to provide the County with comparative quantitative options to facilitate enhanced broadband infrastructure and services within Leduc County, the County was divided into the one urban and four rural study areas shown in Figure 29:

- Urban – Nisku
- Rural West:
  - W-Pigeon
  - W-Rural
- Rural East
  - E–Rural
  - E-Central

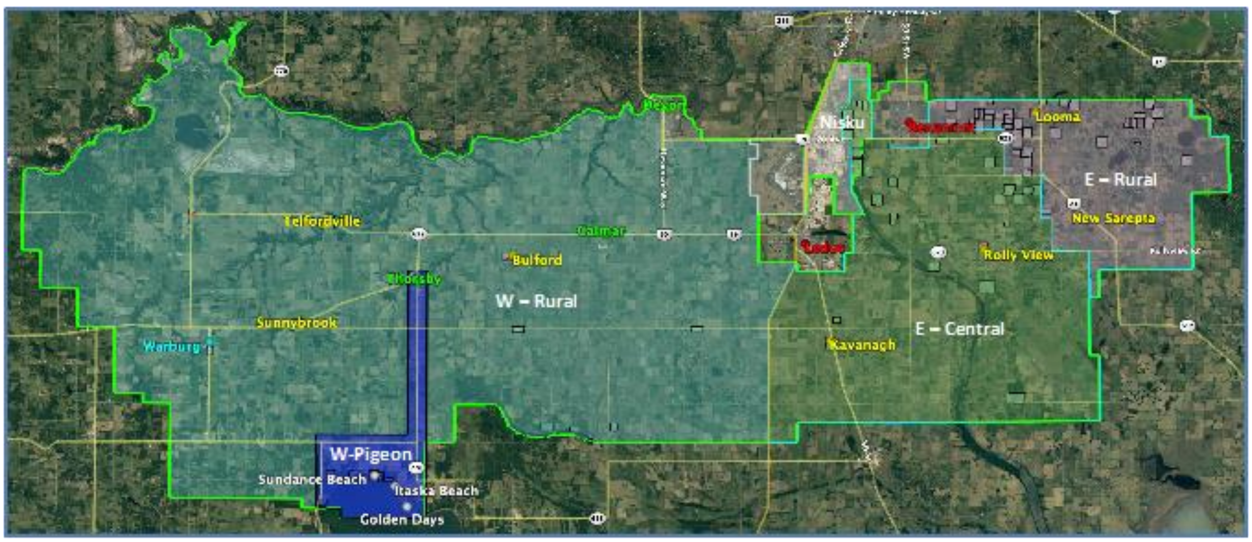

Figure 29. Five study areas in Leduc County

In the urban commercial-industrial hamlet of Nisku, a fibre-to-the-premise network is recommended. While some businesses have arranged for custom fibre connections from the incumbents, copper, coaxial cable, and wireless access infrastructure prevails and, as shown in Figure 25, Internet services are slightly better than what's available in rural areas. With the likes of Amazon moving into the area, fibre is the only option.

Given the high cost of a rural FTTP deployment, in rural areas, the County might consider a two-staged approach in which backbone and feeder components of a fibre network are deployed to provide a high capacity feed to each rural subdivision. Instead of then continuing with FTTP, the fibre is connected to 'gig-wireless' equipment to provide the last mile connection to each subscribing premise. Though there would be additional costs for the wireless equipment required, the option would significantly reduce upfront fibre deployment cost.

Without access to licensed frequencies, traditional macro-cell FWA equipment as currently deployed by ISPs have limited bandwidth and too large a coverage area to be a suitable solution for the rural subdivisions. There are 'small-cell' versions of this equipment available to augment bandwidth inside the macro-cell coverage areas, but their capacity is limited. Besides, duplicating existing ISP infrastructure is inefficient and could be a nightmare politically. If this FWA option is selected, the County might instead consider a partnership with the ISPs and leverage their expertise and asset-base to mutual benefit. More to the point, to spend millions putting fibre in the ground and then not significantly improve service levels would be both poor strategy and a difficult sell.

What is required, then, is an option that provides a good intermediate step or potential stepping-stone to FTTP and one that could significantly postpone the need to deploy FTTP in many or most subdivisions. The solution must therefore have sufficient bandwidth to substantially improve service levels in wooded subdivisions and potentially support open access. Leveraging developments in the 5G space, the new mm-wave, 60 GHz solutions are poised to provide the capabilities required. While the range of these systems is limited to, say, 250m, and strict line-of-sight is required, the access and client devices 'mesh' and the estimated pricing [8]for both is low enough that, even if several access points per rural sub-division are required, the cost-savings over the pure FTTP option are substantial.

For the remaining rural areas of the County, a backbone fibre network is laid out. It provides connections to FWA towers, key commercial-industrial sites, priority County sites, and rural subdivisions. Such a network would provide a base off which fibre could then be extended to any areas of the County that require it and, by connecting to it, local ISPs could enhance the capacity off their towers and improve services.

Rural – West Area

Using customized, world-class design software and detailed terrain and utility information provided by the County, 'conceptual' level air-blown fibre designs were completed for the rural areas. The overall design for a fibre deployment to the west rural area appears in the map in Figure 30. The backbone fibre network is shown in magenta, feeder cables are shown in navy blue, and distribution conduit in cyan. Should the County proceed, these designs are upgradable to full preliminary and detailed versions with minimal rework. As more detail is taken into account, the cost estimates will have to be adjusted.

[8] Product specifications and budgetary pricing are expected to become available in Q4, 2020.

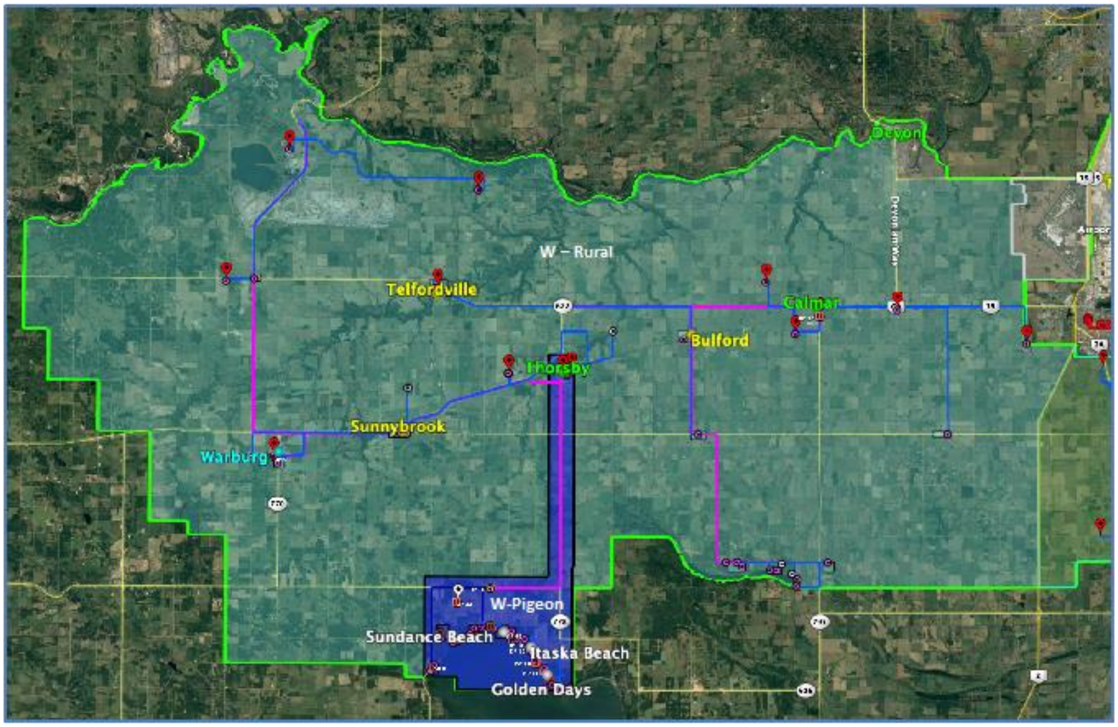

Figure 30. West deployment areas

From a deployment perspective, the area was divided into three zones – County Priority Sites, W-Pigeon, and W-Rural. The County priority sites are small deployments that would provide fibre service to the firehalls in Calmar, Thorsby, and Warburg. The W-Pigeon deployment shown in Figure 31 would provide fibre from a SuperNet POP in Thorsby to the CCI tower and the residential areas bordering Pigeon Lake. Though not technically part of the County, the designs encompassed the summer villages of Sundance Beach, Itaska Beach, and Golden Days.

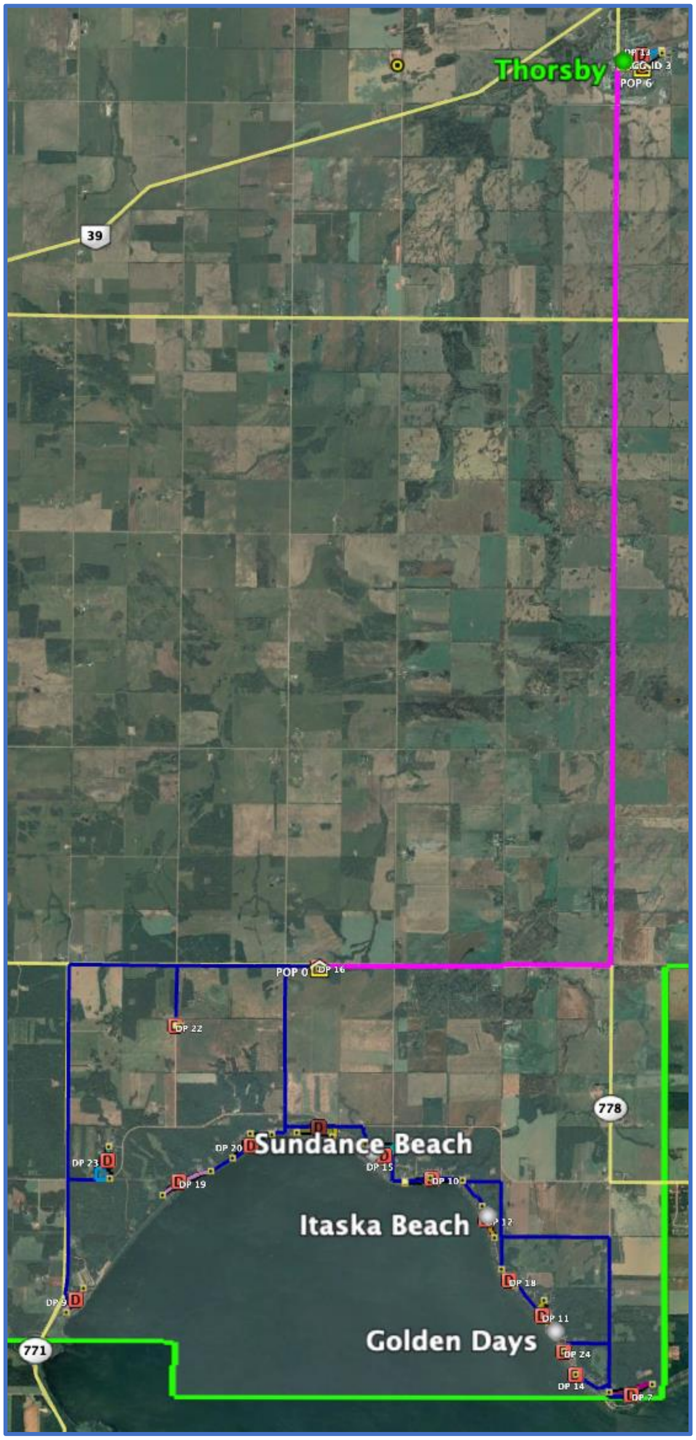

Figure 31. W-Pigeon fibre layout

The W-Rural deployment provides fibre to all remaining County priority sites, all rural subdivisions as well as all FWA and utility towers in the West County area. While the fibre design to the rural subdivisions, residential areas, and summer villages is sized to accommodate an FTTP deployment, the capital estimates only include the conduit and fibre being deployed to potential small-cell wireless sites in each area. As an interim step, the County might then deploy small cell technology on an interim basis and then upgrade the network to FTTP as priorities and funding permits.

The cost estimates to deploy the network appear in Table 3.

Rural – East Area

The overall design for a fibre deployment to the priority sites and rural subdivisions for both the E-Rural and E-Central areas of the eastern County is shown in Figure 32. The rural subdivisions are shown by the semi-transparent white rectangles.

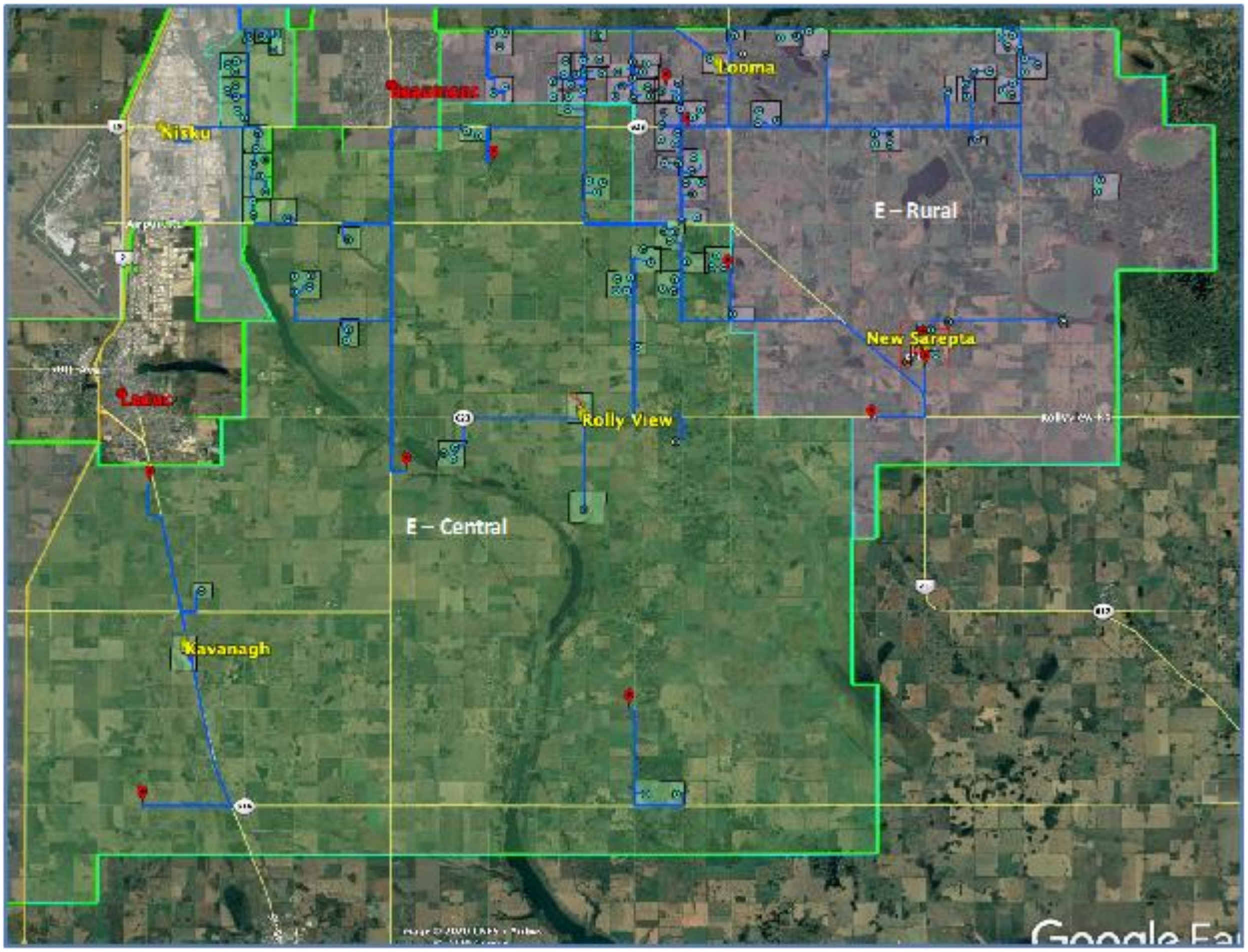

Figure 32. East rural deployment areas

As for the western area, a three-staged implementation was assumed, and the costs estimates are shown in Table 3. The priority deployment in the area was to connect the shop, lift station, transfer station and reservoir in New Sarepta which was estimated as FTTP. For the remaining rural areas, the hybrid fibre-wireless approach outlined for the West Area was used to connect rural subdivisions and key rural facilities such as FWA towers and industrial sites.

Table 3. Capital Deployment Costs – Commercial/Industrial Area

	Leduc County										
	West				East				Totals		
	Priority Sites	Pigeon Lake	Remainder	Total	Priority Sites	East Urban	East Central	Total	Priority Sites	Balance	Total
Fibre											
Civil Works	199,992	2,462,729	2,535,645	5,198,365	144,500	4,822,302	3,639,535	8,606,337	344,492	13,460,210	13,804,702
Backbone	19,186	274,821	1,034,615	1,328,623	17,135	486,684	931,890	1,435,708	36,321	2,728,010	2,764,331
Feeder	15,724	641,082	1,812,332	2,469,139	744	1,723,850	1,511,314	3,235,908	16,469	5,688,578	5,705,046
Distribution	0	137,697	139,534	277,230	7,632	368,594	245,076	621,302	7,632	890,900	898,533
Drops	9,393	42,944	105,592	157,928	2,168	123,462	94,587	220,217	11,560	366,585	378,145
Engineering	19,544	284,742	450,217	754,503	13,774	601,991	513,792	1,129,558	33,318	1,850,743	1,884,061
Sub-total	263,839	3,844,013	6,077,936	10,185,788	185,953	8,126,883	6,936,193	15,249,029	449,792	24,985,025	25,434,817
Wireless											
Stub towers		290,000	180,000	470,000		850,000	620,000	1,470,000		1,940,000	1,940,000
Access points		58,000	36,000	94,000		170,000	124,000	294,000		388,000	388,000
Sub-total	0	348,000	216,000	564,000	0	1,020,000	744,000	1,764,000	0	2,328,000	2,328,000
Network Cost	263,839	4,192,013	6,293,936	10,749,788	185,953	9,146,883	7,680,193	17,013,029	449,792	27,313,025	27,762,817

Nisku

Again, using world-class design software and detailed terrain and utility information provided by the County, a 'conceptual' level air-blown fibre design was completed for Nisku. Though classed as 'conceptual', as all available utility information has been taken into account, the capital cost estimates developed are actually based on designs that are part-way to 'preliminary'. Deep and shallow utility information, together with clearance buffers are shown, for example in Figure 33. Taking this level of detail into account at this stage ensures a much higher level of accuracy than is possible with straight conceptual level plans and thereby helps avoid unpleasant cost increase surprises down the road. That said, the cost estimates will still change as more detailed work is completed. Should the County proceed, however, these designs are upgradable to full preliminary and detailed versions with minimal rework.

Figure 33. Including deep and shallow utility information significantly enhances design accuracy

The design for Nisku appears in Figure 34 and the cost estimates appear in Table 4. The design features a backbone ring for redundancy. The financials assume that the core network to pass every building would be deployed first. Drop connections to connect businesses requesting services would then be deployed as needed. The $14.5M total shown in the Table assumes 100% service penetration, which is unlikely. More refined estimates which include opto-electronics and penetration effects are provided in the financial section.

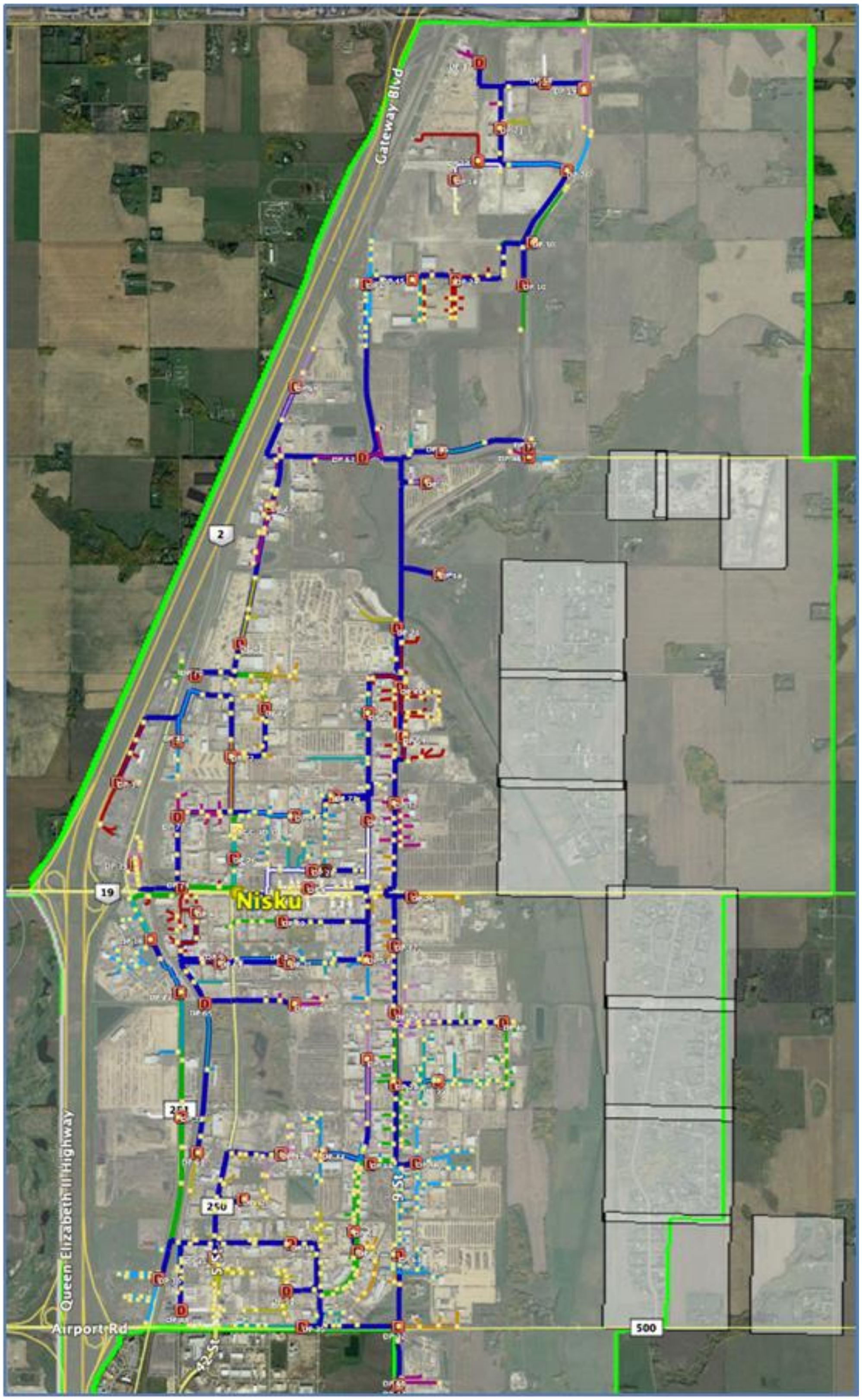

Figure 34. Nisku design

Table 4. Capital Deployment Estimate – Nisku FTTP

	Nisku
Civil Works	9,123,146
Backbone	264,335
Feeder	1,863,505
Distribution	1,096,040
Core Network	12,347,026
Drops	2,149,041
Network Cost	14,496,067

Opto-electronics and Backhaul

Figure 35. A family of ONUs

'Lighting' a fibre network involves placing an optical line terminal (OLT) in the central equipment location and then placing optical network units (ONUs) in each business and premise taking service (Figure 35). The two are connected via an optical fibre.

OLTs generally consist of an equipment chassis into which a number of cards can be placed. To serve the commercial-industrial area and adjacent rural areas to the east of the urban centre, the financials assume the state-of-the-art Calix E9-2 OLT shown in Figure 36. The chassis is referred to as a shelf and each equipment shelf has room for two cards. In the figure, two shelves are shown. The top shelf with two redundant cards is dedicated to routing and control. The lower shelves provide signal distribution throughout the access network.

E9-2 Chassis (two-chassis with two cards each. Capacity is increased by adding chassis.)

E9-2 Cards

Figure 36. Calix E9-2 OLT and cards

Fully loaded, the system assumed for Nisku would consist of 1 aggregation shelf and 4 access shelves. Cards come in different flavours depending on the mix of G-PON (gigabit passive optical network), Active-Ethernet (A-E), XGS-PON and NG-PON2 connections required and each card can support many ONUs. The two access cards shown in the lower shelf, for instance provide 32 symmetrical 10 x 10 Gb/s XGS-PON or 32 symmetrical 40 x 40 Gb/s NG-PON2 connections. At a 1:32 split in the 10 x 10 Gb/s configuration, the two cards together would support up 1,024 client connections. As cards are only purchased when needed, each system would start with a G-PON and an XGS/NG-PON access card and then, over time, add cards as service uptake increases. One E9-2 is capable of handling all connections in the commercial industrial area.

To serve the remainder of the rural area, the simpler Calix E7-2 system is assumed. It operates similarly to the E9 above but does not have routing capability and is limited to 10 Gb/s connections. One E7-2 is assumed to be deployed in each of the three rural areas. As with the E9, premises up to 35 km away can be served at up to 1 Gb/s.

The backbone connection from the Edmonton Internet Exchange (YEGIX) to the OLT also needs to be sized appropriately. Depending on service uptake and bandwidth demands, a single 0.1 or 1 Gb/s connection might initially suffice (with television services, the minimum would be 1 Gb/s). As the client base grows the required backbone capacity would need to be increased. The E9-2 supports backlink connections up to 100 Gb/s while the E7-2 supports connections up to 40 Gb/s.

In summary, the financials developed below assume that Leduc County deploys a buried fibre network throughout the Nisku area and to underserved rural subdivisions throughout the County. Air-jetted, home-run fibre networks are assumed. Ring redundancy is provided in Nisku. The core network passes each premise and drops are only deployed when services at a premise/location are taken. A project manager is hired for the duration of the build. An RFP is let for construction. No leverage from planned civil works are included. Network electronics provided will support up to 40 Gb/s services.

Millimeter-wave (mm) Wireless Access Equipment

In early October, Cambium – a large international supplier – announced cn-Wave, a new 5G, 60 GHz set of wireless access equipment that could provide the County with a lesser expensive alternative to a pure FTTP deployment. With this option, the County would deploy fibre to each rural subdivision and then connect to cn-Wave units that would enable the last-mile connections to each premise. The units are small and can be mounted on streetlights. A sample configuration showing the three types of available cn-Wave units appears in Figure 37.

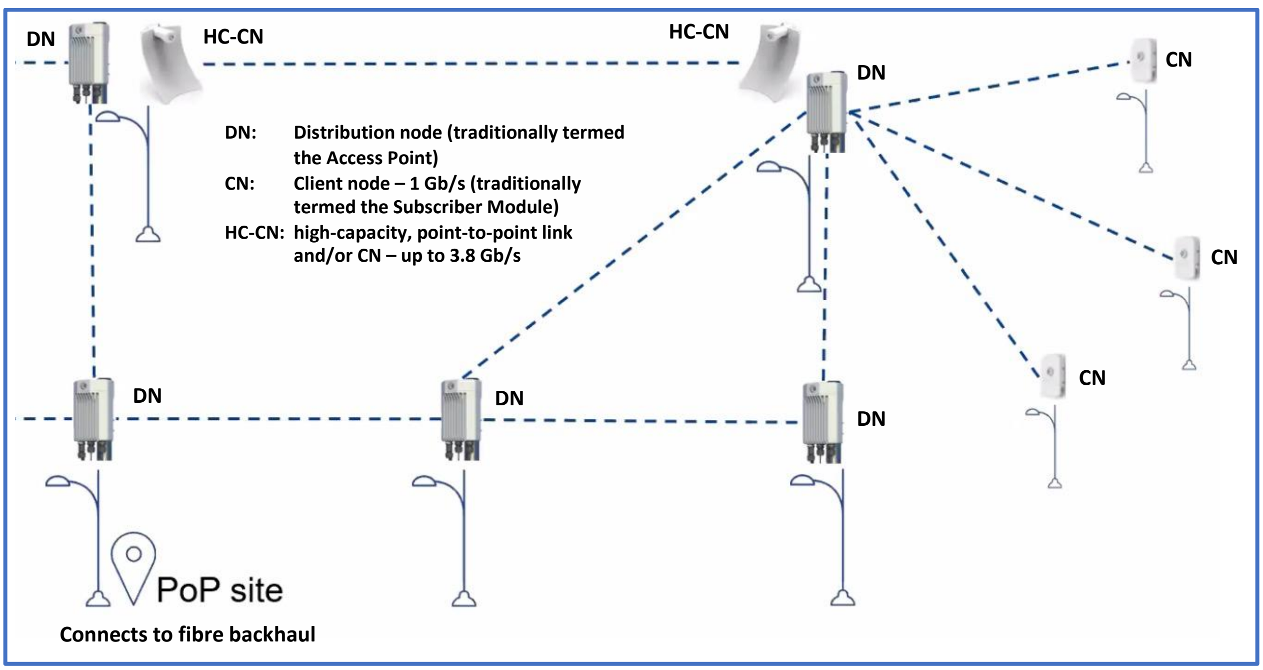

Figure 37. cn-Wave equipment configuration.

Though this relatively inexpensive equipment can deliver up to 3.8 Gb/s per home, line-of-sight is required and, due to its susceptibility to rain, path distances max out at about 250m. To help offset these issues, the units 'mesh', which means any of the units can send and receive data from any of the other units that are within range. Hence, if the signal from one unit is blocked, a signal from another unit can be used instead.

The design and capital estimates presented for this mm-wave solution are based on pre-release data and budgetary costs from mbsiWave, a Medicine Hat based distributor. Product details, specifications, and pricing information became available in Q4, 2020.

Drop Capital

Dividing the total drop capital required for the urban and rural areas by the number of premises implies a per drop cost of $3,000 in the Nisku area. With the hybrid-fibre-wireless option the per drop would not be required. Instead of fibre termination electronics (ONUs), though, a wireless subscriber module is needed.

Options for Municipal Fibre Deployment

Counties and municipalities have the option to design, finance, and deploy fibre networks to facilitate enhanced broadband services to their business and residential communities. In deference to the traditional vertically integrated business model prevalent in Canada, communities can opt to deploy the connectivity infrastructure on a utility basis and then enable local service providers to provide competitive Internet, telephone, and television services over it as illustrated by Leduc-Net in Figure 38. Alternatively, communities may choose to not only deploy the network infrastructure, but to become the primary service provider over it as well.

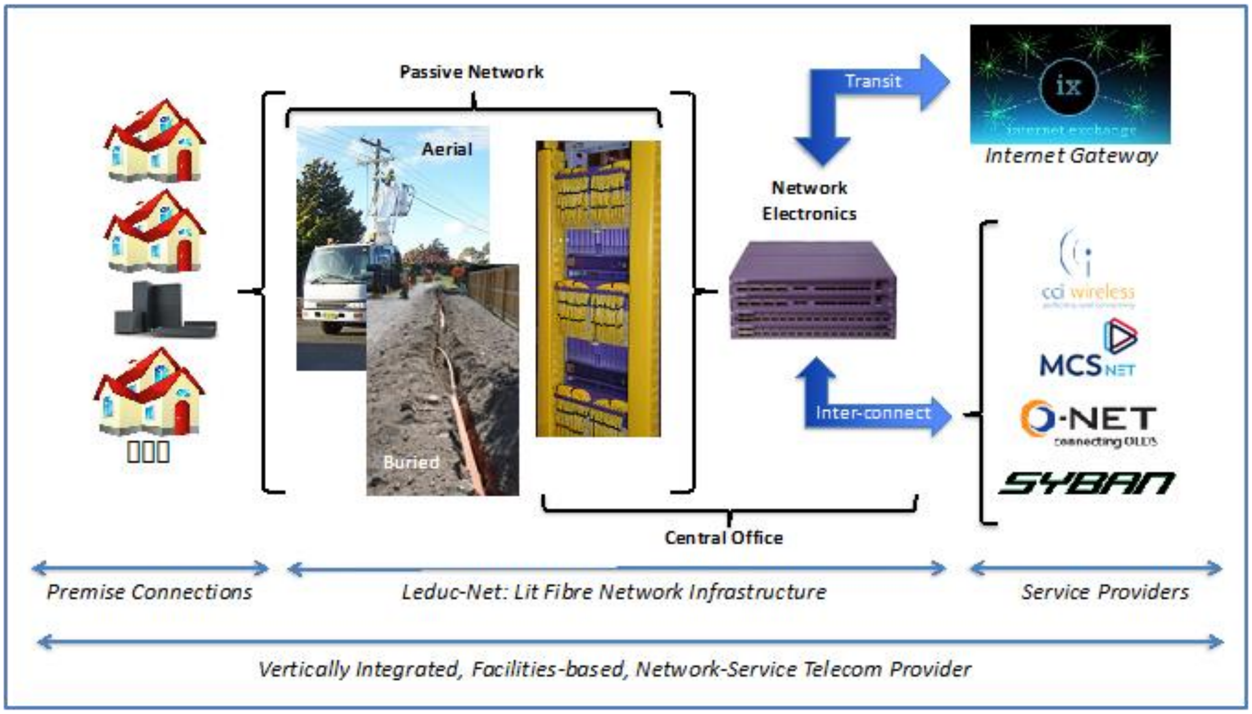

Figure 38. Facilities vs non-facilities -based business models

Augment Market Demand

The first option for the County to consider is that of using financial incentives to compensate for market-failure in low-density rural areas. Hence, the County would provide financial incentives to telecom, cable, and Internet service providers to support their own builds in compliance with the County's Engineering Design guidelines and in the areas the County priorities. The incentives required are typically estimated by modeling the business case for the area targeted and then using the model to determine the financial incentive needed to enable a private provider to make their target return-on-investment (RoI) or internal rate of return (IRR) in the targeted areas within a specified period of time.

In years past, this was the model upon which Wildrose operated and deployed towers in a number of counties. In the Regional Municipality of Wood Buffalo area, this approach was used to improve services in the Gregoire Lake Estates area and, more recently by Lac La Biche to entice a TELUS deployment. Further afield, this is the approach used to deploy the Eastern Ontario Regional Network (EORN), the Southwestern Ontario Integrated Fibre Technology (SWIFT) network, and by Develop Nova Scotia.

The key issue with this approach is that while it does keep municipalities out of the network space, after the initial 5 to 7-year period, ownership and control over all assets vests with the private provider(s). Given the high capital costs associated with infrastructure deployment and the significant municipal contributions to enable the required financial performance, a more equitable arrangement might be one that preserves the municipalities stake in the network over the longer term, affords them the flexibility to meet their broader connectivity requirements, address social-mandate issues, and affords them a risk-adjusted portion of the returns.

Dark Fibre Utility Network

With this option, municipalities deploy connectivity and distribution fibre and make it available on an open-access, wholesale basis to telecom, cable, and wireless service providers and to enterprise clients. To utilize the fibre assets, interested providers would have to light (add opto-electronics to) the fibre. Once lit, service providers could leverage the fibre to provide symmetric Internet services at rates up to 40 Gb/s. Mobility and fixed wireless providers could access the fibre to improve connections to their towers and leverage the capacity to improve their cellular and fixed wireless services. Larger enterprise clients may wish to use the dark fibre to establish secure, very high-speed links between their facilities.

Large dark-fibre deployments are underway in Calgary and have been completed in Coquitlam, New Westminster, and Campbell River. On a smaller scale, the Olds Institute for Community and Regional Development (OICRD) established a dark-fibre network in Olds, Alberta.

While certainly workable in urban areas, issues with this approach in rural areas include:

- Many local ISPs are not set up to light and run fibre networks. Though small relative to the dark-fibre investment, the required opto-electronics investment may be significant to smaller ISPs.
- Once one ISP has lit the fibre, there may not be sufficient incentive for other ISPs to come in – leaving the initial ISP with a de facto monopoly in the area.
- Municipal control over service levels provided by the ISPs is limited.
- Municipalities are not able to leverage the multi-wavelength potential of current FTTP opto-electronic systems.

Lit-Fibre Utility Network – Leduc-Net

With the wholesale lit-network utility option, Leduc County could, over time, make available world-class connectivity infrastructure and facilitate full competition in the services space. The fibre infrastructure will cost-effectively scale to meet all foreseeable bandwidth requirements, minimize cost to all residential and commercial clients, and enable Leduc County to maintain control of critical civic infrastructure.

A schematic showing service delivery and money-flows with the wholesale utility network option appears in Figure 39.

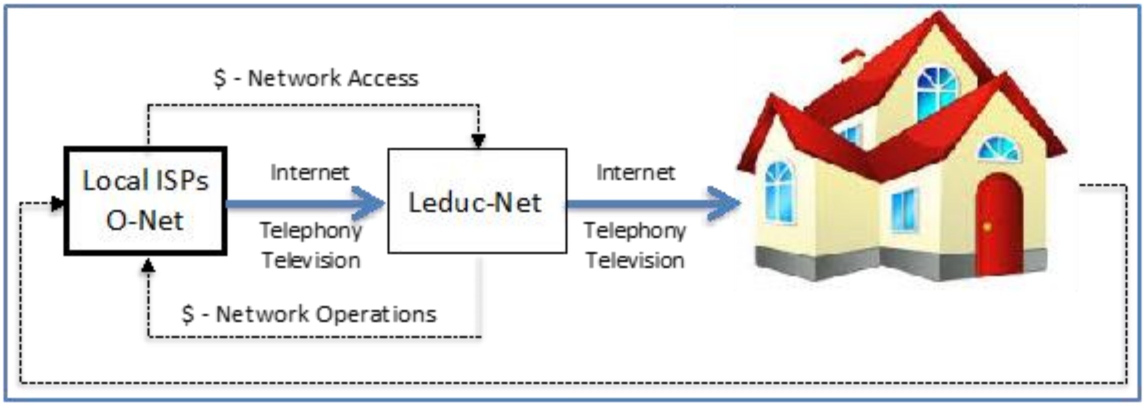

Figure 39. Assumed wholesale, open-access business model

To house and administer the network assets, the County establishes Leduc-Net, which could be either a department within the County or a stand-alone entity. For convenience, the financials assume that Leduc-Net outsources network administration to a qualified provider such as O-Net and hires staff to be the local 'feet-on-the-ground'. O-Net would remotely monitor and manage all network assets and configurations, establish and manage connections to the ISPs providing services over the network, provide the required back-office systems support for asset management and tracking, etc. and direct local staff with respect establishing client connections (client yard surveys, drops, and opto-electronics) to the network, doing cable locates, and providing repair and maintenance services.

All marketing, sales, home and business services installations, billing, client support/help desk services, and service delivery responsibilities fall to the ISPs using the network.

Business Case Financials

Assumptions

Model Parameters

The model parameters and assumptions used to develop proforma financials for the four wholesale lit-network scenarios presented in this section follow. All can be adjusted to improve alignment with County direction and estimated costs.

Financial Parameters

Assumed model financial parameters are shown in Table 5. When financed via debt, both short and long-term loans from the Alberta Capital Finance Authority (ACFA) are assumed. The upper borrowing limits for both are shown. The short-term, eight-year, debenture is used to cover opto-electronics, which are assumed to have an eight-year life, and the twenty-five-year debenture is used to cover deployment costs for the longer term (fibre) assets and to float the operation until positive cashflow is achieved.

Table 5. Model Financial Parameters

General Parameters	
CAD$/US$	1.320
Long Term Bond/Risk Free Rate	2.00%
Inflation - revenue	1.00%
Inflation - cost	2.00%
Tech/BW improvement factor	15.00%

Grant Funding	
Reserve funding	10,000,000

Contingencies	
OpEx contingency	0.00%
CapEx contingency	0.00%

Tax Considerations	
Include tax	No
Corp. tax rate - small bus	12.50%
Small bus limit	500,000
Corporate tax rate - bus	27.00%

Long Term Loan		
Loan Principal Limit	80,000,000	
Term, yr	25	
Interest rate	2.210%	2020-09-01

Short Term Loan		
Loan Principal Limit	1,000,000	
Term, yr	8	
Interest rate	1.405%	2020-09-01

For ease of calculation, the loans are drawn down on January 1st each year to cover the deficit accrued during the previous year. In reality ACFA loans are drawn down twice per year, but the impact is negligible at this level of analysis.

Deployment Schedule

From both strategic and financial perspectives, Leduc County might consider deploying to the Nisku area prior to shifting focus to the rural areas. Strategically, the approach would provide a more competitive business environment given TELUS is deploying fibre in the Edmonton area, and, financially, it would generate cashflow that could be used to help fund the rural deployment.

Below, the business case for Nisku and the rural areas are developed separately. In each case, the deployment is assumed to start in 2021 and complete in 2022. Buried air-blown fibre (ABF) conduit is deployed to pass every premise in the Nisku area and to potential gig-wireless sites in the rural subdivisions. Access (drop) fibre, and opto-electronics are only installed to service those taking service and the wireless access points.

For the combined Nisku-rural deployment shown in the summary section, a four-year deployment is assumed – two years for Nisku followed by a year each for W-Pigeon and the Rural East areas.

Startup Costs

The start-up costs included in the initial capital requirement calculations are shown in Table 6. Legal is to cover partnership agreements, if any, and a non-dominant carrier license (NDC) is required to operate public telecommunications equipment. A project manager will be needed during project deployment and the marketing and community engagement pieces are both to promote the network and help ensure that those in the community know how to best make use of it. The third column relates to tools and test equipment and the fourth to providing new staff with computers and software.

Table 6. Startup Cost Parameters

Startup Costs							
Business Plan	25,000		$/yr	Blowing equipment	40,470		
Operational Partnerships	25,000	Project Manager	90,000	OTDR	5,000	Staff computers	1,500
Legal - incorporation	10,000	Marketing	50,000	Splicing equipment	-	Computer s/w	1,000
Regulatory - NDC, etc.	5,000	Community Engagement	75,000	Locator	1,500	Back office & IT suite	-
				Hand tools	3,000		

Markets and Revenue

As mentioned, both the Nisku and Rural area networks are assumed to each roll out over a two-year period. Over the five-year period commencing with deployment, market penetration increases to the assumed target levels – in this case, 50% for the residential community and 80% for the business connections as shown in Table 7. As penetration increases, drop connections and premise electronics are deployed. Central office opto-electronics, backhaul and gateway services, and staff requirements then scale to accommodate increasing demand. First-year revenue in a newly deployed areas is adjusted to reflect a uniform deployment during the assumed spring-summer-fall construction season.

Table 7. Market Penetration

Assumed Penetration Rates					
	Year 1	Year 2	Year 3	Year 4	Year 5 on
	1	2	3	4	5
Residential penetration	25.0%	35.0%	40.0%	45.0%	50.0%
Business penetration	35.0%	50.0%	60.0%	70.0%	80.0%

Assumed wholesale service pricing is shown in Table 8.

Table 8. Wholesale and Retail Services Pricing

Wholesale Connection Pricing		
	Residential	Commercial
Wholesale Network: $/mo	100.00	200.00

Operational Parameters

Operational costs are many and varied. The base parameters assumed appear in Table 9.

Table 9. Operational Parameters

Admin, etc.		
Regulatory	2,500	$/yr
Legal & accounting	8,000	$/yr
Banking	1.00	$/client/mo
Courier / postage	250	$/mo
Training	10,000	$/yr
Conferences	5,000	$/yr
Subscriptions	1,000	$/yr
Meals	2,500	$/yr

Staff	$/yr	after
General Manager	110,000	
Office Admin/Bookkeepr	72,000	
Mkt/Sales Mgr	0	
Network Ops Mgr	98,000	1,000
OSP Ops Tech	72,000	
# clients / OSP tech	500	25
Tech/CSR	72,000	
# clients / tech	300	25
Benefits	21%	

Staff Support		
Office Supplies	25.00	$/person/mo
Telecom - cell/phone	100.00	$/person/mo
Computer support	50.00	$/person/mo
Crashplan - backup	10.00	$/comp/mo
	185.00	

Insurance		
Contents Insurance	1,600	$/yr
Business Liability Insurance	1,600	$/yr
	3,200	

Network Operations & Software		
Arin	1,200.00	$/yr
GoDaddy Domain/SSL	99.00	$/yr
Router support	1,200.00	$/yr
Firewall support	445.00	$/mo
OSS/sw (Calix)	99.00	US$/mo
Compass Flow Analyzer (<=500)	195.00	US$/mo
Customer Connect (<=500)	245.00	US$/mo
Compass License #	500.00	

Vehicles	Minimum #	# / tech
Vehicles	1	0.4
Lease	1,000	$/mo
Fuel & maintenance	150	$/mo
Insurance	200	$/mo

Utilities		
Power	200.00	$/mo
Water/Waste	75.00	$/mo
Gas	75.00	$/mo
	350.00	

Operations - Support		
Equipment closet - rent	250	$/mo
Equipment room cleaning	100	$/mo
Equipmnt storage	1,200	
UPS Battery maintenance	50	$/mo
Generator maintenance	50	$/mo
Facility locate cost	75	$/locate
# locates/prem passed/yr	0.10	
Max locate cost/yr	66,550	
Pole rental	1.50	$/pole/mo

Transit, Gateway, & YYCIX	100 Mb/s	1 Gb/s	10 Gb/s	100 Gb/s
Shaw	800	1,800	3,600	10,000
Hurricane Electric	500	2,000	5,000	12,000
YYCIX	400	$/mo		

Dark-Fibre Utility Network

As evident in Tables 3 and 4, including engineering and procurement costs, deploying a dark-fibre network in the rural areas and Nisku would require ~$25.4M and $14.5M respectively. Based on the considerations listed in the Options for Municipal Fibre Deployment – Wholesale Dark Fibre Utility Network subsection, both would be infrastructure plays with minimal return on the investment, particularly for that in the rural area. As the tables show the initial capital build numbers only, additional capital would be required to cover any deficits incurred to initiate operations.

Lit-Fibre Utility Network – Leduc-Net

Nisku

Should the County deploy a fibre network to cover the Nisku area over the 2021 to 2022 period and operate it on an open-access, utility basis, the comparative summary results for the undertaking are as shown in Table 10. Three financing options are considered:

1) fully financed by debt (requiring full capital recovery)
2) financed via a $10M grant or reserve funding with the balance financed by debt; there is no magic to the $10M amount, it's simply to provide a balanced option between options 1 and 2
3) fully financed out of reserves (requiring operational sustainability only

Note that the financing requirements in the table are calculated to cover the deficits incurred until the project goes cashflow positive. In this regard, they only indirectly relate to the capital estimates for network deployment. Hence, the longer the project takes to go cashflow positive, the higher the financing requirements will be. Indeed, should the project not go cashflow positive, the financial requirements will increase annually (to cover the on-going deficits) throughout the model's 26-year timeframe.

Table 10. Summary Financial Results for a Wholesale Lit Utility Network – Nisku

	Results		
	Debt	$10M + Debt	Reserves
Years to positive cashflow			
Operating	3	2	2
With debt servicing (p&i)	5	2	2
Financing (to 2046)			
Grants	0	10,000,000	0
Reserve capital	0	0	13,728,373
Debt capital required	14,771,485	3,728,373	0
Total	14,771,485	13,728,373	13,728,373
Net Margin - before debt servicing			
Profit - annual at 10 yr	846,139	1,012,251	1,069,417
Profit - annual at 15 yr	1,050,839	1,174,544	1,217,656
Profit - annual at 20 yr	1,242,138	1,318,844	1,346,381
Profit - annual at 25 yr	1,452,583	1,477,201	1,487,477
Net Margin - after debt servicing			
Profit - annual at 10 yr	324,772	882,478	1,069,417
Profit - annual at 15 yr	473,011	1,030,718	1,217,656
Profit - annual at 20 yr	601,736	1,159,443	1,346,381
Profit - annual at 25 yr	742,832	1,300,538	1,487,477
Mean - 20 years	302,467	776,724	949,280

	Debt	$10M + Debt	Reserves
Net Present Value (NPV)			
10 year	-9,627,714	-8,106,462	-7,625,372
15 year	-5,809,602	-3,730,843	-3,056,646
20 year	-1,671,986	750,664	1,546,389
25 year	2,477,639	5,050,085	5,902,303
Return on capital			
10 year	-67.8%	-57.1%	-53.7%
15 year	-40.7%	-26.2%	-21.4%
20 year	-11.7%	5.2%	10.8%
25 year	16.9%	34.5%	40.4%
Internal rate of return (IRR)			
10 year	-15.9%	-12.4%	-11.4%
15 year	-4.1%	-1.8%	-1.1%
20 year	0.9%	2.5%	3.0%
25 year	3.2%	4.5%	5.0%

As can be seen, the business case for a Nisku build shows a fully sustainable operation whether fully financed by debt or by reserves. As interest coverage on the debt is assumed to be an operational expense, margins associated with the debt funded options are less than with the fully reserve funded option. Indeed, the higher the reserve portion of the required financials the County can provide to fund the network deployment, the better. In the $10M grant plus debt scenario, the project goes cashflow positive the year after the deployment completes and with mean annual net margins in excess of $775-thousand, the venture would be self-sustaining and low risk from a cashflow perspective.

In the second half of Table 10, the net-present value (NPV), return-on-capital, and internal rate of return (IRR) parameters for the project are presented. If the primary intent of the network deployment is to get capable broadband in place on a sustainable basis as quickly as possible – to enhance economic development and quality of life in the County, the project as outlined will be successful financially, even on a full capital recovery basis. On-the-other-hand, as a pure financial investment with no consideration for these off-balance sheet items, these parameters will make it difficult to attract outside investment and to do so may require that at least some County or grant funding be brought to the table.

Annual cashflow results for the $10M grant plus debt-funded scenario in non-discounted dollars are shown in Table 11. Note that whereas the financial requirements in Table 10 are for 2046, the cashflow results shown in Table 11 only go to 2040.

In graphical form, the non-discounted cashflow chart for this scenario appears in Figure 40. The capital (red line) required to finance the project is shown to pretty much all be required upfront and funding must be sufficient to maintain a net-cashflow of at least zero. Operational sustainability is determined by the gap or difference between the revenue (blue) and operational expenditure (green) lines whereas overall sustainability, which includes interest and principal repayment, is the difference between the revenue (blue) and the operational + principal repayment (dotted blue) lines. The bigger the gap, the better. The net overall cashflow line is shown by the orange line.

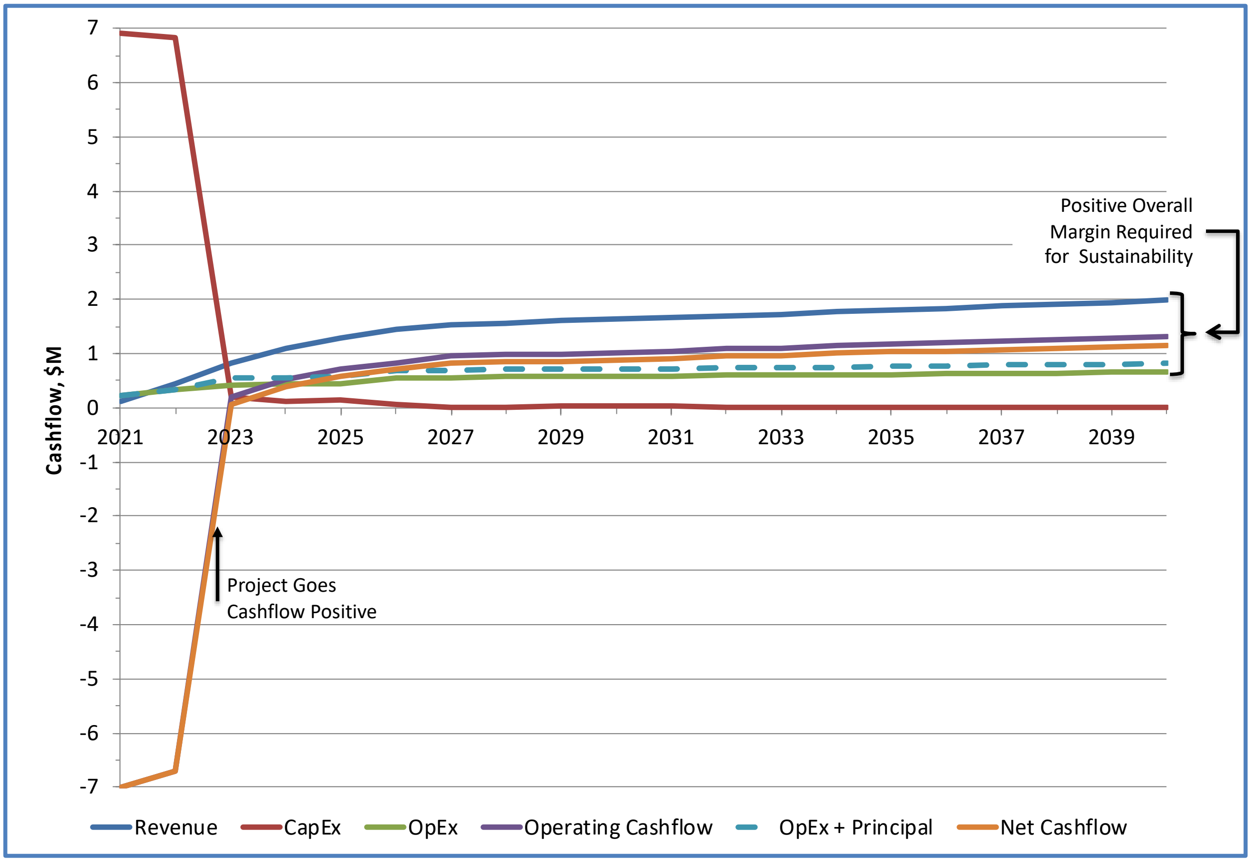

Figure 40. Cashflow chart – Nisku, $10M grant + debt

Table 11. Wholesale Cashflow Results - Nisku, $10M Grant + Debt

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Year	1	2	3	4	5	6	7	8	9	10
Cash-in										
Revenue	112,455	446,800	826,927	1,086,460	1,292,937	1,459,954	1,537,095	1,567,990	1,599,507	1,631,657
Cash-out										
Capital expenses	6,903,846	6,835,186	209,228	126,388	138,319	71,703	8,712	6,713	40,840	36,548
Operating expenses	220,687	327,910	427,645	438,280	447,482	553,540	562,784	569,382	576,106	582,858
Debt repayment	0	0	123,463	125,949	128,486	131,074	133,714	136,409	139,158	129,773
	7,124,533	7,163,096	760,337	690,617	714,287	756,316	705,210	712,504	756,105	749,179
Net income	-7,012,078	-6,716,295	66,590	395,843	578,651	703,638	831,885	855,486	843,402	882,478
Financing										
Reserve Funding / Grants	7,012,078	2,987,922	0	0	0	0	0	0	0	0
Debt	0	3,728,373	0	0	0	0	0	0	0	0
	7,012,078	6,716,295	0	0	0	0	0	0	0	0
Net Cash Position	0	0	66,590	395,843	578,651	703,638	831,885	855,486	843,402	882,478

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
Year	11	12	13	14	15	16	17	18	19	20	
Cash-in											
Revenue	1,664,453	1,697,909	1,732,037	1,766,851	1,802,364	1,838,592	1,875,548	1,913,246	1,951,702	1,990,932	29,795,416
Cash-out											
Capital expenses	32,198	15,238	18,992	11,426	7,768	9,205	17,783	17,631	14,199	11,089	14,533,011
Operating expenses	590,009	597,317	604,745	612,317	620,052	627,921	635,958	644,136	652,474	660,999	10,952,602
Debt repayment	132,469	135,221	138,031	140,899	143,826	146,814	149,865	152,978	156,157	159,401	2,503,687
	754,676	747,776	761,767	764,642	771,647	783,939	803,606	814,745	822,830	831,489	27,989,300
Net income	909,778	950,132	970,269	1,002,209	1,030,718	1,054,652	1,071,942	1,098,501	1,128,872	1,159,443	1,806,116
Financing											
Reserve Funding / Grants	0	0	0	0	0	0	0	0	0	0	10,000,000
Debt	0	0	0	0	0	0	0	0	0	0	3,728,373
	0	0	0	0	0	0	0	0	0	0	13,728,373
Net Cash Position	909,778	950,132	970,269	1,002,209	1,030,718	1,054,652	1,071,942	1,098,501	1,128,872	1,159,443	15,534,489

Rural Network – W-Pigeon

As shown in Figure 30, for analysis purposes, the rural area west of Highway #2 was divided into two parts – the W-Pigeon Lake area, which covers the County priority sites and the population centers in the Pigeon Lake area and the W-Rural where the premise density is uniformly low. As deployment of backbone fibre infrastructure in the W-Rural area is largely an infrastructure play with little to no compensating revenue, the business case here focuses on the W-Pigeon Lake area. Given the high capital cost of rural FTTP options, the approach is to provide a fibre feed to each subdivision and then use new gig-wireless access technologies to provide connections to each premise.

As the fully debt-funded scenario for the W-Pigeon area shown in Table 12 does not go cashflow positive within the first 16-years, the financial requirement ($8.47M) significantly exceeds that for the grant ($5.48M) and fully reserve ($5.67M) funded scenarios which go cashflow positive in years 4 and 3 respectively. Whereas both the debt and grant funded scenarios provide capital recovery, the fully debt funded scenario does not.

As can be seen, both the grant and reserve funded scenarios result in a sustainable longer-term option. As the net annual cashflows are low, options to improve the financials should be considered prior to any deployment.

Annual cashflow results for the $5M grant plus debt-funded scenario in non-discounted dollars are shown in Table 13. Note that whereas the financial requirements in Table 12 are for 2046, the cashflow results shown in Table 13 only go to 2040.

Table 12. Summary Financial Results for a Fibre-Wireless Utility Network – W-Pigeon

	Results		
	Debt	$5M + Debt	Reserves
Years to positive cashflow			
Operating	5	2	2
With debt servicing (p&i)	16	3	2
Financing (to 2046)			
Grants	0	5,000,000	0
Reserve capital	0	0	5,437,580
Debt capital required	8,468,395	479,653	0
Total	8,468,395	5,479,653	5,437,580
Net Margin - before debt servicing			
Profit - annual at 10 yr	81,127	184,924	189,884
Profit - annual at 15 yr	89,024	184,813	188,539
Profit - annual at 20 yr	106,933	175,000	177,359
Profit - annual at 25 yr	128,091	160,535	161,378
Net Margin - after debt servicing			
Profit - annual at 10 yr	-168,453	173,532	189,884
Profit - annual at 15 yr	-215,070	172,188	188,539
Profit - annual at 20 yr	-237,310	161,007	177,359
Profit - annual at 25 yr	-253,431	145,027	161,378
Mean - 20 years	0	131,808	152,049

	Debt	$5M + Debt	Reserves
Net Present Value (NPV)			
10 year	-5,305,933	-4,441,424	-4,390,279
15 year	-4,958,103	-3,702,706	-3,634,840
20 year	-4,614,909	-3,068,921	-2,990,596
25 year	-4,495,705	-2,528,532	-2,445,436
Return on capital			
10 year	-96.2%	-80.5%	-79.6%
15 year	-89.3%	-66.7%	-65.5%
20 year	-82.6%	-55.0%	-53.5%
25 year	-76.5%	-45.1%	-43.6%
Internal rate of return (IRR)			
10 year	-30.6%	-20.8%	-20.4%
15 year	-17.0%	-9.8%	-9.5%
20 year	-10.4%	-5.0%	-4.8%
25 year	-8.3%	-2.5%	-2.4%

In graphical form, the non-discounted cashflow chart for this scenario appears in Figure 41.

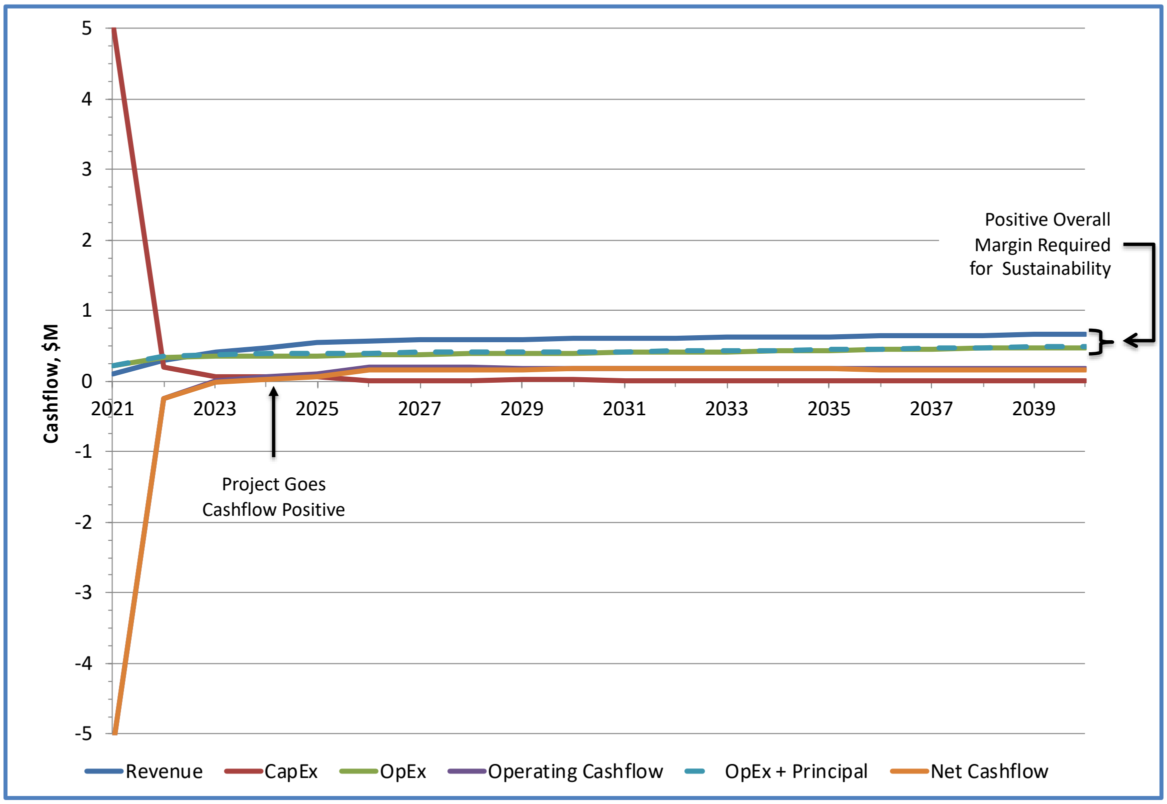

Figure 41. Cashflow chart – W-Pigeon, $5M grant + debt

Table 13. Wholesale Cashflow Results – W-Pigeon, $5M Grant + Debt

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Year	1	2	3	4	5	6	7	8	9	10
Cash-in										
Revenue	101,250	293,637	415,589	478,348	542,321	577,635	583,411	589,246	595,138	601,089
Cash-out										
Capital expenses	5,080,195	200,357	60,879	61,476	74,310	7,749	5,406	5,514	27,001	16,404
Operating expenses	224,703	330,449	347,237	355,214	364,576	372,182	378,690	385,330	391,932	399,761
Debt repayment	0	17,614	28,695	29,808	30,286	30,773	31,267	31,770	15,478	11,392
	5,304,898	548,420	436,811	446,498	469,172	410,704	415,363	422,613	434,411	427,557
Net income	-5,203,648	-254,782	-21,222	31,850	73,149	166,931	168,049	166,632	160,727	173,532
Financing										
Reserve Funding / Grants	5,000,000	0	0	0	0	0	0	0	0	0
Debt	203,648	254,782	21,222	0	0	0	0	0	0	0
	5,203,648	254,782	21,222	0	0	0	0	0	0	0
Net Cash Position	0	0	0	31,850	73,149	166,931	168,049	166,632	160,727	173,532

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
Year	11	12	13	14	15	16	17	18	19	20	
Cash-in											
Revenue	607,100	613,171	619,303	625,496	631,751	638,069	644,449	650,894	657,403	663,977	11,129,278
Cash-out											
Capital expenses	9,337	8,103	11,972	7,901	8,059	8,808	12,687	10,037	7,398	7,387	5,630,981
Operating expenses	407,531	415,112	422,837	430,864	438,879	447,054	455,393	464,060	472,795	481,590	7,986,188
Debt repayment	11,628	11,870	12,116	12,368	12,625	12,887	13,155	13,429	13,708	13,992	354,861
	428,496	435,085	446,925	451,133	459,563	468,750	481,235	487,526	493,900	502,969	13,972,030
Net income	178,604	178,086	172,378	174,363	172,188	169,319	163,214	163,368	163,503	161,007	-2,842,753
Financing											
Reserve Funding / Grants	0	0	0	0	0	0	0	0	0	0	5,000,000
Debt	0	0	0	0	0	0	0	0	0	0	479,653
	0	0	0	0	0	0	0	0	0	0	5,479,653
Net Cash Position	178,604	178,086	172,378	174,363	172,188	169,319	163,214	163,368	163,503	161,007	2,636,900

Rural Network – Rural – East

As both the E-Rural and the E-Central areas in the rural County east of Highway #2, are home to many rural subdivisions, the financials for the two areas, including the priority site connections, will be considered together. Comparative summary results for the debt, grant plus debt, and reserve funded deployments for utility network operations, assuming a fibre feed with wireless access in the rural subdivisions, are shown in Table 14. As for the W-Pigeon Lake results, while both the grant and reserve-funded options result in sustainable operations, the fully debt-funded scenario does not.

Annual cashflow results for the $10-million grant plus debt scenario in non-discounted dollars are shown in Table 15. The associated non-discounted cashflow chart for this scenario appears in Figure 42.

Table 14. Summary Financial Results for a Fibre-Wireless Utility Network – Leduc East

	Results		
	Debt	$10M + Debt	Reserves
Years to positive cashflow			
Operating	4	3	2
With debt servicing (p&i)	16	5	2
Financing (to 2046)			
Grants	0	10,000,000	0
Reserve capital	0	0	18,562,418
Debt capital required	27,210,176	9,203,847	0
Total	27,210,176	19,203,847	18,562,418
Net Margin - before debt servicing			
Profit - annual at 10 yr	342,468	566,937	707,806
Profit - annual at 15 yr	390,448	611,232	717,562
Profit - annual at 20 yr	500,002	662,142	730,347
Profit - annual at 25 yr	628,151	711,178	737,130
Net Margin - after debt servicing			
Profit - annual at 10 yr	-484,649	243,460	707,806
Profit - annual at 15 yr	-602,531	259,177	717,562
Profit - annual at 20 yr	-620,730	271,962	730,347
Profit - annual at 25 yr	-613,947	278,745	737,130
Mean - 20 years	0	180,503	572,424

	Debt	$10M + Debt	Reserves
Net Present Value (NPV)			
10 year	-17,597,970	-15,818,674	-14,647,621
15 year	-16,137,502	-13,480,780	-11,833,891
20 year	-14,530,767	-11,188,714	-9,241,496
25 year	-12,938,110	-9,220,886	-7,132,801
Return on capital			
10 year	-92.6%	-83.2%	-77.1%
15 year	-84.7%	-70.7%	-62.1%
20 year	-76.1%	-58.6%	-48.4%
25 year	-66.7%	-47.5%	-36.8%
Internal rate of return (IRR)			
10 year	-30.4%	-24.1%	-20.9%
15 year	-15.9%	-11.3%	-9.2%
20 year	-8.9%	-5.6%	-4.1%
25 year	-5.2%	-2.8%	-1.7%

Table 15. Wholesale Cashflow Results – Leduc East, $10M Grant + Debt

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Year	1	2	3	4	5	6	7	8	9	10
Cash-in										
Revenue	118,643	440,365	766,230	955,769	1,090,449	1,192,697	1,233,062	1,245,392	1,257,846	1,270,425
Cash-out										
Capital expenses	10,092,994	8,457,101	268,207	129,884	141,238	70,030	12,163	13,369	15,692	12,907
Operating expenses	225,972	348,251	640,172	660,713	671,310	677,674	681,374	684,394	687,251	690,580
Debt repayment	0	20,836	287,308	310,317	320,999	328,746	335,318	342,023	327,124	323,477
	10,318,966	8,826,189	1,195,687	1,100,914	1,133,547	1,076,449	1,028,855	1,039,786	1,030,067	1,026,964
Net income	-10,200,324	-8,385,824	-429,457	-145,145	-43,098	116,247	204,207	205,607	227,780	243,460
Financing										
Reserve Funding / Grants	10,000,000	0	0	0	0	0	0	0	0	0
Debt	200,324	8,385,824	429,457	145,145	43,098	0	0	0	0	0
	10,200,324	8,385,824	429,457	145,145	43,098	0	0	0	0	0
Net Cash Position	0	0	0	0	0	116,247	204,207	205,607	227,780	243,460

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
Year	11	12	13	14	15	16	17	18	19	20	
Cash-in											
Revenue	1,283,129	1,295,960	1,308,920	1,322,009	1,335,229	1,348,582	1,362,067	1,375,688	1,389,445	1,403,339	22,995,247
Cash-out											
Capital expenses	14,365	13,428	14,169	13,971	14,250	15,123	10,670	11,031	10,800	10,800	19,342,193
Operating expenses	694,161	697,950	701,810	705,742	709,746	713,826	717,981	722,053	726,191	730,398	13,087,549
Debt repayment	324,256	330,993	337,870	344,890	352,056	359,370	366,837	374,458	382,238	390,180	6,159,295
	1,032,782	1,042,372	1,053,849	1,064,602	1,076,052	1,088,319	1,095,488	1,107,542	1,119,230	1,131,378	38,589,037
Net income	250,347	253,589	255,071	257,407	259,177	260,262	266,580	268,146	270,215	271,962	-15,593,790
Financing											
Reserve Funding / Grants	0	0	0	0	0	0	0	0	0	0	10,000,000
Debt	0	0	0	0	0	0	0	0	0	0	9,203,847
	0	0	0	0	0	0	0	0	0	0	19,203,847
Net Cash Position	250,347	253,589	255,071	257,407	259,177	260,262	266,580	268,146	270,215	271,962	3,610,057

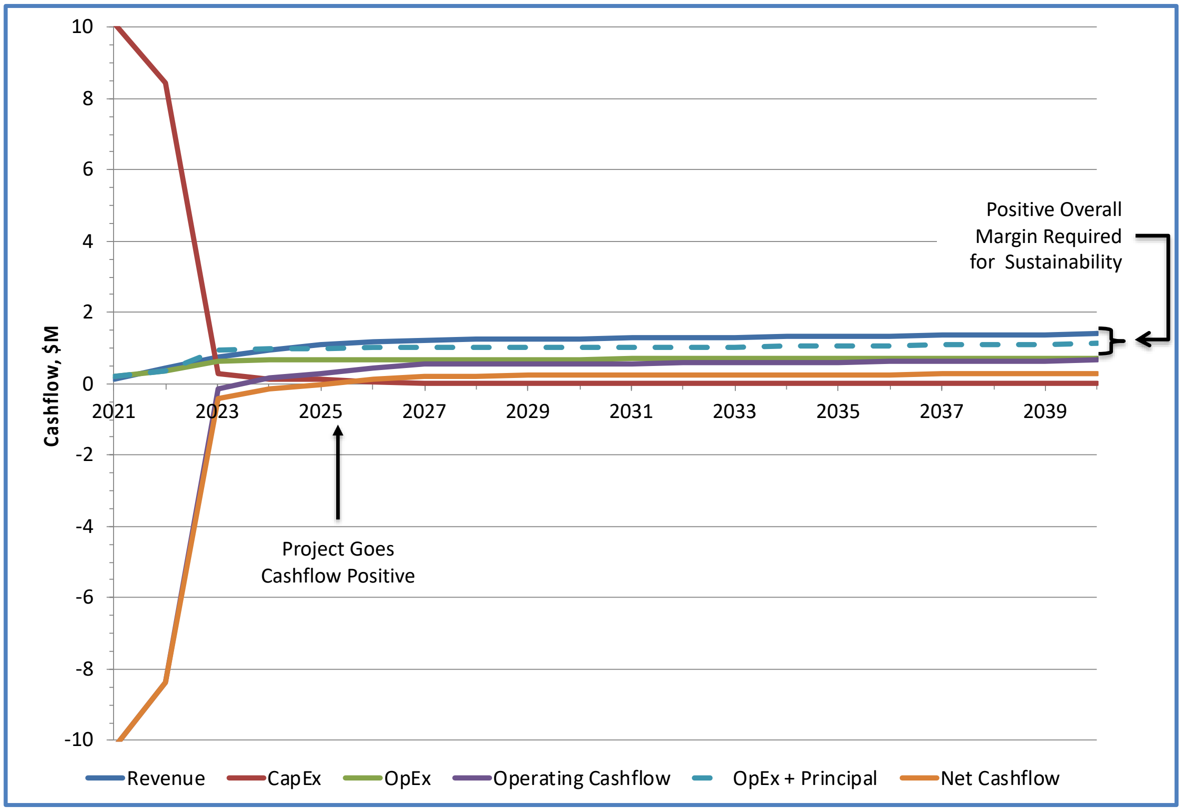

Figure 42. Cashflow chart – Leduc East, $10M grant + debt

Business Case Results Summary

For comparative purposes, the results for the grant plus debt-funded option for the three scenarios presented above as well as for a combined scenario in which all three are rolled out over the 2021 to 2025 timeframe can be found in Table 16. Across the board, and not surprisingly, Nisku and denser rural areas yield more sustainable operational financials than do those for the more truly rural areas. As well, the more that can be financed out of grant funding and reserves, the better.

Interestingly, as network operations are to some extent a scale game, the results for the combined urban/rural deployment are best from a cashflow, if not IRR perspective.

Due to the significant upfront capital required for all scenarios, these are long-term projects. On-the-other-hand, the benefits will accrue much more quickly and, should economic development impacts be taken into account, the financial parameters would improve significantly.

Overall, note that these results are based on a set of initial assumptions to provide a comparative baseline view of the key considerations required to help select the direction that best meets with the County's vision. As the direction solidifies, these assumptions can be creatively adjusted to improve margins and increase confidence in the results. Options include leveraging linear infrastructure builds, capping drop costs to, say, 100m setbacks and then having premise owners cover any costs incurred over that, partnering, adding smart city sensors to the mix and setting up an open data portal so that entrepreneurs can leverage the data to everyone's advantage, contributing a portion of the resulting operational savings to the revenue line, and so on.

Table 16. Comparative Business Case Financials

Comparative Results Grant + Debt	Wholesale			
	Nisku	Rural		Combined
		W-Pigeon	East	
Years to positive cashflow				
Operating	2	2	3	5
With debt servicing (p&i)	2	3	5	5
Financing (to 2046)				
Grants	10,000,000	5,000,000	10,000,000	10,000,000
Reserve capital	0	0	0	0
Debt capital required	3,728,373	479,653	9,203,847	27,662,648
Total	13,728,373	5,479,653	19,203,847	37,662,648
Net Margin - before debt servicing				
Profit - annual at 10 yr	1,012,251	184,924	566,937	2,079,242
Profit - annual at 15 yr	1,174,544	184,813	611,232	2,367,061
Profit - annual at 20 yr	1,318,844	175,000	662,142	2,685,873
Profit - annual at 25 yr	1,477,201	160,535	711,178	2,865,687
Net Margin - after debt servicing				
Profit - annual at 10 yr	882,478	173,532	243,460	1,102,291
Profit - annual at 15 yr	1,030,718	172,188	259,177	1,329,321
Profit - annual at 20 yr	1,159,443	161,007	271,962	1,535,754
Profit - annual at 25 yr	1,300,538	145,027	278,745	1,591,020
Mean - 20 years	776,724	131,808	180,503	849,605

Net Present Value (NPV)				
10 year	-8,106,462	-4,441,424	-15,818,674	-28,000,204
15 year	-3,730,843	-3,702,706	-13,480,780	-19,120,928
20 year	750,664	-3,068,921	-11,188,714	-9,997,007
25 year	5,050,085	-2,528,532	-9,220,886	-1,316,156
Return on capital				
10 year	-57.1%	-80.5%	-83.2%	-73.2%
15 year	-26.2%	-66.7%	-70.7%	-49.7%
20 year	5.2%	-55.0%	-58.6%	-25.9%
25 year	34.5%	-45.1%	-47.5%	-3.4%
Internal rate of return (IRR)				
10 year	-12.4%	-20.8%	-24.1%	-25.2%
15 year	-1.8%	-9.8%	-11.3%	-7.5%
20 year	2.5%	-5.0%	-5.6%	-1.2%
25 year	4.5%	-2.5%	-2.8%	1.7%

As evident in these results, a key issue moving forward is that of how best to provide the financing. Indeed, as will become more evident in the partnership section, other funding options are available. In general, the options available will depend on the overall build (deal) size, the partners selected, and the governance arrangements agreed to. In the end, it is likely that a number of options will be used in combination – say an investment from a private equity firm, contributions in kind from an ISP partner, a federal grant, and a loan from the ACFA. At this directional level, however, the three options provided here should be sufficient to highlight the considerations involved.

Option Overview

Context

The business case financials presented in the previous section are largely agnostic to organizational structure and belie the complexity inherent in deploying broadband infrastructure and establishing wholesale operations. As the required skillsets, procedures, and processes do not typically exist in municipal government operations, municipalities often look to partner with established private sector entities to both fill in the gaps and reduce risk.

To see which private entities might be prepared to partner with the County and on what terms, the County could release a general request for information (RFI) or a more formal and potentially specific request for proposal (RFP). To help set direction here, though, the generic partnership options currently in play around the province are summarized in Table 17. In what then follows, the three approaches for enhancing broadband infrastructure outlined in the Options for Municipal Deployment section will be reviewed in light of the partnerships that may be possible for each.

For comparative purposes, the following icons will be used to characterize each option at a high level.

📙: Planning, Policy | 📐: Engineering | 🛠: Deployment | $–$$$$$: Cost | 💎–💎💎💎💎💎: Benefit

Table 17. Summary of Potential Partnership Options

Partnership Options
Agentis / DIF Capital Partners
• Working with Agentis advisors, DIF Capital Partners focus on small- and mid-sized economic infrastructure investments in the telecom, transportation and energy sub-sectors. Their funds focus on companies and platforms that have a clear buy-and-build strategy – all with an asset-heavy business model. They target investments that offer medium-term contract cover with corporate counterparties and with strong value enhancement potential. • These folks are behind a number of rural builds in southern Manitoba and could be interested in evaluating options with Leduc County.
Connect Mobility
• Using wireless technology developed by Hook'd, Connect Mobility, a Calgary-based start-up, is looking to provide metropolitan-wide wi-fi networks to communities on an infrastructure-as-a-service (IAAS) model. The Hook'd equipment supports higher-speed premise connections and smart applications out-of-the-box. The AP chasses each support multiple radios (say wi-fi, LTE, and a 5G radio) and system intelligence balances the load and aggregate available bandwidths amongst the APs dynamically. • Under the Connect business model, the County would pay to deploy the wireless infrastructure (and the underlying middle-mile fibre network required to connect the APs) while Connect would maintain ownership of the APs and, with that, operational control and upgrade responsibilities.

	The County would 'rent the APs and pay to connect a wholesale rate for each device (cell-phone, pad, laptop, etc.) and premise (inclusive of all devices within the premise) using the network, collect retail rates from the device and premise subscribers, and keep the margin. The margin would need to be sufficient to pay for the required fibre connectivity to the APs, operations of the fibre connectivity network, backhaul, and sales.
Crown Capital	
	• Crown Capital is a relatively new Canadian private equity firm that is interested in helping to support municipal broadband networks. Most recently, they helped fund a component of the Winnipeg Metropolitan Region's broadband initiative. • For them to become involved, they will require a clear view of the financials and the financials would presumably need to show an IRR of 10% or more. • Once the County has selected a go-forward strategy, and if the County were interested in a private equity component, Crown Capital could be approached to see on what terms they might be willing to invest.
Digital Infrastructure Group (DIG)	
	• DIG was established in Canada in August, 2020 by folks from both Smart City Capital (SCC) and Sage Harbour Advisors. Like SCC, they focus on long-term infrastructure development. They work with Nokia and Calix for network electronics and Jacobs Engineering for design and construction services. DIG is backed by a large well-capitalized long-term environmental, social, and governance (ESG) funding partner. • DIG's investment options differ and are subject to negotiation. DIG continues to work with Beaumont and is aggressively working to expand the initiative to include other municipalities within and beyond the Edmonton region.
Digital Ubiquity Capital (DUC)	
	• With significant expertise in financial engineering, Digital Ubiquity operates as a financial broker and puts consortiums of partners together to enable broadband deployments in municipalities across Canada. Both Rock and Valo Networks work with Digital Ubiquity.
Local ISPs	
	• Could be approached to deploy and operate all or portions of any proposed rural network.
O-Net	
	• As the first and to date only municipal gig-services provider in Canada, O-Net is uniquely positioned to provide the County with network operations and, if needed, retail services. Their Internet, telephone, and television service sets can be made available on a wholesale or retail basis.
Rock Networks	
	• Headquartered in Ottawa, Rock Networks, together with a consortium of partners, collaborates with communities to deploy open-access fibre and wireless networks, and then manage them on the community's behalf going forward. With assistance from the Digital Ubiquity, they aim to

have each deployment self-funded and, to reduce risk, they will bring at least one retail ISP to the table.
Smart City Capital (SCC)
• Smart City Capital is a US-based investment firm focused on infrastructure development. To help kick-start a Canadian operation, two-years ago, SCC partnered with Nokia for network electronics and Jacobs Engineering for design and construction services. • SCC investment options differ and are subject to negotiation. While they were initially involved with the Beaumont initiative, the SCC partner involved left and, together with his financial advisor at Sage Harbour, established the Digital Infrastructure Group (see above). At this point, SCC is about to close deals in both the New Market and Niagara areas.
TELUS
• TELUS currently has extensive wireline and mobility network assets and service sets within the County. • TELUS generally proposes to engage with municipalities to determine the capabilities required. TELUS would then determine the investment contribution needed for them to move forward. The investment would enable TELUS to extend its network and services to the more rural areas of Leduc County.
Valo Networks
• Valo generally proposes to do the initial design, build, and commissioning of the required network. Their preference would be for the County to finance the dark network and then, in return for Valo lighting it, would become the exclusive network operator and wholesale ISP.
Xplornet
• Xplornet generally proposes to design, build, and operate hybrid fibre-wireless networks that would support services exceeding the CRTC 50/10 objectives. Should the County wish to own the non-radio infrastructure, Xplornet would ask for a lease arrangement permitting them to operate and provide services over the network. Xplornet would enable resale of their services over the wireless network and enable wavelength access to the dark fibre assets.

Partnerships

In general, partnerships could enable the County to leverage and balance its funding strength with the operational and, perhaps, deployment expertise of private enterprise. Partnerships range from simple contractual outsourcing arrangements to highly structured public-private-partnerships and the special purpose vehicles required to accommodate significant financial arrangements. Depending on the direction the County selects, one or more partnerships may be required. Should the County elect to pursue different arrangements for the Nisku and rural areas, different partners and partnership models may be required to support each area.

As private providers may have agendas that do not align well with those of the County and as, over time, management and their IRR targets or control requirements may change, due diligence on any potential partners is essential. Agreements need to be comprehensive and clear. If network-focused, they should address coverage, deployment timeframes, scalability requirements, service levels, operational requirements, and financials.

Augment Market Demand

| $ – $$$$$ |

Overview

As outlined in the Options for Municipal Deployment section, with this option, the County would provide municipal funding to encourage telecom, cable and Internet service providers to augment their infrastructure in areas which the County prioritizes and in which market failure otherwise limits private sector involvement. The amounts required are typically determined by modeling the business case for the area(s) targeted and then estimating the financial incentive needed to enable a private provider to make their target return-on-investment (RoI) or IRR within a specified period of time.

If the County's primary intent is to get capable broadband more ubiquitously in place on a sustainable basis as quickly as possible, then the focus is likely to be on positive cashflow and, due to the significant upfront deployment expenses, funding via grants, reserves or longer-term (20+ year) debentures. The primary benefits to this lie in off-balance-sheet considerations such as accelerated economic development and improved quality-of-life. As evidenced in the financial estimates provided in the previous section, competitive financial returns are not typically in play, particularly for more expensive builds in commercial areas and rural subdivisions. To incent a private operator to provide and operate a network in such high-cost low-return areas implies that the County would need to make up the financial difference needed to increase the returns to those required by the private entity. As this involves both funding a significant portion of the required infrastructure as well as augmenting the revenue streams associated with it, this option tends to be an expensive one.

Consider, for example, the business case for the wholesale, open-access, fibre network proposed above for Nisku. If funded via $10M in grants and long-term debt, the County would need to provide $3.73M in funding over the initial two-year period. The project has a ten-year IRR of -12.4%. To increase the IRR to, say, 10% over ten-years, a typical minimal IRR requirement, the County would need to provide an additional $11.5M in funding over ten-years.

In summary, for $3.73M the County could deploy and operate a truly open-access network that it owns and controls. For $15.2M, the County could entice a private-sector entity to deploy and operate a non-open-access network that the private partner will own and control.

Partnership Options

Agentis, Digital Infrastructure Group, Smart City Capital, Valo Networks

While these companies prefer to partner with communities, with a financial incentive, they may be open to going it alone to design, deploy, and operate a fibre network in Nisku.

Local ISPs

Local ISPs such as MCSnet for the rural areas and Switch for Nisku could be approached to upgrade their infrastructure and service portfolios in the County.

TELUS

This option perfectly aligns with TELUS' approach, in which they do an analysis and then specify the level of investment they would require from the County in order to enhance their service portfolio in the area. As TELUS typically focuses on more urban centres, it is unclear whether TELUS would consider upgrading infrastructure in the more rural areas of the county or just Nisku. All ownership and control would remain with TELUS and open access would not be provided.

Xplornet

This option effectively aligns with Xplornet's approach, though some ownership of the non-wireless network assets may be possible. How the investment required from the County would be calculated is not known. Xplornet, though, would remain the sole provider of network infrastructure and services, though re-sale of their services would be permitted.

Wholesale Dark Fibre Utility

📙📐🛠 | $$$$$ | 💎💎💎

Overview

With this option, municipalities deploy connectivity, distribution, and possibly premise (drop) fibre connections and make it available on an open-access, wholesale basis to telecom, cable, and wireless service providers as well as enterprise clients. To utilize the fibre assets, interested providers have to light (add opto-electronics to) the fibre. Once lit, service providers could provide symmetric Internet services at rates up to 40 Gb/s over the infrastructure. Mobility and fixed wireless providers could access the fibre to improve connections to their towers and leverage the capacity to improve cellular and fixed wireless services available off those towers. Larger enterprise clients may wish to use the dark fibre to establish secure, very high-speed secure links between their facilities.

Capital cost estimates to deploy a dark fibre network in the rural areas of the County and Nisku are summarized in Tables 3 and 4 respectively.

Partnership Options

Outsourcing Operations – Local ISPs, O-Net

As outlined above, the County can use RFPs to attract partners to outsource any portions of the network wholesale and/or retail operations that it does not wish to undertake in-house.

O-Net, for instance, could be approached to light and operate a fibre network for the County. Indeed, they light and manage the dark fibre network for the Old's Institute for Community and Regional Development in Olds. Shared financing options in which the County would fund O-Net to acquire the required opto-electronics and receive shares in return are available. The shares provide a revenue-sharing arrangement in which both parties benefit.

Valo Networks

Should the County finance a dark fibre network and have Valo both light and operate it on a wholesale basis, the breakdown of the capital investment required over the first five-years to deploy an FTTP network in Nisku is shown in Figure 43. As the overall cost is $13.9M, the dark fibre component to be funded by the County under this proposed arrangement would amount to $13.4M while Valo would fund the $0.5M balance.

Under these terms, for 3% of the investment, Valo gets full control of the network for the first 10 to 15-years, or whatever the initial exclusivity period is. Should the County not be satisfied with the services provided, it would not be possible to remove Valo without the risk of the network going dark and all services going offline for, potentially, a significant period of time – the time it would take to replace the opto-electronics.

Given the significant contribution to the network, the County should be able to negotiate an equitable revenue share arrangement whereby both parties would see a risk-adjusted return on their investment.

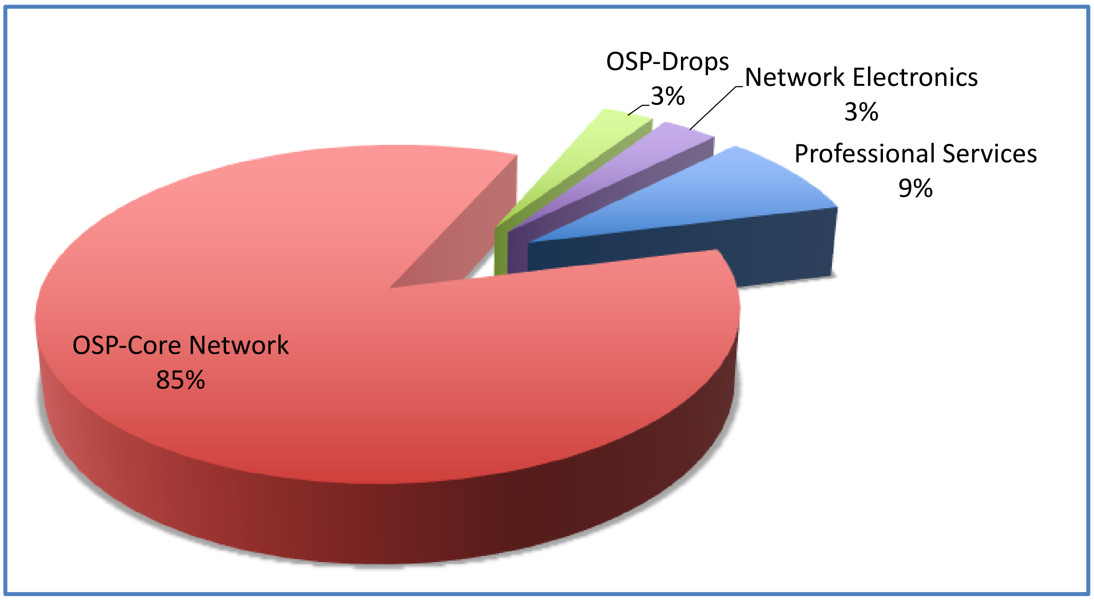

Figure 43. Capital rural FTTP network deployment costs: 2021-2025

Wholesale Lit Fibre Utility – Leduc-Net

📔📐🛠 | $$$$$ | 💎💎💎💎

Overview

In this case, the County would deploy a lit FTTP or hybrid fibre-wireless network and make it available on an open-access, wholesale basis to telecom, cable, and wireless service providers as well as enterprise clients. Once lit, service providers could enhance their service sets and provide symmetric Internet services at rates up to 40 Gb/s over the fibre portion of the infrastructure with little capital investment. Mobility and fixed wireless providers could access the fibre to improve connections to their towers and leverage the capacity to improve cellular and fixed wireless services available off the towers. Larger enterprise clients may wish to use the dark fibre to establish secure, very high-speed links between their facilities.

The business cases associated with establishing wholesale, open-access FTTP network in Nisku and a hybrid fibre-wireless network in the rural areas of the County are provided in the Business Case Financials section. With control of the wireless electronics and the capabilities of the new mm-wave wireless equipment, open-access could still be made available.

Partnership Options

Outsourcing Operations – Local ISPs, O-Net

As outlined above, the County can use RFPs to attract partners to outsource any portions of the network wholesale and/or retail operations that it does not wish to undertake in-house.

O-Net, for instance, could be approached to light and operate a fibre network for the County. Indeed, they light and manage the dark fibre network for the Old's Institute for Community and Regional Development in Olds. Shared financing options in which the County would fund O-Net to acquire the required opto-electronics and receive shares in return are available. The shares provide a revenue-sharing arrangement in which both parties benefit.

Agentis / DIF Capital Partners

Agentis / DIF Capital Partners may be interested in providing a design, build, finance, and operate proposal to the County.

Crown Capital

Crown Capital may be able to help provide a component of the financing.

Digital Infrastructure Group

Though the details are covered by non-disclosure agreements and therefore not available, DIG, together with Jacobs Engineering and Nokia, is in negotiations with Beaumont and Vermilion to design, build, finance, and operate an open-access wholesale lit fibre network and plans to pursue discussions with other municipalities in the Edmonton Region. Various options are being evaluated. Whether or not this would be an option for Leduc County will depend on the terms. Discussions with DIG would certainly be in order. Most likely, DIG would focus on Nisku.

Smart City Capital

Though superseded by DIG in the Beaumont initiative, SCC is likely interested in making up ground in the area. As the predecessor to DIG, they've partnerships with both Jacobs Engineering and Nokia, and are interested in opportunities to design, build, finance, and operate open-access wholesale lit fibre network in for communities. Most likely, SCC would focus on Nisku.

Recommendations

Nisku Area

Given the urban industrial nature of the Nisku area, the varied requirements for broadband services, smart city and connected vehicle support, security issues, and the excellent likelihood of attracting multiple service providers, the open access, wholesale, lit-network utility option is recommended. Further, as a number of the national and international businesses in the area likely need to connect to secure corporate networks that depend on services from a corporately anointed carrier, those businesses require the option to go with their carrier of choice, an option not available should a single incumbent move to deploy fibre in the area. With this option, the County would enable a fully competitive broadband services environment that would support services up to and beyond 40 Gb/s, maintain some control over the infrastructure, and receive a new revenue stream. The network could be fully implemented and operational within three years.

While the business case for the Nisku area is sound, from a cashflow perspective, it is challenging in terms of achieving the target returns private providers and investors may be looking for. The County has a variety of options to 'make it so'. While they could undertake the effort itself, they would be best to concurrently minimize County funding and effort by either pursuing conversations for financing assistance with Agentis/DIF and Crown Capital or, for both financing and a more hands-off, integrated turn-key approach, with DIG, DUC, Rock Networks, and/or Valo.

With the latter set of options, financial, technical, deployment, and operational risk would be managed via the terms of the partnership. That leaves market risk and to manage it, all required service-related partnership agreements should be put in place prior to implementation and detailed market surveys and pre-sales activities leveraged to ensure adequate demand and revenue.

Rural Areas

While fostering competition is a worthy aim, it can be counter-productive in rural areas with market failure. Open-access models increase operational costs and splitting the small potential revenue amongst numerous competitive players simply exacerbates the problem. Based on both this and superior financials, an integrated retail, hybrid fibre-wireless option is recommended.

If a capable ISP can be found to handle the overall deployment and operation of network for the County, that would be ideal. As fibre can be considered critical long-term infrastructure, our recommendation is that the County at least retain ownership of the lit fibre infrastructure and leave the wireless components to the ISP. As the ISP's operations would depend on the fibre, longer-term arrangements, say an IRU on the fibre they require to maintain their wireless operations, would be required.

To accomplish this, the County would negotiate with the ISP to deploy and light the fibre network based on a County specified design – or to also design it, but to County specifications. All fibre network-related central office equipment would be housed in County facilities. The ISP would then be contracted to operate the network on-behalf of the County for a five-year period and use it to feed their version of a gig-wireless solution in all selected rural subdivisions. A longer-term service agreement would ensure continuity of fibre services to the ISP for at least a ten-year period. At five years, the County would have the option to renew the fibre network operations contract with the ISP, internalize the operations, or award the contract to another player. After an agreed-to non-compete term, the County would have the option to extend its fibre network to individual premises.

With this option, the County would significantly enhance broadband service available throughout its rural footprint, deploy and control critical infrastructure, and ensure scalability commensurate with that in urban areas. To be successful, the agreements required would need to ensure the ISP's success as well. The network could be fully implemented and operational with three years.

Technical and deployment risk would be managed by outsourcing fibre design, construction services, and implementation to the ISP. Operational risk and operational efficiencies can be ensured by also awarding the ISP the fibre network operations contract and allowing them to operate the network on an integrated basis – at least for the first five years. Though the biggest risk is that associated with the market, the service set improvements that this approach makes possible almost ensures significant market penetration.

Acronyms

ABF	air blown fibre
ACP	Alberta Community Partnership (program)
ACFA	Alberta Capital Finance Corporation
Admin	administration
A-E	Active Ethernet
AP	(radio) access point
CAD$	Canadian dollar
CapEx	capital expenditure
CIB	Canadian Infrastructure Bank
CIRA	Canadian Internet Registration Authority
CPE	customer premise equipment
CRTC	Canadian Radio-television and Telecommunications Commission
CTI	Connect to Innovate
DP	distribution points
Dwnld	download
EMRB	Edmonton Metropolitan Region
FTTH	fibre-to-the-home
FTTP	fibre-to-the-premise
FWA	fixed wireless access
G	giga, billion (10^9)
Gb/s	gigabits (10^9 bits) per second (1000 Mb/s)
GDP	gross domestic product
G-PON	gigabit passive optical network
GTF	gas tax fund
Hz	Hertz, cycles per second
ICT	information and communications technology
IRR	internal rate of return
IRU	indefeasible right of use
ISED	Industry, Science, and Economic Development (Canada)
ISIS	Islamic State in Iraq and Syria
ISP	Internet Service Provider
IT	information technology
k	kilo, thousand (10^3)
LEOS	low earth orbit satellite
LTE	Long-Term Evolution
m	meter

M	mega, million (10^6)
max	maximum
Mb/s	megabits (10^6 bits) per second
Mgr	manager
mkt	market
mm	millimeter (10^{-3}m)
ms	millisecond (10^{-3}s)
MSI	Municipal Sustainability Initiative
NDC	Non-Dominant Carrier
NE	north-east
NG-PON2	next generation passive optical network version 2
NPV	net present value
OICRD	Old's Institute for Community & Regional Development
ODF	optical distribution frame
OLT	optical line terminal
ONU	optical network unit
OpEx	operational expenditure
Ops	operations
OSP	outside plant
OSS	operational support system
OTDR	optical time-domain reflectometer
P&I	principal and interest
PPP	Private-Public-Partnership
Prem	premise
PTP	point-to-point
Q	quartile
R&D	research and development
RFI	request of information
RFP	request for proposals
RIAP	Rural Internet Access Program
RoC	return on capital
RoI	return on investment
RoW	right-of-way
SCC	Smart City Capital
SCOOP	Strathcona County Online Option Platform
SPV	special-purpose vehicle
SW	south-west
Tech	Technician

UBF	Universal Broadband Fund
UPS	uninterruptible power supply
US	United States (of America)
USO	Universal Service Objective
XGS-PON	ten gigabit/second symmetric passive optical network
yr	year
YEGIX	Calgary Internet Exchange

Appendix

Appendix A: Telecommunications Technology

An Access Technology Comparison

A visual comparison amongst the capabilities of the four major transmission technologies – wireless (tan), copper (tan), coaxial cable (yellow), and fibre (red) appears in Figure 44. In the figure, unless otherwise specified, the numbers shown are in Mb/s.

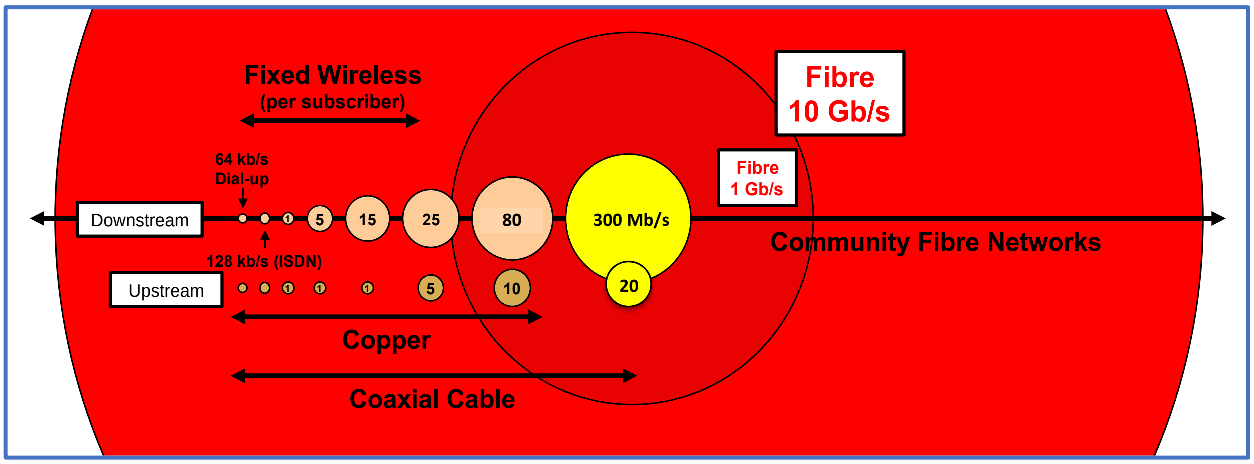

Figure 44. Connectivity speed by technology.

New FWA systems will do up to 100 Mb/s per antenna. This bandwidth is split amongst downstream (from the network to the client, like a Netflix stream) and upstream (from the client to the network, say for uploading photos or backing up data to the cloud) link requirements as needed and would typically be split into something like 75 Mb/s down and 25 Mb/s up. As the available bandwidth is then shared amongst all the homes taking service within the coverage area, if 50 homes took service and happened to be streaming media content concurrently, the maximum available to each would be 1.5 Mb/s down by 0.5 Mb/s up.

Internet data services over the copper plant deployed by the telecommunication incumbents are provided via an evolving family of digital subscriber line (DSL) technologies. Due to the attenuation of higher frequencies required to support broader bandwidth signals, the higher the supported bit rates, the shorter the possible serving distance between the incumbent equipment and the client's home or office. Whereas initial asymmetric DSL equipment supported 6 to 8 Mb/s down and 0.512 Mb/s up could be served from central offices within 4 km of the client, with fibre to every block, current equipment can provide services up to 80 by 10+ Mb/s.

With more capable coaxial cable infrastructure, the current *data over cable service interface specification* (DOCSIS) and the current split ratio (5 – 42 MHz for upstream and 50 – 860 MHz for downstream) subscriber bit rates are typically limited to 600 Mb/s down by 30 Mb/s up. Changing the split to increase upstream bit rates requires changing every active component in the network, as well as the cable modem boxes.

By comparison, the opto-electronics currently deployed to light access fibre networks provides for up to 8 concurrent 10 x 2.4 Gb/s data streams, with each stream supporting 156 Mb/s down by 37.5 Mb/s services to each of 64 premises. As fibre capacity is essentially unlimited, once deployed, network capacity can be increased by simply updating the opto-electronics at each end of the fibre as needed. Opto-electronics typically account for less than 10% of the cost to deploy a network.

Backhaul Fibre Considerations

Opto-electronics used in long distance backhaul networks currently support 160 concurrent data streams at up to 100 Gb/s each in one direction over single span distances in excess of 100 km. For bi-directional systems, two fibres are required.

Fibre Network Considerations

Optical Fibre

Fibre cables are comprised of many individual fibre strands. Cable sizes vary, but a single cable may contain hundreds of fibre strands, as displayed in Figure 45. As fibre strands are glass, the signals are transmitted by pulses of light. As different colours of light can be used on any fibre strand, a single fibre can support the concurrent transmission of multiple data streams.

Fibre's advantages over copper and coaxial cable lines result from the physics of transmitting information using photons of light instead of electrons of electricity. In glass, optical attenuation is much less than the attenuation of electrical signals in copper or coaxial cable and much less dependent on signal frequency/wavelength. In terms of distance and bandwidth, fibre's capabilities are unparalleled. As fibre can theoretically support connection speeds up to 2,800 Gb/s at 1.55 microns (µm) [9] and current access systems operate at only 80 Gb/s, deployed fibre capacity can be increased by 35-fold before its limits are reached. Though it is expensive to deploy due to the civil works involved, with essentially unlimited capacity, it can be considered to be a 40-year asset. To increase capacity, a community only needs to upgrade the opto-electronics at each end of the fibre.

Figure 45. Fibre cable.

Unlike copper wires that radiate signals capable of interfering with other electronic equipment (i.e. radio frequency interference or RFI), fibre is benign and neither radiates RFI nor is susceptible to it, making it immune to lightning strikes, safe when sharing a trench with gas-lines, and an excellent choice for secure communications (it cannot be tapped).

[9] Bandwidth estimate assumes 256 QAM at $\lambda = 1.55$ µm

Deployment

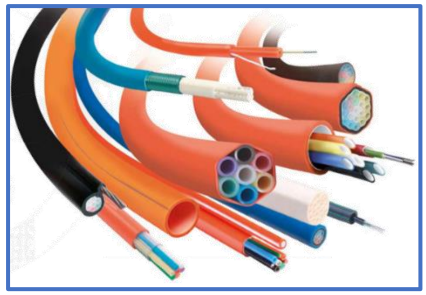

Figure 46. Flavours of fibre conduit.

Fibre infrastructure can be deployed either aerially, via the use of messenger cables in the communications space on power poles, or by burying conduit through which fibre cables can then be blown or pulled. Though aerial deployments are less expensive than buried ones, they are marginally less robust. Aerial deployments reduce deployment expenses by some 30% relative to the buried equivalent. Those estimates, though, assume that the power poles in those areas can be used to deploy fibre. Prior to proceeding with an aerial deployment, the poles will need to be evaluated. If many poles have to be replaced, then a fully buried deployment may be the least expensive option.

In buried deployments, costs vary with ground conditions – soft is better than hard or rock and gravel roads and alleys are less expensive than paved ones. Though fibre cable can be direct buried, for both flexibility and ease of maintenance, it is often placed in conduit. Whereas fibre cable has traditionally been '*pulled*' into conduit, newer methods use compressed air. The latter, referred to as ABF or air-blown fibre, enables smaller conduit sizes (which saves cost) as well as significantly greater deployment distances. With ABF, the conduit can be deployed first and then the fibre only blown in when needed. Samples of ABF conduit appear in Figure 46.

Architecture

Two options for fibre deployment architecture are illustrated in Figure 47. In point-to-point (PTP) or home-run configurations, separate fibre strands are run from a central office (CO) to every premise to be served. This offers the maximum flexibility to the network operator and enables the greatest bandwidths to be delivered to each premise. Active-ethernet (A-E) services over homerun fibre can be used to deliver symmetric, dedicated, 1 and 10 Gb/s services.

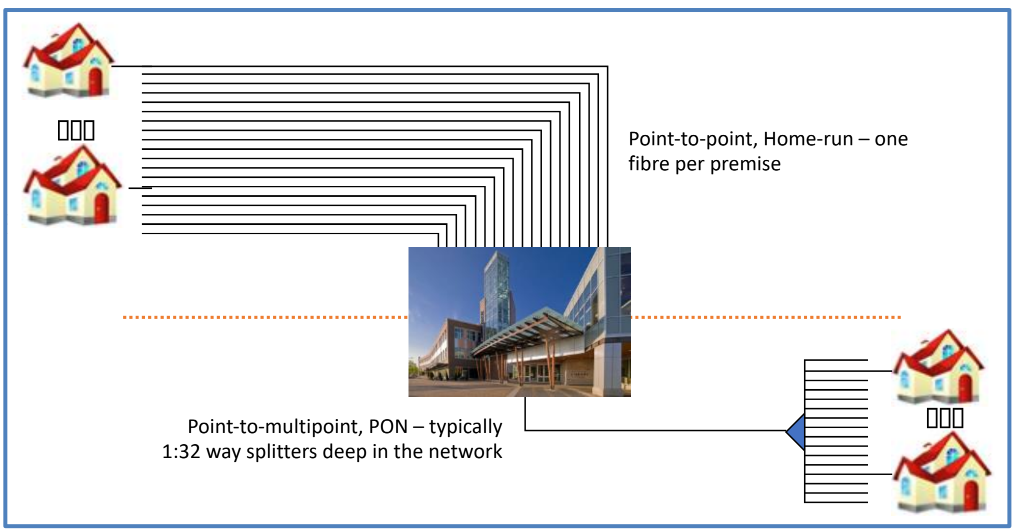

Figure 47. Point-to-point versus point-to-multipoint fibre architectures.

In the gigabit passive optical network (G-PON) architecture, the transmit and receive data-streams on each fibre strand leaving the CO are eventually split and are used to service 2, 4, 8, 16, 32, or 64-fibre strands that then continue to subscriber premises. In this way, one strand at the CO can be used to serve up to 64 premises. While offering some regulatory protection to the incumbents, G-PON configurations both increase the complexity of the required opto-electronics and reduce the concurrent bandwidths that can be delivered to each premise by an amount equal to the split ratio.

As traditional G-PON electronics use a pair of optical wavelengths – one to transmit a downstream bit-stream at 2.488 Gb/s and receive an upstream bit-stream of 1.244 Gb/s, a 1:64 split-ratio reduces this to 38.875 Mb/s by 19.44 Mb/s to each premise, should all 64-premises be using the network concurrently. In Olds, the split-ratio is limited to 1:16, thus ensuring minimum premise bandwidths of 155 by 78 Mb/s. Interestingly, if only one of the sixteen premises happen to be using their connection at a particular time, that premise would experience the whole 2.488 by 1.244 Gb/s service. Current opto-electronics support up to 8-wavelength pairs (colours) in which each transmit and receive pair supports symmetric 10 by 10 Gb/s service. At 10 by 10 Gb/s, a 1:64 split ensures a minimum per home bit rate of 156.25 by 156.25 Mb/s.

Serving Area

In laying out the opto-electronics to support a county-wide deployment, two distance constraints must be considered:

1. the backhaul distance between the opto-electronic units (optical line terminals or OLTs) in each CO and a transit or gateway point and
2. the access distance between the OLT and the premise opto-electronics (optical network units or ONUs) it serves.

Both are fibre quality and distance dependent but (2) also depends on the split ratio and the maximum distance separation between the closest and furthest ONUs from the OLT. Typically, the maximum distance for (1) is ~80 km at 10 Gb/s and 40 km at 40 to 100 Gb/s. On the access side, (2), with a maximum split ratio of 1:16 and long-range optics, these units can serve up to 40 km for connections up to 1 Gb/s and 20 km for connections up to 80 Gb/s. This means that as long as units are not placed more than 80 km apart, the access opto-electronics can serve all premises in-between at rates up to 1 Gb/s.

Wireless Network Considerations

General Considerations

While progress in digital technologies is exponential and both wireless and wireline technologies are progressing rapidly, wireline technologies are currently 100-times more capable than wireless technologies and this lead is unlikely to diminish. Mobile, and especially 5G, technologies get more press, however, and with these rapid advances in, and hype around, wireless technologies, questions around whether wireless could make for a less expensive replacement to fibre often arise. The general answer is no, and reasons include:

- Wireless is typically an access technology only and fibre is generally required to connect wireless access nodes and establish a network. The capacity and quality of the wireless access system therefore depends on the quality of the network connections underlying it.

- Wireless and wireline technologies are complementary – wireless will never have the capacity of wireline for backhaul and wireline technology will never be mobile. Indeed, the '*ideal*' future-proof network will likely be one with a core fibre network connected to either 5G or Wi-Fi-6[10] at the edge. While fibre is, in essence, a medium independent of capacity (effectively unlimited), overtime, the capacity of the 5G and Wi-Fi 6 networks will need to be upgraded as demands increase.

Figure 48. A complementary technology set.

- As a replacement for wireline technology, mobile wireless is less capital intensive, but operationally more expensive and less capable. There are, however, FWA versions of the mobile (cellular) technologies becoming available that provide a good compromise in some access applications.

As access capacity in a wireless system is shared amongst all concurrent users of the system, the Internet speed or bit-rate available to a user is inversely proportional to the number of users – the more users, the slower the available bit-rate. In a fibre access system, beyond the split ratio mentioned earlier, no such sharing takes place. If a premise has a 1 Gb/s access line, they should see a 1 Gb/s service.

Lastly, unlike wireline systems, wireless performance is affected by weather, terrain, vegetation, and buildings along the line-of-sight between the user and the access point (AP) as well as by the distance between them. Wireline systems are essentially immune to these effects.

Scalability

A key difference between wireless and fibre-based access networks is scalability, where scalability refers to the ease and expense related to upgrading system capacity to enable higher bit rate services to end users. As end-user bit rate requirements increase annually, unless the system can be scaled, the provider will eventually run out of capacity. Similar issues arise when the provider's client-base and number of connected devices increases.

When wireless and wireline options are compared, the total costs with scaling, should be considered. Whereas fibre systems are initially more expensive, on a scaled basis, they may not be.

As fibre capacity with a home-run architecture is effectively unlimited, scaling fibre systems is accomplished by upgrading the opto-electronics (typically ~10% of the overall deployment cost). Upgrading wireless access systems is typically more expensive and limited. Options to scale wireless systems involve sectorizing the antennas, adding APs that operate at different frequencies or in a different band, and increasing the number of towers (densification). Furthermore, to enable 5G electronics, the radio equipment at every cell site – of which there will be many – will need to be upgraded.[11]

[10] Wi-Fi 6 is the rebranded IEEE 802.11ax standard and is the most recent standard governing wi-fi networks typically deployed in homes and businesses.

[11] The Cloud Radio Access Network (C-RAN) concept proposes to address this issue by centralizing the radios and only distributing the antennas.

5G

Though 5G wireless technologies will be a significant complement to fibre access networks, they are not a replacement. While the technology is not yet mature, current hype indicates aggregate (shared) data speeds of up to 10 Gb/s. These speeds, though, can only be realized under ideal conditions and for devices located near the radio AP. Including overhead, practical usable bit rates are typically only about 20% of the peak – or 2 Gb/s per AP or cell site in this case. To achieve these rates, higher frequencies (up to ~60 GHz) are used and cell sites must be very small and this evolution to ever smaller cell sites is illustrated in Figure 49. Moving from 3G to 5G requires 400-times more cell sites and thus, 400-times the amount of fibre as these bandwidths can only be supported if the APs are fibre-connected. As each site will also need power and all will need to be replaced to upgrade the system, the capital considerations are significant.

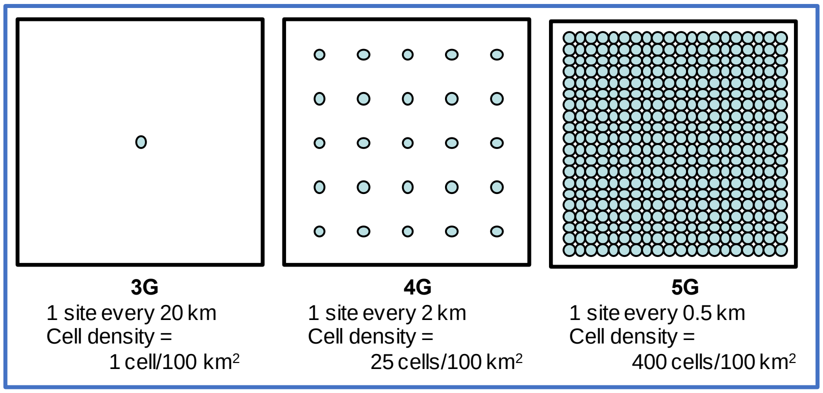

Figure 49. Increased cell tower densities will be needed to meet increased 5G capacity requirements.

For example, in urban areas with premise densities of, 500 premises/km^2, at a 0.5 km spacing, each square-kilometer would be home to 4 APs. With each AP supporting 125 homes, if 40% or 50 homes were sharing the 2 Gb/s capacity of the AP at any time, each premise would only see 40 Mb/s. Increasing this requires even smaller cell sites and a commensurate increase in the number of APs. As 5G standards have yet to be finalized, true 5G services are not likely to be available for three to four-years. With fibre, 10 Gb/s services are available today. As well, the premises equipment typically proposed for utility networks supports the new Wi-Fi-6 standard, thus enabling in-premise wireless connectivity speeds up to 6 Gb/s, with no sharing.

Fixed Wireless Access

As illustrated in Figure 50, fixed wireless or wireless point-to-multipoint (PMP) access networks use a central access point (AP) to provide services to premises in the area surrounding the AP. Coverage areas depend on the height of the AP, local terrain, and foliage. With a 100m tower and near line-of-sight (LOS), signals in the 2 and 3.5 GHz bands can provide services up to 25-30 km away. If the AP has a backhaul link capacity of 100 Mb/s, this is typically split to say 75 Mb/s for downstream and 25 Mb/s for upstream services. These speeds are then shared amongst however many subscribers are concurrently online and utilizing the system. If 100 premises are so doing, then each would see services of only 750 x 25 kb/s. In FWA networks, each premise requires a subscriber antenna to receive signals from the AP and transmit their data back.

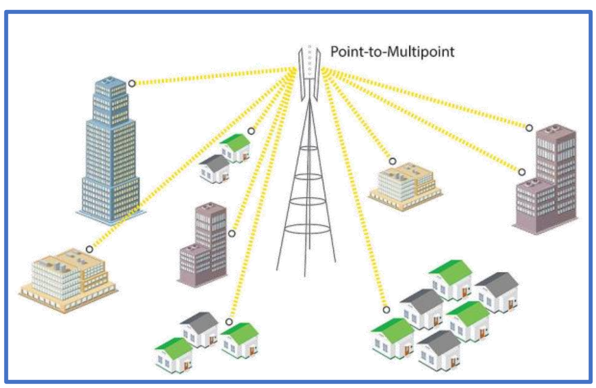

Figure 50. Point-to-multipoint FWA

As advances in 5G will benefit the fixed-wireless and satellite markets and vice-versa, the capability-to-cost ratio with wireless equipment is improving rapidly. FWA versions of 5G cellular systems are becoming available and some, such as that being developed by Starry[12] are being targeted as a replacement to last-mile fibre connections.

To achieve the aggressive capability targets set for 5G systems, all aspects of the radio technology are being exploited, from software-defined radio technology to more complex modulation, signal processing, and antenna (beam-forming) technologies, among others. Of these, beam-forming is especially key, as much for its capabilities as its price-tag. Beam-forming refers to the ability of an antenna to generate multiple '*spot*' beams within its coverage area and coordinate the frequency re-use much more efficiently than that possible with fixed coverage antennas – together this increases the effective capacity of the system significantly. In effect, they create many mini-cells within the macro-cell associated with the fixed antenna equivalent – simultaneously increasing both signal strength and bandwidth.

A concern with technology development dependent on multi-dimensional improvements is that compromises are often required – leading to the analogy of the duck: while a duck can swim, walk, and fly, it doesn't do any of them overly well. It may take a while for 5G systems to truly reach their potential and deliver on the hype.

Appendix B: List of Stakeholders Engaged

Name	Organization	Title
Tanni Doblanko	Leduc County	Mayor
Rick Smith	Leduc County	Councillor
Kelly-Lynn Lewis	Leduc County	Councillor
Kelly Vandenberghe	Leduc County	Councillor
Larry Wanchuk	Leduc County	Councillor
Glenn Belozer	Leduc County	Councillor
Ray Scobie	Leduc County	Councillor
Garrett Broadbent	Leduc County	Agriculture Director
Kent Pudlowski	Leduc County	Corporate Services Manager
Rick Thomas	Leduc County	Deputy County Manager
Clarence Nelson	Leduc County	Enforcement Services Director
Des Mryglod	Leduc County	Engineering and Utilities Director
Dean Ohnysty	Leduc County	Community Services Director
Grant Bain	Leduc County	Planning and Development Director
Keven Lefebvre	Leduc County	Fire Chief
Tara Mulrooney	Edmonton International Airport	VP Technology
Reagan Winchester	Edmonton International Airport	IT Operations Director
Robert Manning	Urban Development Institute	Member
Keith Jansen	Canadian Home Builders Association	Volunteer Chair

[12] https://starry.com

Appendix C: Survey and Speed Test Results

Survey results can be found at the following links:

- Business Survey - https://www.surveymonkey.com/results/SM-TY59BZJG7/
- Resident Survey - https://www.surveymonkey.com/results/SM-KWYHQZJG7/

Alternatively, data from the surveys can be found in the following files:

Leduc County Business Internet Acce

Leduc County Resident Internet Acce

CIRA Speed Test results can be found at the following link:

- https://performance.cira.ca/leduccounty

Alternatively, data can be found in the following file:

CIRA Speed Test Data - September 30,

Appendix D: Glossary

In accordance with industry standards, the following definitions have been developed by the National Telecommunications and Information Administration.

Numbers

3G: The term for the 3rd generation wireless telecommunications standards usually with network speeds of less than 1 Mbps.

4G: The term for 4th generation wireless telecommunications standards usually with network speeds greater than 1 Mbps.

5G: The term for emerging 5th generation wireless telecommunications standards usually associated with network speeds of up to 1 GBPS or more.

B

Backbone: A major high-speed transmission line that strategically links smaller high-speed Internet networks across the globe.[3]

Backhaul: The portion of a broadband network in which the local access or end-user point is linked to the main Internet network.

Bandwidth: The capability of telecommunications and Internet networks to transmit data and signals.[1]

Broadband: The term broadband commonly refers to high-speed Internet access that is always on and faster than traditional dial-up access. Broadband includes several high-speed transmission technologies, such as fiber, wireless, satellite, digital subscriber line and cable. For the Federal Communications Commission (FCC), broadband capability requires consumers to have access to actual download speeds of at least 25 Mbps and actual upload speeds of at least 3 Mbps.[1]

Broadband Adoption: The use of broadband in places where it is available, measured as the percentage of households that use broadband in such areas. Link to Digital Inclusion definition[1]

D

Dark Fiber: Fiber that is in place but not being used for broadband services. ("non-lit" fiber, also see "Lit Fiber").[7]

Digital Divide: The gap between those of a populace that have access to the Internet and other communications technologies and those that have limited or no access.

Digital Equity: Recognizes that digital access and skills are now required for full participation in many aspects of society and the economy. Digital Equity links Digital Inclusion to social justice and highlights that a lack of access and/or skills can further isolate individuals and communities from a broad range of opportunities.

Digital Inclusion: Implies that individuals and communities have access to robust broadband connections; Internet- enabled devices that meet their needs; and the skills to explore, create and collaborate in the digital world.

Digital Literacy: The ability to leverage current technologies, such as smartphones and laptops, and Internet access to perform research, create content and interact with the world.[8]

Digital Skills: Any skills related to operating digital devices or taking advantage of digital resources.

DOCSIS (Data Over Cable System Interface Specification): The international telecommunications standard for cable signaling data and spectrum sharing.[2]

DSL (Digital Subscriber Line): A form of technology that utilizes a two-wire copper telephone line to allow users to simultaneously connect to and operate the Internet and the telephone network without disrupting either connection.[1]

E

eGovernment Services: The government's use of web-based and information technology resources to connect with citizens and provide online services and resources.[8]

F

Fiber (Also referred to as Fiber Strand): A flexible hair-thin glass or plastic strand that is capable of transmitting large amounts of data at high transfer rates as pulses or waves of light.

FTTH or FTTP (Fiber to the Home or Fiber to the Premise): The delivery and connection of fiber optics directly to a home or building.[7]

Fixed Wireless Broadband Access: The use of wireless devices/systems in connecting two fixed locations, such as offices or homes. The connections occur through the air, rather than through fiber, resulting in a less expensive alternative to a fiber connection.[1]

G

Grant: A legal instrument reflecting a relationship between a government agency and a recipient. The main purpose of the relationship is to dispense money or resources in order to accomplish a public purpose. No substantial involvement is anticipated by the government agency during the recipient's completion of the activity.[9]

I

Internet Service Provider (ISP): A company that provides users (individuals or businesses) with access (a connection) to the Internet and related services.[3]

Interconnection: The linking of numerous telecommunications networks to exchange user traffic.[3]

L

Last Mile: The technology and process of connecting the end customer's home or business to the local network provider.[3]

Lit Fiber: An active fiber optic cable capable of transmitting data.

LMDS (Local Multipoint Distribution Service): A wireless broadband service that uses microwave signal to render communications service – voice, data, Internet – to customers within the last mile.[1]

Loan: The giving of money or property in exchange for payment of the principal amount plus interest.

Local Area Network (LAN): A group of network devices that are on a high-speed connection and typically within the same building or location. (cite: Indiana University, https://kb.iu.edu/d/agki)

LTE (Long Term Evolution): A 4G wireless broadband technology that provides speeds up to 100 Mbps download and 30 Mbps upload.

M

Middle Mile: The connection between a local network, also called a "last mile" connection, and the backbone Internet network.[3]

N

Network Infrastructure: The hardware and software components of a network that provide network connectivity and allow the network to function.

O

Open Access Network: Networks that offer wholesale access to network infrastructure or services provided on fair and reasonable terms with some degree of transparency and non-discrimination.

P

Point of Presence: The particular place or facility where local Internet service providers connect to other networks. Distance from the Point of Presence can affect service availability and pricing.[3]

R

Rights-of-Way (ROW): ROW are legal rights to pass through property owned by another. ROW are frequently used to secure access to land for digging trenches, deploying fiber, constructing towers and deploying equipment on existing towers and utility poles.[6]

S

Service Area: The entire area within which a service provider either offers or intends to offer broadband service.[6]

SDSL (Symmetrical DSL): A technology that permits the transfer of data over copper telephone lines. The transmission bandwidth for uploads and downloads is equal.[1]

SONET (Synchronous Optical Network): An American National Standards Institute standard for the simultaneous transmission of data over optical fiber.[10]

Spectrum: A conceptual tool used to organize and map the physical phenomena of electromagnetic waves. These waves propagate through space at different radio frequencies, and the set of all possible frequencies is called the electromagnetic spectrum.[6]

W

WiFi (Wireless Fidelity): A technology that uses radio transmissions to enable electronic devices to connect to a wireless local area network (LAN).

WISP: An ISP that provides service through a wireless network.

Figure 1: Table of Units

The following units are associated with broadband:	
Bit	Smallest unit of digital information
Byte	Equal to 8 bits
bps	Bits per second
kbps	Kilobits per second (1000 bits per second)
Mbps	Megabits per second (1 million bits per second)
Gbps	Gigabits per second (1 billion bits per second)
Tbps	Terabits per second (1 trillion bits per second)

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