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FCC Comment: In the Matter of Connect America Fund

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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Connect America Fund	)	Docket No. 10-90
	)	
Universal Service Reform - Mobility Fund	)	Docket No. 10-208
	)	
Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0- 38.0 GHz and 40.0-40.5 GHz for Government Operations	)	IB Docket No. 97-95

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COMMENT

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SUMMARY

The Broadband Institute of California (BBIC) and the Broadband Regulatory Clinic of Santa Clara Law (BRC) petition the Commission to expressly consider the needs of rural tribal lands in promulgating regulations regarding spectrum allocated for the development of 5G technologies, and encourages the Commission to work with prospective auction participants, broadband service providers and tribal communities to develop 5G use cases targeting rural and tribal needs. Presently, barriers to broadband deployment across tribal lands include geographical isolation, low population densities, difficult terrain, and political fragmentation arising from tribal governance issues. The first portion of this Comment explains these particularly crippling barriers. Enabling tribes with access to broadband connectivity can assist in combatting social problems that arise as a result of these barriers. With regards to geographic isolation, access to healthcare and employment opportunities would improve, without the need for commuting long distances, as consumer markets expand.

The second section of this Comment describes the current intricacies of 5G, a developing fabric of technologies. Because 5G is being designed and developed for urban environments and without the consideration of rural areas, the digital divide is destined to increase on the current trajectory. In the face of a systematically persistent digital divide and in the face of insurmountable need within the tribal lands, we urge the Commissioners to consider the impact of 5G on current broadband infrastructure to decrease the digital divide.

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I. INTRODUCTION

The Broadband Institute of California (BBIC) and the Broadband Regulatory Clinic (BRC) hereby submit their Comment regarding the above captioned proceeding. The BBIC is a Law and Public Policy Institute at the Santa Clara University School of Law engaging in research and education in the areas of technology regulation and public policy. The BBIC collaborates with traditional civil rights and disability rights organizations, urban and rural community oriented organizations, as well as foundations and businesses in the pursuit of its mission. The BRC is a regulatory policy clinic at the Santa Clara University School of Law. The BRC assists civil rights and disability rights organizations, urban and rural community oriented organizations addressing broadband issues and policies.

II. JUSTIFICATION

The Telecommunications Act of 1996 was the first major legislation passed pertaining to the telecommunications industry in over sixty years.[1] Under this Act, the Federal Communications Commission is in charge of reviewing regulations, determining if the regulations are necessary to serve public interest, and repealing or modifying any regulations that no longer serve this interest.[2] The Commission also has the authority to provide incentives for deployment of advanced telecommunications capability, including 4G and 5G infrastructure.[3] This can be done in various manners consistent with public interest or necessity, including promoting competition in the local telecommunications market and other methods that remove barriers to infrastructure investment.[4] With both the statute granting the Commission authority to exercise discretion for telecommunications regulations and the ability to create incentives for infrastructure build out, the Commission is justified in pursuing the Mobility Fund Phase-II in tribal and rural areas.

III. BROADBAND DEPLOYMENT CHALLENGES IN TRIBAL LANDS

The pronounced disparity in broadband availability between tribal lands and the rest of the United States persists in America due to low population density and low-income market.[5] However, in 2014 the FCC adopted a $100 million budget for deployment of broadband in rural America, designated to bridge the broadband access divide.[6]

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[1] David McCabe. *Bill Clinton's telecom law: Twenty years later*, THE HILL (Feb. 7, 2016), http://thehill.com/policy/technology/268459-bill-clintons-telecom-law-twenty-years-later.
[2] 47 U.S.C.A. § 161(a-b).
[3] 47 U.S.C.A. § 1302(a).
[4] *Id*.
[5] *Id.* at 52.
[6] *Id.* at 71-8.

A. Broadband Benefits for Tribal Lands

Geographic isolation restricts service organizations, such as health care, from meeting the needs of tribal land residents.[7] Many outside businesses forego expansion into tribal lands[8] resulting in unemployment rates between 45% and 75%.[9]

Job opportunities for tribal residents are further limited by a lack of educational resources. A lower percentage of Native American students graduate from high school than students in any other racial group.[10] Broadband connectivity allows for a wider support system, access to tutors, and the ability to take courses or do coursework online.

Broadband connectivity would help solve many problems that are the result of tribal isolation and fragmentation. For healthcare, the potential benefits include increased access without the burden of driving long distances. For employment, broadband would offer increased access to jobs, and a greater consumer market both on and off tribal lands.

Tribal Nations cannot easily collateralize assets that are held in trust by the federal government, and cannot easily access investment dollars, so the ability to obtain credit and financing is limited."[11] Therefore, it has been difficult to fund small Internet Service Providers (ISPs) to service tribal lands. A large ISP is often the only option, resulting in high rates, strict

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[7] Michelle Sarche & Paul Spicer, *Poverty and Health Disparities for American Indian and Alaska Native Children: Current Knowledge and Future Prospects*, 1136 ANN. N.Y. ACAD. SCI. 126, 127, 129-30 (2008).

[8] *See* John Koppisch, *Why Are Indian Reservations So Poor? A Look At The Bottom 1%*, FORBES (Dec. 13, 2011), https://www.forbes.com/sites/johnkoppisch/2011/12/13/why-are-indian-reservations-so-poor-a-look-at-the-bottom-1/#21fa07c53c07.

[9] Naomi Schaffer Riley, *One Way to Help Native Americans: Property Rights*, ATLANTIC (Jul. 30, 2016), https://www.theatlantic.com/politics/archive/2016/07/native-americans-property-rights/492941/.

[10] Marie C. Stetser & Robert Stillwell, *Public High School Four-Year On-Time Graduation Rates and Event Dropout Rates: School Years 2010–11 and 2011–12*, U.S. E.D. (Apr. 2014), https://nces.ed.gov/pubs2014/2014391.pdf.

[11] FCC, Office of Native Affairs and Policy, 2012 Annual Report, at 7 (released March 19, 2013), http://transition.fcc.gov/cgb/onap/ONAP-AnnualReport03-19-2013.pdf.

data caps, and poor procedural safeguards.[12] For poverty stricken tribal land residents the current structure of broadband does not offer a way out, even though it could.[13]

B. Barriers to Broadband Access on Tribal Lands in the Current Market: Geographical and Political Fragmentation

Two significant barriers deter external ISPs from investing in tribal lands. First, tribal lands are some of the most unfavorable terrains in the country. Second, tribal land governance creates business complexities. ISPs in the current market have made little headway into broadband expansion on tribal lands.[14]

1. Tribal Lands Have Low Population Densities and Difficult Terrain

Tribal lands are often in remote rural areas with rugged terrain.[15] Tribal lands contain approximately 20 people per square mile.[16] The cost of laying fiber in tribal lands ranges from an estimated $10,000 to $50,000 per mile, depending on easements and/or topography.[17] The potential subscriber base is very limited, and many of them are not able to afford market rates; as a result, major ISPs see no opportunity for a return on their financial investment.[18]

2. Tribal Lands Are Governed By Various Authorities

More than 66 million acres of tribal lands are held in trust by the U.S. on behalf of tribes. Thus, when an ISP wants to do business on tribal lands, there are many different layers of

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[12] Caroline Craig, *4 Reasons Broadband Data Caps Must Die*, INFOWORLD (Sept. 9, 2016), http://www.infoworld.com/article/3118333/broadband/4-reasons-broadband-data-caps-must-die.html.
[13] 2012 Annual Report, *supra* note 11.
[14] Native Nations, National Broadband Map (last visited Apr. 24, 2017), https://www.broadbandmap.gov/summarize/native-nations/.
[15] Lennard G. Kruger, Specialist in Science and Tech. Policy, Congressional Research Service, *Tribal Broadband: Status of Deployment and Federal Funding Program*, CRS REPORT 1 (Dec. 20, 2016), https://fas.org/sgp/crs/misc/R44416.pdf.
[16] Julian Tveten, *On American Indian Reservations, Challenges Perpetuate the Digital Divide*, ARSTECHNICA (Jan. 31, 2016), https://arstechnica.com/information-technology/2016/01/on-american-indian-reservations-challenges-perpetuate-the-digital-divide/ (citing Stephen Roe Lewis, the governor of the Gila River Indian Community in Arizona).
[17] *Id.* (citing Matt Rantanen, director of technology for the Southern California Tribal Chairmen's Association).
[18] *Id.*

governance that a company must satisfy. First, tribal sovereignty rules require them to obtain the permission of the tribe or tribes on the land.[19] Tribes conduct business in different ways, so ISPs face inconsistent regulations and business practices. Second, ISPs must work with the Bureau of Indian Affairs, which "oversees tribal lands as a whole."[20] Finally, construction business ventures face added requirements of environmental and historic preservation studies, enforced by both tribal authorities and U.S. regulations.[21]

The complexity of conducting business on tribal lands has long been recognized, and various incentives have been put in place to encourage business partnerships and investments. However, these incentives alone have not fostered the market for the kind of broadband deployment that is so desperately needed by many tribal land residents.

IV. 5G BROADBAND DEPLOYMENT PROPOSAL

For broadband deployment, tribal lands encompass both rural and urban demographics. Rural demographics include rural tribal lands, as well as rural non-tribal land. Since tribal lands are primarily rural,[22] this argument focuses on 5G deployment in rural areas.

A. FCC Rural 5G Policy

The BBIC and BRC applaud the Commission's recognition of the importance of broadband access to rural and tribal lands, and its decision to set 4G LTE as the standard for service to those areas to "ensure that the Commission does not relegate rural [and tribal] areas to substandard service."[23]

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[19] Tveten, *supra* note 16.
[20] *Id.*
[21] *Id.*
[22] Robin M. Leichenko, *Does Place Still Matter? Accounting for Income Variation Across American Indian Tribal Areas*, 79:4 ECON. GEOGRAPHY 365, 365 (2003).
[23] Summary of the Report and Order and Further Notice of Proposed Rulemaking (*MF-II Order*), WC Docket No. 10-90, WT Docket No. 10-208, FCC 17-11, adopted on February 23, 2017 and released on March 7, 2017.

Establishing 4G LTE as the standard will result in more areas receiving service comparable to that of urban areas. To the extent that 4G LTE becomes the platform on which 5G is built, rural and tribal lands will be better positioned to make the transition. The BBIC supports the Commission's decision to reserve roughly $340 million from the Mobility Fund Phase II for tribal lands and establish the Tribal Lands Bidding Credit to "promote further deployment and use of spectrum over tribal lands."[24]

Recent Commission decisions to subsidize rural deployment and to allocate spectrum for 5G will exacerbate access disparities if they fail to consider how 5G functionality will mesh with rural geography and user needs. The Commission has acknowledged that tribal lands "will be more expensive to serve…due to…lower population density and income levels, lack of power or roads…and the need for federal approval before broadband can be deployed."[25] This failure could delay the evolution of 5G, perpetuating the divide.

Presently, industry,[26] standards bodies,[27] and regulatory agencies[28] develop and consider 5G use cases.[29] The FCC's reliance on industry's development of 5G criteria without established responsive rural use cases raises concerns. Significant evidence suggests that 5G can be adapted

[24] *Id.*
[25] *Id.* at 25.
[26] Joan Engebretson, *Verizon: We Are Taking Lead on 5G and That Includes Rural 5G*, TELECOMPETITOR (Sept. 22, 2016), http://www.telecompetitor.com/verizon-we-are-taking-lead-on-5g-and-that-includes-rural-5g/; Harro Ten Wolde, *AT&T says it has an edge in 5G due to expanded Internet access*, REUTERS (Feb. 22, 2016), http://www.reuters.com/article/us-telecoms-mobileworld-at-t-idUSKCN0VV26K; Edward C. Baig, *AT&T Set to Test Speedy '5G'*, USA TODAY (Feb. 12, 2016), https://www.usatoday.com/story/tech/columnist/baig/2016/02/12/t-set-test-speedy-5g/80261532/; Steve Costello, *Industry Identifies Success Factors for 5G*, HUAWEI (Mar. 20, 2017), http://www.huawei.com/en/publications/winwin-magazine/27/industry-identifies-success-factors-5g.
[27] Phillip Tracy, *5G Standards Process: ITU and 3GPP Lay Groundwork*, RCR WIRELESS NEWS (Jul. 2016), http://www.rcrwireless.com/20160719/internet-of-things/5g-standards-process-tag31-tag99.
[28] Matt Hovis, *5G Leaps Forward - What You Need To Know About 5G Standards, Spectrum and Ecosystems*, CARNEGIE TECH. (Oct. 14, 2016), https://www.carnegietechnologies.com/blog/2016/12/14/5g-leaps-forward-what-you-need-to-know-about-5g-standards-spectrum-and-ecosystems.
[29] 5G Americas, *Global Organizations Forge New Frontier*, 5GAMERICAS (July 2016), http://www.5gamericas.org/files/8714/6774/1431/Global_Organizations_Forge_New_Frontier_of_5G_Final.pdf.

to rural and tribal needs.[30] The BBIC encourages the Commission to invite bidders and existing service providers to develop 5G use cases that target the rural needs in the same way that it has invited comment on "establishing performance requirements for innovative uses associated with the internet of things (IoT)."[31] Quality rural use cases can reduce the need for future funding[32] and provide a forum for the industry and government to narrow the digital divide.[33]

B. Characteristics of 5G: Infrastructure and Technology

5G provides critical opportunities related to economic growth, education, employment, transportation, and healthcare.[34] 5G will connect the predicted hundreds of billions of microchip-enabled products that will comprise the IoT.[35] 5G will use higher-frequency bands than previously thought viable.[36]

Using wavelengths with higher frequencies presents its own issues. Though the spectrum can be reused, the millimeter wave signals travel best in narrow and straight lines.[37] Furthermore, working with higher frequency wavelengths leads to shorter transmission ranges, limiting the range to hundreds of meters, as opposed to 4G, whose range spans over kilometers.[38] Greater distance means increased cost of providing service. Also, 5G wavelengths are easily blocked[39]

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[30] Scholars who have explored the use of 5G in rural and low-income areas suggest that 5G may be reasonably incorporated into rural and low income use cases. Luca Chiaraviglio et. al, *5G In Rural and Low-Income Areas: Are We Ready?* (last visited Apr. 24, 2017), http://ltu.diva-portal.org/smash/get/diva2:1050223/FULLTEXT01.pdf.

[31] Report and Order and Further Notice of Proposed Rulemaking, FCC 287, at 6 (2016), https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-89A1.pdf.

[32] Randy Sukow, *Busy Meeting Focuses on Rural Broadband*, NRTC (Feb. 24, 2017), https://www.nrtc.coop/rural-connect/busy-fcc-meeting-focuses-on-rural-broadband.

[33] FCC Public Notice, FCC (Mar. 27, 2017), http://transition.fcc.gov/Daily_Releases/Daily_Business/2017/db0327/DOC-344081A1.pdf.

[34] *Forging our 5G Future*, FCC (last visited Apr. 24, 2017), https://www.fcc.gov/5G.

[35] *Id*.

[36] *Id.* at 4.

[37] *Id.*; RCR WIRELESS NEWS, *TWS 2015: Millimeter Wave for 5G* (Oct. 16, 2015), https://www.youtube.com/watch?v=hpp-efPnCEU.

[38] *Id.*

[39] RCR WIRELESS NEWS, *supra* note 37.

by common obstacles such as walls, tall buildings, trees, and even a person standing between two endpoints.[40]

The current proposed 5G network was conceptualized for an urban environment.[41] The infrastructure of 5G is still being developed, but several key technologies are laying the groundwork. Traditional cell phone towers are macrocells, or large towers with ranges in the tens of miles. In a 5G world, it becomes harder to use only macrocells because 5G technology uses higher frequencies and those signals have more trouble penetrating walls or traveling longer distances because an object is obstructing the signal. To combat this problem small low-power base stations, or small cells, are used to help redirect a 5G signal to a large cell tower.[42] Hundreds of small cells can be placed around urban areas to ensure connectivity, as small cells can make handoffs to each other, eventually getting the signal back to a macrocell. Alternatively, small cells that exist in areas that already have broadband connections can transmit the signal directly over the fiber backbone.

While small cells are cost efficient in urban areas, the cost is higher in rural areas that currently lack even a 4G connection. For example, to get sufficient 5G coverage, a rural 5G wireless service provider would be installing radios every 1,000-3,000 feet on towers and poles.[43] These towers and poles could be 5G small cells and may require fiber connections to the network backbone which may not exist in some areas. This contrasts with 4G, where towers can be anywhere from 4 to 15 miles apart depending upon terrain.

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[40] IEEE Spectrum, *Everything You Need to Know About 5G*, YOUTUBE (Feb. 6, 2017), https://www.youtube.com/watch?v=GEx_d0SjvS0; RCR WIRELESS NEWS, *TWS 2015: Millimeter Wave for 5G*, YOUTUBE (Oct. 16, 2015), https://www.youtube.com/watch?v=hpp-efPnCEU.

[41] Chiaraviglio, *supra* note 30.

[42] IEEE Spectrum, *supra* note 40.

[43] Bill Coleman, *5G Wireless as Rural Solution: Not Any Time Soon*, BLANDIN ON BROADBAND (Feb. 6, 2017), https://blandinonbroadband.org/2017/02/06/5g-wireless-as-rural-solution-not-any-time-soon/.

In urban areas, there is no shortage of connections to the power grid. If you are deploying 5G in a rural area, a power grid may be unavailable or unreliable, and the power may come from other sources like sun, wind, or even manual hand crank power.

C. 5G Market Considerations For Rural Areas

5G will open markets in rural areas for access to increased capital and build incentives for better products in the market. Solving the rural 5G problem will help to open rural markets and provide opportunities to sell technological advancement internationally. IoT, for example, aims to "enhance connectivity 'any-time, any-place,' [and] for 'any-thing.'"[44] It will work better with access to rural areas among other places. Without improvements into 5G for rural areas, the benefits and profits of the 5G products will be limited. Without 5G in rural areas customers will lack the benefit of the advanced technology within the region, businesses would miss out on profits from the region, and citizens would lose a chance to participate in the advanced market.

Implementing 5G imposes financial challenges. First, 5G will cost more simply because it needs more infrastructure to reliably transmit on higher frequency signals.[45] User costs will rise in turn. For instance, current smartphones are not 5G compatible, so consumers will need to purchase new phones.[46] And the phone prices keep rising in the United States.[47] This poses a problem because as in emerging rural markets, costs should be kept as low as possible in the areas the Mobility Fund will be serving.

D. Proposal for a Specialized 5G Architecture for Rural Areas

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[44] Louis Coetzee & Johan Ecksteen, *The IoT-Promise for the Future? An Introduction*, IST AFRICA (Oct. 2011), https://www.researchgate.net/profile/Louis_Coetzee/publication/232168435_Turn_me_on_Using_the_Internet_of_Things_to_turn_things_on_and_off/links/568faa1308aead3f42f45509.pdf.

[45] IEEE Spectrum, *supra* note 40.

[46] Sean Keach, *What is 5G? 5G vs 4G and the future of UK mobile networks*, TRUSTED REVIEWS (Feb. 24, 2017), http://www.trustedreviews.com/opinions/what-is-5g-a-rough-guide-to-the-next-generation-of-mobile- networks.

[47] Felix Richter, *Smartphone Prices to Drop Everywhere But in North America*, STATISTA (Nov. 27, 2013), https://www.statista.com/chart/1663/smartphone-prices-2013-and-2017/.

Rural and low income regions, such as tribal lands, are often remote areas that lack both the access to power grids for electricity and the requisite finances to establish and maintain broadband infrastructures.[48] In assessing ways to combat the digital divide it is necessary to develop a specialized architecture that can handle these problems.[49] This can be accomplished through the deployment of 5G technologies in ways that are economically efficient and environmentally sustainable.[50] A specialized architecture would involve an alternative set of means to achieve widespread Internet connectivity.[51] Some of those include converged solutions, reusability of network components and functions, deployment of commodity hardware, exploitation of renewable energy sources, and usage of unmanned aerial vehicles (UAVs).[52] The utilization of this infrastructure will lead to reductions in capital expenditures (CAPEX).[53]

1. A Converged Solution

A converged solution seeks to optimize networks by managing services and components in a unified way.[54] Unlike current networks, which have created separations between the last mile, metro, and core, a converged network would operate them in unison.[55] Services would run on the same level of the network components rather than on top of the network.[56] Most importantly, the network provider also acts as the service provider, thereby maximizing its

[48] Communications Workers of America, *Speed Matters: Benefits of Broadband,* SPEEDMATTERS (2010), http://files.cwa-union.org/speedmatters/CWA_Benefits_of_Broadbandr_2010.pdf?nocdn=1.
[49] World Economic Forum, *Internet for All: A Framework for Accelerating Internet Access and Adoption,* WORLD ECON. FORUM (April 2016), http://www3.weforum.org/docs/WEF_Internet_for_All_Framework_Accelerating_Internet_Access_Adoption_report_2016.pdf.
[50] Darrell M. West, *Achieving Sustainability in a 5G World,* CENTER FOR TECH. INNOVATION AT BROOKINGS (Dec. 2016), https://www.brookings.edu/wp-content/uploads/2016/11/gs_20161201_smartcities_paper.pdf.
[51] Chiaraviglio, *supra* note 30.
[52] *Id*.
[53] *Id*.
[54] BMC Software, *Converged Infrastructure vs. Hyper Converged Infrastructure,* BMC (Jan. 2016), http://www.bmc.com/blogs/converged-infrastructure-vs-hyper-converged-infrastructure/.
[55] *Id*.
[56] *Id*.

flexibility in deploying its services and components across the network.[57] In rural and low income settings this flexibility will benefit the government, which is likely to be acting as the provider for both.[58]

2. Virtual Network Components

The standards of high bandwidth and low delays demanded in areas with widespread broadband availability are far less stringent in rural and low income settings which are concerned with basic availability.[59] Therefore, it would make sense to seek to virtualize network elements rather than using underlying hardware.[60] While virtualized components would not perform as highly as proprietary hardware—consisting of Base Stations, routers and computing nodes—they would make network deployment much cheaper.[61] Additionally, this would make network operation more economically viable and Internet connectivity far more feasible in rural and low income areas.[62]

3. Reusability of Network Components

[57] Matt Prigge, *What Converged Networking Really Means*, INFOWORLD (Feb. 2011), http://www.infoworld.com/article/2623381/infrastructure-storage/what-converged-networking-really-means.html.
[58] Chiaraviglio, *supra* note 30.
[59] DSTI/ICCP, *Bridging the Digital Divide: Issues and Policies in OECD Countries*, OECD (July 2001), https://www.oecd.org/sti/broadband/27128723.pdf.
[60] Mark Cummings & Jayanta Dey, *Capturing the Payoff from Network Virtualization*, ORCHESTRAL NETWORKS (Apr. 2015), http://www.wipro.com/documents/capturing-the-payoff-from-network-virtualization.pdf.
[61] Eric Siebert, *Virtualization Benefits Are Worth the Extra Cost Over Physical Servers Alone*, TECHTARGET (Dec. 2009), http://searchvmware.techtarget.com/Virtualization-benefits-are-worth-the-extra-cost-over-physical-servers-alone.
[62] Chiaraviglio, *supra* note 30.

Through virtualization, most of the network components will use virtual functions shared among devices and managed by a central entity.[63] This can be accomplished through the softwarization of network and computing functions, which shifts hardware based functions to the software sphere.[64] By engaging in virtualization through softwarization, each of the virtual elements across the network can be reused multi-functionally across different physical devices and allow for efficient resource allocation.[65] Network and computing capacities are made more flexible, and can be allocated across the network where they are most needed or where energy sources are unavailable.[66]

4. Solar Power

Solar power may provide the solution for the absence of power grids in rural zones.[67] The solar solution, however, poses two issues: (1) the overall size of the solar panels and the associated costs and (2) the natural limits on energy consumption at night and during days with unsuitable weather.[68] Technical innovations should lead to cheaper and more efficient solar panels.[69] Management of the network could address these issues through energy saving policies responsive to the available power and differing traffic demands.

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[63] European Telecommunications Standards Institute, *Network Functions Virtualisation (NFV): Use Cases*, ETSI (Oct. 2013), http://www.etsi.org/deliver/etsi_gs/NFV/001_099/001/01.01.01_60/gs_NFV001v010101p.pdf.
[64] *Id*.
[65] Paulraj & Kanniga Devi, *Efficient Resource Provisioning Using Virtualization Technology in Cloud Environment*, IJIRCET (Mar. 2014), https://pdfs.semanticscholar.org/178f/afa0bc431655da8a7b3a348de79854c3c5b6.pdf.
[66] *Id*.
[67] Quingqing Wu, et al., *An Overview of Sustainable Green 5G Networks* (Sept. 2016), https://pdfs.semanticscholar.org/a2b6/aa90285d92809badbcaae589ca3ff142b90a.pdf.
[68] *Id*.
[69] Vinay Chamola & Biplab Sikdar, *Solar Powered Cellular Base Stations: Current Scenarios, Issues and Proposed Solutions*, 54:5 IEEE COMM. MAGAZINE 108-14 (May 2016), https://www.ece.nus.edu.sg/stfpage/bsikdar/papers/commag_vc_16.pdf.

5. Unmanned Aerial Vehicles and Advanced Radio Techniques

Implementation of the final nodes required to connect rural zones to a network create prohibitive management and installations costs.[70] Innovations in Unmanned Aerial Vehicles (UAVs) and massive antenna arrays provide a wireless solution to connectivity issues.[71] In sparsely populated rural zones, radio nodes that track UAVs mounted with radio elements can connect isolated users to the network.[72] In densely populated rural zones, massive antenna arrays at base stations will provide crucial energy-efficiency for 5G radio standard.[73] Additional innovations are anticipated that will reduce transmission issues and improve energy efficiency.

Facebook recently launched ARIES (Antenna Radio Integration for Efficiency in Spectrum) to address urban and rural access.[74] Using MIMO (multiple input, multiple output) technology, ARIES transmits from urban areas into rural locations as far as 10 kilometers.[75] With nearly 97 percent of the world's population living within 40 kilometer of a major city, this technology could provide a solution to the prohibitive cost of providing backhaul to rural areas.[76]

V. CONCLUSION

For the foregoing reasons the BBIC and the BRC urge the Commission to: (1) consider how 5G may be developed to better suit rural tribal lands, rather than solely urban areas, and (2) invite bidders and existing service providers to develop 5G use cases that target rural and tribal needs. The most efficient solution for Broadband deployment will involve 5G technology that

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[70] Juan Rendon Schneir & Yupeng Xiong, *A Cost Study of Fixed Broadband Access Networks for Rural Areas* (Aug. 2016), http://www.sciencedirect.com/science/article/pii/S0308596116300283.
[71] Neeraj Choubey & Ali Yazdan, *Introducing Facebook's New Terrestrial Connectivity Systems--Terragraph and Project ARIES* (last visited Apr. 24, 2017), https://code.facebook.com/posts/1072680049445290/introducing-facebook-s-new-terrestrial-connectivity-systems-terragraph-and-project-aries/.
[72] *Id.*
[73] *Id.*
[74] Choubey & Yazdan, *supra* note 71.
[75] *Id.*
[76] *Id.*

works for a versatile fabric of architectures. Rather than inefficiently pumping tribal land funds at the back-end of technology development, legislatures and technologists must take advantage of the early stage of 5G.

Respectfully submitted,

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