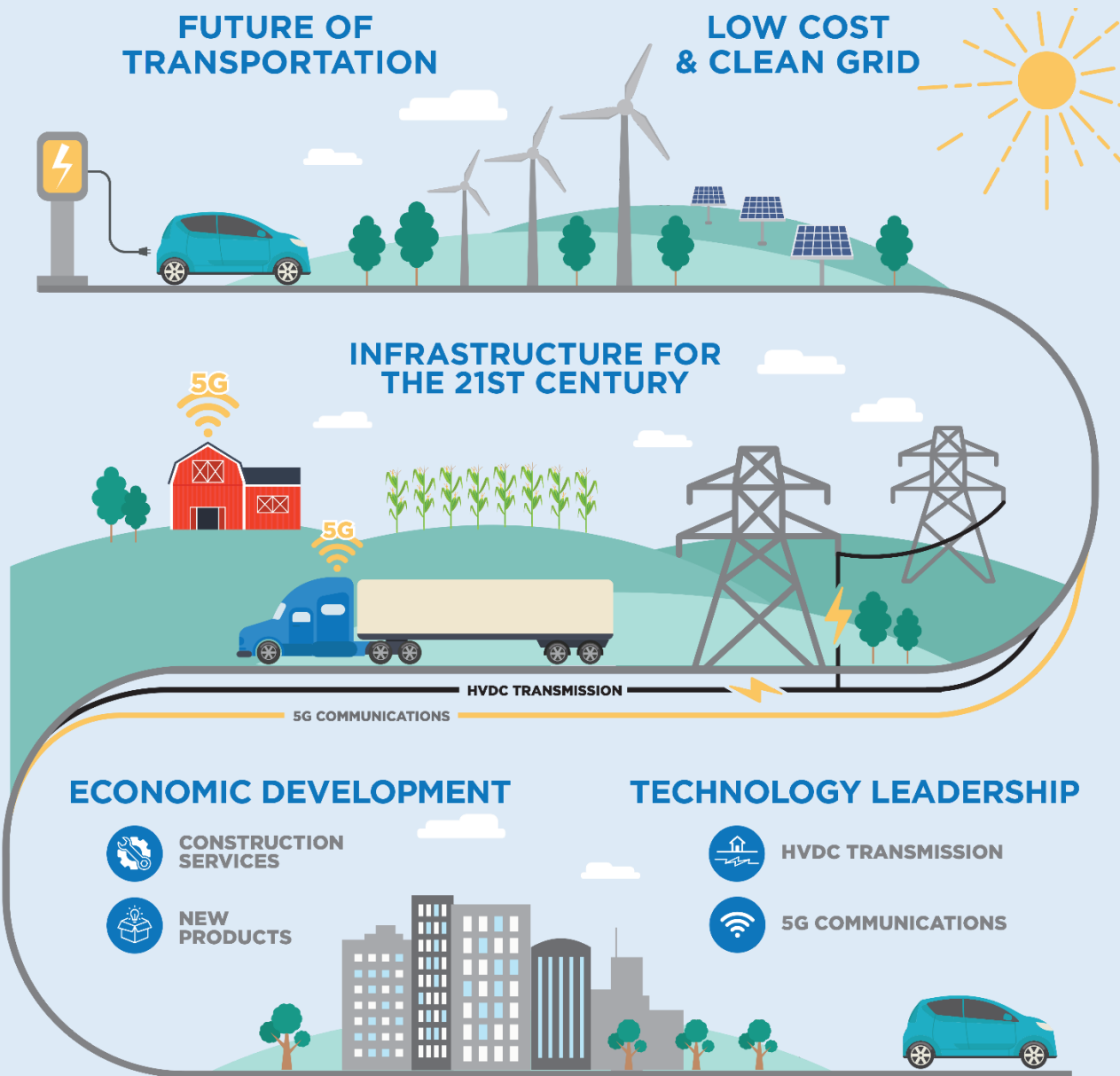


NextGen Highways

CO-LOCATING THE TRANSPORT OF VEHICLES, ENERGY AND INFORMATION



A. Preface

The United States is on the verge of making a generational investment in its infrastructure. The success or failure of this investment will define the economic, environmental, and social health of our country for decades to come.

As federal lawmakers work to fund this investment there are many separate asks but little in the way of a unifying vision that can be sold to the American public. Similarly, as state agencies prepare to direct federal funding, there is not an overarching strategy that would create an outcome greater than the sum of its individual parts.

NextGen Highways are a unifying vision and overarching strategy that:

- **builds for our transportation future** by integrating electric and communications infrastructure into our existing transportation infrastructure
- **drives deep decarbonization** by enabling the interregional transmission needed to affordably achieve 100% clean energy and by ensuring the electric grid can be rapidly strengthened in transportation corridors to support EV charging needs
- **unleashes economic development** by removing barriers that are currently holding back a trillion dollars of private investment; investment that will create new jobs, services, and technologies
- **strengthens national security** by constructing an energy and communications backbone that is hardened against everything from severe weather events to cyber attacks
- **improves equity** by remedying the enduring air quality impacts of the interstate system and by increasing broadband access in rural and urban communities

Furthermore, NextGen Highways would provide a platform to test and deploy the latest communications, computing, and security technologies. In this way they would provide a concrete use-case to guide the \$110 billion authorized under the US Innovation and Competition Act,¹ ensuring that billions of dollars in R&D funding don't merely drive a series of open-ended research projects.

There are no technical barriers to the development of NextGen Highways - merely our will to address institutional hurdles.

The strength of the United States in 2050 will be dependent on multiple factors. Two key ones are whether we are able to rectify our current rural-urban divide and whether we are still a country that can execute against big dreams. NextGen Highways is an opportunity to do both.

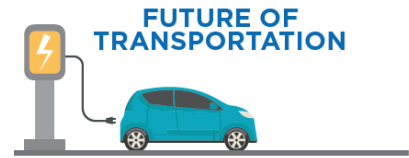
¹ The [US Innovation and Competition Act](#) passed the Senate in June 2021 with bipartisan support.

B. What are NextGen Highways?

NextGen Highways are highways where electric grid and communications infrastructure are strategically co-located along the highway right-of-way.

NextGen Highways would:

- Strengthen the grid, increase grid resiliency, and reduce energy costs
- Rapidly increase the locations where clean energy generation assets can be built
- Enable EV fast charging, especially for medium and heavy-duty trucks
- Improve air and noise quality in communities adjacent to major highway corridors
- Deploy fiber and advanced communications infrastructure to reduce the digital divide and to enable connected and autonomous vehicles
- Drive significant economic development in rural and urban area



C. NextGen Highways Drive Economic Development

As illustrated in the following figure of a re-imagined interstate corridor, **NextGen Highways would create an energy and communications backbone that would drive economic development in both rural and urban areas.**

In rural areas, economic development would be focused on data centers, energy resources (e.g., solar, wind, and storage), and over-the-road charging of electric vehicles.

In urban areas, economic development would be focused on fleet electrification, re-development of retired generation assets (including their transmission infrastructure), data centers, and energy resources.

Throughout the interstate corridor, NextGen Highways would deliver wireless broadband services to communities adjacent to the highways and would support the operation of connected and autonomous vehicles.

Critically, this energy and communications backbone would be hardened against physical and cyber-attacks, allowing it to operate as a provider of last resort in the event of an attack on our existing electric grid and communications infrastructure.

A Reimagined Interstate Corridor



Wireless Broadband Center

- Broadband Access
- Connected & Autonomous Vehicle Support
- Connected & Autonomous Vehicle Support

Rural Development & Resilience Center

- Datacenter Development
- Energy Development
- Over-the-Road EV Charging

Urban Development & Resilience Center

- Fleet Electrification
- Power Plant Redevelopment
- Energy Development

Energy and Communications Backbone

- Military & National Security Needs
- Critical Logistics: Food, Supplies
- Health and Safety Services

D. NextGen Highways Increase our National Security

Our existing energy infrastructure (and by extension much of our other infrastructure and economy) is increasingly vulnerable to severe disruption lasting multiple days, weeks, or even months. Cyber-attacks, hurricanes, cold weather, and wildfires have already resulted in critical parts of our energy infrastructure being offline for multiple days in recent years (see table below). Less likely but significantly more catastrophic, an electromagnetic pulse attack or solar storm could result in the entire electrical grid being offline for many months.

Energy Outage Event	Type	Duration	Impacts
Kincade Fire California, 2019	Weather	Days	Wide-scale electric shut-off impacting millions of customers
Hurricane Ida Louisiana, 2021	Weather	Weeks	City of New Orleans was without power for over a week
Winter Storm Uri Texas, 2021	Weather	Days	\$200 billion of damages, 100 lives lost
Colonial Pipeline Attack Southeast US, 2021	Cyber-Attack	Week	Panic buying of gas
2012 Solar Storm Global Event, 2012 <i>*Missed Earth by 9 days</i>	Geo-Magnetic	Months	\$0.6-\$2.6 trillion of damages in the US; 4-10 years required for full recovery

NextGen Highways would address the vulnerabilities of our existing electric grid and communications infrastructure by establishing a national energy and communications backbone that is physically hardened, cyber-secure, and resilient.

E. NextGen Highways Pay For Themselves

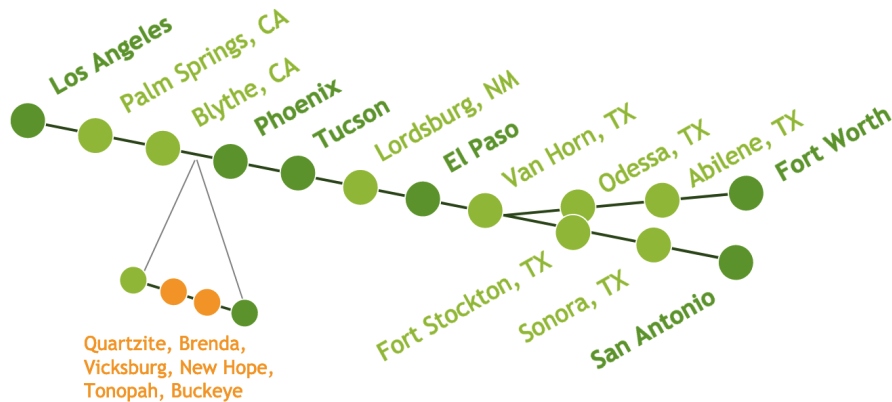
NextGen Highways would pay for themselves through the energy and communications services they enable.

Consider the re-imagined Interstate-10 and Interstate-20 corridors between Texas and California shown below. The cost of the communications infrastructure would be roughly \$2 billion. The cost of the energy infrastructure (4 GW of buried HVDC transmission) would be roughly \$20 billion.

Undoubtedly these are substantial sums of money. But the benefits are also substantial. In fact, they are greater. Over the last five years, there was nearly \$2 billion/year of revenue to be realized by shuttling electrons back and forth between Texas and California with a 4 GW transmission line. **As a result, the \$20 billion cost of the transmission line could be paid back in a little over ten years.** Pretty good for an asset with a fifty-year (or longer) lifetime.

And that payback doesn't account for any societal value from avoided property damages that could otherwise occur without the line. During the February 2021 Texas Blackout, property damages exceeded \$100 billion. Assuming ten percent of these damages (\$10 billion) could have been avoided with an additional 4 GW of power,² the societal benefits during this single weather event would cover half the cost of the buried HVDC transmission line.

A Reimagined I-10/I-20 Corridor



- Nearly \$2 billion/year of revenue for moving electrons between TX and CA
- Autonomous trucking corridor that builds upon existing pilots
- Support for critical military assets

*This figure can be interpreted using the legend from the earlier re-imagined corridor figure

Similarly, the \$2 billion in communications infrastructure can be easily recovered through the benefits it delivers. Roadside communications infrastructure will be a significant enabler for connected and autonomous vehicles by:

- Enhancing a vehicle's ability to navigate in a fully autonomous manner
- Reducing a vehicle's compute and data storage requirements
- Enabling the coordination of travel within a city and across multiple travel modes

In exchange for these capabilities, it is entirely feasible that passenger and commercial vehicles will pay annual usage fees. Assuming usage fees of \$100/yr for passenger vehicles and \$500/yr for commercial vehicles and five million cars and two hundred thousand commercial vehicles using these services³, \$6 billion of revenue would be generated every ten years: **a three-fold return on investment over a ten-year investment period.**

² Property damage resulted from gas and electrical outages. 4 GW of power was ~20% of the electrical shortfall.

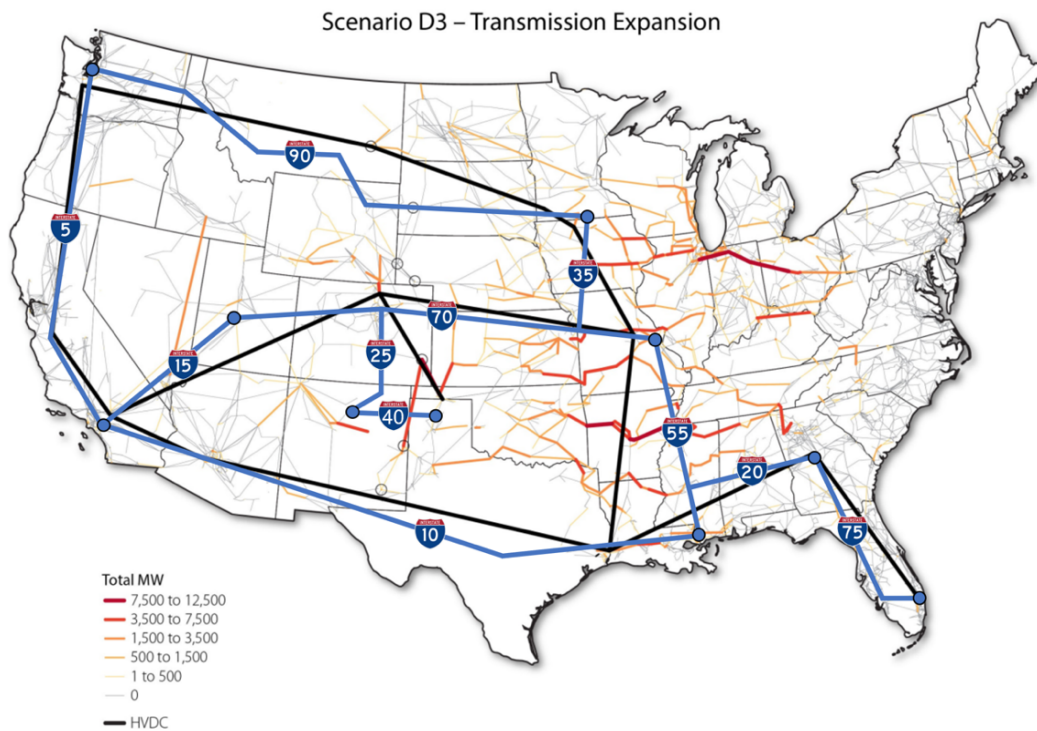
³ For comparison, there are nearly 300 million cars in the US and nearly 4 million heavy-duty commercial vehicles.

F. NextGen Highways Enable a Macro Grid

Our existing grid was planned and constructed by many hundreds of utilities to serve local needs. **Over the last decade, there has been a global recognition of the need for ‘Macro Grids’ that facilitate the transfer of power many hundreds and even thousands of miles.**⁴ Macro Grids enable countries to more fully utilize clean energy resources, to seamlessly transfer power from regions experiencing a surplus to those experiencing a shortfall, and to increase overall grid reliability and resiliency.

In 2016, the National Renewable Energy Laboratory (NREL) modeled a Macro Grid for the United States and found that for every \$1 invested in a Macro Grid, there were \$2-3 of long-term benefits.⁵ NREL additionally found that a Macro Grid enabled renewable energy penetrations up to 85%. It is clear from NREL’s work and subsequent modeling that a Macro Grid is key to low-cost and clean energy, technology-neutral decarbonization, and overall grid reliability.

However, building a Macro Grid is easier said than done. Public opposition to the construction of new transmission lines is often cited as one of the largest barriers (if not the largest barrier) to the construction of a Macro Grid.⁶ It is for this reason that existing right-of-way (such as highway right-of-way) will be needed to construct a national Macro Grid. **And, as the figure below shows, our existing interstate system (blue lines) could be used to construct a nearly equivalent Macro Grid to the one modeled by NREL (black lines).**



⁴ <https://cleanenergygrid.org/wp-content/uploads/2020/11/Macro-Grids-in-the-Mainstream.pdf>

⁵ <https://www.nrel.gov/analysis/seams.html>

⁶ <https://www.niskanencenter.org/transmission-stalled-siting-challenges-for-interregional-transmission/>

G. NextGen Highways Enable the Future of Transportation

Over the last five years, the private sector has invested over \$150 billion in connected, autonomous and electric mobility.⁷ NextGen Highways responds to this loud and clear market signal by establishing the electric grid these vehicles will need to charge and the communications infrastructure they will need to operate across all weather conditions.

A major challenge facing the continued deployment of electric vehicles, especially larger commercial vehicles, is the electric grid's ability to support EV charging needs. In particular, moderate-levels of fleet electrification will require significant grid upgrades^{8,9}. Some of these upgrades - new substations and transmission line extensions - will cost tens of millions of dollars and take five years or longer to build.¹⁰ The first indication of the required upgrades are already visible in California where a roughly year-long grid upgrade process has delayed the roll out of some electric trucks.¹¹



NextGen Highways would enable the development of ultra-fast EV charging stations every 150 miles or less. NextGen Highways would enable these charging stations by proactively making the required grid infrastructures investments while supporting the larger economic development opportunities previously mentioned (e.g., data centers and new energy generation resources). As a result, charging station operators would avoid the significant costs and multi-year lead times associated with the required grid upgrades.

⁷ [The future of mobility is at our doorstep](#)

⁸ <https://westcoastcleantransit.com/>

⁹ <https://rmi.org/insight/seattle-city-light/>

¹⁰ <https://www.bv.com/perspectives/8-steps-fleet-electrification>

¹¹ [CALSTART's 2030 Policy Summit](#)

Communications infrastructure is also needed to support connected and autonomous vehicles. NextGen Highways communications infrastructure will:

- Enhance a vehicle's ability to navigate in a fully autonomous manner
- Reduce a vehicle's compute and data storage requirements
- Enable the coordination of travel within a city and across multiple travel modes (including urban air travel)

It is for these reasons that Michigan has committed to developing an autonomous car lane from Detroit to Ann Arbor.¹² The project is now in a feasibility and design phase that is expected to last two years. Once complete, the project will provide critical real-world data for the development of autonomous vehicles and will ensure that we don't fall too far behind China, which has already constructed an entire highway for autonomous vehicles.¹³



By integrating our transportation, electric grid, and communications infrastructure, NextGen Highways will build the infrastructure platform that the future of transportation requires. The NextGen Highways platform will enable the plug-and-play integration needed by new energy resources, new loads, and new communications equipment. It will be a platform that delivers the scale and repeatability needed to achieve our ambitious goals.

H. NextGen Highways Increase Broadband Access

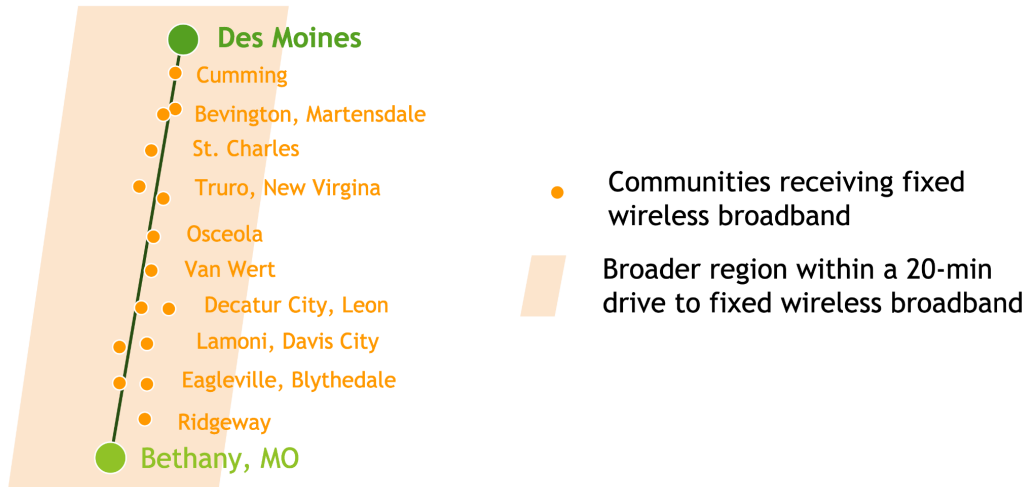
NextGen Highways will increase broadband access in rural and urban areas.

In rural areas, NextGen Highways will increase broadband access in two ways. First, they will deliver fixed wireless broadband to towns that are up to five miles away from a NextGen Highway. This will directly serve the population of rural communities adjacent to a NextGen Highway. It will also indirectly serve the population of adjacent communities by allowing more

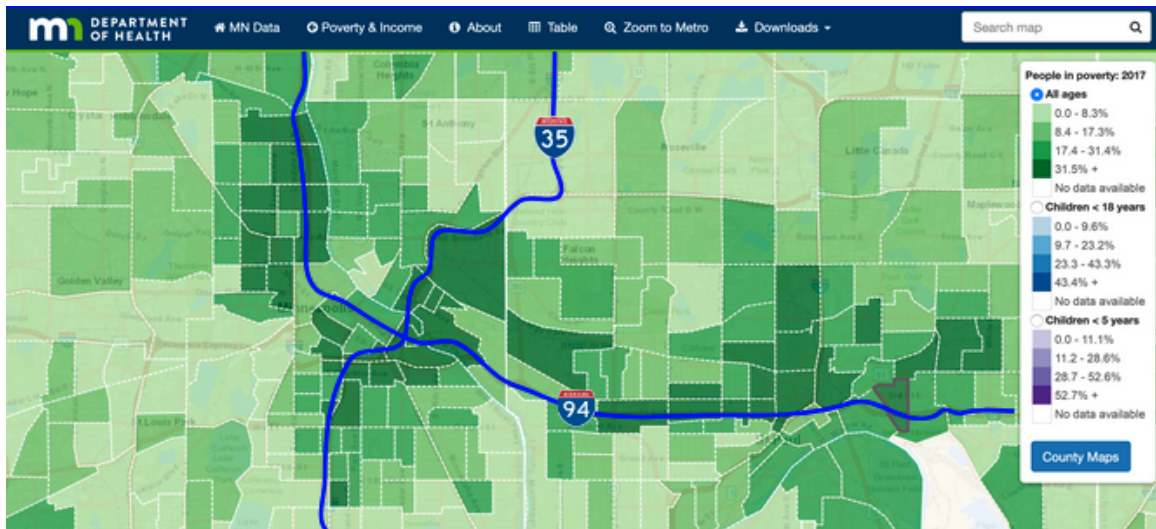
¹² [Starting with Michigan, Sidewalk Infrastructure is looking to build roads specifically for autonomous cars](#)

¹³ [How China's new highway for self-driving cars will boost its AV ambitions](#)

intermittent access to this high-speed broadband resource via a 20-minute drive for specific needs (e.g., telehealth appointments or online classwork). Second, NextGen Highways will increase the deployment of fiber across the country. This will improve the proximity of rural America to a high-quality fiber connection needed for network operators to offer new or improved broadband access in rural America.



In urban areas, NextGen Highways will increase equity by providing fixed wireless broadband in immediately adjacent communities. Many of the communities adjacent to highways in urban areas are BIPOC and/or low-to-moderate income communities (as shown below). This directly results from the fact the federal interstate highway system was built through these communities.¹⁴ NextGen Highways provide the opportunity to partially address this historical injustice by improving broadband access in all communities that are adjacent to the existing interstate system.



¹⁴ <https://www.theguardian.com/cities/2018/feb/21/roads-nowhere-infrastructure-american-inequality>

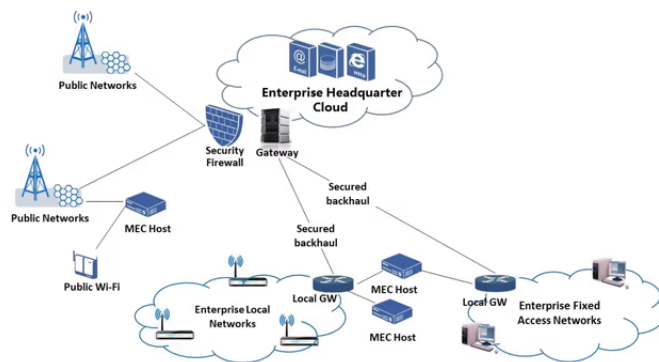
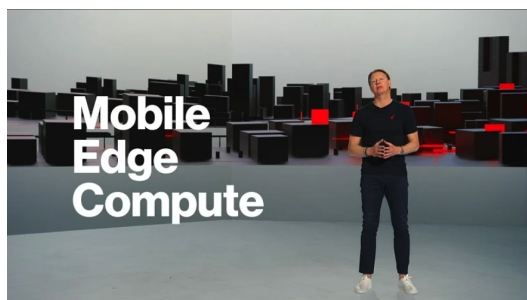
The exact extent that NextGen Highways can increase broadband access requires further study. It also requires access to more granular datasets of broadband access in both rural and urban areas – a known issue within the broadband community.

I. NextGen Highways Support US Manufacturing and Technology

It is hard to overstate the boost to US manufacturing and technology that NextGen Highways could deliver. NextGen Highways would drive US manufacturing by requiring tens of thousands of miles of HVDC transmission cable (below left) and hundreds of thousands of miles of communications fiber. Additionally, installation of the transmission cable and optical fiber will benefit from a wide variety of US-manufactured products, such as Forterra's Red-e-duct precast duct banks (below right).



On the technology front, NextGen Highways would require the extensive deployment of edge computing and small cell communications networks, plus the software and services needed to operate these systems (below).



Lastly, it is worth noting that NextGen Highways would provide a platform to test and deploy the latest communications, computing, and security technologies. In fact, one might reasonably ask whether the \$110 billion authorized under the US Innovation and Competition Act would have a greater impact if used to build NextGen Highways given that NextGen Highways would provide a concrete use-case to guide what could otherwise be a series of open-ended research projects.

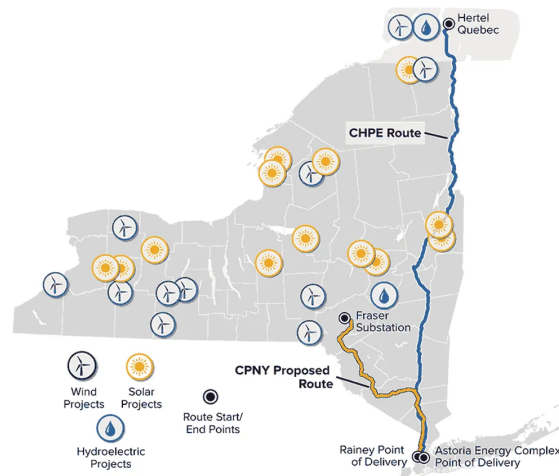
J. NextGen Highways Can Be Built Today

The final thing worth noting about NextGen Highways is that they can be built today. There are no technical barriers - only addressable policy and regulatory hurdles.

France and Italy have already installed buried HVDC transmission in a major highway corridor as illustrated and shown in the images below.¹⁵



Furthermore, Germany and New York are moving forward with multiple buried HVDC transmission projects that utilize waterways and existing road and rail rights of way. In June 2020, utilities in Germany announced 800 miles of buried HVDC transmission projects that will bring wind resources from the North Sea to the manufacturing centers in Southern Germany and improve the overall reliability of the European Grid.^{16,17}



And in September 2021, New York State announced the selection of the Clean Path NY and Champlain Hudson Power Express projects to deliver GWs of solar, wind, and hydropower to New York City.¹⁸

¹⁵ [Savoie-Piémont : 190 km de solidarité européenne entre Chambéry et Turin](#)

¹⁶ <https://www.nenergybusiness.com/projects/suedlink-hvdc-power-transmission-project/>

¹⁷ [Renewable Energy Now Transportable on German SuedOstLink Electricity Highway](#)

¹⁸ [New York OKs underground and underwater transmission lines to deliver...](#)

Simultaneously, telecommunications providers are charging forward with the development of small cell networks in urban areas. NextGen Highways afford the opportunity to scale this development in a coordinated fashion and to expand across the interstate system and into rural areas.

K. In Conclusion

NextGen Highways are a unifying vision and overarching strategy to build the future of transportation, achieve deep decarbonization, drive infrastructure development and economic growth, strengthen national security, and improve equity.

NextGen Highways would unify a diverse collection of legislative asks at the federal level, including:

- Clean, low-cost, and reliable energy advocates wanting to develop a Macro Grid.¹⁹
- Clean transportation advocates wanting to enable charging and fueling infrastructure in transportation corridors.²⁰
- Autonomous and connected vehicle advocates wanting to develop advanced communications networks.²¹
- Environmental and social justice advocates wanting to improve air quality in the most heavily affected regions, which are often transportation corridors.²²
- Broadband advocates wanting to utilize the highway right-of-way, particularly in rural areas.²³

There are no technical barriers to the development of NextGen Highways - merely our will to address institutional hurdles.

The strength of the United States in 2050 will be dependent on multiple factors. Two key ones are whether we are able to rectify our current rural-urban divide and whether we are still a country that can execute against big dreams. NextGen Highways is an opportunity to do both.

¹⁹ <https://acore.org/macro-grid-initiative/>

²⁰ <https://lincubator.org/tepstimulus/>

²¹ <https://autonomy.institute/>

²² <https://www.sierraclub.org/articles/2020/05/bold-clean-transportation-stimulus-for-jobs-health-and-climate>

²³ <https://broadbandnow.com/report/dig-once-digital-divide/>

This white paper was produced by NGI Consulting.

NGI Consulting is based in Seattle, WA and is focused on helping cities, corporations, and states envision a path towards next-generation infrastructure. For more information, contact morgan@buildngi.com.

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