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2025 L&P / Strategic Infrastructure Performance Institute Closing Report

The following is our closing report pursuant to the above referenced contract. As you know, the Institute’s founder, Norman Anderson, passed on during the term of this contract. This project was one of his highest priorities. He was deeply engaged in the formulation of the work plan for this report, and we have faithfully applied his precepts throughout the course of performance.

The three pillars of Norman’s approach to the development of the infrastructure required to support what he called the “Fourth Industrial Revolution” are “Digitalization”, “Electrification” and “Innovation”. This report is organized under those headings.

Digitalization

The technologies of the future –robotics, the Internet of Things, artificial intelligence, autonomous driving systems, machine learning, advanced data analytics and others we have yet to perceive will be driven by data. States that lack the capability to efficiently digitize, transmit and utilize data will inevitably fall behind in the effort to prosper in the 21st century. The volumes of data required to support this development will increase exponentially as will the necessary capacity to transmit, store and utilize those volumes. The commonly stated objective of assuring that all citizens have access to high-speed internet is an insufficient goal for a State that wishes to participate in the Fourth Industrial Revolution. The objective must be that all locations in the State that need advanced digital capacity to prosper and grow have access to a system that provides that capacity. It is highly unlikely that the coordination and capacity required to accomplish this objective can be provided through the state’s existing digital infrastructure and the current approach --operation of uncoordinated separate systems by independent, “last mile” Internet System Providers (ISPs).

The State of Kentucky has taken the visionary step of establishing a state-run project called KentuckyWired <https://kentuckywired.ky.gov/Pages/index.aspx> a “middle mile” backbone which enables quality, high speed, high-capacity fiber optic cable access in every county of the State. The system not only provides efficient and coordinated services for the State’s public entities and institutions, it is accessible to the private sector and ISPs, by lease or similar arrangement, to support the advanced technologies required to allow the State to lead into the future. We have been in discussions with several participants in the KentuckyWired project who will propose a similar project for West Virginia— which, coupled with protocols and applications for data utilization and trading, promises to reduce costs and increase returns to users that sponsor the

system. The development and marketing of such a system offers the potential for bringing new, high-tech businesses into the State and otherwise facilitating creation of a digital economy. We recommend consideration of such a proposal.

Electrification

Combustion-fired Generation

It is evident that the need for electricity in West Virginia will increase radically with the development of the technologies discussed above, the addition of energy consumptive industries such as Datacenters and Steel Production and the shift to electric vehicles. Fulfillment of this need for new capacity is itself a daunting challenge. Meeting that challenge, while at the same time retiring and replacing with renewable or other clean energy sources the 95+ percent of the State's current generating capacity which is fired by combustion may be an unrealistic expectation. Further, the Coal and Natural Gas industries are important elements of the State's economy, and it may be unrealistic to expect complete near-term closures.

European countries, faced with similar dilemmas, have put relatively strong emphasis on plans for the application of technologies and processes to reduce or eliminate CO₂ emissions from combustion fired facilities. As further discussed below, we recommend consideration of this approach.

Wind and Solar

While wind and solar are proven carbon free technologies and the cost per megawatt of both continues to decline, their percentage of West Virginia's electricity slate has remained static or declined. This is likely due in large part to climatological factors (the wind resource is particularly limited). But, in addition, these industries are becoming increasingly competitive and increasingly driven by the financial community. In these circumstances, the climate advantages and superior incentives provided in other states offer strong inducements for location elsewhere. Although the availability of low cost land, particularly the large Abandoned Mine Land sites, is a strong positive factor which could be enhanced by an effort to provide enhanced data and other incentives to facilitate evaluation and development of these and other potential sites, and though solar/microgrid or rooftop projects may have potential, it seems unlikely that solar and wind can be relied upon to fulfill a substantial part of the State's rapidly increasing energy needs in the coming decades.

Hydrogen

As made clear at the Hydrogen Summit which the State sponsored last October and strongly confirmed at recent Senate Energy Committee hearings, Hydrogen technology has to be an important part of any plan to decarbonize. Hydrogen's flexibility and capacity to increase the efficacy and efficiency of essentially all energy sources and of power generation (e.g. providing

clean base load fuel for wind and solar, providing options for carbon free or reduced carbon utilization of natural gas, providing carbon-free power for carbon capture, improved performance of combustion powered power generation etc.) makes it an essential element, particularly in a state such as West Virginia which has both increasing power needs and a mandate to reduce carbon emissions from such a large part of its existing fleet. Although it is clear that a good deal of research, demonstration and development will be required to bring Hydrogen to the point of practical application for all of the purposes needed in WV, we recommend that the State place strong emphasis on the development of hydrogen technology as a major part of its modernization plan. We have recommended outreach to the hydrogen technology presenters at the October conference and others who might be interested in locating in WV, as well as to Ms. Satypal and her DOE colleagues, for assistance in this effort. We continue to believe that this is important. Wyoming's presentation at Senator Manchin's hearing is an example of the progress that can be made in a major coal producing state and it is likely that federal incentives for hydrogen power generation will be enacted. WV should try to emulate Wyoming's progress and become a significant location for hydrogen development.

Carbon Capture, Utilization and Storage

As is the case with hydrogen technology, CCUS has the potential to increase the usefulness of most of the State's energy sources and power generation modes. CCUS has the potential to extend the useful life of the existing combustion fired fleet, extend the market for the State's natural gas resources, and enhance the economics of hydrogen production. As is the case with hydrogen technology and likely even more clearly the case with CCUS, a good deal of research, demonstration and development is required to bring this technology to the point of practical application. As noted above, however, European countries, similarly situated and with similar needs have recognized the critical need here and are placing considerable emphasis on projects to demonstrate feasibility. As with hydrogen technology, we recommend outreach to cognizant DOE resources and potentially interested companies, including leading European entities, to develop projects to demonstrate these technologies in WV.

Hydroelectric

Hydroelectricity follows wind and precedes solar in terms of percentage of West Virginia's power generation slate. Hydro does not involve the intermittency issues that limit the availability of wind and solar. Although West Virginia treasures its wild and scenic rivers and is unlikely to approve the siting of significant new dams, there is likely potential for increasing capacity by upgrading existing facilities. Additionally, a Corps of Engineers study suggests that considerable additional capacity might be provided by electrifying non-electrified dams in its Huntington district. We recommend exploration of these potentials.

Small Modular Nuclear Reactors

Although this technology is probably further from commercialization than the others discussed above, governments and companies in the U.S., Europe and elsewhere are conducting projects to

advance toward that objective (Britain is probably most committed). SMNR technology is carbon free, extremely flexible, and adaptable for a wide range of applications. With the recent repeal of the nuclear prohibition and given its priority with respect to DOE and other federal programs, West Virginia is in a strong position to promote SMNR development within the State. We recommend such an outreach to the cognizant DOE resources and potentially interested companies, both U.S. and International, to that end.

Smart Grid

There is extensive literature on the potential of advanced data analytics and telecommunications to facilitate systems and methodologies for energy conservation and efficient utilization of generation capability. The coordinated, middle mile backbone system described in the first section of this report would enable this approach and greatly enhance the State's capabilities to make optimal use of the power which it is able to generate as well as increase the State's attraction for wind, solar and other clean generation technologies.

Other

While other technologies such as geothermal, pumped storage, fuel from coal waste and recovery of rare earth minerals have been discussed and merit continued consideration, the technologies discussed above merit prioritization, either because of their greater potential for early commercialization or their greater potential for significant beneficial impact in West Virginia. Recognizing that technology will continue to develop, and new discoveries are increasing, we recommend continued close attention and updating.

Innovation

Most of the technologies and projects discussed above can be properly characterized as “emerging”. Thus, innovation, through further research, development, and demonstration, will be required to bring them to the point of broad-scale commercial applicability throughout the State. In short, there needs to be a transition in West Virginia from an economy which is almost entirely resource-driven to one which is driven in major part by innovation. To enable that transition, we see the need for some significant changes in emphasis.

Participation in Federal Innovation Oriented Programs

As was pointed out at the beginning of our engagement, West Virginia, as a State with communities which are “environmentally disadvantaged” and “energy communities” which are heavily impacted by new Clean Energy requirements, is in a priority position with respect to opportunities to participate in Federal programs to facilitate transition to cleaner energy. That priority position is enhanced by other factors such as the strength of the WV delegation and the relationships with NTEL and the Appalachian Regional Council. As pointed out by Ms. Satypal at the Hydrogen Summit and further emphasized in testimony at the recent hearings, the

Department of Energy has a broad range of programs directed towards demonstration and commercialization of clean energy technologies. Pending legislation seems likely to both enhance those programs and provide enhanced incentives for application of clean energy technologies. All of this puts West Virginia in a strong position to attract high tech investment and we strongly recommend a focused effort to take advantage of this position by aggressively accessing federal programs to aid implementation of the projects and technologies discussed in the preceding sections of this Report. To again use the example of Wyoming, we would suggest the same sort of planning, outreach, and activism for West Virginia.

Building a Culture of Innovation

Consistent with Norman's principle that an innovation-driven economy should be driven by world class institutional research capability and world class collaboration with industry, we reviewed the State's innovation related activities including the *Entrepreneurship Ecosystem*, the *WVU Innovation Corporation*, the *Marshall Center for Entrepreneurship and Business Innovation*, the *West Virginia Public Education Collaborative* (<https://wvpec.wvu.edu>), and the *Mid-Atlantic Technology, Research and Technologies Center*. *The West Virginia High Tech Foundation* presented at the Institute's Leadership Conference. We reviewed the published research on the priority technologies discussed in this Report and found significant contributions from both of the two major West Virginia Universities and were pleased with the announcement from the Presidents of WVU and Marshall that the two universities will work collaboratively. These activities, together with the priority position and related resources discussed in the previous section would appear to provide a strong foundation for an innovation culture which will draw both national and international attention (there are already indications of considerable new interest from both the U.S. and abroad).

Seoul National University, a World Top Twenty ranked research university, has expressed interest in engagement in West Virginia. SNU has a strong Nuclear Engineering Department, is a longtime participant in the South Korean Government's *Carbon Capture Initiative* and is a strong proponent of collaboration among international research universities. SNU has been deeply involved in the Korean Government's visionary effort to launch an innovation promotion package called the *Korean New Deal* and, as a result, South Korea has ranked as the most innovative country in the world (number one in the Bloomberg Innovation Index) in seven of the last nine years. A similar effort in West Virginia, including outreach to other Universities such as the University of Texas, which participated prominently in the Hydrogen Summit, and leading national and international companies would make the State a magnet for high tech investment and development in the fields which are critical to the State's prosperity in the 21st century. SNU has expressed interest in West Virginia and has signed an MOU committing to collaboration with the State on these issues.

Wrap-up

We believe that the State of West Virginia is well situated to become a leader in transition to a 21st century energy and innovation economy. That is going to require the capacity to use data to make appropriate decisions, as well as a balanced approach to energy –avoiding the herd mentality and making progress towards clean energy goals that are most efficient and least disruptive of the lives of WV citizens. We believe that the pieces are there to make West Virginia a leader in digitalization and innovation and will continue to support that progress to the absolute best of our ability.

We continue to receive inquiries from leading global companies engaged in cutting edge technologies in most of the fields discussed above as well as from others, ranging from 3G printing, to advanced water and waste management technologies, to Smart Grid and electricity transmission and will continue working to bring these companies to the State.

This opportunity to partner with you is greatly appreciated. Please call upon us whenever we might be of assistance.



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