Catawba Sustainability Center and Catawba Hospital Renewable Energy Site Planning Process Study

Renewable Energy Facility Siting Project

Virginia Polytechnic Institute and State University

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Executive Summary

Virginia Tech's Renewable Energy Facilities Siting (VT-REFS) project was created to help the nation meet our renewable energy goals in an equitable, environmentally sound, and economically beneficial way. Fortunately, there is ample research that building collaborative efforts to find solutions that maximize what is important to each stakeholder (also known as seeking mutual gains), by providing sound scientific information to stakeholders to help local communities make informed decisions about proposed projects. We are applying and adapting that knowledge to help all stakeholders- community members, local and state permitting agencies, and industry, find the best solutions possible to generate clean energy while protecting what local communities' value.

Our goal with the Catawba Valley siting pilot study was to create, test, and support a more comprehensive siting process through which all stakeholders participate in co-creating the knowledge needed to jointly decide how a REF is placed on a site. By siting, our process is to facilitate stakeholder decision about whether stakeholder consider a site as suitable for development, then to explore what scale is suitable, the location of actual facilities, how to maximize and equitably share economic benefits, and to address their environmental and social concerns. Together, all stakeholders, including developers, identify how to gain the most benefits they can from a potential project. The strategy engages stakeholders very early in the process – post site control but pre site acquisition - to identify project parameters the community will support. We recommend this timing to significantly reduce project risk before extensive, and costly, interconnection, site engineering, and environmental studies are conducted.

VT-REFS recruited and prepared a highly multi-disciplinary team to be a neutral party for all stakeholders to use when a developer, community, or landowner proposes a facility. Our faculty team identifies or discovers scientifically sound information for all parties to use in the decision making processes.

In early 2019, VT-REFS identified the Catawba Sustainability Center (CSC) in Catawba, Virginia, as a property owned by Virginia Tech that could be suitable to explore our evolving siting process. The initial project concept was to explore and co-create with the community a site planning process for a small (approximately 2 - 10 MW) solar PV farm and/or approximately three large wind turbines (GE 3.1 MW, approximately 600 feet high). This size renewable energy facility could provide meaningful

amounts of renewable energy for Virginia Tech, and provide an appropriately-scaled pilot project for VT-REFS. This was a faculty initiative, not the VT administration, and will not move forward with changes to VT policies

Five stakeholder meetings were conducted between May and December 2019 to identify their interests and concerns, research needs for decision making, evaluate two iterations of multiple alternatives, and identify their preferred alternative. Nine alternatives were presented through the process. One included a 3.1 MW 600 foot high turbine with sixty acres of solar PV, to 60 acres of solar PV. VT-REFS understood that wind turbines were not economically viable at the sites in a valley, but explored the social acceptability of different sizes and numbers of turbines.

The stakeholder engagement process surprisingly well, as they maintained productive dialogue given extremely strong concern for the viewshed of the iconic Triple Crown section of the Appalachian trail. VT-REFS did not expect the community (excluding the Roanoke Appalachian Trail Club) could accept a large turbine *if* it benefitted the community assets of the Catawba Sustainability Center, the Catawba Hospital, and teaching and research at VT. The final alternative was embraced (with anticlimactic consensus) that sixty acres of carefully placed solar arrays incorporating agrovoltaics (sheep, beef cattle grazing on pollinator/pasture mix) and an acre of PV panels to shade beef would work for their rural community.

The main report provides additional information about the sustainable renewable energy siting approach used by VT-REFS, the stakeholder meetings, the alternatives presented, and project recommendations. VT faculty are developing a testing this new approach to siting, so we provide recommendations for next steps in our research and pilot testing. We seek opportunities and support to develop a full-scale (i.e. 10-100 MW or larger) pilot project that provides opportunities to collaborate in finding economically efficient, socially acceptable, and environmentally sound ways to develop a renewable energy facility.

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Background

Developing renewable energy resources and reducing energy demand are viewed as key strategies to address climate change. Virginia Tech's Renewable Energy Facilities Siting (VT-REFS) project was created to help the nation meet our renewable energy goals in an equitable, environmentally sound, and economically beneficial way. Fortunately, there is ample research that building collaborative efforts to find solutions that maximize what is important to each stakeholder (also known as seeking mutual gains), providing sound scientific information to stakeholders, and meaningful public engagement in planning projects helps local communities make informed – and often positive - decisions about proposed projects (CITE). We are applying and adapting that knowledge to help all stakeholders- community members, local and state permitting agencies, and industry, find the best solutions possible to generate clean energy while protecting what local communities' value.

Broadly speaking, the existing process for larger-scale renewable energy projects require project developers to seek a profit on the project[1] at the same time they seek to provide "green" energy. There is tremendous variability in the degree of meaningful public engagement, environmental considerations, and local economic development taken by developers. At minimum, they must seek a project location that meets three primary conditions: accessibility to transmission lines, adequate demand and price for electricity generated by the facility, and third, the ability to secure land technically suitable for development. Some firms involve stakeholders and the public quite meaningfully, however, many firms seek just enough public support to obtain a permit to construct. Where the permit is only a state-level consideration, then there is little incentive to consider the local community. When permitting is a local decision, then it is still a comparatively minor consideration, with public engagement/outreach and permitting specialists tasked with obtaining approval of local permits. This leads to what we call a "win by one vote strategy" where developers seek to win a local permitting vote by overcoming public opposition. The result too often is highly divisive community conflict, and an overall degradation in the ability of subsequent projects in the region to succeed, creating what we call an "unsustainable siting approach" – eventually, public opposition threatens society's ability to site the enormous number of REFS needed to transform from a fossil fuel to a clean energy economy. Fortunately, we have found that the earlier a project developer includes the public in meaningful discussions on what might work in their community, the more trust is

[1] We are not judging if profit motive is positive or negative, but noting that generating profit is necessary to secure investor funds needed for construction.

developed and project plans can be adapted to meet community interests. It is also clear that the public does not trust information that comes from developers, but does trust universities as a source of information about potential impacts, and solutions to those impacts.

Our goal, in summary, is to create, test, and support a more comprehensive siting process through which all stakeholders participate in co-creating the knowledge needed to jointly decide how a REF is placed on a site. To accomplish this, we simply add an early exploration of potential site feasibility and layout that includes stakeholders identifying what works for their community, to help shape the general size of a facility, the location of actual facilities, how to maximize and equitably share economic benefits, and to address their environmental and social concerns. Together, all stakeholders, including developers, identify how to gain the most benefits they can from a potential project.

The strategy is to engage stakeholders early in the process, and identify project parameters that they will support, before extensive, and costly, interconnection, site engineering, and environmental studies are conducted. Doing this work upfront will reduce community conflict that leads to extensive permitting delays, and improve the overall ability of developers, and society, to site and construct the large number of REFS needed to address climate change.

Stakeholders, including permitting and political bodies, students of, and researchers concerned with siting of REFs are faced with a daunting complexity of factors to assess and weigh in making decisions about whether or not a REF should be sited in a community, and if so, how it should planned so all stakeholders benefit, or are harmed the least. The VT-REFS project adapted the classic sustainability Venn diagram of the three spheres of sustainability (social, environmental, and economic) to help guide our work, shown in Figure 1, below. The basic three spheres of sustainability are very helpful for considering the type of impact a proposed project might have, and what research needs to be done to help stakeholders in their decision making about project alternatives (including a no action alternative).

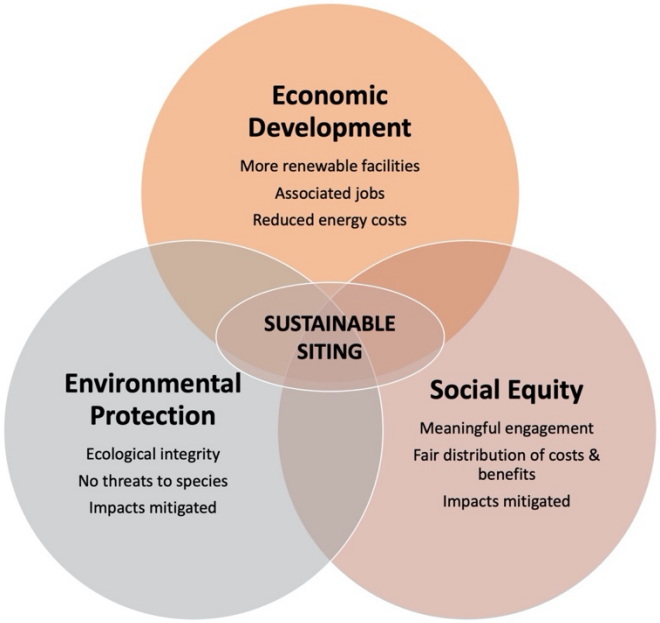

Figure 1: Sustainable Siting Diagram

To support this process, VT-REFS recruited and prepared a highly multi-disciplinary team to be a neutral party for communities, landowners, developers, and permitting authorities to use when a developer proposes a facility in a community, or a community wants to explore developing a PV or wind farm. Our faculty team provides scientifically sound information for all parties about potential impacts and how projects can be planned to not only minimize adverse impacts, but improve local economies, the environment, and the decision making processes. We understand not all proposed developments are suitable for a community, and can help identify if a proposed project may not be able to address significant community concerns early in the process - and avoid contentious and expensive battles.

In early 2019, VT-REFS identified the Catawba Sustainability Center (CSC) in Catawba, Virginia, as a property owned by Virginia Tech that could be suitable to explore our evolving siting process. The initial project concept was to explore and co-create with the community a site planning process for a small (approximately 2 - 10 MW) solar PV farm and/or approximately three large wind turbines (GE 3.1 MW, approximately 600 feet high). This size renewable energy facility would provide meaningful amounts of renewable energy for Virginia Tech, and provide an appropriately-scaled pilot project for VT-REFS.

Catawba Valley is a small rural community (unincorporated village) in Roanoke County. We began to explore with the property manager, and the Catawba Hospital their interest in partnering with us to co-create and pilot test our site planning process. A primary goal was to explore how our early meaningful public engagement siting process would work in practice. Another goal was to collaborate with the stakeholders to identify what information was useful to help them make decisions about whether, and if so, under what conditions (i.e., acreage of solar PV and/or height and number of wind turbines, locations of facilities, etc.) a renewable energy facility *might* work in Catawba. Together, we would help create a site planning process that worked in their community.

As faculty, we were conducting outreach, participatory research, and provide VT with a vetted renewable energy project for their consideration for the time they might be ready to explore such a project. It is critical to state that faculty were neither authorized nor intended to identify an external partner to develop a REF there, or pursue permits for a project. Rather, we wanted to explore what would work for the community, and share how the process worked, and our findings. If Virginia Tech wanted to pursue a project later, that decision would come from and be implemented by the university administration. We hoped that the collaboration with stakeholders would help us refine our public engagement strategy, and in tandem with other research activities being done by VT-REFS, help us identify how our process would fit into existing site planning processes.

Timeline

Figure 2 shows major events in the public engagement, research, and decision making processes. We began outreach to the site managers in early 2019, and concluded this phase of public engagement in December 2019 (if Virginia Tech decides to move forward with the project, we plan to reengage for the detailed site planning process). The effort to involve students in two fall 2019 courses, Urban Affairs and Planning's Environmental Policy Studio, and Architecture's Year 3 studio course, required additional time for them to conduct their research. With the RESP team focused on a project, the timeline for the public engagement portion of the process can be greatly accelerated, to perhaps four months. A rapid assessment of community willingness to engagement in meaningful public engagement to consider a renewable energy facility can be done in about one month. Below we describe the fuller REFS site planning methodology and timeline in greater detail.

Month(s)	Event	Description
July 2018 – March 2019	VT-REFS seeks suitable site for pilot project	VT-REFS seeks site under VT control willing to explore a pilot test of social and environmental components of siting process.
March 2019	VT-REFS and property managers meet	Identified participants interests, concerns, and next steps. All desired renewable energy for environmental and educational reasons, and understood the importance of the Appalachian Trail viewshed.
March – May	Stakeholder recruitment	VT-REFS conducted screening research on technical, economic, environmental, and visual impacts feasibility of project using online databases.
May 2019	1st stakeholder meeting	Stakeholders discussed interests and concerns with potential siting, siting process described.
June 2019	2nd stakeholder meeting	Concerns, interests, and new research question of stakeholders clarified. Six viewpoints for visual assessment identified.
June/July 2019	VT-REFS continued research, and consultations with NPS and Appalachian Trail Conservancy	
July 2019	3rd stakeholder meeting	Alternative visualization methods shared with stakeholders. Stakeholders preferred photorealistic imagery. Five acreage sizes and six numbers of turbines discussed. RATC requests additional viewpoints for visualization studies.
July/September 2019	VT-REFS conducts additional research and stakeholder consultations	
September 2019	4th stakeholder meeting: Student design charrette	Concerns and interests of stakeholders expanded. Strong community support for renewables for environmental benefits and CSC and the Catawba Hospital. Three factor decision making process identified two preferred options for renewable energy at the CSC – maximum solar power generation, and maximum generation of solar and wind power.
December 2019	5th stakeholder meeting: Final design charrette	The decision making process used eight factors to evaluate six project alternatives for both the CSC and Catawba Hospital. Stakeholders again preferred maximum solar power generation, and maximum generation of both types of power.

Figure 2: Timeline Major Events Catawba Pilot VT-REFS Study

September 2018 – March 2019 VT-REFS Seeks Pilot Project Site

VT-REFS had multiple goals for the pilot project that drove site selection process. These included a site:

- Willingness of the property manager to consider hosting this pilot project.
- Under VT ownership/management, so it would be simpler to manage the pilot project, to conduct other research as part of a renewable energy project, we would help meet renewable energy goals for VT, and the results of the study could be used to inform VT decisions about next steps for potential use of the site. Faculty in VT-REFS want to identify a site and site plan that is economically, environmentally, and socially acceptable to help with faculty and student efforts to move VT towards renewable energy.
- Sufficiently close to the Virginia Tech campus so students and faculty could engage with the community, and conduct educational and research activities.
- Willingness of the community to co-develop this innovative public engagement and site planning process. For research purposes, VT faculty wanted the stakeholders to consider the usefulness of different visualization techniques for wind turbines, and research on public opinion concerning wind, even if the site was not economically or socially suitable for large wind turbines. The Roanoke Appalachian Trail Commission participated throughout the process while maintaining strong opposition to wind power at this location.
- With apparent access to the transmission grid, and of enough size to generate a meaningful quantity of renewable energy.

VT-REFS became aware of the CSC and the Catawba Hospital sites and their interest in exploring the potential for a solar PV project in fall of 2018, and began exploring the site potential using online databases and communications with the property manager. Figure 3 shows their location relative to Virginia Tech.

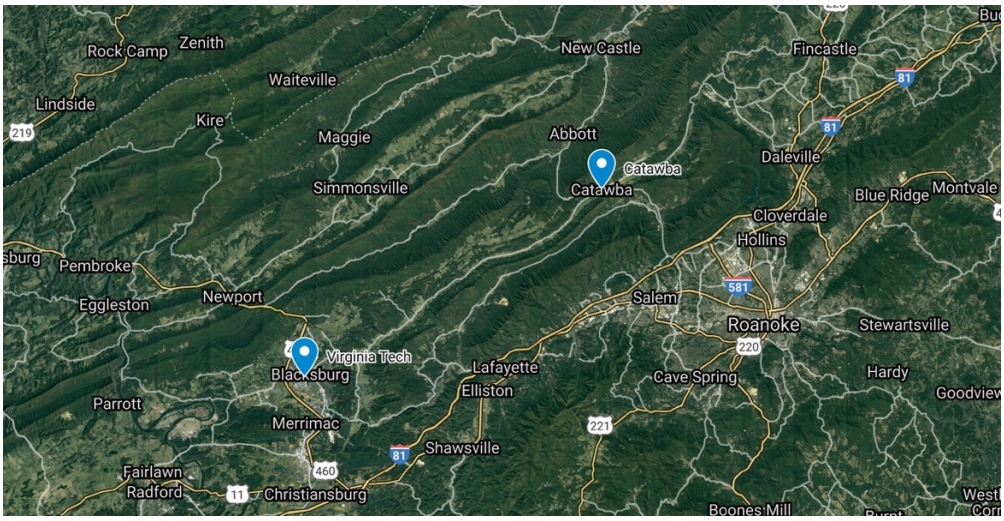

Figure 3: Virginia Polytechnic Institute and Catawba valley locations

The location includes a transmission line that links to Blacksburg. The CSC includes and Catawba Hospital are a 25-minute drive from VT's main campus. The CSC, shown in Figure 4, is ". . . a 377 acre farm property situated in the beautiful Catawba Valley of Virginia and serves as a living laboratory to advance environmental stewardship and community engagement to provide a learning environment for the research, teaching, and demonstration of sustainable practices in agriculture, forestry, and land management." (https://www.vtrc.vt.edu/catawba.html).

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Figure 4: Catawba Sustainability Center

The Catawba Hospital, shown in Figure 5, is part of the Commonwealth of Virginia public behavioral health system that serves adults in need of mental health care. Their goal is to help patients regain and maintain their highest level of mental and physical functioning (http://www.catawba.dbhds.virginia.gov).

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Figure 5: Catawba Hospital

Thus, the site had potential for economic access to the grid to supply electricity to VT, was large enough to generate meaningful quantity of electricity and was accessible to campus. Initial conversations with the property managers indicated interest in participating in the pilot project. Each facility had interest in adding renewable energy facilities to address environmental concerns, and add educational and economic value to their properties to further increase their value to the Commonwealth

March 2019 – Meeting of VT-REFS and Property Managers

The property managers and the VT-REFS team met in March 2019 to clarify our interests, expectations, potential stakeholders, and potential next steps in the pilot project. We visited their properties to discuss potential locations for arrays and or turbines, given their property uses and likely community concerns and interests, and important viewsheds. Figure 6 shows the 2019 Land Use Plan for the CSC, previously developed by the College of Architecture's Design Assistance Center.

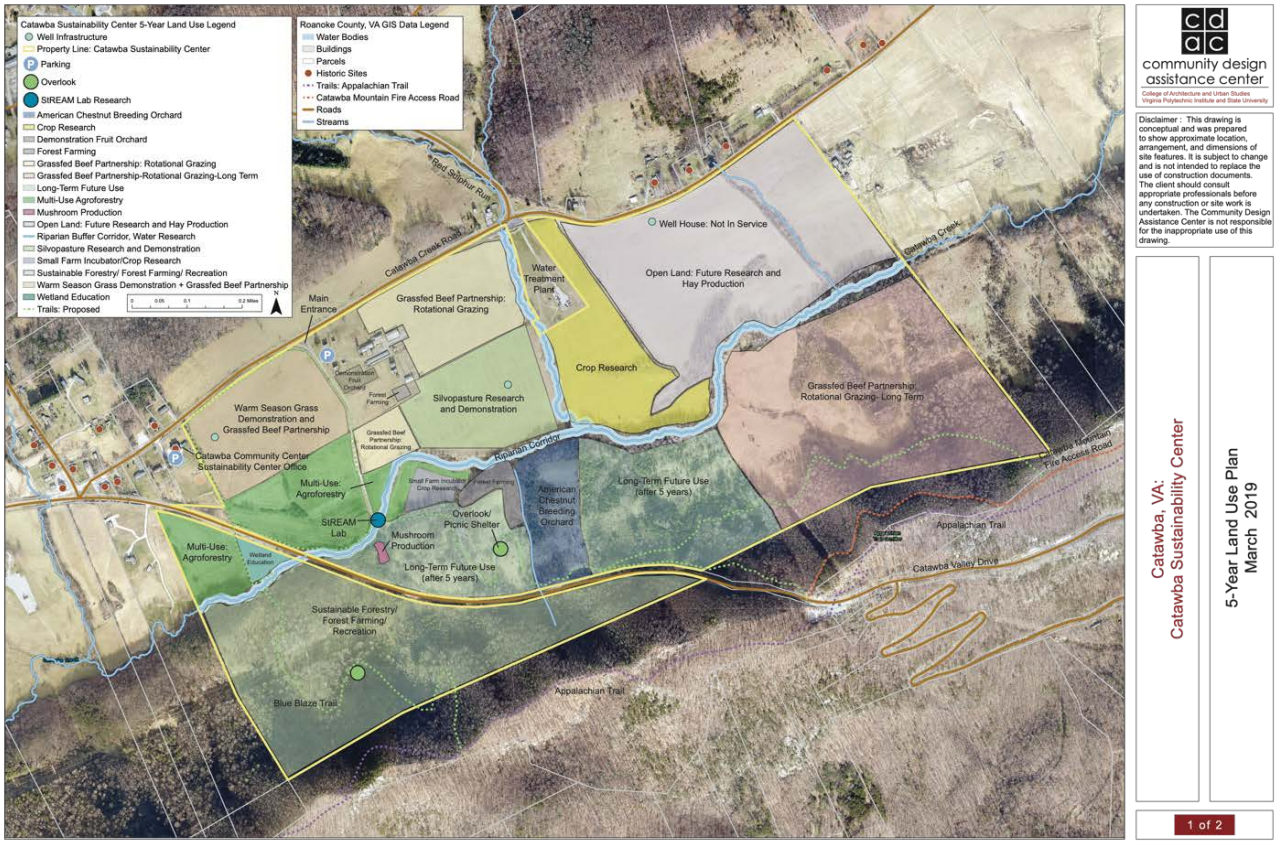

Figure 6: CSC 2019 Land Use Plan

March – May Stakeholder Recruitment, Site Prescreening

The initial group of stakeholders (CSC, Catawba Hospital, VT-REFS collaborated to identify and recruit influential community leaders will to participate in a long-term process to explore the potential for site planning of VT-REFS in Catawba Valley. The VT-REFS team worked with site managers to identify potential parcels of land available for solar and/or wind facilities, finding enough areas for a project. VT-REFS consulted with VT Electric Service to assess their interest as a theoretical purchaser for power, and for overall technical and economic feasibility of the project. They indicated that VT did not have a policy in place to secure renewable energy, and that any such decision would need to be made by the VT administration. However, if it did become VT policy to procure renewable energy, they would be interested in exploring the site. VT-REFS conducted desktop environmental screenings for presence of endangered, threatened, or listed species. The Catawba Valley is within the range of the Indiana bat. The nearest identified winter hibernacula was within approximately 50 miles in Bland County. In March, this finding indicated that it was necessary to conduct additional investigation into the potential impacts of any proposed facilities

and regulatory requirements regarding the Indiana bat, and those efforts continued. The VT-REFS team continued efforts to develop innovative visual impact assessment tools for stakeholder use, including viewshed analysis and computer-generated imagery of potential facilities from likely viewpoints.

May 29, 2019 – First Stakeholder Meeting

A core group of community leaders were recruited and attended the initial stakeholder meeting in May 2019, shown in Figure 7. VT-REFS', the CSC's, and the Catawba Hospital's interests in the project were shared, particularly in working with stakeholders to explore the innovative site planning process to provide renewable energy. Stakeholders discussed their interests and concerns with potential siting, and VT-REFS shared early technical, economic, and environmental screening results in response, and commitments to conduct additional research.

Social Sustainability.

The community shared their interest in supporting CSC and Catawba Hospital missions (as very important community assets) by supporting installation of renewable energy facilities, if environmental and social (i.e., viewshed) concerns are addressed. All agreed that it would be useful to continue to expand the stakeholder group, and continue discussions on what might land might not work in the community.

Figure 7: May 2019 stakeholder meeting

Environmental Sustainability.

Community members identified concerns with potential avian impacts if wind and solar facilities were installed, wondering about impacts to bats and migratory birds along the mountain ridges. A major concern was with the viewshed if large wind turbines or acreages of solar PV were installed, particularly for the Appalachia Trail.

June 18, 2019 – Second Stakeholder Meeting

The second meeting included more stakeholders, including the Catawba Ruritans, other community members, the Appalachian Trail Conservancy https://appalachiantrail.org, and the local Roanoke Appalachian Trail Conservancy (RATC) https://www.ratc.org. The concerns and interests of stakeholders were revisited and discussed in more depth to help identify a co-created research agenda to help stakeholders in decision making, as shown in Figure 8.

Figure 8: June 2019 stakeholders meeting

Social Sustainability.

The necessity for the project was questioned, given that VT's need for renewable energy greatly exceeded what could be placed in the Catawba Valley, and since the Rocky Forge Wind Project had just been permitted, and needed a purchaser for the power. Dr. Meyers reiterated the VT-REFS project purposes (see earlier in this report), of codeveloping this new site planning process with stakeholders, developing a site for VT faculty and students to conduct educational and research activities, and to push VT towards renewable energy. The Rocky Forge wind project did not meet those goals for the VT-REFS team, one of the stakeholders in this process.

Stakeholders were very interested in how this proposed project could assist homeowners in obtaining renewable energy, and questioned the need for solar farms. Dr. Meyers agreed that a program to assist homeowners in obtaining renewable energy would be good to have, that he was not able to create such a program, but that such a recommendation could be made in the final project report. In terms of the need for solar farms, the cost to produce power is about one-third that of rooftop solar. If society is to significantly increase renewable energy production, then economical renewable energy is needed.

Visual impacts were the priority issue, particularly since the ATC was conducting a visual resource assessment of the Appalachian Trail (AT) in the Catawba Valley due to its high scenic value. The ATC's stated position on renewables is that they see need for renewables (the ATC and RATC each

supported the Rocky Forge wind project in Botetourt County with minimal visual impacts nearby on the AT). They prefer solar PV, but need to see impacts before making decisions. In Maine, they seek mitigation funds if closer than ten miles. Community members wanted to better understand the local economic of the AT. Community members were concerned over potential visual impacts if large (i.e. over several hundred feet) turbines were being considered.

An important step VT-REFS added to the site planning process is the cooperative-development of the footprint of a site plan by stakeholders before site engineering studies and a permit application are developed. This early site plan process identified all possible (given existing land uses, owner interests, and technical and environmental considerations) locations for arrays and turbines on the potential project properties. Ten potential sites for PV arrays, totaling approximately 60 acres, and three large (size to be determined) wind turbines were identified in consultation with the landowners prior to the June meeting. No array on the CSC was larger than five acres, and none at the Catawba Hospital were larger than twenty acres. These potential locations were shared and the benefits and concerns about each of these locations were discussed. The stakeholders had not wanted very large arrays given their likely adverse visual impacts, and were pleased that the proposal was not considering siting a single large array on each property. (VT-REFS is seeking funding and partners to conduct another pilot study for a larger PV project at another location.) There were concerns for the potential visual impacts of the arrays closest to the Appalachian Trail and along State Route 301. Stakeholders agreed upon six viewpoints for VT-REFS to develop visualizations needed for their decision making. These included: the Homeplace (a local restaurant), State Route 311 towards CSC, and four on the Appalachian Trail: Mcafee Knob, Dragons Tooth, Sawtooth, and on the AT several hundred yards from the Mcafee Knob parking lot where there is a large tree cut for a power line that allows a sightline into the Catawba Valley. Ironically, the large transmission line (345 kV) runs through the cleared area and is visible from the AT. The viewpoints VT-REFS agreed to study are shown in Figure 9.

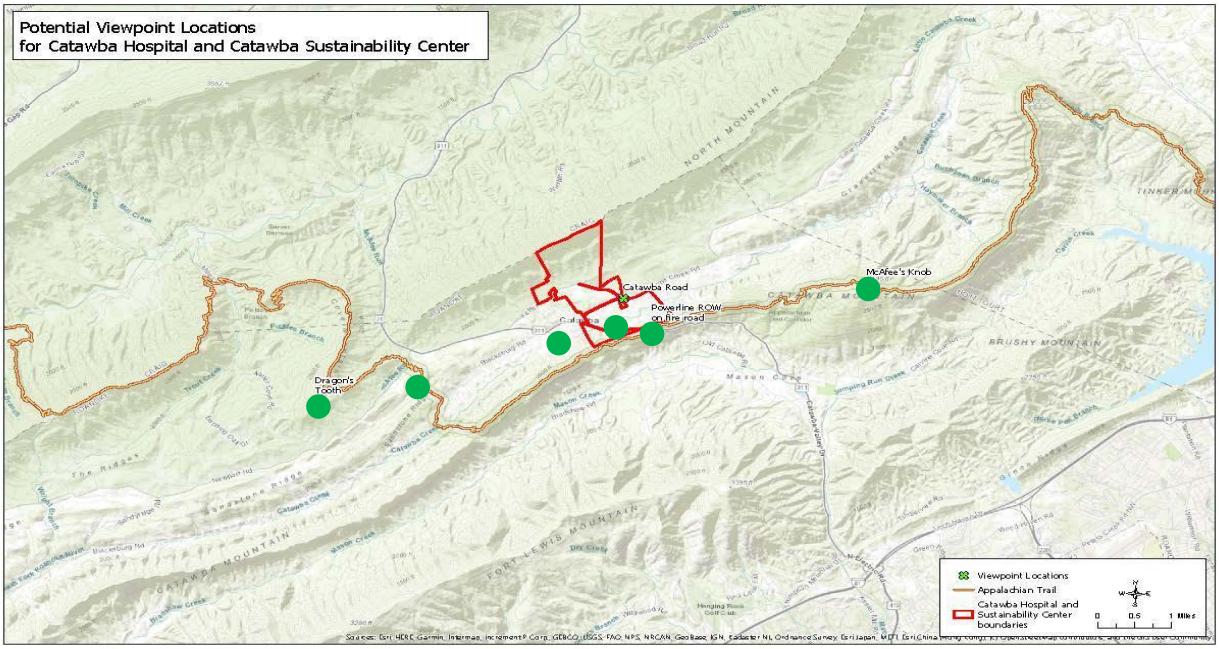

Figure 9: Six viewpoints identified for visual assessment in June 2019

Environmental Sustainability.

Another important issue concerned avifauna (migratory birds and bats). Stakeholders wondered if Catawba Mountain hosted the endangered Indiana Bat, if it was a flyway for bats or birds, and if so, what species might be affected, the heights at which they flew, their seasonality, and possible mitigation measures. Stakeholders wanted to know answers to these questions and the potential impact of wind turbines on avifauna. The VT-REFS agreed to conduct research on these questions and bring information back to stakeholders for their evaluation.

Economic Sustainability.

The economic viability of a potential wind farm was of concern, and to understand potential project timeline, so they wanted to know how long it would take to do a valid wind study. Dr. Meyers responded that Virginia Tech Electric Service had assessed the economics of the site and indicated that it appeared to be economically viable, but that no administrative action would be taken by them or anyone at VT on a potential project until they were authorized by VT administration to do so. It is noteworthy that stakeholders had initially agreed to participate with the understanding that VT faculty wanted to explore public attitudes towards wind turbines in the Catawba Valley given its high scenic value, particularly to assess stakeholder and public responses to different visualization techniques that would show what potential turbines might look like. However, as the process

evolved, there was concern that the wind component was too hypothetical and that discussion of it could adversely affect the ATC by worrying hikers and those concerned with the potential presence of wind turbines near the AT. The RATC became strongly opposed to any consideration of wind energy on the site, or efforts to identify what visualization tools were useful for stakeholder decision making, regardless of visual or environmental impacts but continued to participate in the stakeholder meetings and engage in meaningful discussions.

Stakeholders agreed to meet in about a month to review research progress, and to decide what type of visualization technique they preferred, so all six viewpoints could have that type of visualization developed. We also agreed to identify additional stakeholders to participate.

July 8, 2019 Third Stakeholder Meeting

The July 2019 meeting discussed the need for much more extensive visualization, in response to all stakeholder interests in assessing the visual impacts of a many project alternatives number of viewpoints. The VT-REFS project had an ambitious research agenda that included visualizations of "bare earth" scenarios versus "leaves on trees" scenarios for many different acreages of solar PV and numbers of turbines. Stakeholders requested three additional viewpoints, including one point along the Catawba Valley Road, one point along the North Mountain biking trail, and Tinker Cliffs. The VT-REFS project presented two different types of visualization: photorealistic imagery, where a photograph from the viewpoint is taken and then edited to add in an image of a solar array and/or wind turbine. The second type would use ARCGIS to generate "digital" imagery of the landscape from the viewpoint to the proposed locations of renewable energy facilities. Stakeholders strongly preferred the photorealistic imagery to ARCGIS digital imagery. They explained that the digital imagery did not give enough of a sense of what the landscape and proposed facilities would like upon which to make a siting decision. VT-REFS agreed to continue to work on developing visualizations for stakeholders and other environmental information previously requested. The group agreed to reconvene in September to continue the process.

July - September 2019

VT-REFS conducted research to identify environmental and social impacts (visual) of proposed projects, and continued communicating with stakeholders.

Social Sustainability.

The RATC opposition to exploring the possibility of large wind turbines at the site significantly

increased, including to conducting any surveys of AT hikers about potential visual and other impacts of potential wind turbines, and to VT-REFS conducting visualization studies that included large turbines. VT-REFS agreed that large turbines were neither economically nor socially feasible, and that this aspect (exploring large wind turbines) of the stakeholder effort was designed to identify hiker and public sensitivity to wind turbines in this location, to help with site planning issues elsewhere, as part of efforts to serve others. VT-REFS agreed to not pursue the visual impact research for large (i.e., approximately a 3.1 megawatt, 600 feet high turbine) option but to explore smaller turbines that would be less than 150 feet in height. Those turbines would have significantly fewer visual and environmental impacts. RATC agreed to continue participating as stakeholders and to support research efforts concerning smaller wind. It was agreed that VT-REFS would be able to continue to assess visual impacts of differently sized turbines, identify the quantity and cost of renewable energy generated, and how that impacts stakeholder acceptance. At that point in time, VT-REFS sought to conduct a trail user survey as part of its research.

Environmental Sustainability.

The endangered/threatened species at or near the site were identified using the Virginia Division of Wildlife Resources Wildlife Environmental Review Map Service (WERMS). It showed that project site included the range for the Indiana Bat and the Northern Long Eared Bat. The Northern Long Eared bat had a hibernaculum listed within 5-10 miles of the project site. Since that bat is threatened but not endangered, regulations do not apply to the proposed project. Stakeholders, including VT-REFS, want to know if the project alternatives could have any adverse impacts, and if so, what mitigation measures are available. The project alternatives pose no threat to either one of these species, given the distance to the formerly occupied hibernaculum in Bland County, the behavior of each species, and that no timber is planned to be cut as part of the project that alter or destroy a summer day-roost.

Scott Klopfer, Certified Wildlife Biologist, Director of the Conservation Management Institute, notes that it is not known if Catawba Mountain ridge line is a hotspot for migrating hawks or warblers. However, it is very likely that other migrating birds use Catawba Mountain ridgeline and that the presence of large turbines would result in migrating bird mortalities. The number of mortalities is uncertain. If a project were to be pursued that included large wind turbines, then additional study would need to be done.

In terms of water quality and stormwater runoff, no solar arrays would be located close to Catawba Creek, which flows through the CSC property. To reduce environmental impacts and allow for agrovoltaics, all solar PV alternatives would not use site grading to level the site. The construction technique would be to drive posts directly into pasture to support the solar arrays, and build the "racking" that holds the solar panels. This approach has minimal to no erosion or water quality impacts. At the end of the project life, the solar panels, racking, and posts can be removed, again with virtually no erosion impacts.

During the summer, Dr. Meyers and Dr. Grant, Associate Professor of Architecture collaborated to create a joint studio class held the first month of fall semester 2019. Dr. Meyers dedicated the fall 2019 Urban Affairs and Planning class, the capstone Environmental Problem Solving course UAP 4354 to the Catawba site planning project. Dr. Grant dedicated a portion of her Architecture Studio 3 course as well, and they combined the classes for August and September. Students were able to learn from each other how their respective disciplines approach complex projects and the expertise each brings. They conducted a wide range of research to answer stakeholder questions about environmental and visual impacts and develop presentations for two stakeholder meetings. Interactive lectures by invited speakers and faculty at joint class meetings helped students better understand key project parameters and processes. These included a lecture by Dr. Grant on "Principles of Design;" a lecture by Dr. Richard Hirsh on "Love, Hate, and Renewable Energy Technologies;" a lecture by Patrick Feucht of Baseline Solar on "Solar PV Design Basics;" a lecture by Dr. Matthew Kuester on "Wind Energy: Basics and Siting Considerations;" a lecture by David Hill, ASLA of Hill & Associates on "Visual Quality in the Landscape;" lectures by Dr. Grant on "How to Conduct a Design Charrette" and "Choosing By Advantages;" and a lecture by Todd Schenk on "Collaborative Approaches to Resolving Environmental & Planning Disputes."

September 25, 2019 - Fourth Stakeholder Meeting: Student Design Charrette

The focus of the meeting was to bring information needed to facilitate continuing discussions and decision making regarding potential project alternatives. This included work on the social sustainability, (i.e. the visual acceptability) of alternatives. Potential footprints of the renewable energy facilities for six project alternatives were shared, and extensive visualization from one

viewpoint for the six alternatives. Students in the joint studio course conducted extensive visualization studies for stakeholders, choosing a viewpoint from the parking lot of the Catawba Center, which is adjacent to the CSC. The students made significant contributions to all aspects of the meeting. Research on the environmental sustainability, in terms of water quality, endangered, threatened, and listed species.

Stakeholders used the Choosing By Advantages (CBA) Decision making System originally developed by Jim Suhr for the U.S. Forest Service to evaluate the six alternatives, and provided feedback on the process. Aria Hill's (third year Architecture student at VT) enthusiasm to work with stakeholders on a green energy project is shown in Figure 10.

Figure 10: Architecture III Studio student Aria Hill at September stakeholder meeting

The number of participants for the meeting increased as more members of the RATC and the community attended, shown in Figure 11. Discussion was lively, clear, and collegial as stakeholders shared their interests and concerns and identified two preferred alternatives.

Figure 11: September 25, 2019 stakeholder meeting

Six Project Alternative Presented at September Stakeholder Meeting.

Six project alternatives for stakeholder consideration were developed for the CSC during the summer of 2019 and presented at the September meeting. Five areas in the CSC were identified for further exploration of their suitability for PV arrays, shown in Figure 12. Within each of those five areas, slope and shading analyses were done. The site PV1 included approximately five acres suitable for arrays. Sites PV 2 and 3 had approximately one acre each available, while PV 4 had approximately ten acres, of which about one acre or less would be used PV panels as cattle shading structures. The six project alternatives would be generated by combining each of the potential arrays into a group that was five acres, or ten acres in size. We wanted to understand what overall magnitude of a PV project stakeholders would embrace in this phase of the research, as the land manager for the CSC continued to consider which exact locations on the property were suitable for solar PV that would not only provide a significant energy output, but could also serve as an agrovoltaics demonstration site for grazing that could be adopted by other farmers to diversify economic development on farm lands.

Figure 12: Five alternative solar PV sites for arrays and three potential wind turbine locations at CSC

Additional alternatives that included the Catawba Hospital were planned to be developed after the September meeting for discussion later in the fall, based upon feedback provided about these six alternatives. The alternatives and the results of the CBA Decision Making System were as follows.

Six Alternatives

1. No action. No renewable energy would be developed on the site. No research or educational activities concerning renewables would be conducted, and no new benefits to the community from development would be achieved. No adverse visual impacts would occur. This alternative was included as a standard approach used in project planning to ensure that the impacts and desirability of a no impact alternative was considered. No one preferred this alternative, indicating that there was support for some type of facility. The questions then became, "what type, size, locations, and other mitigations were acceptable?" Figure 13 shows the site as of September 2019.

Figure 13: September Alternative 1: No Action: View from Catawba Center parking lot to CSC

2. Five acres solar PV, no wind, shown in Figure 14. This alternative would provide about 1,240 MW a year, support modest research and educational activities for solar PV, and provide modest benefits to the community from those activities. However, it is likely not economically viable for providing power for VT, since the power output is too small. This alternative was included to test if a small PV facility would be acceptable in the location. Placement alternatives were identified that would have little to no visual impacts. And, alternatives were identified so the public could see the solar PV as part of community education. Two stakeholders preferred this alternative. They indicated that they would support provision of power for the CSC but did not want a large REF in their community due to visual impacts.

Figure 14: September Alternative 2: Five acres solar PV at sites PV2 and PV3

3. Ten acres solar PV, no wind. The ten acres would include arrays in four locations on the property: approximately four acres at site PV1, five acres (total) at sites PV2 and PV3, and one acre of shading structures for beef cattle along Catawba Valley Rd. This alternative provides double the renewable energy of alternative two, about 2,480 megawatts a year. It would support modest research and educational activities for solar PV, and provide benefits to the community from development. Placement alternatives were identified that would have little to no visual impacts – site PV 1 is at a lower elevation than one nearly home, unseeable because it is obscured by the ground. The site by Catawba Road would have very low or no visibility for the same reason. In addition, the shade structures would be relatively small and scattered in the pasture. We did not do additional photorealistic imaging for the additional viewpoints needed, due to time constraints. Five stakeholders preferred this alternative. They indicated that they supported renewable energy generation, and accepted site use for solar PV development to provide VT with power, but did not want the visual impact of wind turbines.

4. Ten acres solar PV, one 130 foot 10kW Bergey wind turbine. This alternative provides an increased amount of renewable energy, adding about 10 MW total production a year, for total renewables generation for alternative four of about 2, 490 megawatts a year. The low energy production from the turbine is due to the site having low wind speed. It is not suitable for wind energy generation, but the option was explored to assess community attitudes towards the alternative. It would also support research and educational activities for both types of renewable energy, and provide more benefits than alternatives two and three to the community from development. Figure 15 shows the visualization of the Bergey turbine provided to stakeholders. The Bergey turbine is barely visible from the parking lot of the Catawba Sustainability Center on the clear day the photo was taken: it is the very thin tower with a small yellow spot next the middle transmission tower. One stakeholder preferred this alternative. They indicated that they supported renewable energy generation, and accepted solar PV development to provide VT with power. The addition of one small turbine was all the visual impact they were willing to accept to provide more renewable energy at this location.

Figure 15: September Alternative 4: One 130 feet tall Bergey wind turbine (10 acres solar PV not

shown)

5. Ten acres solar PV, and three 130 foot 10kW Bergey wind turbines, shown in Figure 16, below. This alternative provides an increased amount of renewable energy, generating about 2,510 megawatts a year. It would support additional research more educational activities for both types of renewable energy, and provide more benefits to the community from development than alternatives one through four. Depending upon placement, no or little adverse visual impacts would occur. Four stakeholders preferred this alternative. They indicated that they supported renewable energy generation, and accepted solar PV development to provide VT with power. The addition of three small turbines was all the visual impact they were willing to accept to provide more renewable energy at this location.

Figure 16: September Alternative 5: Three 130 foot tall Bergey turbines (10 acres solar PV not shown)

6. Ten acres solar PV, one 250 foot 500kW wind turbine. The larger wind turbine would produce about 461 MW per year. This is highly uneconomical, but the alternative was explored to assess community reactions to wind energy. This alternative provides the greatest amount of renewable

energy, generating about 2,971 megawatts a year. It would support research and educational activities for both types of renewable energy, and provide more benefits to the community from development. Stakeholder perceptions of visual impacts varied – some indicated the 250 foot turbine was desirable since it showed the community was progressive, and was not tall enough to be intrusive. Members of the Roanoke Appalachian Trail Club had different views. Some indicated a turbine that size was visually unacceptable given the proximity to the Appalachian Trail, while others expressed that hikers and the RATC should embrace renewable energy facilities, particularly this one. Figure 17, below, shows the visualization provided to stakeholders. Five stakeholders preferred this alternative.

Figure 17: September Alternative 6: One 250 feet tall wind turbine (10 acres solar PV not shown)

Many residents favored renewables as positive image for the community and wanted both wind and solar PV installed to support the CSC and the Catawba Hospital, because they are important community assets to strength. These residents and the RATC also expressed various concerns, including opposition, regarding wind turbines. The RATC strongly wanted to protect the viewshed

from the AT, particularly from large wind turbines.

Discussion returned to stakeholder concerns about potential visual impacts of nighttime lighting on turbines, which could alter the character of the highly rural and valued night sky. VT-REFS summarized its research into FAA regulations concerning lighting for stakeholders. The FAA regulations require an FAA study to determine if the structure(s) over 200 feet high are a navigational hazard that need lighting. Not all structures are a navigational hazard. For example, proximity to airport approach paths can make a difference. It does not appear to VT-REFS that the proposed project site is in the approach paths for the Roanoke Airport. If turbines are smaller than 499 feet, then the lighting requirements lessen. Further exploration of this issue with the FAA is necessary to assess lighting needs.

Social Sustainability

Decision Making Processes: Identifying Mutual Gains and Using Choosing By Advantages.

As noted above, the VT-REFS project's goals included exploring decision making processes with other stakeholders. We used the overall mutual gains and CBA Decision Making Process approaches for the September and December 2019 stakeholder meetings to identify preferred project alternatives, and reflected upon its usefulness and desirability to stakeholders as part of our research. We document the first use of the combination of two processes in some detail. The first process was the early, frequent public engagement strategy to achieve mutual gains for all stakeholders. As noted previously, stakeholders make a commitment to extensive dialogue and use of research to identify and agree to a project alternative that provides each stakeholder with as much as possible of what they value most. A consensus-type approach is taken. The second approach, Choosing By Advantages (CBA), is similar, but adds a more formal identification of the advantages and tabulation of stakeholder-identified importance of the advantages of each alternative. These advantages are based on the attributes of each alternative for a range of factors. The results show the group the alternative(s) that is/are most preferred, and ranks the group's preferences for each alternative. The CBA process is highly organized in how information is gathered and used for decision making. Professor Elizabeth Grant led the effort to incorporate CBA into the pilot study. She is facilitating discussion at the September stakeholder meeting in Figure 18 below.

Figure 18: Architecture Professor Elizabeth Grant leading the September Choosing By Advantages discussion

Stakeholders begin by discussing the factors, or criteria, they want to use to evaluate project alternatives, to make sure the decision includes all the relevant parameters, and then to come to consensus on a list of decision factors. How each factor will be measured or assessed is then identified. For example, the megawatts of energy produced is one way to measure renewable energy production, but more valuable measures are tons of CO2 emissions avoided, and more so, number of households that can be powered with that energy. Students in the UAP 4354 Environmental Problem Solving Studio course and the Architecture III design laboratory gathered the data and information needed for all three factors. The data found for two factors showed clearly which alternatives had the greatest advantages for those factors. In Figure 19, the blocks that student researchers completed are highlighted in yellow. For the third factor, visual impacts, students developed many photorealistic images for project alternatives from just one viewpoint to help stakeholders identify which alternative had the least visual impacts. At the September meeting, stakeholders used those images to decide for themselves which project alternatives had the worst and best visual impacts. Figure 19 shows in pink and blue the cells stakeholders completed, and how the CBA information was organized. This approach put researchers in service of the public, to help

them make decisions about what alternatives meets their interests, an approach known as co-discovery.

FACTOR		Alternative 1 (No Action)	Alternative 2 (5 acres PV)	Alternative 3 (10 acres PV)	Alternative 4 (10 acres + one 130 foot 10kW turbine)	Alternative 5 (10 acres + 3 130 foot 10 Kw turbines)	Alternative 6 (10 acres + one 250 foot 100 kW turbine)
Greenhouse gas emissions reductions	Attribute	None	19,300	38,300	38,400	38,700	45,900
	Advantage		19,300 more than none	38,300 more than none	38,400 more than none	38,700 more than none	**45,9000 more than none**
Environ-mental impacts on birds and bats	Attribute	None	None	None	None	None	1 bird every two years
	Advantage	**1 bird saved every two years**	**1 bird saved every two years**	**1 bird saved every two years**	**1 bird saved every two years**	**1 bird saved every two years**	
Scenic quality	Attribute	*	*	*	*	*	*
	Advantage	X Better than worst alternative	X Better than worst alternative	X Better than worst alternative	X Better than worst alternative	X Better than worst alternative	X Better than worst alternative
Total Importance of Advantages							

Yellow blocks are pre-filled by students
Blue and pink blocks are filled out by stakeholders at meetings
* Assessment of scenic quality: two steps. On a separate sheet, stakeholders write down very low, low, mixed, high, or very high scenic quality for all 6 specific views, then input those evaluations as attributes under scenic quality on this sheet.
The alternative with the least preferred attribute for each of the three factors is underlined.
The alternative with the greatest advantage for each of the three factors is circled in green and bolded (this may be more than one alternative if they have equivalent attributes).
Green blocks are the relative importance of these advantages as decided by the stakeholders at meetings
Figure 19: Choosing By Advantages decision table for September stakeholder meeting

Figure 20: September 2019 stakeholder meeting: discussing project alternatives

For the third factor, participants were provided a photorealistic image of each of the six alternatives from one viewpoint – Catawba Road looking towards CSC. This provided stakeholders, including VT-REFS, the opportunity to assess if the photorealistic images of the alternatives were useful for their decision making. Stakeholders discussed the images and alternatives with each other. Figure 20 shows a student research and community members discussing the photorealistic images. Then each stakeholder filled out their own CBA worksheet. They first underlined the alternative that had (the attribute of) the worst scenic quality, then the alternative that was the most visually acceptable was circled. Then, in the blue blocks, they identified on a scale of 1 (not much better) to 6 (very much better) the scenic quality of each alternative. Their ranking options were from not much better, somewhat better, moderately better, notably better, a lot better, very much better...than the worst alternative. The next step was for each participant to evaluate all the advantages in the table and identify which advantage was the most important (paramount) to them, and write 100 in the green block next to it. They then decided the importance of the remaining advantages on a scale from 0 to 100. This step by step process translated stakeholder preferences for multiple factors into quantified rankings of which alternative provided the most advantage, or gain, for their preferences. This provided a way for the group to discuss individual preferences and compare them with each other. Common preferences emerged quickly, and the differences were shown more clearly by being quantified, while recognizing that the quantification was not precise.

Seventeen stakeholders in the September meeting shared their votes. To maintain focus upon stakeholders in the community and the RATC, neither the VT-REFS team nor students voted, although they are stakeholders who care about VT's responsibility to generate renewable energy, provide research and educational opportunities, and improve the CSC. Three factors were identified by VT-REFS and VT students to use in the September CBA. The three factors and the measurable attributes for each factors were:

- Potential to reduce greenhouse gas emissions: tons greenhouse gas emissions avoided over 20 years
- Environmental impacts on birds and bats: estimated annual fatalities
- Scenic quality of view from Catawba Valley Road toward the project: Participants rated each project alternative.

In summary, stakeholders preferred:

- Solar PV alternatives only = **seven** preferences for those three alternatives
- Solar PV plus all wind turbine alternatives = **ten** preferences for those three alternatives
- Maximum solar PV and maximum solar PV plus the largest wind alternative were tied at five preferences each

Stakeholders nearly unanimously supported putting at least ten acres of solar PV at the CSC, and by a plurality wanted the maximum renewable energy generation option of ten acres of solar PV and the largest (250 feet tall) wind turbine.

Discussion about the meaning of the CBA results by stakeholders agreed that the voting procedure showed that that more renewable energy power generation was preferred to less, that the group was divided over wind (no member of RATC preferred a wind alternative, and no non-RATC member preferred a solar only alternative), but that there was an overall preference for putting up one up to 250 foot wind turbine plus ten acres of solar PV. These results were used to develop alternatives that would include both the CSC and the Catawba Hospital for the final meeting held in December 2019.

Discussion about the CBA process itself was extensive. In summary, stakeholders agreed the research done to quantify each factor (i.e. MW/year generated by each alternative) and the CBA process were very helpful for productive discussion and decision making, albeit too complex. Many suggestions were made to improve the process. The first set revolved around identifying more factors to include in the CBA process. These included:

- Identifying the percent power each project alternative would provide for the CSC, the Catawba Hospital, and Virginia Tech (more is better)
- Add a second visual factor: No degradation of scenic quality (visual impacts already included)
- Meeting research, education, and viability needs for the CSC
- Meeting viability needs for the Catawba Hospital
- Identifying economically viable alternatives

Stakeholders asked that VT-REFS identify potential new factors and consult with the stakeholder group on which ones to add prior to the final stakeholder meeting.

September – December 2019 Student and VT-REFS research for stakeholder decision making

Students in the Environmental Problem Solving studio continued extensive research to address social, environmental, and economic sustainability questions for stakeholders. They sought to address social sustainability issues by finding optimal siting locations for renewable energy sources at the CSC (CSC) and Catawba Hospital, responding to stakeholder concerns about the height of proposed turbines, and conducting extensive visualization studies. In addition, they investigated the permitting requirements in Roanoke County for wind energy systems. They addressed environmental sustainability by investigating potential impacts on waterways (Catawba Creek), and endangered and threatened species (particularly avian). Economic sustainability was addressed by finding the most cost-effective renewable solar PV and wind turbines possible, given the social constraints of no large (i.e., the Roanoke Appalachian Club indicated they would oppose a turbine above about 150 feet height.) wind turbines, and conducting a rough economic analysis of the proposed project. Their findings are provided in the appropriate sections documenting the December stakeholder meeting.

Students identified three alternatives to explore for the December stakeholder meeting, based on stakeholder input at prior meetings and student research.

- Alternative one was solely solar, with 13.9 acres at the CSC and 54.7 acres at Catawba Hospital. This provided maximum solar that land managers wanted on their properties, given other uses, such as forests, recreational areas, and pre-existing farm research and operations. It did not include any wind, for several reasons. First, students and REFS wanted an alternative that would be socially acceptable so an alternative would emerge from the mutual gains and Choosing By Advantages decision making processes. Having no wind and solar of this size was clearly socially acceptable to the stakeholders, based on the prior stakeholder meeting. In addition, we wanted an alternative that could be economically feasible. The agreement to not put turbines over about 150 feet high at the sites meant smaller turbines would need to be used. These would neither generate nor be economical if smaller turbines were used. The most efficient turbines for the site, given these constraints, is the Northwind 100, which is 160 feet high to the tip of the wind blade. They are designed for low wind areas with more variable wind. The cost of the Northwind 100, and the low generation of energy given the low wind speeds of the site, eliminated this turbine from further analysis. study evaluated the 130 and 250 foot turbines was

not evaluated.

- Alternative two included both forms of renewable energy, with the same amount of solar sited at each location, and the addition of three turbines at the CSC and five turbines at Catawba Hospital. This number of turbines was considered modest enough that it might gain stakeholder acceptance, given that they would generate much more power.
- Alternative three consisted of the same amount of solar at both sites as the first two alternatives, but no turbines at the CSC and enough turbines to produce 3 GW of power annually sited at the hospital, which came out to 60 turbines. This alternative was chosen to identify the losses that would be incurred if small wind were used to meet the power needs for Catawba Hospital. The Commonwealth of Virginia has renewable energy funding available for state institutions, so if additional funds were necessary for the project to work, we wanted to know the magnitude of the funds potentially needed.

December 2019: Fifth and Final Stakeholder Meeting: Coming to Consensus

The focus of the meeting was to conclude this phase of a siting process by having stakeholders use research gathered to help them identify which of three project alternative(s) they favored, and why. These conclusions would be documented in this report for potential future use by VT administration if they decide to explore renewable energy generation near VT campus. The final meeting of stakeholders was also helpful for the VT-REFS team to work with stakeholders to reflect on the overall siting process, and obtain their recommendations for improving it. This co-creation and exploration of this innovative siting process was valued by all parties. Discussion was again vigorous and collegial as stakeholders shared their interests and concerns and identified two preferred alternatives. Students in the Environmental Problem Solving Studio made significant contributions to the research and presentation of results for all aspects of the meeting. What follows is largely their work, edited for inclusion into this broader report.

Three Project Alternatives Presented at December Meeting

Alternative One

Included 68.6 acres of solar total: 13.9 acres at the CSC and 54.7 acres at the Catawba Hospital. No wind power was included. The perception of visual impacts of the larger solar arrays varied significantly. Some stakeholders preferred that the solar PV be screened from view, particularly the proposed ten acre array along Catawba Valley Road. Others wanted solar PV to be seen, to make a statement about the community's commitment to renewable energy, and to appreciate their presence

in the community.

Alternative Two

Includes the same 68.6 acres of solar PV as Alternative one, with the addition of eight Northwind 100 wind turbines: Three at the CSC and five at Catawba Hospital. The visual impact analysis for all alternatives by each viewpoint follows.

Alternative Three

Seventy eight acres solar PV plus sixty small wind turbines at the Catawba Hospital. No turbines would be placed at the CSC due to concerns for visual impacts to the Appalachian Trail. This would be enough turbines to produce 3 GW of power annually sited for the hospital. This option was understood to not be feasible, but was done to satisfy VT-REFS research interest in assessing visual impacts of a larger number of smaller turbines, and to generate data on the cost *in*effectiveness of using small turbines.

Social Sustainability.

The Social Sustainability Team was responsible for addressing concerns the community had with visual and acoustic impacts as well as regulatory and permitting issues. To address the issues with visual impacts of the project on the surrounding area, viewpoints were decided upon by team members and stakeholders. Of the twelve viewpoints suggested since May 2019 for visualization studies, the seven locations with the highest priority were completed by students, listed in Figure 21.

Catawba Road toward CSC
Catawba Community Center toward Appalachian Trail/Catawba Mountain
*The Homeplace parking lot towards proposed project
Appalachian Trail Mcafee Knob parking lot towards proposed project
Appalachian Trail Fire Road Trail towards proposed project
*Appalachian Trail at Mcafee Knob towards proposed project
*Appalachian Trail at Sawtooth Ridge towards proposed project
*Appalachian Trail at Dragon's Tooth towards proposed project

Figure 21: Seven viewpoints used for visualization studies conducted for December Catawba stakeholder meeting

Note: An asterisk means that there are no visual impacts to viewpoints from any alternatives

Figure 22 maps the locations of the viewpoints relative to the project site. The CSC and Catawba Hospital property boundaries are in red. The viewpoints were identified by the blue markers on the

map and show perspectives from important areas of interest to the community. The yellow areas are footprints for proposed solar PV arrays.

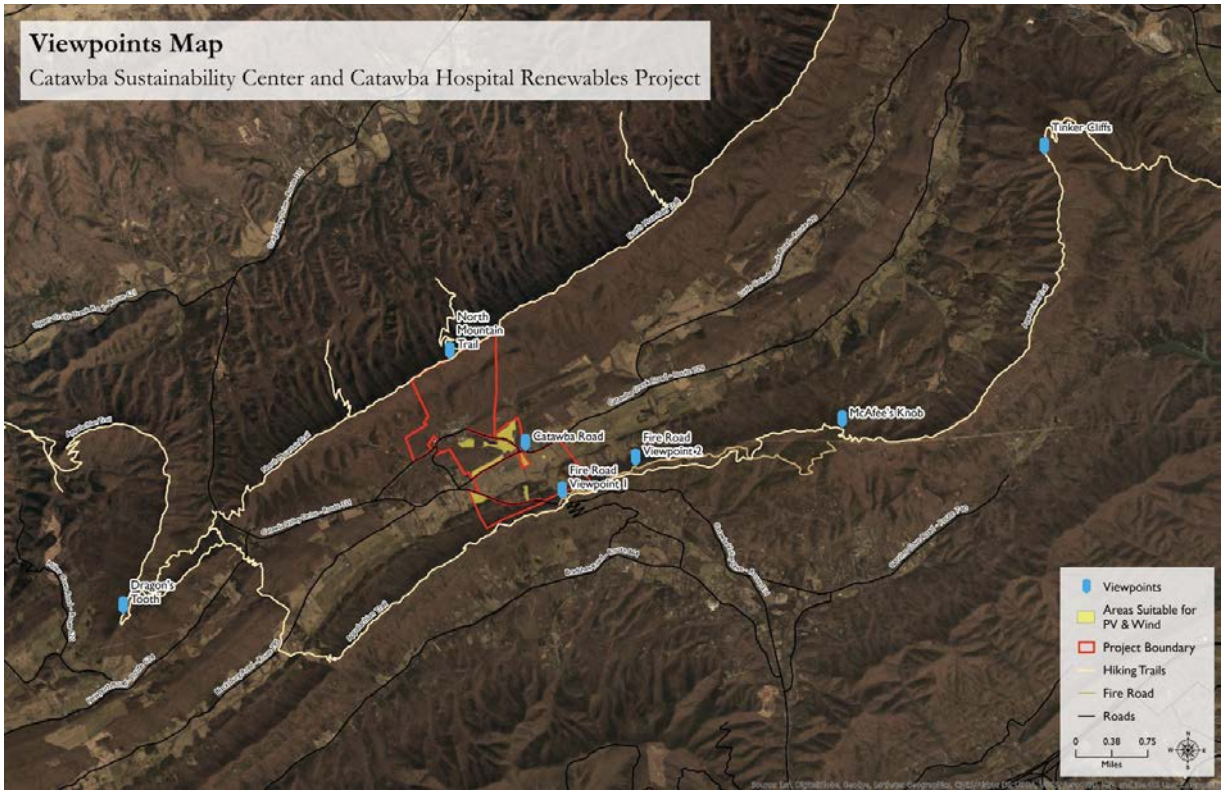

Figure 22: December map: viewpoints, properties, solar PV for CSC and Catawba Hospital

Each viewpoint was assessed using ARCGIS software to identify if the project alternative was visible from the viewpoint. Three techniques were used by the VT team: the first was to conduct terrain elevation analysis to identify if one point on the terrain (the viewpoint) had an unobstructed sightline to the proposed project. This technique was a useful screening exercise for students and VT-REFS to identify viewpoints that were unlikely to see project alternatives[2]. The second approach was to go to the viewpoint, take a photo using proper techniques for photorealistic imaging[3].In cases where the viewpoint does not see any project alternatives, the photograph is helpful for stakeholders. If the viewpoint does see project alternatives, software like Sketch-up is used to insert the appropriately sized solar PV arrays or wind turbines into the photo. Due to time and funding constraints, VT –

[2] Terrain analysis is one tool used by VT-REFS for visual assessment of potential visual impacts of higher turbines
[3] Students made a tremendous effort obtain photos, given that reaching viewpoints on the Appalachian Trail required long hikes in mountainous terrain.

REFS did not use a landscape architect to assist with placing PV arrays or turbines precisely onto the landscape to improve the visual impacts[4]. Therefore, the visualization studies showing the placement of arrays are misleading, in that the arrays were not placed on the landscape to minimize (or improve, depending upon your taste) visual impacts.

Six viewpoints would not see any project alternatives because the location of the Appalachian Trail on hilly terrain resulted in obscured views toward the proposed project site. Per the agreement with the RATC Students did not model the viewability of turbines over 130 feet (height of the Bergey) so the visual impacts, if any, of potential wind turbines larger than 130 feet is unknown. Regulatory and permitting concerns were identified through research into the Roanoke County code and contact with federal and state officials and VT faculty.

Potential Locations of PV and Wind Turbines.
Figure 23 shows the potential locations for PV arrays and wind turbines, with Figure 24 showing these in more detail. The white areas identify PV while blue marks identify the locations suitable for turbines given the land slope. The Catawba Hospital property (owned by the Commonwealth of Virginia) is on the north (upper) portion of the figure, with the CSC on the southern (lower) portion. Catawba Valley Road marks the dividing line between the two properties. The Appalachian Trail is the white line to the south of the CSC, while the North Mountain Trail is the white line to the north of and adjacent to the Catawba Hospital, near the ridgeline.

[4] We would like to incorporate landscape architects into future efforts, as that profession's insights into how to place objects onto the landscape is profound, can create facilities with positive visual and social impacts, and changie a potentially negative attribute of a renewable energy project into a positive attribute.

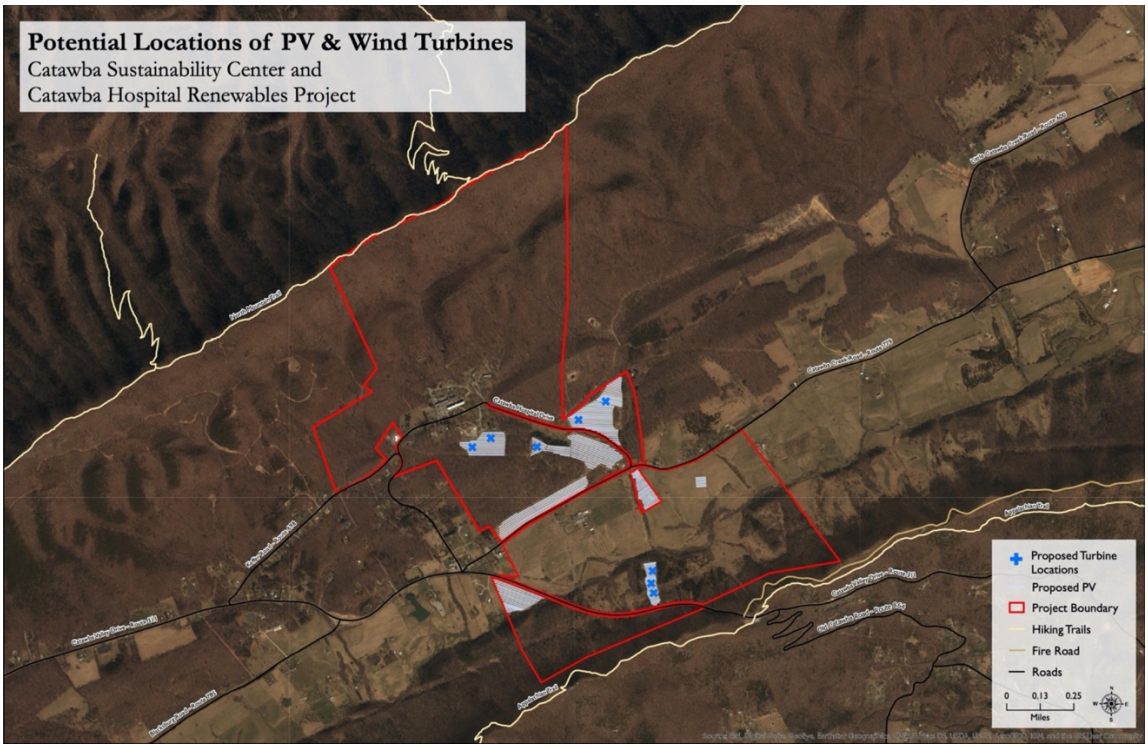

Figure 23: December potential location of solar PV and wind turbines at CSC and Catawba Hospital

Figure 24: December: Detailed locations solar PV arrays at CSC and Catawba Hospital

Visual Assessment Three Project Alternatives Presented at December Stakeholder Meeting.
Students organized their visualization studies so the impacts at each viewpoint could be more easily compared by placing the visualization studies for each viewpoint together.

Four very important viewpoints would not see any of the proposed alternatives: including the critically sensitive Triple Crown viewpoints of Mcafee Knob, Sawtooth Ridge, and Dragon's Tooth. Photographs from those viewpoints to the proposed project area were provided for stakeholders to evaluate for themselves. VT-REFS will recommend additional visualization studies to assess what portions of the Triple Crown loop, the entire hiking trail, would or would not be able to see proposed REFs. Photorealistic imagery approaches are not effective for determining this. Rather, the use of GIS system to digitally identify all segments of the Triple Crown that could see any proposed facilities. Photorealistic visualization studies could then be performed for those segments.

Homeplace Restaurant Visualization Study

The Homeplace Restaurant is a very popular location for individuals visiting Catawba. This image was taken from the parking lot of the restaurant and shows that the trees and hills between the Homeplace Restaurant and the CSC and turbines and PV would not be visible from the site. The image, Figure 25, was taken when the leaves had fallen from some of the trees in the area and shows that even without leaves the site could not be viewed.

Figure 25: December 2019 All alternatives: View from Homeplace Restaurant

Mcafee Knob Visualization Study

Figure 26: Mcafee Knob overlook

Mcafee Knob is an 8.8 mile hike (roundtrip) from the parking lot on Rt. 311, and is on the ridgeline

of Catawba Mountain above Catawba Valley. Figure 26 shows the panoramic view from the overlook. The CSC and Catawba Hospital are approximately four miles west, not in view from the overlook. The view would not be affected by this proposal. The bluff on the far left side of the photograph blocks the view of Catawba Valley as it reaches the project site.

Figure 27 shows the location of the proposed project site, circled in red on the left. Mcafee Knob is the red dot, with the view from the overlook shown in orange. This aerial view depicts that hikers who reach the top of the overlook will neither be able to see the turbines/panels nor will they have any negative visual impacts.

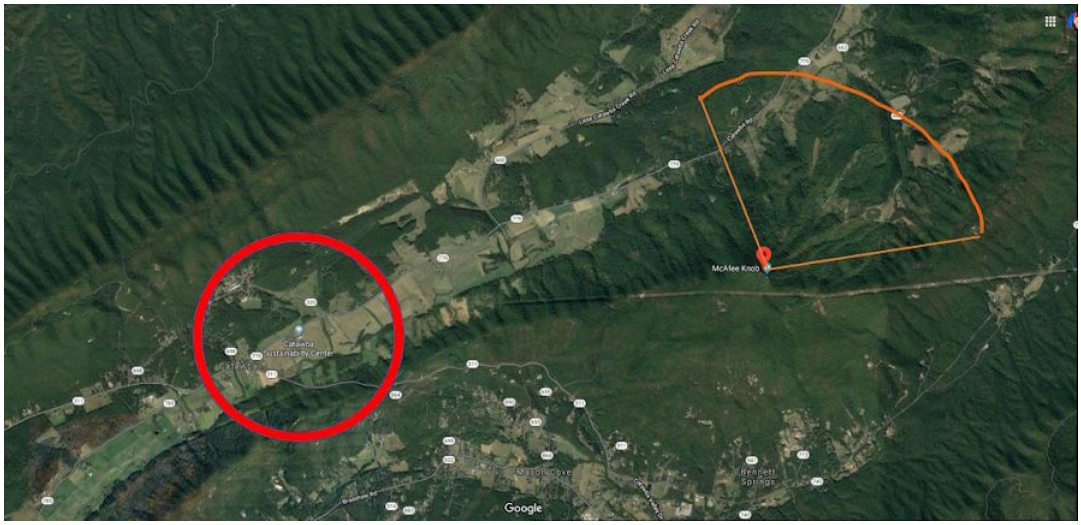

Figure 27: Viewshed from Mcafee Knob overlook

Sawtooth Ridge Visualization Study

Like Mcafee Knob, Sawtooth Ridge is another visually striking and well-travelled hiking trail located in Catawba. Figure 28 below shows the location of the CSC and the Catawba Hospital where the possible alternatives would be placed, circled in red. Sawtooth Ridge overlook is the red dot, with the view from the overlook shown in orange. The overlook from this site does not face the proposed project site. Instead, it overlooks in the completely opposite direction towards Bradshaw.

Figure 28: Viewshed from Sawtooth Ridge overlook

Dragon's Tooth Visualization Study

Dragon's Tooth is one the three jewels of the Triple Crown area hikes. Figure 29 shows the view from Dragon's Tooth overlook towards the Catawba Sustainability Center. To assess if it would impact the view from the overlook, we used Google Earth to obtain a panoramic image of the view, shown in Figure 29. The dotted circle represents, approximately, the proposed project location, which is obscured by the rocks and trees at the summit. The mountain also obscures the view towards the project site from the trail used to reach the overlook. This overlook and the trail will not have any visual impacts from proposed wind turbines and solar PV panels.

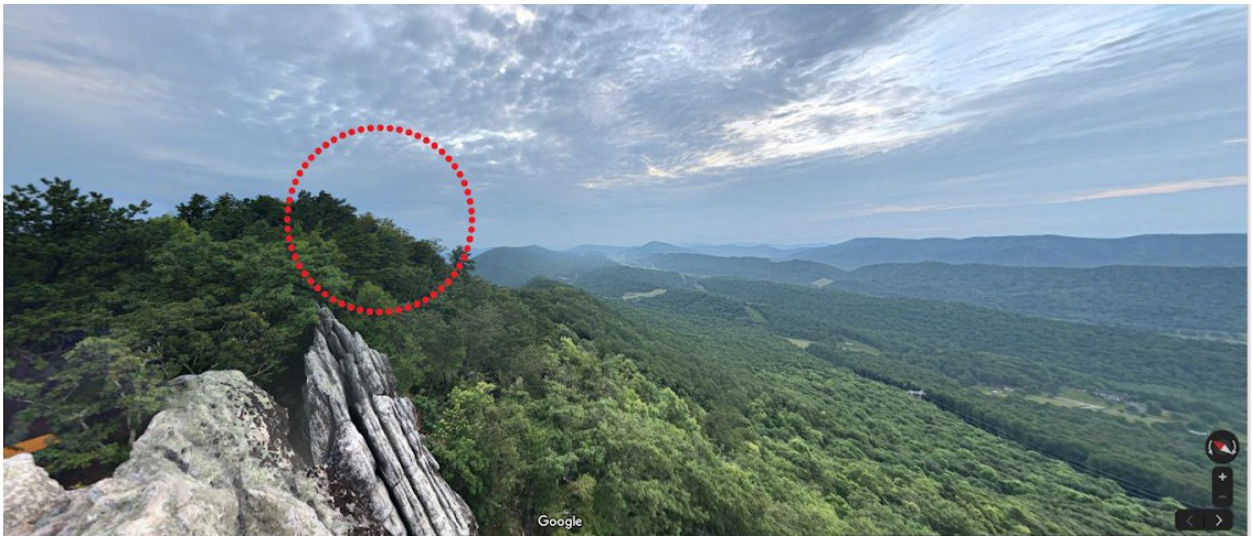

Figure 29: Google Earth view from Dragon's Tooth overlook towards project site

Figure 30, below, provides a viewshed map for the Dragon's Tooth overlook.

Figure 30: Viewshed from Dragon's Tooth overlook

Mcafee Knob Appalachian Trail Parking Lot Visualization Study

The parking lot for the section of the Appalachian Trail that leads to Mcafee Knob, was on the far side of Catawba Mountain. The proposed project site is not viewable because Catawba Mountain ridgeline blocks the view, as well as thick forest. Figure 31 shows the parking lot looking towards the proposed project site.

Figure 31: Mcafee Knob Appalachian Trail parking lot view

Tinker Cliffs & North Mountain Trail

Tinker Cliffs and North Mountain, trails both located near Catawba Valley, are two sites that need to be examined for future observations. Due to the lack of resources and time, these two trails have yet to be explored to see if they have any visual impacts for visitors/hikers. For future observations, it is important to examine not only the overlook of the trails, but the trail up to the overlook as well.

Catawba Road Visualization Study

Figure 32 below shows the view looking south from Catawba Road toward the CSC. This view shows the only visible solar PV from this viewpoint looking towards the Center. Additional solar PV, approximately ten acres along the north side of Catawba Valley Road for the Catawba Hospital. No visualizations were done from Catawba Valley Road toward the Catawba Hospital.

Figure 32: December Alternatives 1 and 3: Viewpoint from Catawba Valley Road

Figure 33: December alternative 2: Viewpoint from Catawba Valley Rd to CSC

Figure 33 depicts Alternative 2 from the road facing the CSC. It shows the location for three potential 120 foot high Bergey wind turbines. Due to existing land uses and slopes, the solar PV array would be placed in the vicinity of the turbines and are depicted on the site as well. A smaller tower is faintly visible. This is the 340 kV powerline that is on the lower portion of the proposed array and turbine. The engineering question of, "how close can the turbines and arrays be to the power line" is being deferred to later steps in a lengthy site development process. Our siting process is to identify what alternative is socially, environmentally, and economically acceptable to the community before expensive engineering studies are conducted. Based on finding from this study, if the project were to move forward, then more detailed engineering studies would be done. The advantage of this process is that engineering studies are very expensive, and if a site plan is developed that is not acceptable to the community, it is very expensive in time, effort, and reputation of the developer to either adjust plans or fight community opposition.

Catawba Community Center Parking Lot Visualization Study

The student team chose to add the view from the Catawba Community Center to the list of

viewpoints because it is an area where the community gathers for events and where the charrettes took place. By using this viewpoint, the team was able to give the community a perspective from the building they were currently sitting in and hopefully allow their imagination of the site to be expanded. Figure 34, below, shows the proposed alternatives one and three for solar PV from the

Figure 34: December alternatives 1 and 3: Viewpoint from Catawba Center parking lot

Figure 35: December alternative 2: View from Catawba Center parking lot

Figure 35 shows the turbines and solar PV that can be seen from the Catawba Community Center.

Appalachian Trail - Fire Road Trail Visualization Study

Figure 36: December alternative 1: AT Fire Road view

Figure 36 shows the photorealistic visualization of Alternative 1 from the AT Fire Road. Catawba

Hospital and Sustainability Center from the Fire Road Trail. If Alternative 1 were put in place, PV would be placed in all the available fields at the Catawba Hospital, and around the wastewater treatment plant. The eight sets of solar PV panels on the right are to be used as shade structures for beef cattle on the Catawba Sustainability Center lands. Beef cattle production is improved when shade is provided. The multiple land use of having solar PV with agriculture is also known as agrovoltaics.

Figure 37: December alternative 2: AT Fire Road view

Figure 37 shows the Catawba Hospital and Sustainability Center from the Fire Road Trail if Alternative 2 were put in place, PV would be placed in all the available fields and five wind turbines would be placed on hospital land. The turbines are at the far end of the solar PV arrays on at the Catawba Hospital, and are barely visible.

Figure 38: December alternative 3: AT Fire Road view

Figure 38 shows the Catawba Hospital and Sustainability Center from the Fire Road Trail if Alternative 3 were put in place. PV would be placed the fields currently being hayed, and 60 wind turbines would be placed on hospital land. The large number of turbines show up on the landscape as small, but quite visible from this viewpoint on the Appalachian Trail. Several stakeholders noted that the view before any renewable facilities was of low visual quality because of the powerline and the cut through the woods.

Roanoke County Permitting Process

The permitting process for solar projects and wind projects is very similar and is considered in two ways, either large scale or small scale projects. A single wind turbine up to 100 kW rated nameplate capacity is considered small wind. Alternatives two and three include multiple wind turbines that are rated at 100kW capacity, suggesting that the wind alternatives for multiple turbines would be considered a large wind project. Roanoke County's Zoning Code describes the permitting process necessary to obtain approval for a large wind project in Sec. 30-87-7. - Wind Energy System, Large; and Wind Energy System, Utility" Municode.com/va/roanoke_county/codes/Sec.30-87-7 Large Wind Energy Systems.

The Roanoke County code states:

> "All potential applicants for a large wind energy system or utility wind energy system shall consult with county staff at least thirty (30) days prior to submitting an application. During this consultation, the applicant shall present information to the county staff regarding the proposed project, its objectives and its potential site and viewshed impacts including potential direct and indirect impacts to a national or state forest, national or state park unit, wildlife management area, or known historic or cultural resource site within five (5) miles of the proposed project. The staff shall provide the potential applicant with information on county policies and standards for large wind energy systems and utility wind energy systems."

This pilot project of the siting process focused was not designed to generate information needed to submit a permit application to the County. See the recommendations section of this report for how VT-REFS will address this subject in the future when we conduct full-scale pilots of our siting process.

Environmental Sustainability

The Environmental Sustainability Team was responsible for identifying potential improvements to the landscape and addressing the potential harm to endangered and threatened species in the area.

The endangered/threatened species that were identified included the Indiana Bat and the Northern Long Eared Bat. The Northern Long Eared bat specifically had a bat hibernaculum found within 5-10 miles of the project site. However, since that species is threatened but not endangered, regulations do not apply to it. The project alternatives pose no threat to local populations of either species, given the distance to the formerly occupied hibernaculum in Bland County, the behavior of each species, and that no timber is planned to be cut as part of the project that alter or destroy a summer day-roost. It should be noted that impacts on bats and birds may be reduced with some very simple restrictions on operation. For example, stopping turbines from Sept. 15 through Nov. 15 when wind speed is < 14 mph (not sure of the exact number) as these are the conditions under which many bats and birds migrate. Also, there is not much loss of wind production during these times so this mitigation strategy neither significantly reduces power generation nor revenues.

The goal of our research was to find the best way to mitigate any adverse impacts of renewable

infrastructure and construction as well as encourage the event of having more educational opportunities that blend sustainable agriculture, forestry, and land management with renewable energy at the CSC. The team looked at how the landscape was currently being used and considered how to improve economic value, sustainability, and maintenance. A balance is needed in preserving species' habitat, natural areas and developing the renewable energy industry. Without this balance, valuable and beneficial clean energy projects will never get past the permitting phase and the likelihood of negative ecological impacts occurring in the developed areas is much higher.

The potential adverse impacts of the renewable energy facilities are minimal at most; however, it is still helpful to consider the impact of the development and identify the best use of the land. Our research led us to conclude that planting a pollinator habitat and incorporating agrovoltaics would be most compatible with the renewable energy infrastructure and the goals we set out to achieve. The pollinator habitat we envisioned would include a garden of diverse, native wildflowers that serve to attract pollinators to the area surrounding the solar panels and/or wind turbines. This could be a very low-cost way to improve the landscape and provide an opportunity for profitable activities such as beekeeping, gardening, and fruit production. The pollinator habitat and pasture seed mixes are presently be pioneered to support livestock. Given concerns that shading from PV panels might reduce nutrient value of pasture, this may be a valuable opportunity to research this question of nutrient value. A pollinator habitat would also provide many benefits to the community such as a thriving bee population, aesthetic value, and more educational opportunities.

Economic Sustainability Team

Students on the Economic Sustainability Team' identified costs, revenues, power outputs, net present values (NPV), and siting locations for each alternative. They created a Google spreadsheet to calculate the information, so we could present the most accurate information possible at each charrette. They identified the costs of purchasing, installing, and maintaining both PV and wind. The team found accurate, power output calculators online to attain those numbers. Students wanted to be highly conservative in assess the economic feasibility of the alternatives, so chose a $0.05 per kWh rate to assess the revenue for each alternative.

The solar panel chosen was a 325W PV panel, as an industry standard for performance and price in 2019. The wind turbine selected was the Northwind 100 on a 117 foot tower, with a total height of

160 feet, based upon consultation with Dr. Kuester of Virginia Tech and Dr. Jon Miles of James Madison University. The tables presented at the final charrette are shown below. Dr. Meyers supported student efforts to make the choice of a very conservative price for the renewable energy power, but believes that revenue estimates are underestimated by about half, and therefore the Net Present Value is skewed to the negative. If VT administration decides to pursue the project, more detailed project planning will occur, including for financial viability. Students did excellent work to obtain all other data and perform the calculations needed to create these tables, shown in Figures 39, 40, and 41.

Alternative 1: Solar only

68.6 acres total solar PV

CSC: 13.9 acres solar, no wind

CH, 54.7 acres solar PV, no wind

Power Source	Purchase + Installation Costs	20 Year Costs	20 Year Revenue	NPV: Calculated over 20 years with a 7% discount rate	Annual Power Output
68.6 Acres of PV Solar	$18,504,850	$3,975,360	$23,752,217	-$7,359,358	18.51 MW
				% Power of 3 GW Annual Goal	0.00617%

Figure 39: December Alternative 1: Power, financials

Alternative 2: Mixed solar & wind at both CSC and Catawba Hospital

68.6 total acres solar PV, 13 total turbines

CSC: 13.9 acres solar, 3 turbines

CH: 54.7 acres solar, five turbines

Power Source	Purchase + Installation Costs	20 Year Costs	20 Year Revenue	NPV: Calculated over 20 years with a 7% discount rate	Annual Power Output
68.6 Acres of PV	$18,504,850	$3,975,360	$23,752,217	-$7,359,358	18.51 MW
8 Turbines	$4,560,000	$875,520	$402,560	-$4,810,496	402.62 MW
				Combined NPV	-$12,169,973
				% Power of 3 GW Annual Goal	14.03 %

Figure 40: December Alternative 2: Power, financials

Alternative 3: Solar only at CSC, solar & wind at Catawba Hospital

68.6 total acres solar PV, 20 turbines

CSC: 13.9 acres solar PV, no wind

CH: 54.7 acres solar PV & 20 turbines to reach 3 GWh/year

Power Source	Purchase + Installation Costs	20 Year Costs	20 Year Revenue	NPV: Calculated over 20 years with a 7% discount rate	Annual Power Output
68.6 Acres of PV	$18,504,850	$3,975,360	$23,752,217	-$7,359,477	18.51 MW
60 Turbines	$34,200,000	$6,566,400	$3,019,620	-$36,078,720	3 GW (3,000 MW)
				Combined NPV	-$43,438,197
				% Power of 3 GW Annual Goal	100%

Figure 41: December Alternative 3: Power, financials

However, in each of the three siting and power output alternatives, the NPV will be negative. The wind turbines, although a great thought in practice, would lead to higher negative Net Present Values that would most likely be infeasible to the University. This is due to the valley not providing productive wind speeds as we had hoped. In fact, the wind speeds present in the valley are both too low, to become economically viable but also inconsistent in nature. With that being said, we do feel as if the implementation of solar panels at the CSC, could provide very useful and valuable for further

education. It is unfortunate that the NPV for each of the three alternatives comes to such a high number, but we have learned a tremendous amount from this research and community outreach process, and will carry this knowledge and experience with us into our future endeavors.

Mutual Gains and Choosing By Advantages Processes for December Stakeholder Meeting

Students and the VT-REFS team used feedback from the September stakeholder meeting to identify eight factors for the December CBA process to support stakeholder decision making, and consulted with stakeholders to ensure these were useful and acceptable. These factors evolved from the five new factors listed at the end of the September meeting due to subsequent conversations, more research, etc. The eight factors are in Figure 42.

Decision factors organized by sustainable renewable energy facility siting approach
Social sustainability
1. CSC & VT research/service/teaching
2. Scenic quality impacts
3. Acoustic quality impacts
Environmental sustainability
4. Percent power provided for CSC and Catawba Hospital (CO2 reductions & number of households powered also provided)
5. Avian impacts
6. Habitat improvement
Economic sustainability
7. Economic feasibility
8. Economic viability of Catawba Valley

Figure 42: Eight decision factors used in December 2019 Choosing By Advantages process

The explanation of the mutual gains and Choosing By Advantages process used at Catawba was described in the section concerning the September stakeholder meeting. The same process was used with a similar stakeholder group for the December stakeholder meeting, so we focus on the results here. Stakeholders indicated that they were satisfied with the eight factors students and VT-REFS brought for their decision making. Stakeholders were more familiar with the CBA process, and the number of alternatives fewer, so the discussion was easier. Figure 43 shows the full CBA spreadsheet developed.

FACTORS		ALT 1- 49 acres PV no wind	Alt 1 - importance of advantage 1 - 100	ALT 2 – 49 acres PV, 3 turbines CSC, 5 turbines CH	Alt 2- importance of advantage 1 - 100	ALT 3 – 49 acres PV, 60 turbines at CH, 0 at CSC	Alt 3 - importance of advantage 1 - 100
Economic sustainability							
1. Economic feasibility	Attribute	-$7MY		-$12MY		-$43MY	
	Advantage	**$36M better than Alt 3**		$31M better than Alt 3			
2. Improve economic viability CSC, CH, Valley	Attribute	Positive		Negative (small turbines inefficient)		Very negative (more small turbines lose more money)	
	Advantage	**Best**		Better than Alt 3			
Social sustainability							
3. Improves CSC & VT research/service mission	Attribute	Opportunities for solar PV research		Solar PV and wind research		Solar PV and more wind research	
	Advantage			More Positive		**Much More Positive**	
4. Scenic quality							
4a. Existing scenic quality (1-5 (high)) for all viewpoints							
4b. Scenic quality with alternative (1-5)							
4c. Net change scenic quality	Attribute						
	Advantage						
Environmental sustainability							
5. Potential to reduce greenhouse gas emissions	Attribute	x MWh/yr. - x houses		x MWh/yr. ~x houses		x MWh/yr. ~x houses	
	Advantage			x MWh/yr. ~x houses better than Alt 1		**x MWh/yr. ~x houses better than Alt 1**	
6. Potential to provide 100% renewable energy for CSC and CH	Attribute	0.006% of energy for CSC and CH		14% of energy for CSC and CH		100% of energy for CSC and CH	
	Advantage			x% more than Alt 1		**x % more than Alt 1**	
7. Avian impacts	Attribute	0 losses		4 bats/yr.		10 bats/yr.	
	Advantage	**saves 10 more bats/yr. than Alt 3**		saves 6 more bats/yr. than Alt 3			
8. Habitat improvement	Attribute	TBD		TBD		TBD	
	Advantage	TBD		TBD		TBD	
Total Importance of Advantages			**0**		**0**		**0**

Figure 43: Eight factor CBA table for December stakeholder meeting

The visualization effort was greatly expanded for the December stakeholder meeting, as described above. The same process for stakeholders to view and discuss the visual assessments was done. The consensus alternative emerged quickly once the economics of the project were discussed. It was clear that wind energy at a smaller scale was infeasible given the low wind regime at the site. The stakeholders indicated strong support for solar PV at the scale proposed. However, there was not consensus about the potential ten acre array on the Catawba Hospital property adjacent to Catawba Valley Road. This reflected disagreement over the aesthetics of solar PV, where those who do not like solar PV arrays but want renewable energy prefer arrays in locations whe Acceptable Less Least impact. Those who aesthetic preference is to see well-designed PV arrays, that do not dominate the landscape but work with it, wanted to have a PV array adjacent to Catawba Valley Road. If a solar PV project at the site is pursued further, stakeholders want to be involved in reviewing more detailed design plans to ensure their acceptability.

At the close of the December meeting, Dr. Grant presented the work of the Architecture III design laboratory students in a PowerPoint slide show. These students had been working independently of the VT-REFS team since the September charrette to design theoretical photovoltaic cattle shading structures situated in the field labeled CSC PV3 in Figure 25, and a proposed renovation and expansion of the existing historic Dairy Barn at the Catawba Sustainability Center to create a new Outreach and Education Facility. These efforts, while not at the scale of the PV installations proposed by the VT-REFS team, were intended to support the visibility of the project and provide a venue for expanded research and education into agrovoltaics and renewable energy on the CSC site. Figures 44 and 45 are a sample of student designs for both the cattle shading structure and the Outreach and Education Facility.

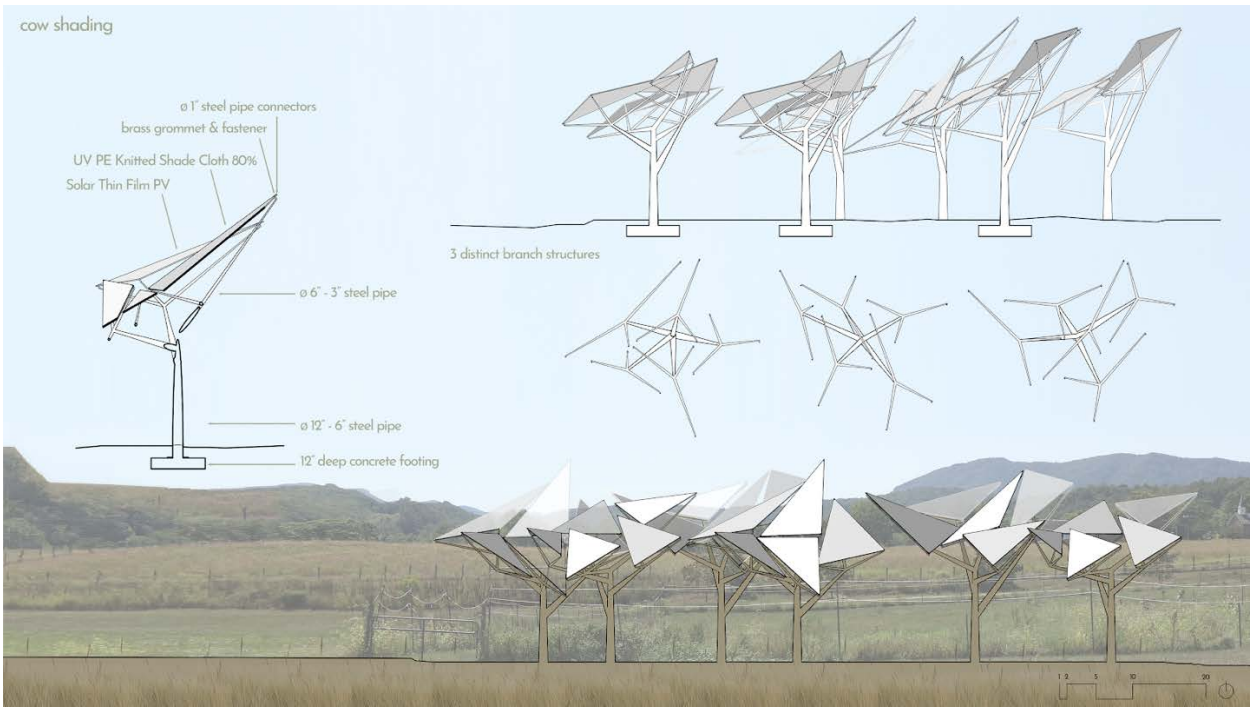

Figure 43: Example of design for cattle shading structure by Isaiah Ho

Figure 44: Example of design for Outreach and Education Facility at CSC by Isaiah Ho

Conclusion

The Catawba Project was a very successful effort to maintain a prolonged stakeholder process to identify what size, type, footprint, and other conditions would work for a stakeholder group.

Stakeholder Agreement

Social Sustainability Conditions

The stakeholders agreed to site about 68 acres of solar PV sited on land currently in the agricultural use of haying, with the arrays strategically located throughout a larger acreage of land. It is Dr. Meyers assessment that if recommendations provided in the next section are followed, a much larger acreage of land would have been acceptable. Large (over 130 feet) wind turbines did not find consensus, nor were they fully explored for the site, due to the site's extreme sensitivity to visual impacts due to it being directly adjacent to what is regarded as the most iconic section of the entire Appalachian Trail. Stakeholders other the Appalachian trail community wanted to explore the economic and social feasibility of several large turbines that would provide enough renewable energy to power the Catawba Hospital. The Appalachian Trail Commission (ATC) indicated in discussion with VT-REFS that they understood that their policy against large (i.e. multi megawatt, multi turbine projects) wind projects within ten miles of the trail needs to be revisited. They support efforts to site REFS as an important strategy to address climate change. They are exploring how to prioritize protecting higher-quality scenic areas, and that in some locations with lower scenic quality siting wind farms closer than ten miles needs to be explored. VT-REFS welcomes the opportunity to collaborate with the ATC and RATC to explore this issue.

Stakeholders requested that if VT moved forward with a project, that site designs be shared with them prior to finalization, for their input.

Stakeholders wanted renewable energy for their households. REFS indicated that the proposed project could not do this because VT was not their power provider, so legal restrictions made it not possible for the project to provide local homeowners an option to purchase power from the project. Blacksburg and Roanoke both have had Solarize programs, which help homeowners identify prescreened solar PV financing and construction firms, and reduce the price of solar PV. VT-REFS does not have the capacity at this time to lead the creation of a program for Roanoke County. However, the final report could recommend that VT, if they pursue the project, request that a program be developed to support their ability as homeowners to put solar PV on their homes.

Environmental Sustainability Conditions

Photovoltaics would be utilized. Stakeholders concern over loss of farmland and the rural character of the area were addressed by recommending that sheep and cattle grazing, and pollinator plants, recognizing the environmental and economic value of this approach. This was a new idea for most the stakeholders, and they embraced it a way to create land that was both agricultural and generated renewable energy.

Site would not be leveled. Stakeholder concern over soil erosion and increased runoff was addressed by recommending that construction methods not level the land, but would place the arrays onto the landscape with its natural slopes.

No arrays placed close to Catawba Creek (distance not specified). Stakeholder concern over soil erosion and water quality being affected by construction of arrays close to Catawba Creek was addressed by siting arrays away from Catawba Creek.

Concerns for avian impacts were addressed when the no-wind recommendation was made. VT-REFS research efforts regarding wind included efforts to identify threatened, endangered, and listed species at the project site, and obtain expert opinion that there would be no adverse impacts on any species appeared to be accepted.

Construction method would be to drive steel posts into the ground. Stakeholder concerns over the loss of agricultural land was also addressed by recommending that steel posts to support racking would be driven into the ground so they could be removed later.

Economic Sustainability Conclusions

The community supported the project alternative that would be most economically viable, to be supportive of the CSC and Catawba Hospital. They did

Environmental Problem Solving Course Student Conclusions

Students in the Environmental Problem Solving course wrote their own conclusions as part of the first draft of this report. Their verbatim conclusions were:

The Environmental Problem Solving Studio's renewable energy site planning project at the CSC and Catawba Hospital has helped the class experience how complicated the process can be. The research and effort that must occur to attain even a basic understanding of site planning renewables is extensive, however, it is worth it to be able to provide accurate estimations of feasibility for projects such as these. Through the studio, we also learned how to facilitate conversations concerning renewable energy to successfully engage the community. This proved to be essential when it came time to present at the final charrette. Community members are important stakeholders when it comes to renewable energy site planning, as they are the people who must live and work near these locations. Their input is extremely valuable and being able to communicate effectively with them to ascertain their opinions is important in being able to take the next steps in the site planning process. As a class, we were able to practice this first hand at the charrette, and it is something that we will take with us as we move into the professional world, whether we end up working in renewable energy site planning or not.

Environmental Problem Solving Studio, Instructor Conclusions

The course was designed to be highly challenging capstone course for students, requiring them to integrate the knowledge and skills – including teamwork – they gained through four years of study in the Environmental Policy and Planning Course. For the first time (to the instructor's knowledge), they were provided a research and engagement project in the community that was highly complex in that we sought to address project economics, environmental considerations, and social equity. The complexity was likely too high with the addition of the student project being part of a larger faculty and community research effort to develop the methods for how to do a siting project. This meant that students were conducting action research on how to do siting well, studying how the processes they were developing (based on prior research by faculty) were working in real time. The process was also highly dynamic. As new information was found by students and the community, it needed to be incorporated into the project and used to slightly alter the direction of the project, particularly with the alternatives being developed and the information needed to share with the community. Like environmental projects, there was high ambiguity, in that there were very few clear answers about what was right or wrong to do. Rather, there were multiple factors that were being taken into consideration to develop and evaluate alternatives, and to guide the community decision making

process. The community had strong opinions and preferences that needed to be considered, and doing so changed the alternatives being considered. The instructor learned that the project was too complex and ambiguous as done for the class as a whole. Additional methods to provide more structure and feedback to students could have been incorporated, and likely would have been very helpful to students.

As noted by Dr. Grant, the course also included the challenge of working across disciplines, thanks to her engagement of the Architecture III Design Laboratory students with our class. Our students benefitted tremendously from the experience, yet it also added complexity.

Architecture III Design Laboratory, Instructor Conclusions

The architecture students participating in the project are accustomed to being presented with more circumscribed projects that allow them individual design freedom, and they are most confident when working in this way. Consequently, participating in this project pushed them out of their comfort zones as they were expected to quickly understand and embrace the potential of renewable technologies, employ decision making systems, guide community meetings, collaborate with peers from a different discipline, and adapt to complex and rapidly changing project parameters. The students found the process stressful, but acknowledged the benefits they gained in terms of a broader understanding of the social, environmental, and economic impacts of REFS, and exposure to community engagement in practice. Both benefits will serve them well in their architectural vocations.

Next Steps for VT-REFS and the Catawba Sustainability Center and the Catawba Hospital Solar PV Projects

Catawba Sustainability Center

VT-REFS is working with the VT Climate Action Plan revision committee to have solar PV development at the Catawba site considered as a priority project. Given the present crisis due to COVID-19, it is uncertain when VT might adopt a revised climate action plan, and if it does so, if the Catawba Sustainability Center will be considered. If the project does move forward, we would welcome continuing the stakeholder engagement and site planning efforts to complete the process through project completion.

Catawba Hospital

Due to the COVID-19 crisis, and the Catawba Hospital 's prioritization of converting their steam boiler to bio-fuels, it is uncertain when a solar PV project will be considered. If the project does move forward, we would welcome working with them for more detailed site planning and continuing the stakeholder engagement and site planning efforts to complete the process through project completion.

Recommendations for Next Pilot of VT-REFS Sustainable Siting Process

Recommendations for Next Pilot of Social Sustainability Process

1) Additional materials and website are needed to explain to stakeholders what the VT-REFS process is, and what VT-REFS role is in promoting sustainable siting practices and projects. This collaboration of the Catawba, Appalachian Trail, and VT faculty communities was the first step to co-create a new, more equitable and sustainable approach to siting renewable energy facilities. When VT-REFS approached the Catawba and Appalachian Trail communities, there was significant confusion about what we were doing, because we were seeking to develop, with them, a new "thing". VT-REFS was, and still is, inventing and testing this approach and how it would fit into and change existing siting processes. After several meetings, the stakeholder group understood the effort and agreed to continue participating in a process to identify research they needed, and evaluate the research, to help identify what renewable energy project would be suitable for Catawba Valley. They also understood that this was a faculty-initiated effort to see what kind of REF was suitable for the site, if any, and that much work needed to be done at VT for it to create policies needed for the administration to even begin to explore siting REFs.
2) Given that this was the first use of the CBA process for renewable energy siting, VT-REFS looks forward to improving all materials used in all processes, including the CBA materials.
3) The next pilot project for the VT-REFS "ideal" process should maintain the approach of bringing no concrete alternative to the first meeting, but describe the proposed process we are suggesting to co-create project alternatives and select one or two project alternatives that maximizes gains for all stakeholders, share the interests, assets, concerns (including important viewpoints), and research questions of all stakeholders. At a second meeting, identify potential total MW options, footprints for PV arrays, factors needed for decision making between specific alternatives, and research efforts proposed to answer stakeholder

questions. At roughly the third meeting, VT-REFS would bring project alternatives and their potential social (including visualization studies), environmental, and economic impacts, and use the choosing between alternatives to facilitate discussion to identify which alternative(s) is/are preferred for maximizing those benefits most important to each stakeholder. If necessary, a fourth meeting would be held to further refine project alternatives and again identify which alternative(s) is/are preferred for maximizing those benefits most important to each stakeholder.

4) The visualization studies should incorporate greater detail and use of landscape architects to help place each solar array and the balance of the PV system so a more realistic sense of the visual impacts can be assessed by stakeholders.

5) The alternatives presented and the recommended alternative(s) should identify how they meet and/or exceed all requirements of county or municipality zoning codes, and next steps in various permitting processes.

6) A sample RFP for land managers to issue's to energy service companies (ESCO's) for competitive bids should be developed to help ensure that all stakeholders obtain the maximum benefits for factors of importance to them.

7) Stakeholders are shown cases of PV projects where siting and community influence were not taken into account, and how the community responded once the projects were installed.

Recommendations for Next Pilot of Environmental Sustainability Process

8) The process should continue to identify ways to place alternatives on the landscape so environmental impact is minimized. This includes minimal cutting of trees, placement so no land leveling is required, and consideration of impacts on wildlife corridors. The consideration of how to improve wildlife habitat through site planning and design should continue.

9) Showcase natural health benefits to solar PV arrays especially on agricultural lands. This could include the solar arrays relationship to cooling soil temperatures at the directly benefit the growth of certain grasses, pollinator, and woody species.

10) The process should be organized so that all environmental permitting needs are clearly identified by the second stakeholder meeting, and the research done by VT-REFS is organized by permits needed. Environmental concerns that go beyond permitting requirements should also be clearly identified as such, so that concerns that are beyond

regulatory requirements are clearly understood as such.

11) The process should identify as specifically as possible the acreages to be devoted for each environmental benefit, the costs for each benefit, and the potential positive impacts of those impacts. This provides helpful information for stakeholders, and builds a record of research for future site planning.

12) Program/grant/cost sharing opportunities to offset costs of actions to provide environmental and wildlife benefits should be identified in as much specificity as possible to provide land managers and the public with the knowledge they need to access these programs at the proposed project and other sites.

Recommendations for Next Pilot of Economic Sustainability Process

13) The practice of identifying project economics for alternatives should be continued.

14) The additional construction/installation costs and reduced maintenance costs, and additional income from agrovoltaics should be included for each alternative to better characterize project economics for stakeholder decision making.

15) Economic breakdown of various agrovoltaic practices that would include energy credits added to vegetable and livestock operations incorporating solar PV into production models.

Limitations of the Project

The fact that there was no project being proposed was a limitation of this project, because it lessened the sense that a project was going to be built. VT-REFS understood this and considered to be a positive aspect of the project, since this was the second pilot test of a process under development. Another major limitation was that VT-REFS role in the project was not the same as what we hope to become. The role that VT-REFS wants to create is two-fold.

The simpler and more traditional role is to serve as a neutral research and information resource on best practices on how to assess, mitigate, and improve environmental, economic, and social impacts of REFs for all parties involved in REF siting. The stakeholders appeared to trust the research and information we developed in response to stakeholder requests.

More innovatively, we hope to be a neutral third party that can work with communities (including

government), ESCO's, and developers to facilitate a stakeholder process to determine if, and if so, under what conditions a REF should be sited in a community, so mutual gains are achieved that benefit all parties. In the Catawba Valley, we initiated the idea of a REF at the site, VT owned and managed the site, while VT-REFS sought to be the neutral party to facilitate the stakeholder process. It was necessary for VT-REFS to set up the project this way given our funding limitations and the need to find a land manager and community that would participate in the study. This ambiguity over REFS role limited our ability to explore and co-create with stakeholders how we could be an external neutral third party. Again, since this was the second pilot study of a process still in development, and given the limitations of the study, VT-REFS accepted this limitation.

Another limitation was that there was significant support for VT, particularly the Catawba Sustainability Center, and the Catawba Hospital in the community and stakeholders. Since the project would benefit these community institutions, the community support for the project was increased. However, since ESCO's and developers understand that it can be very beneficial to identify an important community institution and try to support that institution through the siting process with community benefits funding, perhaps this is not a significant limitation.

A challenge to the project was that the total stakeholder process took from May to December 2019, about eight months. Stakeholder feedback and REFS analysis suggests that compressing the timeline to three months would be feasible and work much better.

Renewable Energy Facilities Siting Project
Catawba Valley Renewables Exploration
Briefing Paper #1: Background and Stakeholder Process

Virginia Tech Project Background

We are VT faculty and staff who believe that better ways to site renewable energy facilities (REFs) need to be found and tested, whereby the public is more satisfied with site choice. Climate change impacts the whole population and every facet of our economy and well-being. Nearly 100% of the polled U.S. public are confident that a changing climate will pose a serious threat in their lifetime. Sixty percent believe climate has begun impacting our lives already. Virginia is experiencing a renewable energy expansion that is likely to significantly increase. For this increase in renewables to help, not hurt, Virginia, the public needs to be better involved in REF siting to address their interests, and proponents and operators need to both protect and enhance existing environmental conditions. We appreciate many locations should not have REFs for a host of reasons, and that public opposition to REFs is warranted due to poor public engagement in the siting process, significant environmental impacts, inequities in the distribution of costs and benefits, and visual and auditory impacts.

We study how to avoid, reduce, and mitigate harmful impacts of siting and operating REFs. Fortunately, research and practice show that meaningful, early public engagement and project-based research can find solutions to community, environmental, and economic siting challenges. We are adapting and extending that research specifically for renewable energy siting challenges so REFs benefit people, the environment, and the economy. We need to conduct practical research on this, and to partner with the Catawba Valley to do it.

Catawba Valley Project Background

Catawba Valley is a beautiful area, home to farm and forests, community members, tourism, and vacation homes. Both Virginia Tech and the Catawba Hospital are local landowners that have sought to benefit the local community and Commonwealth. There are many jobs and valuable research supported at these locations. Both institutions have a need to become more sustainable and generating renewable energy can help achieve this goal.

We are not proposing a specific REF now. VT faculty cannot do that. We want to explore, with Catawba Valley, what kind of public engagement process would help all of us decide if a modest renewable energy facility might work in our community, and if so, under what conditions.

Proposed Community Engagement Process

We are "flipping" this siting process so Catawba residents can share their interests and concerns at the *start* of a potential siting process to help find answers they need to make complex decisions.

- We are forming a Stakeholder Committee, since these are an excellent way to have a long term dialogue to share perspectives, identify research needed for complex community decision making, and evaluate what that research says, together. They reduce community conflict that occurs at public hearings when people only have a few minutes to state their opinion.
- Anyone is welcome to join the Stakeholder group if they are committed to having meaningful dialogue at a series of Stakeholder meetings. There may be three to five over next several months. The rough number and timing of meetings will be set by the Stakeholder group.

- We will decide what information needs to be gathered at an early Stakeholder meeting. New questions can be added later as new information is gathered and considered.
- The next several Stakeholder meetings will share and discuss information gathered to answer the Stakeholder research questions.
- Virginia Tech plans to have students survey Appalachian Trail users for their opinions in the early fall, if the National Park Service gives permission.
- Once the Stakeholder group makes recommendations for whether REFs might be suitable, and recommendations for their siting, this will be written up as a report. We may invite administrators from Virginia Tech to a final meeting to discuss our interests and recommendations.

Renewable Energy Facilities Being Considered

The two properties include about 1,000 acres. Much is wooded, with some steep slopes. The Catawba Hospital land includes many buildings, and walking grounds for patients. The CSC includes pastures for haying, a range of agricultural research activities, and forests.

- Solar PV. The total acreage is unknown. The number of arrays is unknown. Because of some public concerns that solar PV will reduce agricultural character of communities, we are exploring how to maintain agricultural production under and around the arrays. Existing agricultural and forestry experiments will be maintained. Because of concerns for aesthetics, alternative solar PV array designs will be explored, so arrays "follow" the contour of the land, have the framework (racking) painted a neutral color, and other alternatives.

- Wind turbines are being explored. Because no engineering studies have been done, it is not known if wind energy is a viable alternative, since wind speeds and turbulence are unmeasured. The potential number of turbines is unknown but would not exceed seven. The public engagement process is likely to require extensive visualization studies so the community can decide what number, if any, works for the community, given the benefits that renewable energy production will bring to the Catawba Hospital, the CSC, and Catawba Valley. The Appalachian Trail Conservancy will participate in the Stakeholder process to ensure that their interests are protected.

Community Benefits

Catawba Valley benefits extensively from the employment provided at the Catawba Valley Hospital, and from the presence of the CSC. Both institutions would be strengthened by generating renewable energy to reduce their energy bills and supporting research at Virginia Tech. The community may take pride in helping Virginia Tech generate renewable energy, and in being a showcase for how to develop a model renewable energy facility siting process and project. Other benefits can be identified and requested by the Stakeholder committee.

By Ron Meyers, Ph.D., Research Assistant Professor, Department of Fish and Wildlife Conservation, Virginia Tech rbmeyers@vt.edu. 540-570-9535. June 18, 2019.

Glossary

Balance of System – In photovoltaic systems, all the equipment required to generate (and if desired, store) electricity except for the solar panels and the equipment needed to mount the panels onto a roof, the ground, or (rarely) a waterbody.

Site footprint – The specific location for all renewable energy equipment and facilities any educational infrastructure, fencing, and project associated facilities.

Solar cells, modules, panels, arrays, field - A solar cell converts sunlight to electricity. When solar cells are wired together into one large piece, usually about a square yard in size, they are called a solar module. When multiple solar modules are put into a long line of several to hundreds of modules on a roof, or a mounted together on the ground, they are a solar panel. On both roof and ground mounted systems, more than one array is usually placed around obstacles or in locations that are more desirable or technically feasible (i.e., do not interfere with existing land uses, have fewer visual impacts, avoid wooded areas, streams, et al). By Rfassbind - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=34961018

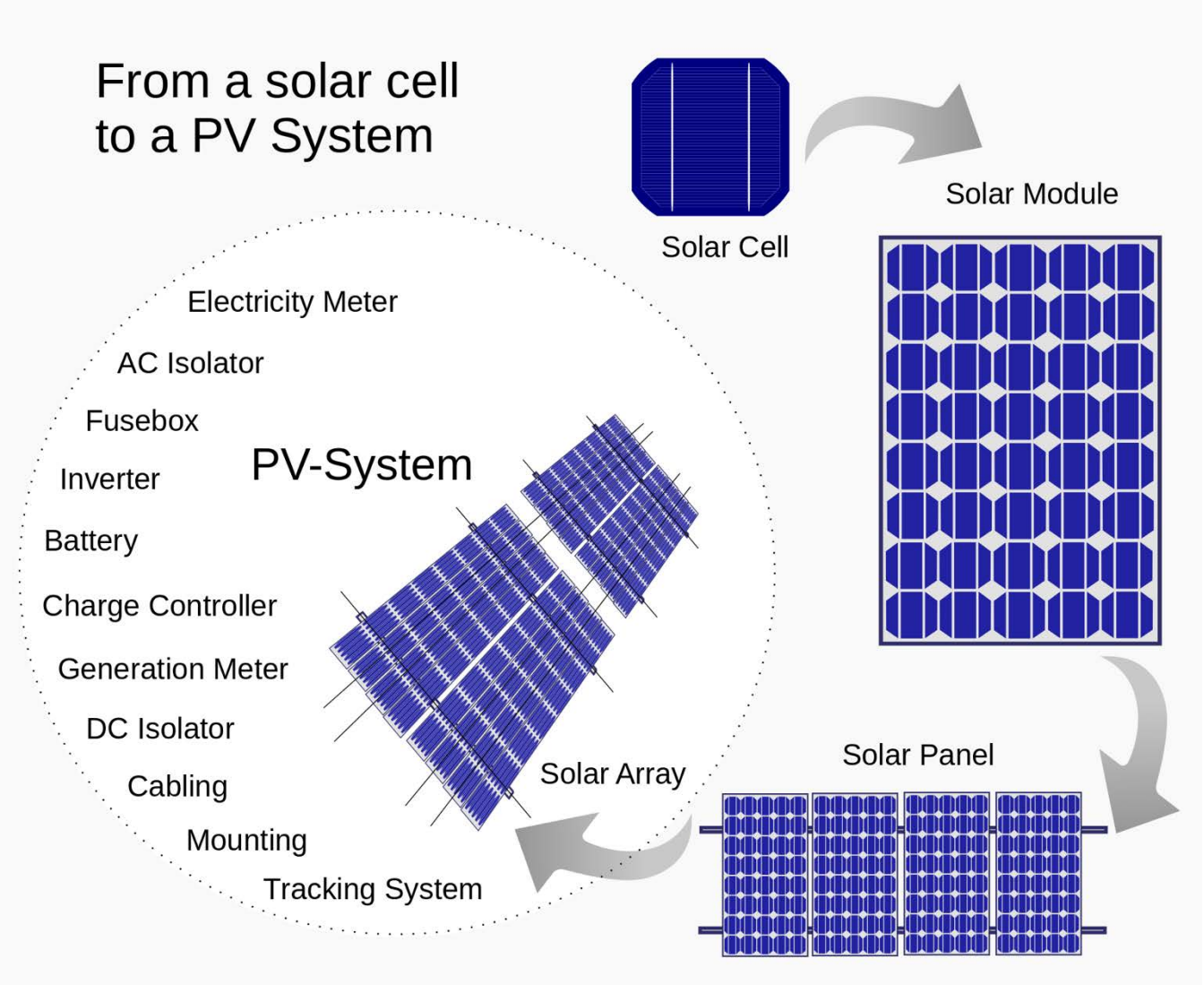

Figure 45: Solar cells, modules, panels, arrays, and systems