Northern Arizona University
NAU Capstone
New Mexico State University
4.B. Development Plan – Construction Plan

1 Summary of Development Plan

Development Plan 4B includes a construction and development plan to implement the proposed designs. It is compiled of the necessary construction and land use permits, compliance with applicable local codes, potential risks to successful deployment, and an approach to address potential concerns and questions of district decision makers and surrounding community members.

2 Analysis of Permitting and Relevant Code Requirements

The State of New Mexico has adopted the 2015 International Building Code (IBC), International Residential Code (IRC), and International Fire Code (IFA) as well as the 2009 International Energy Conservation Code [1]. Given the assumption that the land east of campus located across from the Geothermal Substation is owned by NMSU, the team determined that all of the subsystem's permitting and codes would be governed by the regulations that the state has adopted. The permitting and relevant code requirements are listed in Appendix A, under Table A1.

International Residential Code [2]

R324.4.1 - Roof structures that provide support for photovoltaic panel systems shall be designed for applicable roof live load. This code could be applied to the Spanish Tiles being placed on Hadley Hall, but the Solar District Cup rules tell us to assume structural integrity for all buildings. This code will be met for the Pan American Parking Structures by using structures that have already been manufactured and tested for these applications.

R905.1 - Roof coverings shall be applied in accordance with the applicable provisions of this section and the manufacturer's installation instructions. To meet the requirements of this code the team in charge of installing the Spanish Tiles must follow the manufacturer's installation instructions properly to ensure adequate safety and system functionality.

R301.1 - Buildings and structures, and parts thereof, shall be constructed to safely support all loads, including dead loads, live loads, roof loads, flood loads, snow loads, wind loads and seismic loads as prescribed by this code. The construction of buildings and structures in accordance with the provisions of this code shall result in a system that provides a complete load path that meets the requirements for the transfer of loads from their point of origin through the load-resisting elements to the foundation. This code applies to the ground-mounted system and parking structures. In order to reach these code regulations both systems must meet the climatic and geographic design criteria. This includes wind/snow loads, weathering, and seismic design criteria.

R905.16.2 - Photovoltaic shingles shall be used only on roof slopes of two units vertical in 12 units horizontal (2:12) or greater. The team's photovoltaic Spanish Tiles will be placed on Hadley Hall assuming the roofs slope meets these requirements.

R905.16.3 - Unless otherwise noted, required underlayment shall conform to ASTM D 4869 or ASTM D6757. The underlayment beneath the Spanish Tiles must conform to the ASTM requirements given. These specific underlayments are used in steep slope roofing. R905.16.4 in Appendix A, Table A1 provides the underlayment application requirements. They shall be applied shingle fashion, parallel to and starting from the eave, lapped 2 inches and fastened sufficiently to hold in place.

R905.16.5 - Photovoltaic shingles shall be listed and labeled in accordance with UL 1703. Complying to this will mean all shingles will be listed and labeled appropriately.

R902.3 - Building-integrated photovoltaic products installed as the roof covering shall be tested, listed and labeled for fire classification in accordance with Section R902.1. This code requires all PV products installed on the roof to be tested, listed, and labeled for fire classification which ties into the NFPA 70 guidelines for rapid shutdown of photovoltaic systems.

NFPA 70 [3]

690.12 – Rapid shutdown of photovoltaic systems. This code is extremely important because it allows firefighters to quickly decrease the size of the system to rescue/put out fires. This code will be implemented on all subsystems.

International Building Code [4]

1503.2 - Flashing shall be installed in such a manner so as to prevent moisture entering the wall and roof through joints in copings, through moisture-permeable materials and at intersections with parapet walls and other penetrations through the roof plane. These flashings prevent moisture from penetrating the roof and preserve the structural integrity of the building. 1503.2.1 in Appendix A, describes the locations for the flashings.

406.3.2 - In private garages and carports, the clear height in vehicle and pedestrian traffic areas shall be not less than 7 feet. This code applies to the Pan American Parking structure and will be met by using structures that stand higher than 7 feet.

3306.2 - A walkway shall be provided for pedestrian travel in front of every construction and demolition site unless the applicable governing authority authorizes the sidewalk to be fenced or closed. Walkways shall be of sufficient width to accommodate the pedestrian traffic, but in no case shall they be less than 4 feet in width. All systems will have at least a 4-foot-wide pathway around the development site.

3306.5 - Barriers shall be not less than 8 feet in height and shall be placed on the side of the walkway nearest the construction. Barriers shall extend the entire length of the construction site. Openings in such barriers shall be protected by doors that are normally kept close. Fences of 8 feet will be placed around the entire Pan American Parking Lot, Hadley Hall, and Dirt lot throughout the construction process.

International Fire Code [5]

501.3 - Construction documents for proposed fire apparatus access, location of fire lanes, security gates across fire apparatus access roads and construction documents and hydraulic calculations for fire hydrant systems shall be submitted to the fore department for review and approval prior to construction. These documents must be submitted and approved to obtain construction permit.

105.4.1 - Construction documents and supporting data shall be submitted in two or more sets with each application for a permit and in such form and detail as required by the fire code official. The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed. The team will have to create construction documents for each of the battery and photovoltaic systems independently.

Additional codes that were not mentioned in this section are provided in Appendix A.

3 Construction Approach

Prior to construction, the team must gather the appropriate state, city, county, and fire permits required to begin construction. Initial construction documents and supporting data shall be submitted in two or more sets with each application for a permit in form and detail as required by the fire code official. The team will need to submit applications for each of the battery systems as well as three separate photovoltaic applications as required by IFC. These were theoretically submitted on April 1st giving the fire code official enough time to review them. Assuming they are approved construction may begin on May 1st. All three systems will be constructed simultaneously through the summer of 2020 (neglecting any COVID-19 effects) while many students have returned home.

4 Construction Timeline

The proposed timeline for the construction of the system will be a total of six months. This is assumed based on the rules for this competition. All the systems are also assumed to have the same commercial operation date. With that said, the site plans must be approved by the county and the county fire chief before construction may start. The final site plan is estimated to be completed by April 11th and giving the county and county fire chief time to approve the plans construction would be assumed to start on May 1st. With a six-month construction timeline that would mean that all systems would be operational by November 1st.

5 Strategy to Engage Partner District Decision Makers

Identify Motivations

The team plans on initially identifying what motivates the stakeholders. The primary stakeholder of this project is New Mexico State University. The University established a “zero emissions” goal that they would like to reach by 2050. By providing the energy offset the system will create over the next 20 years will catch the eye of the stakeholders. But what is everybody after? Money. The financial offset will show that not only are they getting closer to their PR goal of “zero emissions” but are also saving money while doing so.

Tell the Truth

Telling the truth even when it isn't what the stakeholders want to hear. Creating trust is essential to establishing relationships between stakeholders. Trust will create chemistry and when one can trust another it makes it much easier to buy into them. Trust will be enhanced throughout the project when deadlines are met and when the team comes together at difficult times.

Communicate Progress

When tasks are completed the team must update the stakeholders and reaffirm goals. This also applies when the project timeline starts to fall behind. Communication is essential in a successful project and having weekly, bi-weekly, or even monthly status meetings, depending on the scope of the project.

Consistency

Project leaders must provide guidance throughout all stages of the project. This will ensure the stakeholder that your project/company is reliable and approachable.

6 Strategy to Engage Community Members and Achieve Buy-in for Project

Hiring a public liaison for the project is a potential strategy to engage community members and achieve buy-in. This liaison would communicate the team's goals for the University to the public. In 2018, Las Cruces, New Mexico declared a goal to reach 100 percent clean energy dependence by the year 2050. With Las Cruces and NMSU trying to obtain the same goal the liaison could create relationships between everyone involved in the project and city council members. This would influence the public to support sustainability and potentially buy-in. This relationship could potentially create solar energy incentives from the city which in turn would benefit the public, solar development company, and the city reach their goals.

7 Discussion of Risks to Successful Deployment

A potential risk to the ground-mounted photovoltaic system implemented east of campus would be the Authority having Jurisdiction (AHJ) changing plans for an adjacent road requiring additional right of way width that may encroach on the site within the project's lifetime. Additionally, the residential area southwest of the Geothermal Ground Mount system may use that area for recreational purposes such as motocross which may present a public hearing in which the company would have to attend and present the proposal to the planning and zoning commission.

8 Approach to Addressing Potential Concerns of Community Members and District Owners

Since New Mexico State University incorporates the implementation of solar energy systems in their master plan the team assumes that the University will not provide any potential concerns. However, the students may not appreciate the increase in cost of parking permits.

The residential area southwest of the Geothermal Substation may be concerned in the aesthetics of the PV system. The team plans to mitigate these by surveying the surrounding area prior to submitting the construction plans to the fire code official. This will allow the team to address the

potential concerns prior to construction. Questions such as; What are your thoughts on this potential design? If this project is implemented how could be create it in a way that benefits the community?

9 Feasibility Analysis

All permits have been acquired from the appropriate districts ensuring all necessary permits have been discovered. All codes required to obtain adequate construction planning has been integrated into the system design which guarantees approval from the fire code official allowing the team to obtain permits to begin construction. Overall, all necessary precautions have been met in order to have a successful deployment.

Works Cited

[1] International Code Council, "State Adoptions," International Code Council, 2015. [Online]. Available: https://www.iccsafe.org/advocacy/adoptions-map/new-mexico/. [Accessed 13 April 2020].

[2] International Codes Council, "International Residential Code," International Codes Council, January 2016. [Online]. Available: https://codes.iccsafe.org/content/IRC2015/toc. [Accessed 13 April 2020].

[3] National Fire Protection Association, "NFPA 70, National Electrical Code (NEC) Softbound," National Fire Protection Association, 2020. [Online]. Available: https://catalog.nfpa.org/NFPA-70-National-Electrical-Code-NEC-Softbound-P1194.aspx?order_src=G010&gclid=EAIaIQobChMI_5bl3Pvl6AIVRT2tBh3c-wtHEAAYASAAEgLrNfD_BwE. [Accessed 13 April 2020].

[4] International Code Council, "2015 International Building Code," International Code Council, 2015. [Online]. Available: https://codes.iccsafe.org/content/IBC2015. [Accessed 13 April 2020].

[5] International Code Council, "2015 International Fire Code," International Code Council, 2015. [Online]. Available: https://codes.iccsafe.org/content/IFC2015. [Accessed 13 April 2020].

Appendix A

Table A1: Codes Adopted by New Mexico

IRC [2]	
R324.4.1 Roof live load.	Roof structures that provide support for photovoltaic panel systems shall be designed for applicable roof live load. The design of roof structure need not include roof live load in the areas covered by photovoltaic panel systems. Portions of roof structures not covered by photovoltaic panels shall be designed for roof live load. Roof structures that provide support for photo-voltaic panel systems shall be designed for live load, Lr, for the load case where the photovoltaic panel system is not present.
R324.5 Building-integrated photovoltaic systems	Building-integrated photovoltaic systems that serve as roof coverings shall be designed and installed in accordance with Section R905
R324.6 Ground-mounted photovoltaic systems	Ground-mounted photovoltaic systems shall be designed and installed in accordance with Section R301
R905.1 Roof covering application.	Roof coverings shall be applied in accordance with the applicable provisions of this section and the manufacturer's installation instructions. Unless otherwise specified in this section, roof coverings shall be installed to resist the component and cladding loads specified in Table R301.2(2), adjusted for height and exposure in accordance with Table R301.2(3)
R905.16 Photovoltaic shingles	The installation of photovoltaic shingles shall comply with the provisions of this section, Section R324 and NFPA 70.
R905.16.2 Deck slope	Photovoltaic shingles shall be used only on roof slopes of two units vertical in 12 units horizontal (2:12) or greater.
R905.16.3 Underlayment	Unless otherwise noted, required underlayment shall conform to ASTM D 4869 or ASTM D6757
R905.16.4 Underlayment Application	Underlayment shall be applied shingle fashion, parallel to and starting from the eave, lapped 2 inches (51 mm) and fastened sufficiently to hold in place
R905.16.5 Material standards.	Photovoltaic shingles shall be listed and labeled in accordance with UL 1703.
R905.16.6 Attachment	Photovoltaic shingles shall be attached in accordance with the manufacturer's installation instructions.
R301.1 Application	Buildings and structures, and parts thereof, shall be constructed to safely support all loads, including dead loads, live loads, roof loads, flood loads, snow loads, wind loads and seismic loads as prescribed by this code. The construction of buildings and structures in accordance with the provisions of this code shall result in a system that provides a complete load path that meets the requirements for the transfer of loads from their point of origin through the load-resisting elements to the foundation. Buildings and structures constructed as prescribed by this code are deemed to comply with the requirements of this section.

R902.3 Building-integrated photovoltaic product	Building-integrated photovoltaic products installed as the roof covering shall be tested, listed and labeled for fire classification in accordance with Section R902.1.
IBC [4]	
1503.2 Flashing.	Flashing shall be installed in such a manner so as to prevent moisture entering the wall and roof through joints in copings, through moisture-permeable materials and at intersections with parapet walls and other penetrations through the roof plane.
1503.2.1 Locations	Flashings shall be installed at wall and roof intersections, at gutters, wherever there is a change in roof slope or direction and around roof openings. Where flashing is of metal, the metal shall be corrosion resistant with a thickness of not less than 0.019 inch (0.483 mm) (No. 26 galvanized sheet).
406.1 General.	Motor-vehicle-related occupancies shall comply with Sections 406.1 through 406.8.
406.3 Private garages and carports	Private garages and carports shall comply with Sections 406.3.1 through 406.3.6.
406.3.1 Classification.	Private garages and carports shall be classified as Group U occupancies. Each private garage shall be not greater than 1,000 square feet (93 m^2) in area. Multiple private garages are permitted in a building where each private garage is separated from the other private garages by 1-hour fire barriers in accordance with Section 707, or 1-hour horizontal assemblies in accordance with Section 711, or both.
406.3.2 Clear height.	In private garages and carports, the clear height in vehicle and pedestrian traffic areas shall be not less than 7 feet (2134 mm). Vehicle and pedestrian areas accommodating van-accessible parking shall comply with Section 1106.5.
406.3.5 Carports.	Carports shall be open on at least two sides. Carport floor surfaces shall be of an approved noncombustible material.
2702.1.2 Electrical.	Emergency power systems and standby power systems required by code or the International Fire Code Shall be installed in accordance with the International Fire Code, NFPA 70, NFPA 110 and NFPA 111.
3306.1 Protection required.	Pedestrians shall be protected during construction, remodeling and demolition activities as required by this chapter and Table 3306.1. Signs shall be provided to direct pedestrian traffic.
3306.2 Walkways.	A walkway shall be provided for pedestrian travel in front of every construction and demolition site unless the applicable governing authority authorizes the sidewalk to be fenced or closed. Walkways shall be of sufficient width to accommodate the pedestrian traffic, but in no case shall they be less than 4 feet (1219 mm) in width. Walkways shall be provided with a durable walking surface. Walkways shall be accessible in accordance with Chapter 11 and shall be designed to support all imposed loads and in no case shall the design live load be less than 150 pounds per square foot.

3306.5 Barriers.	Barriers shall be not less than 8 feet in height and shall be placed on the side of the walkway nearest the construction. Barriers shall extend the entire length of the construction site. Openings in such barriers shall be protected by doors that are normally kept close.
IFC [5]	
3310.1 Required access.	Approved vehicle access for firefighting shall be provided to all construction or demolition sites. Vehicle access shall be provided to within 100 feet of temporary or permanent fire department connections. Vehicle access shall be provided by either temporary or permanent roads, capable of supporting vehicle loading under all weather conditions. Vehicle access shall be maintained until permanent fire apparatus access roads are available.
3310.2 Key boxes.	Key boxes shall be provided as required by Chapter 5.
501.2 Permits	A permit shall be required as set forth in Sections 105.6 and 105.7.
501.3 Construction documents.	Construction documents for proposed fire apparatus access, location of fire lanes, security gates across fire apparatus access roads and construction documents and hydraulic calculations for fire hydrant systems shall be submitted to the fore department for review and approval prior to construction.
506.1 Where required.	Where access to or within a structure or an area is restricted because of secured openings or where immediate access is necessary for life-saving or fore-fighting purposes, the fire code official is authorized to require a key box to be installed in an approved location. The key box shall be of an approved type listed in accordance with UL 1037, and shall contain keys to gain necessary access as required by the fire code official.
105.4.1 Submittals.	Construction documents and supporting data shall be submitted in two or more sets with each application for a permit and in such form and detail as required by the fire code official. The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.
105.7.2 Battery systems.	A permit is required to install stationary storage battery systems having a liquid capacity of more than 50 gallons (189 L).
105.7.15 Solar photovoltaic power systems.	A construction permit is required to install or modify solar photovoltaic power systems. Maintenance performed in accordance with this code is not considered to be a modification and does not require a permit.
NFPA 70 [3]	
690.12	Rapid shutdown of PV System