Westside Airport Solar Siting and Feasibility Study

Final – May 10, 2022

PREPARED FOR
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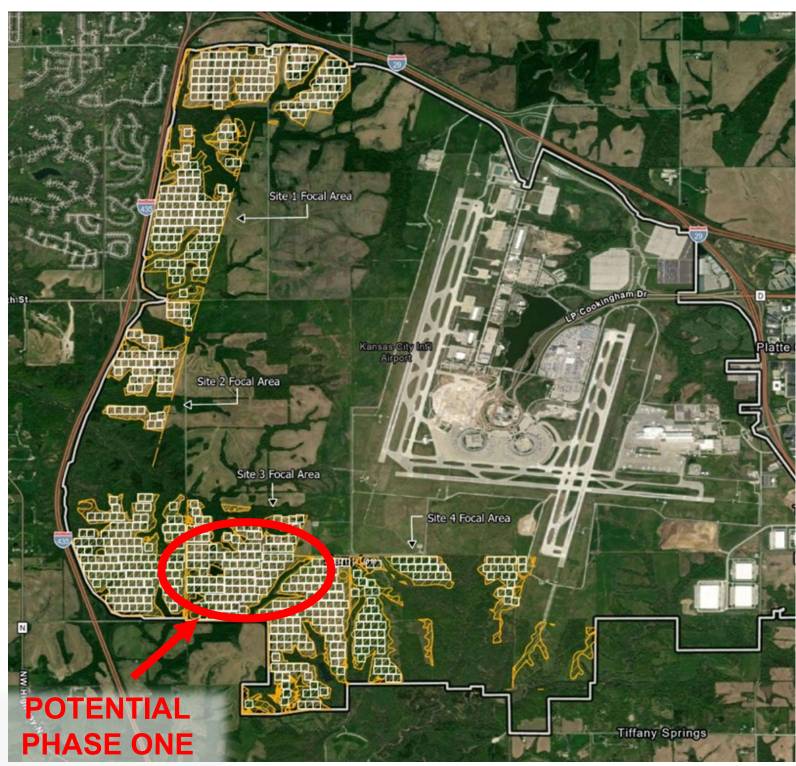
1 Summary

In pursuit of aggressive local and national sustainability goals and energy independence, the Kansas City Aviation Department (KCAD) and the City of Kansas City, Missouri (City) have taken steps to identify opportunities for development of a solar energy facility at the Kansas City International Airport (KCI) by conducting an initial siting and solar feasibility study. The siting and feasibility study includes:

- Lessons learned from other airport solar developments
- Potential land availability for solar development
- Preliminary energy output
- Infrastructure possibilities
- Path to market, and
- Next steps to implementation

The study considered airport property that was non-aviation development areas, primarily on the west and south side of the Airport. **If KCAD and the City were to pursue full clearing of all land and elimination of all environmental features, the site could potentially produce 500 Megawatts (MW) of energy that could power up to 70,000 Kansas City households based on local averages.** The infrastructure possibilities review concluded that while no existing transmission lines or substations near the Airport are currently able to accept newly generated energy, **an investment to the power grid of approximately $62M could produce energy output of up to 285 MW and 462,546-megawatt hours (MWh) annually. This is based on publicly available information and subject to Southwest Power Pool review and authorization. Installation of a fixed tilt system on approximately 1,100 acres that did not contain wetlands, streams, steep slopes, and other environmental constraints could provide enough power for up to 35,000 Kansas City households based on local averages.**

A phased approach will move the solar project forward faster than a full build all at once. A potential Phase One development is located on the south-central portion of Airport property and allows for upgrades or buildouts to necessary infrastructure. **Phase One investment to the grid of $9-$15 million and initial development of 136 acres which incorporates the environmental features with a 35 MW solar array includes over 96,000 fixed photovoltaic panels that could produce 57,553 MWh annually. This Phase One potential could power up to 4,500 Kansas City households.**



Additional costs will include development, construction, and solar panel equipment costs. When compared to other Airports with solar facilities in the U.S., Phase One Development at KCI could provide more annual energy output than airports in Sacramento (8 MW), Denver (10 MW DC), or Indianapolis International Airport (17.5 MW AC).

State and federal environmental reviews and permits are required next steps. Because the site occurs on Airport purchased land using FAA Airport Improvement Plan funds, a National Environmental Policy Act (NEPA) review process is also forthcoming.

Additional next steps include a request for a third-party developer, coordination with SPP and Evergy, and continued coordination with FAA.

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1 Introduction

The Kansas City Aviation Department (KCAD) conducted this initial siting and solar feasibility study to identify potential opportunities for development of a solar energy facility at the Kansas City International Airport (KCI or Airport). Depending upon the preliminary analysis and recommendations, KCAD may determine to take the next step and invest additional resources toward implementation of the solar facilities at the Airport.

Solar photovoltaic (PV) systems convert sunlight into electrical power. A single PV device is known as a cell and is generally small, generating about 1 to 2 watts of power. Cells are linked together into modules to increase power output. Modules can be used individually or linked together into arrays to again increase power output, which is expressed as megawatts (MW). Thus, a PV system can be designed to meet the specific electrical power and energy needs for the location where it is placed.

Within a PV system, arrays (multiple modules linked together) are only one of many pieces of infrastructure necessary. Systems also include mounting racks, conductors to bring electrical power from the arrays to the inverter, and inverters to convert the direct current (DC) electricity produced by the PV arrays into alternating current (AC) that can be used in the local transmission of power.

PV systems can be designed to include fixed arrays or tracking arrays. A fixed array maintains a fixed angle to capture sunlight, resulting in maximum energy output for a few hours in the middle of the day. Alternatively, a tracking array rises quickly to full energy output by adjusting the angle of the modules, resulting in maximum energy output for a larger portion of the day. Tracking arrays are defined as either one-axis – allowing the array to move back and forth in one direction – or dual axis – allowing the array to move in a more direct, circular path. A dual-axis tracking array captures the maximum amount of energy resource from the sun by changing position seasonally and daily, so modules maximize incident sunlight throughout the year. In contrast, a one-axis tracking array is limited to following the sun on the set axis, typically east-west as the sun passes overhead throughout the course of the day.

In general, a tracking array will outperform a fixed array, and a dual-axis tracking array will outperform a one-axis tracking array. A fixed array is considered a cost-effective alternative to a tracking array, depending on location and solar resource, however, the cost difference at larger utility-scale, becomes less significant. A fixed array can fit more panels per acre than a tracking array because they don't need room to move with the sun. A tracking array generally requires more maintenance to operate.

1.1 Organization of the Document

The siting and solar feasibility study is organized in the following manner:

Section 1 Introduction– This section describes the goals of the initial siting and solar feasibility study, a description of the different types of arrays, and how the document is organized.

Section 2 Coordination with other Airports with Solar Farms – There are many airports in the U.S. that are currently operating or leasing land for solar facilities. This section briefly describes KCAD's coordination efforts with other airports that currently have solar farms to understand any lessons learned.

Section 3 Constructability Constraints Analysis (Land Availability) – This section identifies potential areas within the Airport property boundary that may be suitable for potential solar facilities.

Section 4 Energy Output Analysis (Resource Availability) – This section assesses the potential energy output for a solar energy project at the Airport.

Section 5 Interconnection and Transmission Possibilities – This section provides a preliminary review of potential development needs for connection into the grid, such as whether a new substation or a substation upgrade would be needed.

Section 6 Path to Market – This section discusses the potential ways to move a potential solar facility at the Airport to implementation.

Section 7 Next Steps – This section provides the next step recommendations from this initial siting and solar feasibility study.

2 Coordination with other Airports with Solar Farms

2.1 Solar Background at Airports

Many airports in the U.S. and worldwide are already operating solar facilities and airport interest in solar energy is growing. Solar is a renewable energy source that contributes to national and local goals of sustainability and energy independence. Solar is particularly compatible with airports because of the available land area at airports used for non-aeronautical uses and because of the demand for energy. Technology has advanced from the initial solar panels and can now provide a cost-effective and stable long-term energy supply for airports and their surrounding communities.

Existing solar facilities at airports are generally ground-mounted solar panels or solar panels mounted on buildings or over parking structures and airports are utilizing both fixed and tracking systems. Some solar facilities are owned by the airport, while others are owned by private companies that lease property from the airport. As part of this initial siting and solar feasibility study, KCAD conducted coordination efforts with several other airports that currently have solar farms to understand any lessons learned.

2.2 Sacramento International Airport (SMF)

Sacramento International Airport currently has two photovoltaic solar arrays with a combined capacity of 7.9 megawatts (MW). The solar farm consists of a 15-acre site east on Aviation Drive and a 20-acre site north of the runway. SMF's solar facility provides approximately 38 percent of the airport's energy and is the largest on-airport solar facility in California. The Airport has approximately 23,000 LG solar panels mounted on NEXTracker racking system to maximize efficiency and energy production. Borrego Solar Systems, a leading national developer, designer, installer and operator of commercial solar and energy storage systems developed and built the arrays. The airport had no costs for construction. The capital investment was provided by NRG the local energy provider, which financed construction by Borrego Solar. NRG owns and operates the facility and sells electricity to SMF at a reduced rate under a Power Purchase Agreement (PPA). The cost savings from the project are an average of $850,000 annually throughout the 25-year term of the agreement.

The Airport conducted a National Environmental Policy Act (NEPA) study, an owl survey, and the state required California Environmental Quality Act (CEQA) document. The solar glare hazard analysis tool required by FAA at the time, was required of each of the bidders in the request for proposals (RFP) process and was not completed by SMF. The successful bidders glare study was provided to the FAA. **Figure 1-1** illustrates the solar facilities at SMF.

Figure 1-1 Solar Facilities at SMF

Source: Sacramento International Airport.

The RFP process was conducted in the fall of 2014. The contract was awarded in the beginning of 2015. Construction began in March 2016 and took about eight months to complete. The largest time investment for SMF was the FAA approval process. The proposed solar facility sites were both airside and required a land release in order to move forward. The land release required a fair market value analysis of the lease. In this instance the lease was at no cost to the developer in exchange for a reduced energy rate as part of the power purchase agreement. As the savings in electrical costs was a new concept for the FAA, the process was lengthy, and it had to go to FAA headquarters for approval. SMF stated this process held up the approval of their Airport Layout Plan (ALP), which in turn held up FAA's decision on the NEPA environmental review. This added at least nine months to the process.

2.3 Indianapolis International Airport (IND)

The Indianapolis International Airport is home to the largest airport-based solar farm in the world. Comprised of two phases, the IND Solar Farm creates 17.5 MW AC of power. Tellamon Corporation and Johnson Melloh Solutions—partnered with the Indianapolis Airport Authority (IAA), the City of Indianapolis, Indianapolis Power & Light Company (IPL), General Energy Solutions (GES) and Cenergy Power to build the solar farm. The solar energy produced is being sold to IPL through a 15-year power purchase program and feeds into the grid of existing surface transmission lines that connect the airport terminal to the IPL substation west of the airport. The electric energy generation facility includes 87,488 solar photovoltaic panels installed on fixed ground-mounted racking systems (Phase I) and ground-mounted tracker systems (Phase II/III) that fill nearly 183 acres of land on both the east and west sides of the terminal near the entrance to the Indianapolis International Airport. **Figure 1-2** illustrates the solar facilities at IND.

Figure 1-2 Solar Facilities at IND

Source: Indianapolis International Airport.

2.4 Denver International Airport (DEN)

Denver International Airport (DEN) currently hosts eight photovoltaic solar arrays with a combined capacity of 26 megawatts (MW) on 116 acres of Airport property. DEN uses both ground tracking and fixed tilt solar panels in their arrays. All solar arrays were developed by public-private partnerships. Private solar companies own and operate the solar systems, and DEN executes power purchase agreements with the private solar companies. The local energy provider, Xcel, offers rebates to offset the construction costs, purchase excess energy, and retain renewable energy certificates. WorldWater constructed and designed one of the solar arrays at DEN.

DEN's typical projects were taking 18-24 months from bidding into the Utility's annual competitive RFP until the project was operational. Typically, from contract execution, it takes 12-18 months for the developer to build the project. DEN's most recent projects have been on the longer end of that range due to Covid related, international supply chain issues.

The FAA can issue a Section 163 determination that the ALP change would not have a material impact on aircraft operations, adversely impact safety, or have an adverse impact on the value of the land purchased with Federal AIP funds. Projects that receive this determination do not have to go through the full NEPA EA process, saving significant time and costs.

If leasing the land to a third-party developer, DEN suggested to make sure to have sufficient documentation for the process used to determine the fair market value of the lease rate.

Since all of the projects at DEN are third party owned and operated, tracking systems have not resulted in any increased maintenance for airport staff. While there have been some significant maintenance issues with the tracking system on their first solar project from 2008, the newer tracking systems have been much more reliable. For larger projects (>5MW) the increased production of a one axis tracking system is well worth the added complexity/cost. Xcel has a fairly mature and robust program for large, third party owned, behind-the-meter solar projects, and the airport has worked with the same developer on multiple projects. Each project was fairly well defined/understood before bidding for capacity in the utility's annual RFP. Throughout the project DEN staff and the developer held weekly check-ins to manage the project. Additional bi-weekly check-ins between the airport, developer and utility were also set up as soon as the capacity was awarded. **Figure 1-3** illustrates the solar facilities at IND.

Figure 1-3 Solar Facilities at DEN

Source: Denver International Airport.

2.5 Summary of Lessons Learned

These airports experienced the following benefits from operating solar facilities on their property:

- They were able to obtain renewable energy.
- They were able to lower their energy costs by agreeing to buy energy at a reduced cost from the utility for the duration of the PPA.
- They received revenue from leasing the land occupied by the solar facilities.
- They limited their overall costs to implement the solar facilities (third party and utility bear cost of design, construction, and maintenance).
- They reduced greenhouse gas emissions.
- They enhanced the Airport's public image by operating in an environmentally friendly manner.
- They contributed to meeting the Airports and the City's sustainability goals.

Generally, the lessons learned that would benefit the City moving forward with solar at KCI include:

- Make sure to coordinate with the local energy company and the FAA early and often.
- Most solar farms at airports are implemented with PPAs with local utility.
- Airports reviewed do not own and operate the solar farms themselves.
- Most airport solar farms used phased approach and continued to buildout over time.

3 Constructability Constraints Analysis (Land Availability)

3.1 Airport Layout Plan

KCAD prepared an Airport Layout Plan (ALP) in 2018. The ALP serves as a critical planning tool for KCAD that depicts both existing facilities and planned development. Planned development could be 20 to 30 years out into the future, but the airport identifies this to protect the area for potential future use. Preparation of an ALP is a requirement by FAA of a federally obligated airport.

In addition to existing facilities and planned development, the ALP identifies land uses on the Airport property which can include airport operations areas, such as where the runways are located, potential aviation related development areas, and areas that the airport could use for non-aviation development. **Figure 3-1** depicts KCI's ALP land use map from 2018 which is approved by the FAA.

For this initial siting and solar feasibility study, only airport property that was non-aviation development areas were considered for potential solar development. This does not mean other areas could not be utilized for solar facilities, but for this preliminary study these other areas were not considered because of the anticipated additional time and effort to get a revised ALP approved by the FAA.

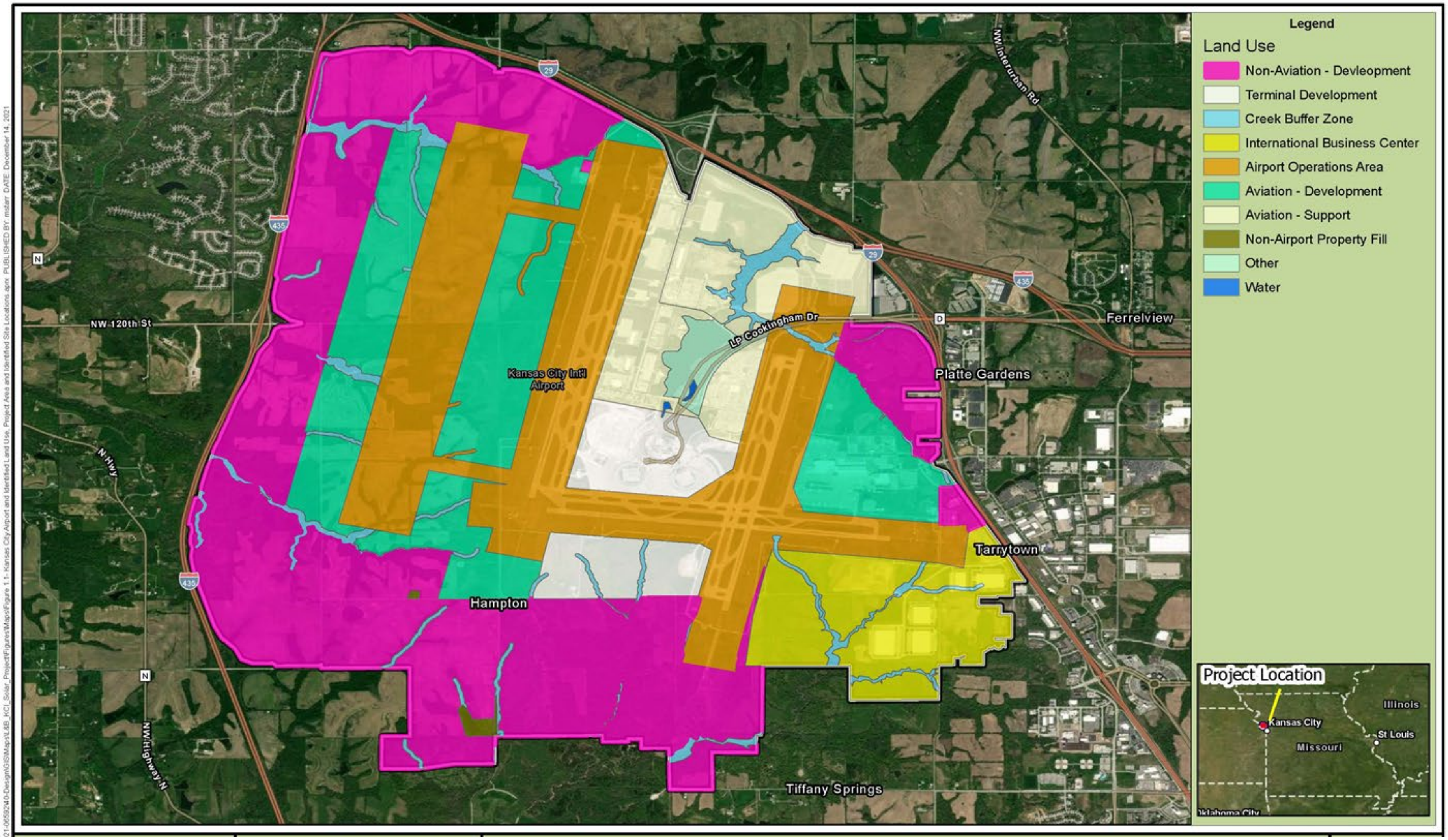
The total non-aviation development area on Airport property totals 3,132 acres. This area was divided into four sites for further investigation. **Figure 3-2** shows the four sites within the non-aviation development area. **Table 3-1** provides the acreage for each site considered for initial development for solar facilities.

Table 3-1 Non-Aviation Development Sites

Site	Acres	General Site Description
1	757	North and northwest of the third proposed runway, bounded by the runway, Interstate 29, Interstate 435, and Northwest 120th Street
2	820	West and southwest of the third proposed runway, bounded by aviation development land, Northwest 120th Street, Interstate 435, and North Brightwell Road.
3	729	Southwest of the third proposed runway, bounded by aviation development land, North Brightwell Road and Northwest Hampton Road.
4	826	South of the first and second proposed runway, bounded by the runways, Northwest Hampton Road, and the eastern boundary of airport property.
Total	**3,132**	

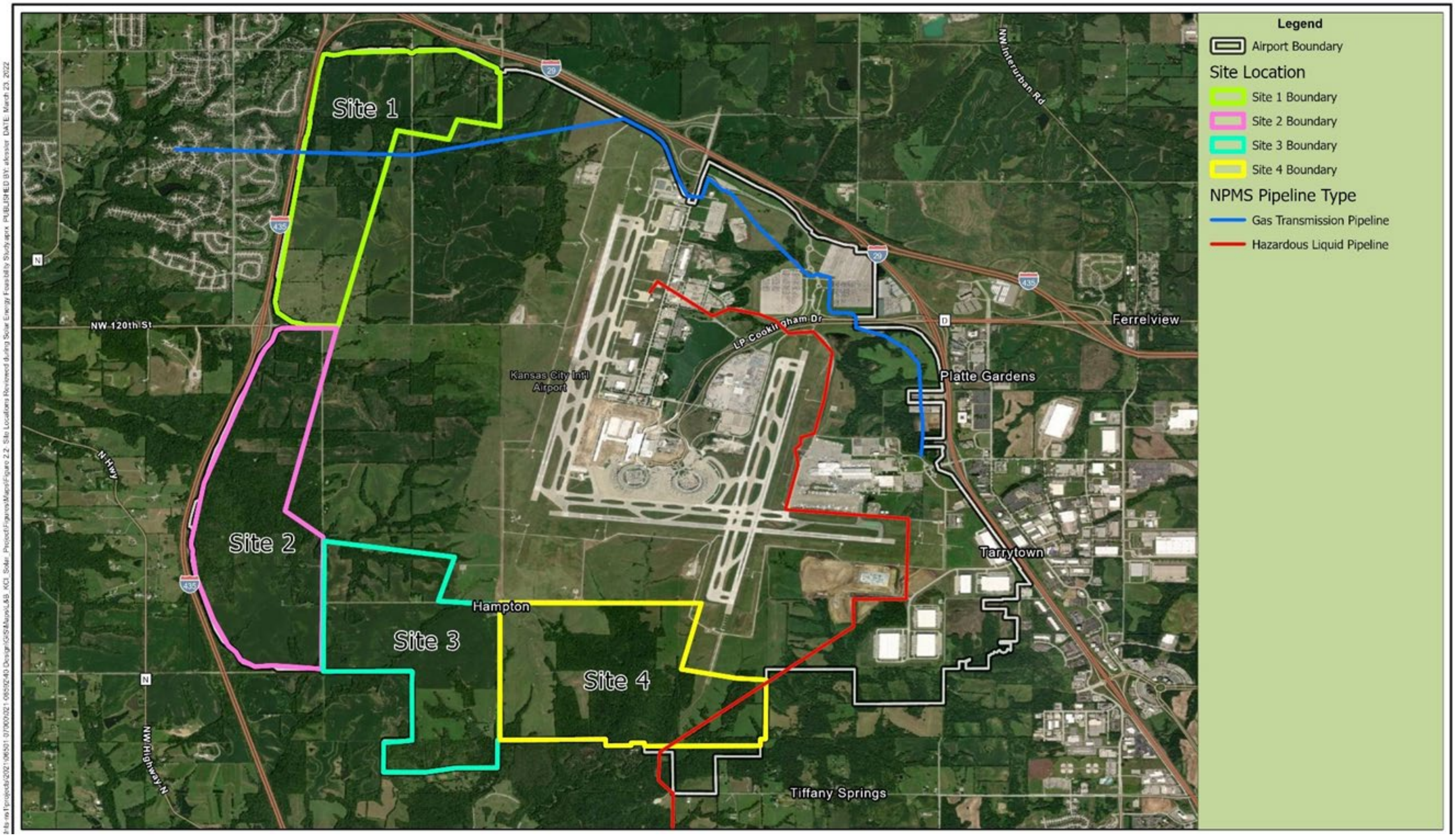
Source: Olsson, 2022.

Figure 3-1 Airport Layout Plan Land Use



Source: KCAD, 2018.

Figure 3-2 Potential Sites



Source: Olsson, 2022.

3.2 Identification of Focal Areas

Wetlands and watercourses; land cover; soil conditions; slope of potential sites; occurrence of cultural resources; occurrence of threatened and endangered species and their habitat; and identified floodplains are potential environmental constraints to solar energy development. These identified constraints generally lead to increases to project siting and development time, therefore, increasing associated costs, due to required additional agency coordination, resulting engineering, and permitting.

For this initial siting and solar feasibility study, areas with identified environmental or permitting constraints were avoided to understand the area available for solar energy development with the least project siting and development time. Again, this does not mean other areas within these sites could not be utilized for solar facilities, but for this preliminary study these other areas were not considered because of the additional time and effort to get approvals or permits. The following data was considered to identify potential areas within the sites that may have environmental or permitting constraints:

- City of Kansas City, Missouri Floodplain Map (Open Data KC 2020)
- Cornell Lab of Ornithology eBird Species Accounts (2019)
- Esri base map sets, including cities, major highways, hydrology, and quadrangle boundaries
- eBird Citizen-based Bird Observation Network (Sullivan 2009)
- Federal Emergency Management Agency (FEMA) National Flood Hazard Layer (FEMA 2020
- Missouri Department of Conservation (MDC), MONHP Missouri Fish and Wildlife Information System (MoNHP 2021)
- U.S. Department of Agriculture (USDA), NRCS Soil Survey Geographic Database (SSURGO) (2019)
- U.S. Fish and Wildlife Servie (USFWS) Birds of Conservation Concern (BCC)
- USFWS Information for Planning and Consultation (IPaC) (USFWS 2021a)
- USFWS National Wetlands Inventory (NWI) data (USFWS 2021b)
- U.S. Geological Survey (USGS) National Hydrography Dataset (NHD) (USGS 2016)
- USGS National Land Cover Database (NLCD) 2019 (Homer 2020)
- USGS Digital Elevation Model (DEM)

Table 3-2 provides a summary of the potential environmental or permitting constraints applied to determine the Focal Areas within each site. After the avoidance areas were applied, the Focal Areas were calculated.

Table 3-2 Summary of Avoidance Areas within the Sites

Constraint Type	Development Constraint Applied
Land Cover	Avoided forested land and open water
Wetlands and Watercourses	Applied 50-foot buffer for wetlands and waterways
Floodplains	Avoided zones A and AE
Federally and State-protected Wildlife	Avoided forested land and open water
USDA Natural Resources Conservation Service	Avoided farmland designated to be of statewide importance
Existing Infrastructure	Applied 15-foot right-of-way for belowground pipelines
Cultural Resources	No mapped concerns at this time
Topography	Avoided land with slope > 20%

Source: Olsson, 2022.

3.3 Site 1

Site 1 has an area of 757 acres and contained a Focal Area of 516 acres (approximately 68% percent of available land within Site 1). Within this site, the predominant constraints were the presence of wetlands and forested land cover, as identified by NWI and NLCD respectively. This site also contained a natural gas pipeline. A 15-foot right-of-way (ROW) was applied as an avoidance area on either side. The Focal Area for Site 1 is presented in **Figure 3-3**.

3.4 Site 2

Site 2 has an area of 820 acres and contained a Focal Area of 437 acres (approximately 53% percent of available land within Site 2). Within this site, the predominant constraints were the presence of wetlands and forested land cover, as identified by the NWI and NLCD, respectively. The Focal Area for Site 2 is presented in **Figure 3-4**.

3.5 Site 3

Site 3 has an area of 729 acres and contained a Focal Area of 556 acres (approximately 76% percent of available land within Site 3). Within this site, the predominant constraints were the presence of wetlands as identified by the NWI. The Focal Area for Site 3 is presented in **Figure 3-5**.

3.6 Site 4

Site 4 has an area of 826 acres and contained a Focal Area of 253 acres (approximately 31% percent of available land within Site 4). Within this site, the predominant constraints were the presence of forested land cover as identified in the NLCD and farmland of statewide importance. This site also contained a hazardous liquids pipeline that required a 15-foot ROW on either side of the pipeline to remain free of surface development. The Focal Area for Site 4 is presented in **Figure 3-6**.

3.7 Summary of Land Availability

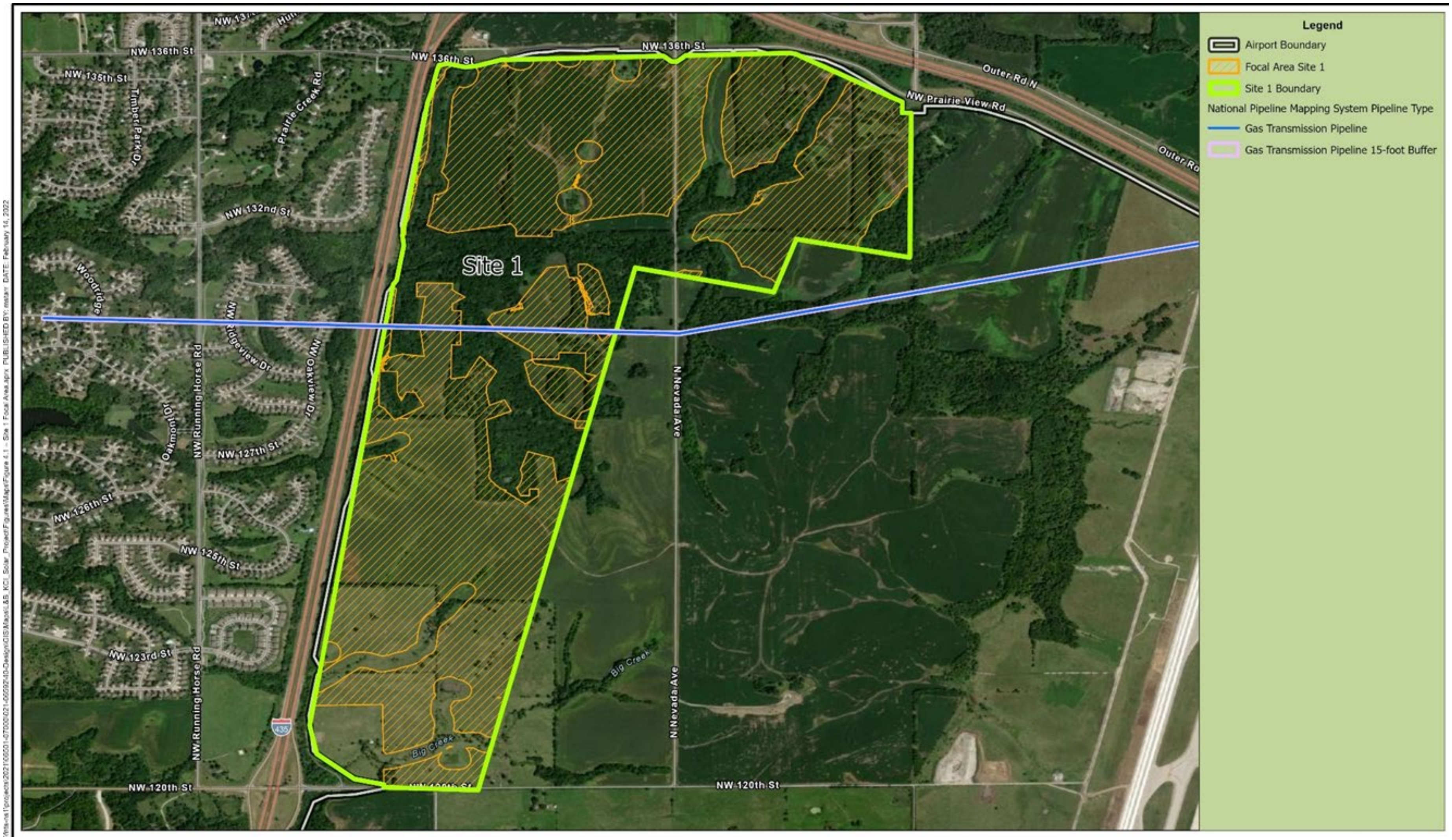
The focal area for each site is summarized in **Table 3-3**. Based on the initial land availability analysis which avoids potential constraints, Sites 1 and Site 3 present the most amount of land for potential solar development. The Constructability Constraints Analysis demonstrates that there is land available at the Airport that could be used for solar development. All of the Focal Areas are shown in **Figure 3-7**.

Table 3-3 Focal Areas

Site	Total Acres	Focal Area Acres
1	757	516
2	820	437
3	729	556
4	826	253
Total	**3,132**	**1,762**

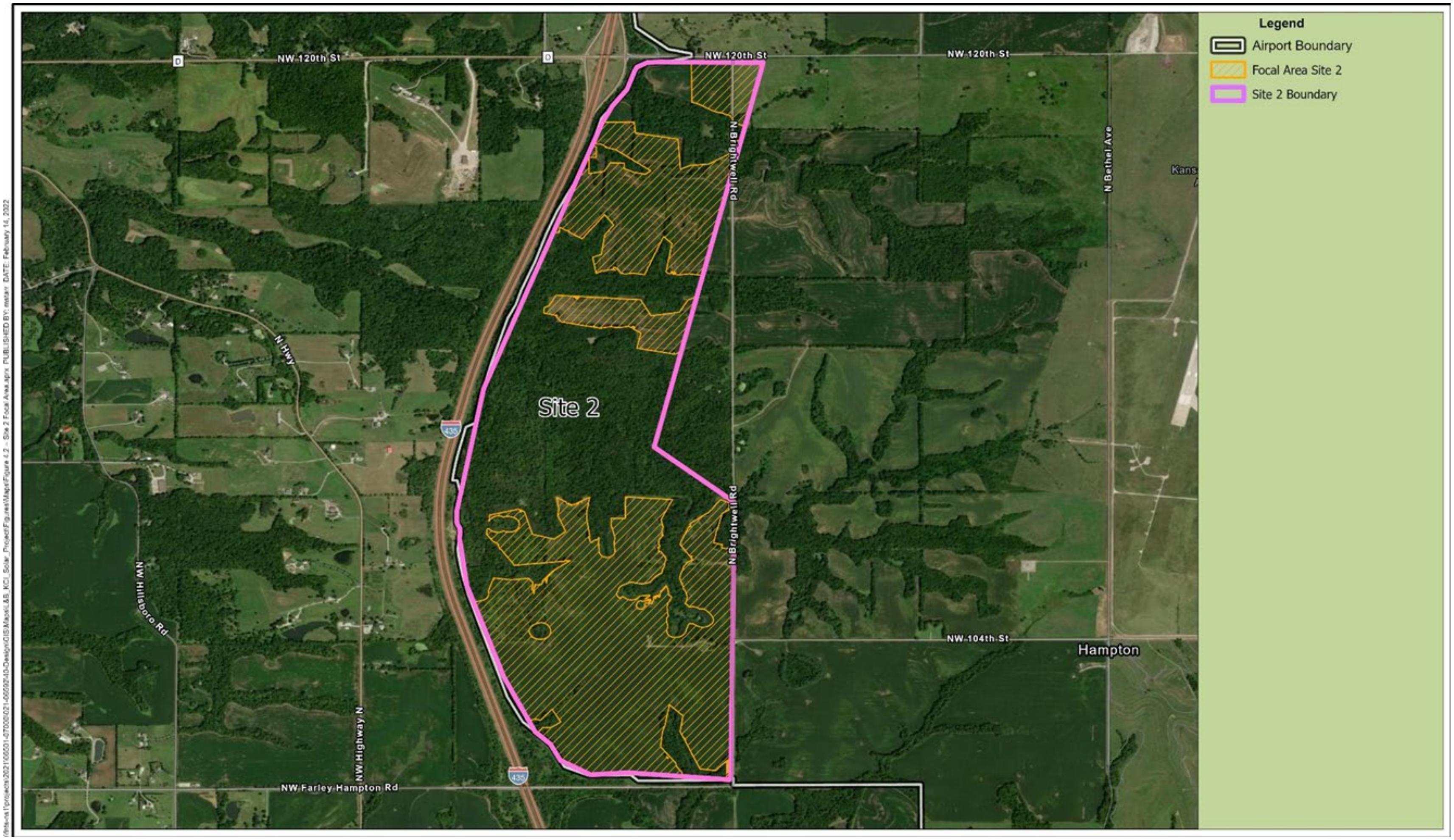
Source: Olsson, 2022.

Figure 3-3 Site 1



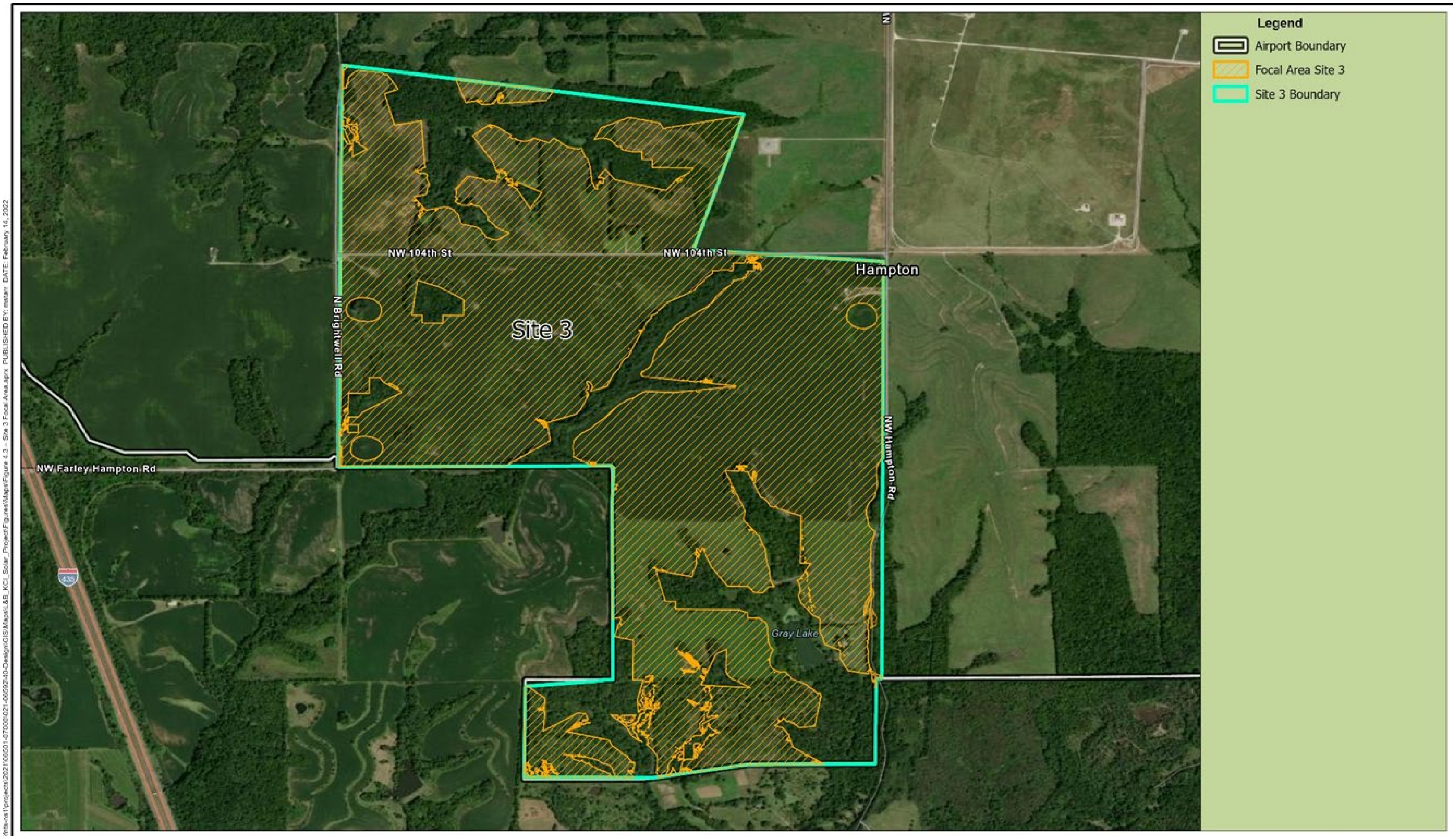
Source: Olsson, 2022.

Figure 3-4 Site 2



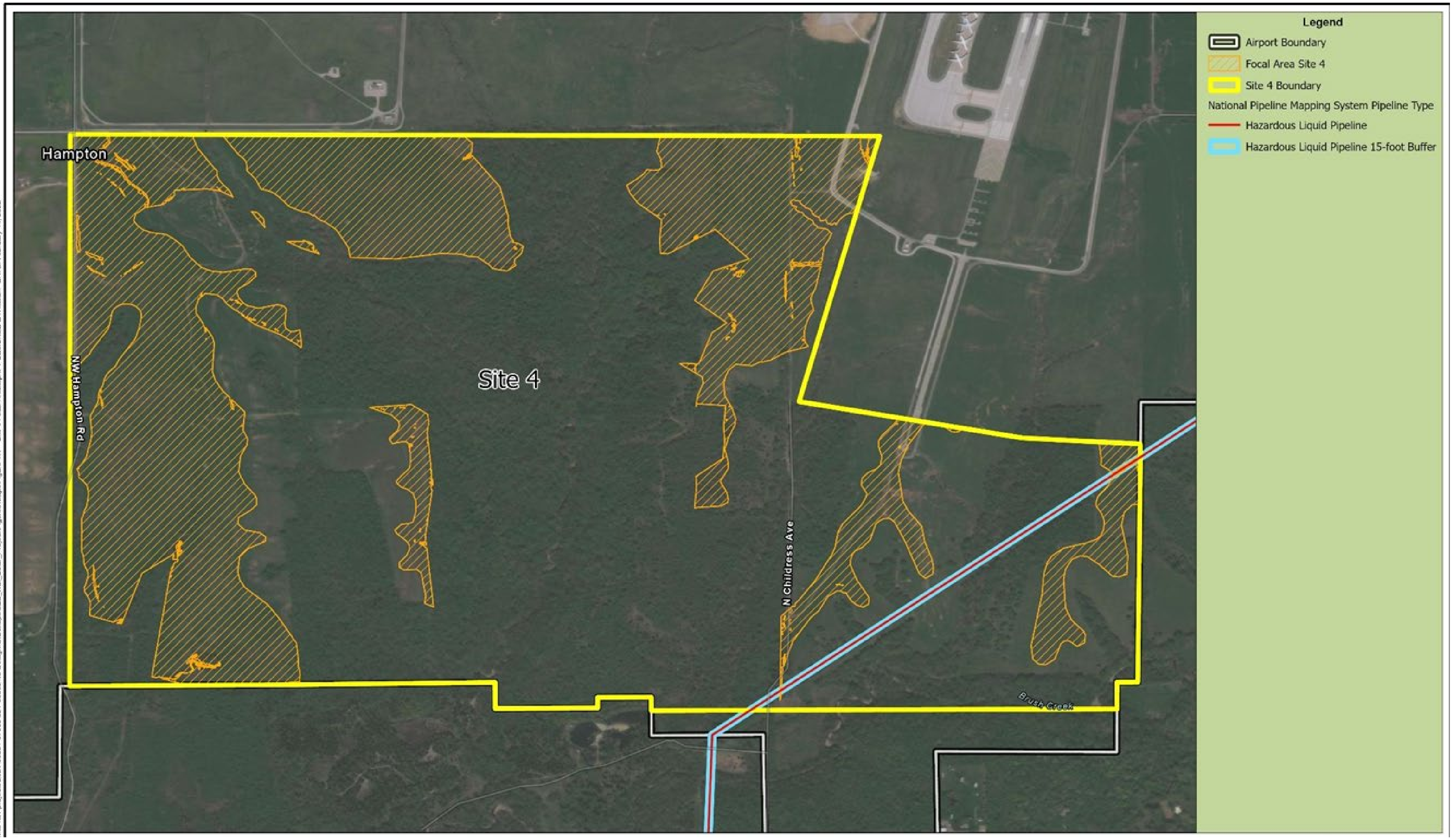
Source: Olsson, 2022.

Figure 3-5 Site 3



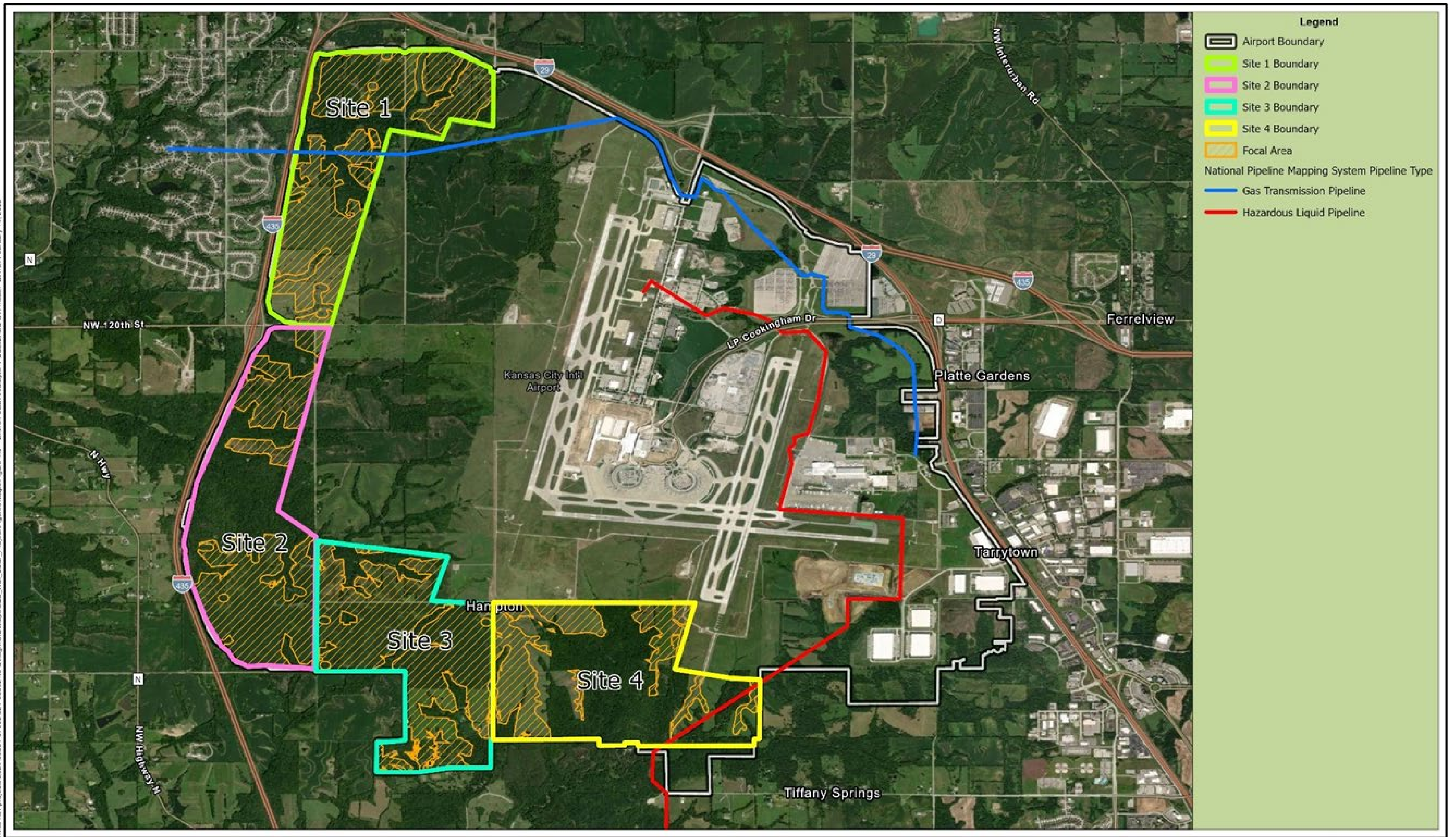
Source: Olsson, 2022.

Figure 3-6 Site 4



Source: Olsson, 2022.

Figure 3-7 Focal Areas



Source: Olsson, 2022.

4 Energy Output Analysis (Resource Availability)

The purpose of this preliminary energy output analysis is to assess the potential energy output for a solar energy project on the identified land available. Two typical 1-2-MW arrays, one fixed tilt and one single-axis tracking, were used to determined MWh/ac-yr. These arrays were extrapolated to the total available acres to determine preliminary energy output. The analysis reviewed utility scale generation where energy is fed directly into the grid. Site-specific meteorological data from the National Renewable Energy Laboratory (NREL) was used as inputs into PVsyst Photovoltaic Software (V7.2.6) to model incident energy on the solar array and determine the solar resource availability. The PVsyst simulation reports are provided in **Attachment A**. It was assumed that the solar development would be built on level ground (less than 20 percent slope) and that the optimization of PV module manufacturer and model, inverter model, and PV field orientation was held constant for the analysis. The energy outputs presented are AC outputs at the inverter and do not consider the energy losses associated with the cable or distribution equipment. Further, the energy outputs are a result of the specific PV panel and inverter specifications selected based on availability at the time of this energy output assessment. A more detailed site layout is needed to determine these losses after design and engineering is completed.

4.1 Near Shading

This study presents the maximum potential energy output available without the need for large-scale land clearing of trees and shrubs that would block sunlight from reaching the solar arrays through incorporating a near shading analysis. It should be noted that the preliminary energy output focused only on scenarios that incorporate near shading considerations. The study focuses on near shading scenarios to provide a recommendation for the path to development that would require the least additional considerations, such as permitting and environmental constraints of development near tree lines.

Shading of arrays, such as the effects of foliage from nearby trees and shrubs that generate shade on the array, influences the energy output of the arrays. During the winter and fall seasons in the northern hemisphere, the sun rises south of due east, traverses the sky south of directly overhead, and sets south of due west. During the spring and summer seasons in the Northern Hemisphere, the sun rises north of due east, traverses the sky south of directly overhead, and sets north of due west. This analysis utilized shading scenes for the typical tracking and fixed tilt arrays to account for losses because of shadings on the potential base system. As stated, site-specific meteorological data was used to model incident energy on the solar array.

A solid tree line of 52-foot-tall trees was defined, based on average tree species data from the MDC surrounding the western, southern, and eastern boundaries of the simulated arrays in PVsyst. With western, southern, and eastern tree lines were defined along array boundaries. The analysis conducted near shading simulations on the winter and summer equinoxes to model the longest and shortest shadows of the year, respectively. These shadows were measured in PVsyst and drafted in AutoCAD as constrained areas within the defined Focal Area further reducing the assumption of available acreage for solar energy development. Due to the lack of accurate detail on exact tree heights, density, and location, these simulations were run based on the perceived worst case, conservative near shading scenarios. The useable area incorporating near shading totals 399 acres. The areas for each site without the need for large-scale land clearing of trees and shrubs are provided in **Table 4-1**.

Table 4-1 Potential Areas for Development Without Large Scale Land Clearing

Site	Focal Area (Acres)	Useable Area Incorporating Near Shading (Acres)
1	516	130
2	437	115
3	556	136
4	253	18
Total	**1,762**	**399**

Source: Olsson, 2022.

4.2 Overall Potential Energy Output

The available power output for the Focal Areas were extrapolated from the fixed and tracking array data. For the full Focal Areas there would be an AC power output of approximately 285 MW (not considering system losses), producing 462,546 megawatt hours (MWh) annually. When considering near shading and the reduced area available for energy production, there would be an AC power output of approximately 104 MW (not considering system losses). **Table 4-2** provides the megawatt output per site for both fixed and tracking systems.

Table 4-2 Preliminary Energy Output

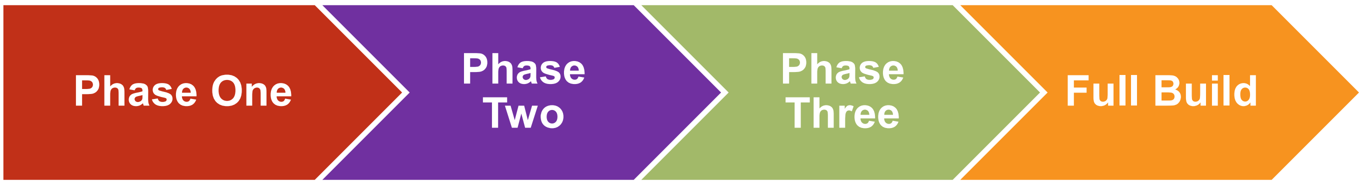
Site	Fixed Tilt Array Peak MW	Tracking Array Peak MW
1	33.88	26.4
2	29.92	28.6
3	35.64	30.8
4	4.84	2.2
Total	**104.28**	**88.0**

Source: Olsson, 2022.

4.3 Phasing Option

Phasing may provide the benefit of moving a solar project forward quicker than moving forward with full build all at once. Phasing benefits include:

- Identifies areas that are most shovel ready
- Allows for step up of infrastructure
- Can provide an example of success for future phases
- Could provide faster regulatory and permitting process



4.4 Phase One Development Energy Output

A potential recommended Phase One development is within the identified Site 3 (generally the south-central portion of KCI property). This would provide space for a utility-scale solar system of approximately 36 MW (AC power output) and 96,000 panels, based on the initial energy output study. Additional phases for building out a larger utility scale system could be done after the Phase One development is completed. Phasing would be contingent on coordination with SPP and developing/building the necessary infrastructure. The estimated costs for upgrades at existing Tiffany substation for Phase One begin at minimum of $9 million based preliminary assessments. **Table 4-3** presents the results of the proposed Phase One development analysis for both a fixed and a tracking system.

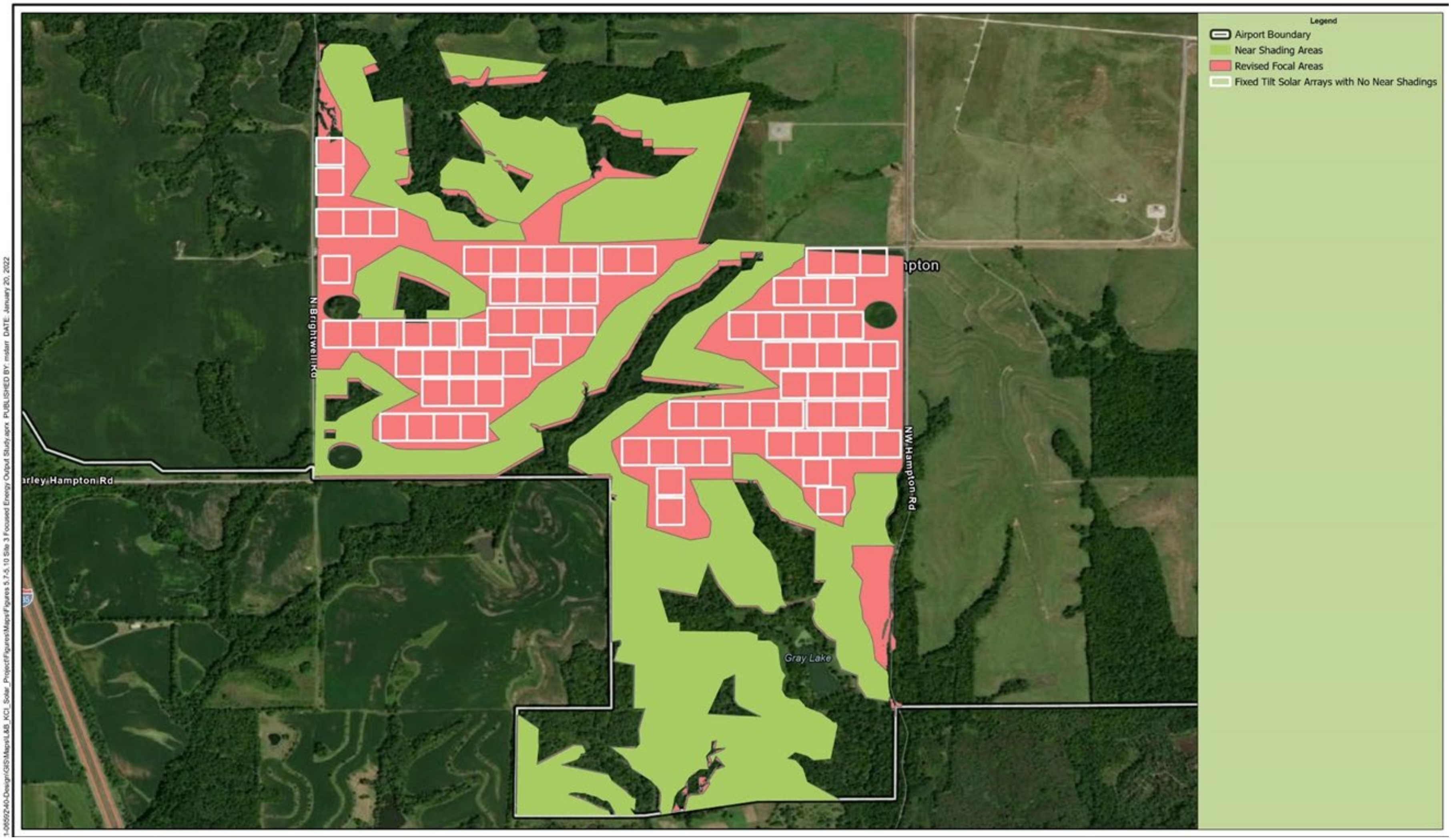
Table 4-3 Preliminary Energy Output Phase One Development

Type of Array	AC Power Output (MW)	Annual Energy Output (MWh)	Normalized Annual Energy Output (MWh/acre)
Fixed Tilt	35.64	57,553	423.19
Tracking	30.8	56,112	588.54

Source: Olsson, 2022.

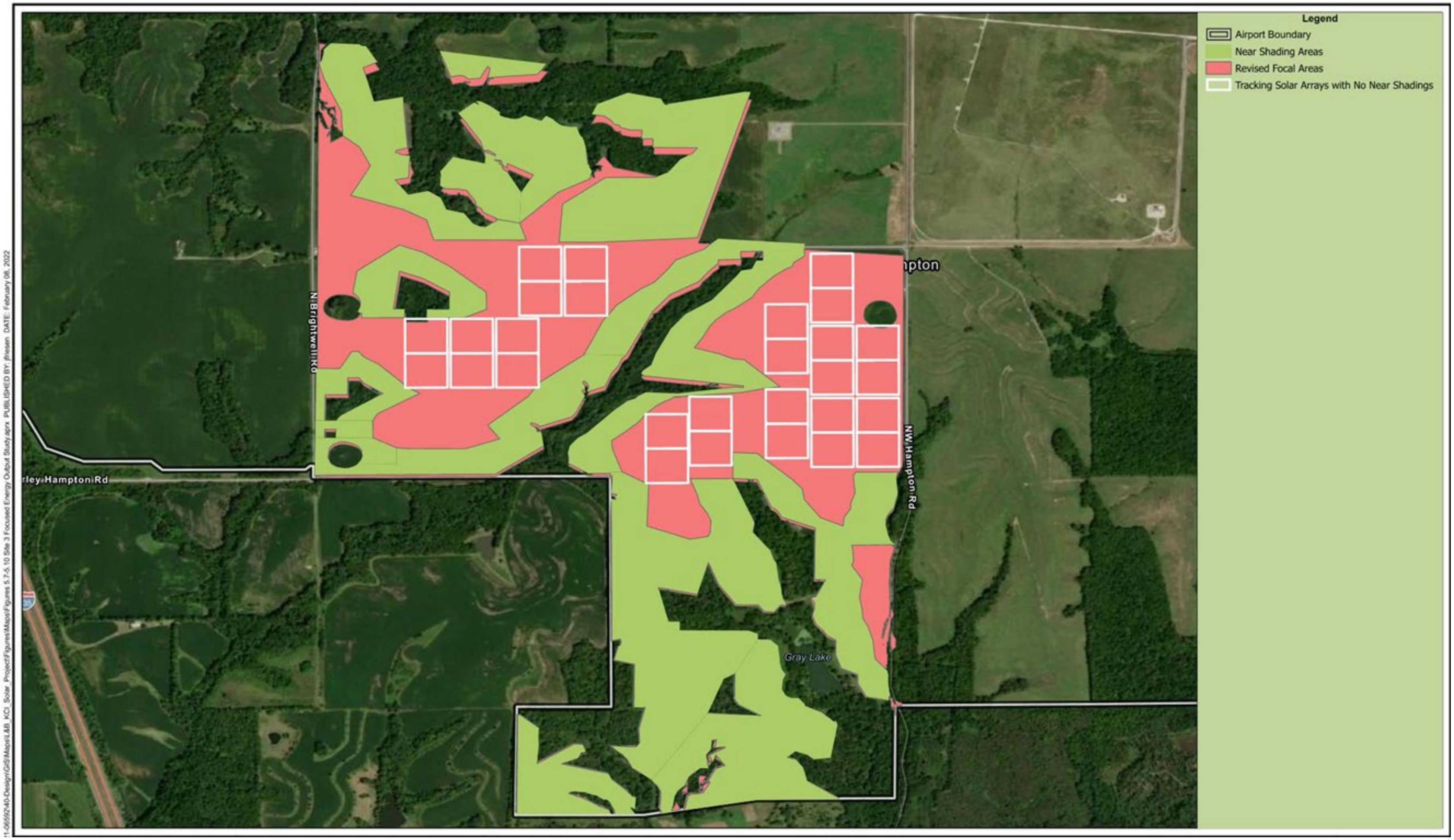
Figure 4-1 and **Figure 4-2** depicts the Phase One development with fixed tilt and tracking arrays respectively.

Figure 4-1 Initial Phasing Option with Fixed Tilt Arrays



Note: Figure represents potential arrays and not individual panels.
Source: Olsson, 2022.

Figure 4-2 Initial Phasing Option with Tracking Arrays



Note: Figure represents potential arrays and not individual panels. Tracking systems have fewer arrays but higher efficiency when compared to fixed systems.
Source: Olsson, 2022.

While this assessment used PVsyst to model the systems reported in this study, there are other PV system modeling software available that may provide different energy outputs based on the PV system parameters they allow the user to define. For example, a commonly used program for quick PV system output modeling is NREL's free, web based PVWatts Calculator. PVWatts allows the user to define system site location, nominal DC power output, fixed/tracking, tilt/azimuth angles, system loss %, DC/AC ratio and inverter efficiency.

A comparison was conducted by modelling the fixed array in PVWatts using the same parameters defined in PVSyst and got an estimated annual energy production of 4,120 MWh/year (13% higher than what PVsyst calculated – 3,576 MWh/year). While a difference in output of this magnitude might raise concerns that PVsyst is overly conservative, the definable system parameter differences between the programs accounts for much of the discrepancy. PVWatts for example does not allow the user to define the physical system site layout. Additionally, PVWatts does not allow the user to define any equipment manufacturers, whereas PVsyst pulls manufacturer's datasheets for both the PV module and inverter for the system calculations. As a result of the detailed modeling parameters, PVsyst provides the user with a detailed system loss diagram as part of the output simulation, whereas PVWatts requires the user to enter an estimated system loss percentage. The results of this analysis should be regarded as conservative estimates of energy output at the inverter terminals and is used in this study to determine preliminary feasibility. Energy output should be reassessed when a specific system and equipment is designed for implementation.

4.5 Cost Assumptions

For this assessment, existing electricity usage and costs were obtained from KCAD. To assess the potential cost savings, the average MWh rate ($58.00) was multiplied by the annual energy output of each scenario, which resulted in a dollar value of the energy produced by the arrays. The dollar value of energy produced by the potential arrays is presented as the Preliminary Annual Savings in **Table 4-4**. Under a power purchase agreement, the utility/and or third-party developer would realize this benefit. The Airport would benefit by being able to lower their energy costs by agreeing to buy energy at a reduced cost and revenue from leasing the land. This Preliminary Annual Savings does not include the principal Project Costs including engineering, equipment procurement, or construction costs. Further financial analyses including a potential payback analysis should be considered before a request for proposals is released for third party developers.

Table 4-4 Preliminary Annual Savings for Phase One Development

Type of Array	Monthly KCAD Average MWh Rate	Annual Energy Output (MWh)	Preliminary Annual Savings (Dollars)
Fixed Tilt Array	$58.00	57,553	$3.3 Million
Tracking Array	$58.00	56,112	$3.2 Million

Source: Olsson, 2022.

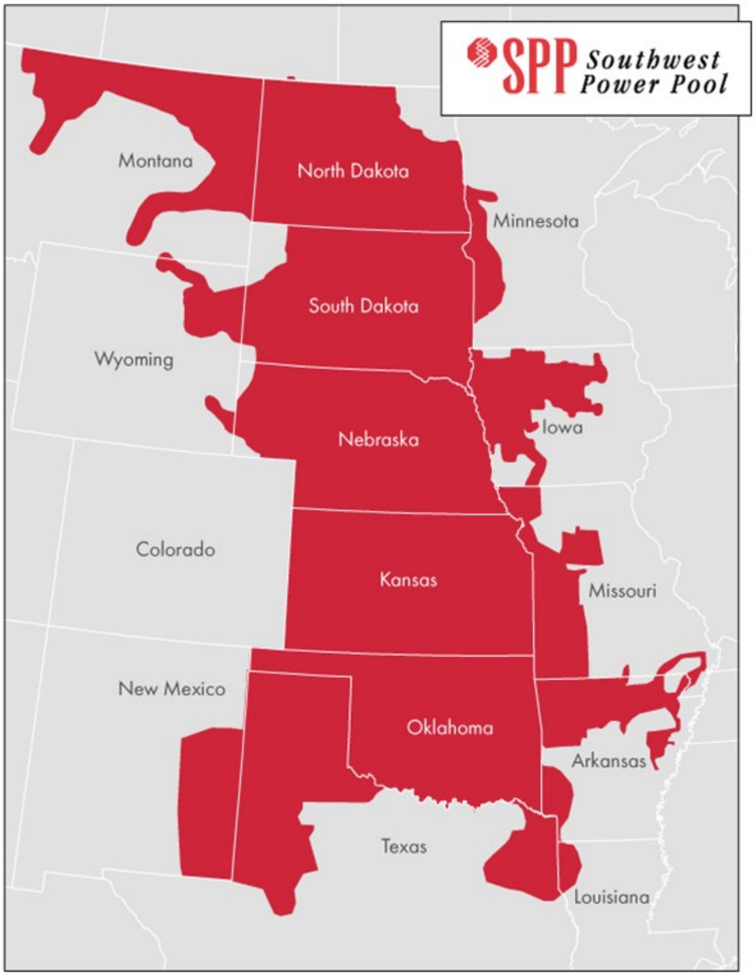
5 Interconnection and Transmission Possibilities

Interconnection of an energy resource affects not only the immediate solar system of interest, but depending on the size, could affect other infrastructure in the region. Considerations need to be made for the proposed size of the energy resource, the host utility, and the electric regulatory entity (Regional Transmission Organization [RTO] / Independent System Operator [ISO]) as key stakeholders for project implementation.

The size of a resource may affect how the resource is used by the developer, if a power purchasing agreement (PPA) is pursued, or if usage offset is the intended use of such a system. Changing the size of a system can affect the path to success of bringing the new resource online. As a continuation of the sizing consideration, the host utility should be engaged early and will specify the ownership demarcation, owned equipment, and potential impact studies needed. This approach will address issues such as, the extent of interconnection upgrades and lead times of long lead equipment, scheduling of build effort and transmission outages, and others as applicable that are integral in establishing a potential timeline for project realization. The RTO/ISO interconnection application will also affect the timeline of development and a developer/project sponsor should become familiar with the application process and deposits are required to enter a study queue. Study queues are presently quite delayed and may take years to finalize.

Southwest Power Pool (SPP) is a regional transmission organization and transmission owner in this area. To manage transmission on the grid, SPP manages what generation occurs (such as a solar energy project) and what improvements are required to support entry of that energy to the grid. Evergy, which provides electricity to the Airport is part of the SPP. The SPP operational areas are shown in **Figure 5-1**. KCAD and the City must coordinate and get approval from SPP to produce any energy that connects to the grid.

Figure 5-1 SPP Areas



Source: Graphic provided by Olsson, 2022.

5.1 Existing Infrastructure Review

A review was conducted to analyze the feasibility of a solar installation at the Airport considering the existing infrastructure. It has been demonstrated that there is the available land at the Airport to produce a large solar facility, however while there is land available, it may not be feasible for the grid to accept additional power in the short term without significant costs.

To determine the best potential connection to the grid, local utility transmission lines and substations were located via satellite imagery and mapped. The potential sites for solar development were divided into two regions (North and South) for further investigations and to determine the nearest substations and transmission lines to the project sites. There were two transmission lines identified below in the region that may provide potential connection points to the power grid for a potential solar energy.

- 161 kilovolt (kV) lines typically consisting of 795 Drake or 1192 Bunting conductor with a maximum rating of 290/365 megavolt amp (MVA) respectively.

- 69 kV lines that are typically 556 aluminum conductor steel reinforced (ACSR) Dove conductor with a maximum rating of 99 MVA.

5.2 North Region

For the North Region, the closest interconnection point is approximately three miles north of the Airport property at an existing Evergy substation known as Platte City (Substation 319). This would be the most likely interconnection for Site 1 and Site 2.

The Platte City Substation has three 161 kV lines and two 69 kV lines. The two 161 kV lines on the east side of Platte City Substation appear to be Drake conductor and connect to Evergy substations Smithville (Substation 355) and KCI (Substation 270). The third 161 kV line on the west side of the substation appears to be 1192 ACSR (Bunting) and connects to the Evergy substation Weston (Substation 438).

Connection to Platte City Substation would require building a small step-up substation within the area to be used for solar development, as well as a new 161 kV transmission line (or extension/tap from existing lines). Additionally, the Platte City Substation would then require a new transmission line entrance and associated upgrades needed to expand the existing ring bus. This new connection would likely push the other existing 161 kV lines over maximum capacity, based on the expected MW outputs. If the entirety of the expected MW outputs is built out, the potential infrastructure improvements required will additionally include the possibility of a transmission line upgrade (or installing a double circuit).

An interconnection study from Evergy and Southwest Power Pool will be required to determine if other system upgrades are required. It is anticipated that potential required substation upgrades for the Evergy system could include Weston (Substation 438), Smithville (Substation 355), KCI (Substation 270), and associated transmission lines.

5.3 South Region

The potential interconnection identified for the two proposed sites south of the airport (Site 3 and Site 4) is the Evergy substation known as Tiffany (Substation 39). Tiffany Substation includes two 161 kV lines that appear to be Drake conductor. The line on the north side of Tiffany Substation connects to Evergy substation Roanridge (Substation 337). The line on the south side connects to Evergy substation Weatherby (Substation 49).

A small step-up substation at the solar energy project area would be required due to the expected MW outputs. Additionally, a new 161 kV line and substation expansion at Tiffany Substation to accommodate the new transmission line entrance would be required.

An interconnection study from Evergy and Southwest Power Pool will be necessary to determine other system upgrades that may be required. For a total build-out, it is anticipated that possible required substation upgrades for the Evergy system would include Roanridge (Substation 337) and Weatherby (Substation 49). However, the proposal to build a Phase One solar project on Site 3 may result in fewer upgrades being necessary.

5.4 Cooperative Substations

There are also several small substations closer in proximity to the Airport's westside that are owned by a local cooperative (co-op). The smaller substations are designed to provide service to the surrounding suburbs only and are not equipped for bidirectional flow, which is required for generation interconnection; therefore, the existing co-op substations would not be suitable candidates for interconnection points. These substations are served via 69 kV transmission lines from Platte City Substation built with the smaller Dove conductor.

5.5 Summary of Interconnection and Transmission Possibilities

The installation of the entire proposed solar development over all four sites would require a substantial investment to connect it to the grid. With a combined output of potentially up to 250 MW, these facilities represent a large source of energy generation. Connecting this amount of power into the grid would require costly upgrades. The exact extent of these upgrades is unknown until an interconnection study is performed with Evergy and SPP.

Roughly, it is estimated that upgrading Evergy Platte City Substation 319 would require roughly $15-25 million dollars and upgrading Evergy Tiffany Substation 39 would require approximately $15-plus million. The 161 kV lines may need to be upgraded, and construction of that nature can run around $1.5 million dollars per mile. At a minimum, connecting the proposed solar sites would take around 15 miles of transmission line construction, and the interconnection study could reveal further upgrades are necessary. A rough estimate using the numbers above results in a cost of $62 million dollars to connect the solar project to the grid, with many factors still left as unknowns until an interconnection study is completed. These numbers are just an estimate, and an interconnection study would provide more exact budgetary considerations for this project.

A more targeted approach of installing a subset or portion of the proposed solar project would lessen the costs to integrate into the grid. An interconnection study would still be required, but a lower MW output would lessen the number of upgrades needed on the transmission grid in the area. This approach could lower the dollar figure of those upgrades significantly. Additionally, if KCAD uses the solar output to offset its own usage the amount of energy being transferred to the grid could be further reduced.

The infrastructure review conducted as part of this siting and feasibility study suggest that while no existing transmission lines or substations near the Airport could accept newly generated energy, with an initial investment to the infrastructure, connection to the grid is feasible.

6 Path to Market

There are really three different pathways to bring the power to the market. If the Airport owns and operates the solar facility the Airport holds all of the developmental and operational risk associated with the solar project, but also gets all of the benefits. The second pathway would be to partner directly with Evergy for both land lease and solar offtake. Evergy recently announced a 10 MW solar project at its Hawthorn coal-fired power plant. The third pathway would be for the City and KCAD to execute a lease agreement with a third-party private developer to finance, build, own, and operate the solar facility. The third-party developer can sell the electricity at a lower price and pass some of that savings on to the Airport as the host, either through a lease agreement or by selling the Airport less expensive electricity than it currently purchases. The private developer can also take advantage of tax-related incentives to lower their costs.

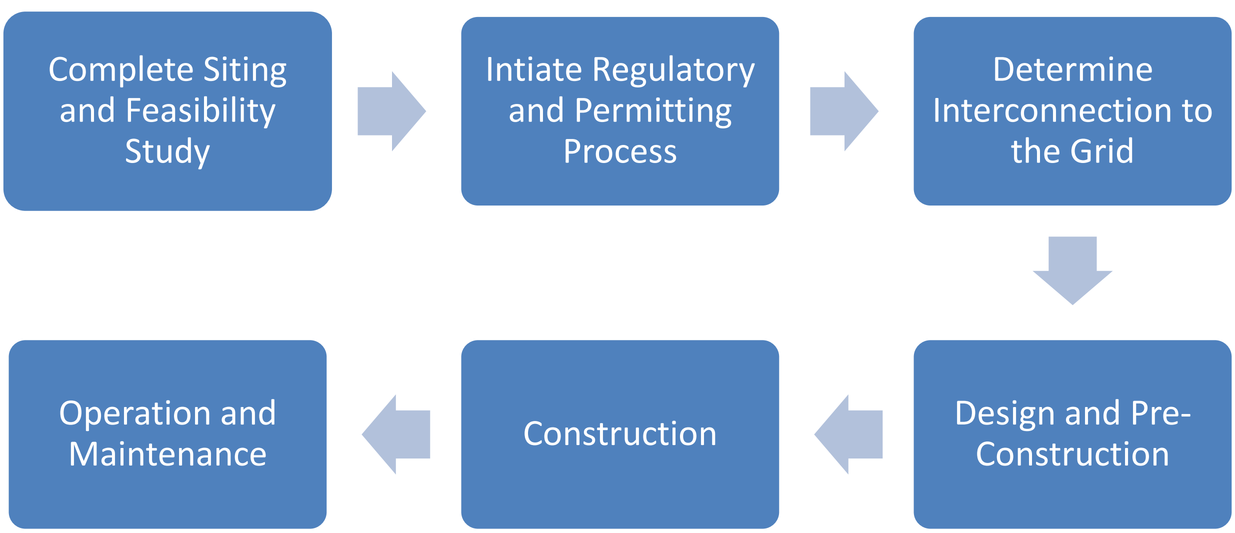
Because the private developer is the owner and operator, it assumes more of the risk. This option is relatively low risk option for the City. If the Airport secures a lease agreement with the third-party developer, it would potentially get lease payments for the land that are comparable to their existing farming and cattle leases. If the City and KCAD can negotiate a PPA price to buy some or all of the electricity, it also can benefit as the price of electricity may rise in the future. However, there is risk if in the future regional electricity prices drop.

6.1 Existing Land Leases

The Airport currently leases land for farming and cattle grazing in all of these sites. The current lease rates for these areas were reviewed. The leases are generally based on a five-year term. Lease rates in the areas for potential solar development range from approximately $88/acre to $200/acre. If KCAD and the City determine to move forward with the solar development project, a more detailed fair market value of airport real property to be leased or sold would be needed for FAA and a detailed evaluation of other land lease rates in the region would be helpful to compare the competitiveness of the site for potential developers. If the land proposed for solar will be leased to a private developer, the lease must be approved by the FAA. A fair market analysis of the lease arrangement would be needed to ensure that the lease supports the Airport business to the maximum extent. The Airport will have to provide comparable information regarding the market value of the land (such as previous leases for agricultural use) to facilitate the FAA's review. If the Airport is purchasing electricity as part of the arrangement, the FAA may also review the power purchase agreement as the land lease value may be rolled into the overall electricity purchase price.

7 Next Steps

A simplified overview of the next steps in the multiyear process is provided below:



- **Initial Siting and Feasibility Study**: This is the first step in the process towards implementation. This document represents this first step to analyze the land availability, the solar resource and potential energy output, infrastructure possibilities, and the preliminary path to market.
- **Regulatory and Permitting Process**: This step includes the permitting and environmental site due diligence considerations. For example, during this step the level of NEPA documentation can be determined by the FAA and completed by KCAD. The process for completing the analysis and permitting can be expected to take 6-24 months. Environmental permitting may be required from other agencies

including the U.S. Army Corps of Engineers, the Missouri State Historic Preservation Office, and/or the U.S. Fish and Wildlife Service.

- **Interconnection to the Grid:** This step includes potential involvement by third-party site developers, utility representatives, and local, state, and federal governmental agencies: This step assesses whether development of a utility-scale generation system is possible in the identified area and the specific interconnection considerations. This step could take up to 4 or 5 years to complete the interconnection study process and transmission approval depending on the location in the study queue.
- **Design and Pre-Construction Refinement**: In coordination with KCAD, specific equipment selection, detailed economic and environmental reviews, and finalized permitting is initiated in this step. KCAD will begin to have an accurate idea of all costs, infrastructure and otherwise, that will be incurred during project completion. This is also when KCAD will finalize financing, including but not limited to the following outside resources: grants; local, state and utility incentives; Energy Saving Performance Contracts (ESPCs); tax equity incentives; Renewable Energy Certificate (REC) monetization, etc.
- **Project Construction:** During this phase, material procurement, construction, and interconnection to the grid begins. Depending on the project size to be implemented and the location within KCAD property, this phase can be expected to last 12-18 months.
- **Operation and Maintenance:** Once construction is completed and the Project is energized, the operations and maintenance stage will be ongoing for the life of the Project. This phase includes maintaining agreements (local, environmental, performance, etc.); monitoring and maintaining the system (cleaning panels, replacing broken parts, etc.); and monitoring interconnection components, transmission, substation infrastructure maintenance (if applicable), etc. This is where Project’s success will ultimately be determined by increasing efficiency, decreasing downtime, minimizing maintenance costs, extending the system lifetime, etc.

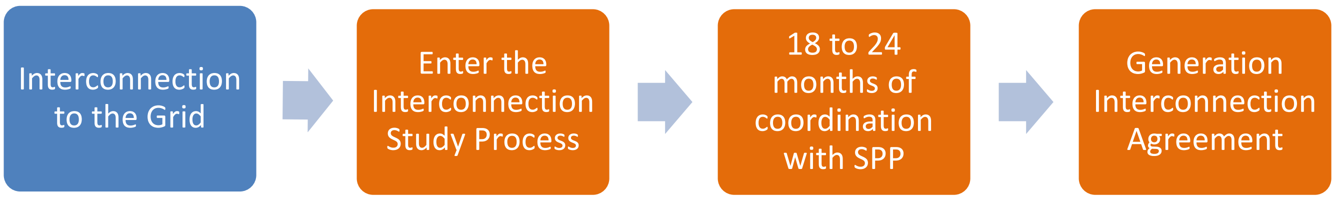
7.1 KCAD to engage NREL for Additional Analysis Needed

The National Renewable Energy Laboratory (NREL) is the U.S. Department of Energy’s (DOE’s) premiere national laboratory for renewable energy, energy efficiency, advanced transportation, and energy security. KCAD could retain NREL as a consultant for the City of Kansas City to advise on the solar development and conduct any additional tasks and analysis needed to move the project towards implementation. NREL tasks could include:

- Estimate detailed renewable energy development generation potential based on developable land estimates
- Provide technical and economic development scenarios including conducting a payback analysis to determine how attractive the development may be to a third-party developer
- Assist with the energy consumption totals for the Airport and City of Kansas City governmental operations
- If the City and KCAD decides to move forward, NREL could provide assistance with developing a request for proposals including language recommendations, technical requirements, and bid evaluation to help KCAD identify third party developer options
- Provide additional transmission/distribution system evaluation
- Provide utility or developer negotiation assistance

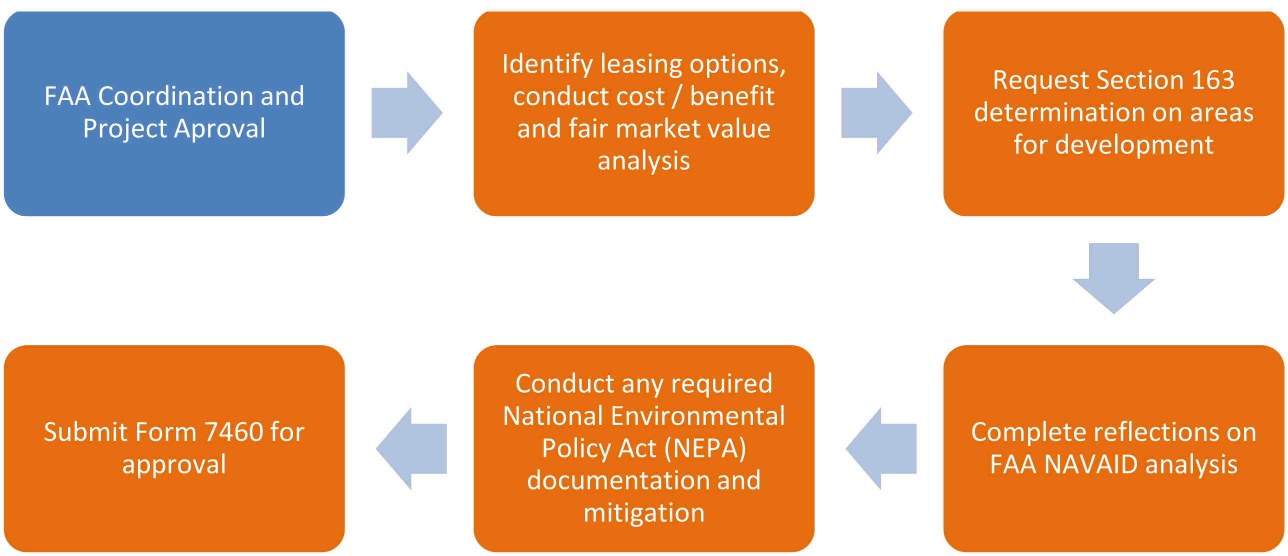
7.2 KCAD to Coordinate with SPP and Evergy

KCAD and the City need to begin the coordination efforts with SPP and Evergy about the siting and feasibility study and the desire to potentially implement a solar facility at the Airport. KCAD can determine if it is best to enter the interconnection study process as the sponsor or wait until a potential third-party developer would enter the process. The next steps to coordinate with SPP and Evergy include:



7.3 KCAD to Move forward with FAA Coordination

KCAD and the City have been providing updates to the FAA on the status of the siting and feasibility study. The next steps for KCAD to move forward with FAA coordination and project approval include:



- **KCAD to Conduct Fair Market Value Analysis:** KCAD would conduct a detailed fair market value of airport real property to be leased. In addition, KCAD would conduct a detailed evaluation of other land lease rates in the region to compare the competitiveness of the site for potential developers. This information would be provided to the FAA and potentially used in the RFP for third party developers.
- **KCAD to request Section 163 Determination on Areas proposed for Development:** In October 2018, Section 163 of the FAA Reauthorization Act of 2018 (Section 163) became law. Section 163 limits the FAA's statutory authority over certain airport development projects. Airports at the beginning of any project need to submit information to the FAA so they may determine FAA's regulatory authority. Information on the previous funding of the parcels to be used in the project and the project description are some of the information needed by FAA to make their determination. **Figure 7-1** shows several of the

parcels in Site 3 were obtained with FAA and Airport Improvement Program (AIP) funding. In addition, other parcels in all of the sites were obtained with FAA and AIP funding.

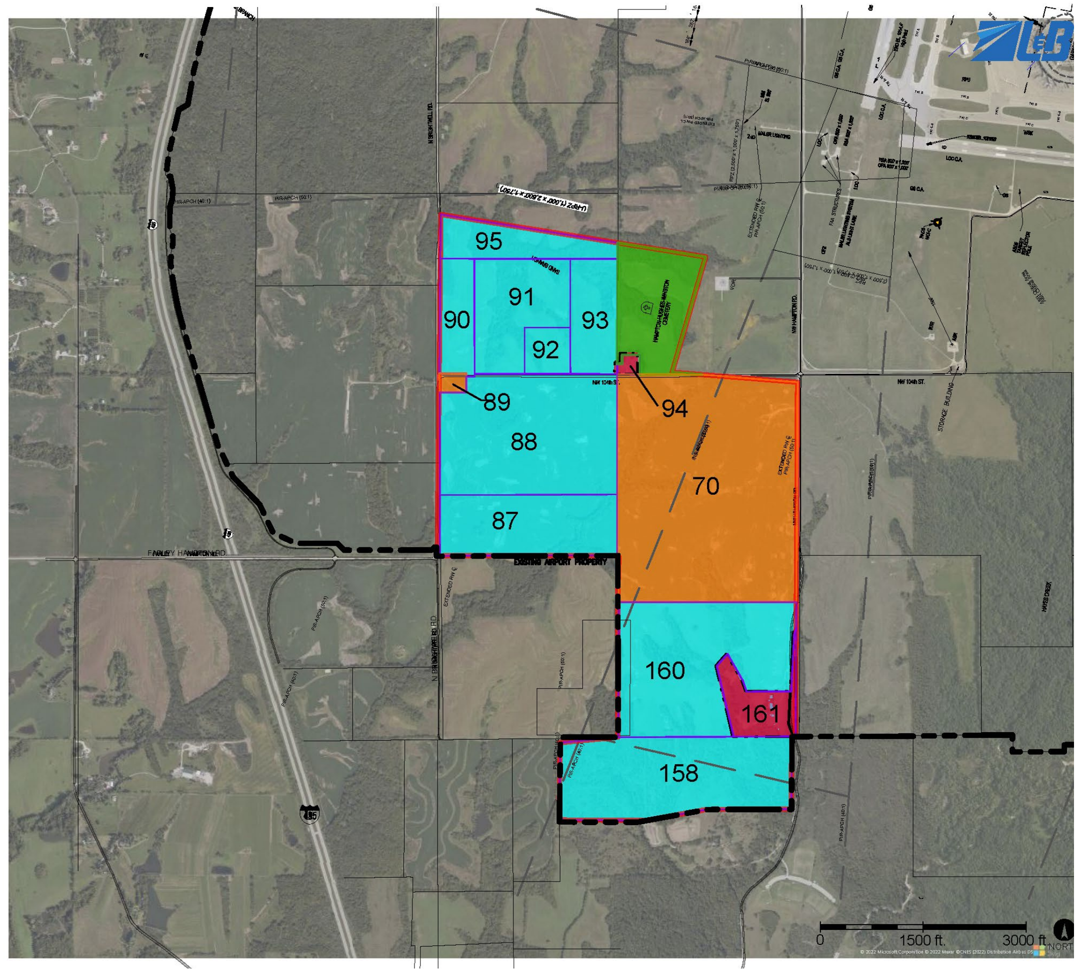
- **KCAD to Conduct Any Required NEPA Documentation and Implement Mitigation if applicable:** KCAD would coordinate with FAA and other applicable agencies to conduct and complete the NEPA documentation needed to implement the solar development. By completing the NEPA documentation, KCAD could provide this information to a third-party developer to make the project more attractive.
- **Complete Reflections on FAA NAVAID Analysis:** The May 2021 FAA policy eliminated the requirement for KCAD to submit a glare report/analysis. KCAD now just needs to include a statement in the 7460-1 confirming there would be no ocular impact to the airport traffic control tower. However, the FAA would need analysis on any potential reflection with airport surveillance radar systems and confirmation that the solar development would stay out of the VOR critical areas.
- **KCAD to Conduct Airspace Review and submit 7460 Form**: KCAD would need to prepare a 7460 submittal to cover all the project elements of a solar development. FAA requires submission at least 45 days prior to start of project and construction activities.

Figure 7-1 Airport Property Funding

AIRPORT PROPERTY FUNDING

AIRPORT PROPERTY	TYPE OF FUNDS USED	TRACT NUMBER	PURCHASE DATE	TRACT ACREAGE
(green)	** FAAP NO. 9-23-057-702 ** FAAP NO. 9-23-057-0601	Multiple	1953	4,805.5
(cyan)	*** AIP NO. 3-29-0040-02	87	1986	52.5
	*** ADAP NO. 6-29-0040-17	88	1980	105.0
	*** ADAP NO. 6-29-0040-10	90	1977	20.2
	*** ADAP NO. 6-29-0040-10	91	1980	44.7
	*** AIP NO. 3-29-0040-39	92	2000	9.7
	*** AIP NO. 3-29-0040-39	93	2000	25.6
	*** ADAP NO. 6-29-0040-10	95	1977	59.3
	*** AIP NO. 3-29-0040-39	158	2001	89.9
	*** AIP NO. 3-29-0040-54	160	2006	99.6
(orange)	CITY FUNDS ONLY	70	1987	201.4
		89	1989	2.5
(red)	EXCEPTIONS	94,161		(-21.5)

NOTES:
** Federal Aid Airport Report (FAAP) with city funds.
*** Airport Development Aid Program (ADAP) and Airport Improvement Program (AIP) with city funds.



Source: KCAD, 2022.

Attachment A PVsyst Simulation Report

Version 7.2.6

PVsyst - Simulation report

Grid-Connected System

Project: KCAD Energy Output Study

Variant: New simulation variant

Sheds on ground

System power: 2792 kWp

KCAD - United States

Author

Olsson (United states)

PVsyst V7.2.6
VCN, Simulation date:
18/11/21 11:42
with v7.2.6

Project: KCAD Energy Output Study

Variant: New simulation variant

Olsson (United states)

Project summary

Geographical Site		Situation		Project settings	
KCAD		Latitude	39.32 °N	Albedo	0.20
United States		Longitude	-94.75 °W		
		Altitude	281 m		
		Time zone	UTC-6		

Meteo data
KCAD
NREL NSRDB Typ. Met. Year PSMv3_1998 to 2016 - TMY

System summary

Grid-Connected System — **Sheds on ground**

PV Field Orientation		Near Shadings	User's needs
Fixed plane		Detailed electrical calculation	Unlimited load (grid)
Tilt/Azimuth	30 / 0 °	acc. to module layout	

System information

PV Array		Inverters	
Nb. of modules	5940 units	Nb. of units	1 Unit
Pnom total	2792 kWp	Pnom total	2200 kWac
		Pnom ratio	1.269

Results summary

Produced Energy	4539 MWh/year	Specific production	1626 kWh/kWp/year	Perf. Ratio PR	84.67 %

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General parameters, PV Array Characteristics, System losses — 3
Near shading definition - Iso-shadings diagram — 4
Main results — 5
Loss diagram — 6
Special graphs — 7

General parameters

Grid-Connected System

Sheds on ground

PV Field Orientation

Orientation		Sheds configuration		Models used	
Fixed plane		Nb. of sheds	90 units	Transposition	Perez
Tilt/Azimuth	30 / 0 °	**Sizes**		Diffuse	Imported
		Sheds spacing	5.00 m	Circumsolar	separate
		Collector width	2.07 m		
		Ground Cov. Ratio (GCR)	41.3 %		
		Shading limit angle			
		Limit profile angle	17.9 °		

Horizon
Free Horizon

Near Shadings
Detailed electrical calculation
acc. to module layout

User's needs
Unlimited load (grid)

PV Array Characteristics

PV module		Inverter	
Manufacturer	SunPower	Manufacturer	SMA
Model	SPR-X21-470-COM	Model	Sunny Central 2200
(Original PVsyst database)		(Original PVsyst database)	
Unit Nom. Power	470 Wp	Unit Nom. Power	2200 kWac
Number of PV modules	5940 units	Number of inverters	1 unit
Nominal (STC)	2792 kWp	Total power	2200 kWac
Modules	594 Strings x 10 In series	Operating voltage	570-950 V
At operating cond. (50°C)		Pnom ratio (DC:AC)	1.27
Pmpp	2595 kWp		
U mpp	707 V		
I mpp	3671 A		

Total PV power		Total inverter power	
Nominal (STC)	2792 kWp	Total power	2200 kWac
Total	5940 modules	Nb. of inverters	1 Unit
Module area	12843 m²	Pnom ratio	1.27
Cell area	11633 m²		

Array losses

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 20.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 3.1 mΩ
Loss Fraction 1.5 % at STC

Module Quality Loss
Loss Fraction -0.8 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

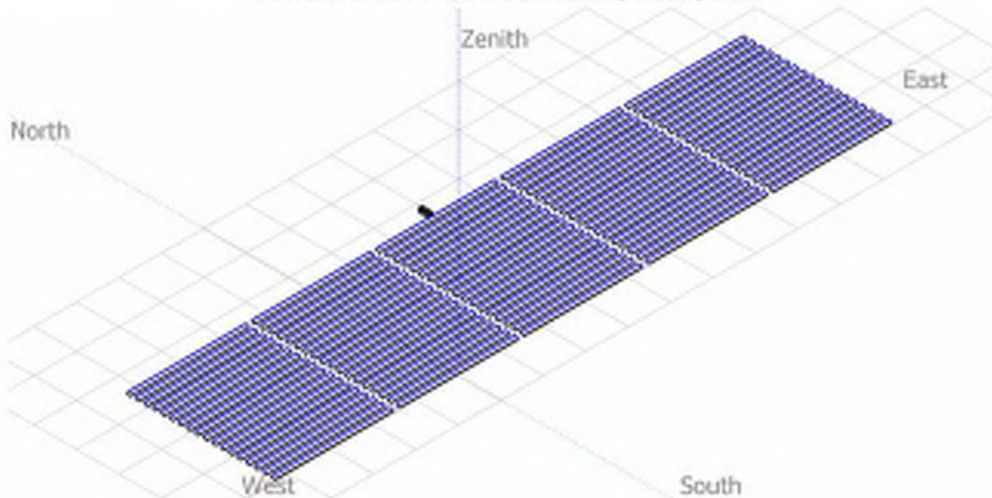
Strings Mismatch loss
Loss Fraction 0.1 %

IAM loss factor
Incidence effect (IAM): Fresnel AR coating, n(glass)=1.526, n(AR)=1.290

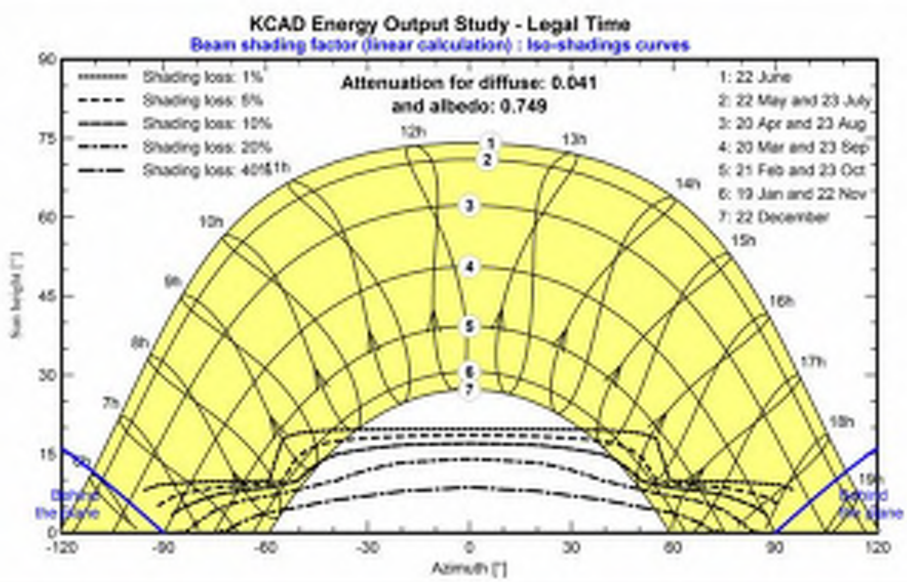
0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000

Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram



Main results

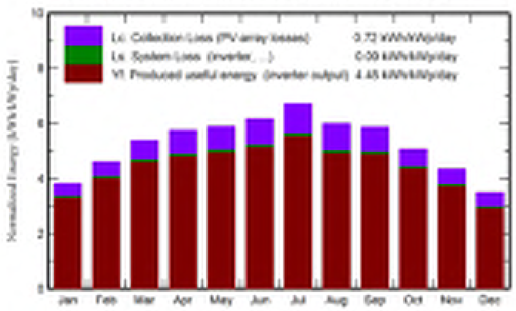
System Production

Produced Energy 4539 MWh/year

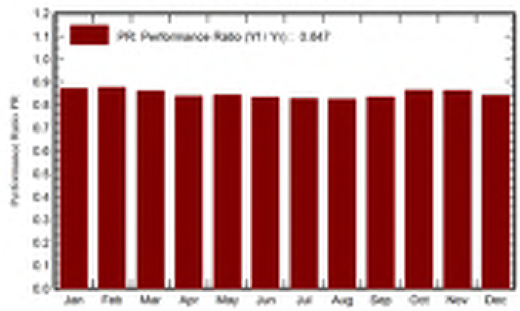
Specific production 1626 kWh/kWp/year

Performance Ratio PR 84.67 %

Normalized productions (per installed kWp)



Performance Ratio PR



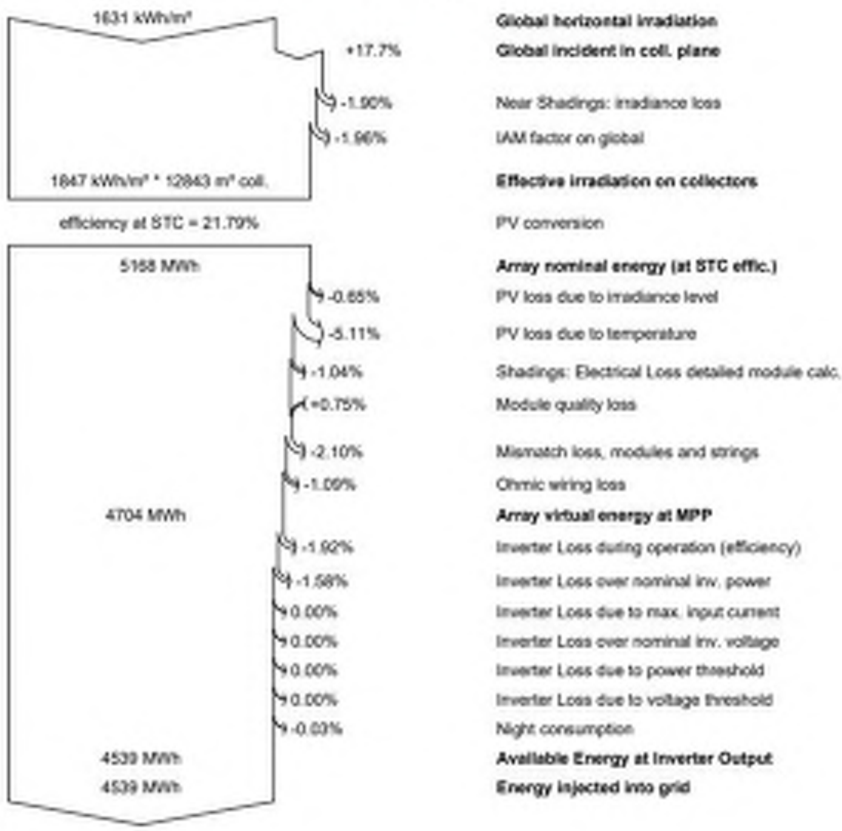
Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR ratio
January	70.4	23.62	-3.47	118.3	114.0	294.0	287.8	0.871
February	87.9	30.61	-0.19	128.9	124.9	322.1	315.4	0.877
March	134.5	51.32	6.99	166.8	161.1	408.8	400.6	0.860
April	158.7	61.99	12.78	172.7	166.1	413.1	404.9	0.840
May	185.8	79.71	17.95	182.6	174.5	438.7	430.3	0.844
June	197.3	70.13	21.94	185.2	177.0	440.1	431.6	0.836
July	214.3	73.37	25.14	208.1	199.8	490.9	481.5	0.829
August	178.2	64.80	25.57	185.9	178.7	436.9	428.6	0.826
September	148.3	49.04	20.27	176.3	170.2	419.4	411.3	0.836
October	114.4	37.88	13.36	157.1	152.2	386.5	378.9	0.864
November	79.4	24.03	5.01	130.1	125.4	320.2	313.6	0.863
December	62.1	24.09	-2.43	108.3	103.1	260.1	254.7	0.842
Year	1631.1	590.59	11.98	1920.3	1846.9	4630.8	4539.2	0.847

Legends

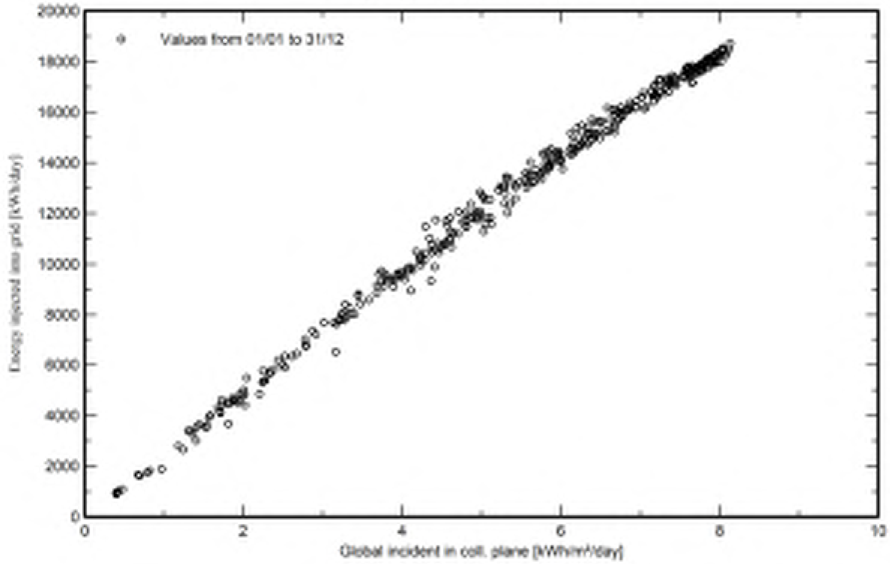
GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse irradiation
T_Amb	Ambient Temperature
GlobInc	Global incident in coll. plane
GlobEff	Effective Global, corr. for IAM and shadings
EArray	Effective energy at the output of the array
E_Grid	Energy injected into grid
PR	Performance Ratio

Loss diagram

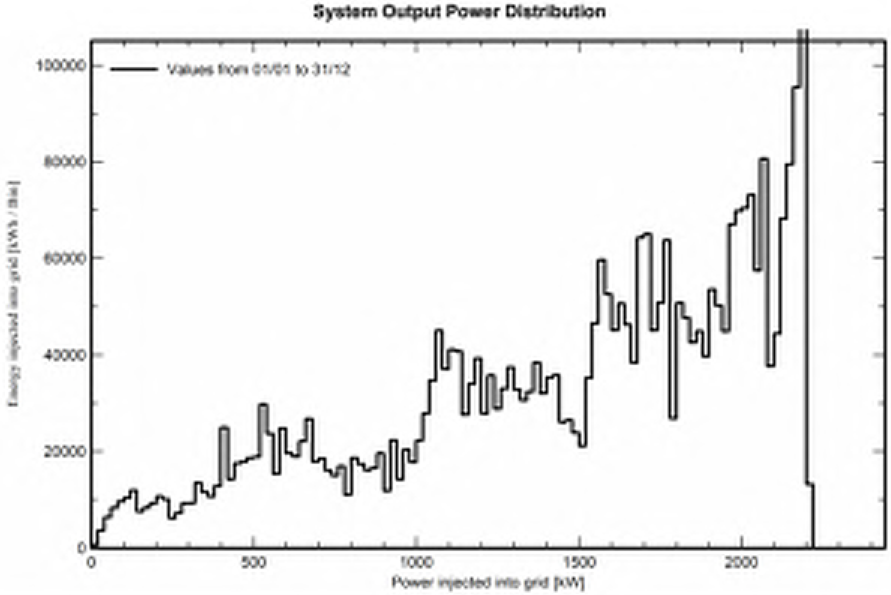


Special graphs

Daily Input/Output diagram



System Output Power Distribution



Version 7.2.6

PVsyst - Simulation report

Grid-Connected System

Project: KCAD Energy Output Study

Variant: New simulation variant

Tracking system with backtracking

System power: 2688 kWp

KCAD - United States

Author

Olsson (United states)

PVsyst V7.2.6
VCM, Simulation date:
18/11/21 11:54
with v7.2.6

Project: KCAD Energy Output Study

Variant: New simulation variant

Olsson (United states)

Project summary

Geographical Site
KCAD
United States

Situation

Latitude	39.32 °N
Longitude	-94.75 °W
Altitude	281 m
Time zone	UTC-6

Project settings

Albedo	0.20

Meteo data
KCAD
NREL NSRDB Typ. Met. Year PSMv3_1998 to 2016 - TMY

System summary

Grid-Connected System

Tracking system with backtracking

PV Field Orientation
Tracking plane, horizontal N-S axis
Axis azimuth 0 °

Near Shadings
Detailed electrical calculation
acc. to module layout

User's needs
Unlimited load (grid)

System information

PV Array		Inverters	
Nb. of modules	5720 units	Nb. of units	1 Unit
Pnom total	2688 kWp	Pnom total	2200 kWac
		Pnom ratio	1.222

Results summary

Produced Energy	4898 MWh/year	Specific production	1822 kWh/kWp/year	Perf. Ratio PR	86.74 %

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Near shading definition - Iso-shadings diagram 4
Main results 5
Loss diagram 6
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General parameters

Grid-Connected System

Tracking system with backtracking

PV Field Orientation

Orientation
Tracking plane, horizontal N-S axis
Axis azimuth 0 °

Backtracking strategy
Nb. of trackers 52 units
Sizes
Tracker Spacing 4.50 m
Collector width 2.07 m
Ground Cov. Ratio (GCR) 45.9 %
Phi min / max. -/+ 52.0 °
Backtracking limit angle
Phi limits +/- 62.2 °

Models used
Transposition Perez
Diffuse Imported
Circumsolar separate

Horizon
Free Horizon

Near Shadings
Detailed electrical calculation
acc. to module layout

User's needs
Unlimited load (grid)

PV Array Characteristics

PV module

Manufacturer	SunPower
Model	SPR-X21-470-COM
(Original PVsyst database)	
Unit Nom. Power	470 Wp
Number of PV modules	5720 units
Nominal (STC)	2688 kWp
Modules	572 Strings x 10 In series
At operating cond. (50°C)	
Pmpp	2499 kWp
U mpp	707 V
I mpp	3535 A

Inverter

Manufacturer	SMA
Model	Sunny Central 2200
(Original PVsyst database)	
Unit Nom. Power	2200 kWac
Number of inverters	1 unit
Total power	2200 kWac
Operating voltage	570-950 V
Pnom ratio (DC:AC)	1.22

Total PV power

Nominal (STC)	2688 kWp
Total	5720 modules
Module area	12367 m²
Cell area	11202 m²

Total inverter power

Total power	2200 kWac
Nb. of inverters	1 Unit
Pnom ratio	1.22

Array losses

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 20.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 3.3 mΩ
Loss Fraction 1.5 % at STC

Module Quality Loss
Loss Fraction -0.8 %

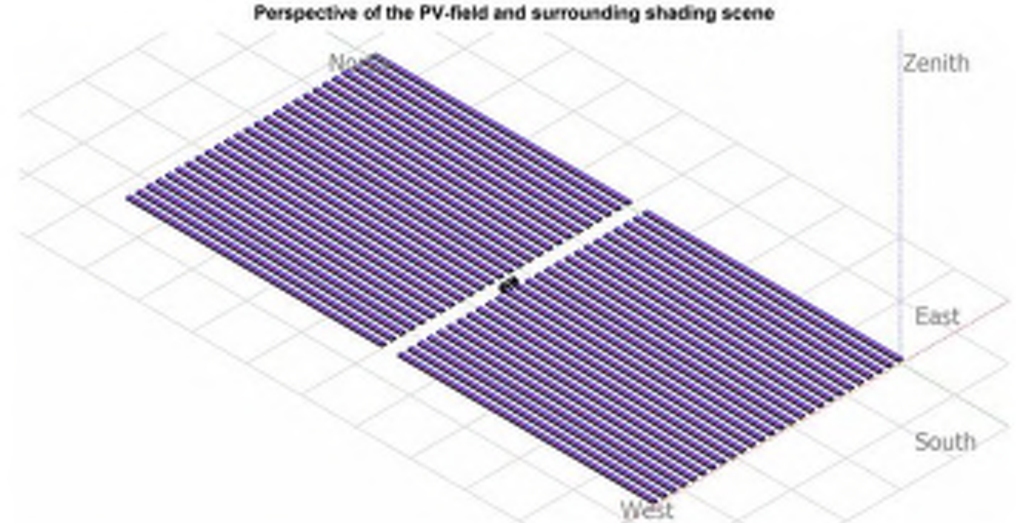
Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.1 %

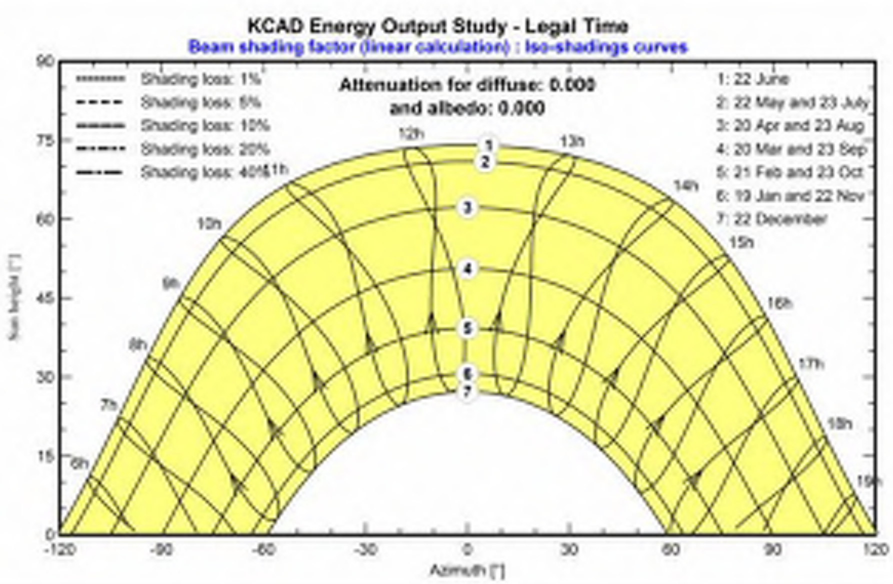
IAM loss factor
Incidence effect (IAM): Fresnel AR coating, n(glass)=1.526, n(AR)=1.290

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000

Near shadings parameter



Iso-shadings diagram



Project: KCAD Energy Output Study

Variant: New simulation variant

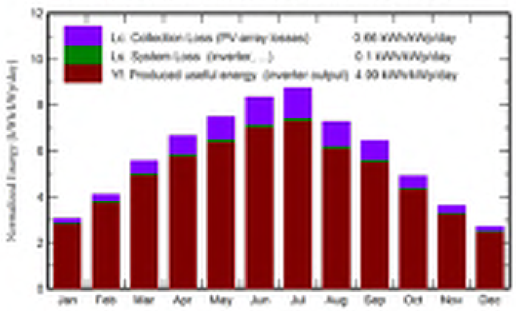
Olsson (United states)

Main results

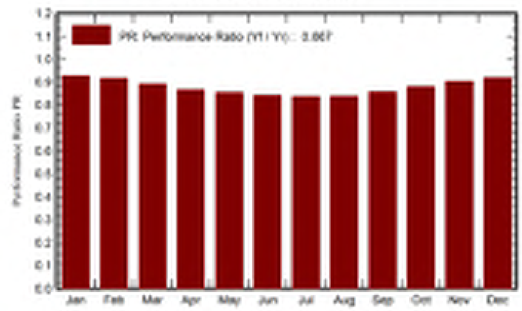
System Production

Produced Energy	4898 MWh/year	Specific production	1822 kWh/kWp/year
		Performance Ratio PR	86.74 %

Normalized productions (per installed kWp)



Performance Ratio PR



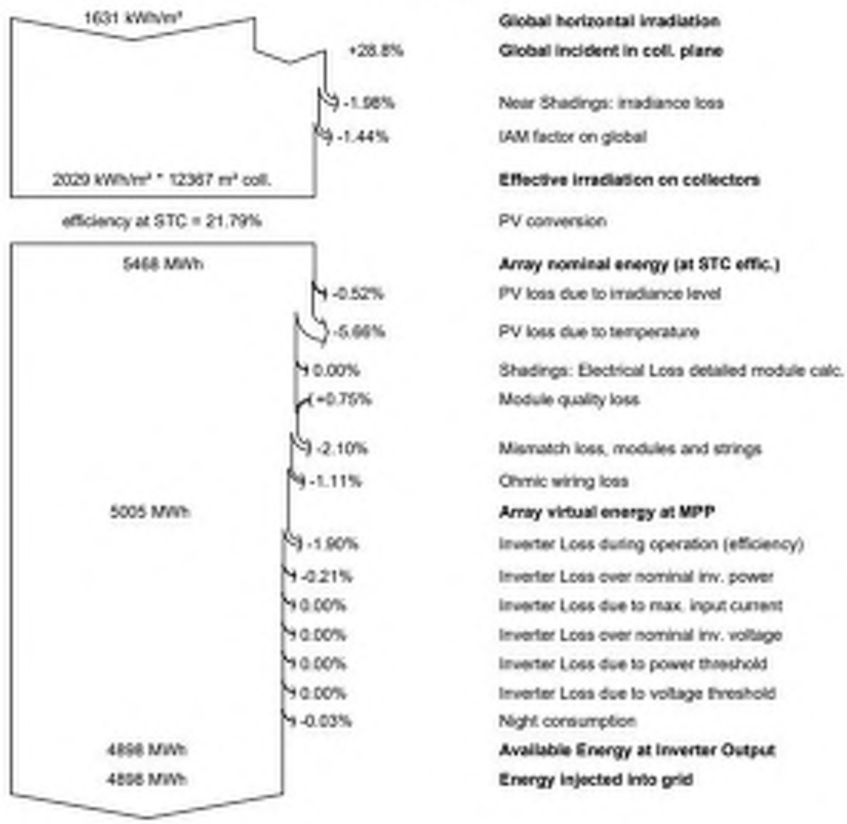
Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR ratio
January	70.4	23.62	-3.47	94.5	89.6	240.6	235.8	0.929
February	87.9	30.61	-0.19	115.0	110.2	289.4	283.6	0.917
March	134.5	51.32	6.99	172.6	166.7	422.0	413.8	0.891
April	158.7	61.99	12.78	200.2	194.0	475.7	466.3	0.866
May	185.8	79.71	17.95	232.6	225.2	544.8	534.3	0.855
June	197.3	70.13	21.94	250.8	243.6	579.0	567.9	0.842
July	214.3	73.37	25.14	271.0	264.1	622.6	610.8	0.838
August	178.2	64.80	25.57	225.6	219.1	518.9	509.1	0.839
September	148.3	49.04	20.27	193.7	187.9	454.4	445.8	0.856
October	114.4	37.88	13.36	152.4	146.9	367.6	360.7	0.880
November	79.4	24.03	5.01	108.5	103.4	268.8	263.6	0.904
December	62.1	24.09	-2.43	83.6	78.5	210.9	206.7	0.920
Year	1631.1	590.59	11.98	2100.5	2029.3	4994.8	4898.4	0.867

Legends

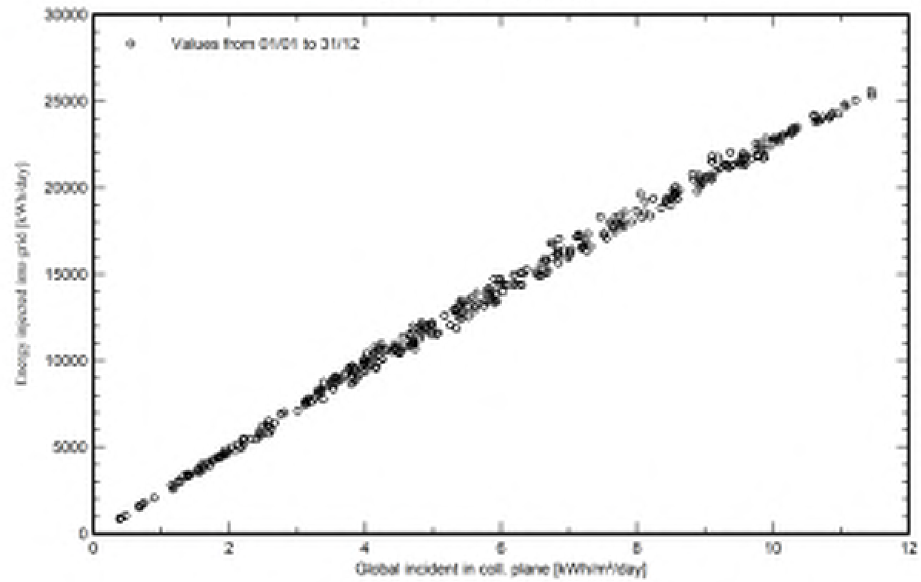
GlobHor	Global horizontal irradiation	EArray	Effective energy at the output of the array
DiffHor	Horizontal diffuse irradiation	E_Grid	Energy injected into grid
T_Amb	Ambient Temperature	PR	Performance Ratio
GlobInc	Global incident in coll. plane		
GlobEff	Effective Global, corr. for IAM and shadings		

Loss diagram



Special graphs

Daily Input/Output diagram



System Output Power Distribution