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INDEPENDENCE POWER & LIGHT

IPL Generation Replacement

Generation Siting Study

INDEPENDENCE
MISSOURI
A GREAT AMERICAN STORY

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Independence Power & Light (IPL) is a municipal electric utility serving the City of Independence (City), Missouri. Recently, IPL retired 98 MW generating capacity at the Blue Valley Power Station (BVPS) located adjacent to Substation A. The remaining generation capabilities within the IPL system are aging (having been installed between 1968 to 1974) and not as efficient as new generation equipment and require increasing investment to maintain operational status. In the process of replacing the aging and retired generation assets, IPL seeks to help ensure that future extreme events will not lead to rolling blackouts for the customers served by the utility. To move forward in a strategic manner to address aging assets while building generation resilience, IPL has commissioned a two-phased effort consisting of a siting study (Phase 1) and then the issuance of a Request for Proposal (RFP) for procuring new generating assets (Phase 2) at IPL-owned substations. The purpose of the Phase 1 siting study is to investigate and screen potential replacement options to determine the most appropriate replacement generation type at one or more of the substations considered. Past studies had indicated that the City would need to make an investment of over $30 million into the transmission system to maintain the current level of reliability should all the generation be retired at Substations H, I and J.

The purpose of this study is to find the most appropriate technologies and locations for replacement of up to 108 MW of existing and/or recently retired electrical generating capabilities at locations within the existing IPL infrastructure. Generation is to be located at one or a combination of up to four different electrical substation locations identified by IPL for use. Additionally, IPL prefers to utilize the Southwest Power Pool (SPP) Generating Facility Replacement process to maximize the new generation capacity at each location up to the approved SPP transmission interconnection limit. By utilizing the SPP Generation Facility Replacement process, the time frame for SPP approval reduces from 4-5 years to 6-12 months. SPP is currently evaluating Generation Interconnection requests that were submitted in 2017. The Generation Interconnection process also has unknown costs related to additional transmission system improvements that may be required by the SPP analysis and would be avoided utilizing the Generating Facility Replacement process. These costs can be substantial depending on the grid modeling results and requirements imposed.

Five main constraints were identified that help to further guide the objectives. These are:

- Electrical Capacity and Dispatch – The new equipment should be more efficient to allow the units to operate more frequently in the SPP market. This equipment is expected to have an annual capacity factor of approximately 30%. It is also expected that these new units may experience multiple daily starts and stops during portions of the year.
- High Availability and Reliability – The new units should be available during all conditions including extreme weather events or other power shortage conditions.
- Multiple Fuel Sources – The equipment should be capable of utilizing multiple fuels in case costs or supply prohibit the use of the primary fuel source.
- Hydrogen Fuels – The selected technology (if combustion powered) would ideally support the use of hydrogen as a future fuel source.
- Decarbonization and Renewables – Any new equipment should be compatible and adaptable to work with renewable technologies as the market shifts in the future.

Multiple technologies were selected for consideration based on the goal and guiding constraints. These included:

1. Combustion Turbine.
2. Reciprocating Engine.
3. Wind.
4. PV Solar.
5. Solar Thermal.
6. Battery Energy Storage Systems (BESS).

Specific siting constraints were reviewed for each selected technology at the four identified substation locations. This included:

- Substation Electrical Capacity.
- Available Footprint.
- Available Utilities:
    - Natural Gas.
    - Fuel Oil.
    - Water.
    - Wastewater.
- Environmental Permits.
- Social / Aesthetics.
- Capital and O&M Costs.

Based on the siting analysis, the top recommended selection is the addition of large, dual-fueled (natural gas and oil) aeroderivative combustion turbines for the Blue Valley Power Station/Substation A location. This technology meets the requested power generation capability, fits within the identified footprint, and can be easily interconnected into the existing substation facility. This technology also allows for future use of hydrogen fuel and integration with BESS or other renewable technologies co-located at the facility. Alternatively, reciprocating engines can also be utilized at this location to achieve the desired goals. Although the heat rate (efficiency) of reciprocating engines is slightly better than combustion turbines, the cost of these machines is 25 – 30% higher and they have higher O&M costs.

If the SPP Tariff waiver is not approved for the BVPS/Substation A location, The alternate selection for IPL's consideration is aeroderivative combustion turbines at Substation I due to the transmission reliability impact in retiring generation at this location. Past studies have determined that significant investment in the transmission system would be required to maintain the current level of reliability under system contingencies if all generation was retired at this location.

The City could move forward with an RFP to procure new generation to be in service within the next 2-3 years at Blue Valley pending Federal Energy Regulatory Commission (FERC) approving a waiver from certain aspects of the SPP Tariff. Denial of the waiver request could delay SPP approval for new generation at Blue Valley 4-5 years and incur additional unknown transmission upgrade costs.

Although both options recommend the use of aeroderivative combustion turbines, certain attributes of reciprocating engines may ultimately determine this equipment to be the preferred choice. It is recommended that the RFP allow for the consideration of both combustion turbine and reciprocating engine technology. Evaluation criteria including capital cost, efficiency, operating cost and partial load operation can then determine the best option to suit IPL's goals.

BACKGROUND/PURPOSE

IPL is a municipal electric utility serving the City of Independence (City), Missouri. IPL has approximately 795 miles of distribution lines, 76 miles of transmission lines, one switching station, and fourteen substations. IPL was established in 1901 and serves over 57,000 electric customers located within the corporate limits of the City of Independence through a mix of owned assets and purchased power. IPL currently operates six (6) generating units located at three (3) substations on IPL's system. In addition, the City owns a 12.3 percent share of the Dogwood Energy Facility and has several long-term power purchase agreements (PPAs). Recently, IPL retired 98 MW of generating capacity at the Blue Valley power plant located adjacent to Substation A.

IPL is interconnected into the SPP transmission system. SPP is a regional transmission organization which is a nonprofit corporation mandated by FERC to ensure reliable supplies of power, adequate transmission infrastructure and competitive wholesale electricity prices on behalf of its members. Currently, SPP oversees the bulk electric grid and wholesale power market in the central United States for utilities and transmission companies covering 17 states.

The remaining generation capabilities within the IPL system are aging (having been installed between 1968 to 1974) and not as efficient as new generation equipment and require investment to maintain operational status. Additionally, recent storm events such as the extreme cold event that occurred in February 2021 have highlighted the need for enhancing IPL's resiliency to allow operation in extreme conditions and broadening IPL's electrical generation capabilities with a greater variety of fuel sources. In the process of replacing the aging and retired generation assets, IPL seeks to help ensure that future extreme events will not lead to rolling blackouts for the customers served by the utility.

To move forward in a strategic manner to address aging assets while building generation resilience, IPL has commissioned a two-phased effort consisting of a siting study (Phase 1) and then the issuance of a Request for Proposal (RFP) for procuring new generating assets (Phase 2). The purpose of the Phase 1 siting study is to investigate and screen potential replacement options to determine the best course of action. POWER Engineers, Inc. has been retained to perform the siting study and provide recommendations for the installation of up to 108 MW (total) of new electrical generation capabilities located at one or more of substations A, H, I, and/or J. The screening process, system constraints, and other study bounds are described below.

METHODOLOGY

In conjunction with IPL, POWER Engineers, Inc. (POWER) developed the methodology to be utilized for this siting study. After receipt of the contract to perform the work, POWER met with IPL staff to further understand the objectives of this effort, assumptions, and the factors most important to the utility and the customers that it serves. A summary of the approach methodology is:

1. Define the goal.
2. Outline overall system constraints.
3. Review technologies considered.
4. Outline site constraints.
5. Identify viable options for each site.
6. Develop viable combinations to meet overall goal.
7. Recommend best options for consideration.

Each of these items will be further defined and reviewed within this document.

ANALYSIS

Define the Goal

The purpose of this study is to find the best available technologies and locations for replacement of up to 108 MW of existing and/or recently retired electrical generating capabilities at locations within the existing IPL infrastructure. Generation is to be located at one or a combination of up to four different electrical substation locations identified by IPL for use. Additionally, IPL prefers to utilize the SPP Generation Facility Replacement process to maximize the new generation capacity at each location up to the approved SPP transmission interconnection limit. By utilizing the SPP Generation Facility Replacement process, the time frame for SPP approval reduces from 4-5 years to 6-12 months and avoids unknown costs related to additional transmission system improvements that may be required by the SPP analysis.

Outline Overall Constraints

To achieve the goal listed above, certain guiding constraints have been developed based on discussions and feedback from IPL. These guiding constraints serve to help influence the best site(s) for additional generators, the type of technology to be used, and the capacity of the generator in comparison to the amount of usable space at each site (2 to 4-acres at BVPS/Substation A and about 0.75-acre at each of the other substations). These guiding constraints seek to balance the needs of all stakeholders so that the final recommendation is suitable for all parties including IPL, the Independence City Council, citizens of Independence, and IPL customers.

Electrical Capacity and Dispatch

IPL has identified the goal of replacing up to 108 MW of existing and/or recently retired generation capacity with new generation units. While this represents the total peak power production capacity requested, it does not describe how much the new generation will run throughout the year or the total amount of annual electrical energy production expected. This would allow the systematic retirement of the existing generation assets but does not provide for additional capacity anticipated to be needed when then current Capacity contract expires in 2030.

Like other members of the SPP regional transmission organization, electrical energy from IPL generating units is bought and sold in the integrated marketplace. SPP operates two types of markets: Day-Ahead and Real-Time. The Day-Ahead market commits the most cost-effective and reliable mix of generation for the region. Generators bid into this market at their lowest price that they will accept for coverage of certain operational costs. This type of market serves to incentivize the most efficient units as those with lower operating costs can accept lower sale prices per unit of electrical energy. Less efficient units are therefore only economically viable when the market prices are higher – such as during extreme weather conditions or times of large generating unit outages. Similarly, the Real-Time market economically dispatches generation to balance real-time generation and load while ensuring system reliability. The most efficient or cost-effective units that can start-up quickly and reach full electrical output quickly are dispatched first in this market. Less efficient units are brought online only when needed during times of large system demand and/or events that threaten system reliability.

The existing IPL combustion turbines are aging, not as efficient as modern electrical generating units, and some fire only fuel oil which is generally a more costly fuel. These units are infrequently dispatched and operate with a very low annual capacity factor (defined as the ratio of the actual electrical energy output over a given period to the maximum possible electrical energy output over that period). Based on previously completed analyses, IPL expects replacement equipment to have an annual capacity factor of approximately 30%. It is also expected that these new units may experience multiple daily starts and stops during portions of the year and will help support increasing reliance on renewable energy resources. This type of operating profile lends itself to generation that is capable of peaking type operation (as opposed to base load operation).

High Availability/Reliability

Reliability is critical to maximize the benefits of the new generation equipment within the SPP marketplace and for the customers of IPL. Availability in the electrical generation industry is the ratio of the number of hours that the unit is operating or ready to operate, to the total hours in a year. Planned maintenance outages and unplanned (forced) outages for maintenance or other reasons all reduce the availability of a unit. Units with high availability indicate a asset that can be relied upon to operate when needed. IPL seeks to have this type of highly available electrical generation within their portfolio to help ensure that electricity is available to its customers under a range of situations and conditions.

Multiple Fuel Sources

For units that utilize fuel energy to produce electrical energy, IPL desires the equipment to be capable of using multiple types of fuel. Fuel pricing and availability, specifically for natural gas, can become volatile if there are supply chain issues or periods of high demand. Generation equipment tied to a single fuel source is directly impacted by these costs and may either experience periods of curtailment until supplies increase or high operating costs when fuel costs are inflated.

Some of the current IPL combustion turbine equipment utilize fuel oil as the sole fuel source while other equipment considered “dual-fueled” utilizes natural gas as the primary fuel source with fuel oil as a secondary (backup) fuel source. During the recent extreme winter weather in February 2021, this multiple fuel capability proved invaluable as natural gas supplies experienced interruptions and the cost increased dramatically. IPL was able to continue operation of their “dual-fueled” power generation units by switching to fuel oil stored on-site in large storage tanks, and to also operate their equipment which is fuel oil fired only. This eased the strain within the SPP grid and helped ensure IPL customers were not significantly impacted by the energy shortage.

Hydrogen Fuels

IPL seeks to ensure new equipment considers the future landscape and is competitive and efficient over the entire life of the equipment. Equipment manufacturers are researching and exploring the potential use of hydrogen as a supplement to or replacement fuel for equipment that is traditionally fueled by fossil fuels such as natural gas and oil. Hydrogen may be produced from non-renewable or renewable sources; however, the goal for the future is to have a plentiful source of hydrogen available from renewable sources. Hydrogen production, storge, transmission and distribution infrastructure will also need to be developed and constructed to maximize the benefits of the clean, renewable hydrogen fuels.

Should this infrastructure be developed, IPL seeks to have generation equipment that is ready and capable of utilizing these fuels. Technology that uses fuel to generate electricity should have the ability for fuel flexibility and be able to use hydrogen as a fuel source.

Decarbonization and Renewables

IPL incorporates purchased wind and solar generated electricity into their distributed mix. As the market continues to move towards less carbon intensive power generation strategies, IPL seeks to be positioned to be adaptable and able to further incorporate this new technology into their system. Generation assets that are selected and installed to support current operations should be done with the future in mind. Equipment and designs should allocate provisions for future installation of battery storage or other systems that can help offset the more traditional, carbon-based generation equipment.

Technologies Considered

Based on the guiding overall constraints, specific technologies were selected for consideration and screening at each of the four locations. The equipment considered focused on those technologies that are currently commercially viable and have proven installations at the utility energy production scale. The aspects of each type of generation technology are summarized below.

Combustion Turbine Generator

A combustion turbine is a type of internal combustion engine in which combustion occurs in a continuous manner. The main components of a combustion turbine are:

1. Compressor section.
2. Combustion system.
3. Turbine.

Ambient air is drawn into the engine by the compressor where it is pressurized. Combustion turbine compressors typically contain multiple stages of blades to sequentially increase the air pressure to higher and higher pressures.

Once the air is sufficiently compressed, it is admitted into the combustion system where it is mixed with fuel and burned. Combustion temperatures are typically higher than 2,000 degrees F. The product of the combustion system is high temperature, high pressure gas that is utilized to perform work. Various methods of fuel injection into the air stream are utilized in modern gas turbine technology. Annular combustors are comprised of a ring that encircles the combustion turbine shaft. Although fuel is injected at certain points within the annular ring, combustion occurs uniformly around the combustion turbine shaft. Conversely, can type combustors are self-contained combustion chambers that each contain a fuel injector, igniter, and air inlets. A series of can type combustors encircle the turbine shaft. The combustion method is selected by the combustion turbine vendor based on the final characteristics desired such as ease of maintenance, emission control, weight limitations, and overall efficiency.

The final main element of the combustion turbine is the expansion turbine section. This section is comprised of alternating rows of stationary and rotating aerofoil type blades attached to either the turbine casing (stationary) or to the turbine shaft (rotating). The high temperature, high pressure gas exits the combustion system and is directed to the turbine blades where it expands and rotates the blades and turbine shaft. A portion of the spinning energy is utilized to drive the compressor section of the combustion turbine. In power generation applications, the remaining energy in the hot pressurized gas is utilized to rotate an electric generator and produce electricity. The amount of power generated through this air inlet, compression, and expansion process is significantly impacted by the temperature of the ambient air, with hotter ambient air resulting in a drop-off of power output. Equipment can be installed which cools the inlet air such as evaporative cooling or through a mechanical chilling system to restore some of the power output lost with hotter ambient temperatures.

Figure 1 shows a typical modern combustion turbine. The compressor section is on the left side of the image and the turbine/exhaust are on the right side of the image. An annular combustion system is shown upstream of the turbine section.

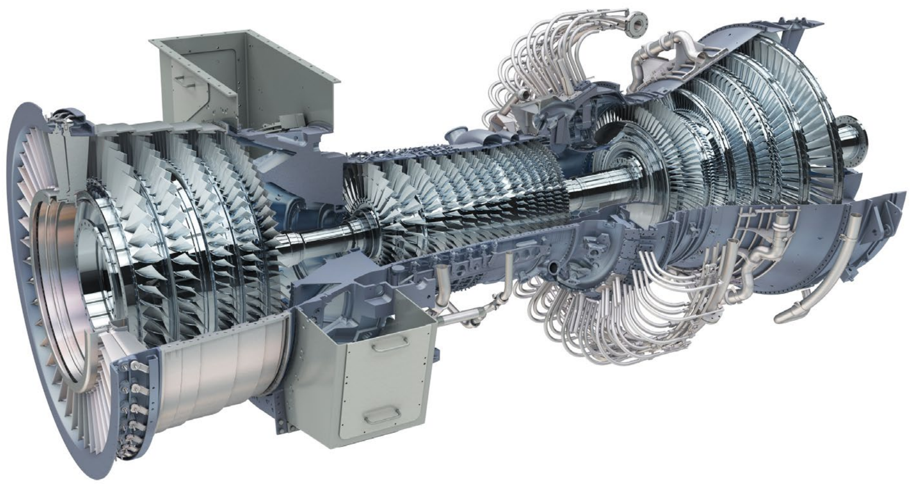


Figure 1: Combustion Turbine

Gas turbines utilized for power generation typically fall into two categories: aeroderivative type units and frame type units. Aeroderivative combustion turbines are designs derived from jet engines used for aviation purposes. One of the main differentiating characteristics is the pressure ratio of the turbine. Pressure ratio is defined as the ratio of the compressed air entering the combustion system to the inlet air pressure. Aeroderivative engines typically utilize high pressure ratios of 30 or higher while frame engines utilize lower pressure ratios typically below 20. Since aeroderivative engines are adapted from aviation technology, they tend to be more compact than frame units and sized for smaller power outputs. Frame units tend to be larger, heavier engines and are typically utilized when large power outputs are desired. Power outputs for aeroderivative engines can range from 5 MW – 100+ MW while frame machines typically range from 50 MW – 300+ MW. The current IPL units are frame style units with nominal electrical outputs below 20 MW – less than the current typical range of frame unit outputs. While smaller frame units are available for certain applications, advancements in aeroderivative engines have made these units more efficient for an equivalent power output.

Depending on the combustor technology selected, stable minimum load for combustion turbines can be as low as 25% of maximum electrical output when singular annular combustors are used. Can combustors offer better emission reductions but can only operate down to approximately 50% of maximum electrical output.

Optionally, equipment can be added to the combustion turbine unit which recovers the heat from the hot exhaust gases leaving the turbine and uses this heat to create steam which in turn is sent to a steam turbine generator to produce additional electrical output. Adding this heat recover and steam generator equipment (also known as combined cycle) can increase the unit output by approximately 50%. However, this adds substantial cost to the price of this power plant, requires significant additional space, increases the complexity of the plant operation, and reduces the ability for fast and frequent plant startup and shutdowns compared to combustion turbines without heat recovery and steam production.

Reciprocating Engine Generator

A reciprocating engine is a type of internal combustion engine in which combustion occurs in a cyclical manner. These engines are analogous to the internal combustion engines utilized in automobiles. The expansion of gasses within a cylinder drive a piston connected to a crankshaft. The linear motion of the piston is converted by the crankshaft connection to rotational movement. In power generation applications, the crankshaft is connected to an electric generator to produce electricity.

Figure 2 shows a typical reciprocating engine power plant utilizing two reciprocating engine generators. The generator is on the bottom of the image and the engines are towards the top with air intake and exhaust exiting out of the building.

Figure 2: Reciprocating Engine Power Plant

Like smaller combustion engines, reciprocating engine generators are further defined by the number of strokes to complete one cycle as well as the type of ignition source used. For power generation engines, a four-stroke cycle is typically utilized which is comprised of intake, compression, power, and exhaust strokes. The intake stroke draws in air and fuel as the piston moves to the bottom of the cylinder. On the compression stroke, the piston moves towards the top of the cylinder and compresses the fuel/air mixture. The mixture is ignited as the piston reaches the top of the cylinder and the hot gasses force the piston back down to the bottom of the cylinder. On the exhaust stroke, a valve is opened, and the hot expanded gases are pushed out of the cylinder. These engines can be bought as either natural gas fired only, fuel oil fired only, or with dual fuel firing capability.

Combustion of the air/fuel mixture can either be via spark-ignition (Otto cycle) or by compression-ignition (Diesel cycle). Spark-ignition combustion is ignited by a spark plug installed at the top of the cylinder. These engines are characterized by lower compression ratios. A compression-ignition engine uses higher compression ratios to generate more heat during compression that leads to auto-ignition of the air/fuel mixture without the need for a spark plug. Note that natural gas fired compression ignition engines require a small amount of fuel oil to be injected to serve as the ignitor fuel.

Unlike combustion turbine technology, reciprocating engines are minimally impacted by ambient conditions. These engines will produce nearly the same amount of power on hot summer days as they will on cold winter days. Reciprocating engines also maintain a relatively constant efficiency from minimum to maximum electrical output. Stable minimum loads for reciprocating engines can be as low as 25% of maximum electrical output.

Reciprocating engine startup time to full power output is quite short, typically less than 5 minutes. This is shorter than times associated with combustion turbines which may take 10 – 15 minutes to reach full operating load from cold start-up conditions.

The size range available for individual reciprocating engines typically utilized in utility power applications is from 1 MW for the smallest units to approximately 18 MW for the largest. Thus, it is more typical to install a number of reciprocating engines together in a bank as compared to larger available per unit combustion turbines.

Wind Turbine Generator

Wind turbines are relatively simple machines in terms of operating philosophy. Wind forces act on aerofoil type blades attached to a central shaft. The wind action causes the blades to generate lift and rotate the central shaft. The central shaft is connected, either directly or through a gearbox, to an electrical generator. As the shaft rotates, the generator produces electrical power.

Wind turbines are characterized into two types: horizontal-axis turbines and vertical-axis turbines.

Horizontal-axis turbines are similar in design to historical windmills. These devices include a nacelle mounted at the top of a tall tower that includes the electrical generator and supports the rotor shaft. Most horizontal-axis turbines include a three-bladed rotor and utilize aerofoil type blades to generate lift and spin the rotor. The rotor is typically located upstream of the tower (pointed into the wind) due to potential turbulence caused by the tower which can cause performance issues. This type of design is used on large, utility scale turbines with electrical outputs of 2 – 5 MW per wind turbine. Taller hub heights, as defined by the distance from the ground to the center of the rotating shaft, allow the wind turbine to access stronger wind speeds and increase their electrical output. Smaller horizontal-axis wind turbines are also available for lower capacity installations.

Figure 3 shows a typical utility scale horizontal axis wind turbine.

Figure 3: Horizontal-Axis Wind Turbine

Table 1 lists reference installations within the local area. The key aspect of this table is the large amount of area required for wind turbine installations. Wind farms that can produce the level of generation requested by IPL are set in rural areas with large expanses of real estate. Wind turbines require large amounts of separation between adjacent turbines to ensure each turbine does not interfere with the performance of the others. Additionally, wind resources are typically higher over flat, open areas of land as compared to denser, urbanized areas. For these reasons, the selected sites for analysis are not favorable for wind power generation.

TABLE 1: INSTALLED EXAMPLES OF WIND POWER FACILITIES		
LOCATION	**CAPACITY/AREA**	**ACRES/MW**
Elk River, Kan.	150 MW/8,000 acres	53
Ford County, Kan.	100.5 MW/5,000 acres	50
Smoky Hills, Kan.	100.8 MW/20,000 acres	198
Spearville, Kan.	100 MW/10 mi^2	64

* Source: http://www.aweo.org/windarea.html

Vertical-axis wind turbines have the main rotor shaft mounted vertically with the blades spinning horizontally about the main shaft. The generator and other auxiliary components of the wind turbine are mounted at the base of the shaft near the ground. Depending on the height of the rotor shaft, the vertical-axis wind turbine rotor may be self-supporting or require guy wires for supplemental support. Typical production from a vertical-axis wind turbine is 1 – 10 kW. Figure 4 shows a typical vertical-axis wind turbine.

Figure 4: Vertical-Axis Wind Turbine

Vertical-axis wind turbines offer several advantages over a horizontal-axis wind turbine. They can produce power from wind flow in any direction – eliminating the need for yaw and pitch motor control components to orient the turbine into the current windflow direction. Additionally, most equipment requiring maintenance is mounted at ground level which makes maintenance easier. Vertical axis wind turbines are also more suitable for areas with adverse weather conditions and are not as affected by extreme conditions.

However, application of vertical-axis wind turbines for utility scale power generation is hampered by a variety of factors of this style of design. Efficiency is reduced due to the turbine being mounted closer to the ground where average winds speeds are lower than those aloft. Additionally, only one blade is producing power at any given time which further reduces output. As noted, power production per wind turbine is an order of magnitude less than that of a horizontal-axis wind turbine (10 kW vs. 2-5 MW per turbine), requiring many more turbines to be deployed for an equivalent power production level.

Photovoltaic Solar Power

Photovoltaic (PV) Solar relies on the ability of certain materials to convert the energy of light directly into electrical energy. The typical material utilized in this application is silicon. The basic building block of a photovoltaic system is the solar cell. Each cell is typically small and generates less than 1 – 2 watts of electricity. To boost the output, these cells are combined into a solar module or solar panel. Typically, each solar panel contains 30 – 100 cells depending on the desired footprint dimensions and electrical output. These solar panels are then connected into a solar array to further increase the overall electrical generation to the desired aggregate production level. Solar panels may be mounted on rooftops or ground mounted on specialized racking systems. For utility scale power production, ground mounted systems are typically selected. An example of a utility scale system is shown in Figure 5.

Figure 5: Utility Scale Photovoltaic Solar

Fixed mount solar arrays are the lowest cost racking system. These systems hold the solar panels at a fixed angle oriented to the south for general solar exposure throughout the day. However, because the position is fixed, the solar incidence angle varies throughout the day and is not maintained at the most optimal angle. Therefore, these fixed mount systems produce the lowest amount of energy production.

Single axis tracking systems allow the module to follow the east to west progression of the sun throughout the day. These systems typically consist of a long central tube that pivots about a north-south axis. An electric motor drives one or more rows of the tracking array through the use of a programmable controller that accounts for time of day, time of year, and latitude/longitude of the plant location. However, as the trackers only move in one direction the vertical angle that maximizes solar incidence is not maintained throughout the year as the seasons change.

Dual axis trackers solve both limitations of the single axis and fixed mount systems. These arrays track the angle of the sun both throughout the day as well as throughout the year to achieve the maximum conversion of solar energy to electricity. Compared to a fixed mount system, this may equate to 30 – 45% more energy conversion on an annual basis. However, these systems are the costliest to install and maintain.

Table 2 lists reference installations within the local area. Again, the key takeaway is the amount of area required and the relatively low power density per unit of footprint compared to other technologies. Many of the sites considered are space constrained and do not have sufficient land available to support utility scale photovoltaic power generation.

TABLE 2: INSTALLED EXAMPLES OF PV SOLAR POWER FACILITIES		
LOCATION	**CAPACITY/AREA**	**ACRES/MW**
Springfield, MO	5 MW/25 acres	5
Nixa, MO	7.9 MW/65 acres	8
Independence, MO	14.7 MW/50 acres	3.5

* Source: https://www.seia.org/sites/default/files/2021-06/Missouri.pdf and using Google Earth for measurement of areas.

Solar Thermal Power Plant

Solar thermal power plants collect and concentrate energy from the sun to produce high temperatures that drive power generation systems. Solar thermal plants utilize a collection system that consists of mirrored reflectors that capture and concentrate the solar energy onto a receiver system. Several different types of solar thermal plants have been developed and operated; however, two options are the most viable for commercial operation:

1. Solar Power Tower.
2. Linear Concentrating Systems.

Solar Power Tower designs utilize a large field of mirrors to reflect sunlight onto a receiver system located at the top of a central tower. A heat transfer fluid, typically either water or molten salt, is pumped into the receiver vessel where it is heated by the concentrated solar energy. In the case of water, this generates steam which is then directed to a steam turbine generator. The steam turns the turbine which is connected to an electric generator and produces electricity. If molten salt is used, an intermediate hot salt to water/steam heat exchanger is used. Molten salt systems allow for some thermal energy storage capacity in the power plant for continuous production during partial cloud cover or other interruptions. Figure 6 shows a solar power tower including mirror field and molten salt storage tanks.

Figure 6: Solar Power Tower

Linear concentrating systems operate on a similar approach compared to solar power towers. However, instead of the use of a central tower, linear systems utilize parabolic troughs to concentrate the solar energy onto a long pipe located at the center of the curved mirror. The heat transfer fluid is pumped along this piping where the temperature is continuously increased. In the case of water, this generates steam which is then directed to a steam turbine generator. The steam turns the turbine which is connected to an electric generator and produces electricity. If molten salt is used, an intermediate hot salt to water/steam heat exchanger is used. Figure 7 shows a portion of a parabolic trough field at a linear concentrating solar facility.

Figure 7: Linear Concentrating Solar

Both types of solar thermal power plants must utilize some form of solar tracking to maximize the energy reflected to the heat transfer fluid. These systems can grow quite complicated as the amount of reflectors required for utility scale power production can be extensive. The footprint of these facilities is very large and typically requires relatively flat terrain. For these reasons, coupled with the high levels of solar irradiance, solar thermal power plant siting in the US has been limited to the Southeastern region of California, Nevada, and Arizona.

Battery Energy Storage Systems

Although not considered to be a form of generation similar to the resources listed above, Battery Energy Storage Systems (BESS) are playing an increasingly larger and important role in the overall electrical generation, storage, and distribution system. BESS is relatively simple in theory: electrical energy is stored in battery banks until needed. When energy is required, the batteries are discharged until depleted. This cycle can occur many times over the lifetime of the batteries. In practice, the charging and discharging of these devices is highly controlled to maximize the benefits of the stored energy. However, the energy stored in the batteries is finite and systems are typically rated for a maximum of two to eight hours of energy storage. Once depleted, they can no longer support the grid until recharged by other generating assets. Therefore, SPP does not consider these assets at their full installed capacity when determining their accredited capacity. Instead, the accredited capacity is well below the installed maximum output value which affects the operating characteristics and income generation from these installations.

The latest approach to offering BESS has been containerized solutions that can be installed individually or grouped together in a modular approach to develop the desired level of battery storage. These self-contained units contain the batteries, racking systems, control systems, and HVAC/battery cooling systems. When grouped together, a common control system is used to integrate each system into a cohesive unit. Figure 8 shows a sample BESS module with cutaway to view the internal battery and racking system.

Figure 8: Example BESS module

BESS can be installed as stand-alone grid connected systems or integrated with new generation equipment such as combustion turbines or reciprocating engines. When installed with power generation equipment, the control system can be used to further optimize the entire system – determining when to operate the generating equipment or when to discharge the BESS based on current electrical demand and market conditions.

In order to minimize loss of life, batteries are generally not allowed to fully charge or fully discharge in each cycle. Instead, the BESS is operated in a range of 30 – 80 % of its maximum capacity. This further reduces the output available from the BESS and relates to the SPP reduced accredited capacity for these systems.

Outline Site Constraints

Many specific constraints must be factored when reviewing the adequacy of a particular site for new generation equipment. The following section describes some of these parameters that were considered as part of this analysis.

Electrical Capacity

From the SPP grid perspective, each substation has two ratings that correlate to the maximum allowable generation capacity to be interconnected at that location. The SPP accredited capacity of is based on recent testing of the existing combustion turbines to prove available resources installed at the site. However, there is also a higher SPP interconnection limit associated with each substation that is beyond the accredited rating. Both values are assumed to be at summer (high ambient temperature) conditions. It is expected that the new generation at the facility would maximize the use of the current interconnect agreements and be as close to these values as possible. If exceeded, additional capacity could be added to the grid but needs to go through the SPP Generation Interconnection study process that can take approximately 4 – 5 years to complete and gain approval.

Each substation currently has several generator step-up transformers that convert the lower voltage power output from the generator to the transmission/distribution voltage of the electrical grid. In the considered substations, the transformers convert from the electrical generator output voltage of 13.8 kV to 69 kV. Transformer ratings are based on the maximum output voltage and current they can deliver, listed in kilovolt-amps (kVA) or megavolt-amps (MVA) depending on the size.

Typically, multiple ratings are provided for each transformer that equate to different oil temperatures or types of cooling. Higher allowable oil temperatures increase the rating of the transformer. Additionally, transformer ratings can be increased using forced air cooling for the oil system. Electrical fans can be installed on the oil radiators to mechanically increase air flow over the radiator fins instead of relying on natural convection alone. This increases heat transfer to the environment and allows the transformer to operate at higher power levels.

Electrical generators and transformers also need to consider the power factor of the system. Power factor is defined as the ratio of the real power absorbed by the electrical load to the apparent power flowing in the circuit. Higher power factors loosely equate to more efficient power distribution systems; however, typical systems operate with a power factor around 0.85 and is the value expected for these generators. Transformer and generator ratings must all be corrected for the power factor to allow for direct comparisons. The formula for conversion is:

$$Power\ (MW) = MVA\ Rating * Power\ Factor$$

Physical Footprint

Beyond the power output desired, perhaps the next most critical component is the available land for installation of new equipment. Different technologies require more or less depending on the number of auxiliary components required, number of generators, spacing between generators, and access requirements for operation and maintenance. Table 3 lists the various technologies considered along with a generalized footprint per generating unit as well as the overall footprint required to generate 100 MW of power.

TABLE 3: MINIMUM FOOTPRINT REQUIREMENTS			
GENERATOR TYPE	**APPROXIMATE GENERATOR SIZE**	**TOTAL FOOTPRINT REQUIRED**	**SITE FOR 108MW**
INDUSTRIAL COMBUSTION TURBINE	5 MW	0.25 ACRES	5.5 ACRES
SMALL AERODERIVATIVE COMBUSTION TURBINE	22 – 33 MW	0.35 ACRES	2 ACRES
LARGE AERODERIVATIVE COMBUSTION TURBINE	45 – 55 MW	0.65 ACRES	2 ACRES
SMALL RECIPROCATING ENGINE	4 – 5 MW	0.15 ACRES	4 – 5 ACRES
MEDIUM RECIPROCATING ENGINE	9 – 11 MW	0.35 ACRES	2 ACRES
LARGE RECIPROCATING ENGINE	18 MW	1 ACRES	6 ACRES
HORIZONTAL AXIS WIND TURBINE	2-3 MW	50 ACRES	5400 ACRES
VERTICAL AXIS WIND TURBINE	10 KW	0.05 ACRES	540 ACRES
PHOTOVOLTAIC SOLAR	1 MW	6 ACRES	648 ACRES
SOLAR THERMAL	100 MW	500 ACRES	540 ACRES
BATTERY ENERGY STORAGE SYSTEM	1 MW / 4 MW-HR	0.03 ACRES	3 – 4 ACRES

The above table includes only the footprint required for the new generation equipment and auxiliary systems. Not included in this footprint is fuel storage tank footprints, electrical transformers, substation equipment, and laydown maintenance areas. These components exist at the proposed substation facilities and are not planned to be modified unless required by the selected technology.

As the table indicates, reciprocating engines and combustion turbines can generate the most power per given footprint of land. Currently, renewable technologies are lower power density components and require a much larger footprint to generate the equivalent power output.

Utilities

Natural Gas

Combustion turbines and reciprocating engines both require a reliable supply of natural gas in large volumes for proper operation. These units are usually supplied from a large pipeline from the natural gas transmission and distribution system. If no natural gas infrastructure exists near the proposed generator site, the costs associated with installing a new pipeline to connect the facility to the supply system can be substantial.

Combustion turbines mix the natural gas with high pressure air from the compressor section of the turbine. For proper operation, the natural gas must also be at high pressure which in most instances is above the transmission/distribution pipeline supply pressure. On-site gas compressor skids are used to increase the pressure of the incoming natural gas supply to the required operating pressures, typically around 500 – 750 psig. Additionally, the natural gas quality must be closely controlled to ensure no contaminants are admitted into the combustion turbine. A gas filtration system is usually installed upstream of the combustion turbine to ensure any water and particulate matter entrained in the natural gas stream are removed prior to use.

Reciprocating engines are less sensitive to fuel supply pressure and quality. The supply pressure found in natural gas pipelines is typically more than sufficient for proper operation of the engine. These facilities do not require gas compressor skids as part of the auxiliary equipment system. Gas cleanup equipment may still be required similar to that required for combustion turbines to ensure that the proper quality is maintained.

Natural gas is not required for the operation of wind turbines, solar facilities, or BESS (unless onsite generation for the BESS is included). However, if gas is available these facilities may still utilize a small amount for heating of office and warehouse spaces.

Fuel Oil

In general, combustion turbines and reciprocating engines can utilize fuel oil as a secondary (backup) fuel source for operation when the use of natural gas is curtailed or not desirable. Unlike natural gas, fuel oil can be stored on-site in large aboveground or belowground tanks until needed. These fuels do not significantly degrade over time and can be stored for long periods before being consumed. Replenishment of the fuel supply is typically done by tanker truck deliveries.

A pump and filter skid is installed between the storage tanks and the combustion turbine or reciprocating engine. The pump skid cleans the stored fuel and increases the pressure to the appropriate level before supplying it to the turbine. This skid may also contain a heater that is used during cold ambient conditions to ensure the fuel oil viscosity is maintained at levels that avoid gelling. Additionally, the fuel oil piping may also be insulated and heated with heat trace tape to maintain flowability.

Fuel oil is not required for the operation of wind turbines, solar facilities, or BESS.

Potable/Non-Potable Water

Combustion turbine power plants require water for operation and maintenance activities. The primary water usage is for washing of the compressor blades. Over time, particulates in the ambient air build up on the compressor blades and change the airflow characteristics. As the accumulation grows, the performance of the turbine decreases and removal is required through high pressure water spray cleaning. High quality water, typically of demineralized quality, is required for these cleaning applications. Depending on the size of turbine and frequency of cleaning, the water may either be transported to site or produced on-site with water treatment equipment.

Some combustion turbines may also use a stream of water during normal operation. High pressure water sprays are utilized in combustion systems to limit pollutant production – specifically nitrous oxides – by reducing the overall combustion temperatures. Water can also be injected to increase the power output of the combustion turbine by increasing the overall mass throughput of the machine.

Some water may also be used by combustion turbine plants if an evaporative cooling system is installed to lower the ambient air inlet temperature as a means to restore lost power output during hotter temperature days. The supplied water is evaporated within the inlet air system as a means to cool off the inlet air prior to the turbine, thus fresh water would need to be added to the system as the water is evaporated and passes through the combustion turbine.

Reciprocating engine power plants do not usually require a permanent supply of water for operation. These units are typically cooled by closed-loop radiator systems that once filled do not require constant make-up. However, potable water may be required if any bathroom facilities are in the engine hall or for fire protection purposes.

Wind turbines do not require a supply of water for operation. Potable water may be required if a central office/administration building is installed for sanitary and fire protection systems. However, any water required for washdown or maintenance of equipment is brought to the turbine location and not through piping infrastructure.

Solar photovoltaic plants use water for dust removal and cleaning of the solar modules. Potable water quality is typically sufficient for these cleaning applications.

Solar thermal power plants require water for make up for the steam cycle to re-supply water lost due to leakages and other venting. Additional water usage is required if the cycle is designed with wet cooling utilizing cooling towers. In these applications, losses to evaporation can be significant and a large water make-up stream is required.

Battery energy storage systems do not require water during normal operation. Some systems may require water storage or municipal water for fire protection purposes or thermal energy management.

Wastewater

Wastewater discharges from the types of plants considered is typically minimal. Many of the facilities may only have a sanitary discharge stream for bathrooms or other washdown purposes.

For combustion turbine plants which utilize water injection for emission control or for power augmentation, a water demineralization system will be required to treat the water prior to injection. There is wastewater discharged from this water treatment equipment. This water is normally allowed to discharge into the municipal sewer system as the water quality is not hazardous or harmful to the municipal water treatment equipment.

Combustion turbine washdown water is one waste stream that must be treated separately than normal discharges. Trace metals dislodged from the turbine casing or blades may be present in the water and can be considered hazardous waste. Turbine washdown water is typically collected in a small storage tank and periodically removed by a vacuum truck for treatment at appropriate facilities.

These plants will all also have stormwater drainage, collection, possible processing, and discharge systems which must be designed, permitted, and installed.

Environmental Permits

The list of permits that may be required for new power generation equipment can be extensive and varied from locale to locale as well as on the type of technology to be used. Many different agencies must be informed at the federal, state, and local levels. Examples of permits that may need to be considered and obtained:

- Air construction permit.
- Air operating permit.
- Spill prevention control and countermeasure plan.
- National pollution discharge elimination system permit.
- Federal Aviation Authority obstruction evaluation.
- Land use permit.
- Hazardous waste permit.

Noise

Noise, or unwanted sound, is one of the most common environmental exposures in the United States. The goal of noise management is to maintain low noise exposures, such that human health and well-being are protected. Exposure to high noise levels can be hazardous to humans and can cause hearing damage or exacerbate other conditions. However, noise does not necessarily have to be harmful to be a nuisance or detrimental to the overall well-being of affected individuals. Certain frequencies or sounds occurring during the night or at other inconvenient times can be especially impactful and cause frustration in those affected.

Noise from power generating equipment is addressed through a variety of measures. The best approach is to mitigate the noise at the source through the design of the equipment. However, this is not always feasible and may still leave portions to be addressed. Acoustic insulation, mufflers, and silences may all be installed on the offending component to further reduce the sound impacts from the equipment. Additionally, sound barriers may be added between the equipment and the trouble areas to deflect or block the noise and reflect it to other less sensitive areas.

For equipment where these measures are insufficient or infeasible, the distance between the equipment and the noise receptors can be increased to lower the perceived sound pressure levels.

Visual

Public concerns about how proposed projects may change the visual character and impact the visual quality of an area are often key elements of concerns about proposed power generation projects. The industrial appearance and geometric and linear forms and lines of utility-scale energy facilities often contrast strongly with their surroundings in both rural and urban landscapes. In addition to direct effects on scenic views in more natural and rural areas, the public is often concerned about how a proposed project will affect their existing views and thus impact their quality of life and property values. Other visual concerns may be related to site lighting and the impacts to surrounding properties from light pollution.

Visual concerns are best addressed during the planning and design phases of a project as they are much more difficult to integrate after a project is completed. Some examples of items that can be considered to help minimize the overall impact to the surroundings are:

- Use products or finishes that minimize glare.
- Select appropriate colors and finishes to best match and blend with the surrounding locations.
- Minimize structure and equipment heights.
- Shield and orient lighting downward to eliminate offsite light spillage.

Capital and Operations/Maintenance Costs

Total project cost including capital costs as well as Operations and Maintenance (O&M) costs is critical to the success over the lifetime of the project. Capital costs include the purchase of major equipment, construction contractor costs, and any development costs incurred such as permitting, interconnection, and land acquisition costs.

O&M includes both fixed and variable costs. Fixed O&M costs are those that represent the cost of operating and maintaining a unit's availability to produce power. These costs are independent of the amount of power generated by the unit. Examples of fixed O&M include labor, materials, costs for routine maintenance or overhauls, and administrative costs. Variable costs include those that vary based on the amount or frequency of power generation from the unit. Examples of these costs are chemicals, water consumption, wastewater and waste discharge, and consumables such as lubricants and gasses. Fuel is also a variable cost but is usually presented separately and not included in the O&M rates listed in this report.

The costs presented in this report are based on high level estimates based on data from industry sources, modeling software, and historical experience. These numbers are meant as representative data to compare the overall costs required for installing and operating different power generation technology. However, actual costs of these plants can vary greatly based on many factors including location, commodities pricing, contracting methodologies, and other project specific factors. The cost information presented in this report should be validated prior to project execution.

Identify Viable Options for Each Site

Substation H

Substation H is located at the southeast quadrant of the intersection of Salisbury Road and Missouri 291 Highway in Jackson County. The property is bounded by 291 Highway on the west, Salisbury Road on the north, and South Peck Road on the east. The property is surrounded mostly by residential properties. However, there are properties in the vicinity to the south, towards Truman Road, that include operations dedicated to underground storage and over-the road trucking. A railroad siding is located at Truman Road that ties into Union Pacific to the west that could be used for delivery of major equipment components. There are two 69 kV lines owned by IPL and two 69 kV lines owned by KCP&L that are on site. The substation site also includes two natural gas/distillate-fired GE Frame 5 combustion turbines that have been in operation on this site since the early 1970s.

Site Constraint Review

Electrical Capacity

The current SPP accredited capacity of Substation H is 35 MW. This capacity is based on recent testing of the existing combustion turbines to prove available resources installed at the site. However, the SPP interconnect limit for Substation H is slightly higher at 45 MW.

The substation has two generator step-up transformers that convert the lower voltage power output from the generator to the transmission/distribution voltage of the electrical grid. In this case, the transformers convert from the electrical generator output voltage of 13.8 kV to 69 kV.

The maximum transformer rating for each of the two generator step-up transformers is 33.6 MVA. Table 4 summarizes the various ratings discussed in this section.

TABLE 4: SUBSTATION H ELECTRICAL RATINGS		
DESCRIPTION	LIMIT/RATING (MVA)	LIMIT/RATING (MW)
SPP ACCREDITED LIMIT	41.2	35
SPP INTERCONNECT LIMIT	53.0	45
TRANSFORMER #1 RATING	33.6	28.6
TRANSFORMER #2 RATING	33.6	28.6

*Assumes 0.85 Power Factor

Note that the combined ratings of Transformer #1 and #2 exceed the current SPP interconnect limit and equate to a total capacity of 57.2 MW. Since the SPP interconnect limit is a regulatory value and not an equipment rating limitation, this could be increased to match the installed equipment if desired by IPL. However, this additional capacity would need to go through the SPP Generation Interconnection study process that can take approximately 4 – 5 years to complete and gain approval.

Footprint

The substation is comprised of two different parcels of land totaling approximately 2.25 acres of land within the main substation limits. However, not all of the footprint is available for development and use in installing new electrical generation equipment. A portion of the footprint is used for the electrical substation equipment including the transformers, breakers, and distribution/transmission line supports. Additionally, some areas contain steep grades or slopes that would be difficult or cost-prohibitive to prepare for new equipment. Areas for access roads and maintenance also need to be considered and reserved from the available footprint for new generation. Once these items are removed, the total available footprint is approximately 0.62 acres.

The figures at the end of this section shows the layout of the existing substation with parcel boundaries and available and unusable areas highlighted:

- Small Reciprocating Engine:

  The available land footprint area is sufficient for the installation of six small reciprocating engine sets (4 – 5 MW each) capable of producing 24 – 30 MW of total power generation. Units of this size are either supplied as a containerized package or separate for installation in a common engine hall. The containerized option allows for a more compact installation and less field installation time. However, the disadvantage to these types of units can be the levels of noise generated as there is less room for insulation and other sound abatement components to be installed within the container. Additional auxiliary equipment, such as low voltage electrical distribution equipment, would be installed adjacent to the engine containers. A sample layout utilizing the containerized engines is included at the end of this section.

- Medium Reciprocating Engine:

  The available land footprint area is sufficient for the installation of two medium reciprocating engine sets (9 – 11 MW each) capable of producing 18 – 22 MW of total power generation. Units of this size are typically installed in a common engine hall but may be offered as a containerized package (typically consisting of multiple containers per unit). The noise abatement issues are expected to make a containerized offering impractical at this substation for this engine size. Engines of this size require a separate radiator component that is mounted adjacent to the engine hall. Additional auxiliary equipment, such as low voltage electrical distribution equipment, would be installed within the engine hall itself. Transportation/setting of these modules is expected to be challenging as room for site access roads is limited. A sample layout is included at the end of this section.

- Large Reciprocating Engine:

  The available land footprint area is insufficient for the installation of large reciprocating engines (18 MW each). The length of these units from engine through exhaust equipment/stack are greater than the longest sections available at the substation. Additionally, the transport/installation of equipment of this size is difficult for tight areas where sufficient access roads are not installed.

- Industrial Combustion Turbine:

The available land footprint area is sufficient for the installation of four industrial combustion turbines (4 – 5 MW each) capable of producing 16 – 21 MW of total power generation depending on the selected combustion turbine model. Units of this size are containerized with the engine and generator in a common enclosure. Air inlet filter and stack equipment would sit above and adjacent to the turbine module. Fuel gas compression equipment could be shared between the combustion turbines and contained on a common skid along the perimeter of the substation. Additional auxiliary equipment, such as electrical equipment and chemical equipment for pollution control systems can be installed and shared across the turbines. A sample layout is included at the end of this section.

- Small Aeroderivative Combustion Turbine:

  The available land footprint area is sufficient for the installation of two small aeroderivative combustion turbines (20 – 30 MW each) capable of producing 40 – 60 MW of total power generation depending on the selected combustion turbine model. Options are available for these units to be trailer mounted for quick install/setup or installed in a more traditional modularized approach. Either option serves to reduce site setup time and minimize the overall field connections required. Air inlet filter and stack equipment would sit above and adjacent to the turbine module. Fuel gas compression equipment could be shared between the combustion turbines and contained on a common skid along the perimeter of the substation. Additional auxiliary equipment, such as electrical equipment, water treatment equipment (if required) and chemical equipment for pollution control systems can be installed and shared across the turbines. A sample layout is included at the end of this section.

- Large Aeroderivative Combustion Turbine:

  The available land footprint area is sufficient for the installation of one large aeroderivative combustion turbines capable of producing 39 – 49 MW of total power generation. These units are supplied in multiple modules including the combustion turbine, generator, lube oil equipment, and pollution control equipment. Air inlet filter and stack equipment would sit above and adjacent to the turbine module. Fuel gas compression equipment can be contained on a common skid along the perimeter of the substation. Additional auxiliary equipment, such as electrical equipment, water treatment equipment (if required) and chemical equipment for pollution control systems would also be installed adjacent to the turbine for easy access during operation.

  Modifications to the substation would be required to utilize a large aeroderivative turbine at this substation. Neither generator step-up transformer has sufficient capacity to accept the electrical output from this generator. At a minimum, a new transformer would be required to be installed. Likely, upgrades to the circuit breaker, bus, and other substation equipment would also be required.

  A sample layout is included at the end of this section.

- Wind:

  The available land footprint area is sufficient for the installation of a single horizontal axis wind turbine capable of producing 2 – 5 MW. However, the proximity of the nearby electrical transmission/distribution lines would make installation very difficult to avoid interferences and negative impacts on either system. Therefore, this is not considered to be a feasible use of the available site footprint.

- PV Solar:

  The available land footprint area is sufficient for the installation of approximately 100 kW of photovoltaic solar modules. The installation would be a fixed mount system as the area is insufficient for the economical use of single or dual axis tracking systems. Additional equipment would include the inverters necessary to convert from direct current to alternating current power. Given that only 100 kW of generation is possible, PV Solar is not considered feasible for this location.

- Battery Energy Storage:

  The available land footprint area is sufficient for the installation of approximately 15 MW / 60 MW-hr battery energy storage systems. The installation would include approximately 15 containerized battery storage systems that are typically installed in 20-foot ISO shipping containers. Additional equipment would include the inverters necessary to convert from direct current to alternating current power.

  The system evaluated has an operating capacity up to 4 hours at full power output. This limits the functionality of these systems to meet the IPL guiding constraints as a direct replacement for electrical generation equipment. These systems can be paired with other generating equipment to function like a hybrid automobile. For short output periods, the BESS outputs stored electrical energy to the grid. Once depleted, the electrical generation equipment would operate until the batteries could be recharged.

  A sample layout of all BESS equipment on the substation is included at the end of this section for reference. This layout is meant to present an indicative footprint for consideration when mixing BESS with other generating equipment.

Utilities

Two fuel oil storage tanks are installed at the facility to support operation of the existing combustion turbines. Each tank has a nominal capacity of 40,000 gallons and can store approximately 36,000 gallons of fuel when the proper free space within the tank is considered. When both tanks are full, the site can store 72,000 gallons between the two tanks. For those generators that utilize fuel oil such as reciprocating engines or combustion turbines, this equates to approximately 25 hours of run-time for generators equating to the SPP interconnect limit rating. During extreme weather events or other abnormal conditions where the generators are operated extensively on fuel oil, daily deliveries may be required. Otherwise, the tank capacity should be sufficient for less frequent deliveries (weekly, bi-weekly, etc.) during normal operation.

Spire currently provides natural gas to the facility to support operation of the existing combustion turbines. Through recent discussions, they have confirmed that 500 MCF/hr can be supplied to this facility without issue. For those generators that utilize natural gas such as reciprocating engines or combustion turbines, this amount is sufficient to support operation up to the current SPP interconnect limit. However, the pressure of the supply pipeline is below that required for operation of the combustion turbine equipment. Fuel gas compression equipment can be installed on-site to increase the pressure to the required levels.

City water is currently available at the substation. Depending on the generation technology selected, the capacity of this existing infrastructure can be verified and upgraded if required. Wastewater services do not currently exist at the substation. However, the facility is located within the city boundary and the necessary infrastructure exists nearby serving other customers.

Environmental Permits

The Substation H site is covered by an air Permit to Operate issued by the Missouri Department of Natural Resources (MDNR). The site also has an oil Spill Prevention Control and Countermeasure (SPCC) Plan.

The air Permit to Operate (OP2017-008) expires on January 26, 2022 and IPL submitted a permit renewal application on May 21, 2021. The Permit to Operate describes the facility as a "major source" as it has the potential to emit more than 250 tons per year of at least one regulated pollutant. The permit covers the two existing combustion turbines (firing natural gas or fuel oil) as well as their on-board starting diesel engines. The permit also lists the two large fuel oil storage tanks as well as four (4) small underground waste oil storage tanks. The permit limits the sulfur content of the fuel oil to no more than fifteen (15) parts per million of sulfur. The permit does not limit the amount of operation of the combustion turbines. Based on historical records the facility has had limited operation and emitted much less than 250 tons per year of any pollutant.

Replacing generating capacity with new combustion turbines or engines would require an air construction permit and a revision to the air Permit to Operate. At a minimum the combustion equipment would need to meet stringent federal New Source Performance Standards (NSPS) required for newly built sources. The existing generating equipment at the substation are "grandfathered" from these new limits. Thus, the new generating equipment will have significantly lower emission levels because of NSPS, the more modern technology, and because of the much greater efficiency of the equipment. Because of these low NSPS emission levels the construction air permitting of the newly installed equipment options will likely have less than 250 tons per year of any regulated pollutant and thus not need to follow the Prevention of Significant Deterioration (PSD) "major source" construction permit review process. Without the need for PSD dispersion modeling and control technology analyses the air construction permitting process would be more streamlined.

The combustion turbine technology options would not require an SCR and oxidation catalyst to comply with federal NSPS. However, not installing SCR could lead to MDNR requesting a demonstration that the new installation complies with National Ambient Air Quality Standards (NAAQS) which would lengthen the permitting schedule and might result in even higher levels of emission controls. All combustion turbine options at Substation H will be under the "major source" thresholds so long as the annual amount of fuel oil is limited to something reasonable. The oil-firing operational limitation would not be restrictive and could be avoided by installing an SCR. Beyond the construction and operating permitting process, any new replacement generating units with generator nameplate capacity greater than 25 MW (per unit) would in addition be required to comply with the federal Acid Rain program and the associated continuous emissions monitoring system (CEMS) requirements. Thus, for the combustion turbine options considered with units greater than 25 MW these requirements would be triggered along with the additional CEMS equipment, reporting requirements, and be subject to the allowance program of Acid Rain as well as the allowance program of the regional Cross-State Air Pollution Rule (CSAPR). These allowances must be procured each year for both the annual timeframe and the ozone seasonal timeframe. The smaller (less than 25 MW) combustion turbine options have the advantage of avoiding these additional CEMS requirements and need to procure, track, and report allowances.

The reciprocating engine technology options would require an SCR and oxidation catalyst to comply with federal NSPS. All engine options at Substation H will be under the PSD "major source" without placing operational limitations on natural gas or oil firing. The engine options would not be subject to the Acid Rain Rule or the CSAPR and, therefore, also have the advantage of not having to procure emission credits to operate. The engines would require an MDNR Section 6 air construction permit (6 to 9 months) and either a Title V Permit to Operate or an Intermediate operating permit (not needed before construction).

The SPCC Plan specifies oil related reporting, inspections, training, and certifications as required by the Environmental Protection Agency (EPA) regulations. This Plan is updated every 5 years or whenever there are substantive changes to the facility which impact the Plan. Each of the proposed options would require substantive revisions to the SPCC Plan, but these revisions would not result in any significant issues which would be a concern to the selection of any of the options.

Social/Aesthetic

Substation H is adjacent to a heavily trafficked highway but also adjacent to single family residential areas. A residential dwelling is located approximately 150 feet southeast of the substation equipment, another dwelling is located approximately 300 feet east of the existing power generation equipment, and another dwelling is approximately 250 feet north of the generating equipment. There are additional dwellings slightly further than these in these same directions. There are additional dwellings to the west but slightly more distant and are across 291 Highway. There is a short barrier wall surrounding the facility, but taller equipment is visible to the surrounding public.

The existing noise environment is heavily influenced by traffic noise on the nearby 291 Highway. Traffic on this highway travels at a higher rate of speed given the nature of the road. Because there is a stop light at Salisbury Road, there are frequent cycles of louder traffic noise associated with the acceleration of the automobiles as well as large trucks including semi-tractor trailers. The nearby residential public currently perceives an audible environment controlled by this heavily trafficked highway noise. During low traffic periods such as during nighttime hours, the sound environment would take on a more traditional residential neighborhood sense. During these times the public may be able to discern the substation transformer sounds (humming) as well as "crackling" sounds from the high voltage power lines during periods of higher atmospheric moisture levels. The Substation H generation equipment has been at this site for approximately 50 years.

Replacing generating capacity with new combustion turbines or engines would not change the noise environment substantially when operating compared to times when the current turbines are operating. However, because the anticipated operating frequency will substantially increase, the nearby public will experience these operating sounds more often. Thus, the selection of replacement generation should consider utilizing above average noise quieting features such as buildings, sound absorption barriers, and additional air inlet and exhaust silencing baffle performance. Because they would be installed without a building housing them, the small engines option may have higher noise impacts compared to the other options and would require additional cost to mitigate to acceptable levels.

Utility scale wind turbines can be perceived to have unacceptable noise emissions (swooshing) caused by the rotation of the large blades through the air. In addition, the height of the supporting structure and the rotating blades are quite high and would be visible for a significant distance. Both the type of noise generated and the visible nature are much different than the existing environment and would make the wind turbine(s) addition more pronounced. Wind turbine farms installed in urban areas need to consider these factors that are not as important in rural installations.

Viable Options

Table 11 summarizes the review of each of the various site constraint parameters. Items highlighted in green represent adequate or viable options while items in red denote unfavorable or not currently viable conditions are present. Items highlighted in yellow are not currently satisfied but could be corrected and are marked as such in the table.

TABLE 5: SUBSTATION H CONSTRAINT MATRIX										
CONSTRAINT	SUBSTATION CRITERIA	SMALL RECIP ENGINE	MEDIUM RECIP ENGINE	LARGE RECIP ENGINE	INDUSTRIAL TURBINE	SMALL AERO TURBINE	LARGE AERO TURBINE	WIND	PV SOLAR	BESS
AVAILABLE FOOTPRINT	0.62 ACRES	YES, 6 UNITS	YES, 2 UNITS	NO	YES, 4 UNITS	YES, 2 UNITS	YES, 1 UNIT	YES, 1 TURBINE	YES, 100 KW	YES, 15 UNITS
ACHIEVES SPP INTERCONNECT LIMIT	45 MW	NO, 24 – 30 MW	NO, 18 – 22 MW	NO	NO, 16 – 21 MW	YES, 40 – 60 MW	YES, 39 – 49 MW	NO, 2 -3 MW	NO, 100 KW	NO, 15 MW
ADEQUATE SUBSTATION FACILITIES	33.6 / 33.6 MVA	YES	YES	YES	YES	YES	FEASIBLE	YES	YES	YES
ADEQUATE NATURAL GAS AVAILABLE		YES	YES	YES	YES	YES	YES	N/A	N/A	N/A
ADEQUATE FUEL OIL AVAILABLE		YES	YES	YES	YES	YES	YES	N/A	N/A	N/A
ADEQUATE WATER AVAILABLE		FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	N/A	FEASIBLE	N/A
ADEQUATE WASTEWATER AVAILABLE		FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	N/A	FEASIBLE	N/A
MANAGEABLE NOISE IMPACTS		NO	YES	YES	YES	YES	YES	NO	YES	YES
MANAGEABLE VISUAL IMPACTS		YES	YES	YES	YES	YES	YES	NO	YES	YES
MAJOR EQUIPMENT COST ($/KW)		$1,000	$1,000	$1,000	$950	$650	$600	---	---	---
TOTAL INSTALLED COST ($/KW)		$2,000	$1,900	$1,800	$2,100	$1,350	$1,150	$3,500	$2,500	$3,500
TOTAL COST ($)*		$48 MM - $60 MM	$34 MM - $42 MM	---	$34 MM - $44 MM	$54 MM - $81 MM	$45 MM - $57 MM	$7 MM - $11 MM	$2.5 MM	$53 MM
MINIMUM OPERATING LOAD**		1 MW	2.25 MW	---	2 MW	5 MW	9.75 MW	2 MW	100 KW	1 MW
FIXED O&M COST ($/MW-HR)		$6.00	$5.00	$5.00	$5.00	$4.75	$4.75	$3.00	$1.75	$2.85
VARIABLE O&M COST ($/MW-HR)		$6.00	$5.00	$4.75	$2.00	$2.00	$2.00	$0.00	$0.00	$0.00

*Ranges of costs shown correlate to range of MW values for each technology. These ranges are not meant to infer bounds of the cost estimate itself.
**Minimum load is the lowest stable operating point of the generating units. For sites utilizing multiple units, this represents the minimum load of a single generator with all other units offline. Combustion turbine minimum loads are affected by the selected emissions control technologies and may be higher than the values listed here.

The only technology options that meet the main goal of power generation up to the SPP interconnect limit at the facility are the small and large aeroderivative size combustion turbines. These technologies can achieve the desired power production within the current footprint constraints of the substation facility. The small aeroderivative units are similar in footprint and size compared to the existing combustion turbine units. However, the larger aeroderivative sized units may have a larger visual impact than the existing units. This may require the extension of existing barrier walls or positioning of additional barriers based on the final equipment layout.

Either option will require demolition of the existing combustion turbines located at the site prior to construction of the new units. It is unlikely that any existing foundations are usable with the new equipment due to changes in anchoring details and weights/loads. Other underground mechanical utilities should be reviewed during demolition for condition and replaced as required. Construction may require the use of additional nearby areas for temporary laydown, construction trailers, and craft parking during demolition and construction activities.

Substation H

LEGEND

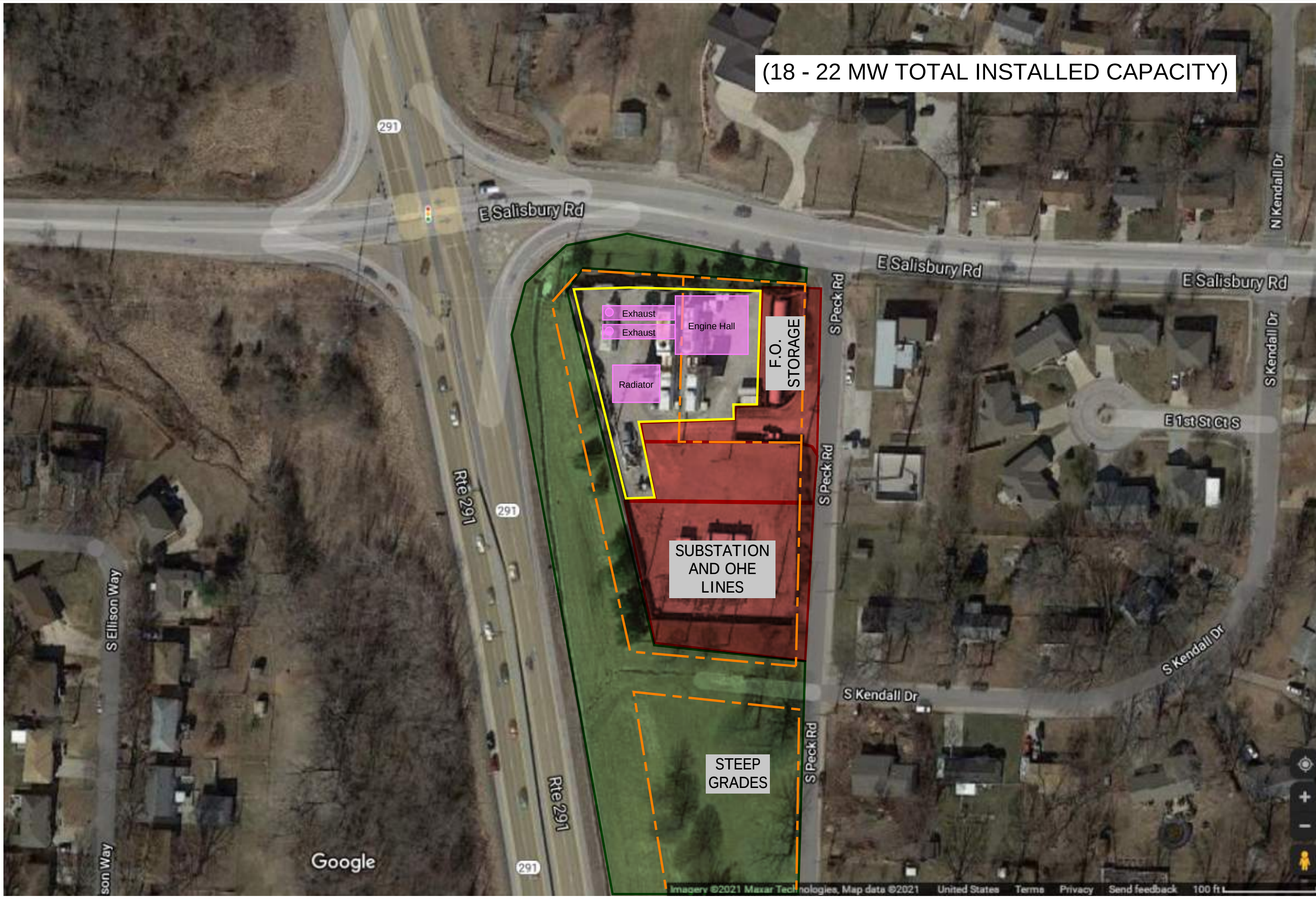
- PROPERTY LINE
- EXISTING INFRASTRUCTURE
- EXISTING/UNUSABLE GREENSPACE
- USABLE SPACE

Substation H: 4 - 5 MW Recip

LEGEND

- PROPERTY LINE
- EXISTING INFRASTRUCTURE
- EXISTING/UNUSABLE GREENSPACE
- USABLE SPACE
- NEW EQUIPMENT

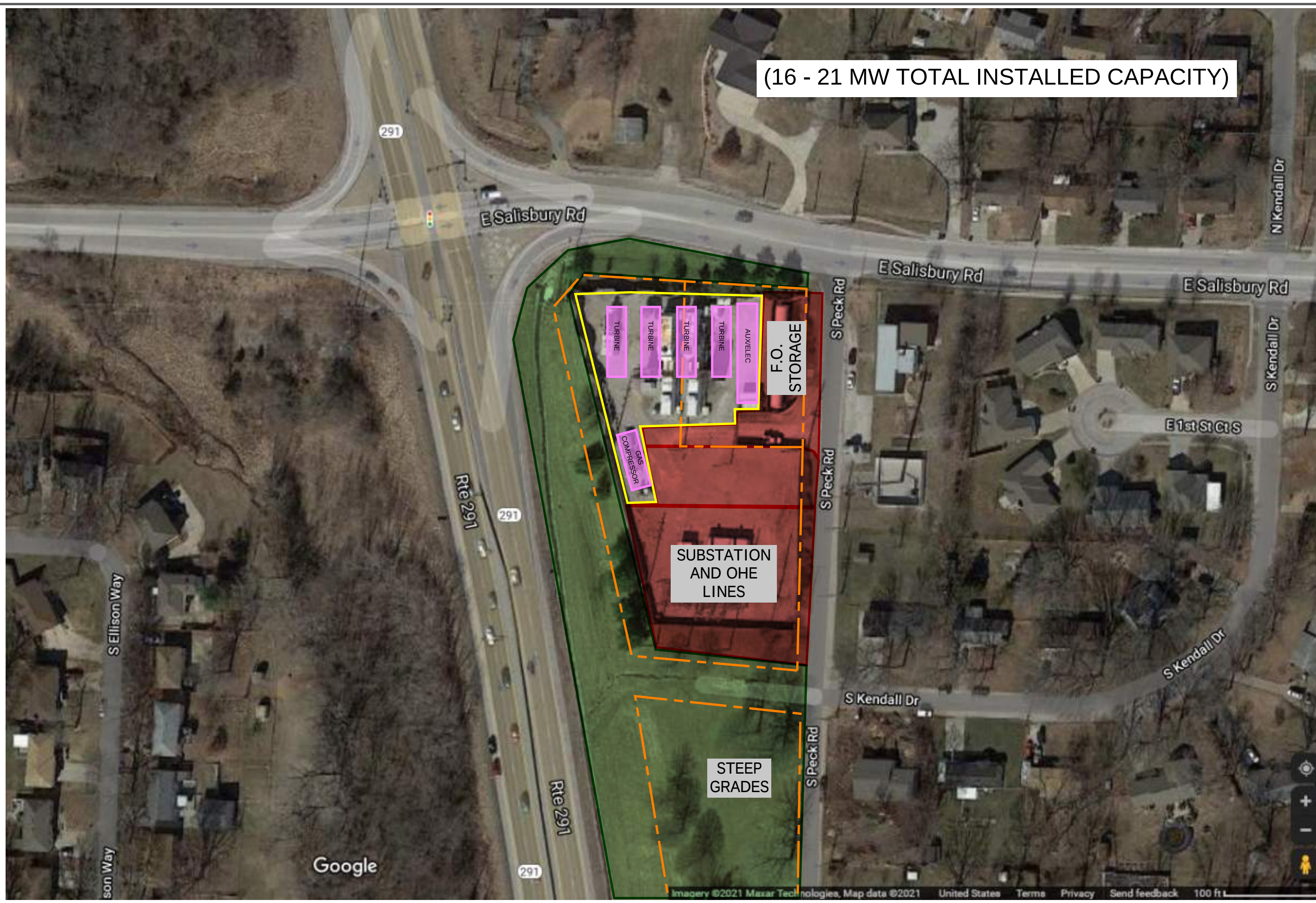
Substation H: 9 - 11 MW Recip



LEGEND

- PROPERTY LINE
- EXISTING INFRASTRUCTURE
- EXISTING/UNUSABLE GREENSPACE
- USABLE SPACE
- NEW EQUIPMENT

Substation H: Industrial Turbine



INDEPENDENCE
★ POWER & LIGHT ★

LEGEND

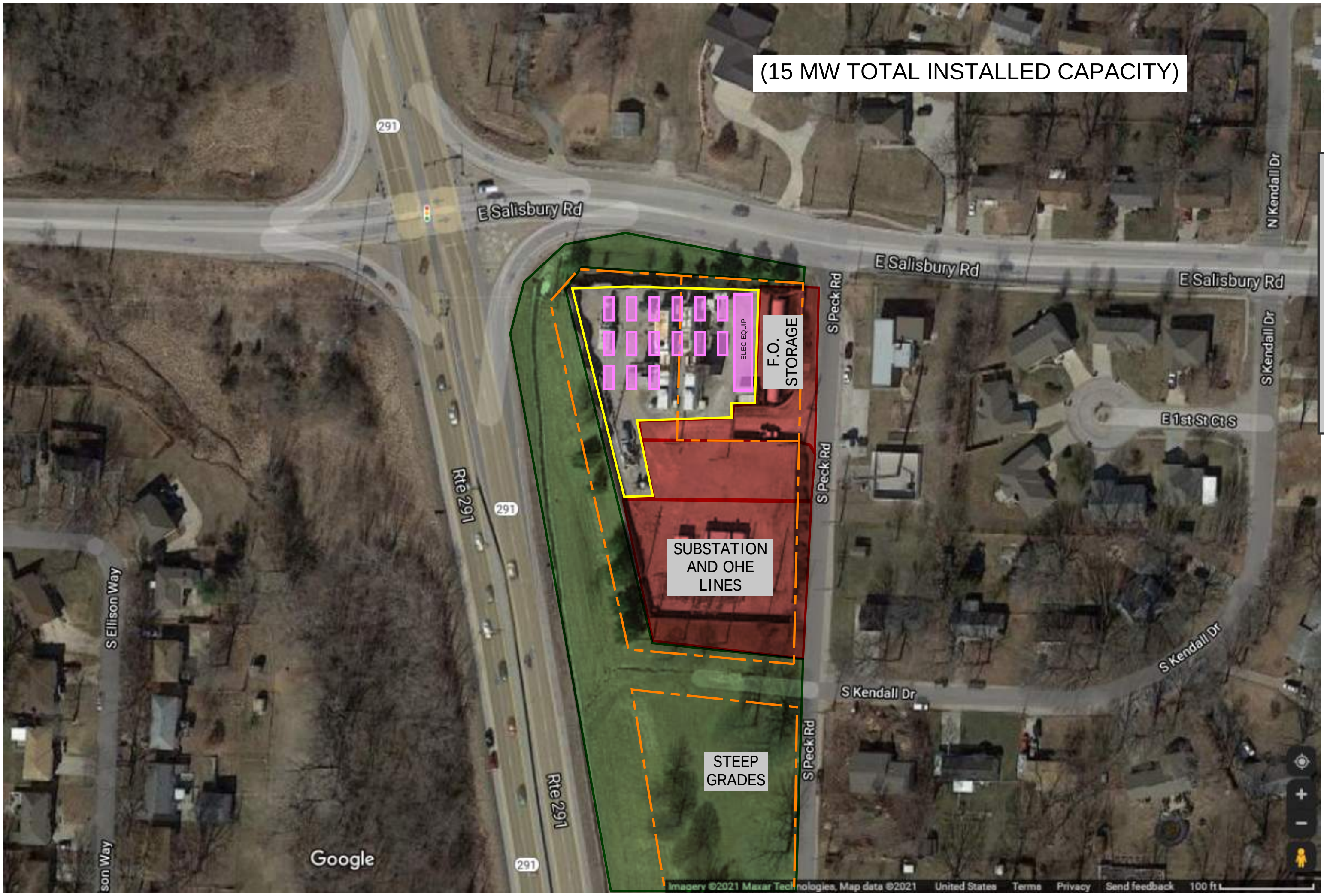
- PROPERTY LINE
- EXISTING INFRASTRUCTURE
- EXISTING/UNUSABLE GREENSPACE
- USABLE SPACE
- NEW EQUIPMENT

Substation H: Small Aero Turbine

Substation H: Large Aero Turbine

LEGEND
- PROPERTY LINE
- EXISTING INFRASTRUCTURE
- EXISTING/UNUSABLE GREENSPACE
- USABLE SPACE
- NEW EQUIPMENT

Substation H: Battery Storage



LEGEND

- PROPERTY LINE
- EXISTING INFRASTRUCTURE
- EXISTING/UNUSABLE GREENSPACE
- USABLE SPACE
- NEW EQUIPMENT

Substation I

The Substation I site is adjacent and south of the Drumm Farm Golf Course and across the street and west of the new Midcontinent Public Library Midwest Genealogy Center on 34th Street. The site is bounded on the south by the Kansas City Southern railroad in Jackson County. Substantial residential development exists south of the rail line. There is one 69 kV line owned by IPL on site. The substation site currently holds two distillate-fired GE Frame 5 combustion turbine generator sets.

Site Constraint Review

Electrical Capacity

The current SPP accredited capacity of Substation I is 33 MW. This capacity is based on recent testing of the existing combustion turbines to prove available resources installed at the site. However, the SPP interconnect limit for Substation I is slightly higher at 44 MW.

The substation has two generator step-up transformers that convert the lower voltage power output from the generator to the transmission/distribution voltage of the electrical grid. In this case, the transformers convert from the electrical generator output voltage of 13.8 kV to 69 kV.

The maximum transformer rating for each of the two generator step-up transformers is 33.6 MVA. Table 6 summarizes the various ratings discussed in this section.

TABLE 6: SUBSTATION I ELECTRICAL RATINGS

DESCRIPTION	LIMIT/RATING (MVA)	LIMIT/RATING (MW)
SPP ACCREDITED LIMIT	38.8	33
SPP INTERCONNECT LIMIT	51.8	44
TRANSFORMER #1 RATING	33.6	28.6
TRANSFORMER #2 RATING	33.6	28.6

*Assumes 0.85 Power Factor

Note that the combined ratings of Transformer #1 and #2 exceed the current SPP interconnect limit and equate to a total capacity of 57.2 MW. Since the SPP interconnect limit is a regulatory value and not an equipment rating limitation, this could be increased to match the installed equipment if desired by IPL. However, this additional capacity would need to go through the SPP Generation Interconnection study process that can take approximately 4 – 5 years to complete and gain approval.

Footprint

The substation is comprised of two different parcels of land totaling approximately 3.15 acres of land within the main substation limits. However, not all of the footprint is available for development and use in installing new electrical generation equipment. A portion of the footprint is used for the electrical substation equipment including the transformers, breakers, and distribution/transmission line supports. Additionally, some areas contain steep grades or slopes that would be difficult or cost-prohibitive to prepare for new equipment. Areas for substation access roads and maintenance also need to be considered and reserved from the available footprint for new generation. Once these items are removed, the total available footprint is approximately 0.65 acres. The figures at the end of this section shows the layout of the existing substation with parcel boundaries and available and unusable areas highlighted.

- Small Reciprocating Engine:

  The available land footprint area is sufficient for the installation of five small reciprocating engine sets capable of producing 20 – 25 MW of total power generation. Units of this size are either supplied as a containerized package or separate for installation in a common engine hall. The containerized option allows for a more compact installation and less field installation time. However, the disadvantage to these types of units can be the levels of noise generated as there is less room for insulation and other sound abatement components to be installed within the container. Additional auxiliary equipment, such as low voltage electrical distribution equipment, would be installed adjacent to the engine containers. A sample layout utilizing the containerized engines is included at the end of this section.

- Medium Reciprocating Engine:

  The available land footprint area is sufficient for the installation of two medium reciprocating engine sets capable of producing 18 – 22 MW of total power generation. Units of this size are typically installed in a common engine hall but may be offered as a containerized package (typically consisting of multiple containers per unit). The noise abatement issues are expected to make a containerized offering impractical at this substation for this engine size. Engines of this size require a separate radiator component that is mounted adjacent to the engine hall. Additional auxiliary equipment, such as low voltage electrical distribution equipment, would be installed within the engine hall itself. Transportation/setting of these modules is expected to be challenging as room for site access roads is limited. Some work to existing access roads outside of the substation parcel may be required to support heavy haul equipment and crane areas. A sample layout is included at the end of this section.

- Large Reciprocating Engine:

  The available land footprint area is insufficient for the installation of large reciprocating engines. The length of these units from engine through exhaust equipment/stack are greater than the longest sections available at the substation. Additionally, the transport/installation of equipment of this size is difficult for tight areas where sufficient access roads are not installed.

- Industrial Combustion Turbine:

  The available land footprint area is sufficient for the installation of four industrial combustion turbines capable of producing 16 – 21 MW of total power generation. Units of this size are containerized with the engine and generator in a common enclosure. Air inlet filter and stack equipment would sit above and adjacent to the turbine module. Fuel gas compression equipment could be shared between the combustion turbines and contained on a common skid near the steep grade areas to maximize access to the turbines. Additional auxiliary equipment, such as electrical equipment and chemical equipment for pollution control systems can be installed and shared across the turbines. A sample layout is included at the end of this section.

- Small Aeroderivative Combustion Turbine:

  The available land footprint area is sufficient for the installation of two small aeroderivative combustion turbines capable of producing 40 – 60 MW of total power generation. Options are available for these units to be trailer mounted for quick install/setup or installed in a more traditional modularized approach. Either option serves to reduce site setup time and minimize the overall field connections required. Air inlet filter and stack equipment would sit above and adjacent to the turbine module. Fuel gas compression equipment could be shared between the combustion turbines and contained on a common skid near the steep grade areas to maximize access to the turbines. Additional auxiliary equipment, such as electrical equipment, water treatment equipment (if required) and chemical equipment for pollution control systems can be installed and shared across the turbines. Space for this arrangement is very limited and access/maintenance aisles will need to be carefully planned. A sample layout is included at the end of this section.

- Large Aeroderivative Combustion Turbine:

  The available land footprint area is sufficient for the installation of one large aeroderivative combustion turbines capable of producing 39 – 49 MW of total power generation. These units are supplied in multiple modules including the combustion turbine, generator, lube oil equipment, and pollution control equipment. Air inlet filter and stack equipment would sit above and adjacent to the turbine module. Fuel gas compression equipment can be contained on a common skid near the steep grade areas to maximize access to the turbines. Additional auxiliary equipment, such as electrical equipment, water treatment equipment (if required) and chemical equipment for pollution control systems would also be installed adjacent to the turbine for easy access during operation. Space for this arrangement is very limited and access/maintenance aisles will need to be carefully planned.

  Modifications to the substation would be required to utilize a large aeroderivative turbine at this substation. Neither generator step-up transformer has sufficient capacity to accept the electrical output from this generator. At a minimum, a new transformer would be required to be installed. Likely, upgrades to the circuit breaker, bus, and other substation equipment would also be required.

  A sample layout is included at the end of this section.

- Wind:

  The available land footprint area is sufficient for the installation of a single horizontal axis wind turbine capable of producing 2 – 5 MW. However, the proximity of the nearby electrical transmission/distribution lines would make installation very difficult to avoid interferences and negative impacts on either system. Therefore, this is not considered to be a feasible use of the available site footprint.

- PV Solar:

  The available land footprint area is sufficient for the installation of approximately 100 kW of photovoltaic solar modules. The installation would be a fixed mount system as the area is insufficient for the economical use of single or dual axis tracking systems. Additional equipment would include the inverters necessary to convert from direct current to alternating current power.

- Battery Energy Storage:

  The available land footprint area is sufficient for the installation of approximately 14 MW / 56 MW-hr battery energy storage systems. The installation would include approximately 14 containerized battery storage systems that are typically installed in 20 foot long ISO shipping containers. Additional equipment would include the inverters necessary to convert from direct current to alternating current power.

  The system evaluated has an operating capacity up to 4 hours at full power output. This limits the functionality of these systems to meet the IPL guiding constraints as a direct replacement for electrical generation equipment. These systems can be paired with other generating equipment to function like a hybrid automobile. For short output periods, the BESS outputs stored electrical energy to the grid. Once depleted, the electrical generation equipment would operate until the batteries could be recharged.

  A sample layout of all BESS equipment on the substation is included at the end of this section for reference. This layout is meant to present an indicative footprint for consideration when mixing BESS with other generating equipment.

Utilities

Two fuel oil storage tanks are installed at the facility to support operation of the existing combustion turbines. Each tank has a nominal capacity of 50,000 gallons and can store approximately 45,000 gallons of fuel when the proper free space within the tank is considered. When both tanks are full, the site can store 90,000 gallons between the two tanks. For those generators that utilize fuel oil such as reciprocating engines or combustion turbines, this equates to approximately 32 hours of run-time for generators equating to the SPP interconnect limit rating. During extreme weather events or other abnormal conditions where the generators are operated extensively on fuel oil, daily deliveries may be required. Otherwise, the tank capacity should be sufficient for less frequent deliveries (weekly, bi-weekly, etc.) during normal operation.

Natural gas is not currently available at substation I. Through recent discussions, Spire has confirmed that 500 MCF/hr could be supplied to this facility without issue. A new pipeline would be required from the existing Spire infrastructure to the substation. Installation costs for this pipeline would be paid by IPL. For those generators that utilize natural gas such as reciprocating engines or combustion turbines, this amount is sufficient to support operation up to the current SPP interconnect limit. However, the pressure of the supply pipeline is below that required for operation of the combustion turbine equipment. Fuel gas compression equipment can be installed on-site to increase the pressure to the required levels.

Water and wastewater services do not currently exist at the substation. However, the facility is located within the city boundary and the necessary infrastructure exists nearby serving other customers.

Environmental Permits

The Substation I site is covered by an air Permit to Operate issued by the MDNR. The site also has an oil SPCC Plan.

The air Permit to Operate (OP2017-007) expires on January 26, 2022 and IPL submitted a permit renewal application on May 21, 2021. The Permit to Operate describes the facility as a “major source” as it has the potential to emit more than 250 tons per year of at least one regulated pollutant. The permit covers the two existing combustion turbines (firing fuel oil only) as well as their on-board starting diesel engines. The permit also lists the two large fuel oil storage tanks as well as two (2) small underground waste oil storage tanks. The permit limits the sulfur content of the fuel oil to no more than fifteen (15) parts per million of sulfur. The permit does not limit the amount of operation of the combustion turbines. Based on historical records the facility has had limited operation and emitted much less than 250 tons per year of any pollutant.

Replacing generating capacity with new combustion turbines or engines at this substation would require an air construction permit and a revision to the air Permit to Operate. At a minimum the combustion equipment would need to meet NSPS. The existing generating equipment at the substation are “grandfathered” from these new limits. Thus, the new generating equipment will have significantly lower emission levels because of NSPS, the more modern technology, and because of the much greater efficiency of the equipment. Because of these low NSPS emission levels the construction air permitting of the newly installed equipment options will likely have less than 250 tons per year of any regulated pollutant and thus not need to follow the PSD “major source” construction permit review process. Without the need for PSD dispersion modeling and control technology analyses the air construction permitting process would be more streamlined.

The combustion turbine technology options would not require an SCR and oxidation catalyst to comply with federal NSPS. However, not installing SCR could lead to MDNR requesting a demonstration that the new installation complies with NAAQS which would lengthen the permitting schedule and might result in even higher levels of emission controls. All combustion turbine options at Substation I will be under the “major source” thresholds so long as the annual amount of fuel oil is limited to something reasonable. The oil-firing operational limitation would not be restrictive and could be avoided by installing an SCR. Beyond the construction and operating permitting process, any new replacement generating units with generator nameplate capacity greater than 25 MW (per unit) would in addition be required to comply with the federal Acid Rain program and the associated CEMS requirements. Thus, for the combustion turbine options considered with units greater than 25 MW these requirements would be triggered along with the additional CEMS equipment, reporting requirements, and be subject to the allowance program of Acid Rain as well as the allowance program of the regional CSAPR. These allowances must be procured each year for both the annual timeframe and the ozone seasonal timeframe. The smaller (less than 25 MW) combustion turbine options have the advantage of avoiding these additional CEMS requirements and need to procure, track, and report allowances.

The reciprocating engine technology options would require an SCR and oxidation catalyst to comply with federal NSPS. All engine options at Substation I will be under the PSD “major source” without placing operational limitations on natural gas or oil firing. The engine options would not be subject to the Acid Rain Rule or the CSAPR and, therefore also share the advantage of not requiring emission credits to operate. The engines would require an MDNR Section 6 air construction permit (6 to 9 months) and either a Title V Permit to Operate or an Intermediate operating permit (not needed before construction).

The SPCC Plan specifies oil related reporting, inspections, training, and certifications as required by the EPA regulations. This Plan is updated every 5 years or whenever there are substantive changes to the facility which impact the Plan. Each of the proposed options would require substantive revisions to the SPCC Plan, but these revisions would not result in any significant issues which would be a concern to the selection of any of the options.

Social/Aesthetic

Substation I is adjacent to the Drumm Farm Golf Club (to the north and northwest), South Kiger Road on the east, the Midwest Genealogical Center beyond Kiger Road to the east, South Lee’s Summit Road beyond South Kiger Road to the northeast, a railway line (along the south border), and a residential area immediately beyond the railway to the south. The nearest dwelling is approximately 230 feet south of the existing generating equipment. There are additional dwellings to the south, southwest, and southeast but slightly more distant. There is a barrier wall along the south and east boundary, but taller equipment is visible to the surrounding public.

The existing noise environment is influenced by traffic noise on the nearby South Lee’s Summit Road and intermittent railroad noise. Traffic on this highway travels at a normal rate of speed, although there is a stop light at South Kiger Road which causes cycles of louder traffic noise associated with the acceleration of the automobiles and trucks. During low traffic periods, the sound environment would take on a traditional residential neighborhood sense. During these times the public may be able to discern the substation transformer sounds (humming) as well as “crackling” sounds from the high voltage power lines during periods of higher atmospheric moisture levels. The Substation I generation equipment has been at this site for approximately 50 years but has operated infrequently.

Replacing generating capacity with new combustion turbines or engines would not change the noise environment substantially when operating compared to times when the current turbines are operating. However, because the anticipated operating frequency will substantially increase, the nearby public will experience these operating sounds more often. Thus, the selection of replacement generation should consider utilizing above average noise quieting features such as buildings, sound absorption barriers, and additional air inlet and exhaust silencing baffle performance. Because they would be installed without a building housing them, the small engines option may have higher noise impacts compared to the other options and would require additional cost to mitigate to acceptable levels.

Utility scale wind turbines can be perceived to have unacceptable noise emissions (swooshing) caused by the rotation of the large blades through the air. In addition, the height of the supporting structure and the rotating blades are quite high and would be visible for a significant distance. Both the type of noise generated and the visible nature are much different than the existing environment and would make the wind turbine(s) addition more pronounced. Wind turbine farms installed in urban areas need to consider these factors that are not as important in rural installations.

Viable Options

Table 7 summarizes the review of each of the various site constraint parameters. Items highlighted in green represent adequate or viable options while items in red denote unfavorable or not currently viable conditions are present. Items highlighted in yellow are not currently satisfied but could be corrected and are marked as such in the table.

TABLE 7: SUBSTATION I CONSTRAINT MATRIX											
CONSTRAINT	SUBSTATION CRITERIA	SMALL RECIP ENGINE	MEDIUM RECIP ENGINE	LARGE RECIP ENGINE	INDUSTRIAL TURBINE	SMALL AERO TURBINE	LARGE AERO TURBINE	WIND	PV SOLAR	BESS
AVAILABLE FOOTPRINT	0.65 ACRES	YES, 5 UNITS	YES, 2 UNITS	NO	YES, 4 UNITS	YES, 2 UNITS	YES, 1 UNIT	YES, 1 TURBINE	YES, 100 KW	YES, 14 UNITS
ACHIEVES SPP INTERCONNECT LIMIT	44 MW	NO, 20 – 25 MW	NO, 18 – 22 MW	NO	NO, 16 – 21 MW	YES, 40 – 60 MW	YES, 39 – 49 MW	NO, 2 -3 MW	NO, 100 KW	NO, 14 MW
ADEQUATE SUBSTATION FACILITIES	33.6 / 33.6 MVA	YES	YES	YES	YES	YES	FEASIBLE	YES	YES	YES
ADEQUATE NATURAL GAS AVAILABLE		FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	N/A	N/A	N/A
ADEQUATE FUEL OIL AVAILABLE		YES	YES	YES	YES	YES	YES	N/A	N/A	N/A
ADEQUATE WATER AVAILABLE		FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	N/A	FEASIBLE	N/A
ADEQUATE WASTEWATER AVAILABLE		FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	N/A	FEASIBLE	N/A
MANAGEABLE NOISE IMPACTS		NO	YES	YES	YES	YES	YES	NO	YES	YES
MANAGEABLE VISUAL IMPACTS		YES	YES	YES	YES	YES	YES	NO	YES	YES
MAJOR EQUIPMENT COST ($/KW)		$1,000	$1,000	$1,000	$950	$650	$600	---	---	---
TOTAL INSTALLED COST ($/KW)		$2,000	$1,900	$1,800	$2,100	$1,350	$1,150	$3,500	$2,500	$3,500
TOTAL COST ($)*		$40 MM - $50 MM	$34 MM - $42 MM	---	$34 MM - $44 MM	$54 MM - $81 MM	$45 MM - $57 MM	$7 MM - $11 MM	$2.5 MM	$49 MM
MINIMUM OPERATING LOAD**		1 MW	2.25 MW	---	2 MW	5 MW	9.75 MW	2 MW	100 KW	1 MW
FIXED O&M COST ($/MW-HR)		$6.00	$5.00	$5.00	$5.00	$4.75	$4.75	$3.00	$1.75	$2.85
VARIABLE O&M COST ($/MW-HR)		$6.00	$5.00	$4.75	$2.00	$2.00	$2.00	$0.00	$0.00	$0.00

*Ranges of costs shown correlate to range of MW values for each technology. These ranges are not meant to infer bounds of the cost estimate itself.
**Minimum load is the lowest stable operating point of the generating units. For sites utilizing multiple units, this represents the minimum load of a single generator with all other units offline. Combustion turbine minimum loads are affected by the selected emissions control technologies and may be higher than the values listed here.

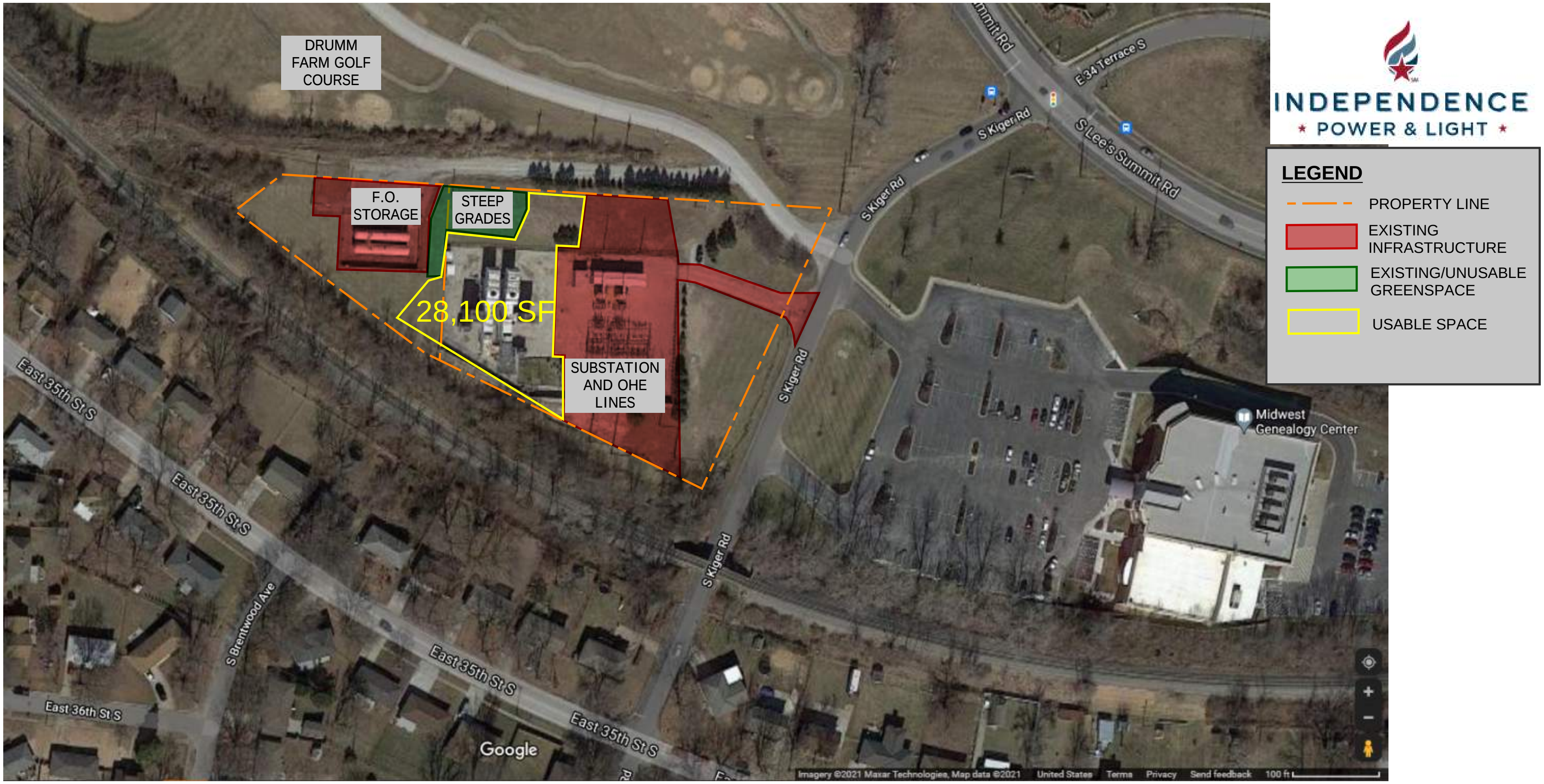
The only technology options that meet the main goal of power generation up to the SPP interconnect limit at the facility are the small and large aeroderivative size combustion turbines. These technologies can achieve the desired power production within the current footprint constraints of the substation facility. The small aeroderivative units are similar in footprint and size compared to the existing combustion turbine units. However, the larger aeroderivative sized units may have a larger visual impact than the existing units.

Although natural gas service is possible at this substation, it does not currently exist and will need to be factored into the overall cost and schedule for installation of new equipment.

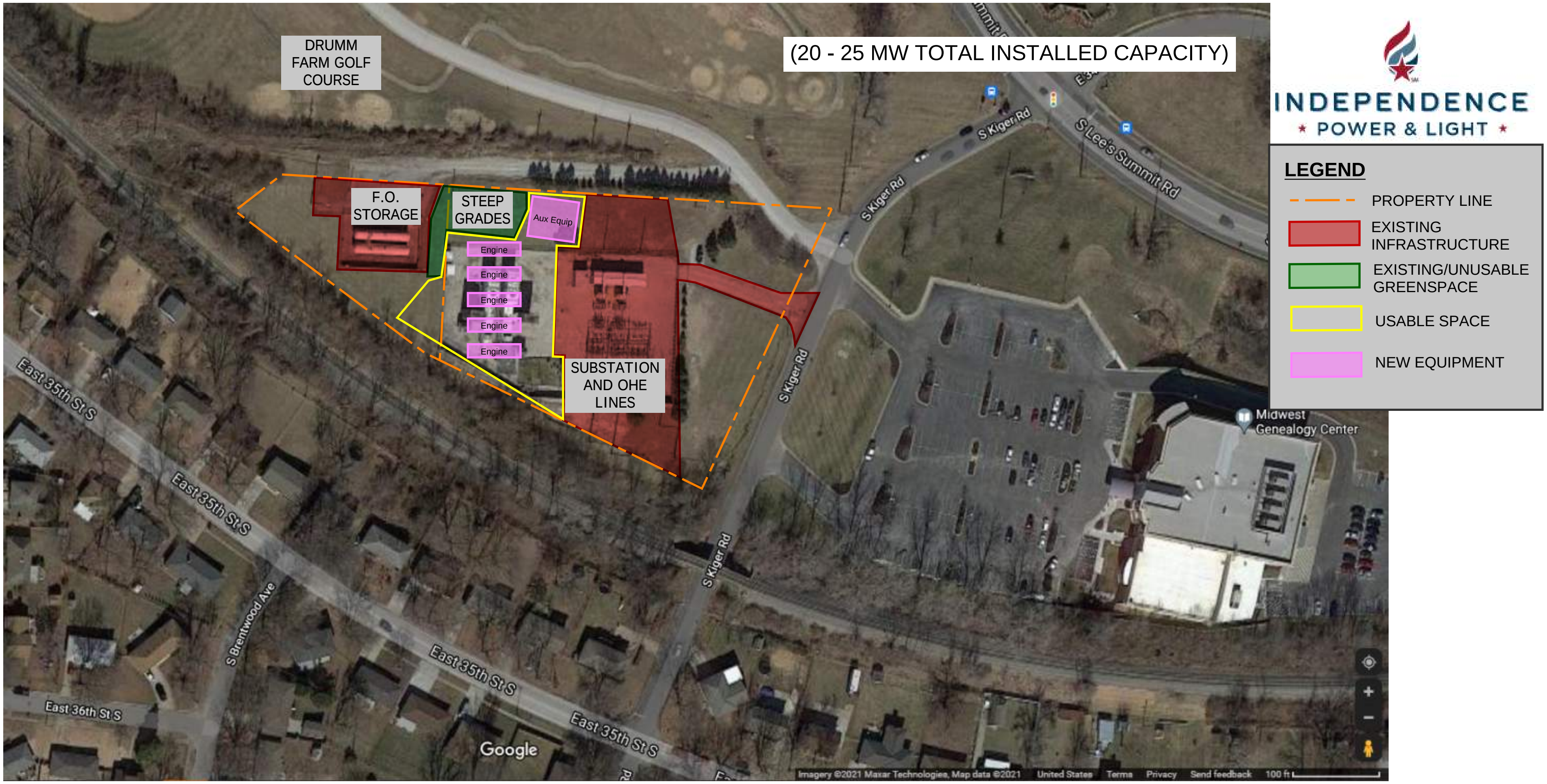
From an overall system perspective, this location provides the most benefit to support system reliability during other facility outages. This may make maintaining generating assets at this location more preferential than the other substations considered. A transmission study can help identify the impacts to the grid of maintaining or not maintaining generating capabilities at the substation.

Either option will require demolition of the existing combustion turbines located at the site prior to construction of the new units. It is unlikely that any existing foundations are usable with the new equipment due to changes in anchoring details and weights/loads. Other underground mechanical utilities should be reviewed during demolition for condition and replaced as required. Construction may require the use of additional nearby areas for temporary laydown, construction trailers, and craft parking during demolition and construction activities.

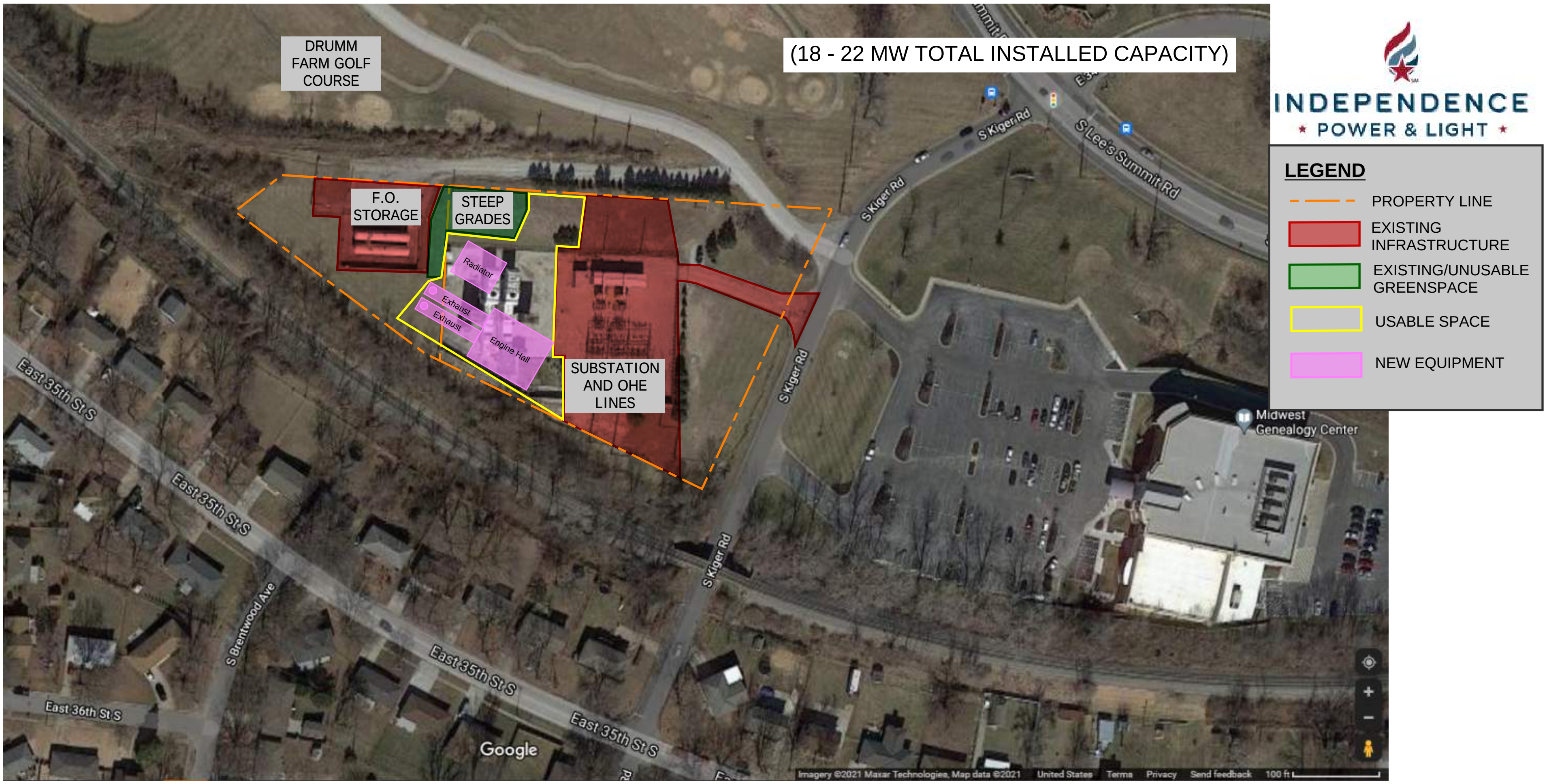
Substation I



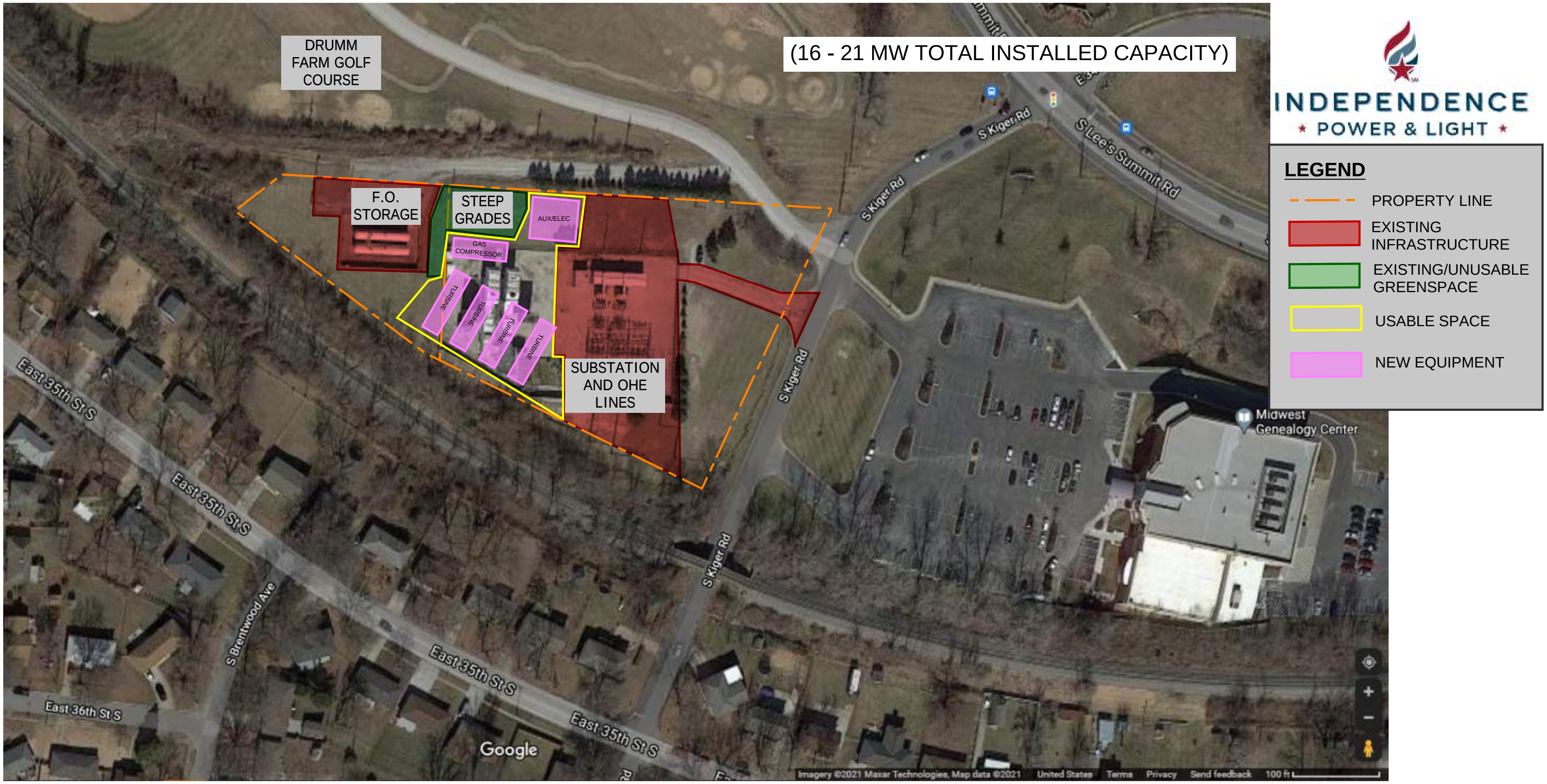
Substation I: 4 - 5 MW Recip



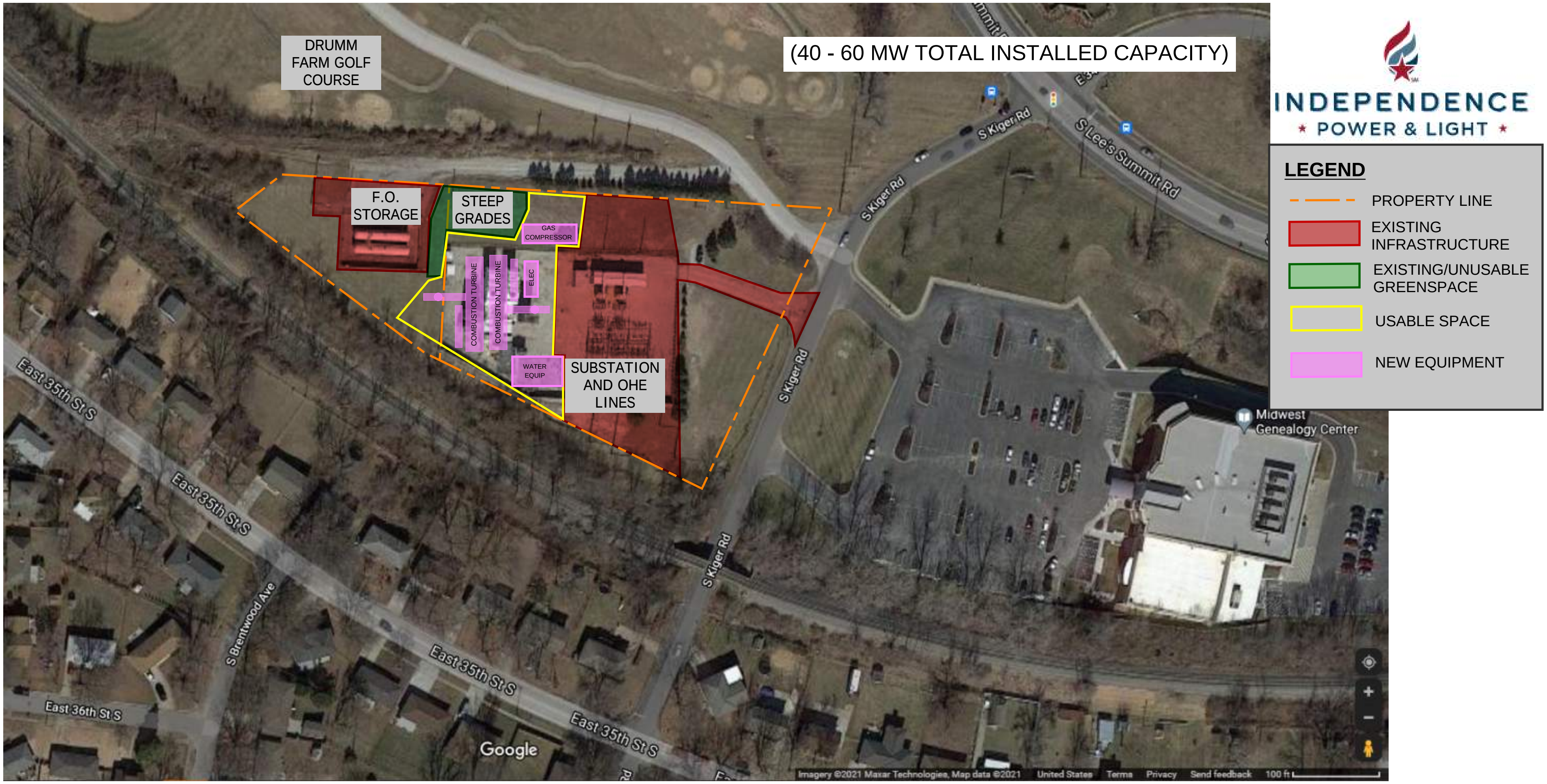
Substation I: 9 - 11 MW Recip



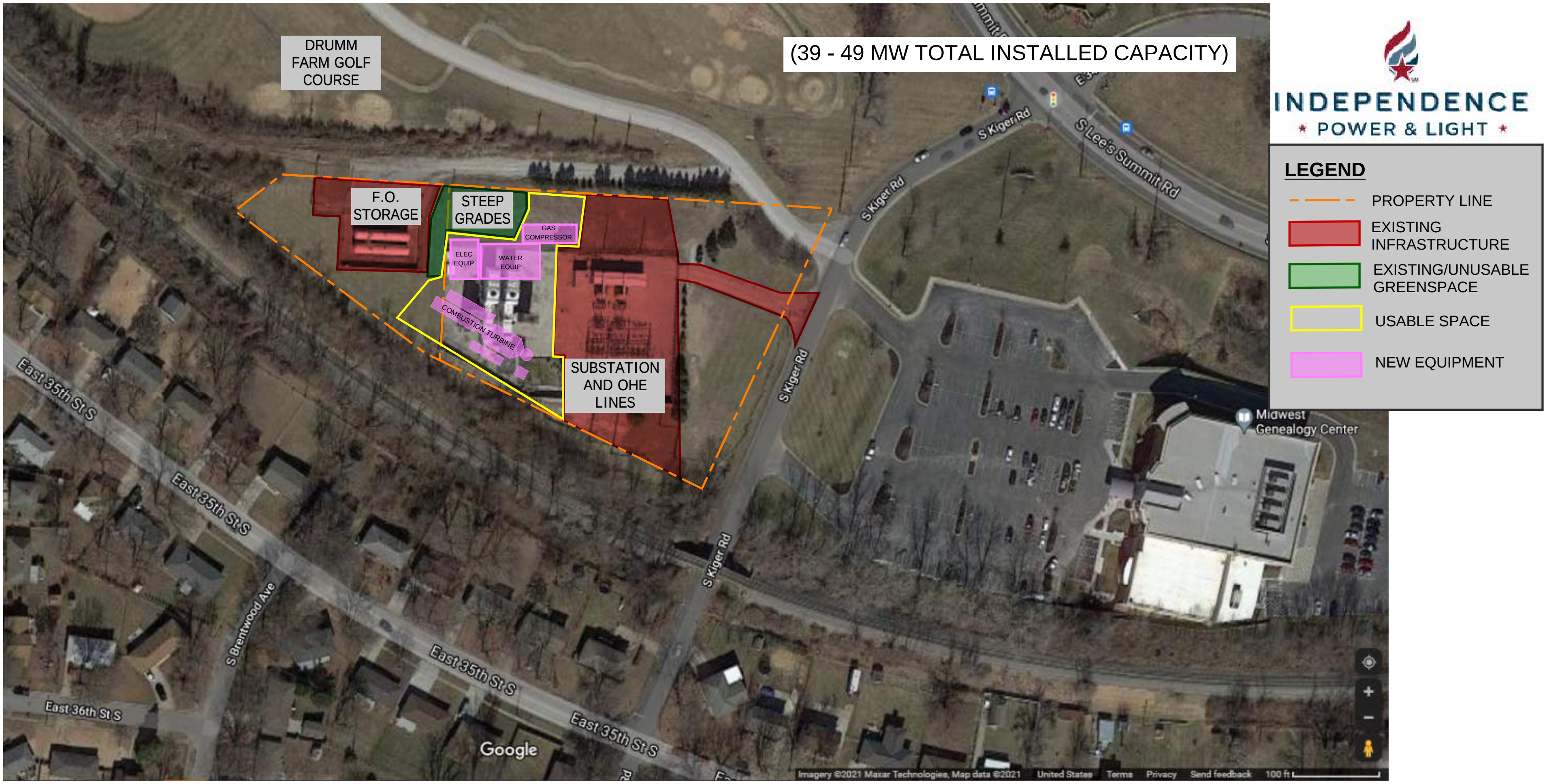
Substation I: Industrial Turbine



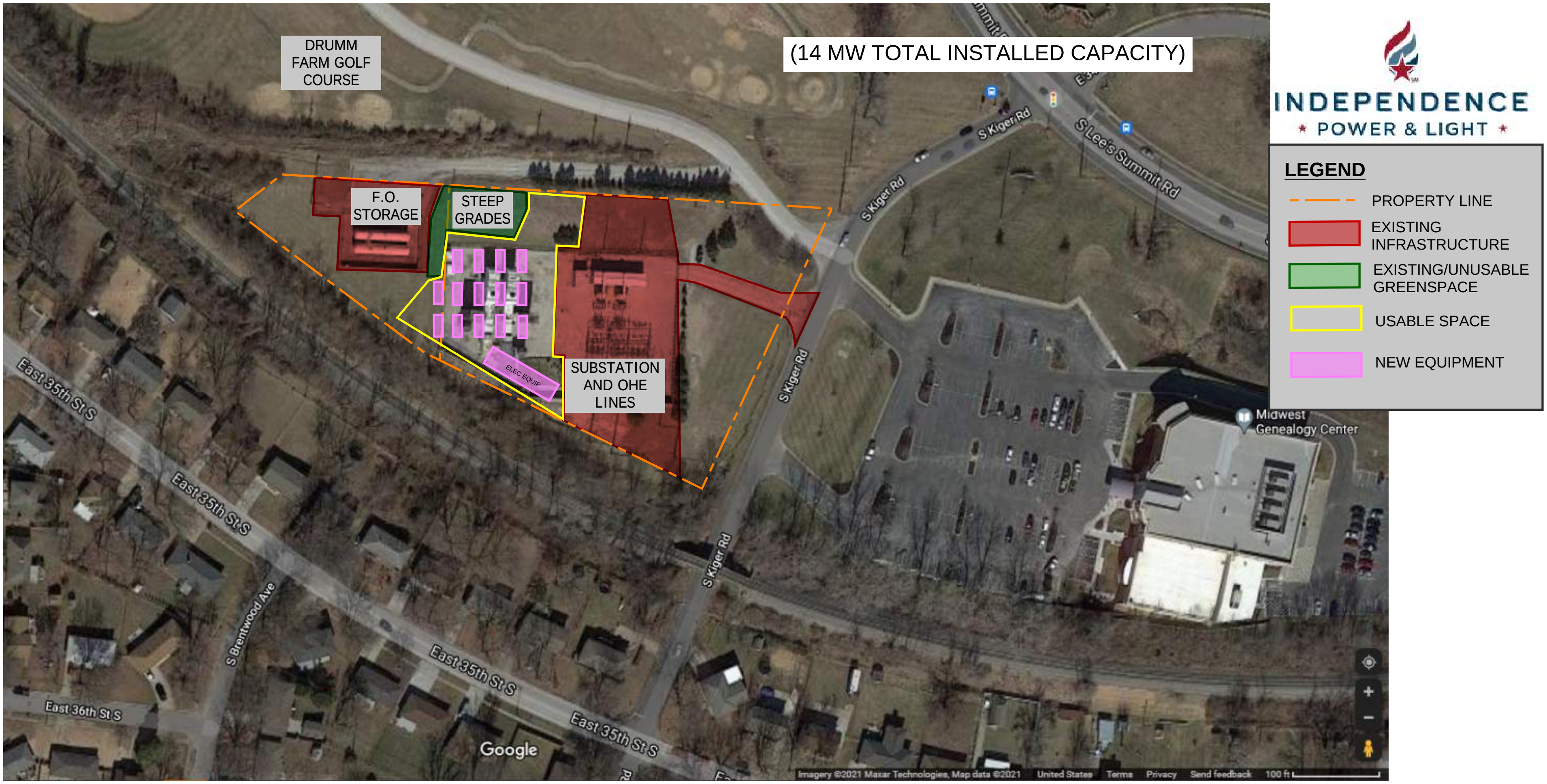
Substation I: Small Aero Turbine



Substation I: Large Aero Turbine



Substation I: Battery Storage



Substation J

The Substation I site is located just north and east of the Independence Police Department near downtown Independence on the corner of Nolan Road and Truman Road. The site is bounded on the north by Farmer Avenue and on the east by Dodgion Street. Residential development exists to the north and east sides of the substation while areas to the south and west are mainly comprised of municipal buildings and facilities. The substation site currently holds two distillate-fired GE Frame 5 combustion turbine generator sets.

Site Constraint Review

Electrical Capacity

The current SPP accredited capacity of Substation J is 26 MW. This capacity is based on recent testing of the existing combustion turbines to prove available resources installed at the site. However, the SPP interconnect limit for Substation J is slightly higher at 34 MW.

The substation has two generator step-up transformers that convert the lower voltage power output from the generator to the transmission/distribution voltage of the electrical grid. In this case, the transformers convert from the electrical generator output voltage of 13.8 kV to 69 kV.

The maximum transformer rating for each of the two generator step-up transformers is 33.6 MVA. Table 8 summarizes the various ratings discussed in this section.

TABLE 8: SUBSTATION J ELECTRICAL RATINGS

DESCRIPTION	LIMIT/RATING (MVA)	LIMIT/RATING (MW)
SPP ACCREDITED LIMIT	30.6	26
SPP INTERCONNECT LIMIT	40.0	34
TRANSFORMER #1 RATING	33.6	28.6
TRANSFORMER #2 RATING	33.6	28.6

*Assumes 0.85 Power Factor

Note that the combined ratings of Transformer #1 and #2 exceed the current SPP interconnect limit by a significant margin and equate to a total capacity of 57.2 MW. Since the SPP interconnect limit is a regulatory value and not an equipment rating limitation, this could be increased to match the installed equipment if desired by IPL. However, this additional capacity would need to go through the SPP Generation Interconnection study process that can take approximately 4 – 5 years to complete and gain approval.

Footprint

The substation is comprised of two different parcels of land totaling approximately 4.45 acres of land within the main substation limits. However, not all of the footprint is available for development and use in installing new electrical generation equipment. A portion of the footprint is used for the electrical substation equipment including the transformers, breakers, and distribution/transmission line supports. Additionally, some areas contain steep grades or slopes that would be difficult or cost-prohibitive to prepare for new equipment. Areas for substation access roads and maintenance also need to be considered and reserved from the available footprint for new generation. Once these items are removed, the total available footprint is approximately 0.75 acres. The figures at the end of this section shows the layout of the existing substation with parcel boundaries and available and unusable areas highlighted.

- Small Reciprocating Engine:

  The available land footprint area is sufficient for the installation of six small reciprocating engine sets capable of producing 24 – 30 MW of total power generation. Units of this size are either supplied as a containerized package or separate for installation in a common engine hall. The containerized option allows for a more compact installation and less field installation time. However, the disadvantage to these types of units can be the levels of noise generated as there is less room for insulation and other sound abatement components to be installed within the container. Additional auxiliary equipment, such as low voltage electrical distribution equipment, would be installed adjacent to the engine containers. Access road area already reserved for access to the fuel oil tanks would provide maintenance and operations access to the new generating equipment. A sample layout utilizing the containerized engines is included at the end of this section.

- Medium Reciprocating Engine:

  The available land footprint area is sufficient for the installation of three medium reciprocating engine sets capable of producing 27 – 33 MW of total power generation. Units of this size are typically installed in a common engine hall but may be offered as a containerized package (typically consisting of multiple containers per unit). The noise abatement issues are expected to make a containerized offering impractical at this substation for this engine size. Engines of this size require a separate radiator component that is mounted adjacent to the engine hall. Additional auxiliary equipment, such as low voltage electrical distribution equipment, would be installed within the engine hall itself. Access road area already reserved for access to the fuel oil tanks would provide maintenance and operations access to the new generating equipment. Construction of this equipment may be challenging as there is little laydown room outside of the planned equipment footprint. A sample layout is included at the end of this section.

- Large Reciprocating Engine:

  The available land footprint area is insufficient for the installation of large reciprocating engines. The length of these units from engine through exhaust equipment/stack are greater than the longest sections available at the substation. Additionally, the transport/installation of equipment of this size is difficult for tight areas where sufficient access roads are not installed.

- Industrial Combustion Turbine:

The available land footprint area is sufficient for the installation of five industrial combustion turbines capable of producing 20 – 26 MW of total power generation. Units of this size are containerized with the engine and generator in a common enclosure. Air inlet filter and stack equipment would sit above and adjacent to the turbine module. Additional auxiliary equipment, such as electrical equipment and chemical equipment for pollution control systems can be installed and shared across the turbines. A sample layout is included at the end of this section.

- Small Aeroderivative Combustion Turbine:

  The available land footprint area is sufficient for the installation of two small aeroderivative combustion turbines capable of producing 40 – 60 MW of total power generation. Options are available for these units to be trailer mounted for quick install/setup or installed in a more traditional modularized approach. Either option serves to reduce site setup time and minimize the overall field connections required. Air inlet filter and stack equipment would sit above and adjacent to the turbine module. Additional auxiliary equipment, such as electrical equipment, water treatment equipment (if required) and chemical equipment for pollution control systems can be installed and shared across the turbines. Access road area already reserved for access to the fuel oil tanks would provide maintenance and operations access to the new generating equipment. A sample layout is included at the end of this section.

- Large Aeroderivative Combustion Turbine:

  The available land footprint area is sufficient for the installation of two large aeroderivative combustion turbines capable of producing 78 – 98 MW of total power generation. These units are supplied in multiple modules including the combustion turbine, generator, lube oil equipment, and pollution control equipment. Air inlet filter and stack equipment would sit above and adjacent to the turbine module. Additional auxiliary equipment, such as electrical equipment, water treatment equipment (if required) and chemical equipment for pollution control systems would also be installed adjacent to the turbine for easy access during operation. Access road area already reserved for access to the fuel oil tanks would provide maintenance and operations access to the new generating equipment.

  Modifications to the substation would be required to utilize a large aeroderivative turbine at this substation. Neither generator step-up transformer has sufficient capacity to accept the electrical output from this generator. At a minimum, a new transformer would be required to be installed. Likely, upgrades to the circuit breaker, bus, and other substation equipment would also be required.

  Space for operation and maintenance access is small in this arrangement. Additionally, the equipment layout does not provide for many areas of construction laydown or setting of crane equipment. As this equipment is the largest and heaviest, it will also require the largest cranes for installation. Given these factors and that the power output from two large turbines is well above the current SPP interconnect limit, a single large aeroderivative is perhaps a better consideration for this site.

  A sample layout is included at the end of this section.

- Wind:

  The available land footprint area is sufficient for the installation of a single horizontal axis wind turbine capable of producing 2 – 5 MW. However, the proximity of the nearby electrical transmission/distribution lines would make installation very difficult to avoid interferences and negative impacts on either system. Therefore, this is not considered to be a feasible use of the available site footprint.

- PV Solar:

  The available land footprint area is sufficient for the installation of approximately 100 kW of photovoltaic solar modules. The installation would be a fixed mount system as the area is insufficient for the economical use of single or dual axis tracking systems. Additional equipment would include the inverters necessary to convert from direct current to alternating current power.

- Battery Energy Storage:

  The available land footprint area is sufficient for the installation of approximately 21 MW / 84 MW-hr battery energy storage systems. The installation would include approximately 21 containerized battery storage systems that are typically installed in 20 foot long ISO shipping containers. Additional equipment would include the inverters necessary to convert from direct current to alternating current power.

  The system evaluated has an operating capacity up to 4 hours at full power output. This limits the functionality of these systems to meet the IPL guiding constraints as a direct replacement for electrical generation equipment. These systems can be paired with other generating equipment to function like a hybrid automobile. For short output periods, the BESS outputs stored electrical energy to the grid. Once depleted, the electrical generation equipment would operate until the batteries could be recharged.

  A sample layout of all BESS equipment on the substation is included at the end of this section for reference. This layout is meant to present an indicative footprint for consideration when mixing BESS with other generating equipment.

Utilities

Two fuel oil storage tanks are installed at the facility to support operation of the existing combustion turbines. Each tank has a nominal capacity of 50,000 gallons and can store approximately 45,000 gallons of fuel when the proper free space within the tank is considered. When both tanks are full, the site can store 90,000 gallons between the two tanks. For those generators that utilize fuel oil such as reciprocating engines or combustion turbines, this equates to approximately 32 hours of run-time for generators equating to the SPP interconnect limit rating. During extreme weather events or other abnormal conditions where the generators are operated extensively on fuel oil, daily deliveries may be required. Otherwise, the tank capacity should be sufficient for less frequent deliveries (weekly, bi-weekly, etc.) during normal operation.

Natural gas is not currently available at substation J. Review of the location with Spire has indicated that no appropriate natural gas pipeline infrastructure exists nearby. Extending a pipeline from the current Spire infrastructure has been deemed cost-prohibitive and not feasible.

Water and wastewater services do not currently exist at the substation. However, the facility is located within the city boundary and the necessary infrastructure exists nearby serving other customers.

Environmental Permits

The Substation J site is covered by an air Permit to Operate issued by the MDNR. The site also has an oil SPCC Plan.

The air Permit to Operate (OP2017-006) expires on January 26, 2022 and IPL submitted a permit renewal application on May 21, 2021. The Permit to Operate describes the facility as a “major source” as it has the potential to emit more than 250 tons per year of at least one regulated pollutant. The permit covers the two existing combustion turbines (firing fuel oil only) as well as their on-board starting diesel engines. The permit also lists the two large fuel oil storage tanks as well as two (2) small underground waste oil storage tanks. The permit limits the sulfur content of the fuel oil to no more than fifteen (15) parts per million of sulfur. The permit does not limit the amount of operation of the combustion turbines. Based on historical records the facility has had limited operation and emitted much less than 250 tons per year of any pollutant.

Replacing generating capacity with new combustion turbines or engines at this substation would require an air construction permit and a revision to the air Permit to Operate. At a minimum the combustion equipment would need to meet NSPS. The existing generating equipment at the substation are “grandfathered” from these new limits. Thus, the new generating equipment will have significantly lower emission levels because of NSPS, the more modern technology, and because of the much greater efficiency of the equipment. Because of these low NSPS emission levels the construction air permitting of the newly installed equipment options will likely have less than 250 tons per year of any regulated pollutant and thus not need to follow the PSD “major source” construction permit review process. Without the need for PSD dispersion modeling and control technology analyses the air construction permitting process would be more streamlined.

The combustion turbine technology options would not require an SCR and oxidation catalyst to comply with federal NSPS. However, not installing SCR could lead to MDNR requesting a demonstration that the new installation complies with NAAQS which would lengthen the permitting schedule and might result in even higher levels of emission controls. All combustion turbine options at Substation J will be under the “major source” thresholds so long as the annual amount of fuel oil is limited to something reasonable. The oil-firing operational limitation would not be restrictive and could be avoided by installing an SCR.

Beyond the construction and operating permitting process, any new replacement generating units with generator nameplate capacity greater than 25 MW (per unit) would in addition be required to comply with the federal Acid Rain program and the associated CEMS requirements. Thus, for the combustion turbine options considered with units greater than 25 MW, these CEMS requirements would be triggered along with the additional monitoring equipment, reporting requirements, and be subject to the allowance program of Acid Rain as well as the allowance program of the regional CSAPR. These allowances must be procured each year for both the annual timeframe and the ozone seasonal timeframe. The smaller (less than 25 MW) combustion turbine options have the advantage of avoiding these additional CEMS requirements and need to procure, track, and report allowances.

The reciprocating engine technology options would require an SCR and oxidation catalyst to comply with federal NSPS. All engine options at Substation J will be under the PSD "major source" without placing operational limitations on natural gas or oil firing. The engine options would not be subject to the Acid Rain Rule or the CSAPR and, therefore also have the advantage of not requiring emission credits to operate. The engines would require an MDNR Section 6 air construction permit (6 to 9 months) and either a Title V Permit to Operate or an Intermediate operating permit (not needed before construction).
The SPCC Plan specifies oil related reporting, inspections, training, and certifications as required by the EPA regulations. This Plan is updated every 5 years or whenever there are substantive changes to the facility which impact the Plan. Each of the proposed options would require substantive revisions to the SPCC Plan, but these revisions would not result in any significant issues which would be a concern to the selection of any of the options.

Social/Aesthetic

Substation J is adjacent to Young Park to the east across North Dodgion Street, commercial zones to the north across East Farmer Avenue, commercial zones to the west across North Noland Road, and commercial zones to the south across East Truman Road. A residential area is to the southeast across North Dodgion Street. The nearest dwelling is approximately 170 feet southeast of the substation equipment and 260 feet southeast of the existing generating equipment. There are additional dwellings to the southeast and east but slightly more distant. There is a barrier wall along the south boundary. The existing facility equipment is visible to the public to the east and the north.

The existing noise environment could be characterized as urban/commercial and is influenced by traffic noise on the nearby East Truman Road and North Noland Road. Street traffic in this area travels at a normal urban/commercial rate of speed, although there is a stop light at East Truman Road and North Noland Road which causes frequent cycles of louder traffic noise associated with the acceleration of the automobiles and trucks. During low traffic periods, the sound environment would take on a traditional urban neighborhood sense. During some very quiet times the nearby public may be able to discern the substation transformer sounds (humming) as well as "crackling" sounds from the high voltage power lines during periods of higher atmospheric moisture levels. The Substation J generation equipment has been at this site for approximately 50 years but has operated infrequently.

Replacing generating capacity with new combustion turbines or engines would not change the noise environment substantially when operating compared to times when the current turbines are operating. Compared to times when the current equipment is not operating, the urban/commercial nature of the existing noise environment would somewhat mask the additional noise from the new equipment when operating. However, during lower ambient noise conditions with little traffic such as at night, the operating new equipment could be discernable. Because the anticipated operating frequency will substantially increase, the nearby public will experience these operating sounds more often. Thus, the selection of replacement generation should consider utilizing above average noise quieting features such as buildings, sound absorption barriers, and additional air inlet and exhaust silencing baffle performance. Because they would be installed without a building housing them, the small engines option may have higher noise impacts compared to the other options and would require significant additional cost to mitigate to acceptable levels.

Utility scale wind turbines can be perceived to have unacceptable noise emissions (swooshing) caused by the rotation of the large blades through the air. In addition, the height of the supporting structure and the rotating blades are quite high and would be visible for a significant distance. Both the type of noise generated and the visible nature are much different than the existing environment and would make the wind turbine(s) addition more pronounced. Wind turbine farms installed in urban areas need to consider these factors that are not as important in rural installations.

Viable Options

Table 9 summarizes the review of each of the various site constraint parameters. Items highlighted in green represent adequate or viable options while items in red denote unfavorable or not currently viable conditions are present. Items highlighted in yellow are not currently satisfied but could be corrected and are marked as such in the table.

TABLE 9: SUBSTATION J CONSTRAINT MATRIX										
CONSTRAINT	SUBSTATION CRITERIA	SMALL RECIP ENGINE	MEDIUM RECIP ENGINE	LARGE RECIP ENGINE	INDUSTRIAL TURBINE	SMALL AERO TURBINE	LARGE AERO TURBINE	WIND	PV SOLAR	BESS
AVAILABLE FOOTPRINT	0.75 ACRES	YES, 6 UNITS	YES, 3 UNITS	NO	YES, 5 UNITS	YES, 2 UNITS	YES, 2 UNITS	YES, 1 TURBINE	YES, 100 KW	YES, 21 UNITS
ACHIEVES SPP INTERCONNECT LIMIT	34 MW	NO, 24 – 30 MW	YES, 27 – 33 MW	NO	NO, 20 – 26 MW	YES, 40 – 60 MW	YES, 79 – 98 MW	NO, 2 -3 MW	NO, 100 KW	NO, 21 MW
ADEQUATE SUBSTATION FACILITIES	33.6 / 33.6 MVA	YES	YES	YES	YES	YES	FEASIBLE	YES	YES	YES
ADEQUATE NATURAL GAS AVAILABLE		NO	NO	NO	NO	NO	NO	N/A	N/A	N/A
ADEQUATE FUEL OIL AVAILABLE		YES	YES	YES	YES	YES	YES	N/A	N/A	N/A
ADEQUATE WATER AVAILABLE		FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	N/A	FEASIBLE	N/A
ADEQUATE WASTEWATER AVAILABLE		FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	N/A	FEASIBLE	N/A
MANAGEABLE NOISE IMPACTS		NO	YES	YES	YES	YES	YES	NO	YES	YES
MANAGEABLE VISUAL IMPACTS		YES	YES	YES	YES	YES	YES	NO	YES	YES
MAJOR EQUIPMENT COST ($/KW)		$1,000	$1,000	$1,000	$950	$650	$600	---	---	---
TOTAL INSTALLED COST ($/KW)		$2,000	$1,900	$1,800	$2,100	$1,350	$1,150	$3,500	$2,500	$3,500
TOTAL COST ($)*		$48 MM - $60 MM	$51 MM - $63 MM	---	$34 MM - $44 MM	$54 MM - $81 MM	$91 MM - $113 MM	$7 MM - $11 MM	$2.5 MM	$53 MM
MINIMUM OPERATING LOAD**		1 MW	2.25 MW	---	2 MW	5 MW	9.75 MW	2 MW	100 KW	1 MW
FIXED O&M COST ($/MW-HR)		$6.00	$5.00	$5.00	$5.00	$4.75	$4.75	$3.00	$1.75	$2.85
VARIABLE O&M COST ($/MW-HR)		$6.00	$5.00	$4.75	$2.00	$2.00	$2.00	$0.00	$0.00	$0.00

*Ranges of costs shown correlate to range of MW values for each technology. These ranges are not meant to infer bounds of the cost estimate itself.
**Minimum load is the lowest stable operating point of the generating units. For sites utilizing multiple units, this represents the minimum load of a single generator with all other units offline. Combustion turbine minimum loads are affected by the selected emissions control technologies and may be higher than the values listed here.

The only technology options that meet the main goal of power generation up to the SPP interconnect limit at the facility are the small and large aeroderivative size combustion turbines and medium reciprocating engines. These technologies can achieve the desired power production within the current footprint constraints of the substation facility. The small aeroderivative units are similar in footprint and size compared to the existing combustion turbine units. However, the larger aeroderivative sized units may have a larger visual impact than the existing units. The reciprocating engines would require the highest capacity of the medium engine category to meet the SPP interconnect limit; however, either size of the medium range could produce up to the current SPP accredited limit.

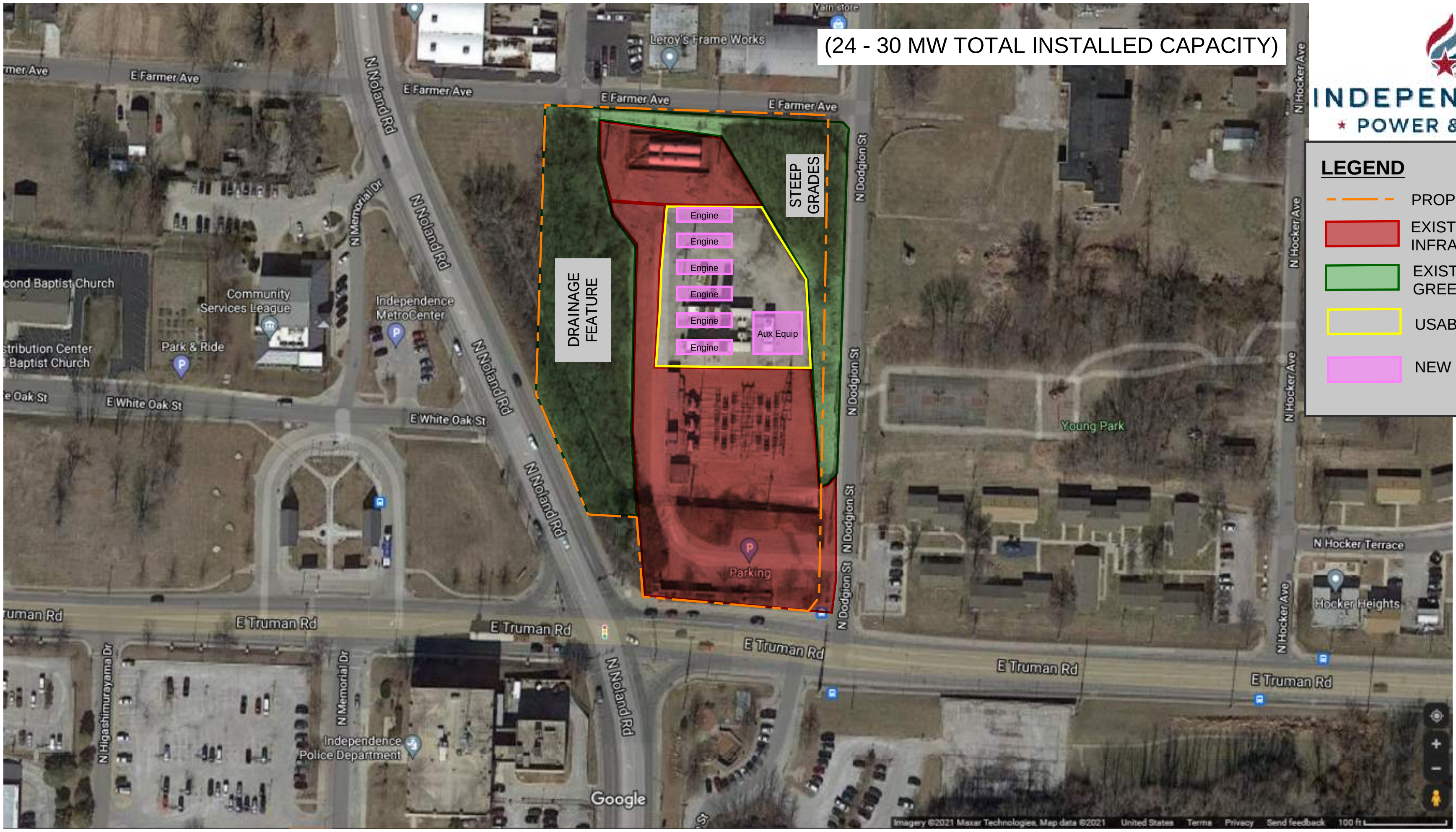
At this time, natural gas service to this location is cost prohibitive and not viable. As such, any combustion driven technology installed at this location is limited to fuel oil only.

Aside from BVPS, this location has the largest footprint available for new technology as well as the most rectangular area. The existing equipment arrangement at this location is also the most favorable for siting new equipment. Access roads are well aligned to not interfere with the proposed installation area.

Any of the three options will require demolition of the existing combustion turbines located at the site prior to construction of the new units. It is unlikely that any existing foundations are usable with the new equipment due to changes in anchoring details and weights/loads. Other underground mechanical utilities should be reviewed during demolition for condition and replaced as required. Construction may require the use of additional nearby areas for temporary laydown, construction trailers, and craft parking during demolition and construction activities.

Substation J

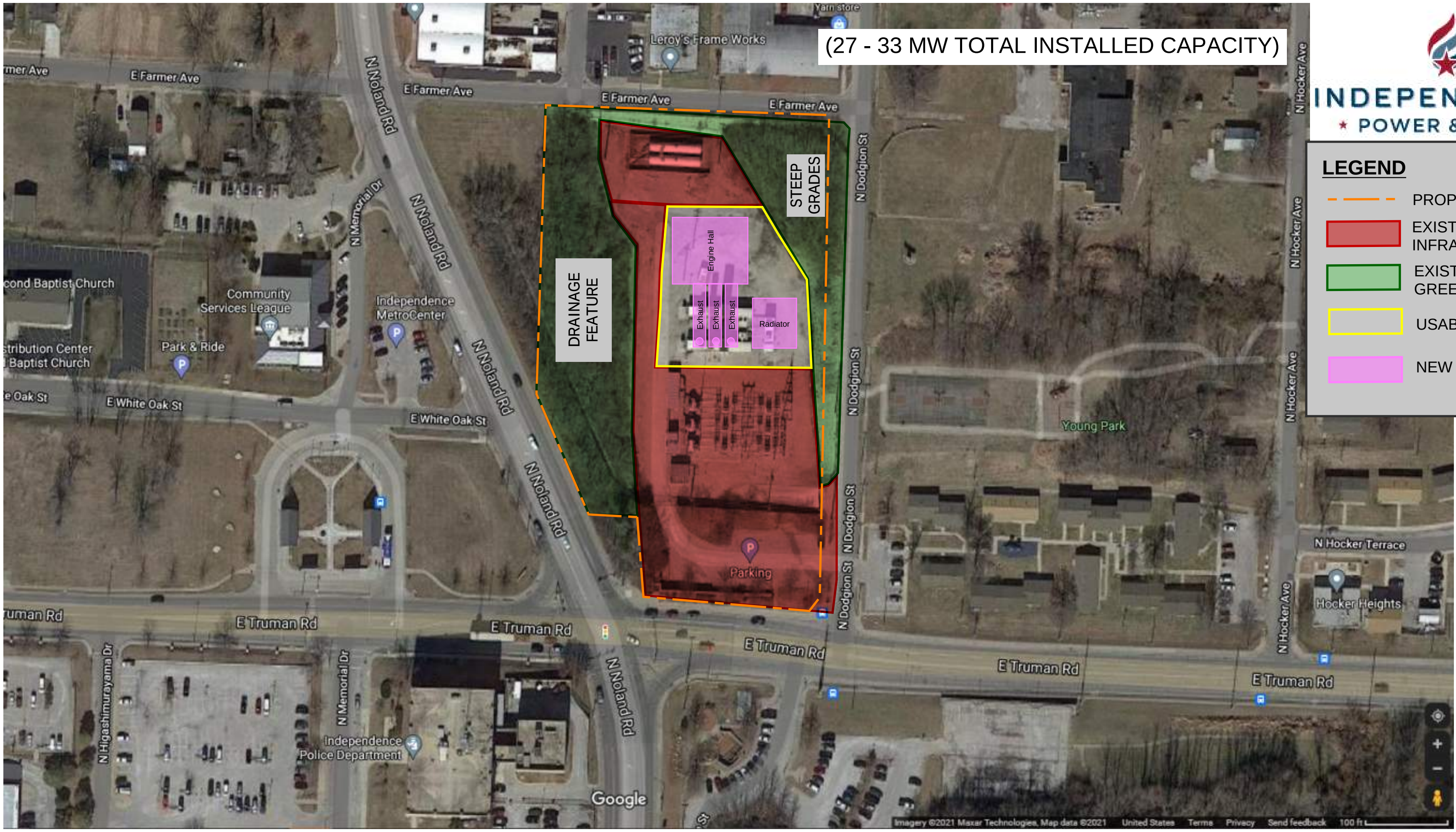
Substation J: 4 - 5 MW Recip



LEGEND

- PROPERTY LINE
- EXISTING INFRASTRUCTURE
- EXISTING/UNUSABLE GREENSPACE
- USABLE SPACE
- NEW EQUIPMENT

Substation J: 9 -11 MW Recip



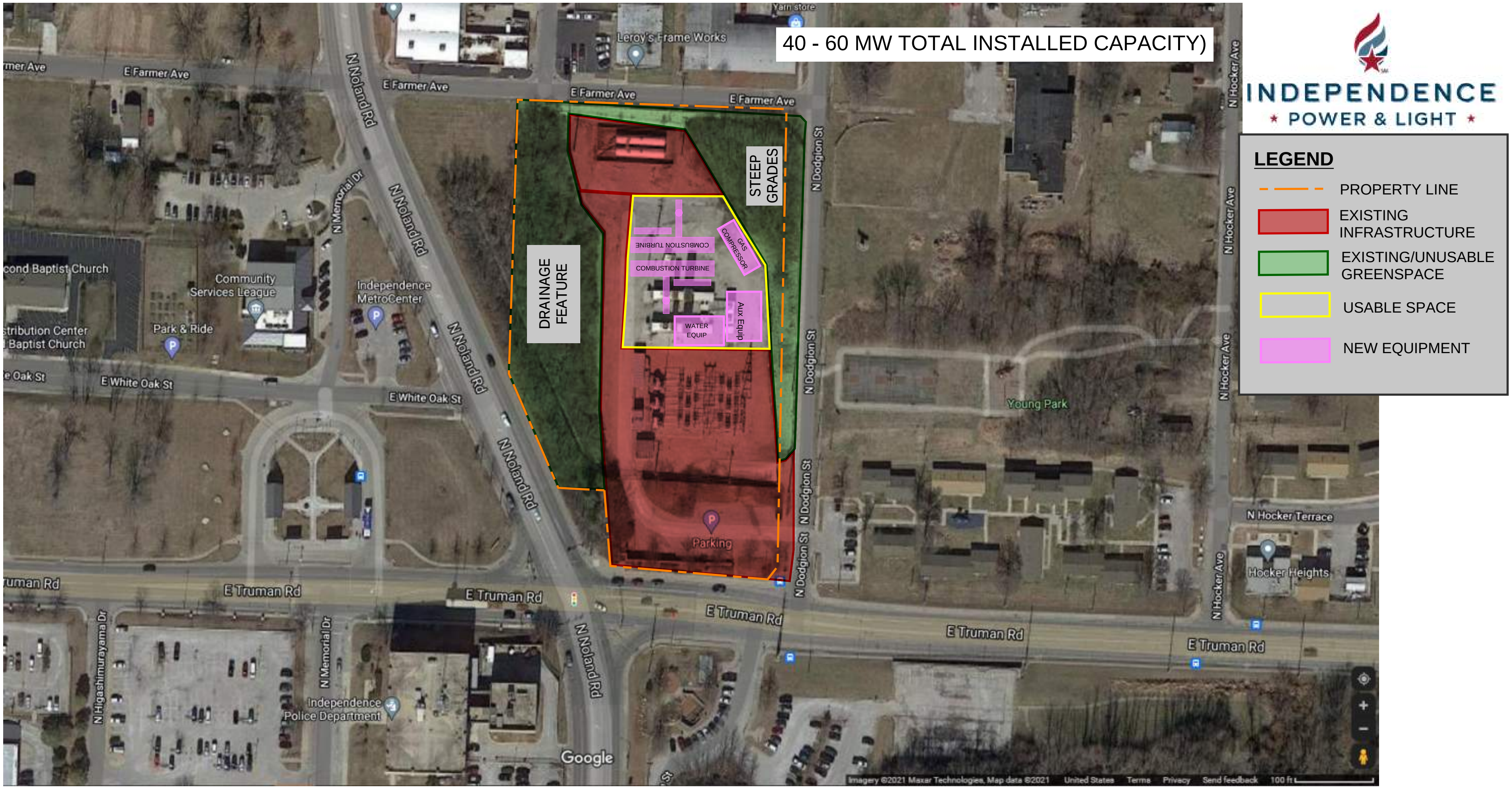
INDEPENDENCE
POWER & LIGHT

LEGEND

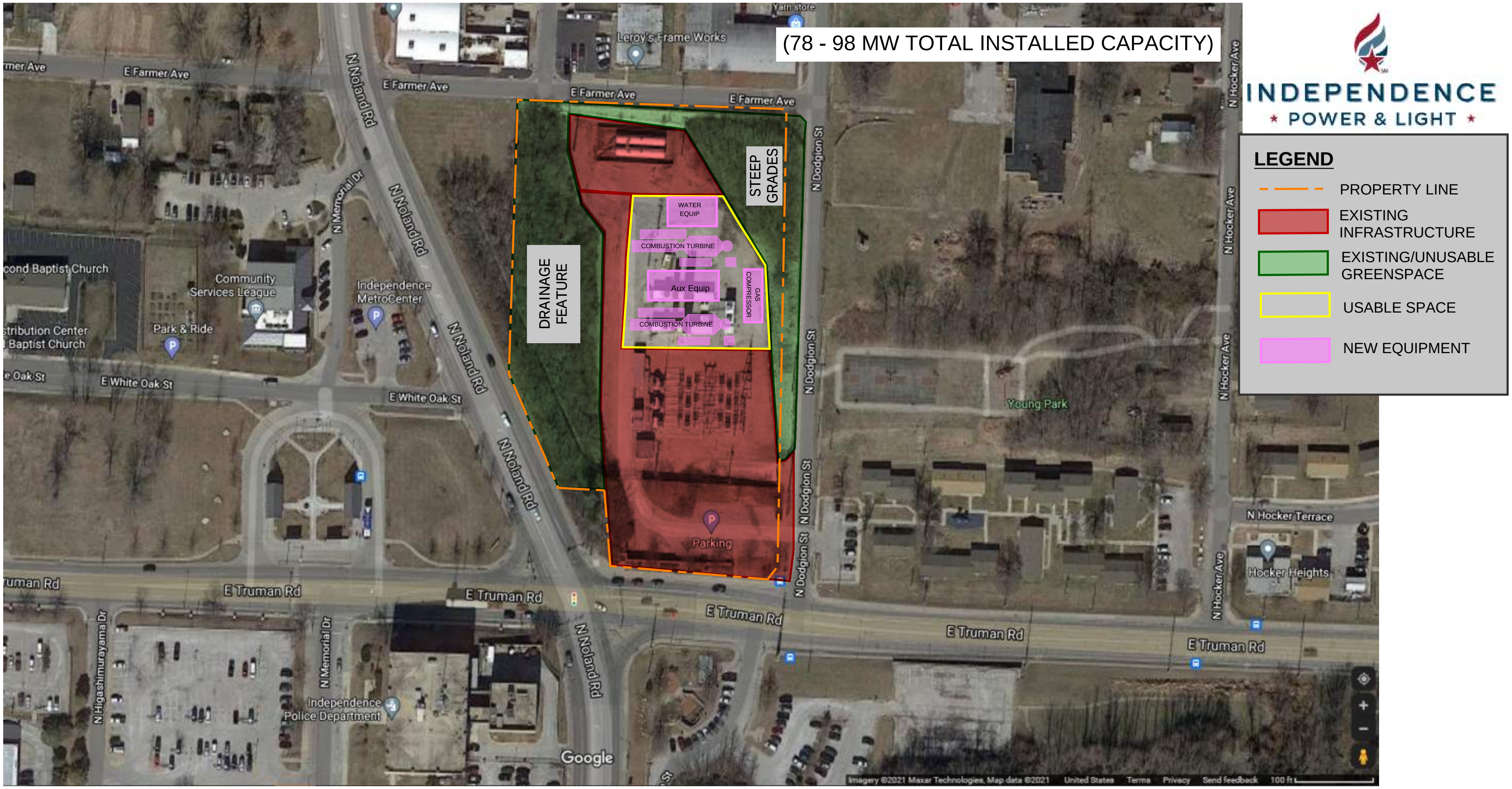
- PROPERTY LINE
- EXISTING INFRASTRUCTURE
- EXISTING/UNUSABLE GREENSPACE
- USABLE SPACE
- NEW EQUIPMENT

Substation J: Industrial Turbine

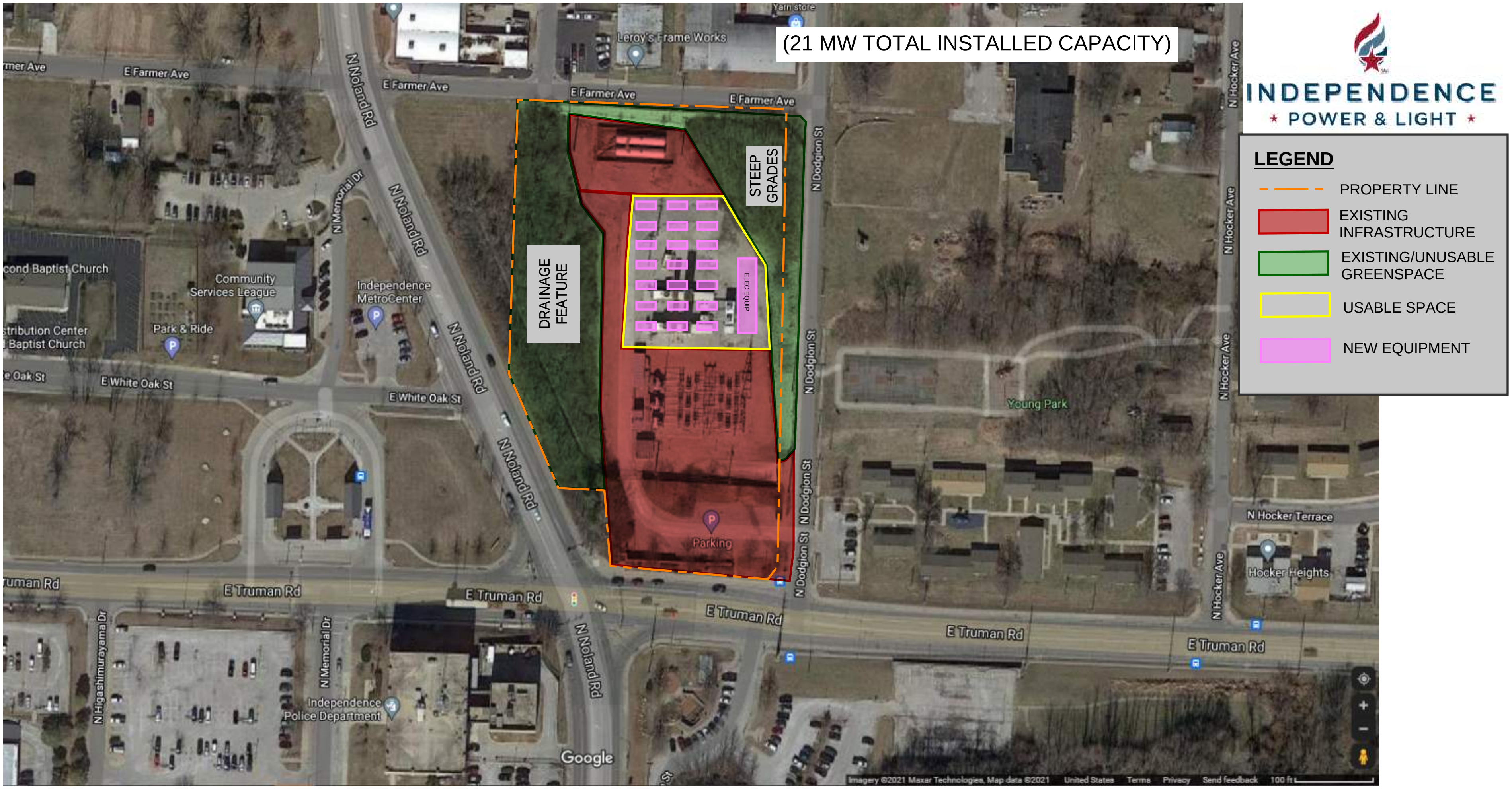
Substation J: Small Aero Turbine



Substation J: Large Aero Turbine



Substation J: Battery Storage



Blue Valley Power Station / Substation A

The Substation A site is located adjacent to the Blue Valley Power Station (BVPS) and is located in the northwest quadrant of the intersection of East Truman Road and 23rd Street (MO 78 also known as Lake City Buckner Road). The property is bounded on the west side by Powell Road and on the south by Truman Road. The property is located within the City limits and likely zoned industrial. Five IPL 69 kV lines, one KCP&L 69 kV line, and two IPL 161 kV lines enter the property. Blue Valley Power Station included three fossil fueled power generating units which have all been recently retired. A combustion turbine unit was also previously installed south of substation A and interconnected into the 69 kV system. This unit has been demolished; however, the generator step-up transformer and substation infrastructure remain.

Site Constraint Review

Electrical Capacity

The current SPP accredited capacity of Substation A/BVPS is 98 MW with an SPP interconnect limit of 99 MW.

The substation has multiple generator step-up transformers that served the previous generating units. However, the transformer that previously served the combustion turbine unit is the best location for interconnection of the new generating equipment. In this case, the transformer converts from the electrical generator output voltage of 13.8 kV to 69 kV. Additionally, there are two transformers that further step-up from 69 kV to 161 kV for transmission into the grid at higher voltage levels.

The available transformer rating at the 13.8kV/69kV level is 70 MVA. Table 10 summarizes the various ratings discussed in this section.

TABLE 10: BVPS/SUBSTATION A ELECTRICAL RATINGS

DESCRIPTION	LIMIT/RATING (MVA)	LIMIT/RATING (MW)
SPP ACCREDITED LIMIT	115.2	98
SPP INTERCONNECT LIMIT	116.4	99
TRANSFORMER RATING	70	59

*Assumes 0.85 Power Factor

The available transformer rating is below the substation SPP accredited and interconnect ratings as previous operation of the facility included multiple generating units and step-up transformers making up the total capacity of the substation. These units have been retired and will not operate in the future. These step-up transformers, specifically the transformer associated with BVPS Unit 3, may be available for re-use to accept generation from the new equipment. However, this may require relocating the transformer or reconfiguring the substation layout to make the electrical routing work with the location of the new generating equipment. Otherwise, a new transformer could be installed in parallel with the existing available transformer to support the new generating units.

If additional capacity is desired from the new equipment, new physical infrastructure as well as SPP approval will be required. This additional capacity would need to go through the SPP Generation Interconnection study process that can take approximately 4 – 5 years to complete and gain approval.

Footprint

The footprint of the BVPS and Substation A facility is quite large at over 100 acres. The existing power plant buildings and equipment remain at the facility and are not planned for demolition at this time unless required for the installation of new equipment. Other areas that included coal and ash storage from the previous facility operation are not considered as available due to the environmental regulations and limitations of utilizing these areas. Like the other substation areas, BVPS also includes steep grades and drainage areas that are not ideal for development and siting of new equipment. Each technology will discuss the areas reviewed and assumed to be usable for that equipment.

The figures at the end of this section shows the layout of the existing substation with parcel boundaries and available and unusable areas highlighted.

- Medium Reciprocating Engine:

  Sufficient space exists across the BVPS site to install significantly more reciprocating engine generators than are required to meet the SPP interconnect limit or the IPL output goal. The focus of review was for the most efficient parcels that minimized demolition costs, utility interconnection costs, etc. The primary parcel that allows for the easiest electrical interconnection of the equipment is south of substation A near the location of the demolished combustion turbine unit. Any generating equipment could easily connect to the substation using the existing generator step-up transformer.

  The available land footprint area in this location is sufficient for the installation of eight medium reciprocating engine sets capable of producing 72 – 88 MW of total power generation. An additional unit may be installed by reducing the amount of existing parking lot reserved for future use. This would increase the total power generation to 81 – 99 MW, nearly matching the transformer and SPP ratings.

  Units of this size are typically installed in a common engine hall given the size and number of engines required. Engines of this size require a separate radiator component that is mounted adjacent to the engine hall. Additional auxiliary equipment, such as low voltage electrical distribution equipment, would be installed within the engine hall itself. Main access would remain from the existing site roads south of substation A and north of the proposed new equipment. A sample layout is included at the end of this section.

- Large Reciprocating Engine:

  Sufficient space exists across the BVPS site to install significantly more reciprocating engine generators than are required to meet the SPP interconnect limit or the IPL output goal. The focus of review was for the most efficient parcels that minimized demolition costs, utility interconnection costs, etc. The primary parcel that allows for the easiest electrical interconnection of the equipment is south of substation A near the location of the demolished combustion turbine unit. Any generating equipment could easily connect to the substation using the existing generator step-up transformer.

The available land footprint area in this location is sufficient for the installation of three large reciprocating engine sets capable of producing 54 MW of total power generation. An additional unit may be installed by optimizing the layout of the radiator equipment and engine hall within the available area. This would increase the total power generation to 72 MW.

Units of this size are installed in a common engine hall given the size and number of engines required. Engines of this size require a separate radiator component that is mounted adjacent to the engine hall. Additional auxiliary equipment, such as low voltage electrical distribution equipment, would be installed within the engine hall itself. Main access would remain from the existing site roads south of substation A and north of the proposed new equipment. A sample layout is included at the end of this section.

- Small Aeroderivative Combustion Turbine:

  Sufficient space exists across the BVPS site to install significantly more combustion turbine generators than are required to meet the SPP interconnect limit or the IPL output goal. The focus of review was for the most efficient parcels that minimized demolition costs, utility interconnection costs, etc. The primary parcel that allows for the easiest electrical interconnection of the equipment is south of substation A near the location of the demolished combustion turbine unit. Any generating equipment could easily connect to the substation using the existing generator step-up transformer.

  The available land footprint area is sufficient for the installation of six small aeroderivative combustion turbines capable of producing 120 – 198 MW of total power generation. Options are available for these units to be trailer mounted for quick install/setup or installed in a more traditional modularized approach. Either option serves to reduce site setup time and minimize the overall field connections required. Air inlet filter and stack equipment would sit above and adjacent to the turbine module. Fuel gas compression equipment could be shared between the combustion turbines and contained on a common skid near the steep grade areas to maximize access to the turbines. Additional auxiliary equipment, such as electrical equipment, water treatment equipment (if required) and chemical equipment for pollution control systems can be installed and shared across the turbines. Main access would remain from the existing site roads south of substation A and north of the proposed new equipment.

  Modifications to the substation would be required to utilize this quantity of small aeroderivative combustion turbines at this substation. The current generator step-up transformer does not have sufficient capacity to accept the electrical output from these generators. At a minimum, a new transformer would be required to be installed. Likely, upgrades to the circuit breaker, bus, and other substation equipment would also be required.

  A sample layout is included at the end of this section.

- Large Aeroderivative Combustion Turbine:

Sufficient space exists across the BVPS site to install significantly more combustion turbine generators than are required to meet the SPP interconnect limit or the IPL output goal. The focus of review was for the most efficient parcels that minimized demolition costs, utility interconnection costs, etc. The primary parcel that allows for the easiest electrical interconnection of the equipment is south of substation A near the location of the demolished combustion turbine unit. Any generating equipment could easily connect to the substation using the existing generator step-up transformer.

The available land footprint area is sufficient for the installation of three large aeroderivative combustion turbines capable of producing 117 – 147 MW of total power generation. These units are supplied in multiple modules including the combustion turbine, generator, lube oil equipment, and pollution control equipment. Air inlet filter and stack equipment would sit above and adjacent to the turbine module. Fuel gas compression equipment can be contained on a common skid near the steep grade areas to maximize access to the turbines. Additional auxiliary equipment, such as electrical equipment, water treatment equipment (if required) and chemical equipment for pollution control systems would also be installed adjacent to the turbine for easy access during operation. Main access would remain from the existing site roads south of substation A and north of the proposed new equipment.

Modifications to the substation would be required to utilize this quantity of large aeroderivative combustion turbines at this substation. The current generator step-up transformer does not have sufficient capacity to accept the electrical output from these generators. At a minimum, a new transformer would be required to be installed. Likely, upgrades to the circuit breaker, bus, and other substation equipment would also be required.

A sample layout is included at the end of this section.

- Wind:

  Based on the average acreage per turbine figures discussed above, the available land footprint area across the entire parcel is sufficient for the installation of two to three horizontal axis wind turbine capable of producing 6 – 15 MW. Siting around the site could be done to minimize impacts on the existing infrastructure and drainage areas.

- PV Solar:

  The available land footprint area is sufficient for the installation of up to 8 MW of PV solar modules. However, this assumes all unused land including that under the existing power equipment is utilized for solar module installation. The demolition costs associated with removal of the existing power plant will be significant and likely preclude the use of this area. Additionally, other areas of the facility are currently used for laydown for other city services and would need to be re-located to other facilities which may not be practical. The actual limit of installed PV solar modules is less than 4 MW given these factors.

- Battery Energy Storage:

The primary parcel that allows for the easiest electrical interconnection of the equipment is south of substation A near the location of the demolished combustion turbine unit. The BESS could easily connect to the substation using the existing generator step-up transformer.

The available land footprint area is sufficient for the installation of approximately 56 MW / 224 MW-hr battery energy storage systems. The installation would include approximately 56 containerized battery storage systems that are typically installed in 20 foot ISO shipping containers. Additional equipment would include the inverters necessary to convert from direct current to alternating current power.

The system evaluated has an operating capacity up to 4 hours at full power output. This limits the functionality of these systems to meet the IPL guiding constraints as a direct replacement for electrical generation equipment. These systems can be paired with other generating equipment to function like a hybrid automobile. For short output periods, the BESS outputs stored electrical energy to the grid. Once depleted, the electrical generation equipment would operate until the batteries could be recharged.

Given the modularity of the BESS equipment and the large amount of land available at the facility, this technology could easily be added in phased sections across the site to complement any new electrical generation equipment.

Utilities

No fuel oil supply or storage tanks are currently installed at the BVPS. Assuming the same type of frequency for filling during extreme weather events or other abnormal conditions discussed for the other substations, daily filling would be required. At the SPP interconnect limit of power generation, a storage capacity of approximately 200,000 gallons of storage would be required in either one or multiple storage tanks. However, additional storage may be desired as refueling this amount each day may be a logistical challenge. Otherwise, the tank capacity should be sufficient for less frequent deliveries (weekly, bi-weekly, etc.) during normal operation.

Natural gas is currently supplied to the facility through a 16-inch pipeline that runs along the south side of the property. The volume of gas that can be supplied from this pipeline can accommodate all generation up to the SPP interconnect limit. Additional capacity above this value is likely available to support the installation of multiple combustion turbines if desirable.

Water and wastewater services currently exist to serve the industrial and sanitary users at the BVPS. Any new generation technology can tie into these systems without issue.

Environmental Permits

The Blue Valley Power Plant / Substation A site is covered by an air Permit to Operate issued by the MDNR. The site also has an oil SPCC Plan, Storm Water Pollution Prevention Plan (SWPPP), and National Pollution Discharge Elimination System (NPDES) water permit issued by the MDNR.

The air Permit to Operate expires on March 28, 2022. Because the steam generating units at the facility have been retired, IPL is considering withdrawing the Permit to Operate. This would not impact the selection and permitting of new generation options at this facility since new equipment would need a construction permit and follow the same rules anyway.

Replacing generating capacity with new combustion turbines or engines at this substation would require an air construction permit and a revision to or new air Permit to Operate (depending on whether the current one is withdrawn). At a minimum the combustion equipment would need to meet NSPS. Because of these low NSPS emission levels the construction air permitting of the newly installed equipment options will likely have less than 250 tons per year of any regulated pollutant and thus not need to follow the PSD “major source” construction permit review process. Without the need for PSD dispersion modeling and control technology analyses the air construction permitting process would be more streamlined.

The combustion turbine technology options would not require an SCR and oxidation catalyst to comply with federal NSPS. However, not installing SCR could lead to MDNR requesting a demonstration that the new installation complies with NAAQS which would lengthen the permitting schedule and might result in even higher levels of emission controls. All combustion turbine options at Blue Valley Power Plant / Substation A will be under the “major source” thresholds so long as the annual amount of fuel oil is limited to something reasonable. The oil-firing operational limitation would not be restrictive and could be avoided by installing an SCR.

Beyond the construction and operating permitting process, any new replacement generating units with generator nameplate capacity greater than 25 MW (per unit) would in addition be required to comply with the federal Acid Rain program and the associated CEMS requirements. Thus, for the combustion turbine options considered with units greater than 25 MW, these requirements would be triggered along with the additional CEMS equipment, reporting requirements, and be subject to the allowance program of Acid Rain as well as the allowance program of the regional CSAPR. These allowances must be procured each year for both the annual timeframe and the ozone seasonal timeframe. The smaller (less than 25 MW) combustion turbine options have the advantage of avoiding these additional CEMS requirements and the need to procure, track, and report allowances.

The reciprocating engine technology options would require an SCR and oxidation catalyst to comply with federal NSPS. All engine options at Blue Valley Power Plant / Substation A will be under the PSD “major source” without placing operational limitations on natural gas or oil firing. The engine options would not be subject to the Acid Rain Rule or the CSAPR and, therefore also have the advantage of not requiring emission credits to operate. The engines would require an MDNR Section 6 air construction permit (6 to 9 months) and either a Title V Permit to Operate or an Intermediate operating permit (not needed before construction).
The SPCC Plan specifies oil related reporting, inspections, training, and certifications as required by the EPA regulations. This Plan is updated every 5 years or whenever there are substantive changes to the facility which impact the Plan. Each of the proposed options would require substantive revisions to the SPCC Plan, but these revisions would not result in any significant issues which would be a concern to the selection of any of the options.

Similarly, the SWPPP and NPDES permit would require modifications based on revisions to the storm water flow and water discharges. But none of these revisions would result in any significant issues which would be a concern to the selection of any of the options.

Social/Aesthetic

Blue Valley Power Plant / Substation A is adjacent to industrial / commercial zones on all sides. A residential area is to the southwest across East Truman Road. The nearest dwelling is approximately 1,200 feet southeast of the substation equipment and approximately 1,000 feet southeast of the possible new generating equipment. There are additional dwellings to the southwest and west but slightly more distant. The existing facility equipment is visible to the public to the west and the south with the taller equipment being visible from much greater distances.

The existing noise environment could be characterized as commercial/industrial and is influenced by traffic noise on the nearby East Truman Road and the existing industrial and commercial activities. During low traffic periods and absence of industrial activity, the sound environment would take on a traditional neighborhood sense. During quiet times the residential area to the southeast may be able to discern the substation transformer sounds (humming) as well as “crackling” sounds from the high voltage power lines during periods of higher atmospheric moisture levels. The Blue Valley Power Plant generation equipment has been retired and thus no longer part of the existing noise environment although was at this site for approximately 50 years.

Replacing generating capacity with operating new combustion turbines or engines would not change the noise environment substantially when compared to times when there is traffic, commercial, and industrial activities. Compared to times when there is low traffic and the absence of commercial and industrial activity, the new generation equipment could be discernable but at a relatively low level due to the 1,000 foot plus distance. The selection of new generation should consider utilizing some noise quieting features such as buildings, barriers, and air inlet and exhaust silencing baffles to minimize noise levels that could be discernable within residential areas during the quieter periods of background noise. Because they would be installed without a building housing them, the small engines option may have higher noise impacts compared to the other options and would require additional cost to mitigate to acceptable levels.

Utility scale wind turbines can be perceived to have unacceptable noise emissions (swooshing) caused by the rotation of the large blades through the air. In addition, the height of the supporting structure and the rotating blades are quite high and would be visible for a significant distance. Both the type of noise generated and the visible nature are much different than the existing environment and would make the wind turbine(s) addition more pronounced. Wind turbine farms installed in urban areas need to consider these factors that are not as important in rural installations.

Viable Options

Table 11 summarizes the review of each of the various site constraint parameters. Items highlighted in green represent adequate or viable options while items in red denote unfavorable or not viable conditions are present. Items highlighted in yellow are not currently satisfied but could be corrected and are marked as such in the table.

TABLE 11: BVPS/SUBSTATION A CONSTRAINT MATRIX								
CONSTRAINT	SUBSTATION CRITERIA	MEDIUM RECIP ENGINE	LARGE RECIP ENGINE	SMALL AERO TURBINE	LARGE AERO TURBINE	WIND	PV SOLAR	BESS
AVAILABLE FOOTPRINT**	2 ACRES	YES, 6	YES, 3	YES, 6	YES, 3	YES, 3	YES, 8 MW	YES, 56
ACHIEVES SPP INTERCONNECT LIMIT	99 MW	NO, 72 – 88 MW	NO, 54 MW	YES, 120 –198 MW	YES, 117 – 148 MW	NO, 6 -15 MW	NO, 8 MW	NO, 56 MW
ADEQUATE SUBSTATION FACILITIES	70 MVA	YES	YES	FEASIBLE	FEASIBLE	YES	YES	YES
ADEQUATE NATURAL GAS AVAILABLE		YES	YES	YES	YES	N/A	N/A	N/A
ADEQUATE FUEL OIL AVAILABLE		YES	YES	YES	YES	N/A	N/A	N/A
ADEQUATE WATER AVAILABLE		YES	YES	YES	YES	N/A	YES	N/A
ADEQUATE WASTEWATER AVAILABLE		YES	YES	YES	YES	N/A	YES	N/A
MANAGEABLE NOISE IMPACTS		YES	YES	YES	YES	YES	YES	YES
MANAGEABLE VISUAL IMPACTS		YES	YES	YES	YES	YES	YES	YES
MAJOR EQUIPMENT COST ($/KW)		$1,000	$1,000	$650	$600	---	---	---
TOTAL INSTALLED COST ($/KW)		$1,900	$1,800	$1,350	$1,150	$3,500	$2,500	$3,500
TOTAL COST ($)*		$137 MM - $167 MM	---	$162 MM - $267 MM	$135 MM - $170 MM	$21 MM - $53 MM	$20 MM	$196 MM
MINIMUM OPERATING LOAD***		2.25 MW	4.5 MW	5 MW	9.75 MW	2 MW	1 MW	1 MW
FIXED O&M COST ($/MW-HR)		$5.00	$5.00	$4.75	$4.75	$3.00	$1.75	$2.85
VARIABLE O&M COST ($/MW-HR)		$5.00	$4.75	$2.00	$2.00	$0.00	$0.00	$0.00

*Ranges of costs shown correlate to range of MW values for each technology. These ranges are not meant to infer bounds of the cost estimate itself.
**Available Footprint represents best available portion of the facility for development
***Minimum load is the lowest stable operating point of the generating units. For sites utilizing multiple units, this represents the minimum load of a single generator with all other units offline. Combustion turbine minimum loads are affected by the selected emissions control technologies and may be higher than the values listed here.

The only technology options that meet the main goal of power generation up to the SPP interconnect limit at the facility are the small and large aeroderivative size combustion turbines. These technologies can achieve the desired power production within the current footprint constraints of the substation facility. The small aeroderivative units are similar in footprint and size compared to the existing combustion turbine units. The layout of the large aeroderivative machines is the most optimal use of the footprint and meets or exceeds the goal of achieving the SPP interconnect limit for power generation.

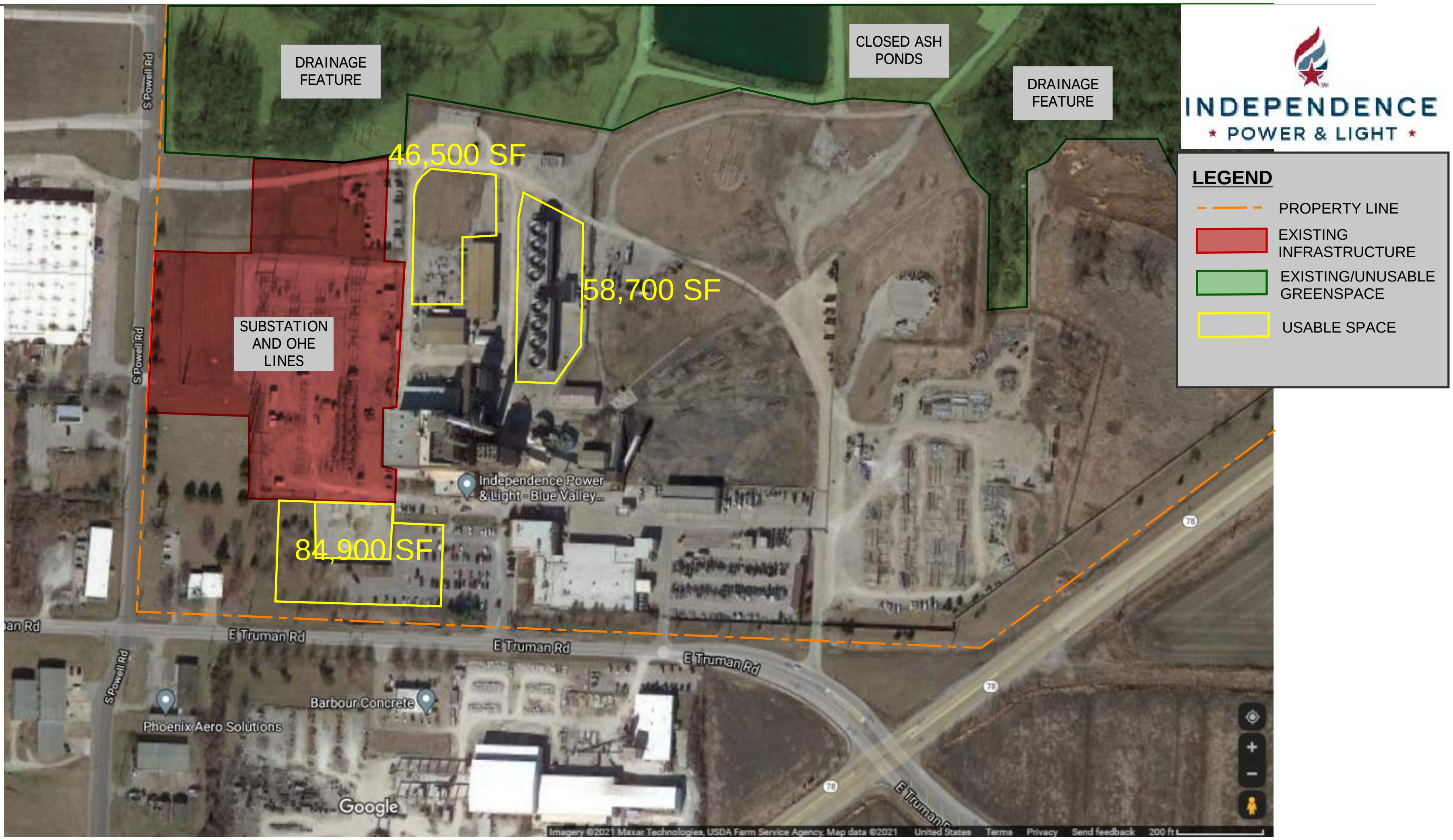
All utilities are currently interconnected at the facility and available in sufficient quantities to support the operation of the new generation equipment.

Total costs are listed for the full capacity of the facility – even if the SPP interconnect limit is exceeded by the number of units that may fit in the footprint. The cost on a $/kW basis can be used to compare technologies for a given power output.

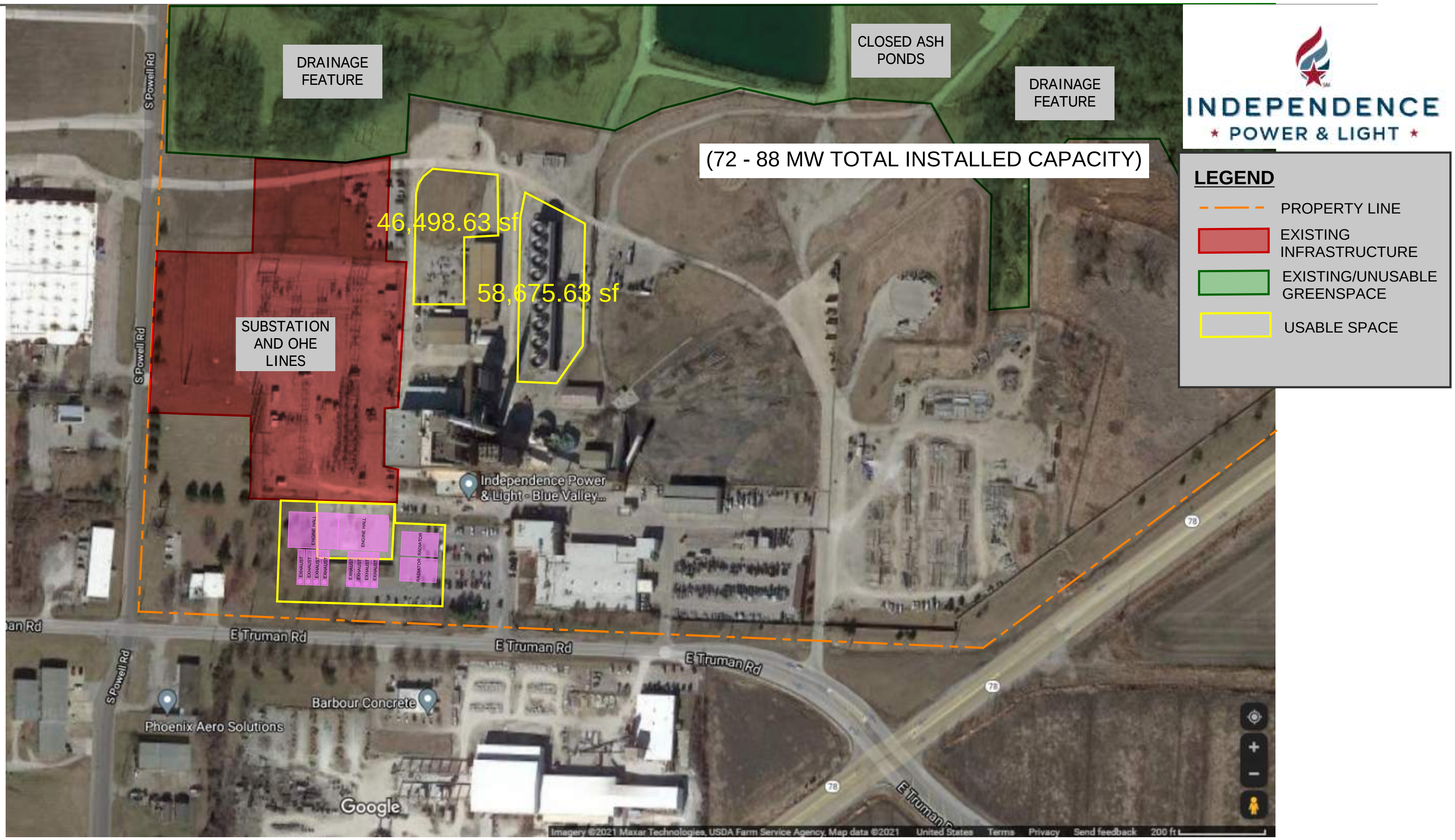
Should the maximum amount of generation be installed, modifications to the existing substation will be required as the current transformer cannot support this load. The removal of the three existing units from service has created sufficient room within the substation equipment to accommodate these modifications.

Minimal demolition is required at this location of the BVPS as the area proposed for the new generation is not currently utilized by the existing power plant. Some pavement and existing concrete will need to be removed as well as removal/re-location of the visual barrier system at the south of the facility.

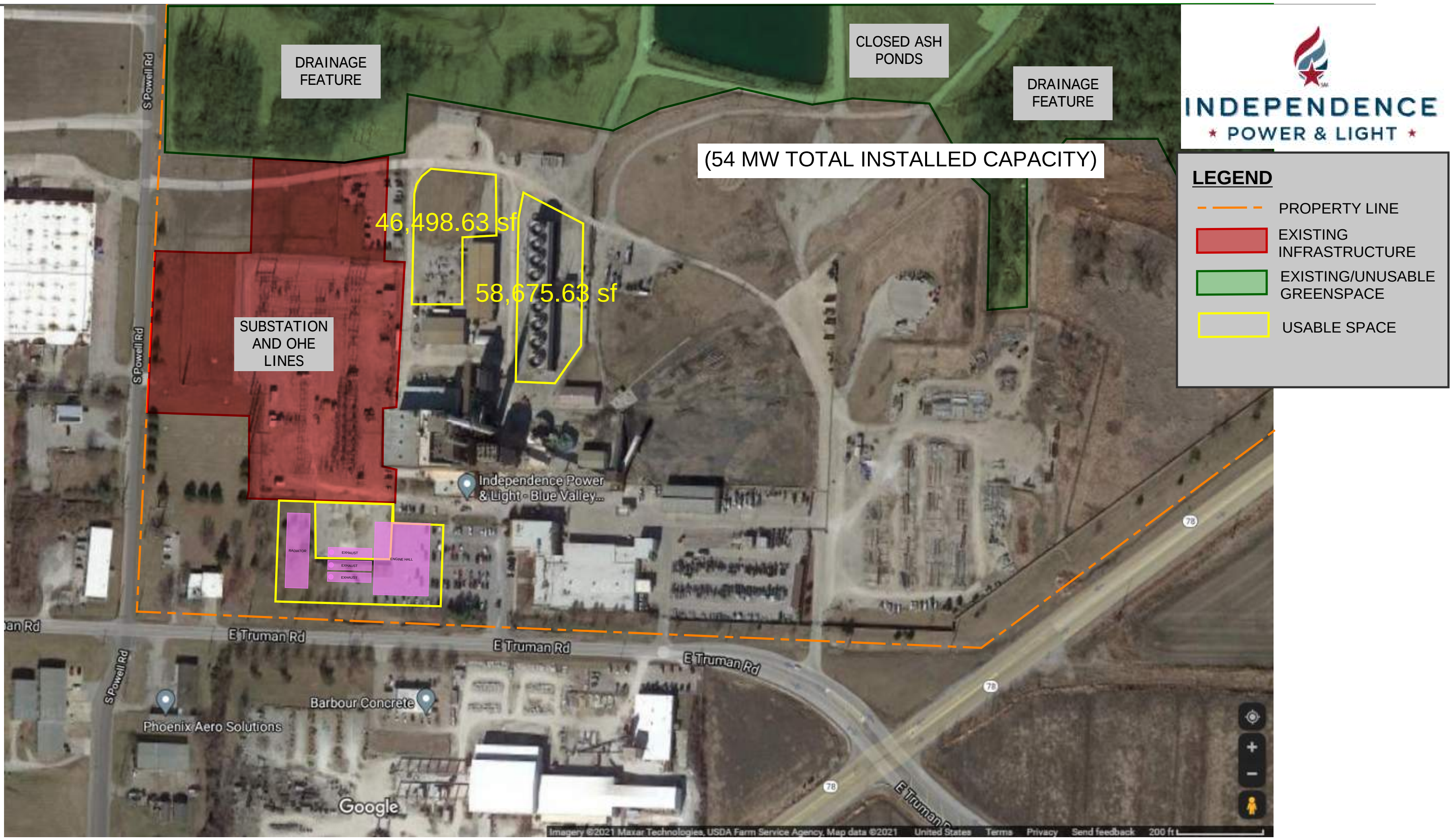
BVPS & Substation A



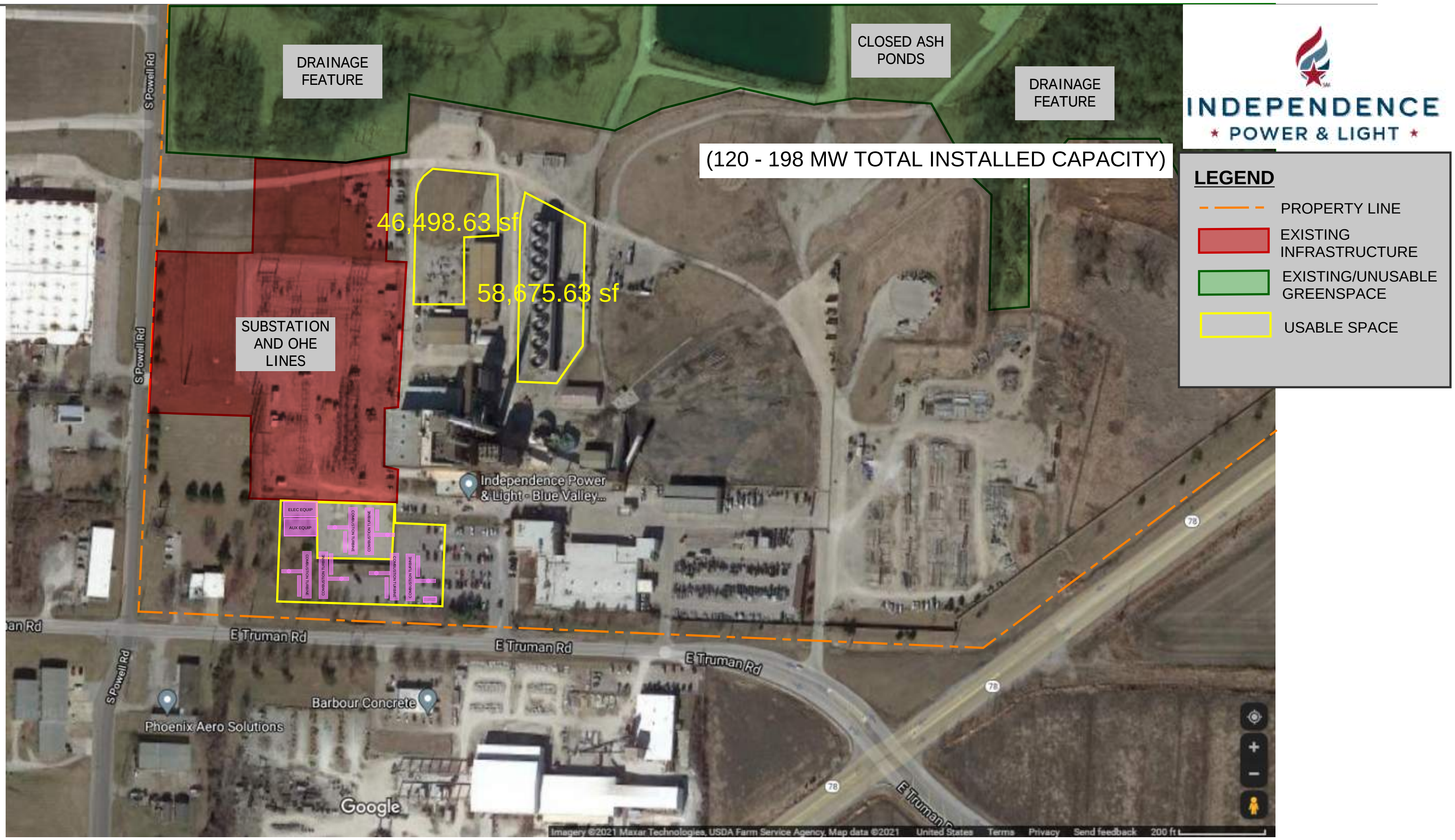
BVPS & Substation A: 9 - 11 MW Recip



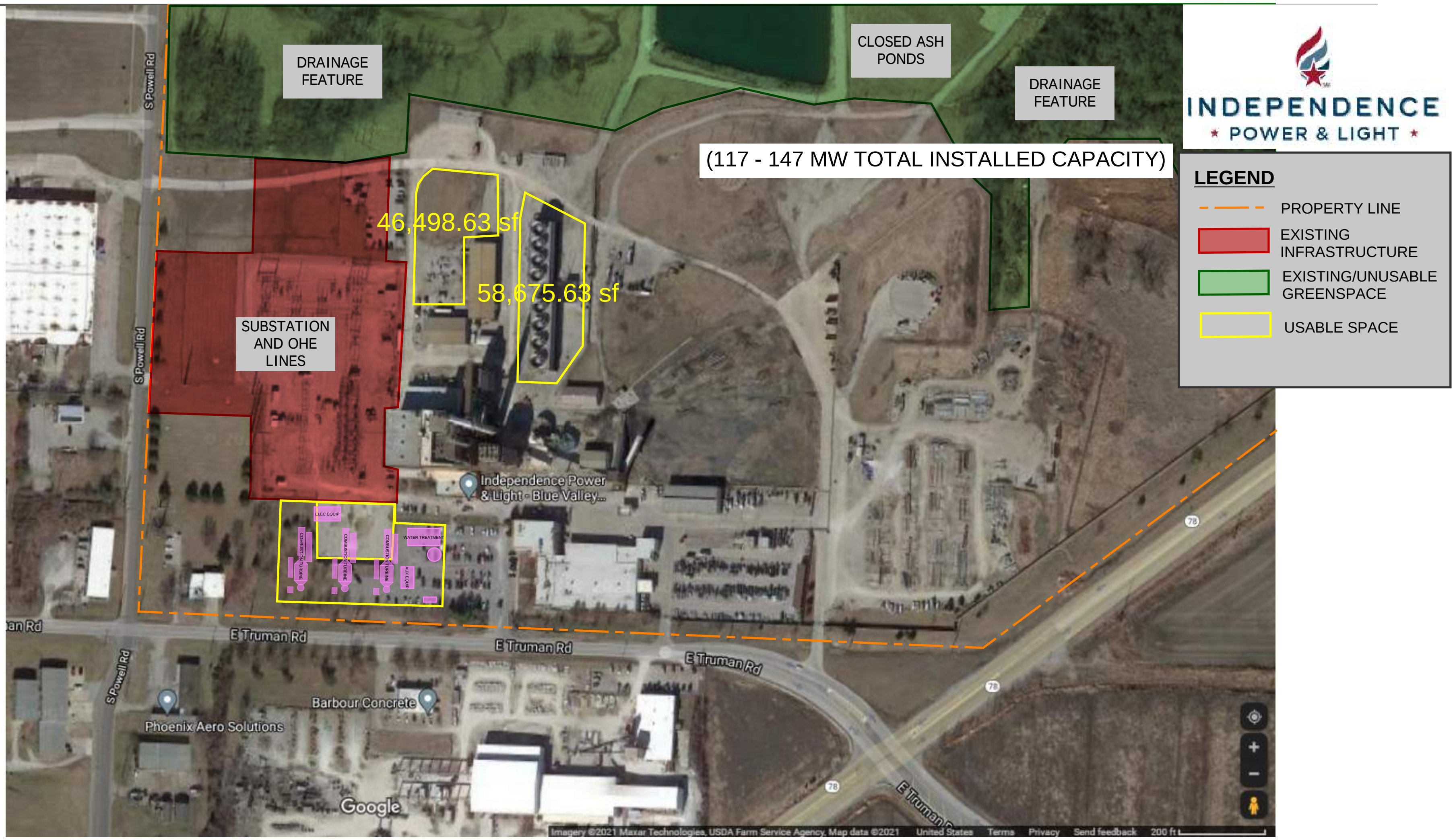
BVPS & Substation A: 18 MW Recip



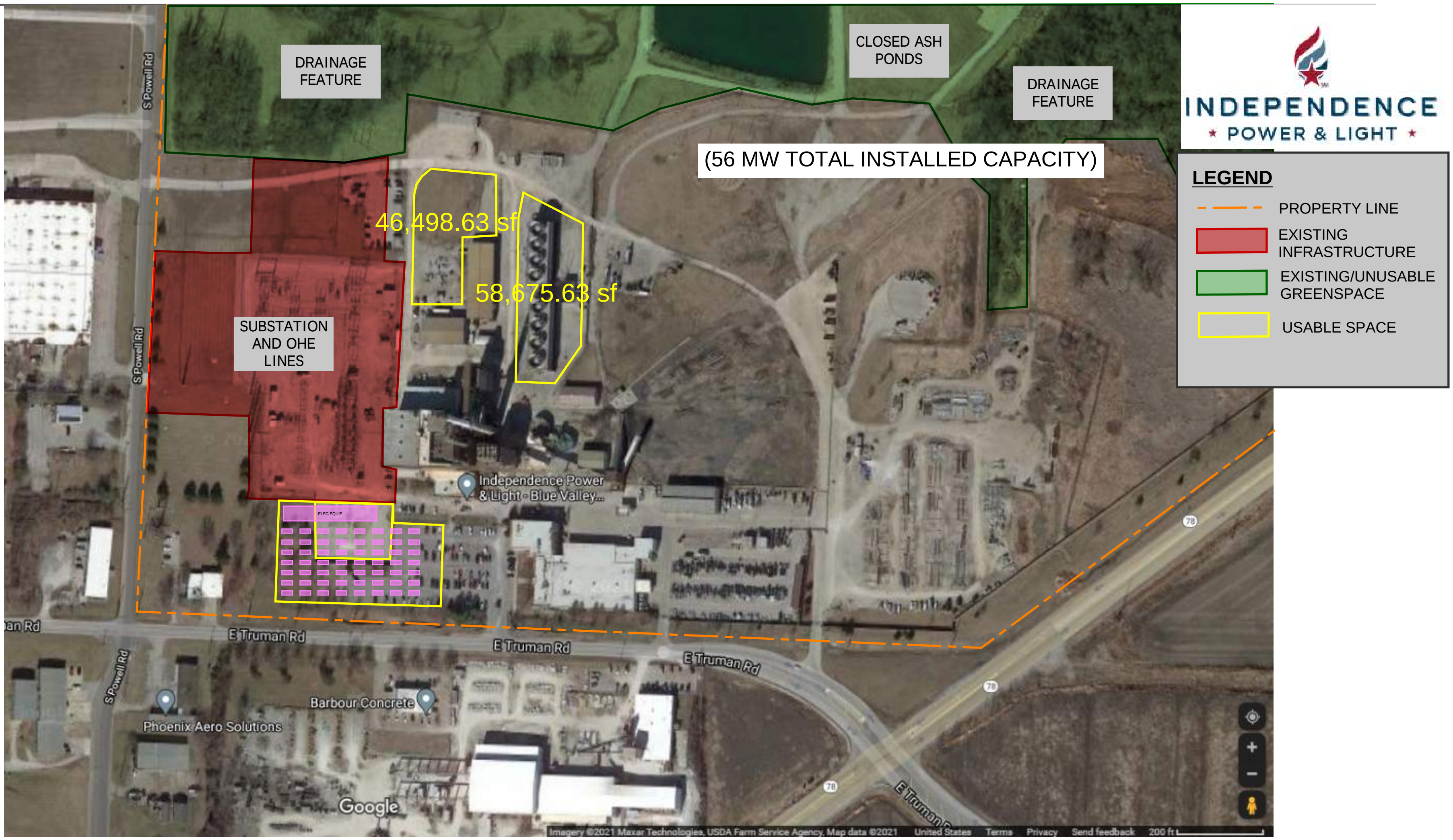
BVPS & Substation A - Small Aero



BVPS & Substation A - Large Aero



BVPS & Substation A - Battery Storage



RECOMMENDED OPTION FOR CONSIDERATION

The Blue Valley Power Station/Substation A is the recommended location for the installation of new generation equipment. This facility has the most available space from the four substation locations reviewed. Most of the necessary utilities including natural gas, water, and wastewater all exist at the property and are available in sufficient quantities to support all types of new equipment considered. The area considered south of the existing substation requires minimal demolition work to occur prior to construction of the new equipment. Unlike other sites, no generators need to be removed prior to installing new equipment – simplifying schedule coordination issues as IPL's generating capacity would not be reduced during this construction window.

The recommended technology for installation is the large aeroderivative type combustion turbine. These units can achieve the expected capacity factor and operating profile that has been identified based on the anticipated heat rate and SPP market conditions. IPL staff is already familiar with the operation of combustion turbines from their experience with the existing units. The area selected can facilitate three units which can generate well above the SPP interconnect limit of the facility. Two large aeroderivative units can achieve the desired output and will allow for optimization of the footprint in this area to mitigate any noise, visual, or other ancillary concerns.

The alternate technology recommended for installation is the medium reciprocating engines. Although the heat rate (efficiency) of these units is slightly better than combustion turbines, the cost of these machines is 25 – 30 % higher than turbine technology. Additionally, these units have a higher O&M cost as they consume oil continuously during operation and require more regular preventative maintenance. The benefit of these units is that due to their lower heat rate, they should be dispatched for more hours of the year in the SPP market compared to the turbine technology. The proposed footprint can nearly accommodate the number of reciprocating engines required to meet the SPP interconnect limit of the facility. By slightly expanding the area considered, an additional unit can likely be sited to increase the total generation capacity.

By selecting the BVPS/Substation A location, IPL can also utilize other areas of the property to meet the future decarbonization and renewable installation goals. Battery energy storage systems can be installed across the facility in large blocks or in a phased approach as necessary to meet future conditions. BESS pairs well with either the combustion turbine or reciprocating engine technologies recommended for this site and can be integrated together into a comprehensive operating system.

If the SPP Tariff waiver is not approved for the BVPS/Substation A location, the alternate recommendation is small aeroderivative combustion turbines located at Substation I. Additionally, generation resources at Substation I are important for the overall grid reliability as indicated by previous studies. A transmission study should be conducted to help further analyze this reliability impact. Although natural gas infrastructure does not currently exist, the gas utility has indicated that this interconnection is feasible. Water and wastewater exist nearby and can be interconnected into the facility. The size of these units is comparable to the existing combustion turbines and can be sited in a similar arrangement.

The following matrix shows the order of recommended sites from most to least favorable. Substation I is ranked above substation H due to the importance of this location to future grid reliability. The existing dual fuel infrastructure and lowest age of generating equipment at Substation H makes this site a viable option to remain in-service in the current arrangement. Additionally, the site does not currently qualify for the SPP Generation Replacement Process until H5 is returned to service.

TABLE 12: SITE RANKINGS		
RANKING	**SUBSTATION SITE**	**QUALIFIES FOR SPP GENERATION FACILITY REPLACEMENT PROCESS?**
1	BLUE VALLEY POWER STATION / SUBSTATION A	NO*
2	SUBSTATION I	YES
3	SUBSTATION H	NO**
4	SUBSTATION J	YES

*FERC waiver has been requested for this facility. If approved, this will qualify this location for the SPP Generation Facility Replacement process.

**Unit H5 is not currently eligible for the SPP Generation Facility Replacement process unless it is returned to service.