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RENEWABLE ENERGY FOR FEDERAL LAND MANAGEMENT AGENCIES IN SOUTHERN NEVADA

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ABSTRACT

The National Park Service, the U.S. Fish and Wildlife Service, and the USDA Forest Service governmental agencies in southern Nevada have collaborated with the Center for Energy Research at the University of Nevada, Las Vegas to explore the feasibility of becoming energy neutral by 2010. The three federal agencies have set a goal to offset their combined annual energy demand (currently supplied by local utility companies) with an equal amount of power produced by renewable energy sources.

The study results indicate that the three federal agencies above consume just over 3,000 megawatt-hours of electrical energy per year in and around the Las Vegas Valley. Upon researching various types of renewable energy, it was determined that wind, geothermal, and biomass technologies either failed to have sufficient resources available in southern Nevada or conflicted with the resource management philosophies of the federal agencies. Solar energy is the most abundant feasible source of renewable energy within the study area, and it was determined that a 1.5 megawatt fixed photovoltaic (PV) system is best suited for this project.

INTRODUCTION

The National Park Service, the U.S. Fish and Wildlife Service, and the USDA Forest Service are guided in their efforts to reduce energy consumption and better protect the environment through the Energy Policy Act of 2005 and by Executive Order 13424, established in January 2007. Excerpts from the federal guidelines, as they pertain to the three federal agencies in this report, are presented below.

The Energy Policy Act of 2005
SEC. 203. FEDERAL PURCHASE REQUIREMENT.

(a) REQUIREMENT.—The President, acting through the Secretary, shall seek to ensure that, to the extent economically feasible and technically practicable, of the total amount of electric energy the Federal Government consumes during any fiscal year, the following amounts shall be renewable energy:

(1) Not less than 3 percent in fiscal years 2007 through 2009.

(2) Not less than 5 percent in fiscal years 2010 through 2012.

(3) Not less than 7.5 percent in fiscal year 2013 and each fiscal year thereafter.

Executive Order 13423 – Strengthening Federal Environmental, Energy, and Transportation Management

Sec. 2. *Goals for Agencies*. In implementing the policy set forth in section 1 of this order, the head of each agency shall:

(a) improve energy efficiency and reduce greenhouse gas emissions of the agency, through reduction of energy intensity by (i) 3 percent annually through the end of FY 2015, or (ii) 30 percent by the end of FY 2015, relative to the baseline of the agency's energy use in FY 2003;

(b) ensure that (i) at least half of the statutorily required renewable energy consumed by the agency in a fiscal year comes from new renewable sources, and (ii) to the extent feasible, the agency implements renewable energy generation projects on agency property for agency use;

(c) beginning in FY 2008, reduce water consumption intensity, relative to the baseline of the agency's water consumption in FY 2007, through life-cycle cost effective measures by 2 percent annually through the end of FY 2015 or 16 percent by the end of FY 2015.

> **Sec. 3.** *Duties of Heads of Agencies.* In implementing the policy set forth in section 1 of this order, the head of each agency shall:
>
> (a) implement within the agency sustainable practices for (i) energy efficiency, greenhouse emissions avoidance or reduction, and petroleum products use reduction, (ii) renewable energy, including bioenergy, (iii) water conservation . . .

The development of the renewable energy sector relies on support from the federal government. Similar to the advancement of solar technology in the 1950s and 1960s necessary to power NASA satellites, current support of renewable energy research is essential to ensure further innovation. By setting a goal to become energy neutral by 2010, the federal agencies in the Las Vegas Valley will exceed the minimum goals stated above while further spurring renewable energy development.

The National Park Service has previously demonstrated its commitment to energy conservation. The NPS currently uses bio-diesel fuel for more than 675 pieces of equipment and vehicles at 23 national parks and has over 700 photovoltaic applications installed [1].

RENEWABLE ENERGY SOURCES IN SOUTHERN NEVADA

Nevada has one of the largest capacities for renewable energy in the nation. Realizing the importance of developing the technology, Nevada legislators passed regulations requiring that renewable sources account for 15 percent of the state's electricity production by 2013. At least 5 percent of the energy must come from solar power.

After reviewing the availabilities and potential advantages of several renewable sources (hydroelectric, geothermal, biomass, wind, and solar), it was determined that solar power provides the largest resource for this particular project. With high temperatures and more than 300 sunny days per year, Las Vegas has one of the most ideal solar resources in the world.

Solar power benefits

Over the past several decades, solar power has been developed and harnessed to provide high quality energy with few or no undesirable consequences to the environment. Solar power systems make little or no noise, emit zero emissions, require very little water for cleaning purposes, and typically have long lifecycles because they contain few or no moving parts.

Generally constructed of modular, readily available materials, solar power plants are easier to site than conventional plants and can typically be built in a few years, or in as little as a few months. The short lead times of solar power plants, and the ability to incrementally expand existing facilities, allow them to more suitably handle rapid increases in energy demands. Solar power systems can be constructed near the site of the consumer, a practice of "distributed generation" that avoids unnecessary transmission line construction and distribution power losses (rural electric utilities typically lose about 12 percent of the electricity sent over distribution lines [2]).

The further development of PV technology may spur advancements in the automobile industry, as the utilization of solar energy to produce engine-powering hydrogen gas is currently under research. With many more renewable energy advancements on the horizon, thousands of technologically-advanced career opportunities are opening. In Germany for example, solar power is the second largest source of new jobs (after the automotive industry), employing about 200,000 people in the nation of 80 million [3].

Clark County, home to Las Vegas, Red Rock Canyon, Spring Mountain National Recreation Area, acres of Desert National Wildlife Range land, and the western shore of Lake Mead, has a current population of nearly 1.8 million residents. The region is one of the nation's fastest growing areas with an increase in population of 29 percent from 2000 to 2006 [4]. Additionally, nearly 40 million people visit Las Vegas each year. The population growth necessitates an easily expandable energy system, and solar power fulfills this need.

Types of solar power

With several types of viable solar power technologies available, the advantages and disadvantages of each were weighed and evaluated.

Concentrating solar thermal power, including dishes, power towers, and parabolic troughs, have demonstrated the ability to produce clean, reliable electrical energy at a relatively low cost, but these systems are typically used for large-scale power generation, such as the new 64 megawatt system in Boulder City, Nevada. Concentrating solar thermal systems show even more promise for the future – the U.S. Department of Energy has a goal to install an additional 1,000 megawatts capacity of concentrating solar power systems by the year 2010 [5]. With further technological advancements in conjunction with increased manufacturing, electricity produced by concentrating solar power could decline from $0.12 to $0.14 per kilowatt-hour today to $0.04 to $0.06 within the next decade [6]. Unfortunately, the physical nature of concentrating solar thermal systems may cause visual quality concerns within federal conservation lands.

Like concentrating solar thermal power, solar electric power comes in a wide variance of type and application. For this project, thin films and concentrating photovoltaic systems were considered, but neither technology satisfied the federal agencies' needs. Thin films, which are lighter and less expensive to manufacture than traditional crystalline solar panels, have a much lower efficiency than traditional silicon cells and thus are typically not used in systems of this size. Concentrating solar photovoltaic systems require mechanisms to perfectly track the sun (dual-axis trackers) creating a large path of rotation, and thus may also cause visual obstructions in federally preserved areas.

Photovoltaic panels comprised of crystalline solar cells, on the other hand, can provide highly dependable renewable

energy to the federal agencies while having little effect on the protected lands.

Installing photovoltaic panels in a fixed configuration is the simplest method to design and maintain because no moving parts are involved. Fixed panels can be mounted horizontally flat (zero-degree) or at an angle facing the southern horizon to better capture direct sunlight. Fixed panels are the most efficient when mounted at an angle equal to that of the location's latitude, but panels at a slight angle of 10 to 15 degrees have significantly higher efficiencies than fixed zero-degree panels. Panels mounted at an angle tend to collect less dust particles than zero-degree panels, maintaining cleaner, more efficient panel surfaces that rainwater will easily run off. As a drawback, panels mounted at angles will shade adjacent panels unless proper spacing is allotted (shading effects drastically reduce panel efficiency). This spacing increases the overall footprint of the solar array.

In an effort to better capture direct sunlight, many photovoltaic systems are powered by tracking systems. Since PV panels are most efficient with direct sunlight, PV panels that perfectly track the sun are the most efficient. However, the added cost and complexity of dual-axis trackers are often not worth the slightly higher efficiency benefit, and many mid- and large-scale systems opt to utilize single-axis trackers.

Photovoltaic panels are typically comprised of monocrystalline or polycrystalline silicon. Though monocrystalline silicon cells are more efficient, they are also more expensive and not as readily available as the more commonly used polycrystalline silicon cells.

Matters specific to the federal agencies

Though solar power plants require a sizeable amount of land area, it is common to install solar power instrumentation atop or adjacent to existing structures or previously disturbed land. To avoid creating visual quality concerns, many types of solar power can be shaped to blend in with the landscape.

During the examination of different locations capable of housing a renewable energy system in the Las Vegas Valley, sites with preexisting structures held precedence due to their developed infrastructure. Were a renewable power facility to be built on previously undisturbed land, a road to the site would be required and transmission lines, either above ground or trenched through the land, would have to be run to the nearest grid connection point. The shear cost of new roads and transmission lines could be prohibitive, and their construction conflicts with maintaining forests, refuges, and federal park lands in their original state.

ENERGY DEMAND AND BILLING STRUCTURE

The National Park Service, the U.S. Fish and Wildlife Service, and the USDA Forest Service have facilities distributed across much of southern Nevada. The facilities receive most of their energy from Nevada Power, the state's largest investor-owned utility company. Also serving these facilities is a mix of municipal and locally managed utilities.

The Center for Energy Research at the University of Nevada, Las Vegas, collected monthly utility bills for each of the three federal agencies' locations during the 2005 billing period. The locations under study within the Lake Mead Recreation Area include only those in the state of Nevada (the eastern side of the Lake Mead Recreation Area in Arizona is not included in this project). As shown in Table I, the National Park Service is the major power purchaser, consuming 90 percent of the three agencies' entire yearly energy use. In 2005, there were a total of 157 electric energy meters that registered 3,156 megawatt-hours. The total cost of the energy was $290,800.

Managing the actual energy among the three federal agencies proved to be challenging, as each of the 157 electric energy meters is treated as an individual customer (different agencies pay their electric bills accordingly). The existing utility regulatory environment in Nevada would not support consolidating all three agency utility bills, nor would it permit offsetting energy use at the 157 different locations by one renewable energy facility through net-metering.

In order to offset the electricity used by the three federal agencies, the following options were considered:

1. *Connect a renewable energy system to each of the existing 157 electric meters:* This method was initially requested by Nevada Power. The system would operate under net-metering guidelines, whereby any excess electricity produced on a monthly or yearly basis would be purchased by Nevada Power. However, the time needed to accomplish this task was projected to take more than 50 years. Installing and maintaining the 157 individual renewable energy systems would create an overwhelming workload for the agencies, which are already challenged to maintain the existing facility base.
2. *Connect renewable energy systems to the largest energy consumption meters only:* This option, also acceptable to Nevada Power, was rejected on the basis that the renewable energy systems would only benefit one agency and thus would not meet the goal of energy neutrality for all three agencies. However, this may be a viable option for agencies to pursue individually before the construction of new facilities or renovation projects.
3. *Install a single renewable energy system to feed the utility grid; use net-metering benefits for each agency:* This option, while logistically practical, is not permitted under current utility regulations. Nevada state laws allow public utilities to impose fees on net-metered systems greater than one hundred kilowatts. Total system size allowed for net-metering purposes is limited to less than one megawatt. These limitations would therefore not allow the agencies to meet their energy neutrality goal.
4. *Investigate a Power Purchase Agreement by utilizing a renewable energy facility sited on federal lands:* This method will allow a single renewable energy system to

generate as much electricity as the three federal agencies consume annually. Under such an arrangement, the federal agencies are permitted to sell electricity generated by an agency-owned renewable energy system to a third party, while retaining the credit for the renewable energy production. The renewable energy produced by the proposed system will offset the utility-provided energy that the agencies will continue to consume. This option can be operational in a relatively short time frame (less than three years) and will create minimal additional workload for the agencies. This option was selected as the best available method.

TABLE I: YEARLY ENERGY CONSUMPTION AND ASSOCIATED COST

Agency Name	Power Provider	Number of Meters	Yearly Energy Use (2005)	Yearly Energy Cost (2005)
National Park Service	Overton Power District	26	505 MWh	$46,700
	Nevada Power Co.	82	1,783 MWh	$177,800
	Boulder City	7	550 MWh	$34,000
Fish and Wildlife	Valley Electric	4	55 MWh	$7,000
	Overton Power District	5	29 MWh	$3,300
	Alamo Power	9	100 MWh	$7,100
	Nevada Power Co.	9	45 MWh	$5,400
USDA Forest Service	Nevada Power Co.	15	89 MWh	$9,500
Total		**157**	**3,156 MWh**	**$290,800**

POTENTIAL LOCATIONS

Determining the location of the proposed renewable energy system was governed by the budgetary authority under the Southern Nevada Public Lands Management Act, which directs the expenditure of funds to projects on lands owned or managed by one of the federal partner agencies. According to the previously cited Executive Order 13423, renewable energy projects used by federal agencies are to be built on federal lands.

When the Bureau of Land Management, originally a fourth partner in the collaborative study, declined to participate in this project, lands within the Lake Mead National Recreation Area became a logical choice for the system site. The Lake Mead Recreation Area offers several sites with access to existing power transmission lines. Lands maintained by the U.S. Bureau of Reclamation were also considered.

Locations considered for a renewable energy site had to satisfy several prerequisites set by the federal land management agencies:

1. The site needed to be on or adjacent to previously disturbed land, so as to not disturb land still in its natural state.
2. The site needed to be accessible by road, so a new road would not need to be built for the facility's construction.
3. The site needed direct access to the electrical grid, so new transmission lines would not need to be installed.
4. In order to have maximum exposure to the sun's rays, the site could not be shaded by surrounding structures or terrain.

Further criteria required that the installation should be invisible to the visitors of the area such that it does not obscure or obstruct the natural beauty of the area. Security concerns such as preventing vandalism were priorities in the planning process. The sites considered for the renewable energy system are shown in Fig. 1.

FIG. 1: LAYOUT OF POTENTIAL SITES.

The most suitable site – SNWA pumping station

Among the numerous sites examined for installation of the proposed solar power plant, the best location for this solar power plant was determined to be at the Southern Nevada Water Authority (SNWA) pumping station situated at the western shore of Lake Mead on State Route 166 (exact location of the pumping station: 36°04.199'N, 114°48.789'W; elevation: 1242 ft.). The pumping station sits far enough away

from surrounding mountains such that shading effects are negligible. The site is located about 1,200 yards from Lake Mead's western shore, thirty miles from downtown Las Vegas. The site is secure and well protected.

The SNWA pumping station offers acres of area suitable for solar power. All potential locations at the pumping station are above existing structures, meaning a solar energy system's effects on the land, as well as any visual concerns, would be minimal.

The pumping station offers five specific sites suitable for the installation, as shown in Figure 2. Four sites are located above sets of flocculation basins and filtration tanks and have a total area of 155,000 square feet. The fifth site is located above an underground clear-well storage tank, which offers a total area of 210,000 square feet. Because there may be shading concerns at the fifth location, the areas above the flocculation basins and filtration tanks show the most potential at the pumping station.

FIG. 2: LOCATIONS OF POTENTIAL PHOTOVOLTAIC SITES AT THE SNWA PUMPING STATION

SNWA has expressed interest in pursuing a Power Purchase Agreement with the federal agencies, whereby the renewable energy would directly feed the pumping station and SNWA would later reimburse the federal agencies for the consumed energy. The federal agencies would retain the credit for the renewable energy production.

The preferred method for installing the solar power system is to mount PV panels on canopies over several flocculation and filtration basins within the pumping station facility. This site has ample space for future expansion of a solar power plant.

The proposed photovoltaic system is not as cost effective as the existing method of purchasing electricity generated by fossil fuels, but the federal commitment to reducing the impact of global climate change on America's public lands outweighs decisions based solely on financial rates of return. The project will demonstrate that the monthly reduction in energy costs and ensuing benefits to the environment and society can counterbalance initial construction expenses. Installing a single PV system allows for the outsourcing of its operation, provides a much shorter construction to operation timeframe compared to the installation of several smaller systems, and will have minimal impact on protected lands. A single site PV arrangement will not be restricted under current state utility regulations.

The overall solution not only satisfies the energy neutral requirement, but also provides a new business plan model for the federal government, as well as other entities with non-centralized facilities, to achieve the benefits of renewable energy.

PLANT TYPE, SIZE, AND COST

With the exception of fixed photovoltaic panels, all solar power arrays require a motor-driven tracking system in order to follow the sun. Due to the additional weight and complexity of tracking systems, they are typically only suitable for ground installations (i.e., not on top of structures). Therefore, the preferred area above the SNWA pumping station's flocculation basins and filtration tanks should be fitted with fixed photovoltaic panels. Manually altering the panel tilt angle to coincide with the seasons was not considered due to the large scale of the project and the desire to keep labor costs at a minimum.

In discussions with representatives from the Southern Nevada Water Authority, the preferred method of providing renewable energy to the pumping station is to construct carport-style canopies above the flocculation basins and filtration tanks; PV panels would then be mounted on top of the structures. The structures would not only provide a flat mounting surface for the PV panels, but would also provide shading benefits for the underlying water tanks. The shade would inhibit algae growth within the tanks, thereby reducing the amount of chlorine needed to sanitize the water. As a result, fewer chemicals would need to be removed from the water in order to produce clean drinking water. As a secondary benefit, the shade would reduce the amount of water that evaporates from the tanks.

The figures in this study were calculated assuming the panels are to be installed horizontally flat (at a zero-degree angle), which will provide the most amount of shade and make the installation process as simple as possible. This arrangement, while taking advantage of the most amount of area above the flocculation basins and filtration tanks, will reduce the amount of direct sunlight received by the panels.

The specific arrangement of the photovoltaic panels will be researched further during the design phase of this project.

Sizing the system

According to Table I, the annual energy demand of the three federal agencies is 3,156 megawatt-hours. In order to produce this amount of electricity with fixed zero-degree photovoltaic panels, a size analysis was undertaken.

The industry average efficiency for photovoltaic modules is 10 to 12 percent, though there are more efficient modules available. Mid- and large-scale production modules typically consist of 36 individual PV cells wired in parallel, and the modules are connected to form panels. Because PV panels produce direct current (DC) electricity, inverters are necessary to convert the electricity into industry-compatible alternating current (AC) electricity. Inverters typically have efficiencies from 90 to 95 percent. Including the transformers needed to handle the large electric load and losses from additional electronic equipment, the overall efficiency of mid- and large-scale systems is typically 20 to 25 percent below the module efficiency. Therefore if higher-quality PV panels are used (at an efficiency of 13.5 percent) and a 22.5 percent drop from module to system efficiency is assumed, then the overall efficiency of the PV system will be approximately 10.5 percent.

Average monthly and yearly solar radiation for the Las Vegas Valley was obtained from the *Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors* produced by the National Renewable Energy Laboratory [7]. For a fixed zero-degree PV system, the annual average solar radiation received is 5.7 kilowatt-hours per square meter per day. This means that a 1 kilowatt peak capacity rated panel will produce 5.7 kilowatt-hours per day in the Las Vegas Valley (photovoltaic systems are rated in peak power output). Calculating the system rating size and required area yields:

System rating:

$$3156\frac{MWh}{year}\times\frac{1kW}{5.7kWh/day}\times\frac{1year}{365days}\times\frac{1MW}{1000kW}\times\frac{1000kWh}{1MWh}=1.52MW$$

Required area:

$$3156\frac{MWh}{year}\times\frac{m^2\cdot day}{5.7kWh}\times\frac{1year}{365days}\times\frac{1000kWh}{1MWh}\times\frac{1}{0.105}=14{,}447\,m^2(155{,}506\,ft^2)$$

According to representatives with the National Renewable Energy Laboratory, the estimated cost of installing fixed PV arrays on the ground or on top of existing structures is approximately $7 per rated watt, though this cost could decrease substantially within the next few years. At this price, installing a system with a peak power generating capacity of approximately 1.5 megawatts will cost an estimated $10.5 million. Installation of the carport-style mounting structures above the pumping station's flocculation basins and filtration tanks could increase the cost by an additional $2 to $4 per rated watt.

Installation at the SNWA pumping station

Referring back to Figure 2, Location 1 houses a set of two flocculation basins that measure approximately 350 feet by 100 feet (a total footprint area of 70,000 square feet). This area has a total peak capacity potential of approximately 700 kilowatts. The light poles that presently service the flocculation basins (see Fig. 3) would need to be removed because the shading effects of the poles would drastically reduce the panels' efficiency and the lights would no longer illuminate the basins. New lights would need to be installed to the underside of the newly constructed carport-style canopies. To accommodate maintenance work on the basins, the PV system would need to be modular such that it could be temporarily removed. Because the basins are nearly identical, design costs should be minimal.

FIG. 3: FLOCCULATION BASIN AT THE PUMPING STATION.

Locations 2 and 3 have two filtration tanks each, all four tanks measuring approximately 200 feet by 75 feet (a total area of 60,000 square feet). These locations have a total peak capacity potential of approximately 600 kilowatts. An array above the filtration tanks could be installed in a similar fashion as those above the flocculation basins.

At Location 4 is a set of two filtration tanks measuring 125 feet by 100 feet each (a total footprint area of 25,000 square feet). Installation would be similar to that of the other sites. The two filtration tanks have a total peak capacity potential of approximately 250 kilowatts.

These four sites at the SNWA pumping station offer a total area of 155,000 square feet for a total peak capacity potential of approximately 1.55 megawatts. This matches well with required energy demand of the federal agencies (about 1.52 MW).

FIG. 4: FILTRATION TANKS AT THE PUMPING STATION.

Location 5, an alternative site situated above an underground clear-well storage tank, has 210,000 square feet of available area, with a total peak capacity potential of approximately 2 megawatts. However, power generation may be limited because this location is approximately twelve feet below surrounding structures and is shaded to the east and the west.

Emissions reduction

Emissions reduced by the proposed system are based upon the reduction in utility-provided energy currently consumed by the SNWA pumping station. The pumping station presently receives its power from the Colorado River Commission. The actual emissions discharged during the production of the electricity that is consumed by the SNWA pumping station are unavailable. However, if the proposed solar power system were to replace electricity produced by a public utility, for example Nevada Power, emissions figures are available from the Environmental Protection Agency [8].

A renewable energy system, producing approximately 3,156 megawatt-hours of electricity each year that would replace an equivalent amount of electricity produced by Nevada Power, would therefore prevent the following emissions from entering the air annually:

- Nitrogen oxides: 8,881 pounds
- Sulfur dioxide: 1,458 pounds
- Carbon dioxide: 2,931 tons
- Mercury: 41 pounds

Size and cost variance

Many variables come into play when estimating a suitable photovoltaic system of this size. Several conditions could marginally or significantly alter the system's energy output and cost.

As previously stated, the efficiency of the entire photovoltaic system will depend upon several factors. The individual module efficiencies may vary by as much as 3 to 4 percentage points. This may seem trivial, but by incorporating thousands of PV modules into a large-scale array, the overall energy output will vary considerably depending upon the quality of the PV modules and the quality of the installation. The efficiencies of the inverters, transformers, and other electrical components will further affect the overall system performance. Dust and sand that may collect on top of the panels will slightly decrease their efficiency.

Alternative approaches

If the area above the flocculation basins and filtration tanks at the SNWA pumping station is deemed unsuitable to generate the required electricity needed, many alternatives do exist.

One alternative approach to reach energy neutrality would be to simply expand the system, installing additional panels above the underground clear-well storage tank. As previously mentioned, there are potential shading issues from surrounding structures at this area. However, with approximately 210,000 square feet of available area, this location should provide plenty of space for expansion.

If the area above the underground clear-well storage tank is deemed suitable to support the entire renewable energy system, fixed tilted or tracking photovoltaic panels could be installed, decreasing the total number of panels needed. Panels tilted at an angle equal to the location's latitude receive the most sunlight (in the case of the Las Vegas Valley, about 36 degrees from horizontal). However, a high tilt angle causes shading concerns with adjacent panels, and more area is needed for proper spacing. Panels angled at 15 degrees less than latitude, in this case 21 degrees, receive nearly the same sunlight as panels installed at latitude. Therefore, a compromise between panel tilt angle and spacing can be made by installing the panels at about 20 degrees. Many mid- to large-scale PV systems are installed in this fashion.

Installing PV panels, either fixed or single-axis tracking, above the underground clear-well storage tank will have a minimal effect on the environment. The land, which is unsuitable for most other structures, would not be disturbed by a photovoltaic array. The individual panels can be mounted on concrete footers placed directly atop the soil (no digging for a foundation is necessary). Installing the entire system at this site will not provide the shading benefits that accompany the potential system situated above the flocculation basins and filtration tanks, but the construction of the carport-style canopies would not be necessary. This measure would save an estimated $3 million to $6 million in initial construction costs.

System life expectancy and maintenance costs

Because fixed panels require no moving parts and tracking systems rotate extremely slowly, photovoltaic systems are durable, reliable, and easy to maintain. PV panels come standard with 25 year warranties and typically last for 30 years or longer. Inverters should be required to have 10 year warranties and typically fail after 10 to 15 years. On

average, PV panels lose less than one percent of their efficiency per year. (Assuming an initial 13.5 percent panel efficiency, the panels would maintain efficiencies greater than 13.365 percent during their second year of operation).

System maintenance is minimal. Periodic washing will keep panel efficiency near peak performance. If a water supply is nearby, hosing off the panels once every few months is recommended. Vendors will provide service contracts if so desired, and can be looked into further during the preliminary design.

FINANCIAL CONSIDERATIONS

In order to best serve its citizens, the federal agencies are responsible for maintaining its facilities in an environmentally-friendly and economical manner. Referencing the Instructions for Implementing Executive Order 13423 (in the document *Strengthening Federal Environmental, Energy, and Transportation Management*), the objectives and duties of the federal agencies are detailed in the excerpts below.

> Executive Order 13423, Section 1: It is the policy of the United States that Federal agencies conduct their environmental, transportation, and energy-related activities under the law in support of their respective missions in an environmentally, economically and fiscally sound, integrated, continuously improving, efficient, and sustainable manner.
>
> In implementing the policy, goals, and objectives of E.O 13423, agencies shall apply the following overarching directives:
>
> (3) Life-cycle costs. Each agency shall consider life-cycle costs and savings in planning and making determinations about investments in all capital assets, services, and procurements, which will lower the government's costs, achieve sustainable design principles, reduce energy and water consumption, and reduce the environmental impact/footprint of the government's operations as it implements its primary mission and improves the quality of service and effectiveness of government. In some cases, evaluation of life-cycle costs may result in a higher up-front cost with significantly lower maintenance costs, or longer life.

Renewable energy credits and the federal agencies

The federal agencies will own the renewable energy credits (RECs) generated by the proposed photovoltaic system; the RECs will not be sold to public utility companies, private corporations, or individual citizens. Although RECs sell for more than fossil fuel-produced energy on the open market (allowing the producers of RECs to profit from their sale), the federal agencies will retain the rights to the RECs, thus maintaining their obligation to operate in an energy neutral capacity. Were the RECs sold to a public utility for instance, the public utility would simply pass the premium rate on to consumers, thereby conflicting with the federal agencies' stewardship role.

Estimated initial investment and future revenue stream

Though a 30 percent tax credit is available to private firms installing renewable energy systems of this size, there are no financial incentives available to the three federal agencies. The initial cost of the system will be covered by funding specifically intended for this type of project and requires no payback. Therefore each agency will realize an immediate budget relief that can be used to provide more services to the public or better carry out stewardship responsibilities. Under a Power Purchase Agreement with the Southern Nevada Water Authority, the value of the energy produced by the photovoltaic system is estimated at $60 per megawatt-hour. With an annual energy output of 3,156 megawatt-hours, the total revenue from the system is estimated to be $189,360 per year. This represents 65 percent of the total yearly energy bill for the three federal agencies. Table II details the revenue stream for each federal agency and associated power provider under the scenario above (using 2005 data).

It is important to note that the information provided in Table II can vary widely depending on the actual energy output of the system, the increase or decrease in energy demand of the federal agencies, the details of the Power Purchase Agreement between the federal agencies and the Southern Nevada Water Authority, and any future rate changes by the public utility providers.

TABLE II: FUTURE REVENUE STREAM.

Agency Name	Power Provider	Proportional Cost	Proportional Revenue	Yearly Energy Cost (2005)
National Park Service	Overton Power District	16.1%	$30,550	$46,700
	Nevada Power Co.	61.1%	$115,750	$177,800
	Boulder City	11.7%	$22,200	$34,000
Fish and Wildlife	Valley Electric	2.4%	$4,600	$7,000
	Overton Power District	1.1%	$2,210	$3,300
	Alamo Power	2.4%	$3,950	$7,100
	Nevada Power Co.	1.9%	$3,650	$5,400
USDA Forest Service	Nevada Power Co.	3.3%	$6,350	$9,500
Total		**100%**	**$189,360**	**$290,800**

CONCLUSION

To date, the efforts of the National Park Service, the U.S. Fish and Wildlife Service, and the USDA Forest Service, in collaboration with the Center for Energy Research at the University of Nevada, Las Vegas, have determined the following:

1. There exists sufficient renewable energy in southern Nevada to supply the power necessary to operate the various facilities in southern Nevada maintained by the three federal agencies.
2. Solar power is the preferred source of renewable energy in southern Nevada. Photovoltaic technology is the preferred method to capture that energy.
3. Installing individual renewable energy systems on a one system per one electric meter basis (or installing systems only at major energy consumption facilities) cannot achieve the energy neutral goal for each agency nor accomplish the goal within a short time frame.
4. Net metering a single large renewable energy system to offset the combined load of the three agencies is not permitted under the current regulation of utilities in the state.
5. The federal agencies do not believe selling renewable energy credits to public utility companies, private entities, or individual citizens is a means for lowering expenses.
6. There are no financial incentives or rebates available to the federal agencies to offset the initial cost of the renewable energy system.
7. Pursuing a Power Purchase Agreement, using a government-owned renewable energy system, and selling the power to a third party is an acceptable method to achieve energy neutrality.

In the future, the three federal agencies will be required to:

1. Secure funding and authority to proceed.
2. Negotiate a Power Purchase Agreement with Southern Nevada Water Authority.
3. Negotiate an agreement between the National Park Service and Southern Nevada Water Authority to allow construction and operation of a renewable energy system within the Lake Mead National Recreation Area.
4. Award contracts for design and construction of the renewable energy system.
5. Watch for changes in the regulatory environment that may impact this effort.
6. Establish internal financial mechanisms to accept payments and make utility bills with appropriate fiscal controls, oversight, and audits.
7. Either expand the proposed renewable energy system or construct net-metered systems for all new facility development by any of the three agencies in order to maintain the energy neutral position.

Future expansion

In the future, any new or renovated facilities in southern Nevada operated by federal land management agencies should incorporate sustainable building materials (such as wood approved by the Forest Stewardship Council) and sufficient renewable energy design features so as to support the energy neutrality goal. Supplementary possibilities for maintaining energy neutrality in the years to come include expanding the proposed solar power system at the SNWA pumping station atop the clear well storage tanks, partnering with the Lake Mead Concession operations on covered slips and marinas, and the installing individual renewable energy systems at future facilities.

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