RENEWABLE ENERGY EVALUATION

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1.0 Executive Summary

Earlier this year, the Town of Oro Valley (TOV) selected APS Energy Services as an energy partner to promote fiscal responsibility, environmental stewardship and TOV employee well-being. Included in this effort was an evaluation of the facilities to determine the best potential locations for the installation of Solar Photovoltaic Power Generation and determination of the best, fiscally responsible project.

The Town of Oro Valley has submitted for and has been approved for a Clean Renewable Energy Bond to provide low-cost funding for the project

1.1. Key Milestones

The preliminary findings from the audit process indicate there is significant energy, water and operational efficiency cost reduction opportunities, and subsequent pages will outline the findings to-date. To ensure success, the following Table lists key milestones for the Renewable Energy evaluation process.

Table 1-0. Renewable Energy Key Milestones

Key Milestones	Date
Audit Contract Approved	08.19.09
30% Review Report Submitted	09.08.09
60% Review Report Submitted	10.01.09
90% Review Report Submitted	10.21.09
Final Report Submitted	11.04.09
Town Council Meeting	11.18.09
Finalize Contract Negotiations	TBD
Finalize Financing	TBD

2.0 Renewable Energy Evaluation Overview

The Town of Oro Valley has identified opportunities for Solar Photovoltaic Energy Production at the Town Hall Complex. The APS Energy Services team worked with TOV to reconcile any long term plans for use of the facilities with the proposed project, other planned projects, compliance with local, State and Federal requirements, as well as, minimizing disruption to occupants during system installation.

The evaluation was designed to accomplish the following:

- Evaluate various locations at the Town Hall Complex to determine the best and most cost-effective locations for system implementation.
- Provide recommendations to maximize electrical production.
- Make improvements to the environment that positively highlight the Town's efforts to reduce its carbon footprint and provide positive examples of sustainable facilities for visitors and residents.
- Maximize use of alternative funding sources to help pay for the project.

The results of the evaluation and the resulting recommended program, indicate that TOV will realize a total cost avoidance of **$650,389** over a 20 year period. The cost of the project is **$2,394,288** and will be funded through a Clean Renewable Energy Bond with an anticipated effective interest rate of 1% APR. The project is structured to be 100% self-funding from reductions in the existing utility budget. These reductions are used to cover the cost of the project plus finance costs over a 15 year financing term.

Please see Table 2-0 below for the costs and savings for the Solar PV project. A detailed Energy Conservation Measures Matrix can be found in Section 3.0 Technical Summary.

Table 2-0. Proposed Energy Conservation Measures Costs and Cost Avoidances

Energy Conservation Measure	Annual Electrical Consumption Savings (kWh)	Annual Electricity Savings $	Rebates $	Total Annual Savings $	Total Project Cost $
Solar Photovoltiac at Town Hall Complex Parking	553,392	$ 70,805	$ 85,776	$ 70,805	$ 2,394,288
TOTALS:	553,392	$ 70,805	$85,776	$ 70,805	$ 2,394,288

TOV will realize a carbon footprint reduction by implementing projects that reduce fossil fuel consumption. Electrical generation uses fossil fuel and fossil fuels are also used directly for heating processes. Less energy consumed translates into less power plant production and pollution into the air. The energy cost avoidances for electricity, natural gas and water for the proposed project have been calculated and their environmental benefit recorded in Section 6.0 Environmental Benefits.

- Electricity Reduction: **553,392** kWh/yr (6% Reduction)

These annual cost avoidances, once achieved, will produce the following environmental benefits summarized in Table 4-0 Environmental Benefits:

Table 2-1. Environmental Impact

Type of Pollution	Pollutants Reduced	
Carbon Dioxide (CO_2) Eliminated:	**916,971**	Pounds (lbs)
Sulfur Dioxide (SO_2) Eliminated:	**529**	Pounds (lbs)
Nitric Oxide (NO_x) Eliminated:	**843**	Pounds (lbs)

2.1. Financial Highlights

2.1.1. Financial Summary

APS Energy Services has identified a 362.88 kW Solar Photovoltaic Project that will provide covered parking for approximately 165 vehicle spaces Based upon the current utility rates, the identified project will produce a total first year cost avoidance of $70,805. This annual revenue stream creates the funding source that pays for the recommended project for TOV. Highlights of the project are summarized below:

• First Year Project Savings	**$**	**70,805**
• 15 Year Project Savings (with escalations and rebates)	**$**	**2,362,472**
• Project Principal Amount	**$**	**2,394,288**
• Annual Lease Payment	**$**	**171,956**
• 15 Year Net Project Savings*	**$**	**- 3,948**
• Estimated Rebates (20 Year term)	**$**	**1,634,028**
• Financing Term Length		**15 Years**
• Estimated Annual Financing Rate		**1.00%**

** Net project savings is based on projected utility rate increases of 3.1% annually.*

2.1.2. Construction Cost

The construction cost to implement the recommended project is $2,394,288.

The Program also provides:

- Assistance in obtaining all available utility incentives.
- All work to be performed at a not-to-exceed price.

2.1.3. Implementation Overview

APS Energy Services will coordinate all activities of the multiple professionals and trades in a consistent manner of that TOV has come to expect. Over the last 11 years, APS Energy Services has successfully completed each of our projects while experiencing no contractor-generated change orders. Additionally, and most importantly, APS Energy Services has performed work at similar facilities to that of TOV under tight timeframes and high pressure situations with zero recorded safety incidents.

3.0 Technical Report

APS Energy Services is submitting the following Renewable Energy Project to TOV. This report is to identify the most advantageous renewable project to maximize energy production and reduce the Town's carbon footprint.

The results of the Audit reveal total electric savings opportunity of **$70,805** per year.

The recommended Renewable Energy Project can be found in the following Table 3-0.

Table 3-0. Energy Conservation Measures

Facility	Solar Photovoltaic System
Town of Oro Valley Library Parking Area	X
Administration Building Parking Area	X
Oro Valley Water Utility Building Parking Area	X
Magistrate Court Building Parking Area	X
Development Services Building Parking Area	X
Oro Valley Police Dept. Main Station Parking Area	X

3.1. Town Hall Complex Parking Area

Facility Overview

The Town of Oro Valley Town Hall Complex Parking Area consists of a relatively flat paved area bordered by the Library, Police HQ, Development Services, Courts, Water and Administration Building. The overall area has approximately 325 parking spaces with more parking planned to be added over the next 5 years.

Proposed Project

Photovoltaic Parking Structure Installation

The Proposed system includes the installation of steel structures with solar photovoltaic panels installed on top of the structures to provide shaded parking areas. All Structures will be designed to meet all applicable codes and standards and will be painted to meet TOV requirements.

The Proposed System Layout is shown on the following page and consists of 10 separate canopies spread throughout the parking area to provide a variety of covered parking available for each facility. The total rated system output is 362.88 kW-STC and provides shade coverage of approximately 165 parking spaces (approximately 50% of total parking area)

Approximately 1344 solar panels of 270 watts each will provide DC electrical energy to three Satcon Inverters ranging from 70 to 100 kW each and will be interfaced to the campus electrical system.

The necessary interconnection agreement with Tucson Electric Power will be arranged by APS Energy Services on behalf of the Town and any required electrical switchgear will be provided under this project.

A weather and solar production monitoring system is included in this project and will provide data to the Energy Management System at the Main Town Hall Complex including Temperature, Wind, Solar Radiance and Kilowatt-Hour production.

362.88 kW-STC System
Approximately 1,344
270w Suntech Panels
3 x Powergate Inverters
Covers Approximately
165 Parking Spaces

4.0 Environmental Benefits

The Town of Oro Valley will realize a carbon footprint reduction by implementing projects that reduce fossil fuel consumption. Electrical generation uses fossil fuel and fossil fuels are also used directly for heating processes. Below is an example of what will be used to document the environmental benefits associated with each building's recommended improvements.

Table 4-0. Environmental Benefits

By reducing your energy use it indirectly lowers energy production at the source. A great deal of the energy, which is consumed your facility(s), is produced by power plants burning fossil fuels. The burning of these fuels contributes to environmental contamination.

According to the United States Environmental Protection Agency, and other groups it can be calculated just how much of the pollutants can be reduced or eliminated based on the amount of energy that is saved. This information differs by area based on sev

Annual kWh saved through project implementation: **553,392**

Type Of Pollution	Health Effect	Environmental Effect	Reduction / kWh	Reduction / Therm	Pollutants Reduced
Greenhouse Gasses (CO_2)	Can cause respiratory and other health problems, particularly in children and the elderly.	Climate change on a global scale has been attributed to increased emissions of carbon dioxide (CO_2)	1.657 pounds / kWh	12.5 pounds / therm	916,971 lbs (CO_2) reduced
Volatile Organic Compounds (VOC)	Ozone (smog) effects, cancer and other serious health problems	Ozone (smog) effects plants life included vegetation damage.	0.000061 pounds / kWh	.0005 pounds / therm	34 lbs (VOC) reduced
Nitrogen Oxides (Nox)	Lung damage, respiratory illness, ozone (smog) effects.	Acid rain also causes buildings, statues and monuments to deteriorate.	0.001523 pounds / kWh	.014 pounds / therm	843 lbs (NOx) reduced
Carbon Monoxide (CO)	Reduces ability of blood to bring oxygen to body cells and tissues.	One of the six "criteria pollutants" the US EPA tracks related to power production reduces environmental quality	0.00041 pounds / kWh	.0019 pounds / therm	227 lbs (CO) reduced
Sulfur Dioxide (SO_2)	Respiratory illness, breathing problems, may cause permanent damage to lungs.	Precursor of acid rain, which can damage trees, lakes, and soil; aerosols can reduce visibility.	0.000956 pounds / kWh	.0001 pounds / therm	529 lbs (SO_2) reduced
Particulates (PM10)	Eye, nose, and throat irritation; lung damage; bronchitis, cancer, early death	Source of haze which reduced visibility. Ashes, smoke, soot and dust can dirty and discolor structures	0.00002 pounds / kWh	.0004 pounds / therm	11 lbs (PM10) reduced
Mercury (Hg)	Liver, kidney, and brain damage; neurological and development damage	Accumulates in the food chain.	0.003404 milligrams / kWh	0 or negligible pounds / therm	1,884 Mg of (Hg) reduced

Saving 10,000 kWh is equivalent to the CO_2 emissions avoided by taking 1.3 cars off the road for a year, not burning 808 gallons of gas, emissions from .94 of a typical home, sequestered from planting 182 tree seedlings and letting them grow 10 years, or	Removing	77	cars from the road / year
	Or Not Burning	44,714	Gallons of gas / year
	Or saving enough energy to power	55	typical american homes for a year
	Or the annual environmental benefit of this project is equivalent to planting and growing for 10 years	11,068	trees / year
	Or Avoiding the greenhouse gas emmissions by not landfilling	138	tons of waste / year

Sources: www.cleanerandgreener.org
http://www.epa.gov/cleanenergy/energy-resources/calculator.html

Table 4-1. Environmental Impact		
Type of Pollution	Pollutants Reduced	
Carbon Dioxide (CO_2) Eliminated:	**916,971**	Pounds (lbs)
Sulfur Dioxide (SO_2) Eliminated:	**529**	Pounds (lbs)
Nitric Oxide (NO_x) Eliminated:	**843**	Pounds (lbs)

Table 4-2. Reduction Equivalents	
Reduction is Equivalent to the...	
	annual greenhouse gas emissions from **77** passenger cars, *or*
	CO_2 emissions from **44,714** gallons of gasoline consumed, *or*
	CO_2 emissions from the electricity use of **55** homes for one year, *or*
	planting and growing for 10 years **11,068** trees/year, *or*
	greenhouse gas emissions avoided by recycling **138** tons of waste instead of sending it to the landfill.

5.0 Measurement and Verification

5.1. Introduction

This document contains the energy savings Measurement and Verification (M&V) plan for the Solar Photovoltaic System for the Town of Oro Valley (TOV) Town Hall Complex Parking Area.

APS Energy Services is responsible for the evaluation, pre-retrofit measurement, energy calculations, installing equipment and required post retrofit verification as outlined herein. TOV operates and maintains all equipment installed. **Proper operation and maintenance of equipment and systems is critical to long term achievement of energy production.**

APS Energy Services warrants that for the first year following the date of Substantial Completion (the "Guarantee Period"), TOV, following the schedules and maintaining the comfort levels as set out in this report, dated November 4, 2009, shall realize $70,805 in utility cost savings ("Annual Energy Cost Avoidances"), as shown in Table 2-0.

APS Energy Services agrees to complete or cause its Qualified Provider to complete the M&V Reports and deliver them to TOV within forty-five (45) days of Substantial Completion and prior to the completion of the Warranty Period.

In the event that the M&V Report does not verify the Expected Project Savings in accordance with the M&V Plan, then APS Energy Services, or its subcontractor, shall repair, replace, or substitute a correction for the system that is not performing at the required level, as identified in the M&V Report. APS Energy Services or its subcontractor shall re-perform the relevant M&V work for the affected system(s) and amend or supplement the M&V Report.

If the M&V Report demonstrates that the Work will achieve one hundred percent (100%) of the Expected Project Savings, then APS Energy Services shall have satisfied the energy performance guarantee obligations for the entire guarantee period and TOV shall accept the M&V Report.

If, after the opportunity to make corrections, the M&V Report, as amended, indicates that verified savings are less than the Cost Avoidances for that year as shown in Table 2-0, then APS Energy Services shall pay TOV (within thirty (30) days of receipt of the M&V Report) the shortfall amount for the entire guarantee period. However, under no circumstances will the amount paid for the total of the energy savings shortfalls exceed the principal amount of the contract (Contract Amount). Construction period savings dollars and any prior-year, post-project completion excess savings dollars earned shall be used to offset shortfalls identified for an annual reconciliation. For clarification of calculations, no adjustments will be made for the time value of money.

This Guarantee is subject to the satisfactory performance by TOV of its obligations under this agreement including operations and maintenance practices at the site.

Measurement and Verification (M&V) is a methodology based on standard industry protocol intended to provide reasonable assurance that energy savings calculated are realized over the term of the contract. The development of this M&V plan is based on the IPMVP-2001 (International Performance Measurement and Verification Protocol), the FEMP-1996 (Federal Energy Management Protocol NTIS Publication DE96-000521) and the application of sound engineering and business guidelines to the overall need for verification of energy savings for each ECM. This plan contains methodology that shall cost effectively provide reasonable assurance of equipment savings through stipulated values, short term or spot measurements, and engineering calculations and/or modeling. The necessary components to a well established M & V Plan are:

- Specific identification of each ECM and proposed M & V. Reporting requirements for overall savings.
- Participation of all parties and any necessary coordination with independent review.

5.2. M&V Costs

The costs for the M&V report are included in the total cost of the project. This includes pre-retrofit measurements, post-retrofit measurements and a final report for TOV.

5.3. Overview of M&V Project

The M&V plan provides an agreed upon method of verifying the project results using the most cost efficient approach. The cost of various M&V approaches is balanced against the size of the investment and the savings risk. APS Energy Services' approach to M&V is to use established standard methods of verification, such as the IPMVP and FEMP protocols for M&V. APS Energy Services develops site-specific M&V plans for each measure based on the specific technology of the ECM, APS Energy Services and TOV long-term responsibilities, measurement equipment capabilities, ability to capture and isolate the key variables demonstrating effectiveness of the ECM, and the cost to perform the M&V.

5.3.1. Project Risks and Responsibilities

As recommended by the IPMVP and FEMP Guidelines, APS Energy Services evaluates the contract responsibilities associated with a project when developing the M&V plan. To do this, APS Energy Services has prepared a list of potential project risks and the party responsible for managing those risks. The tables that follow list the financial, equipment performance and operational responsibilities.

Table 6-1. Financial Responsibility Matrix

Financial Factors	Responsible Party	Notes
Interest Rates	Neither	Set by market structure
Energy Prices	Neither	Set by market structure
Savings Methodology	APS Energy Services	
Construction Costs	APS Energy Services	Contract determines overall requirements for construction costs and changes
M&V Costs	APS Energy Services	Depending on methods or alternatives suggested/selected.
Delays	APS Energy Services or Client	Depending on cause

Table 6-2. Equipment Performance Responsibility Matrix

Performance Factors	Responsible Party	Notes
Investment Grade Assessment and Savings Calculations	APS Energy Services	All calculations are provided to M&V Professional.
Investment Grade Assessment, Savings Review, M & V Plan Review	APS Energy Services and Client	Schedule coordination and submittals to APS Energy Services and Client required from all parties.
Field Adjustments to Investment Grade Assessment and Savings Calculations as necessary to enhance project	APS Energy Services and Client	Where necessary, parties shall review and modify ECM to ensure appropriate savings and appropriate payback. M&V requirements shall be incorporated into changes as outlined.
Initial Equipment Performance	APS Energy Services	Upon completion of commissioning and necessary measurements as detailed herein.
Pre and Post Retrofit Measurements	APS Energy Services or M&V Professional	Required as indicated for ECM analysis and as outlined in the M&V plan.
Long-Term Equipment Performance	Client	Tied to Operation and Maintenance.
Engineering Calculations and Adjustments as necessary	APS Energy Services or M&V Professional	As outlined in M&V engineering calculations, modeling, and adjustments may be necessary for each ECM.
Maintenance	Client	Tied to long-term performance.
Operation	Client	Tied to long-term performance.

Table 6-3. Operational Responsibility Matrix

Operational Factors	Responsible Party	Notes
Major Facility Changes	Client	Facility changes affect many of the ECMs considered for this plan. The M&V plan as presented herein assumes existing usage patterns except where explicitly stated. Client shall inform designated APS Energy Services Representative of any changes to facilit
Operating Hours	Client	This is stipulated and/or developed for the ECMs considered herein based on information provided by Client.
Load	Client	See analysis methodology descriptions.
User Participation	Client	Baseline conditions assumed.

Project risks can be broadly divided into two main categories: performance risk and usage risk.

Performance Risk
Performance risk is the uncertainty associated with achieving a specified level of equipment performance. It can result from poor baseline definition, inappropriate equipment selection, improper commissioning, or other equipment-related factors. Because APS Energy Services assumes responsibility for equipment and system performance by ensuring that equipment at installation is performing acceptably, unrealized savings resulting from poor equipment performance is a risk that APS Energy Services assumes. To validate performance, APS Energy Services shall perform all functions related to M&V as outlined herein for each ECM.

Another factor of performance risk is long term equipment performance. Long term equipment performance depends on how well the equipment is maintained and operated. Because TOV is responsible for ongoing equipment operation and maintenance for this project, TOV assumes the long term equipment performance risk.

Usage Risk
Usage risk is the uncertainty associated with how well the equipment operating hours or load factors are known when the savings are initially guaranteed. It refers to how often equipment is used, the time of day that it is used and at what levels the equipment is loaded. Savings fluctuate depending on how many hours equipment is used or how many BTUs of heating or cooling are provided. Usage is often related to weather, human behavior, occupancy, and/or other factors beyond either party's control. Usage risk is mitigated to some extent by establishing an appropriate baseline with which to assess ECM savings. The following techniques are effective in mitigating some usage risk:

- ***Field Measurements:*** APS Energy Services provides a level of assurance related to engineering assumptions by performing some field measurements. ECMs such as efficient motor replacement and lighting provide some field measurements for specific variables. Using these measurements provides a better assurance of the overall savings from full implementation of any ECM.

- ***Calibration of Models:*** Where appropriate models can be calibrated using field measurements or other appropriate data to arrive at more accurate models.

- ***Industry Standards:*** Software or industry standards provide a basis for establishing baseline energy consumption for equipment and systems. Such standards lower the overall range for error and mitigate the usage risk to some extent.

- ***Sound Engineering:*** Knowledge of systems, equipment usage, and other sound engineering fundamentals provide some mitigation of usage risk.

Other factors related to usage risk cannot be easily measured or assessed. While some information may be available, these factors may not lend themselves to any reasonable assurance of accuracy through the techniques described above. APS Energy Services cannot assume responsibility for

such factors, and therefore a stipulation or agreement to usage of an agreed value for these factors is necessary. Such factors include:

- ***Operating Hours:*** While some data may be available, in general operating hours are assessed and agreed to by stipulation.

- ***Weather Data:*** Weather affects many ECM calculations. Because upcoming weather is not a certainty, the use of 30-year average weather data is typically stipulated. For the calibrated modeling, APS Energy Services provides some mitigation by utilizing actual weather data as related to utility billing or metered data. This provides a more direct calibration to actual information. Savings analysis is completed using normalized 30-year weather data to provide the most accurate savings projections.

- ***Other Operating Related Factors:*** Factors related to operating conditions and usage of equipment may be stipulated if detailed data or information is not available.

Once both parties stipulate a value, it becomes the value used for both the baseline and ECM savings calculations. Values are often stipulated because the cost to monitor and analyze the variable outweighs TOV savings by implementation of the ECM, and often the increased accuracy by measurement and analyzing the variable is minimal.

5.3.2. Measurement and Verification Models

Methods of M&V vary in accordance with the type of project, level of assurance of savings, cost and availability of data, financing constraints, and energy costs. The methods selected must be cost effective given the financial savings to TOV. The methods used for the ECMs detailed herein were selected to minimize M&V costs while still providing a reasonable assurance of the savings calculations.

The IPMVP-2001 guideline provides the following options related to methodology for M&V:

5.3.2.1. Option A – Partially Measured Retrofit Isolation

Option A uses a combination of stipulated and measured factors to calculate baseline usage and savings associated with the ECM. Spot or short-term measurement would be used for the measured values. Stipulated values are supported by TOV input, historical data or manufacturer data.

- Baseline and savings calculations are provided through engineering calculations, component or system models.
- Depending on number of points measured, Option A provides the least cost alternative to M&V.

5.3.2.2. Option B – Retrofit Isolation

Option B provides for measurement to provide data for assessing values or variables. Spot or short-term measurement, taken at the component and/or system level are taken when variations in factors can be accounted for or eliminated. Continuous measurement at the component and/or system level can also be used to account for the variations in factors over time.

- Baseline and savings calculations are provided through engineering calculations, component or system models.

- Cost is variable depending on the points measured, and the term of the measurement process used. Option B provides a better scenario for ECMs where a small number of factors can be accurately measured with a measurement plan.

5.3.2.3. Option C – Whole Building

Option C involves the use of utility meters or whole building sub-metering to assess the energy performance of the entire building. After an ECM is implemented the billing data is assessed in accordance with an approved plan to determine actual ECM savings.

- Baseline is established through utility data and engineering/regression analysis.
- Engineering calculations or modeling initially provides estimated ECM savings.
- Actual ECM savings are based on the utility or metered data. Savings must be adjusted for changes in building operation and variables assumed in the engineering calculations or modeling (such as weather, occupancy, etc.).
- Cost of this approach is variable based on the availability of utility data, sub-metered data, and overall savings guarantee. If the metered data is used for a savings guarantee, all variables related to building performance must be measured and adjusted, usually on an annual basis. Option C usually requires a substantial amount of time and effort to establish the baseline, and especially track the savings of any specific ECM on a building or metered total basis.

5.3.2.4. Option D – Calibrated Computer Simulation

Option D uses computer-modeling techniques to provide an engineering model of component and/or system performance. The inputs to the computer simulation may be made by engineering estimates, short or long term measurements, and utility or other metered data. Once the model is properly calibrated it is used for the establishment of the baseline and savings by changing appropriate inputs.

- Baseline is established through a calibration process for the computer modeling. Appropriate measurements and inputs are reflected against regression analysis for the metered data.
- Once the model is calibrated and the baseline established, inputs are varied for the proposed ECM to establish savings.
- Actual ECM savings are stipulated based on the computer model. There may be follow up calibration of the model with the ECM in place to affirm the overall building simulation model.
- Cost of this method varies based on the complexity and accuracy of model desired, availability of data and overall measurement required.

5.3.2.5. Option S – Stipulated Savings

Option S entirely uses stipulated factors to calculate baseline usage and savings associated with the ECM. Stipulated values are supported by Client input, historical data, or manufacturer data. The savings can then be calculated by computer building simulations or engineering calculations.

The IPMVP and FEMP guideline is similar to the IPMVP –2001 protocol except that it allows for full stipulation of all variables in Option A. This type of approach is applicable where the savings for any ECM do not justify the cost of measurement of any variable for purposes of compliance with the IPMVP protocol. In order to determine the most effective method of M&V for any particular project or ECM, the following considerations must be taken into account:

- ***What are the expected annual savings for the ECM in comparison with the estimated cost to verify the ECM savings****?* It would not be cost effective, for example, to verify savings for a lighting retrofit when the M&V cost exceeded the annual savings for implementing the measure.

- ***What data is readily available?*** The data availability is important in deciding the appropriate methodology. If data is not readily available it shall likely lead to additional stipulation or additional M&V cost. Again, the overall data availability may increase the M&V cost and time frame for ECM savings verification.

- ***What level of assurance is required?*** Complex modeling and measurement is not necessary if the level of assurance required is met by a lower cost M&V option. For example, lighting retrofit savings can be calculated with little or no measurement with a very small potential for error. Installing long-term measurement and expending the time and capital to model the lighting retrofit within the building would not provide any greater level of assurance than simple calculations and spot measurements.

- ***Is there a critical project path?*** Time is usually a critical factor in all projects. Time required for completion may dictate an alternate M&V option. If data is not available, it may not be possible to monitor all factors for a long period of time in order to establish a baseline under Options C or D. This may dictate using Options A or B due to project timing constraints. Option D may be applied if the calibration time can be accommodated with the project schedule.

For the system covered under this M&V plan, the Option selected to confirm energy production for the system is Option D

The particular option selected for each ECM was based on a number of related issues including:

- ECM projected energy savings and ECM cost.
- ECM savings and cost related to overall project cost avoidances and cost.
- Accuracy issues over measurement in any particular measure.
- Overall cost of Measurement and Verification to provide a reasonable assurance of savings.

In general,

- *Savings ($/yr) = ($/yr (existing system)) - ($/yr (Post ECM)) +or- Adjustments*
- *Simple Payback (yrs) = Project Cost ($)/Savings ($/yr)*

The baseline and the post-installation energy use depend on various system and external factors, such as energy demand, operating hours, weather conditions, motor loading, energy rates, and occupancy. Development of the baseline, post ECM consumption, cost avoidances and simple payback for each ECM covered by this M&V plan includes:

- ***Stipulated Values:*** These values are important in the overall calculations for energy consumption, financial calculations, and operating conditions. APS Energy Services and TOV have agreed to these values for purposes of establishing savings.

- ***Developed/Measured Values:*** These are the values determined by spot or short-term measurement. Values are determined based on a sound engineering approach to variable determination. Both values used for baseline consumption and values to be measured/ determined as part of the post ECM implementation is detailed.

- ***Assumptions:*** Some values that are assumed in order to calculate energy use are necessary in certain circumstances.

- ***Calculations:*** The necessary calculations for baseline energy and demand usage, the calculation of the energy and demand components with implementation of the ECM, the calculation of costs, and annual savings are the primary tool for assessing the estimated and actual savings of any ECM.

- ***Instrumentation:*** The type and specifications, if applicable, for any instrumentation used for developed/measured values is provided to ensure appropriate meters and measurement equipment is used for specified applications.

- ***Pre Retrofit Measurements:*** Each ECM has a section detailing the measurements required prior to the retrofit. These measurements are used to establish the baseline or adjustments required to establish an accurate baseline.

- ***Post Retrofit Measurements:*** Each ECM has a section that details the measurements required if any after the retrofit is completed. This section is utilized to detail the type of measurements required for verification of the energy savings calculations.

- ***Adjustments:*** Each ECM has a section for adjustments. This section includes possible adjustments to the actual Investment Grade Assessment and energy information, appropriate adjustments to the M&V plan, and adjustments to any savings guarantee. This section is utilized to anticipate changes necessary due to field conditions and provide an appropriate response in the verification of actual energy and cost avoidances.

- ***Commissioning:*** Each ECM has a section regarding the commissioning process. This provides the detail for how the savings will be verified upon project completion, and the type of inspection that will be completed, and the billing method for verified savings. This section is utilized to provide a standard approach for each ECM upon project completion.

5.3.3. Measurement and Verification Documentation and Implementation

The M&V process continues during design, construction, commissioning, and the measurement phase. The following are the major steps in the technical M&V process:

5.3.3.1. Engineering Review

Engineering calculations of savings and documented supporting assumptions have been reviewed. Critical engineering parameters and facility or system characteristics have been identified and verified with TOV. Sources of weather data, facility occupancy schedules, manufacturer operational specifications, utility rate schedules and other assumptions are clearly identified in this M&V plan. Average historical weather data is used to account for any variations that may occur over the life of the contract. Occupancy schedules are verified and reviewed by TOV. The engineering methods used to calculate the energy savings are clearly documented in this plan. All savings calculations and operational or maintenance savings should be reviewed and accepted by TOV.

5.3.3.2. Design Review

The design documents are reviewed to ensure that they meet the requirements of the ECMs.

5.3.3.3. Construction Review

Equipment shop drawings are reviewed to ensure that they meet the design intent. Site visits are made to ensure that the ECM is built in accordance with the specifications.

5.3.3.4. Commissioning

After installation is complete, the ECM equipment and systems are fully commissioned and functional tests are conducted to verify performance. An appropriate Measurement and Verification Specialist will perform all formal commissioning on HVAC and DDC systems where Option A is selected. The appropriate Measurement and Verification Specialist will provide a commissioning report which must be attached to any final M&V Report. This requirement includes all re-commissioning of existing buildings.

5.3.3.5. Measurements

As detailed herein, measurements may be required for ECM savings verification. For all measurements, Appropriate Measurement and Verification Specialist shall have a certified and assume responsible charge.

5.3.3.6. On-Site Inspections

On-site post-installation inspections are conducted during or after commissioning to ensure proper equipment operation. During these inspections, APS Energy Services performs a final verification of ECM data, such as equipment ratings, quantities and applications. Diagnostic measurements are also collected, as necessary. Short-term-interval data may be monitored as well.

5.3.3.7. Project-Specific Impact Assessments

For some measures, site-specific evaluations are performed using metering and instrumentation. The exact measurements taken depend on the particular technology. Also, the measurement time period varies depending on the characteristics of the technology and its use.

In accordance with the IPMVP and FEMP Guidelines, the following outline for each measure has been established to clearly indicate each of the specific parameters, protocols, objectives and overall plan for Measurement and Verification.

- References to the Investment Grade Assessment
- Introduction
- Stipulated Values
- Measured/Developed Values
- Assumptions
- Calculations
- Instrumentation
- Post Retrofit Measurements
- Adjustments
- Interactive Effects
- Commissioning

APS Energy Services will follow the agreed-upon M&V protocols for the measurement period and will prepare post-installation reports with supporting documentation for TOV. The cost of M&V is included in the project cash flow requirements and reduces the net cost avoidances. Therefore, APS Energy Services is careful to match the complexity of the M&V approach to the available cost avoidances to maintain the cost-effectiveness of the measure.

5.3.3.8. Follow-On Report

The Follow-On M&V report shall be performed by an appropriate Measurement and Verification Specialist. The follow on reporting requirements are dictated by:

- Contractual obligations between APS Energy Services and TOV.
- Additional requirements as deemed necessary or part of overall customer service between APS Energy Services and TOV.

The Follow-On Report shall be submitted to TOV within 90 days of the anniversary date of the final M&V Report (date of final M&V Report shall be considered final data when all parties have signed and approved the report) submitted in accordance with this Plan. TOV may assign the follow on work to an individual other than the Appropriate Measurement and Verification Specialist with written approval. Should TOV assign any M&V work to an individual other than the Measurement and Verification Specialist, the Measurement and Verification Specialist assumes no liability for any savings or M&V work completed to date.

5.4. Global Assumptions and Definitions

5.4.1. Global Data

The global data in the Table that follows was used to calculate the energy savings in the Investment Grade Audit, and will be used in all Measurement and Verification calculations.

Table 6-5. Technical Reference Definitions

Data Type	Values Assumed	Source	Notes
Demand and Energy Pricing ($/kW, $/kWH)	Client has electrical service provided by XXX. For this analysis, the savings methodology described in detail herein was utilized for purposes of establishing the annual dollar cost avoidances.	Electric rates and tariffs, Client provided billing data or other reliable sources as detailed herein.	Savings Methodology and information contained herein.
Propane	Client has propane service provided by XXX Propane. For this analysis, the savings methodology described in detail herein was utilized for purposes of establishing the annual dollar cost avoidances.	Propane rates and tariffs, Client provided billing data or other reliable sources as detailed herein.	Savings Methodology and information contained herein.
Baseline Year	2008-2009 (most current full billing year): Where necessary and as detailed in the Investment Grade Audit, the data provided may have been modified or adjusted due to lack of data or due to data timing.	Client provided data or authorization to acquire data.	The billing data utilized reflects the most current consumption history available.

5.4.2. Buildings Considered

Section 4.0, Technical Report, details the buildings considered for M&V and included in the Investment Grade Audit. This Plan also includes a table detailing the proposed ECM by building for additional reference.

6.0 Commissioning

6.1. Photovoltaic Commissioning Process Checklist

6.1.1 Make sure all disconnect switches are open and power is not applied.

Customer _____ APS Energy Services _____

6.1.2 Resistance to Ground

Measure and record hardware components metal frames and housing resistance to ground.

Item	Measurement
1. Array Structure	
2. Junction Box	
3. DC Disconnect Frames	
4. Inverter Frame	
5. AC Distribution Panel	
6. Other	

Customer _____ APS Energy Services _____

6.1.3 Disconnect Switches

Make sure all disconnect switches are open, fuses are removed from combiner boxes, and that power is not applied.

Customer _____ APS Energy Services _____

6.1.4 Source Circuit Voltage Polarity Tests

Measure and record in section 6.4.3 each source circuit's open circuit voltage and note the amplitude and polarity. Each string must be within three percent of the mean. Current measurements are made later after all source circuit polarity has been verified. Complete this section for each inverter first before moving to starting the inverter system.

Customer _____ APS Energy Services _____

6.1.5 Combiner Box Fuse

Insert Combiner Box fuses

Customer _____ APS Energy Services _____

6.1.6 DC Connect Switches

Verify the polarity and open-circuit DC voltage magnitude of PV input to switch are correct for each disconnect switch.

Customer _____ APS Energy Services _____

6.1.7 Activate DC Disconnect Switches

Turn on DC Disconnects (not the inverter's DC interface).

Customer _____ APS Energy Services _____

6.1.8 Inverter DC Input

Verify polarity and DC voltage magnitude at the DC Interface are correct.

Customer _____ APS Energy Services _____

6.1.9 Inverter AC Input

Verify polarity and AC voltage magnitude of utility connection to inverter are correct.

Customer _____ APS Energy Services _____

6.2. System Operational Tests

6.2.1 Apply AC power to the inverter (close the circuit breaker and/or AC disconnect switch).

Customer _____ APS Energy Services _____

6.2.2 Apply DC power to the inverter (close DC disconnect switch)

Customer _____ APS Energy Services _____

6.3. System Operation

6.3.1 With the system operating verify that system AC output ceases when the DC disconnect switch is shut off.

Customer _____ APS Energy Services _____

6.3.2 With the system operating verify that the system AC output ceases when the AC disconnect switch is shut off.

Customer _____ APS Energy Services _____

6.4. System Data

6.4.1 Commissioning Tests

Open Circuit Voltage, Inverter, and String I-V Curve Trace tests shall be performed in accordance with procedures detailed in this section 6.4.1, and test data shall be recorded in Section 6.4.3, prior to commissioning of the Generating Facility.

Commissioning Test Procedures:

6.4.1.1 Open Circuit Voltage Test

Purpose: Open Circuit Voltage Testing provides a simple method to determine that all strings are properly connected (module and string polarity) and that all PV modules are producing an appropriate voltage level.

Scope: All Strings

Party: APS Energy Services technical personnel

Equipment/Materials:

- Rubber Insulating Gloves
- Voltmeter With An Accuracy Of At Least 1 Percent Of Reading
- Fuse Puller
- Infrared Thermometer Or Thermocouple
- PV Specification For Voc As A Function Of Temperature
- Jumper Wire

Conditions:

This test will be conducted under full sun (>500 W m 2) and stable sky conditions, generally between the hours of 10:00 a.m. and 2:00 p.m. If such conditions are not available due to the season of the year, then APS Energy Services shall not conduct such test until the earlier of the date on which such conditions exist and 3 business days following the date on which the test would otherwise have been conducted. If, upon the expiration of the foregoing period, such conditions are still not available, then the test will be conducted under stable sky conditions with a minimum irradiance of 200 W/m2; provided, however, that Customer shall have the option to cause APS Energy Services to conduct any such test on the original date therefore regardless of the sky conditions on such date.

Procedure:

- Measure the temperature of the PV modules using an infrared thermometer or thermocouple. (It is sufficient to measure the temperature of 2-3 modules and take the average.)
- Calculate Expected Voc: Referring to the PV manufacturer-supplied equation for Voc as a function of temperature, calculate the expected Voc of each string.
- Remove Fuses: Wearing rubber insulating gloves and using a fuse puller, carefully remove the fuses from the combiner box. Failure to remove the fuses will result in identical voltage measurements for every string since they are in parallel with the fuses in place.
- Test String Voltages: Place the positive lead on the fuse block of the string being tested while the negative lead is attached to the negative block. Continue testing each string by moving to each positive string fuse block. Test and record the voltage of each electrical string.

Criteria:

- For stable sky conditions and irradiance above 500 W-m-2, string voltages should conform to within 5% of expected voltage as calculated in Step 2 above and each string should conform to within 2% of the average string voltage in the same combiner box under identical temperature and irradiance conditions.
- For irradiance less than 500 W m 2or for unstable sky conditions (if irradiance changes by more than 10%, or ambient temperature changes by more than 5°C), compare each string's measured voltage to periodic measurements on a known good (reference) string. The reference string must be measured at irradiance above 500 W m 2 and its measured voltage must be within 5% of the voltage calculated using Step 2 above. Voltage on non-reference strings should be within 5% of the reference string voltage under the same temperature and irradiance conditions.
- For irradiance less than 200 W m 2, test results may be used only to confirm proper string connection, and not to evaluate voltage performance.

6.4.1.2 Inverter Commissioning

Purpose: Verify the proper operation of the inverter systems

Scope: All inverters

Party: APS Energy Services and/or manufacturer, with APS Energy Services supervision

Schedule: At inverter start-up

Equipment/Materials:

- Rubber Insulating Gloves
- Digital Multi-Meter With An Accuracy Of At Least 1 Percent Of Reading For Voltage
- Other Equipment As Required By Manufacturer

Procedure: Follow all manufacturer's guidelines for inverter start-up and commissioning, including verification of safety and control features.

Conditions: No special conditions apply.

Criteria: The inverter and controls should operate as stated in the purchaser or manufacturer specifications.

Comments: Remote functions should only be tested on those systems that will utilize this feature.

6.4.1.3 String I-V Curve Test

The following Commissioning test in this Section 6.4.1.3 shall be completed by APS Energy Services after receipt of the Certificate of Mechanical Completion but prior to submission of the Application for Substantial Completion.

Purpose: I-V curves are useful for identifying array problems and characterizing array performance. The purpose of this test is to compare strings on a qualitative basis. For this test, I-V Curve Traces will be taken on a sample size consisting of all strings in 10% of all combiner boxes. I-V Curve Traces quantify actual photovoltaic module or string characteristics.

Scope: A sample size consisting of a sample of all strings in 10% of all combiner boxes.

Party: APSES technical personnel

Equipment/ Materials:

- Rubber Insulating Gloves
- I-V Curve Tracer Or Similar Instrument

Procedure:

- Follow the manufacturer's procedures for use of the I-V curve tracer.
- Isolate the portion of the array of interest (plus and minus leads) from the inverter (a DC disconnect switch may suffice) and from other array segments. Connect the curve tracer load to the array leads. (Be aware of array and load polarities.) Sweep the load such that it operates the array over its range of Voc and Isc (or as the load will allow). Record voltage and current readings for at least 10 steps.
- Along with the series of current voltage pairs, array and ambient conditions should be recorded for each curve including:
  - Irradiance (of the appropriate components and orientation)
  - Module Temperature
  - Ambient Temperature
  - Wind Speed (Optional)
  - Date and Time
- An indication of irradiance stability, such as pre and post curve irradiance, may also be recorded and is especially important if the curve takes more than one second.
- The measurement equipment must be capable of monitoring the array with sufficient speed and accuracy. During the curve sweep, typically only the array current and voltage are measured, with irradiance stability measurements taken before and after the curve, and the remaining parameters measured once before or after the curve.

Conditions:

- I-V curves must be taken under clear and stable sky conditions. For this test, irradiance must be above 500 W m 2.
- A reasonable attempt will be made to perform this test under ideal sky conditions; however, if ideal weather is not anticipated because of seasonal changes, the test will not be required for acceptance.

Criteria:

The string Voc should meet the criteria defined in Section 1 – Open Circuit Voltage Test above. The string Isc should meet the criteria defined below:

$$I_{sc,expected} = n \cdot I_{sc,REF} \cdot \frac{G}{G_{REF}} \cdot 0.95 \qquad (1)$$

- Under sky conditions of 500 W/m2 or greater, the measured current should be within 5% of the expected Isc calculated using equation above:

Where:

- n = number of modules in parallel in test segment
- Isc, expected = expected short-circuit current of the test segment, A
- Isc, REF = module short-circuit current at some specified reference conditions, A
- G = measured plane of array irradiance, W-m-2
- GREF = irradiance at some specified reference conditions, W-m-2
- 0.95 = factor to account for soiling, misalignment, and other factors.

Under sky conditions of less than 500 W/m2, the measured short circuit current should be within 10% of the Isc calculated using the above equation.

All I-V curves should be similar in shape (other than differences due to changes in irradiance or temperature).

This test will be conducted under full sun (>500 W-m-2), generally between the hours of 10:00 a.m. and 2:00 p.m. If such conditions are not available due to the season of the year, then the APS Energy Services shall not conduct such test until the earlier of the date on which such conditions exist and 3 business days following the date on which the test would otherwise have been conducted. If, upon the expiration of the foregoing period, such conditions are still not available, then the test will be conducted under stable sky conditions with a minimum irradiance of 200 W/m2; provided, however, that Customer shall have the option to cause the APS Energy Services to conduct any such test on the original date therefore regardless of the sky conditions on such date.

Comments: If results show anomalies, including fill factor, voltages, or currents outside expected limits or humps on the curve, then investigate for bypass diode conduction, out-of-tolerance module performance, or other possible problems. Rectify any flaws and re-test.

6.4.2 Operating Verification Tests

The following Commissioning test in Section 6.4.2 and Section 6.4.3 shall be completed by APS Energy Services after receipt of the Certificate of Mechanical Completion but prior to submission of the Application for Substantial Completion.

Operating Current and Operating Voltage tests shall be performed in accordance with procedures detailed in this section 6.4.2, and test data shall be recorded in Section 6.4.3, prior to Final Completion of the Generating Facility.

6.4.2.1 Operating Current and Operating Voltage Test

Purpose: The purpose of this test is to ensure that all strings are producing an adequate and consistent operating current and voltage.

Scope: All strings, after connection with utility grid and inverter start-up

Party: APS Energy Services technical personnel

Equipment/Materials:

- Rubber Insulating Gloves That Have Been Properly Tested For Voltage Leaks
- Dc Clamp-On Ammeter, 0-40 A Scale With 2 Per Cent. Of Full Scale Accuracy

Procedure:

- Start the Inverter: Start the inverter if it is not already running, making sure all fuses are installed. Wait 5 minutes for the power tracker to stabilize.
- Prepare for Readings: Open the combiner box, turn on the ammeter, and carefully zero the meter. Keep the clamp away from large bundles of wire, as they will affect the zero, and therefore the actual reading on the meter.
- Record the "Zero" Value: Wearing rubber insulating gloves, place the meter near a string's homerun wire. Record the "zero" value.
- Record the Current Value: While still wearing gloves, clamp the meter on each service loop in the box, recording the current readings.
- Calculate Actual Current: Calculate and record the actual string currents as the difference between the string current reading and the "zero" value.

Example:

"Zero" value = 0.3 A

Current reading = 3.0 A

Actual Current: 3.0 A - 0.3 A = 2.7 A

- Record the Current Voltage Value: While still wearing gloves, measure the voltage across a closed breaker

Conditions:

Measurements will be made during clear and stable sky conditions. The total inverter output should be at least 50% of the aggregate rating of the active inverters. This test will be conducted under full sun (>500 W-m-2), generally between the hours of 10:00 a.m. and 2:00 p.m. If such conditions are not available due to the season of the year, then the APS Energy Services shall not conduct such test until the earlier of the date on which such conditions exist and 3 business days following the date on which the test would otherwise have been conducted. If, upon the expiration of the foregoing period, such conditions are still not available, then the test will be conducted under stable sky conditions with a minimum irradiance of 200 W/m2; provided, however, that Customer shall have the option to cause the APS Energy Services to conduct any such test on the original date therefore regardless of the sky conditions on such date.

Criteria:

Under clear and stable sky conditions with irradiance greater than 500 W m 2, current readings within each combiner box should be within 5% of the average under identical sky conditions. A reasonable effort shall be made to conduct this test under conditions with irradiance greater than 500 W m 2; however, if such conditions are not available in the commissioning period, then the Current Test will be performed as a sign-of-life test only, without the 5% criteria.

6.4.2.2 System Output Verification

Purpose: Verify the kWh output of the Generating Facility to system design

Scope: the Generating Facility

Party: APS Energy Services with Customer and/or 3rd-party engineer supervision

Equipment/Materials:

- Functioning SCADA with pyranometer measuring irradiance in the plane of the array(s) of the Generating Facility providing 15-minute interval data.

Procedure: Record the SCADA for 5 continuous, uninterrupted days and compare actual system output to expected output per system design under recorded insolation for same time period.

Conditions: No special conditions apply.

Criteria:

Comments:

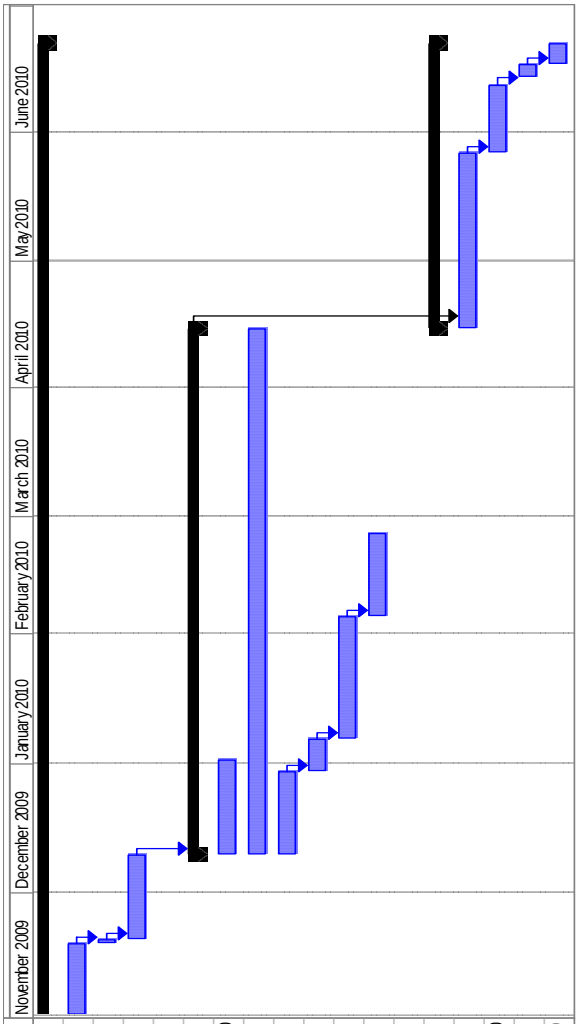
6.4.3 Inverter #1

Parameter	Measurement	Comments
PV Power (DC)		
PV Volts		
PV Current		
Inverter Power (AC)		
Voltage (AC) Ph A		
Voltage (AC) Ph B		
Voltage (AC) Ph C		
Current Ph A		
Current Ph B		
Current Ph C		

Inverter #1
Source Circuit Combiner Box #1
[] Strings of [] in Series Solar Modules

String #	Inverter #	Open Circuit Voltage (Volts DC)	Operating Voltage (Volts DC)	Operating Current (Amps)	I-V Curve Trace Test	Insolation (Wh/m2)	Ambient Temperature (°C)
1	1						
2	1						
3	1						
4	1						
5	1						
6	1						
7	1						
8	1						
9	1						
10	1						

Customer _____ 3rd-party engineer _____ APS Energy Services ___

7.0 Schedule

ID	Task Name	Duration	Start	Finish
1	**Town of Oro Valley Solar PV**	**166 days**	**Mon 11/2/09**	**Mon 6/21/10**
2	100% Board Presentation	13 days	Mon 11/2/09	Wed 11/18/09
3	Board Approval	1 day	Thu 11/19/09	Thu 11/19/09
4	Final Contract	14 days	Fri 11/20/09	Wed 12/9/09
5				
6	**Solar Photovoltaic**	**90 days**	**Thu 12/10/09**	**Wed 4/14/10**
7	Order Panels	17 days	Thu 12/10/09	Fri 1/1/10
8	Order Inverters	90 days	Thu 12/10/09	Wed 4/14/10
9	Engineer Structural	14 days	Thu 12/10/09	Tue 12/29/09
10	Procure Subcontractor	6 days	Wed 12/30/09	Wed 1/6/10
11	Erect Steel	21 days	Thu 1/7/10	Thu 2/4/10
12	Electrical	14 days	Fri 2/5/10	Wed 2/24/10
13				
14	**Close Out**	**48 days**	**Thu 4/15/10**	**Mon 6/21/10**
15	Commissioning	30 days	Thu 4/15/10	Wed 5/26/10
16	Punch List	12 days	Thu 5/27/10	Fri 6/11/10
17	Final Close Out	3 days	Mon 6/14/10	Wed 6/16/10
18	Demobilization	3 days	Thu 6/17/10	Mon 6/21/10