SECTION CONTENTS

5.1 NO PROJECT ALTERNATIVE 5-1

5.2 POWER PLANT SITE ALTERNATIVES 5-1

5.2.1 RAINBOW SITE 5-1

5.2.2 ORANGE GROVE SITE 5-2

5.3 COOLING ALTERNATIVES 5-2

5.3.1 WATER SUPPLY ALTERNATIVES 5-2

5.3.2 ALTERNATIVE COOLING TECHNOLOGIES 5-3

5.3.2.1 Once-Through Cooling 5-3

5.3.2.2 Packaged Cooling Towers 5-3

5.3.2.3 Air-Cooled Condenser 5-3

5.3.2.4 Hybrid Wet/Dry System 5-4

5.3.2.5 Conclusion 5-5

5.4 ELECTRICAL TRANSMISSION LINE ALTERNATIVES 5-5

5.5 GENERATION TECHNOLOGY ALTERNATIVES 5-6

5.5.1 SELECTION METHODOLOGY 5-6

5.5.2 ALTERNATIVE NATURAL GAS-FIRED TECHNOLOGIES 5-6

5.5.2.1 Combined-Cycle (Selected) Generating Technology 5-6

5.5.2.2 Conventional Boiler-Steam/Turbine 5-7

5.5.2.3 Supercritical Boiler-Steam/Turbine 5-7

5.5.2.4 Simple Combustion Turbine 5-7

5.5.2.5 Advanced Gas Turbine Cycles 5-7

5.5.3 ALTERNATIVE COMBUSTION TURBINE TECHNOLOGIES 5-8

5.5.4 ALTERNATIVE EMISSIONS CONTROL TECHNOLOGIES 5-9

5.6 REFERENCES 5-10

SECTION ACRONYMS/ABBREVIATIONS

ACRONYM/ ABBREVIATION	DEFINITION
CAISO	California Independent Systems Operator
CEMS	Continuous Emission Monitoring System
CO	Carbon Monoxide
CTG	Combustion Turbine Generator
gpm	Gallons Per Minute
HHV	Higher Heating Value
kW	Kilowatts
LHV	Lower Heating Value
MMBtu/hr	Million British Thermal Units Per Hour
NOx	Nitrogen Oxides
OTSG	Once Through Steam Generators
ppmvd	Parts Per Million Volume Dry
RFO	Request for Offers
RO	Reverse Osmosis
SCR	Selective Catalytic Reduction
SDG&E	San Diego Gas & Electric
SPPE	Small Power Plant Exemption
VOC	Volatile Organic Compounds

5.0 ALTERNATIVES ANALYSIS

This section addresses the alternatives evaluated by Orange Grove Energy during the development of the Project. Before selecting the 96 MW project size, Orange Grove Energy evaluated a 48 MW alternative wherein only one GE LM6000 PC SPRINT CTG would be installed. Extensive discussions with SDG&E, however, resulted in the determination that they strongly preferred the 96 MW project size.

5.1 NO PROJECT ALTERNATIVE

The Project is needed by SDG&E in order to meet growing load requirements in the local area. The Project is proposed in response to the SDG&E RFO, which was initiated as a result of the power supply disruptions experienced by SDG&E customers in the past. Specifically, SDG&E initiated this project on a fast track schedule in order to address reliability concerns raised by the summer 2006 “heat storm”. With normal load growth in the SDG&E service area, a repeat heat storm in summer 2008 could pose serious reliability issues for the SDG&E system. Delay or cancellation of the project would leave the system vulnerable to heat events.

The “No Project” alternative was considered but rejected in view of SDG&E objectives to enhance the reliability and efficiency of power supply to its customers. In addition, the No Project Alternative would result in greater potential environmental impacts, including socioeconomic impacts of potential electric supply shortfalls, and increased air pollution levels because new, cleaner peaking generation plants would not be placed in service to replace older, less efficient peaking power plants with greater emission levels.

5.2 POWER PLANT SITE ALTERNATIVES

Two sites were evaluated before selecting the proposed project site. The criteria used in the selection process included the proximity to existing transmission lines, natural gas pipelines, water supply sources, adequate property sizes, and environmental, local land use and zoning compatibility. The sites considered were the Orange Grove and Rainbow sites, both located in the Pala area. The specific requirements of the SDG&E RFO limited Project options to these two sites.

5.2.1 Rainbow Site

Investigation of the Rainbow site, located in an area 4 miles to the north of the Orange Grove site and requiring access through an adjacent privately- owned property, resulted in the determination that ingress, egress, and other constructability factors were challenging, and led to the rejection of the site. The Rainbow site also does not have a favorable gas interconnection route, and for transmission, would require construction of a new substation.

5.2.2 Orange Grove Site

The Orange Grove site was determined to not possess the handicaps of the Rainbow site related to ingress, egress, and constructability factors. Access to the site directly from Pala Del Norte Road was observed to be free of encumbrances from other properties, and the difficult constructability factors inherent in the Rainbow site were not evident. SDG&E recently built a substation adjacent to the site and has included an open bay for interconnection of a potential generating facility. As a result, the Orange Grove site will require minimal work at the substation to interconnect new generating capacity. For these reasons, the Orange Grove site was selected for the Project over the Rainbow site.

5.3 COOLING ALTERNATIVES

5.3.1 Water Supply Alternatives

The Project evaluated several potential alternatives for the supply of water, with emphasis on potential sources of brackish water, reclaim water, or other non-fresh water sources. The relatively isolated geographic location of the Project largely controls the available sources of non-fresh water, since there is limited infrastructure in the Project vicinity. No ground water remediation sites are known nearby that could potentially provide a feasible water source. No natural brackish waters occur in the vicinity.

One potential source of reclaim was identified and evaluated and found not to be feasible for the Project. The potential reclaim water source that was identified is secondary treated sewage from the Pala Casino Spa Resort, about 1.5 miles east of the Project Site. Orange Grove Energy met with the Pala Band of Mission Indians to discuss the Orange Grove Project and determine the availability of potential wastewater. Project staff were informed that there is no wastewater available (Volturino, 2007). The wastewater from the treatment plant currently is discharged to percolation ponds after secondary treatment. The Tribe is preparing to modify the wastewater treatment plant to provide tertiary treatment with reuse of all water for agriculture and landscaping. Therefore, no water is available for the Project from this potential source.

Due to the relatively remote location of the Project site, no other potentially feasible reclaimed water sources were identified. The remoteness of the location proved to be a problem in sourcing even Rainbow Municipal Water District (District) water. Numerous discussions with the District resulted in the determination that an adequate supply of water was available. The District has an existing pipeline with 3,000 gpm capacity approximately near the ridge line less than a mile north of the site on Pala Del Norte Road. A water pipeline lateral will be installed in Pala Del Norte Road connect the Site to the existing infrastructure.

5.3.2 Alternative Cooling Technologies

5.3.2.1 Once-Through Cooling

Because of the limited supply of water available to the Project, Once- Through cooling was determined to be infeasible. This cooling technique has been used when large sources of cooling water, such as an ocean or river, are adjacent to the proposed plant. No such source exists in the vicinity of the Project.

5.3.2.2 Packaged Cooling Towers

Packaged cooling towers, integrated into the CTG combustion inlet air chiller system, will use make-up water provided by Rainbow. A water-cooled system was selected for this Project due to the need to preserve power output and plant efficiency as compared to an air-cooled solution, which is described below.

5.3.2.3 Air-Cooled Condenser

Evaporative cooling systems have been kept to a minimum at the Project through the use of oil-to-air-cooling technology for combustion turbine, generator and fuel gas compressor lubricating oil systems and air-cooling for the generators. The black-start generator system and emergency diesel-driven fire pump utilize automotive-style radiators. Project water treatment equipment, required for production of pure water for NO_X emissions control as well as for power augmentation, is based on portable, trailer-mounted demineralizers which are regenerated off-site and as a result waste virtually no site water, as opposed to reverse-osmosis (RO) systems which reject a considerable quantity of water in operation.

Project CTG combustion inlet air chiller condensers utilize a circulating water system and relatively small evaporative cooling tower for rejection of heat to the atmosphere. Alternative forms of cooling include a “dry” cooling system whereby process heat loads are rejected to the atmosphere using air-cooled fin-fan heat exchangers.

Use of a dry cooling system would reduce Project water consumption beyond that already accomplished. However, the use of dry cooling technology would adversely affect other areas of environmental importance including:

- Visual impact – inclusion of dry cooling would require an increase of the footprint of the Project and the dry cooling system would be a substantially larger piece of equipment compared to the proposed small evaporative cooling tower.
- Noise – air-cooling requires many times the airflow of evaporative cooling, accomplished through fans. Such fans are very noisy as compared to an evaporative cooling tower.
- Cycle (fuel) efficiency – the additional horsepower requirements of a dry system will result in poorer Project cycle efficiency, i.e. significantly increased fuel usage for a

given net power output as compared to an evaporative system. This is particularly true during hot weather, when a peaking power facility is most likely to be activated.

- Power generating capability – use of a dry system will result in reduced Project power output as compared to an evaporative system; for a peaking power facility, maximum hot-day performance is naturally a paramount consideration.

Based on an analysis of projected water consumption numbers for the Project, it is estimated that the use of dry cooling could potentially reduce water consumption by approximately one quarter. However, in addition to the impacts of dry cooling described above, the technology would increase the parasitic power consumption for cooling from 1.8 MW to 2.9 MW, an increment of 60%. Maximum increases in parasitic load would occur when peaking power is most needed, during hot weather. Furthermore, the net incremental power output (over a baseline power output with no inlet cooling) with dry cooling technology would be about 10 MW, or 20% lower than the 12 MW incremental output from the use of wet cooling. Finally, the space required for the dry cooling chiller system is expected to be approximately 2,400 square feet, an increase of over 80% over the 1,300 square feet required by the wet cooling chiller system.

5.3.2.4 Hybrid Wet/Dry System

A "wet-dry" system is a hybrid of the evaporative cooling and dry cooling systems whereby either 1) water is sprayed on the exterior of the fin-fan heat exchanger to improve heat rejection, or 2) a supplemental evaporative cooling tower is employed on hot days. Use of a wet-dry cooling system would reduce Project water consumption beyond that already accomplished. However, the use of wet-dry cooling technology would adversely affect other areas of environmental importance including:

- Visual impact – hybrid cooling would require an increase of the footprint of the Project and the dry cooling system would be a substantially larger piece of equipment compared to the proposed small evaporative cooling tower. If an evaporative cooling tower is included in the hybrid system, then visual impacts would be greater than for dry cooling alone.
- Cycle (fuel) efficiency – the additional horsepower requirements of a wet-dry system will result in poorer Project cycle efficiency, i.e. significantly increased fuel usage for a given net power output as compared to an evaporative system. This is particularly true during hot weather, when a peaking power facility is most likely to be activated.
- Power generating capability – use of a wet-dry system will result in reduced Project power output as compared to an evaporative system; for a peaking power facility, maximum hot-day performance is naturally a paramount consideration.

Based on an analysis of projected water consumption numbers for the Project, it is estimated that the use of hybrid wet/dry cooling could potentially reduce water consumption when compared with wet cooling. The actual reduction would depend on the specific design of the system, but this reduction would be less than that provided by dry cooling. However, the technology would increase the parasitic power consumption when compared with wet cooling. As noted above, the

greatest parasitic load would occur when peaking power is most needed, during hot weather periods.

5.3.2.5 Conclusion

The Project is consistent with the use preference hierarchy and water quality protection measures of the State Water Resources Control Board Resolution 75-58 on the use and disposal of inland waters used for power plant cooling. This policy is provided for planning of new power generating facilities to protect beneficial uses of the state's water resources and to keep the consumption of fresh water for power plant cooling to that minimally essential for the welfare of the citizens of the State. The CEC's integrated energy policy recognizes SWRCB Resolution 75-58 as reflective of the State's concerns over discharges from power plant cooling, as well as the conservation of fresh water for cooling purposes. The CEC has adopted a policy of approving the use of fresh water for power plant cooling purposes only where alternative water supply sources and alternative cooling technologies are shown to be "environmentally undesirable" or "economically unsound" (CEC, 2003).

As discussed above, wet cooling has been selected in part due to the negative impacts of dry cooling, including the higher parasitic load and lower power output associated with dry cooling, that would be most pronounced during hot weather periods when peaking power is especially needed.

Orange Grove Energy has evaluated the SWRCB and CEC water policy requirements in the context of the design of the entire plant, and has designed the plant to minimize water consumption to the maximum extent that is consistent with the welfare of the citizens of the State. The plant will use of water cooling only for the air inlet chiller system. Air inlet cooling is essential to the welfare of the citizens of the State in that it will augment power output of the units during hot weather when the power is needed most.

Orange Grove Energy has evaluated all potential sources of water in the Project area and, other than fresh water, there is no feasible water source. During operations, Orange Grove Energy will continue to evaluate potential alternative water source opportunities and will implement an alternative water supply if an appropriate supply becomes available.

Considering measures integrated in the Project design to reduce water use to that minimally essential for the citizens of the State, and considering there are no feasible non-fresh water sources, the project will be consistent with CEC and SWRCB policies.

5.4 ELECTRICAL TRANSMISSION LINE ALTERNATIVES

The Pala substation was designated by SDG&E in the RFO process as the preferred interconnect point. Orange Grove Energy submitted its interconnection request to the CAISO on April 19, 2007. The request identified the Pala substation as the primary interconnection point. The feasibility study has been completed and the impact study is in progress. CAISO expects to complete the impact study in October 2007. The facility study is expected to be completed in

March, 2008. Following the facility study and the completion of the interconnection agreement between the project and SDG&E, the interconnection facilities will be constructed by SDG&E. The interconnection facilities will include upgrades to the Pala substation and any system reinforcement required by CAISO.

Alternative transmission options would involve above ground lines and/or new substations. A 230 kV circuit crosses in close proximity to the site, but it does not enter the Pala substation. Connection with the 230 kV circuit would require above ground lines and a new substation.

5.5 GENERATION TECHNOLOGY ALTERNATIVES

5.5.1 Selection Methodology

Technologies considered were those that could provide rapidly available peak or mid-merit power to meet, as closely as practical, SDG&E's stated needs in the RFO.

The alternatives considered included other fuels, ranging from coal and biomass to oil and waste fuels. These fuels, however, do not provide the project with the environmental benefits of natural gas, and were rejected.

Alternative technologies for power generation were also considered. These included solar, wind, hydroelectric, nuclear, and fuel cell generation, all of which were determined to be cost prohibitive and infeasible for this project. In addition, bio- diesel was determined to be infeasible as its use would not comply with air quality limits, and fuel supply is limited.

5.5.2 Alternative Natural Gas-Fired Technologies

5.5.2.1 Combined-Cycle (Selected) Generating Technology

This technology integrates the Brayton cycle (simple-cycle combustion turbine) with the Rankine cycle (steam turbine) to achieve higher overall plant efficiencies. The simple-cycle combustion turbine normally exhausts spent gases directly to the atmosphere, although a considerable amount of energy is still present. In the combined-cycle technology, the exhaust gas is passed through a heat recovery unit creating steam that is used to drive a steam turbine/generator. The resulting efficiency for the combined system is 50 to 60 percent, which is considerably greater than most other alternatives. The combined-cycle system, therefore, is usually one benchmark against which other technologies are compared.

While this technology is commercially available, and some systems that include once-through steam generators (OTSG) allow for relatively rapid start-up times, at least to part load, considerable quantities of water are required in steam production, and plant footprint and vertical height are greatly increased, adversely affecting visual impact. Considering these factors, the proposed Project does not incorporate combined-cycle technology.

5.5.2.2 Conventional Boiler-Steam/Turbine

A conventional boiler was determined to be unsuitable for this project due to required quick ramp rates for peaking operations and environmental reasons (e.g., water consumption).

5.5.2.3 Supercritical Boiler-Steam/Turbine

A supercritical boiler was determined to be unsuitable for this project due to required quick ramp rates for peaking operations and environmental reasons (e.g., water consumption).

5.5.2.4 Simple Combustion Turbine

This technology uses a combustion turbine to drive a generator. Air is compressed in the compressor section of the combustion turbine, passes into the combustion section where fuel is added and ignited, and the hot combustion gases drive a turbine, which in turn drives not only the compressor section of the combustion turbine but also a generator. The combustion turbines have a relatively low capital cost with efficiencies of 37 percent or higher in the larger units. Because the combustion turbines are fast starting and have a relatively low capital cost, they are used primarily for meeting high-peak demand (3,000 hours per year or less), when their relatively low efficiency is not as great a concern. Applying the review methodology, this technology is commercially available, and can be implemented at the identified site. The cost of generation is relatively high, approximately 5.5 to 7.5 cents per kilowatt-hour, depending on fuel costs. However, this technology typically is used to generate electrical power during peak-demand periods, when electricity costs are typically higher.

5.5.2.5 Advanced Gas Turbine Cycles

Numerous efforts in the industry have been made to enhance the performance and/or efficiency of gas turbines by injecting steam, intercooling, and staged firing. These include the massively steam-injected gas turbine (Cheng cycle), the recuperated combustion turbine, the intercooled combustion turbine, the chemically recuperated gas turbine, and the humid air turbine cycle.

- The Cheng cycle, which combines the Brayton and Rankine cycles into one unit based on a modified Rolls Royce (formerly Allison) flight engine, is commercially available from Cheng Power Systems. It is a small unit (6 MW nominal) with efficiency approaching that of the LM6000. Its small size disqualifies it from consideration, as does the fact that all steam used in the unit is lost to the atmosphere through the stack, meaning that water needs are very high. Clearly, this is unacceptable for this Project. Cheng and GE have teamed to offer similar technology using GE's LM2500 unit, for power production similar to that of the LM6000 at greater efficiencies. Unfortunately the total loss of water disqualifies it from consideration.
- A recuperated unit, the Mercury 50, is commercially available from Solar Turbines, Inc. This is a small unit (5.5 MW) and cycle efficiency, while excellent for a small unit, is no better than that available with the LM6000. Therefore, this technology was eliminated from consideration.

- The intercooled combustion turbine is available in the form of the GE LMS 100, discussed more fully above. As noted, this unit received careful consideration for use at the Project but was ultimately rejected because of the relative technology risk as compared to the LM6000, the increased footprint requirement when equipped with an air-cooled intercooler, and the marginal expected efficiency increase when equipped with an air-cooled intercooler.
- Staged combustion, whereby fuel is introduced at two points in the combustion zone, is available in the Alstom GT 24. This is a very large industrial unit (180 MW) and does not meet the project requirements for a peaking unit.

5.5.3 Alternative Combustion Turbine Technologies

The proposed nominal 96-MW configuration of the Project is the result of a variety of design and operating considerations. The LM6000 PC SPRINT was selected due to:

- Efficiency and good operating economics – the LM6000 is among the most efficient combustion turbines available, with a full-load efficiency of approximately 40 percent (LHV).
- Lack of technology risk – over 600 LM6000s are in service which have accumulated over 10 million operating hours. While all rotating machinery presents maintenance issues from time to time, the LM6000 is a relatively known quantity.
- Staff familiarity with LM6000 units – operating and management personnel with LM6000 experience are relatively plentiful given the large number of similar facilities in operation. As well, training times can be expected to be relatively short which should deliver a more reliable project sooner.

The GE LMS 100 received careful consideration for use in the Project. The LMS 100 is a new offering from GE combining the core (high pressure compressor, combustor, high pressure turbine, intermediate pressure turbine) of a CF6-80E flight engine, which is a very close relative of those components installed in the LM6000, with a low pressure compressor derived from the GE Frame 6 heavy-duty CTG, and a new, industrial power pressure turbine derived from the GE90 flight engine. (The generator is driven from the power turbine in a hot end-drive configuration.) Flow from the low pressure compressor is ducted outside of the unit through an intercooler and then back into the combustor, greatly increasing mass flow. The intercooler can be either air- or water-cooled, although at the Project site air-cooling would be required. The LMS 100 was evaluated in detail for the Orange Grove Project and the following conclusions were made:

- Technology risk – the LMS 100 was introduced into service in 2005 and only a very few machines are in commercial operation. Major parts life is not yet known. Many newly introduced CTG technologies have required several years of manufacturer-sponsored improvement before achieving an adequate service life.
- Footprint – two LM6000s have a smaller footprint than a single LMS 100 when an air-cooled intercooler is incorporated into the LMS 100 design.

- Efficiency -- the LMS 100 has significantly higher published full-load efficiency than does the LM6000 when a water-cooled intercooler is employed, 46 percent vs. 40 percent HHV considering the CTG alone. However, at the Project site, an air-cooled intercooler would be required, and fuel gas compressors of higher horsepower would be required due to the higher combustion pressures encountered in the LMS100. Therefore the net installed advantage to the LMS 100 would be expected to be no more than approximately 2 – 3 percent. While this is significant, the applicant does not believe that it outweighs the other factors under consideration.

Other simple cycle combustion turbines considered included:

- The Rolls Royce RB211-6761 – produces lower output than does the LM6000 SPRINT and so would require three units to provide the output of two LM6000s, disqualifying it from further consideration.
- The Rolls Royce Trent 60 – while slightly more efficient than the LM6000 SPRINT and of a comparable size, it has experienced technological problems which have prevented its widespread commercial acceptance. Therefore, the applicant viewed its technology risk as unacceptable.
- The Pratt and Whitney FT8 TwinPack – while having a published output similar to the LM6000, it is actually comprised of two combustion turbines driving a common generator. Thus the Project would be made up of four combustion turbines and two generators, likely reducing reliability and nearly doubling CTG maintenance costs. As well, efficiency is some 3 percent lower than the LM6000's. For these reasons, the FT8 TwinPack was dropped from further consideration.

5.5.4 Alternative Emissions Control Technologies

As described in Section 2.0, the proposed CTG will feature the use of water injection to the turbine in order to reduce NOx formation. Turbine NOx emissions will be further controlled by the use of a SCR system, and CO and VOC emissions will be controlled by an oxidation catalyst system. This control strategy for NOx, CO and VOC emissions is widely used in CTG projects and has a demonstrated track record of success in the industry. For this reason, both the regulatory community and gas turbine manufacturers recognize this combination of technologies as the BACT standard.

Two emerging technologies received consideration in the Project. XONON is a flameless catalytic system for NOx emissions control developed by Catalytica Combustion Systems and has achieved 4 ppmvd and lower NOx emissions in a 1.5 MW Kawasaki simple- cycle turbine. The technology was acquired by Kawasaki in 2006. There is no experience yet on a large scale commercial turbine, and the technology is not offered for the LM6000 series. For these reasons, this technology was eliminated.

SCONOX is another new technology for NOx emissions control, and was developed by Goal Line Environmental Technologies. SCONOX uses a catalyst with a potassium carbonate absorption coating. NOx is reacted with the coating to form potassium nitrites and nitrates,

without the use of ammonia, in a temperature window between 280 to700 F. These reaction products deposit on the coating, so it must be regenerated later in order to sustain its performance. The regeneration step involves formation of new potassium carbonate, thereby refreshing the coating with no net consumption of the potassium carbonate. This temperature range of 280 to 700 F, however, is much lower than the LM6000 operating temperatures of 837°F (at 100% load) to 956° F (at 50% load), rendering the technology unsuitable for the Project. In addition, SCONOX has not been demonstrated in simple- cycle peaking turbine operation. Consequently, the technology was not selected for use in the Project.

5.6 REFERENCES

California Energy Commission, 2003 Integrated Energy Policy Report

Guidance for Power Plant Siting and Best Available Control Technology, California Air Resources Board, Stationary Source Division, June 1999

Imperial Irrigation District, Niland, Application for Small Power Plant Exemption, Submitted to California Energy Commission March 13, 2006

Kings River Conservation District Peaking Plant, Application for Small Power Plant Exemption, Submitted to California Energy Commission November 26, 2003

Riverside Energy Resource Center , Application for Small Power Plant Exemption, Submitted to California Energy Commission April 26, 2004

Volturino, Lenore. Director of Environmental Services, Pala Band of Mission Indians. Personal communication, June 27, 2007.