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March 3, 2011

Iain Fisher
CEQA Project Manager
Energy Division
California Public Utilities Commission
c/o Dudek
605 Third Street
Encinitas, California 92024

Greg Thomsen
Project Lead
United States Bureau of Land Management
c/o Dudek
605 Third Street
Encinitas, California 92024

Re: Calculating the Tule Wind Project's Capacity to Offset Greenhouse Gas and Criteria Air Pollutant Emissions in California

Dear Messrs. Fisher and Thomsen:

Iberdrola Renewables, Inc. (IRI), proponent of the Tule Wind Project, submits the following analysis to illustrate the benefits of the Tule Wind Project, as modified, and the drawbacks to Tule Wind Alternative 5, which would eliminate at least one half of the Project's electric power production and corresponding environmental benefits provided through the displacement of fossil fuel fired power production.

I. Description of the Proposed Tule Wind Project and the Modified Project Layout

As studied in the Draft Environmental Impact Report / Draft Environmental Impact Statement (DEIR/DEIS), the Tule Wind Project will consist of up to 134 wind turbines, from 1.5 to 3.0 megawatts (MW), and would have a generating capacity of 201 MW. DEIR/DEIS, Section B, page B-2, Table B-1.

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Through its comments on the DEIR/DEIS, Tule Wind, LLC has submitted a Modified Project Layout, which makes minor adjustments to the Tule Wind Project studied in the DEIR/DEIS to avoid resources and reduce total project impacts. If accepted as proposed, the Modified Project Layout would slightly reduce the maximum number of wind turbines to be constructed in the Tule Wind Project from 134 to 128 turbines, while continuing to have a generating capacity of 201 MW.

A. Tule Wind Alternative 5

One of the alternatives to the proposed Tule Wind Project studied at depth in the DEIR/DEIS is Tule Wind Alternative 5 (Alternative 5), which proposes the elimination of the portions of the project with the strongest winds, including the ridge, and which would result in the loss of 62 of the 134 turbines in the Tule Wind Project. As described in the DEIR/DEIS:

> Under this alternative, the proposed Tule Wind Project would be the same as that described in Section B of this EIR/EIS with the exception that this alternative would remove 62 turbines including J1 through J15; K1 through K12; L1 through L11; M1 and M2; N1 through N8; P1 through P5; Q1 and Q2; R1 through R10, and R13. Note that there are no turbines labeled J7, J12, K6, or K10.

DEIR/DEIS, Section C, page C-40. The 62 wind turbines that would be removed from the Tule Wind Project by Alternative 5 are graphically represented in Figure 1, “Original EIR Layout – Alternative 5.”

If the Tule Wind Project is modified as described above in the Modified Project Layout, however, the number of wind turbines that would be affected by Alternative 5 would increase slightly, from 62 to 65 turbines. *See* Figure 2, “Current Modified Layout – Alternative 5.”

Accordingly, if the Modified Project Layout is accepted, the maximum build-out of the Tule Wind Project would be 128 wind turbines. If both the Modified Project Layout and Alternative 5 are selected, however, the maximum build-out of the Tule Wind Project would be 63 wind turbines (128 wind turbines less 65 wind turbines removed by Alternative 5).

B. Alternative 5 Would Significantly Reduce the Tule Wind Project's Capture of Potential Wind Energy

The Tule Wind Project is comprised of turbine sites that can topographically be described as either "ridge" turbines (turbines located on wind-swept ridges that are elevated from surrounding geographic features) or "valley" turbines (turbines located in areas that are lower than the surrounding geographic features). The average observed wind speed at the "ridge" turbine locations in the Tule Wind Project is higher than that for the "valley" turbine locations.

Based on six years of meteorological data, the wind speed at the "ridge" turbine locations (identified in Figure 1 as the J, K, L, M, N, P, and Q string turbines, and in Figure 2 as the H, I, J, K, L, M, N, P, and Q string turbines) is 8.0 meters per second. In contrast, the average wind speed at the "valley" turbine locations (identified in Figure 1 as the A, B, C, D, E, F, G, and R string turbines, and in Figure 2 as the A, B, C, D, E, F, G, R, S, and T string turbines) is 7.3 meters per second.

The power available in the wind is proportional to the cube of the wind speed. *See* Gasch, R., Twelve, J., Wind Power Plants: Fundamentals, Design, Construction, and Operation at p. 181 (Solarpraxis Publishing 2004). Accordingly, the Tule Wind Project's "ridge" turbines will generate substantially more energy than the "valley" turbines, simply by virtue of the fact that average wind speed at those locations is higher.

Furthermore, because Alternative 5 would eliminate all of the "ridge" turbines within the Tule Wind Project (see DEIR/DEIS, Section C, page C-40 [Alternative 5 eliminates J1 through J15; K1 through K12; L1 through L11; M1 and M2; N1 through N8; P1 through P5; Q1 and Q2; R1 through R10, and R13]), it would disproportionately affect the Tule Wind Project's ability to capture potential wind energy within the project area by removing all of the higher energy "ridge" turbines.

As illustrated in Table 1, below, even though there are less "ridge" turbines than "valley" turbines in the original 134 turbine layout and 128 turbine Modified Project Layout, under both scenarios the "ridge" turbines will produce a greater proportion of the project's energy. Under the 134 turbine layout, although "ridge" turbines only comprise 38% of the total turbines, they would generate over 43% of the project's energy. For the Modified Project Layout, although "ridge" turbines only comprise 44% of the total turbines, they would generate 50% of the project's energy.

Table 1. Ridge and Valley Turbine Breakdown, and the Effect of Alternative 5 on Potential Wind Energy Generation

	134 Turbine Layout	Alternative 5 (72 turbines)	128 Turbine Layout	Alternative 5 (63 turbines)
Ridge Turbines	51	0	57	0
Valley Turbines	83	72	71	63
% Ridge Turbines	38.1%	0%	44.5%	0%
Wind Speed Ridge, m/s	8.0	n/a	8.0	n/a
Wind Speed Valley, m/s	7.3	7.3	7.3	7.3
Wind Energy per Ridge Turbine[1]	512	n/a	512	n/a
Wind Energy per Valley Turbine	389	389	389	389
Total Energy, Ridge Turbines[2]	26,112	n/a	29,184	n/a
Total Energy, Valley Turbines	32,288	28,009	27,620	24,508
Total Energy	58,400	28,009	56,804	24,508
% Total Energy, Ridge Turbines	44.7%	n/a	51.4%	n/a
% Energy Reduction, Alternative 5	**n/a**	**(52.0%)**	**n/a**	**(56.9%)**

Table 1 Notes.
1. Wind energy is proportional to wind speed ^ ^{3}.

2. Total wind energy = # of turbines * wind energy per turbine.

Furthermore, as illustrated in Table 1, if Alternative 5 is applied to the 134 turbine project layout, it will reduce the Tule Wind Project's ability to capture wind energy by 52%. If Alternative 5 is applied to the Modified Project Layout, it will reduce the Tule Wind Project's ability to capture wind energy by 56.9%.

Not only will this loss in ability to capture potential wind energy affect the Tule Wind Project's renewable energy generation, but it will also diminish the project's ability to accomplish other important public benefits, including offsetting existing greenhouse gas emissions, criteria air pollutant emissions, and water use from fossil-fuel fired electricity generation. The following section provides a comparison of the Tule Wind Project's potential to offset greenhouse gas emissions, criteria air pollutant emissions, and water use, and describes the reduction in that potential if Alternative 5 were to be selected.

II. Analysis of the Tule Wind Project's Potential to Offset Greenhouse Gas Emissions, Criteria Air Pollutant Emissions, and Water Use From Fossil-Fuel Fired Electrical Generation

A. Tule Wind Project Will Most Likely Displace Older Natural Gas-Fired Generation

Due to their low variable operating cost and contract type (as compared to natural gas-fired power plants) hydroelectric, nuclear, and coal-fired power plants are typically operated continuously at full load. In contrast, it is California's natural gas-fired projects that are ramped up and down to meet the incremental changes in demand that occur during the day. Therefore, the generation type mostly likely to be offset by the renewable electricity generated by the Tule Wind Project will be natural gas-fired units.

Natural gas-fired power plants built in recent years are increasingly energy efficient, and more are employing air cooling systems, which significantly reduces water use. These state of the art projects have low heat rates (high efficiency). Accordingly, it is likely that the Tule Wind Project's electricity will displace electricity that otherwise would have been generated by the older, less efficient natural gas-fired plants that employ water cooling systems because of their higher variable cost as compared to the newer more efficient plants. Therefore, in the California Independent System Operator (CalISO) system where plants with the higher variable operating costs are dispatched down first, the wind energy from the Tule Wind Project would likely displace generation from the older combined-cycle, water-cooled gas-fired power plants.

The Tule Wind Project's net capacity factor is approximately 0.31 (based on six years of meteorological data measured at the site), and includes estimated losses in collecting and transforming the wind power to 138 kV for delivery to the San Diego Gas & Electric (SDG&E) transmission system. Using this net capacity factor, it is possible to estimate the amount of greenhouse gas (GHG) emissions that the Tule Wind Project will offset from California-based natural gas-fired generation by relying on CO_2 emission estimates prepared for the California Public Utilities Commission (CPUC).[1] *See* E3, "New Combined Cycle Gas Turbine (CCGT) Generation Resource, Cost, and Performance Assumptions" (November 2007), *available at* http://www.ethree.com/GHG/21%20Gas%20CCGT%20Assumptions%20v4.doc.

It is also possible to conservatively estimate the amount of criteria air pollutant emissions and water use that will be offset by the Tule Wind Project. This analysis conservatively assumes that the Tule Wind Project will displace generation from SDG&E's Palomar Power Project (or a plant of similar generating capacity). The Palomar Power Plant is located in San Diego County, in the City of Escondido, and is a modern, efficient, natural gas generating station that began commercial operations in 2006. *See* http://www.energy.ca.gov/sitingcases/palomar/index.html. Accordingly, if the Tule Wind Project displaces generation from older and less efficient power plants than Palomar, the amount of criteria air pollutant emissions and water use offset will be higher than calculated below.

B. Calculating the Tule Wind Project's Ability to Offset Greenhouse Gas Emissions, Criteria Air Pollutant Emissions, and Water Use

1. Tule Wind Project's Ability to Offset Greenhouse Gas Emissions

Using CPUC estimates of carbon dioxide (CO_2) emissions rates for natural gas-fired generation, the Tule Wind Project will offset approximately 231,744 metric tons of CO_2 per year, generating a net reduction in CO_2 emissions of 231,407 metric tons per year.[2] *See* Table 2, Tule Wind Project Greenhouse Gas Offset Calculation. If the GHG emissions offset from the embodied energy in water saved from the Tule Wind Project is added (803 metric tons of CO_2 emissions per year), the Tule Wind Project would offset 232,210 metric tons of CO_2 emissions per year. *See id.*

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1 The net capacity factor of a wind project is the ratio of the actual output of the project over a period of time and its output if it had operated at full nameplate capacity the entire time. A wind project's net capacity factor is less than 1.0 because the wind does not blow constantly.

2 This calculation accounts for the Tule Wind Project's 337 metric tons of CO_2 emissions per year, including yearly operational emissions (73 metric tons of CO_2 emissions per year) and amortized annual construction emissions (264 tons of CO_2 emissions per year).

Table 2. Tule Wind Project Greenhouse Gas Offset Calculation

Natural Gas-Fired Electricity Generation Tule Wind Would Offset	
Tule Net Capacity Factor (%)[1]	0.31
Tule's Annual generation per MW of wind turbine capacity (MWh)[2]	2,716
Tule Annual Generation at 201 MW (MWh)[3]	545,836
CO_2 Emissions From California-based Natural Gas-Fired Power Plant Operations	
CO_2 emitted from CA natural gas-fired power plant[4] (lbs/million BTU)	117
Assumed Heat Rate (BTU/kWh)[5]	8,000
Natural gas consumed per MWh (million BTU)	8
CO_2 emitted from CA natural gas-fired power plant (lbs/MWh)	936
Metric tons (MT) of CO_2 per MWh[6]	0.4246
CO_2 Emissions Avoided by 201 MW Tule Wind Project Operations	
Tule's Annual CO_2 offset per MW of wind turbine capacity (MWh)	1,153
Tule's Annual CO_2 emissions, incl. amortized construction (MT)	337
Tule's Annual CO_2 Offset at 201 MW (MT)	**231,744**
Tule's Net Annual CO_2 Offset at 201 MW[7] (MT)	**231,407**
Tule's Annual CO_2 Offset at 201 MW for Avoided Water Use[8] (MT)	803
Tule's Net Annual CO_2 Offset at 201 MW, incl. Avoided Water Use (MT)	**232,210**
CO_2 Emissions Offset Lost by Alternative 5	
Alternative 5 annual CO_2 offset loss (72 turbines) (MT)[9]	**(120,749)**
Alternative 5 (Modified Project Layout) annual CO_2 offset loss (63 turbines) (MT)[10]	**(132,128)**

Table 2 Notes:

1. The 0.31 Tule Net Capacity Factor is based on three years of meteorological data measured at the site. This is a net capacity factor so losses in collecting and transforming the power to 138 kV for delivery to the San Diego Gas and Electric transmission system have been subtracted from the gross power production.
2. Calculation: 0.31 net capacity factor * 8,760
3. Calculation: Annual generation per MW * 201 MW
4. Source: *See* E3, "New Combined Cycle Gas Turbine (CCGT) Generation Resource, Cost, and Performance Assumptions" at 1 (November 2007), *available at* http://www.ethree.com/GHG/21%20Gas%20CCGT%20Assumptions%20v4.doc.
5. Source: *See* E3, "New Combined Cycle Gas Turbine (CCGT) Generation Resource, Cost, and Performance Assumptions" at 1, n.3 (November 2007), *available at* http://www.ethree.com/GHG/21%20Gas%20CCGT%20Assumptions%20v4.doc.
6. This calculation is a conservative estimation of the GHG emissions the Tule Wind Project will offset. The U.S. Energy Information Administration calculates that U.S. natural gas generation in 1999 emitted 337 million metric tons of CO_2 to generate 562 million MWh of electricity, for a CO_2 per MWh rate of .5996. *See* http://www.eia.doe.gov/electricity/page/co2_report/co2report.html#electric, Table 1.
7. Calculation: Tule's Annual CO_2 offset * 201 MW – Tule's Annual CO_2 emissions.
8. Source: Valorie Thompson, Ph.D., Scientific Resources Associated, Letter Report to Patrick O'Neill, HDR Inc. (Jan. 31, 2011).
9. Calculation: 201 MW annual pollution offset in MT * 52% reduction in energy generation potential.
10. Calculation: 201 MW annual pollution offset in MT * 56.9% reduction in energy generation potential.

2. Tule Wind Project's Ability to Offset Criteria Air Pollutant Emissions

Using the conservative assumption that the Tule Wind Project will displace electricity generation from the Palomar Power Plant (or a plant of similar efficiency), the Tule Wind Project will offset approximately 12.4 short tons/yr of oxides of nitrogen (NOx), 11.1 short tons/yr of particulate matter 10 microns or less in size (PM10), 14.7 short tons/yr of carbon monoxide (CO), 3.8 short tons/yr of oxides of sulfur (SOx), and 3.8 short tons/yr of volatile organic compounds (VOC). *See* Table 3, Tule Wind Project Criteria Air Pollutant Offset Calculation.

Table 3. Tule Wind Project Criteria Air Pollutant Offset Calculation

	NOx	PM_{10}	CO	SOx	VOC
Palomar Power Plant Average Hourly Emissions per 273 MW Unit (lb/hr)[1]	12.5	11.1	15.3	3.8	3.8
Pollutants emitted (lbs/MWh)[2]	0.046	0.041	0.056	0.014	0.014
Tule's annual pollutants emitted (lbs/yr)[3]	164	7	1,180	0	33
Tule's annual pollutant offset (201 MW)[4] (lbs/yr)	24,828	22,186	29,411	7,598	7,565
Tule's annual pollutant offset (201 MW) (short tons/yr)[5]	**12.4**	**11.1**	**14.7**	**3.8**	**3.8**
Criteria Air Pollutant Emissions Offset Lost by Alternative 5					
Tule's annual pollutant offset loss, Alternative 5 (72 turbines) (short tons/yr)[6]	(6.4)	(5.8	(7.6)	(2.0)	(2.0)
Tule's annual pollutant offset loss, Alternative 5 (Modified Project Layout) (63 turbines) (short tons/yr)[7]	(7.1)	(6.3)	(8.4)	(2.2)	(2.2)

Table 3 Notes:

1. Source: "Palomar Power Project", CEC Final Staff Assessment (January 2003), Table 10, p. 4.1-21, assuming each unit operated at 62ºF, 100% load, no duct burning.
2. Calculation: lbs pollutant/273 MW
3. Source: Table D.11-14, Tule Wind Project Daily Operation and Maintenance Emissions, annualized
4. Calculation: 545,836 Tule Annual Generation at 201 MW (128 turbine capacity) * Pounds Pollutant emitted per MWh – Tule Annual pollutants emitted.
5. Calculation: (annual pollution offset in lbs/yr) / (2,002.25 lbs per short ton).
6. Calculation: 201 MW annual pollution offset in short tons/yr * 52% reduction in energy generation potential.
7. Calculation: 201 MW annual pollution offset in short tons/yr * 56.9% reduction in energy generation potential.

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3. Tule Wind Project's Ability to Offset Water Use

Using the conservative assumption that the Tule Wind Project will displace electricity generation from the Palomar Power Plant (or a plant of similar efficiency), the Tule Wind Project will offset approximately 149 million gallons of water per year (approximately 457 acre-feet of water). See Table 4, Tule Wind Project Water Conservation Calculation.

Table 4. Tule Wind Project Water Conservation Calculation

Tule Wind Project Electricity Generation	
Tule Net Capacity Factor (%)[1]	0.31
Annual generation per megawatt of wind turbine capacity (MWh)[2]	2,716
Tule Annual Generation (201 MW) (MWh)[3]	545,836
Tule Wind Project Operational Water Use	
Tule Annual Water Use (million gallons)[4]	.913
Palomar Natural Gas Fire Generation[5]	
Palomar Gas-fired Power Plant Water Use (gal/minute)	2,500
Gas-fired Power Plant Generation (MW)	546
Gas-fired Power Plant Water Use (gal/MWh)	274.73
Annual water use offset (201 MW) (million gallons)[6]	**149**
Water Use Offset Lost by Alternative 5	
Tule's Annual Water Offset Loss under Alternative 5 (72 turbines)(million gallons)[7]	**(77.48)**
Tule's Annual Water Offset Loss under Alternative 5 (63 turbines)(million gallons) [8]	**(84.78)**

Table 4 Notes:

1. The 0.31 Tule capacity factor is based on 6 years of meteorological data measured at the site. This is a net capacity factor so losses in collecting and transforming the power to 138 kV for delivery to the San Diego Gas and Electric transmission system have been subtracted from the gross power production.
2. Calculation: 0.31 net capacity factor * 8,760.
3. Calculation: Annual generation per MW * 201 MW
4. Based on anticipated operational water use of 2,500 gal/day at the Operations & Maintenance Building. See Draft EIR/EIS, pg. D.12-30.
5. Source: "Palomar Power Project", Cal. Energy Commission Final Staff Assessment, January 2003. p. 4.9-A24. The Palomar Energy Project utilizes reclaimed water from City of Escondido's Hale Avenue Resource Recovery Facility.
6. Calculation: (Tule Annual Generation (201 MW * (Gas-fired power plant water use/1,000,000) – Tule Annual Water Use)).
7. Calculation: 201 MW annual pollution offset in short tons/yr * 52% reduction in energy generation potential.
8. Calculation: 201 MW annual pollution offset in short tons/yr * 56.9% reduction in energy generation potential.

C. Alternative 5 Will Significantly Decrease the Tule Wind Project's Ability to Offset Existing Greenhouse Gas Emissions, Criteria Air Pollutant Emissions, and Water Use

As described in Table 1, above, if Alternative 5 is applied to the 134 turbine project layout, it will reduce the Tule Wind Project's ability to capture wind energy by approximately 52%. If Alternative 5 is applied to the Modified Project Layout, it will reduce the Tule Wind Project's ability to capture wind energy by approximately 56.9%.

Applying these reductions in wind energy capture to the previously calculated emissions offset benefits that would otherwise be provided by the Tule Wind Project provides an estimate of how Alternative 5 would reduce the Tule Wind Project's ability to offset existing CO_2 emissions, criteria air pollutant emissions, and water use.

As demonstrated in Table 5, below, if Alternative 5 is selected, it will result in the continued emissions of substantial amounts of GHG emissions, criteria air pollutants, and the continued use of substantial water associated with existing natural gas-fired generation.

Table 5. Alternative 5 Offset Loss Per Year

	CO_2 Emissions (MT)[1]	Water Use (million gallons)[2]	NOx (MT)[3]	PM10 (MT)	CO (MT)	SOx (MT)	VOC (MT)
Tule Wind Project Offsets	**232,210**	**149**	**12.4**	**11.1**	**14.7**	**3.8**	**3.8**
Alternative 5 Offset Loss (72 turbines)	(120,749)	(77.48)	(6.4)	(5.8	(7.6)	(2.0)	(2.0)
Alternative 5 Offset Loss, Modified Project Layout (63 turbines)	(132,128)	(84.78)	(7.1)	(6.3)	(8.4)	(2.2)	(2.2)

Table 5 Notes:

1. CO_2 emissions offset reduction drawn from Table 2, above.
2. Water use offset reduction drawn from Table 4, above.
3. Criteria air pollutant emissions offset reduction drawn from Table 3, above.

III. Conclusion

As described in Section D.15 of the DEIR/DEIS, the Tule Wind Project is designed to help California meet major public policy goals associated with the reduction of greenhouse gas emissions, the increase in renewable energy generation, reduction of water use, and reduction of criteria air pollutant emissions. In particular, the Tule Wind Project will help California meet its greenhouse gas targets under AB 32 and renewable energy portfolio standards.

Despite acknowledging this important public policy goals, the DEIR/DEIS currently does not document the degree to which the Tule Wind Project's anticipated offset of existing natural gas-fired greenhouse gas emissions, criteria air pollutant emissions, or water use will help the State achieve these goals. Please consider including the estimated emissions offset figures presented above in the Final EIR/EIS.

Furthermore, the DEIR/DEIS also does not include any information on the amount of existing natural gas-fired greenhouse gas emissions, criteria air pollutant emissions, or water use that would not be offset in the event that Alternative 5 is chosen and at

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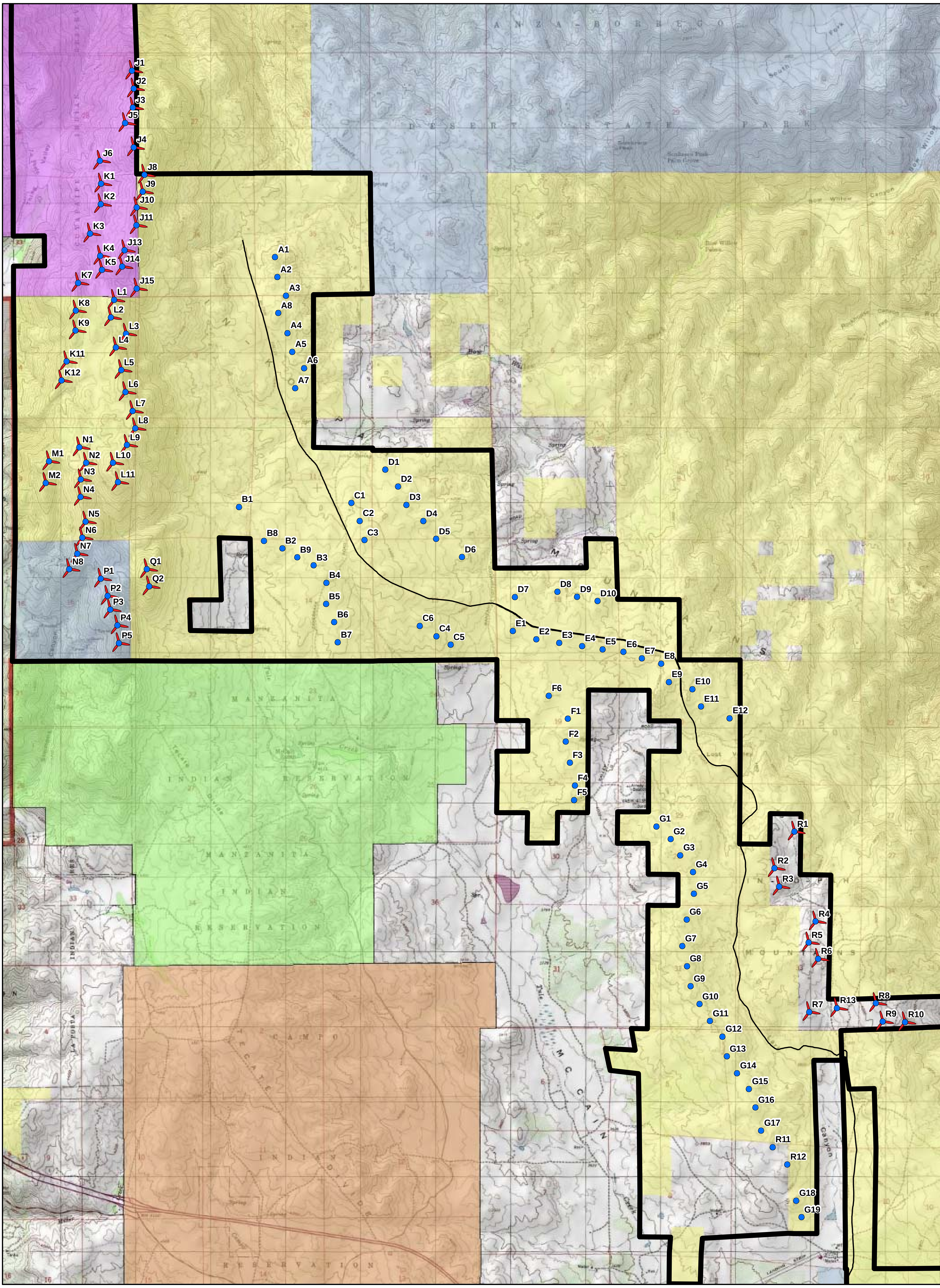
least 62 turbines are removed from the proposed project. Please consider including the reduced offset figures presented above in the Final EIR/EIS as a consequence of selecting Alternative 5.

Sincerely,

Edmund V. Clark, Chemical Engineer
IBERDROLA RENEWABLES, Inc.

Gennaro H. Crescenti, Director, Meteorologist
IBERDROLA RENEWABLES, Inc.

Enclosures



Original EIR Layout - Alternative 5

Tule Wind Project

Legend

- Turbine Removed by Alternative 5
- Original 134 Turbines
- McCain Valley Road
- Site Boundary
- State
- BLM
- Campo Reservation
- Ewiiaapaayp Reservation
- Manzanita Reservation

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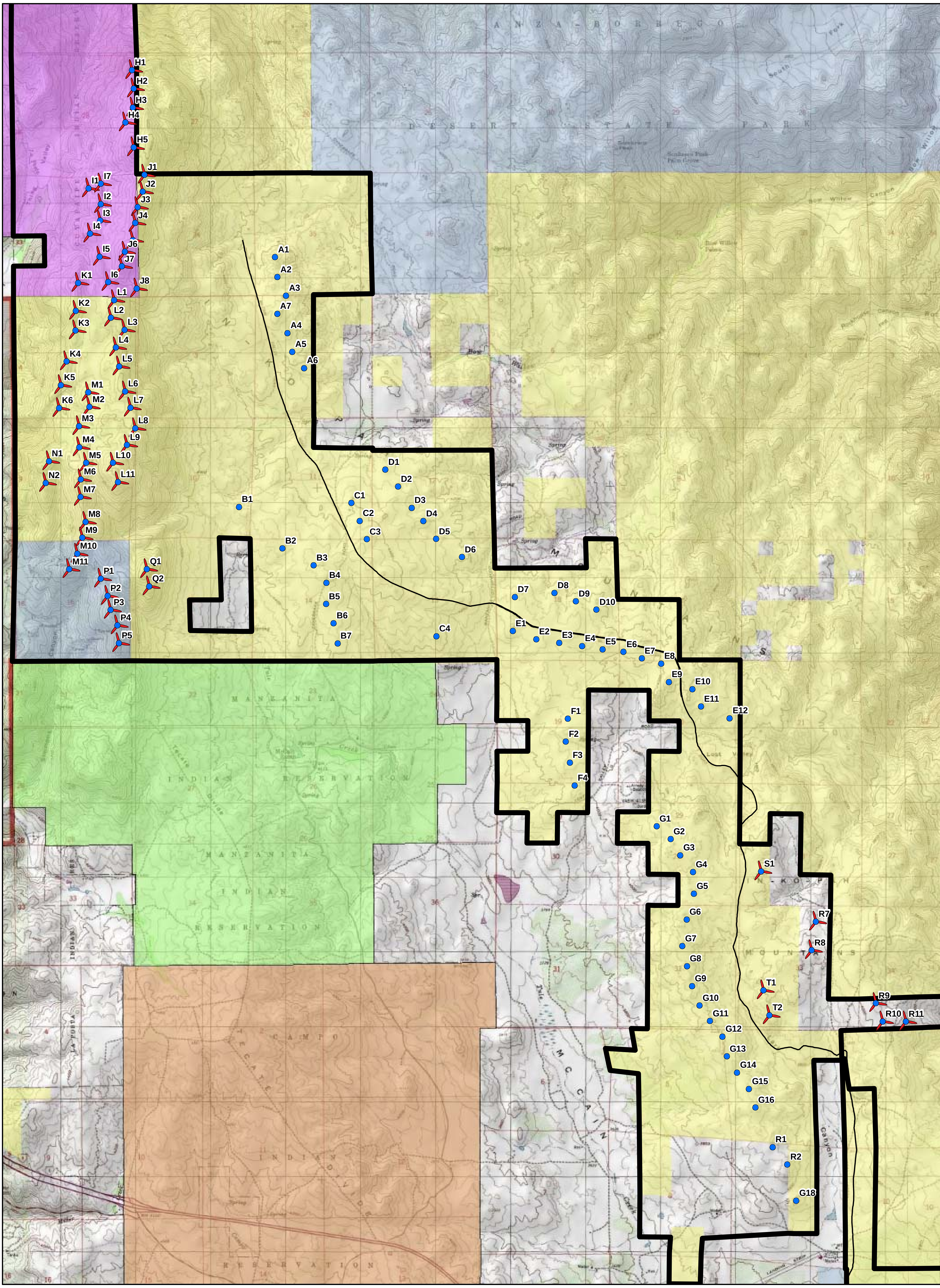

Current Modified Layout - Alternative 5

Tule Wind Project

Legend

- Modified 128 Turbines
- Turbine Removed by Alternative 5
- McCain Valley Road
- Site Boundary
- State
- BLM
- Campo Reservation
- Ewiiaapaayp Reservation
- Manzanita Reservation

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Modified Date: 2/23/2011

Edmund V Clark

Iberdrola Renewables

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E-mail: Ed.Clark@IberdrolaRen.com

Current Occupation

As Director Business Development for Iberdrola Renewables responsible for the development of the Company's California and Pacific Northwest wind power plants; including the 200 megawatt Tule Wind Project in eastern San Diego County and the 300 megawatt Manzana Wind Project in Kern County, California.

Education

BS Chemical Engineering, Montana State University (1973)

MA Management, University of Redlands, (1987)

Professional Affiliations

Senior Member, American Institute of Chemical Engineers

Senior Member, Association of Energy Engineers

Experience

37 year career in energy production and conversion focused on the design, development, construction and operation of clean energy facilities. The last 8 years spent working on wind power project design and development. Prior work in simple- and combined-cycle gas fired plants, biomass, and clean coal facilities. Previous employers have included the Electric Power Research Institute--Advanced Power Systems Division, Texaco, Union Oil of California, American Natural Gas and PPM Energy.

GENNARO H. CRESCENTI

EDUCATION

M. S. Meteorology, Florida State University, 1988
B. S. Earth Science, Southern Connecticut State University, 1984

PROFESSIONAL EXPERIENCE

Iberdrola Renewables (formerly PPM Energy), Portland, OR

Director, Meteorology, May 2008 – Present
Manager, Meteorology, July 2007 – May 2008
Lead/Senior Meteorologist, April 2006 – July 2007

Manage and lead team of meteorologists, engineers, and analysts that is responsible for internal wind and solar resource and project energy assessment for Iberdrola Renewables. Provide meteorological support to Business Development, Renewable Origination, and Asset Management. Responsibilities include on-site surveys and staking locations for meteorology towers, sodars and lidars, quality assurance and quality control of on-site data sets, data analysis, wind resource and energy assessments, wind turbine layout design using GIS, wake loss determination, turbine micrositing, site suitability analysis, and operational performance of wind farms and reconciliation against original energy predictions.

FPL Energy, Juno Beach, FL

Meteorologist, February 2003 – April 2006

Provided meteorological support to development and operation of numerous wind farms. Responsibilities include wind resource assessments, site surveys, wake losses analysis, turbine layout and optimization, investigation of operating assets, relocation of underperforming wind turbines. Evaluation of external wind resource assessments and reports from external consultants, specification of meteorological instruments, configuration, and meteorological tower deployments. Areas of interest include short-range forecasting, seasonal probability outlooks, and long-term variability of wind resource, and application of advance sensor technologies.

NOAA Air Resources Laboratory, Idaho Falls, ID

Meteorologist, September 1997 – February 2003

Provided meteorological support to Department of Energy's (DOE) Idaho National Engineering and Environmental Laboratory (INEEL). Analyzed meteorological data from INEEL Mesonet, including developing climatology of atmospheric boundary layer over Snake River Plain from radar wind profiler and radio acoustic sounding system. Participated in transport and diffusion experiments at several study sites (Dugway Proving Ground, Salt Lake City, Snake River Plain). Principal investigator of aircraft-based air-sea research studies using state-of-the-science instrumentation suite on Long-EZ aircraft. Helped in development of advanced instrumentation including extreme turbulence (ET) probe for measurement of turbulence in hurricane force winds. Continued research with Doppler sodars for various field studies.

NOAA Air Resources Laboratory, Research Triangle Park, NC

Physical Scientist, June 1992 – September 1997

Provided technical and scientific guidance to Environmental Protection Agency on meteorological instruments and observation techniques. Helped develop guidance on ground-based remote sensors including Doppler sodars, radar wind profilers, and radio acoustic sounding systems (RASS). Aided in development of meteorological guidance for the Photochemical Assessment Monitoring Station (PAMS) network for ozone nonattainment regions. Other research activities included investigation of air pollution episodes from coal-burning power plant in northern Thailand, effect of clouds on incoming UV-B radiation, and dispersion of inert tracer gases.

North Carolina State University, Raleigh, NC

Graduate Research Assistant, August 1991 – June 1992

Air-sea interaction research of light-wind regimes over tropical oceans to improve understanding behavior of large scale global phenomena.

Woods Hole Oceanographic Institution, Woods Hole, MA

Research Assistant III Meteorologist, April 1988 – August 1991

Responsibilities included testing and evaluation of various in-situ meteorological instruments to improve turbulent flux measurements over the ocean from ships and buoys. Variables included wind speed and direction, air temperature, relative humidity, barometric pressure, precipitation, incoming solar and longwave radiation. Participated as flight scientist in the Experiment on Rapidly Intensifying Cyclones Over the Atlantic (ERICA) and on research cruise deploying research buoys.

Florida State University, Tallahassee, FL

Graduate Research Assistant, August 1984 – March 1988

Conducted air-sea interaction research of nonhomogeneous marine atmospheric boundary layer across sea-surface temperature fronts. Participated in the Frontal Air-Sea Interaction Experiment (FASINEX) as flight scientist on NCAR Electra and NRL P3 aircraft. Aided in design of research flight plans and forecasts.

PROFESSIONAL MEMBERSHIPS AND ACTIVITIES

American Meteorological Society (1983 - Present)
AMS Committee on Measurements, (1997 - 2002), Chair (1998 - 2001)
AMS Energy Committee (2009 – Present)
AMS Renewable Energy Committee (2010 – Present), Co-chair (2011 – Present)

ANSI/ANS-3.11 Work Group for Determining Meteorological Information at Nuclear Facilities.

National Research Council (NRC) Research Advisor (July 1999 - February 2003)

NOAA / Office of Oceanic and Atmospheric Research (OAR) Outreach Committee (May 2000 - February 2003)

Chair, *Eleventh Symposium on Meteorological Observations and Instrumentation*, January 14-18, 2001, Albuquerque, NM, American Meteorological Society.

Organizer, *Short Course on the Introduction to Meteorological Instrumentation and Observation Techniques*, January 14, 2001, Albuquerque, NM, American Meteorological Society.

AWARDS

U. S. Department of Commerce Bronze Medal, October 2000, with Timothy L. Crawford and Jeffrey R. French, *for design and application of a novel airborne instrument system to advance scientific knowledge of air-sea exchange*.

U. S. Department of Commerce Bronze Medal, November 1994, with John E. Gaynor, Alan H. Huber, and J. J. Streicher, *for the provision of technical support to Thailand in an air pollution emergency*.