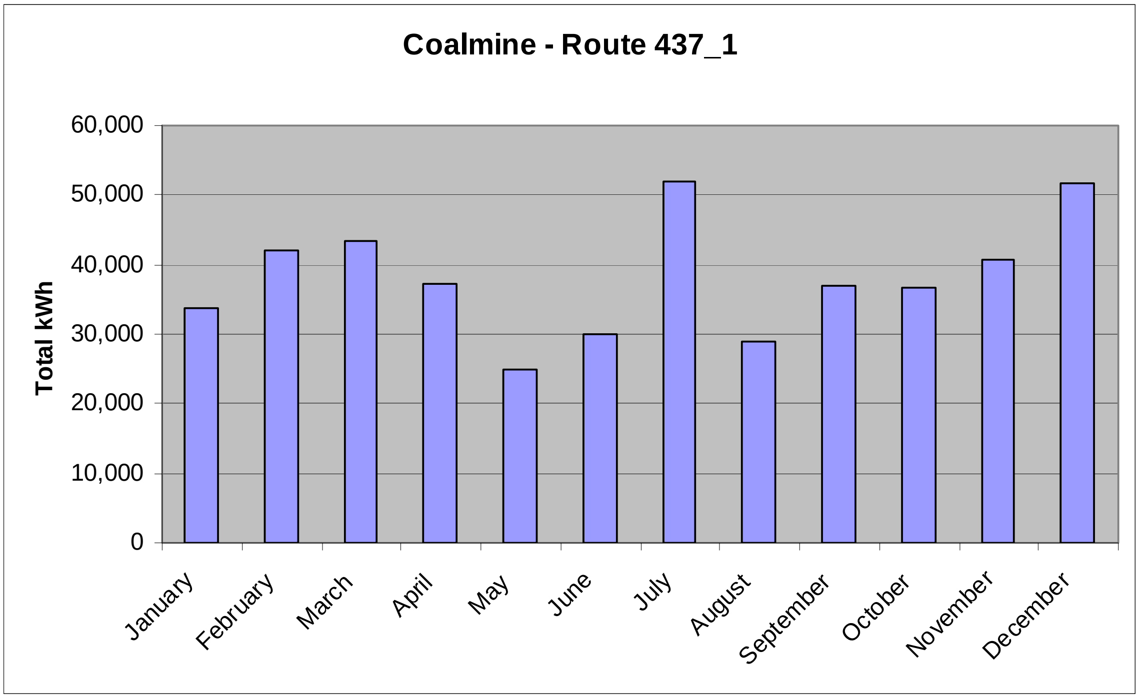
COAL MINE MESA

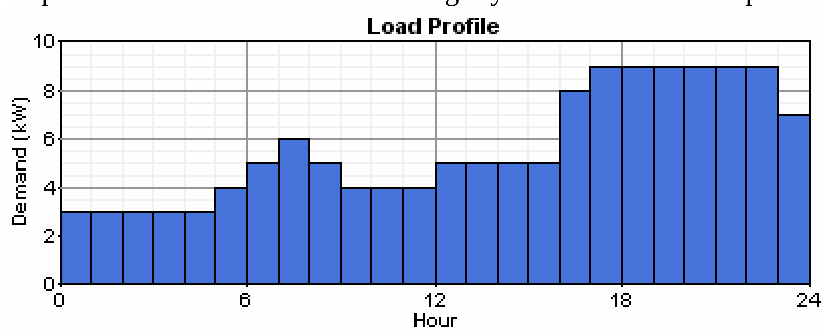
Coal Mine Mesa is an isolated community at the end of a distribution line of approximately 70 miles in length. Power quality and voltage sags are difficult to maintain over that length of distribution line. This makes Coal Mine Mesa a potential candidate for a distributed generation system to provide voltage support. We assumed that voltage drop becomes problematic when the load reaches 100 kW, so the distributed generation system would be called upon to supplement the grid whenever the load exceeded 100 kW.

LOADS

The community of Coal Mine Mesa has 74 customer accounts. The total monthly consumption in Coal Mine Mesa for 2004 is shown below.



The total kWh per year is 458,218. There is no information on the load factor or peak load for the community. NTUA's system-wide load factor is 60.5%, but the load factor for a small community such as Coal Mine Mesa should be much lower. Assuming a 50% load factor would result in a peak load of 105 kW. We also don't have any information on the daily load shape so we used the same estimated load shape used in the White Rock analysis. We scaled that load shape and reduced the randomness slightly to reflect an annual peak load of 105 kW.



SOLAR RESOURCE

Solar Resource data was obtained from NREL's resource database through HOMER's automatic data retrieval mechanism for Latitude 36 6' North and 111 16' West. The annual average radiation is 5.15 kWh per square meter per day. The monthly values reach a high of about 8 kWh per square meter per day during June and a low of about 3 kWh per square meter per day during December and January. The monthly data is shown graphically in Figure 3.

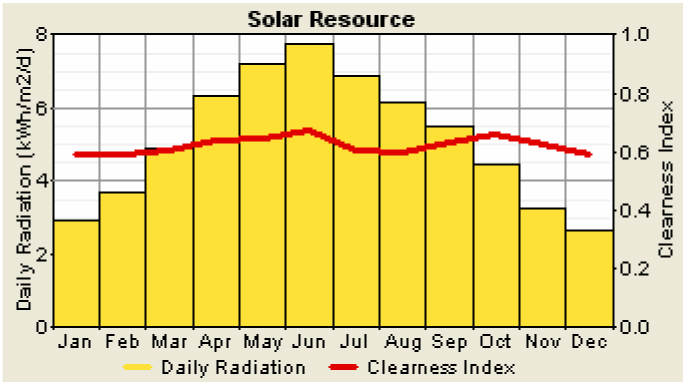


Figure 3

The effect of shorter winter days is clearly evident in the daily radiation columns. To a lesser extent the slight increase in cloudiness during the winter is also apparent. The July – August monsoon is more pronounced for this location than in White Rock, NM.

WIND RESOURCE

The wind resource is much more site specific than the solar resource, nor is good wind data as conveniently available. In the attached spreadsheet we have assembled some available wind data for the Four Corner States. We have used data from Flagstaff as a proxy for Coal Mine Mesa under the assumption that the seasonal and daily patterns and the statistical properties, such as the autocorrelation and Weibull k factor will be similar. The overall strength of the wind resource may be different so a sensitivity analysis was performed on the annual average wind speed, while keeping these other parameters constant. If wind power looks potentially promising a more extensive resource assessment should be performed at the specific site.

NATURAL GAS RESOURCE

The Coal Mine Mesa area is located on the southwestern edge of the Black Mesa basin in Coconino County. The Black Mesa basin is a roughly circular structural downwarp in northeastern Arizona that is approximately 65 miles in diameter. The structure is Larimide in age. Outcrops in the basin center consist of Sediments of Upper Cretaceous age. The rim of the basin is effectively defined by a narrow band of outcrop of the Dakota formation that circles the region.

Surface Geology in the immediate area of Coal Mine Mesa consists of outcrops of Morrison, Dakota, and Mancos formations. The Coal Mine Canyon area contains surface outcrops of Dakota formation including coal beds that have been mined at the Tuba City mine. Coal beds reach a total thickness of up to 10 feet in the Coal Mine canyon outcrop and Tuba City mine area. Coal quality in the Dakota coal of the Coal Mine Mesa area is widely variable, ranging in heat value from 5 to 10,000 Btu/lb, and ash content from 11 to 30%.

Other Cretaceous formations contain coal in the Black Mesa basin, but these younger rocks are removed by erosion in the Coal Mine Mesa area. Coal is present in the Toreva and Wepo formations in the central and northern portions of the basin. Coal is being mined from the Wepo formation in the northern portion of the basin. Thickness of the coals in the mining area reaches

70 feet, and averages 40 feet. These formations are stratigraphic equivalents to the Mesaverde group of sediments in other parts of the Colorado Plateau region.

Oil and gas potential in the Coal Mine Mesa area and the Black Mesa Basin is present primarily in carbonate rocks which are correlative to the Pennsylvanian Paradox formation in the Paradox basin to the north. The correlative productive dolomite facies of the Ismay and Desert Creek sections of the Paradox basin are not present in the majority of the Black Mesa Basin area. The lithology of the Paradox formation is primarily dense crystalline limestones in the basin area. Minor anticlines are mapped at the surface throughout the area of the basin. It is unknown whether these structures are of adequate magnitude to trap oil or gas. The entire sedimentary section in the central portion of the Black Mesa Basin is estimated to be 6500-7000' thick. The section consists of sediments from Cretaceous to Cambrian in age. It includes sandstone in the Permian age Cutler formation, and limestones and dolomites of Mississippian and Pennsylvanian age. Cretaceous sediments, if productive, would be found at shallow depths in structural traps in the central portion of the basin.

The closest oil and gas exploratory test to the Coal Mine Mesa is located approximately 10 miles to the southeast NW NW Sec. 11 T 29 N R 14 E. This well is the Pennzoil United Inc. Pennzoil United #1 Hopi 11. The well was spudded in Jurassic Navajo sandstone, drilled to a total depth of 6945' and encountered Pre-Cambrian rocks at a depth of 6868'. No shows of oil or gas were recorded in this well.

There is no natural gas infrastructure in the area. Significant study of the area is necessary.

GENERATORS

We analyzed two different types of generators, a micro turbine and a reciprocating engine. Both were powered by natural gas. The reciprocating engine had a lower capital cost and higher efficiency, but the micro-turbine had lower maintenance costs. The lower maintenance costs were somewhat offset by a higher standby service call cost, which HOMER does not have a way to model. All of the input assumptions are summarized in Appendix X. We scaled cost data for 250 kW generators down to 30 kW. This underestimates the cost of a smaller generator. Additional analysis is planned looking at more expensive small generators.

RESULTS

The results show that to keep the peak load below 100 kW a dispatchable generator would have to run for 241 hours. Additional analysis could determine how the number of operational hours for the generator depends on the maximum allowable grid demand. It would be appropriate to collect better load data before performing that more detailed analysis.

The results also show that PV is not a viable option for this application because the peak load hours were assumed to be in the evening. If better data showed that the load peaked during the daytime, then further analysis of the PV option would be appropriate.

At 5 and 7 meters per second annual average windspeed, there is sufficient correlation between the wind power and the load to keep the peak grid load below 100 kW. However, this is not nearly as cost-effective as the generator for this application.

Wind Speed (m/s) 7 Natural gas Price ($/m3) 0.4

Double click on a system below for simulation results.

PV (kW)	EW15	Gen1 (kW)	Gen2 (kW)	Conv. (kW)	Grid (kW)	Initial Capital	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	Natural gas (m3)	Gen1 (hrs)	Gen2 (hrs)
		30			100	$ 7,200	$ 185,581	0.032	0.00		511	241	
		30	30		100	$ 34,200	$ 206,447	0.035	0.00		511	241	0
			30		100	$ 27,000	$ 207,455	0.035	0.00	1,186			241
10		30		10	100	$ 84,200	$ 267,574	0.046	0.04		483	228	
10		30	30	10	100	$ 111,200	$ 288,441	0.049	0.04		483	228	0
10			30	10	100	$ 104,000	$ 289,088	0.049	0.04	1,122			228
	1	30			100	$ 127,200	$ 294,268	0.048	0.38		254	119	
	1		30		100	$ 147,000	$ 312,750	0.052	0.38	585			119
	1	30	30		100	$ 154,200	$ 315,134	0.052	0.38		254	119	0
10	1	30		10	100	$ 204,200	$ 376,388	0.061	0.41		241	113	
10	1		30	10	100	$ 224,000	$ 394,705	0.064	0.41	556			113
10	1	30	30	10	100	$ 231,200	$ 397,255	0.064	0.41		241	113	0

Wind becomes cost-effective if there is a need to limit grid demand to 40 kW and the annual average wind speed is 7 meters per second. Limiting the grid demand to that low a level without wind requires so the generator to run for 6,309 hours. With wind the generator run time is reduced to 4,490 hours.

Double click on a system below for optimization results.

Wind (m/s)	PV (kW)	EW15	Gen1 (kW)	Conv. (kW)	Grid (kW)	Initial Capital	Total NPC	COE ($/kWh)	Ren. Frac.	Natural gas (m3)	Gen1 (hrs)
2.874			90		40	$ 21,600	$ 680,467	0.116	0.00	66,752	6,309
5.000			90		40	$ 21,600	$ 680,467	0.116	0.00	66,752	6,309
7.000		1	60		40	$ 134,400	$ 533,421	0.088	0.38	33,458	4,490

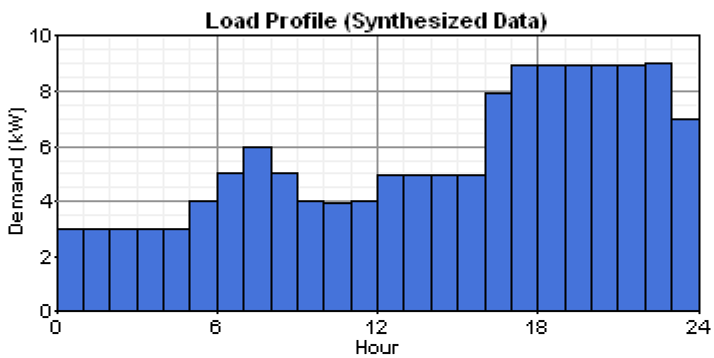
APPENDIX

HOMER INPUT SUMMARY

File name: Coal Mine Mesa 2.hmr
File version:
Author:

AC LOAD: COAL MINE MESA

Data source: Synthetic
Daily noise: 6.2%
Hourly noise: 5.1%
Scaled annual average: 1,255 kWh/d
Scaled peak load: 105.0 kW
Load factor: 0.498



PV

Size (kW)	Capital ($)	Replacement ($)	O&M ($/yr)
1.000	7,000	7,000	0

Sizes to consider:	0, 10 kW
Lifetime:	20 yr
Derating factor:	90%
Tracking system:	No Tracking
Slope:	36.1 deg
Azimuth:	0 deg
Ground reflectance:	20%

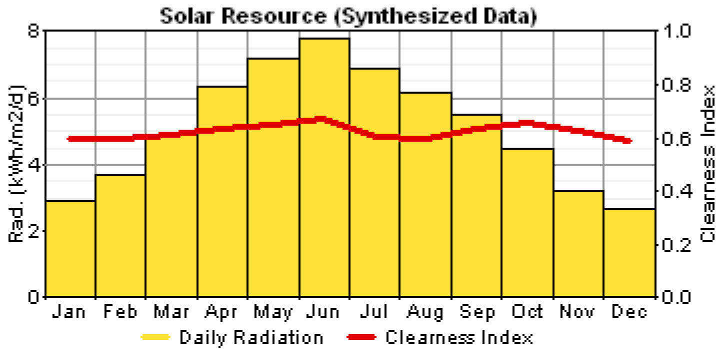
SOLAR RESOURCE

Latitude:	36 degrees 6 minutes North
Longitude:	111 degrees 16 minutes West
Time zone:	GMT -7:00

Data source: Synthetic

Month	Clearness Index	Average Radiation
		(kWh/m^2/day)
Jan	0.596	2.920
Feb	0.596	3.720
Mar	0.609	4.930
Apr	0.639	6.320
May	0.650	7.210
Jun	0.672	7.760
Jul	0.608	6.870
Aug	0.599	6.170
Sep	0.635	5.520
Oct	0.658	4.460
Nov	0.624	3.240
Dec	0.593	2.660

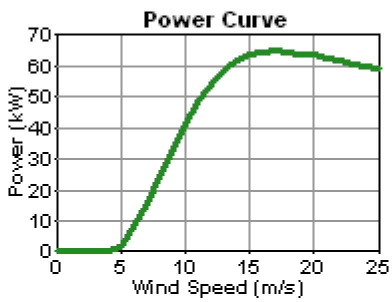
Scaled annual average: 5.15 kWh/m2/d



AC WIND TURBINE: EW 15

Quantity	Capital ($)	Replacement ($)	O&M ($/yr)
1	120,000	100,000	2,000

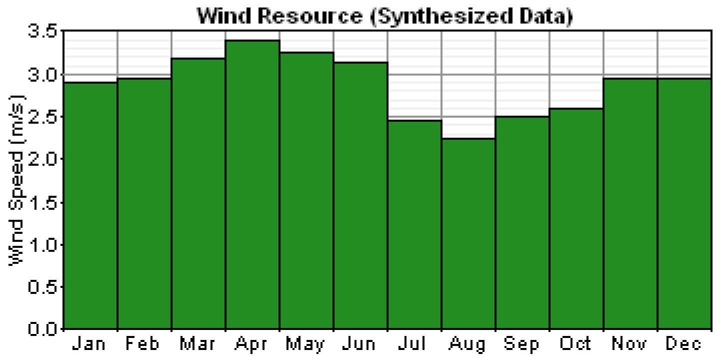
Quantities to consider:	0, 1
Lifetime:	15 yr
Hub height:	25 m



WIND RESOURCE

Data source: Synthetic

Month	Wind Speed (m/s)
Jan	2.91
Feb	2.95
Mar	3.17
Apr	3.40
May	3.26
Jun	3.13
Jul	2.46
Aug	2.24
Sep	2.50
Oct	2.59
Nov	2.95
Dec	2.95

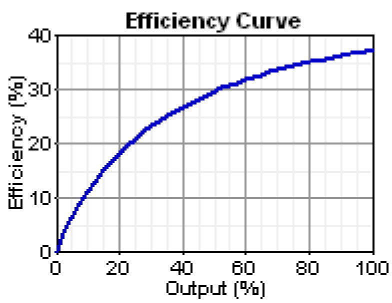


Weibull k:	1.537
Autocorrelation factor:	0.922
Diurnal pattern strength:	0.447
Hour of peak wind speed:	14
Scaled annual average:	2.87, 5.00, 7.00 m/s
Anemometer height:	10 m
Altitude:	1,380 m
Wind shear profile:	Logarithmic
Surface roughness length:	0.01 m

AC GENERATOR: RECIP

Size (kW)	Capital ($)	Replacement ($)	O&M ($/hr)
250.000	60,000	60,000	3.000

Sizes to consider:	0, 30 kW
Lifetime:	15,000 hrs
Min. load ratio:	0%
Heat recovery ratio:	0%
Fuel used:	Natural gas
Fuel curve intercept:	0.07 L/hr/kW
Fuel curve slope:	0.2 L/hr/kW

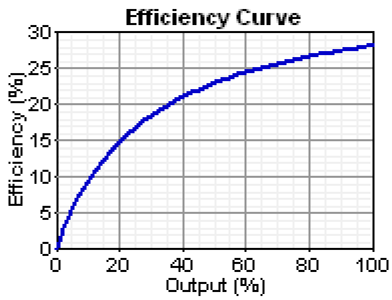


AC GENERATOR: GENERATOR 2

Size (kW)	Capital ($)	Replacement ($)	O&M ($/hr)
250.000	225,000	225,000	2.000

Sizes to consider:	0, 30 kW
Lifetime:	15,000 hrs

Min. load ratio:	30%
Heat recovery ratio:	0%
Fuel used:	Diesel
Fuel curve intercept:	0.08 L/hr/kW
Fuel curve slope:	0.28 L/hr/kW



FUEL: DIESEL

Price:	$ 0.57/L
Lower heating value:	43.2 MJ/kg
Density:	820 kg/m3
Carbon content:	88.0%
Sulfur content:	0.330%

FUEL: NATURAL GAS

Price:	$ 0.1, 0.2, 0.3, 0.4/m3
Lower heating value:	45.0 MJ/kg
Density:	0.790 kg/m3
Carbon content:	67.0%
Sulfur content:	0.330%

CONVERTER

Size (kW)	Capital ($)	Replacement ($)	O&M ($/yr)
1.000	700	700	0

Sizes to consider:	0, 10 kW
Lifetime:	15 yr
Inverter efficiency:	90%
Inverter can parallel with AC generator:	Yes
Rectifier relative capacity:	100%
Rectifier efficiency:	85%

GRID

Rate	Power Price	Sellback Rate	Demand Rate	Applicable
	$/kWh	$/kWh	$/kW/mo.	
Rate 1	0.03	0.03	0	Jan-Dec All week 00:00-24:00