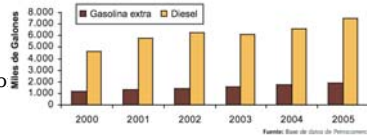


The Galapagos

- Unique ecosystem, but...
- Growing population
- Subsidized fuel - \$1/gallon
- Growing energy demand

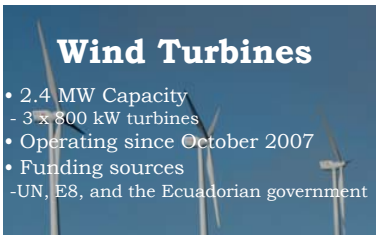


Wind Project on San Cristobal



	Santa Cruz	San Cristobal	Isabella
Population	11,405	5,970	1,749
Average Power Usage (kW)	1,667	747	189
Energy Usage (kWh/yr)	14,603,200	6,546,056	1,655,270
Number of Vehicles	1,276	633	142
Diesel Consumption (L/yr)	17,579,035	8,226,124	2,384,709

- Second largest island in the Galapagos
- Three 650 kW diesel generators provided all of the electricity until the installation of wind turbines.

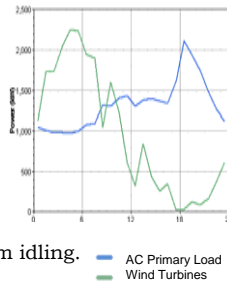


Goals

- Find the most economically and environmentally effective approach to utilize the excess wind energy
- Cover at least 50 % (currently 41%) of load with newly installed wind turbines

Problems

- Mismatch between demand and wind generation
- No Storage
 - All of the excess energy is wasted
- Lack of Spinning Reserve
 - two of the generators are kept idling even when wind fully meets the load;
 - 22% of the diesel consumption comes from idling.

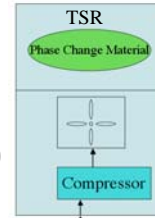


Methodology

Analyze 3 Approaches to Better Wind Energy Utilization Using HOMER Software

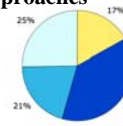
1. **Energy Efficiency** - Replace old and inefficient electric appliances with Energy Star counterparts
2. **Demand Management** - Use DM to modulate a portion of the load (40% in this case) in the following two methods

- **Temporary load-shifting (Downsize)**
Replace one of the 650 kW generators with two 325 kW substitutes and use DM to reduce spinning reserve so that one of them can be shut down.
- **Permanent load-shifting (Deferrable)**
Defer the load up to 6 hrs/day to utilize the excess wind energy.
Ex: thermal storage refrigerators (TSR)



3. **Energy Storage (EVs)** - Store excess wind energy in EVs and reduce fuel use from the transportation sector
- ❖ **6 scenarios were built based on the above approaches**

Scenario	Wind	Efficiency	Downsize	Deferrable	EVs
1	0				
2	0	0			
3	0		0		
4	0			0	
5	0				0
6	0	0	0	0	0



- Scenario 2-5 incorporate one of the above approaches into the grid system.
- Scenario 6 combines all approaches except EVs. Economics of EVs will be added to the model later.

Grid Modeling with HOMER

INPUT

Inputs	Unit	Value
Diesel generators		
Capital and replacement cost	\$/kW	300
Operation and maintenance cost	\$/kW/yr	15
Operation life	Hrs	30,000
Energy efficiency		
Replacement for energy efficiency	Fridge%/Lighting%	75/75
Replacement cost of a refrigerator	\$/kW	2000
Replacement cost of lighting	\$/kW	75
Demand management		
Deferrable load	KW	274
Deferrable capacity	KWh/day	1644
Signal receiver cost	\$/unit	20
Signaling device (Radio Data System)	\$/unit	10,000
Operation and maintenance cost	\$/kW/yr	30
EVs		
Ave fuel economy of EVs	miles/kWh	4
Ave fuel economy of ICES	miles/gallon	20
Demand	KW	274
Storage capacity	KWh/day	1644

- INPUT ASSUMPTIONS**
- Capital cost of turbines - \$0
 - Discount rate - 8.5%
 - Simulation period-15 years
 - Operating reserve - 12 %
 - Idling rate of generators-25%

❖ Load profile and wind data were provided by IEA, which is a member of ES

Run through HOMER



OUTPUT

Output	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Diesel Use (L/yr)	1,801,802	1,171,368	1,734,197	1,500,797	1,858,609	846,794
Capital Cost (\$)	0	518,167	241,784	46,507	N/A	759,080
Annual Cost (\$/yr)	162,078	179,842	223,703	152,010	N/A	198,618

These values, obtained from HOMER calculation, were used to analyze the effectiveness of each scenario - Details are described in the below Results section.

Results

	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Fuel Saving Potential (L/yr)	630,434	67,605	301,005	394,438	955,008
Capital Cost (\$)	518,167	241,784	46,355	N/A	759,080
Cost of Saving Fuel (\$/L)	0.028	0.912	-0.033	N/A	0.038

1. Fuel saving potential (L/yr)

= Diesel use of scenario 1 - Diesel use of each scenario (except for scenario 5)

For scenario 5 (EVs)

= (EV load (kWh/day) * 365 days/yr * 4 miles/kWh) / ((20 miles/gallon) / (3.76L/gallon))

- (Diesel use of scenario 5 - Diesel use of Scenario 1)

2. Capital Cost (\$)

= provided on output table

3. Cost of saving fuel (\$/L)

= (Annual cost of each scenario - Annual cost of scenario 1) / Fuel saving potential

- Subsidized diesel costs \$1/gallon (\$0.27/L) on the island; therefore, the utility company will save expenditure on diesel fuel if the cost of saving fuel is less than \$0.27/L. All of the scenarios, except scenario 3, yield substantially lower costs.
- Scenario 5 indicates that EVs have a high potential to save diesel consumption on the island; however, heavily subsidized diesel and gasoline might make difficult to provide the local drivers incentives to switch to EVs.

Future Plan

- Thermal Storage Refrigerator Development (Energy Efficiency Center/ University of California Energy Institute)
 - to store and discharge energy more efficiently
- Economics of introducing EVs on the island
- Water purification facility as pumped hydro
- Pilot project in Isabella (100kW Fish cooler)
- Apply the modeling scheme to other grid

Project Partners



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