Purpose

Investigate wind energy potential in Chile by comparing radiosonde wind speed with wind farm production and statistics.

Introduction

- Chile gets 65% of its energy from thermal plants burning imported fossil fuels, 34% from domestic hydro power, and 1% from renewables, including wind (ACERA, 2010).
- Frequent unpredictable droughts reduce the reliability of hydroelectric power, and events like the Argentina gas supply crisis cause energy shortages (Watts and Jara, 2010).
- Increasing the percentage of wind energy and other renewables will increase Chile’s energy security.
- Siting wind farms correctly is critical to taking advantage of Chile’s wind energy potential.
- Wind speed, wind direction, and topography are important factors in siting wind farms.

Methods

- Determined the average wind speed at 80 m by interpolating wind speeds at 1000 hPa and at the surface using the power law relation (Elliot et al. 1986; Arya 1988) and logarithmic law (Arya 1988; Jacobson 1999).

\[
V(z) = V_0 \left( \frac{z}{z_0} \right) ^ {1/7} 
\]

\[
2 \ln \left( \frac{z}{z_0} \right) \frac{z}{z_0}^{1/7} = \frac{1}{7} \ln \left( \frac{z}{z_0} \right) + \frac{1}{7} \ln \left( \frac{z}{z_0} \right) + z - z_0 
\]

For the power law relation, \( V(z) \) is wind speed at elevation \( z \) above the topographical surface (80 m), \( V_0 \) is wind speed at the reference elevation \( z_0 \), and \( \alpha \) is the friction coefficient (1/7).

- Determined that the power law was the most accurate interpolation method to estimate the wind speed at 80m and applied a daytime correction of + 0.2 m s\(^{-1}\) to account for power law underestimate (Archer and Jacobson 2003).
- Modeled hypothetical wind farms co-located with the radiosonde stations using turbine specifications for wind farms near the respective radiosonde station (See Table 1).
- Used average wind speeds calculated from the power law to determine yearly power production possible at each radiosonde location (See Table 2).
- Calculated the wind speed required to meet the yearly power production at wind farms located near the soundings at Santo Domingo, Puerto Montt, and Punta Arenas using the following equation (Muljadi and Butterfield, 2000):

\[
V = \left( \frac{P}{0.5 \rho A \alpha} \right)^{1/4} 
\]

where \( V \) is wind speed in m/s, \( P \) is the power of an individual turbine, \( \epsilon \) is efficiency (0.40), \( \rho \) is air density (1.225 kg/m\(^3\)), and \( A \) is the cross-sectional swept area of the wind turbine.

Results and Conclusions

- Based on installed capacity and yearly production, wind farms in this study likely operated about 30% of the year.
- Mean radiosonde wind speeds did not yield the yearly power output observed at nearby wind farms.
- Mean winds needed to generate observed yearly production need to be significantly higher than mean winds from the radiosondes: 1.1 m/s higher at Alto Baguales, 2.3 m/s higher at Canela, 2.4 m/s higher at El Totoral, 1.8 m/s higher at Lebu Sur, and 2.2 m/s higher at El Toqui.
- Spatially and temporally sparse radiosonde data can be considered to sample the synoptic-scale atmospheric circulation, but are like not representative of local wind speeds at wind farm sites and Therefore should not be the only factor used in determining optimal wind farm locations.
- However, knowledge of variability in synoptic-scale wind direction can aid siting if individual turbines are situated along preferentially favored topographic ridge lines (Ragheb, 2008).

Sources

- Domingo, Puerto Montt, and Punta Arenas using the following equations (Muljadi and Butterfield, 2000):