Using Renewable Energy To Recharge Industrial Forklifts At Borroughs Corporation

By Nathan Christensen
Research Associate
Western Michigan University
About the Company

- Borroughs was established in 1937 and is located on North Burdick in Kalamazoo, MI.
- Borroughs manufactures a variety of industrial and commercial shelving systems and storage systems.
- Borroughs is an ISO 14001:2004 registered company for Environmental Management Systems.
About the Project

• Objectives:
  – To estimate the size and cost of a wind and solar system needed to provide power for 20% of their new forklift fleet (~3 vehicles).
  – To provide guidance on wind and solar systems contractors and site locations.
Current Forklift Information

- Requires ~2.5 charges per 10 hr. workday.
- DC Driven with at 1020 Amp-Hr, 36 Volt Battery
- Battery Capacity of 36.7 kWh.
- Max Usage of 115 kWh per day per vehicle.
  - Based on 2.5 full charges.
- Max cost of electricity per day?
  - ~$15.00 at an on peak cost of $0.13 per kWh.
New Forklift Information

• Should only require one full charge per day.
  – Opportunity charging may take place during breaks and lunch.

• AC Driven with a 36 Volt, 1020 Amp-Hr Battery.

• Battery capacity of 36.7 kWh.

• Max daily use of 39 kWh.
  – Based on using a charger with a 94% efficiency rating.

• Estimated daily cost of electricity?
  – ~$2.10 at an on peak cost of $0.054 per kWh.
Current Battery Charging System

- Number of chargers in use: 27
  - Main HUB with 17 chargers.
  - Ten additional chargers spread throughout the facility.
  - Charger output of 200 Amp-Hr.
    - Recharge time of 5.5 – 7.5 hrs.
- Currently, opportunity charging is used:
  - End of shifts.
  - During breaks.
New Battery Charging System

• New charging system to focus on timed charging.
  – Opportunity charging when possible.
    • Ideally once per shift during lunch or break(s).
  – Timed off-peak charging would considerably cut down on-peak electricity costs.
    • $0.054 per kWh versus $0.02 per kWh

• Considerable reduction in phantom loads.
  – .2415 kW per hour versus .0166 kW per hour.
Renewable Energy Sources
Local Wind Turbine Performance

- **Wind Turbine One**
  - Estimated .55 kWh per Day
  - $2.1 per kWh

- **Wind Turbine Two**
  - Estimated .4 kWh per Day
  - $2.89 per kWh

- **Wind Turbine Three**
  - Estimated production of 3.5 kWh per Day
  - $.46 per kWh
Mariah Windspire

- 1.2 kW @ 24.6 MPH (11 m/s)
- 11 MPH winds will generate ~2000 kWh per year.
- Ground mounted.
- Designed to work optimally in areas with an average wind speed of 11 MPH.
Cascade Swift

- 1.0 kW @ 24.6 MPH (11 m/s)
- 11 MPH winds will generate ~2000 kWh per year.
- Building or ground mounted.
- Design allows for the elimination of pole height restrictions.
Southwest Skystream 3.7

- 2.0 kW @ 22 MPH (10 m/s)
- Ground Mounted
- Capable of generating ~4000 kWh per year in 11 MPH winds.
- Allows you to record wind and energy data via the Skyview 2.0 software available with the system.
Solar Systems

• Uni-Solar
  • Modular Frame Panel
    • Capacity range of 5 – 64 watt.
    • Cost per Watt: $8.28
  • Laminated Panels
    • Very Flexible
    • $3.00 - $5.00 per Watt (Not Installed)
    • Capacity Range: 68 – 144 Watt
Solar System Performance
(For the Kalamazoo area.)

• Daily production?
  – 1.8 kW System:
    • 2.9 kWh per day per kW
    • 1921 kWh per year
  – 12 kW System:
    • 3.75 kWh per day per kW
    • 16,425 kWh per year

• Cost
  – 1.8 kW System: $7.25 per Watt
  – 12 kW System: $8.33 per Watt
Possible Renewable Energy Locations

Wind Turbine mounted on the corner of the building.
Laminate solar array along the south wall of the facility.
Modular solar panel array.
Renewable Energy Locations

- Laminate or Modular solar array possible due to ample room on the roof.
- Modular or Laminate solar array on the roof.
- Modular solar array on long the north side of the parking lot.
- Pole mounted wind turbine in the grassy field opposite the facility.
- Wind Turbine along the street to make use of a natural wind tunnel.
What’s Next?

• This project will be ongoing over the course of several more months.
  – Deciding which forklift, battery, and charger manufacturer is best suited for the company.
  – Meeting with additional local wind and solar contractors.
  – Wind study tests to determine the most efficient location for where and what type of wind turbine.
  – Continue the ongoing analysis on how much energy is needed by their current forklift fleet.
  – Forklift drivers to undergo training that will help them become more efficient