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Electric Vehicle Battery - Wind Energy Storage System

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Technical Track 5: Energy Storage

Electric Vehicle Battery - Wind Energy Storage System

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Abstract

The proposed concept utilizes the EV battery waste stream as a means to store wind energy in order to increase wind energy capacity factor, improve utilization, and make more efficient use of EV batteries prior to recycling. Michigan is an ideal location for such a facility because many of the battery and automotive manufacturers are located here. A 200 MW wind farm can charge a battery farm which consists of all reject and post-consumer batteries and all EVs located in Michigan by 2015. Michigan is on track to meet a 10% renewable portfolio by 2015 with over 1100 MW of planned new wind projects to be installed by then. Therefore, Michigan has plenty of wind capacity to charge the EV battery wind-storage facility and all of Michigan consumer EVs.

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1.0: Situational Environment

Technology and government policy are in constant development to meet global environmental and social needs. It is up to the engineering community to address opportunities to utilize technology to meet government standards in a manner which is economically viable. The electric vehicle (EV) battery reuse concept for off-peak wind energy storage system has the opportunity to help utility providers meet renewable portfolio standards and make more efficient use of the potential high-volume EV waste stream. The proposed concept utilizes the EV battery waste stream as a means to store wind energy in order to increase wind energy capacity factor, improve utilization, and make more efficient use of EV batteries prior to recycling. The analysis indicates that enough wind capacity will be installed in Michigan as per the Renewable Portfolio Standard (RPS) to charge the proposed battery bank and all EV's potentially deployed in Michigan.

1.1: Electric Vehicle Batteries

As the consumer market begins its shift from internal combustion engines (ICEs) to EVs, the lifecycle infrastructure must progress to accommodate this emerging industry. The production volume of EV lithium-ion (Li-ion) batteries will grow with market demand. In turn, the capacity to reuse and recycle these batteries must grow in kind.

All batteries lose storage capacity per cycle (charge & discharge). Eventually, a battery's storage capacity reduces to the point where it is no longer considered usable. As an example, a 12-volt car battery rated for 600 amps and typically needs about 250 amps to start a 6-cylindar ICE. The battery is replaced when the power cannot turn the engine over (exacerbated in cold temperatures); therefore, the battery is replaced at slightly less than 50% of its load capacity. This reduction typically occurs within a five-year period.

EV batteries will follow a similar cycle which will be driven by consumer performance preferences. EV batteries will be able to propel the vehicle for an initial (rated) distance per charge. The distance will reduce as the EV battery loses charging capacity throughout its life. The consumer will replace the battery when the travel distance per charge reduces below the consumer's minimum threshold. EV batteries can be expected to follow a similar rate of capacity reduction as their 12-volt counterpart.

It is projected that there will be approximately 500,000 to 600,000 EVs on the road in the United States by 2015 (CAR, 2011). Consequently, the battery reuse and recycling infrastructures must be designed to accommodate the projected rate of EV post-consumer battery production.

1.2: RPS & Wind Energy

The United States is to obtain 20% of its energy from wind by 2030 as per the federal DOE (American Power Act, 2009). Michigan has set an intermediary RPS of 10% by 2015 (MI House Bill 5548, 2007). Planned wind energy projects are the primary source of new renewable energy in Michigan. The capacity factor of wind turbines will vary based on the natural wind patterns (primarily speed) of a geographical area.

Michigan is assumed to have an average capacity factor of 25% (this will vary based on geography and strategic siting). Methods to store wind energy and discharge it on-demand are active areas of research. The proposed concept utilizes the EV battery waste stream as a means to store wind energy in order to increase wind energy capacity factor, improve RPS, and make more efficient use of EV batteries prior to recycling.

2.0: Concept Description

The EV battery reuse for off-peak wind energy storage system is a storage facility which consists of hundreds of thousands of post-consumer (PC) and reject batteries in a distribution facility (battery farm). This facility will be located near a wind farm and a li-ion battery recycling facility. Wind intensity is generally higher at nighttime; however, the grid needs additional energy for peak demand which occurs during the daytime. Therefore, the wind turbines will redirect their electricity to the battery farm during off-peak and discharge the battery bank during on-peak demand periods based upon the utility provider's preferences to optimize the benefit.

Michigan is an ideal location for an industry-scale system for this application. Several battery manufacturers are located in west-Michigan. Michigan wind projects located on Lake Michigan (west-coast) can provide the wind energy for the system. Many warehouses are vacant near Lake Michigan, which are potential locations for the battery farms. The proposed system includes the following:

1. Battery Manufacturing Facilities
2. Battery Farm
3. Wind Farm
4. Electric Grid
5. Recycling Center
6. EV Manufacturing Facilities

Figure 1 below provides a flow diagram of the concept.

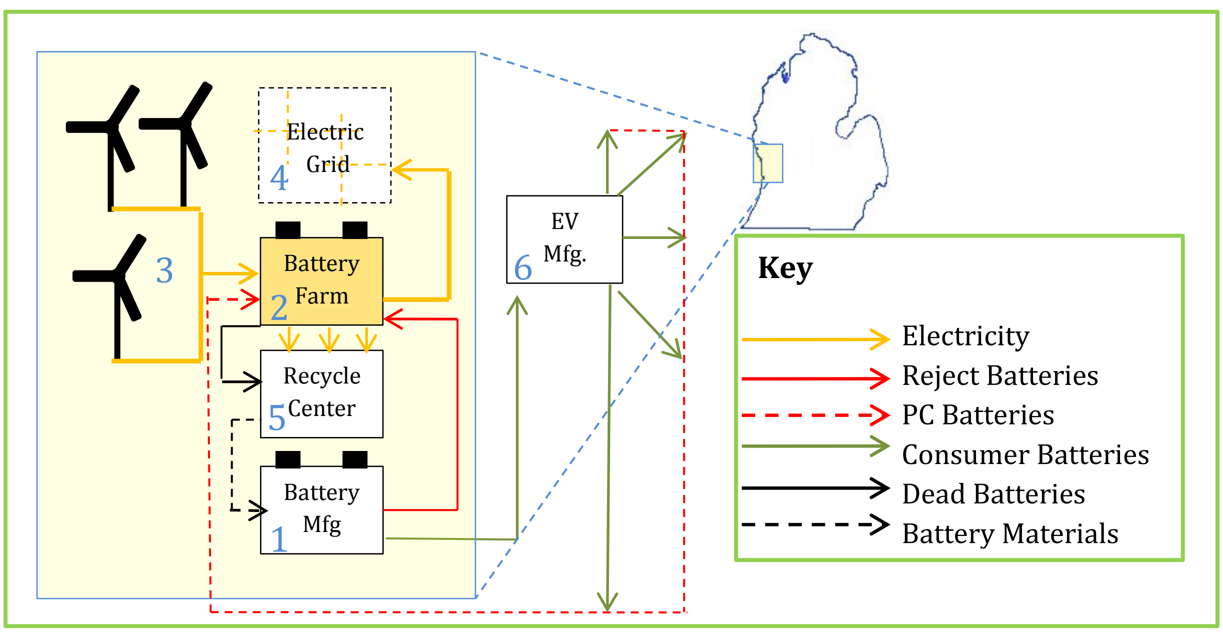


***Figure 1:* Flow Diagram - EV Battery Wind Storage System**

3.0: Technical Analysis

The following analysis provides projections on the storage capacity of reject and post-consumer batteries, compares the required wind capacity to charge those batteries to wind projects required to meet Michigan RPS.

3.1: Battery Availability & Capacity

The batteries available for the battery farm will consist of reject and PC batteries. The rejected batteries are assumed to operate in the battery farm for ten years while the PC batteries are assumed to operate for five years. The following boxes outline the battery production and capacity assumptions which shape the following analysis.

Table 3.1.1: **Battery Availability & Capacity Assumptions**

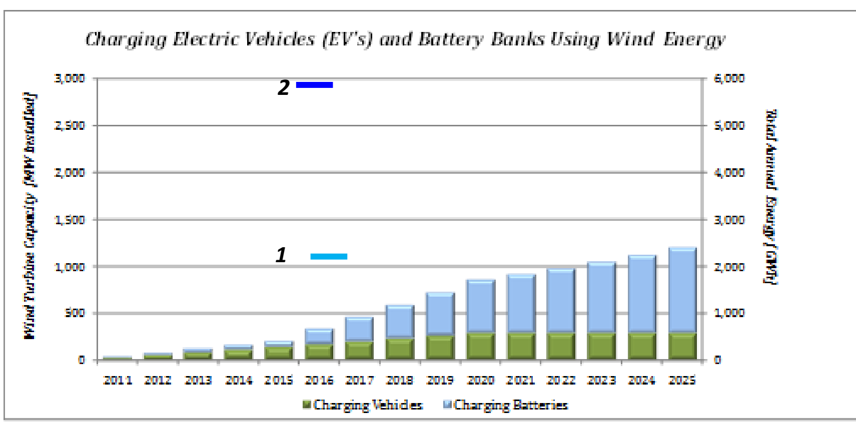
Battery Production
- 2011 PV: 100,000 EV
- PV increase: 10% annually
- 2015 Total: 610,000
- Reject Rate: 10%

Consumer Batteries
- Rated Cap.: 10 kWh
- Reduction: 7% annually
- User Life: 5 yrs
- PC Usage: Battery Farm
- Farm Life: 5 yrs

Reject Batteries
- Reject Cap.: 7.5 kWh
- Reduction: 7% annually
- User Life: 0 yrs
- Reject Use: Battery Farm
- Farm Life: 10 yrs

Consumer EV Characteristics
- Miles Driven: 6,000 miles/yr
- Performance: 3.5 mi/kWh
- Annual charge: 1.71 MWh/yr per EV
  (Patten & Christensen, 2011)

These assumptions allow a storage capacity schedule for the battery banks to be forecasted. ***Figure 3.1.1*** below provides the required wind farm capacity to charge the batteries and charge the consumer EV's in Michigan.



<u>10% by 2015[1]</u>

1. Minimum 1,100 MW Capacity Installed per RPS[1]
2. Up to 2,800 MW Installed
   *see Table 3.2.1

The green bars represent the energy required to charge EV's in Michigan and the blue bars represent the energy required to charge the battery farm.

Figure 3.1.1: **Battery Availability & Capacity Assumptions**

By 2015, the battery farm and all Michigan EV's will require 450 GWh per year. Assuming a wind capacity factor of 25% in Michigan, a 200 MW wind farm can meet these power requirements. Michigan will have a minimum of 1100 MW; therefore, Michigan will have plenty of wind capacity to charge the wind farm and all of Michigan's EVs.

3.2: RPS & Required Wind Projects

With the Michigan RPS of 10% by 2015, ***table 3.2.1*** provides the Michigan power production, current renewable portfolio and additional renewables required. The final figure in the table provides the required wind capacity installed to meet the additional renewables required to meet the RPS of 10% by 2015.

Table 3.2.1: **Michigan Power Production & RPS**

Current Status		
Current Production	96,611	GWh/yr
Renewable Portfolio	3,507	GWh/yr
Renewable %	3.63	%
Michigan RPS 2015		
Standard	10	%
2015 Renewables Req.	9,661	GWh/yr
Additional Renewables		
Additional Production	6,154	GWh/yr
Wind Equivalent (25% capacity factor)	2.81	GW

(MI-PSC,2011)

Michigan will generate nearly 97,000 GWh per year in 2015 (MI-PSC, 2011) and will be required to produce an additional 6,000 GWh per year of renewable power by then. Assuming an average wind capacity factor of 25% in Michigan, the RPS can be met with an installed rated wind capacity of 2.80 GW. The Michigan RPS requires that a minimum of 1100 MW of wind are installed and that the balance can be achieved with wind or other renewables projects.

3.3: Facility Volume

Batteries give off heat during cycling and will require spacing for ventilation. EV batteries are of various shapes and sizes; therefore, the following assumptions were used to standardize the space requirements per battery.

The batteries will require 38 cubic feet per 5 kWh of capacity of storage space based upon the battery space requirements assumptions. In 2015, the 60,000 batteries in the battery farm will require 2.3 Million cubic feet of warehouse space. Assuming 20ft warehouse ceilings, 115,000 square feet of floor space will be required ~ 2.4 football fields.

Table 3.3.1: Battery Size Assumptions

- Length: 4 ft
- Width: 2 ft
- Height: 1 ft
- Spacing: 7 inches (all dir.)
- Volume: 38 ft^3

Conclusions

A sustainable method of utilizing and recycling EV batteries must be established by the time EVs become commonplace in the American market. The EV battery wind energy storage system has the opportunity to reuse these usable batteries and increase the state and nation’s renewable portfolio.

Automotive manufacturing, EV battery manufacturing, and large wind projects are all located in Michigan making the Lake Michigan coastline an ideal location for a wind energy storage battery farm. The 1100 MW power capacity of planned wind projects in Michigan far exceed the 450 GWh per year of power required to charge the wind energy storage battery farm and charge all Michigan EVs in 2015.

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