Renewable Energy Generation and Deployment Model by Wind and Vehicular Mobility with Discharge Stations

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Abstract: The objective of the research paper is to propose a renewable energy generation and deployment model by wind and vehicular mobility with number of discharge stations along the traveling path. The wind energy can be converted into equivalent electrical energy through proper installation of blades at the top of each vehicle so as to convert the passing wind energy with the help of turbines designed for that purpose. An analytical approach in calculating the energy that can be generated with number of parameters that caused like average wind velocity, tip speed ration, diameter of the wind turbine and the area swept by the blade. A distributed model of energy generation and discharging is proposed within the renewable energy laws that govern the system processes. The deployment of number of discharging stations is determined by the V2G and V2V techniques with a prototyping of two batteries connected and controlled by a pair of programmable System on Chip Micro controller circuit.

Key-Words: - renewable energy, analytical model, energy laws, energy generation, discharging V2V, system on chip controller

1 Introduction

The energy crisis and the discovery of alternate energy sources are the two important activities that are discussed in the world of power system engineers and scientists. The acute shortage of electrical power due to poor rainfall periods and shortage of fuels in the thermal power plants are aggregating the crisis situation. The renewable energy generation and its engineered deployment will solve these critical situation to a level maximum it can perform. The wing energy transformation in all its forms is the context on which the work is focused. In earlier works, the research community brought the usage of real wind turbine in accordance of with annual wind data that are reproduced using an emulator which uses a permanent magnet generator driven by variable speed induction motor. The technical details shows that as a power interface, an inverter with front end as a boost stage and bidirectional buck boost converter are used. A super capacitor battery hybrid storage system is used as buck boost converter stage is employed as energy storage. The inverter, fed by a constant DC link voltage, is connected both to household load and grid [1]. The other area of renewable energy is associated with vehicle-to-grid (V2G) technology. This is a two-way interfacing technology conceptualized to supply electricity back to the grid via EV battery discharge. A joint program me between NRG Energy Inc. and the University of Delaware earlier this year successfully demonstrated the V2G concept. Though not yet commercial, key outcomes of such a pilot validate the possibility for EVs to provide frequency regulation and energy storage by leveraging many smaller power sources into one large resource [2]. The other area of research is onto the vehicle manufacturers who are already equipping new vehicles with navigation and infotainment devices as well as with wireless technologies to support vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication provided by e.g.., 3G and future 4G cellular networks or IEEE 802.11p. Conceivability, this trend will likely to continue for e-vehicles [3]. In all these models and technology, it is shown that the value of pitch angle affects the maximum received power so a control method is needed to get the maximum power coefficient. This method is recommended to be used to give feedback information regarding the value of received power from the wind by the wind turbine blades [4]. The focus of the paper is to conceptually model a renewable energy generating system with the help pf wind turbines using wind energy and discharge the accumulated charges into discharging stations along the highway periodically. A pair of system on chip mixed signal micro controllers are used to implement the model in switching across the predefined logics based on charge or timings.

The paper is organized as follows: Section 2 explores the role of vehicle mobility towards a factor in the distributed model for energy generation and discharging and explains the discharging process by the excess charges after having charged the vehicle battery at different points of discharging stations that are connected as the overlay network with the help of micro controllers. Section 3 proposes a few laws in the context of conflicts, worst case conditions and multiple causes for any incident over the generation and discharging processes. Section 4 discusses the analytical way of calculating the maximum and average energy that can be generated in the model and when the generated charges are to be discharged with sample data and turbine specifications. These networks are finally connected to the nation power grid with proper isolation and monitoring application software installed at needed points.

2 Electrical Vehicle mobility

Vehicular mobility models address different aspects as reflected by the classification provided in stochastic models and select topologies and road characteristics randomly for the models. In commercial scenarios, traffic stream models look at vehicle flows at a macroscopic level. These models account for the relationship between cars and surrounding vehicles in terms of distance, speed, acceleration, etc. And at the same time, queuing network models focus on car densities on road, and behavioural models address driving characteristics derived from social rules [3]. For example, in the market , the available electric drive train has the ability to accelerate from 0 to 60 mph in less than eight seconds and a tested " real world " range of 120 to 150 miles on a charge with alternating current with 150 power units built through propulsion. It controls the conversion of high voltage DC into an AC power. The electric motor the vehicle also has the ability to operate as a DC-AC inverter from the battery to grid and to match the voltage and precisely synchronize the resulting AC signal to line phase and also shunting the resulting power not to the electric motor but to the grid [6].

3 Renewable Energy Laws

The proposed renewable energy model satisfies basic laws that are based on three main aspects in the context of vehicles charging through wind energy. That are namely timed conflict action, worst condition and multiple cause order. These three concepts are considered for the bounded model checking of the charging system available in automotive. Timed conflict action describes the logical action performed on time based on situations.

Table 1. Bounded Model Controlling Factors

Timed Conflict Action	Worst Condition	Multiple Cause Order
A condition where energy can be discharged from generating battery before entering into a place where more energy generation is possible.	Due to natural disasters like cyclone, flood and earthquakes, Where any action in energy generation or discharge is not possible can be dealt last in the decision making.	During traffic and crowded environment, the energy cannot be generated due to insufficient speed of the vehicle.
If the next discharging station is very far from the current one, then the battery should be discharged in the current discharging station.	Condition of overheating of the generating battery would damage the system and hence consider as the first.	Loss of Connections with the critical components in the charging and discharging circuit and their causes are to be identified
The battery need not be discharged while travelling to a place where energy generation is difficult even if the default time exceeds.	Poor vehicle running conditions has to be considered as the medium case as per severity of the conditions.	When a battery is fully charged, it can either discharge in the discharge station or it can be discharge to discharging battery of vehicle.

If the vehicle is to be in stop or stationary condition for a long time then the discharging battery need not be discharged.	Improper fixing of turbine onto the vehicle should be addressed first.	Suppose both the discharging as well as charging batteries are completely charged, the circuit breaker will stop the charging process even though the turbine is set into rotation.
Break the charging circuit using circuit breaker if both the batteries are fully charged or the discharging station is far away.	Vehicular collision with external objects may lead to worst conditions that considered as last.	The battery need not be discharge electrical energy from the generating battery as it can be used for alternative purposes such as home appliances etc.

3.1 Timed conflict action

For example, the battery need not to be discharged while travelling in a place where energy generation is difficult even if the default time exceeds. Such logical action are performed in timed conflict action. These concepts are expressed in the following representations.

Battery(Generating) ↦ Windy.Place.Battery(running) ↦ generation
(Discharge)Station Far ↦ (Discharge) Station Discharge.Current
(Generating) Battery ↦ (Generating) Region
(Generating) Battery ↦ Vehicle (Stationary)
Battery(Operating).Battery(Generating) ↦ (Apply)Circiut Breaker

3.2 Worst condition

Worst condition describes about certain unavoidable circumstances where energy generation becomes impossible. Natural disaster such as cyclone, flood etc. comes under worst condition. These concepts are expressed in the following representations.

Battery(Charging).Battery(Discharging) ↦ NotEnergy (Generation)
Battery(Generating) ↦ Battery(Damage)
Vehicle(Running Condition) ↦ Consideration
Turbine(Improper Fixing) ↦ Consideration
Vehicle.External object(Collision) ↦ (Damage)Circuit

3.3 Multiple cause order

Multiple cause order describes about various reason why the battery is charging or not charging & why the battery is discharging & not discharging. For example when a vehicle is travelling in a crowded location, the battery is unable to charge due to insufficient speed for generation. This describe the reason why the battery is not charging. If there is a loss of connection with critical components the battery cannot discharge either in the discharging station or any other alternative purpose. This describes the reason why the battery is not discharging. These concepts are expressed in the following representations.

Battery(Operating).Battery(Generating) ↦ (Apply)CircuitBreaker
Traffic.(Crowded)Environment ↦ Not Energy (Generation)
Circuit (Connecting) Componet(Charging & Discharging) ↦ Identification
(Discharging)Battery ↦ (Discharging)Station or (Charging)Vehicle
(Generating) Battery ↦ Home.Appliances(Charge)

BLOCK DIAGRAM

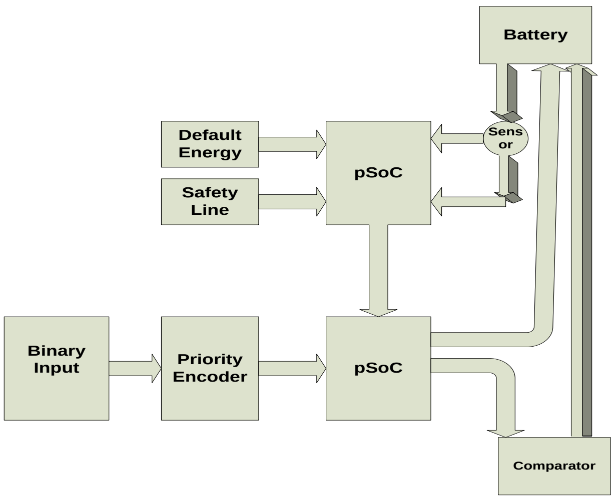

Fig .1 On-Chip Micro Controller Circuit of the battery

The block diagram explains about how the battery is charged and discharged with the help of microcontrollers (pSoC). Initially the battery is connected to sensor which converts the energy signal that can be read by the microcontroller. Another input of the microcontroller is from the turbine which generates default energy. Safety conditions are also given as input to the microcontroller to sense the safety operation. This microcontroller is connected to another microcontroller. The binary input is connected to a priority encoder which compresses the multiple binary input into a small number of outputs which is

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given to the other microcontroller. The microcontroller integrates and the output is given to a comparator and the battery. The comparator compares the energy signal and the output is given to battery for discharging purpose.

4 Analytical model of renewable energy

Renewability is a function of allowed sustainability accepted susceptibility and anticipated dissipation of energy sources over given duration from multiple energy source. The aerodynamic power P, of wind turbine is given by

$$P = \frac{1}{2}\rho\pi R^2 v^3 C_p \quad (1)$$

Where ρ is the air density , R is the turbine radius is wind speed and C is a function of the tip-speed ratio(λ),as well as the blade pitch angle (β) in a pitch controlled wind turbine. λ is defined as ratio of the tip speed of the turbine blades to wind speed and given by:

$$\lambda = \frac{R\Omega}{v} \quad (2)$$

Where Ω is rotational speed of wind turbine [5].

4.1 Energy Calculation

The blade speed or the tip Speed can be relatively calculated with respect to the wind speed. The ratio λ can be determined from the average wind velocity as shown in the equation below.

$$\lambda = \frac{Mean\ Blade\ Tip\ Speed}{Mean\ WInd\ Speed} \quad (3)$$

Where,

$$Blade\ Tip\ Speed = \frac{Rotational\ Speed \times \pi \times D}{60} \quad (4)$$

in which D represents the diameter of wind turbine.

Wind Turbine Energy Output Calculator

i) Calculate wind turbine power from the rotor diameter given in meters

ii) Calculate the wind turbine power when for various wind velocities according to Betz law.

iii) Calculate wind turbine energy output at optimum site in kwh/year.

iv) Obtain mean wind speed at actual location

v) From wind map. Obtain mean speed of wind turbine for given hub height

vi) Finally corrected wind speed for hub height and roughness height is measured in meter /seconds.

Calculation of Energy Output:

Energy of wind can expressed with formula

$$P = \frac{1}{2} \times \rho \times v^3 \times A \quad (5)$$

Where,

P=Power of wind in watts

ρ=density of air in kg/m (cube)

v=velocity of wind

A=area that is swept by rotor blades.

$$Betz\ law = \frac{16}{27} \times P(wind) \quad (6)$$

Energy acquired by vehicle

$$E(Kwh) = \frac{8760}{1000} \times 0.48 \times C_p \times V^3 \times D^2 \quad (7)$$

Where,

E (kWh) =annual energy acquired by vehicle

C_p=efficiency factor

V=velocity of wind speed

D=rotor diameter of wind turbine

Our assumption to find energy by taking C_p= 0.6, v=3.5, D=0.2

$$E(Kwh) = \frac{8760}{1000} \times 0.48 \times 0.6 \times 3.5^3 \times 0.2^2$$
$$= 4321.8\ watts$$

The following table and the graph shows the energy generated for various efficiency factor of the turbine.

Table 2: Efficiency Factor versus Energy

S. no	Efficiency factor of turbine	Velocity of Wind speed(m/s)	Rotor Diameter (meter)	Energy (kw/ hour)
1.	0.1	3.5	0.4	3.20
2.	0.2	3.5	0.4	6.42
3.	0.3	3.5	0.4	9.64
4.	0.4	3.5	0.4	12.85
5.	0.6	3.5	0.4	19.28
6.	0.7	3.5	0.4	22.50
7.	0.8	3.5	0.4	25.71
8.	0.95	3.5	0.4	30.53
Average				16.26

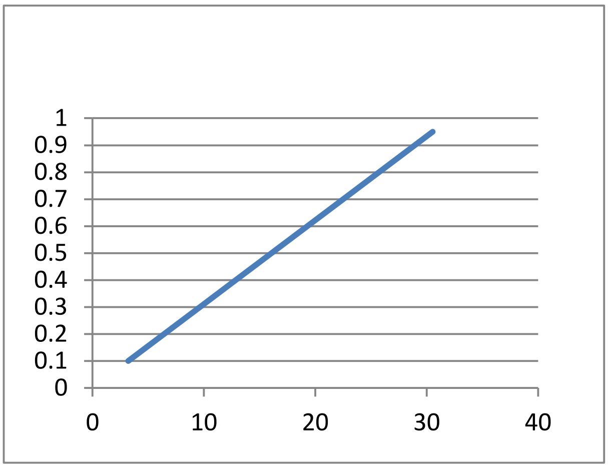

Fig.2 Efficiency factor of turbine versus Energy generated in KW.

The following table and the graph represents the energy generated during the travelling time of the vehicle.

Table 3: Running time versus Energy generated

Type of Vehicle	Travelling Time (hours)	Velocity Of Wind	Energy Generated (kwh)	Factor Based On vehicle
Vehicle 1	4	3.5	25.68	0.2
Vehicle 2	6	3.5	57.84	0.3
Vehicle 3	8	3.5	102.80	0.4
Vehicle 4	10	3.5	192.80	0.6
Vehicle 5	12	3.5	270.00	0.7
Vehicle 6	15	3.5	385.65	0.8
Vehicle 7	19	3.5	588.05	0.95

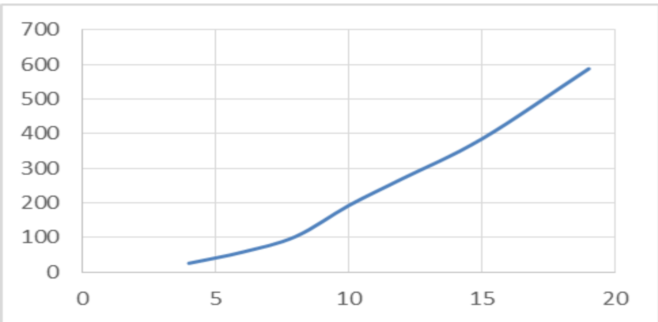

Fig.3 Travelling time in Hours versus Energy generated in KW.

5 Conclusion

The proposed strategy of converting the wind energy through turbine and blade sets mounted on the moving cars has been analytically derived for its output. Considering the mean car velocity, number of cars passing by and the blade diameters are considered to determine the overall effective energy that can be generated. The energy is discharged at discharge stations based on the excess energy generated over the running car battery. The serious limitations of the work is the non- inclusion of different types of automotive like trucks and vans and the inner roads. The other factor is the deployment of the power interface in each and every vehicle as per the ISO standards with all its safety compliances. The model works effectively good in the case of cars and long by pass roads to save energy and fuel.

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