International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 9 No. 2 Nov. 2014, pp. 812-818

http://www.ijias.issr-journals.org/

Power Generation from Alternative Resources with Highest Efficient Device and Control System Reducing Carbon Emission at Lowest Cost: A Simple Plan on hybrid system that supports one another, one step closer to smart power generation system

S.M. Hasibul Hoq, Asif Mahmood Abbas, and Mohsin ahmed

Department of Electrical and Computer Engineering,
North South University (NSU),
Dhaka, Bangladesh

ABSTRACT: Today's world is very competitive in the field of technological invention. Power generation sector is one of the major sectors in these competitive fields; many researches are undergoing to develop this field to a more and more efficient one. Today's power generation are mostly dependent on non renewable resource, which is why power generation cost is higher, have negative environmental impact, less resources to develop new techniques etc. Considering above facts, we are proposing something different methodology that will replace all these existing difficulties. We design the whole system with generation unit, control unit, storage unit, and distribution unit. An ultra modern solar array device, smallest in size will give so far the highest efficiency. Even little sunlight temperature is enough to get optimum output voltage. We develop a hybrid system including wind turbine unit and fuel cell unit that will give support one another in case of failure. Each unit is independent but all are interdependent in case of emergencies and integrated all way to the existing power system. Our control system is very advance to handle each unit. Overall the whole system will reduce carbon emission, dependency on non renewable source and settle down power sector to a sustainable one. Further discussion of technical terms on each unit, and engineering economics and management in each unit, is discussed throughout the paper.

KEYWORDS: resources, electricity, solar cell, efficiency, hybrid system, controller, grid integration, carbon emission, cost effectiveness, environmental impact.

1 INTRODUCTION

No matter what technology we develop, there is always a question raise, "Is the technology environmental friendly, sustainable, affordable, and reliable one?" Scientist, Engineers, Researcher often have to find solution through these questions. The world day by day face an increasing challenges when it comes to the term of electricity generation using alternative resources. Independent studies show us that technological growth rate is much higher than practical implementation of them. This is due to national budget failure, internal corruption, implementation place shortage, higher cost compare to efficiency. So this is a big challenge for us to build technology in a sustainable, affordable, reliable way. Here we discuss solutions on existing difficulties, so that we can reach to a smart power generation.

2 POWER SECTOR SCENARIOS

Most of the bulk power generation systems are based on non-renewable sources. That's why we see a huge environmental degradation over last few decades. Switching to alternative resources has become mandatory for the upcoming days. Statistics show us that only 16% of global final energy consumption comes from renewable energy of which

Corresponding Author: S.M. Hasibul Hoq

2.8% from solar, wind and other renewable sources. This percentage is below our expectation due to lack of innovation in our technology.

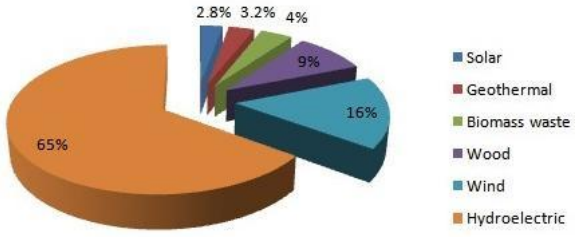

Figure 1: Renewable contribution worldwide 2010.

We see that the lowest percentage is from solar energy. Still we need to put a lot of contribution to increase solar electricity production **[3, 42]**.

3 WORLDWIDE PLAN

Every country, both government and private sectors are planning to meet electricity crisis and ensure mass electricity within 2030. In fact government encourages other private sectors, to come together to meet this goal successfully. A statistics of 2009 says that 79% of the people in the third world, almost 50 poorest nations have no access of electricity even 1.5 billion of world's population have no access of electricity **[1, 2, 3]**.

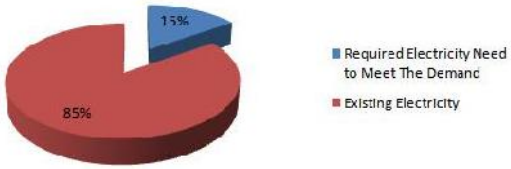

Figure 2: Required power that can be replaced by Alternative source

4 SOLAR ENERGY STATISTICS AND MODELING

We don’t get constant rate of radiation due to earth's rotation and climate changes. Statistics show us average insolation (KWh/m^2/day) of sunlight in our country, also daytime sunlight availability **[5] [7]**.

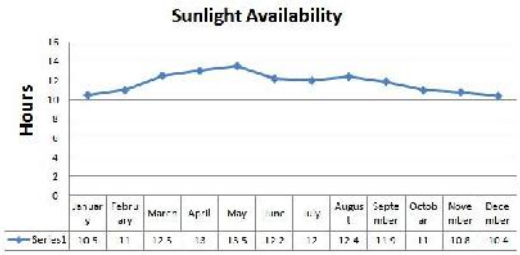

Figure 3: Sunlight duration.

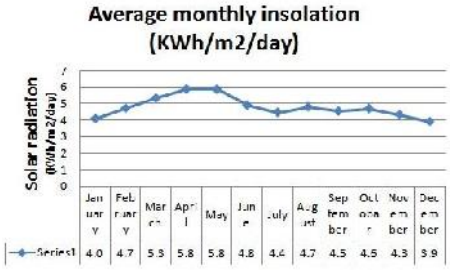

Figure 4: Average sunlight insolation.

There are different kinds of solar cell technology available and here we propose four junction solar cells technology for our solar unit. Basically it's a four junction solar cell that allows sun light to radiate on it with maximum concentration using concentrated photovoltaic technology with updated sunlight tracking and control system **[10]**. The device use wafer bonding as packaging technology on materials of III-V semiconductors to connect two semiconductor crystal at each steps, otherwise it cannot be produced as high quality crystal due to their structure **[11]**. A single sub cells absorb different wavelength ranges of the solar spectrum and produce potential difference at each layer that initiate current (known as dark current according to quantum physics. As efficiency is almost double than conventional outcome, so grid integration of the overall system is much easier in case of mass electricity generation rather than small backup system **[12]**. Let us show a cell wise output graph of this solar cell.

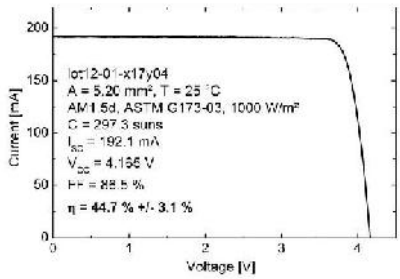

Figure 5: Output response of a single solar cell.

*Source: Fraunhofer Institute for Solar Energy System **[10]***

When sunlight hit cell, it becomes able to take different suitable wavelength due to dispersion of sunlight into different wavelength because of its unique structure. At each junction layer it creates voltage difference and that produce current, overall in one directional current. We can calculate theoretically using quantum physics current vs. voltage equations **[11, 43].**

5 WIND ENERGY STATISTICS AND MODELING

Wind energy system generally converts the wind's kinetic energy into mechanical or electrical energy. From this basic understanding we can get the energy flow rate of wind power which is an equation of energy flow rate per unit area proportional to thrice of the air velocity **[8, 9]**. Another statistics says 5KW generating capacity of wind turbine is good enough on an average for home usage **[6]**. Our independent research suggests the horizontal axis wind turbine for their easy appliance and to achieve the maximum efficiency of 59% to 70% for small house to large wind turbine field especially in the forest area using that fundamental concept; as velocity is multiplied by thrice itself. On an average 10 to 25 feet in diameter rotors stands upwards of 30 feet can supply power for home and small business and they can supply below 50KW. In wind turbine field the size varies depending on the geographical areas. And if we consider the above mentioned things, then we can utilize even small resource available to setup wind firm to produce electricity **[20, 21]**. Let us show an area wise wind speed over a half decade on a particular area.

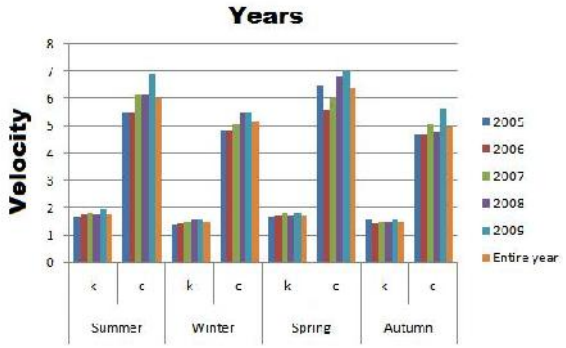

Figure 7: Seasonal shape parameters, standard Deviation (k) and scale parameters, c (m/s) X-Axis and Y-axis-velocity.

*Source: Data collected, wind velocity analysis **[16]***

(2005-2009) WIND SPEED

By properly utilizing these data and through this proposed structure, we can extract significant amount of output.

6 FUEL CELL ANALYSIS AND MODELING

One of one greatest advantage of fuel cell technology is that fuel cells are not limited by Carnot efficiency because of their galvanic nature device. Worldwide in this field, more and more researches are undergoing. Based on our independent study we propose to our overall system, a fuel cell unit that will support the overall power system dynamically depending on control system. Statistics say that fuel cell works more than 85% efficiently comparing to the conventional generator. Based on electrolyte compositions and how efficiently the device can be modeled and integrated each cell, are the factors that define efficiency. In our research, we find that there are many electrolyte compositions like Proton exchange membrane fuel cell, Phosphoric acid fuel cell, Molten carbonate fuel cell, Solid oxide fuel cell. Of them molten carbonate fuel cell has the highest efficiency but we proposed here the Solid oxide fuel cell considering low carbon emission and other facts; also here efficiency is good enough, almost 45% to 55% **[8, 18, 19]**. We get our electrolyte composition using renewable fuels and use it repeatedly as a means of renewable **[22, 23, 24].**

7 CONTROL UNIT

The control unit is the most important part of this proposed technology. Through this unit all the power generating units including conventional units are integrated and communicated each other, to meet the peak demand. In control unit a real time monitoring system is employed, so that if there is any real time fault or over load fault will be monitored before any disturbance occurs, and our hybrid units all together tackle that future fault, future prediction. The whole area, say country; will be divided into many sub area and generation, control, storage and distribution units will be there for each respective area for greater benefits of maintenance. Accompanied with conventional power generation units all together this hybrid system reduces dependency of non-renewable based power plants and easy to handle power distribution as per required. Through this control system transmission and distribution even generation loss will be reduced almost half of the cost as anticipated through engineering economics concept **[25-27, 33-35, 39, 40]**.

8 STORAGE & DISTRIBUTION UNIT

In this unit there will be several electrical energy storage devices, and they will be integrated so that it can store more change in a parallel connection. Our goal is to grid integration of the whole system so that the cost will be lower as usual and that is why we use grid tie inverter for the grid integration purpose**[17]** .Through distribution units, controlled by control section, we can efficiently distributed our generated power as per required through automation. Though Smart grid system is still just a concept but through this proposed technology and management system, we can precede one step closer to smart system. For our modeling purpose, here we designed just solar cell unit's grid integration process and we skipped the control unit for easy understanding of this unit **[25-35]**.

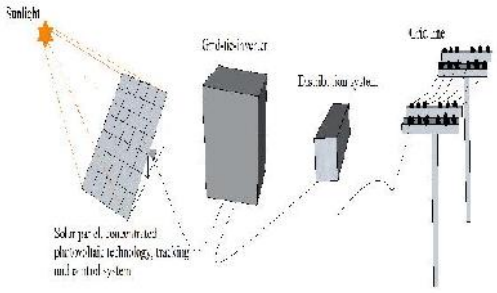

Figure 8: Grid line integration using a grid-tie-Inverter simple block diagram of only one Unit of the whole system. (Independent research i.e. google.com, [13])

Source: Independent research (photo credit self)

9 IMPLEMENTATION

As each unit is renewable resource based, so place selection for implementing these units is a big issue. The solution is not that straight forward. We have to go through a little bit analysis on some facts like solar insolation rate, sunlight availability, wind availability and other matters. We have to analyze statistical data for example for a particular region like mentioned before, to reach to a proper reliable solution to implement this hybrid system economically, efficiently in a long term basis and sustainable way. As electrical power transmission is done by transmission wire, so there is a great possibility of power loss at each unit, and to tackle this loss our control system unit plays an important role, that reduces the power loss, maintain power flow and transfer as per required **[36-38]**.

10 EFFECTS

The major advantage of this whole system is that, the each unit works independently and it's a dynamic system that supports continuously each other and in case of failure of any unit, the storage unit starts contributing to supply through control system by automation, to ensure the continuous flow of electricity. And through engineering economics concepts the implementation cost and other cost will turn into benefits, within half of a decade as extension of both the consumer surplus and producer surplus. Further research on engineering management to afford the implementation cost is undergoing.

11 CONCLUSION

This paper is based on many dependent or independent studies, done over time. Through innovation, we are able to choose selective technologies, methodologies and management system by doing researches and studies, to extend the electric power system to a most sustainable and reliable stage. We analyzed our present scenario of power sector, and gradually we develop a simple practical solution. Further extension on this proposed plan is still undergoing, and very soon this may reach us to a smart power generation in the long run.

ACKNOWLEDGEMENT

Myself S.M. Hasibul Hoq, would like to thank all my mates, teachers, researchers, internet resources and especially my Creator, parents, family members, seniors, juniors. I would like to thank co-author Asif Mahmood Abbas and Mohsin Ahmed.

REFERENCES

[1] Ministry of power, Energy and Mineral Resources
[2] A path to sustainable energy by 2030, Mark Z. Jacobson and Mark A. Delucchi, Scientific American.
[3] Electricity gap developing countries energy wood charcoal, Nathanial Gronewold, Scientific American.
[4] Renewable Energy, Introduction, Statistics;
[5] Solar-Green-Wind; Solar Grid System;
[6] American wind energy association, research wind turbine, small wind.
[7] Solar PV Energy Achievement and Prospect in Development of Rural Bangladesh; International Journal of Science and Research, India Online 2319-7064
[8] Black %Veatch: "Power Plant Engineering", Springer, NY, 1996; Chapter 24.
[9] A. Khaligh and O.C. Onar: "Energy Harvesting", CRC Press, N.U., Chapters 3,4,5
[10] Fraunhofer Institute for Solar Energy System ISE; Efficient Solar Power Through Industry Oriented Research.
[11] III-V Multi Junction Solar Cells for Concentrating Photovoltaics; Hector Cotal, Chris Fetzer, Joseph Boisvert, Geoffrey, Richard King, Peter Herbert, Hojun Yoon and Nasser Karam; Receiver 3rd June 2008, Accepted 1st September 2008 DOI:10.1039/b809257e
[12] Fraunhofer Institute for Solar Energy System ISE; World Record Solar Cell with 44.7% Efficiency.
[13] Solar Energy Grid Integration Systems: Ward Bower , Sigifredo Gonzalez, Abbas Akhil, Scott Kuszmaul, Lisa Sena-Henderson, Carolyn..Prepared by Sandia National Laboratories Albuquerque, New Mexico 87185 and Livermore, California 94550
[14] Solar Panel Pose Environmental Hazards Claim Report,Venturebeat;
[15] High Efficiency Single-Stage Grid-tied PV Inverter for Renewable Energy System, Zheng Zhao, April20, 2012
[16] Statistical analysis of wind speed and wind power potential, Temitope R Ayodele, Adisa A jimoh, Josiah L Munda, John T Agee.
[17] Redox Flow Battery, Fraunhofer-Gesellschaft.
[18] Battery and EnergyTtechnology, Electropaedia
[19] Prime Power Generation,Fuel cell today, South korea
[20] Wind Power System, Tracy Dahl, Technology with white paper,polar power.
[21] Wind Power Plans, Power and productivity for a better world.
[22] Reversible Solid Oxide Fuel Cell Technology for Green Fuel and Power Production, Nguyen Q.minh and Mogens B.Mogensen.
[23] Poultry Litter as Renewable Energy Resource using SOFC Technology, International Electrical Engineering Journal(IEEJ), Vol.4(2013) No.1, pp.914-917, ISSN 2078-2365
[24] Renewable and Sustainable Energy Reviews 6 (2002) 433-455.
[25] A Control and Communications Model for a Secure and Reconfigurable Distribution System, Anthony M. Giacomoni, Graduate Student Member, IEEE, S.Massoud Amin,IEEE, Bruce F. Wollenberg, IEEE
[26] Next Generation Monitoring, Analysis, and Control for the Future Smart Control Center, Pei Zhang, IEEE, Fangxing Li, IEEE, and Navin Bhatt, IEEE.-
[27] Smart Grid Power System Control in Distributed Generation Environment, Pertti Jarventausta, Sami Repo, Antti Rautiainen, Jarmo Partanen.
[28] Electricity Energy Storage Technology Options, 1020676, A White Paper Primer on Application, Costs, and Benefits, Power Delivery Utilization, Electric Power Research Institute.
[29] Energy Storage System for Advance Power Application, Paulo F. Ribeiro, Brian K. Johnson, Mariesa L. Crow, Aysen Arsoy, Yilu Lie, IEEE
[30] Electrical Energy Storage, White Paper, IEC.
[31] Battery Energy Storage For Smart Grid Application, EUROBAT.
[32] The Role of Energy Storage with Renewable Electricity Generation, Paul Denholm, Erik Ela, Brendan Kirby, and Michael Miligan, National Renewable Energy Laboratory.
[33] A Study of TCSC Controller Design for Power System Stability Improvement, Alberto D. Del Rosso, CAudio A. Canizares, Victor M.Dona.
[34] Power System Stabilizer Controller Design for SMIB Stability Study, Balwinder Singh Surjan, Ruchira Garg, ISSN: 2249-8958, Volume-2, Issue-1, IJEAT.
[35] Integration STATCOM and Battery Energy Storage System for Power System Teansient Stability: A Revie and Application, Arindam Chakraborty, Sharavana K. Musunuri, Advance in Power Electronics.

[36] Design & Integration of Wind-Solar Hybrid Energy System, Yandra Shivrath, P.Badari Narayana, pp-2974-2950 ISSn:2249-6645
[37] Power Electronics System Integration for Electric and Hybrid Vehicles, Martin Marz, Andreas Schletz, Fraunhofer Institute of Integrated System and Device Technology, Germany
[38] Energy Management and Power Control of a Hybrid Active Wind Generator for Distributed Power Generation and Grid Integration, Tao Zhou and Bruno francois, IEEE
[39] Energy Analysis of Power System, World Nuclear Association.
[40] Energy and Cost Analysis in pulp and Paper Industry by Auditing Techniques, Harsh Harit, Pardeep Gupta, S.C. Gupta, ISSN 0974-3154, IJERT.
[41] Cost Effectiveness of Electricity Energy Efficiency Programs, Toshi H. Arimura, Shanjun Li, Richard G. Newell and Karen palmer.
[42] World Energy Consumption, Wikipedia
[43] Electricity from Alternative Source, S.M. Hasibul Hoq, National Conference on Natural Science and Technology'2014, Asian University for Women.