Smart Grid Input Power Optimization Using Wind Turbine

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***Abstract*—Although this paper is made for smart grid technology which is a future technology to emerge, the same method can be applied to contemporary grid. By using wind turbine output equation, we tried to find out which is the efficient turbine speed to provide generated power to smart grid by wind turbines. A wind Turbine equation was programmed using MATLAB and most effective amount of energy delivery was determined using Bisection, Newton-Raphson and Genetic alogorithm methods. After finding the outputs from the above mentioned three methods the optimal output was found out. Hence the turbine speed for optimal power generation was determined and the benefits of smart grid is mentioned.**

Index- Smart Grid, Algorithm, Analysis, Energy

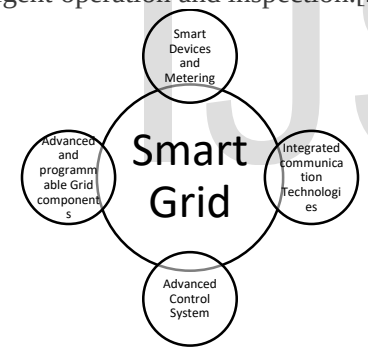
I. INTRODUCTION

A smart grid is an electricity grid enabling a two-way flow of electricity and data whereby smart metering is often seen as a first step. Smart grids – as a concept – became known over a decade ago. An introduction with definitions, trends and essential characteristics of smart grids. Big data and advanced analytics are essential technology drivers in smart grids whereby analytics shift to the edge as in edge computing. Smart grids leverage more technologies but aren't just about IT nor even technologies. There have been several catalysts for the recent attention to the Smart Grid, including but not limited to: recent changes in the landscape of electric power generation resources from centralized and deterministic to distributed and stochastic; increased environmental impact concerns; determination of federal energy future planning, and improvements in enabling technologies, such as communication networks and information technologies [1]. Different types of Generation units can be connected to smart grid we have calculated the effective way of operating wind turbine which can provide most efficient amount of energy to smart grid.

II. SMART GRID TECHNOLOGY

A smart grid is an electricity network enabling a two-way flow of electricity and data with digital communications technology enabling to detect,

react and pro-act to changes in usage and multiple issues. Smart grids have self-healing capabilities and enable electricity customers to become active participants. A smart grid serves several purposes and the movement from traditional electric grids to smart grids is driven by multiple factors, including the deregulation of the energy market, evolutions in metering, changes on the level of electricity production, decentralization (distributed energy), the advent of the involved 'prosumer', changing regulations, the rise of microgeneration and (isolated) microgrids, renewable energy mandates with more energy sources and new points where and purposes for which electricity is needed. Using constructed. Intelligent patrol, intelligent research and judgment, intelligent early warning, intelligent decision-making and intelligent dispatch of power grid equipment, break through the traditional passive operation and maintenance mode, comprehensively improve the quality and efficiency of operation and maintenance, and lead the change of the era of intelligent operation and inspection.[2]



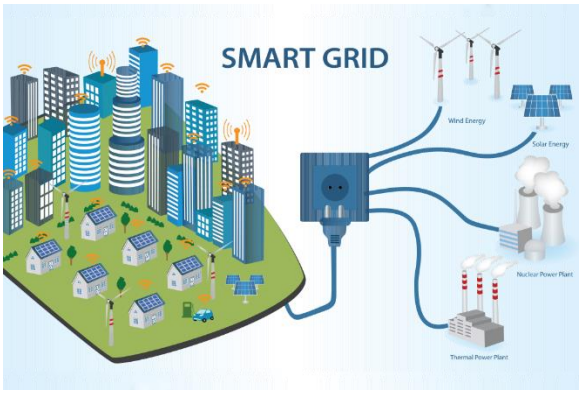
Technology can realize real-time two-way communication reliably with advantages of safe data transmission and strong anti-interference, completely satisfy the requirements of networking, communicate and control in System and smart appliance. [3]

III. Energy Delivery By SMART GRID

An electrical grid or electric grid is a network to deliver electricity from the producer(s) and places where it's generated and transformed (power plants and substations) to the final destinations where electricity is 'consumed': households, businesses, various facilities and the consumer in general. In practice it is a highly interconnected network with several components such as substations, transmission lines and wiring, distribution lines, transformers and more. Some people in the industry don't talk about smart grid anymore. They see that term as referring to a first stage where advanced metering infrastructure (AMI) initiatives were deployed with first-generation smart meters. They prefer to speak about power grid modernization, for example, as that is what it's really about with far more elements than smart metering, sending data in two directions and adding power to the grid in the opposite direction. However, although many countries, regions, states etc. already took such smart metering initiatives a decade ago there are still several where this is only really starting. In many countries the challenges of grid players are mainly seen in the decentralization of the production of energy and the transport of it. The Conceptual Model breaks the Smart Grid into "seven domains". These domains are: Bulk Generation, Transmission, Distribution, Customer, Operations, Markets and Service Providers [3]

IV.GENERATING UNITS CONNECTED WITH SMART GRID

The figure below shows an imaginary picture of generating units connected with smart grid. Smart grid is just like a plug point coming from a distribution network. Power Generation units are connected with this plug point as a power source.



V. USAGE OF SMART GRID

For Internet of Things companies such as All Things Talk the challenge energy and grid players ask them to help resolve is the connection of a multitude of meters and the normalization of the data, enabling to roll out faster and in an automated way. Time for a further exploration into some elements of smart grids – or grid modernization if it is preferrd. According to the EU a smart grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies to: Better facilitate the connection and operation of generators of all sizes and technologies; Allow consumers to play a part in optimizing the operation of the system; Provide consumers with greater information and options for how they use their supply; Significantly reduce the environmental impact of the whole electricity supply system; Maintain or even improve the existing high levels of system reliability, quality and security of supply; Maintain and improve the existing services.

VI. EQUATION OF WIND TURBINE

The equation below shows the amount of electricity produced y by wind turbine where the wind speed is x.

$$y = \frac{404165.5}{230-2x} + \frac{10400}{x-30} \dots\dots\dots\dots\dots (equation: 1)$$

VII. FIGURES AND TABLES OF DIFFERENT METHODS

The equation 1 is executed in MATLAB by varying wind speed x between 40 rms and 90 rms where bi-section, newton Raphson and genetic algorithm were used the obtained outputs are tabulated below

Bisection Method

y	x	
	Lower limit a	Upper limit b
	40	90
	40	65
	40	52.5
	40	46.25
	43.125	46.25
	44.688	46.25
	45.469	46.25
	45.469	45.859
	45.664	45.859
	45.664	45.762
	45.713	45.762
	45.713	45.737
3578.476	45.713	45.725

Newton Raphson method

x	y=F(x)	Derivative	Second Derivative
45	3580.230	-4.981	7.341
45.678	3578.481	-0.256	6.610
45.717	3578.476	-0.001	6.573

Genetic Algorithm

	x	y
489	43.8774	3590.7499
490	43.8774	3590.7499
491	43.8774	3590.7499
492	43.8774	3590.7499
493	43.8774	3590.7499
494	43.8774	3590.7499
495	43.8774	3590.7499
496	43.8774	3590.7499
497	43.8774	3590.7499
498	43.8774	3590.7499
499	43.8774	3590.7499
500	43.8774	3590.7499
501	43.8774	3590.7499

VIII. Analysis

The equation 1 shows the amount of power delivered to the grid generated from wind turbine where the generated power y is the function of wind speed x. Wind speed x is varied between 40 rms and 90 rms using matlab and optimum generated power y is determined. It is found that optimum wind speed is between

43.877 to 45.717 rms. A comparison of wind speed and generated Power is shown in the table below.

Output	Optimum wind speed x in rms	Optimum generated power y in KW
Bi section algorithm	45.713	3578.476
Newton Raphson algorithm	45.717	3578.476
Genetic algorithm	43.877	3590.749

By comparing it can be found that the most optimum generated Power is 3590.749 KW at 43.877 rms turbine speed.

IX. Benefits of Smart Grid

It sums up some benefits associated with the Smart *Grid (again, the initiative, but you can expand it to smart grids overall* More efficient transmission of electricity;
Quicker restoration of electricity after power disturbances; Reduced operations and management costs for utilities, and ultimately lower power costs for consumers; Reduced peak demand, which will also help lower electricity rates; Increased integration of large-scale renewable energy systems; Better integration of customer-owner power generation systems, including renewable energy systems.

X. Challenges of Smart Grid

Obviously, there are also challenges regarding the movement to a smart grid. Some were addressed earlier in this overview. Additional ones include consumer concerns (privacy and personal data protection) and cybersecurity.
In countries where smart meter initiatives have started we often see resistance from consumers (whereby often the installation of a smart meter in the end becomes an option; in other countries refusing leads to financial consequences or, let's say accepting means a financial reward).A second challenge is certainly the overall cybersecurity aspect which is typical in all industrial environments where digitization and digital transformation are ongoing, data become key and IT and OT converge (IT stands for information technology, OT for operational technology).

XI. Acknowledgement

First of all, we would like to express our profound gratitude to our honorable course instructor, Abu Hena Md. Shatil , for his constant and meticulous supervision, valuable suggestions, his patience and encouragement to complete the paper work. We with the opportunity to have an experience as part of our curriculum for the master's program. Finally, we would like to thank everybody who supported and provided with guidance for the completion of this paper

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