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Optimization of Reliability System using Solar Energy Grid Integration System ''SEGIS''

Scholar Roshan Lal
Dept. of M.E.(Power Electronics)
Raipur Institute of Technology, Raipur

Associate Professor Ritesh Diwan
Dept. of Electronics & Telecommunication Engineering
Raipur Institute of Technology, Raipur

Chatauna, Mandir Hasaud, Raipur (C,G,) India- 492101, E-mail- contactus@rit.edu.in

***Abstract* – The inevitable transformation of the electrical grid to a more distributed generation configuration requires solar system capabilities well beyond simple net-metered, grid-connected approaches. Time-of-use and peak-demand rate structures will require more sophisticated systems designs that integrate energy management and/or energy storage into the system architecture. Controlling power flow into and from the utility grid will be required to ensure grid reliability and power quality. Alternative protection strategies will also be required to accommodate large numbers of distributed energy sources.The scope of the SEGIS program includes improving the reliability and increasing the value of PV inverter/controllers while developing interfaces for advanced grid integration. SEGIS products are needed that will increase the value of solar energy systems in today's "one-way" distribution infrastructure and/or will increase the value of systems in tomorrow's two-way" grid or micro-grid. The heart of the SEGIS hardware, the inverter/controller, will manage generation and dispatch of solar energy to maximize value, reliability, and safety. The inverter/controllers will interact with building energy management systems and/or smart loads, with energy storage, and with the electric utility to allow the integration of relatively large amounts of PV energy while maintaining or increasing grid reliability.**

***Keywords*– Grid connected PV, Harmonics, Anti-islanding, Performance Ratio (PR), RSCAD, RTDS.**

I. INTRODUCTION

Introduction to energy consumption and production any change that takes place in the universe is accompanied by a change in a quantity that we name energy. We do not know what energy exactly is, we use this term to describe a capacity of a physical or biological system for movement or change. Energy comes in many forms, such as electrical energy, chemical energy, or mechanical energy, and it can be used to realize many forms of change, such as movement, heating, or chemical change. Any activity, and human activity as well, requires energy. Human beings need it to move their bodies, to cook, to heat and light houses, or to drive vehicles. Human being is a greedy consumer of energy. An active young man needs about 2500 kcal (2.9 kWh) per day to fulfil his daily energy requirements. This means the energy of about 1060 kWh per year. The present global energy consumption is around 19 000 kWh per inhabitant per year. It means that on average a man consumes about 19 times more energy than is needed for his survival and satisfactory health. The mankind has witnessed an enormous increase in energy consumption during last 100 years. While in 1890 the energy use per inhabitant per year was around 5800 kWh it reached 20200 kWh in 1970. Since 1970 the energy use has dropped to the present level of 19000 kWh per inhabitant per year. The increase in energy use in the 20th century can be related to an evolution process that has started about five centuries ago. The underlying motivation of this process was formulated during the Enlightenment period in the 18th century as the philosophy of human progress. The aim of the process was an examination of the surrounding world and its adaptation to the needs of people whose life would become more secure and comfortable. This process was accompanied by growing industrialization and mass production, which were demanding more and more energy. At the end of the 19th century coal was the main source of energy.

II. RENEWABLE ENERGY SOURCES

The negative aspects of today's energy system have led to the formulation of sustainable human development. The realization of the sustainable development requires an alternative energy system that is based on: i) policies for efficient energy use and ii) renewable energy sources. The world's largest oil company Shell has published recently a vision on future energy consumption and potential energy sources. One of the largest energy producers in the world expects that the restructuring of power industry will take place in near future. The Shell's scenario that is called the "Sustained Growth" is presented. The company has concluded that the fossil fuels are still important, but they reach a plateau by 2020. At this time, renewable energy will become a significant source of energy. At first, renewable energy will grow in niche markets rather than compete with traditional sources of energy. The market will decide a share of different forms of renewable energy. In future, the energy supply will become more diversified and hence more robust. It is interesting to notice that Shell expects the photovoltaic (PV) solar energy to become a major energy source within fifty years. Renewable energy sources are based on the continuing flows of energy that is considered inexhaustible from the point of view of human civilisation. Solar radiation represents such an infinite source of energy for the Earth. The sun delivers 1.2 × 1014 kW energy on the Earth, which is about 10.000 times more than the present energy consumption. The energy that the Earth receives from the sun in just one hour is equal to the total amount of energy consumed by humans in one year.

III. MOTIVATION

A proper load forecasting will help power management companies to take decision related to energy management. Since at present we are looking forward towards utilizing renewable energy the best way possible. Hence having a couple day ahead load forecasting will help in deciding the precise amount of additional non-renewable energy source to be kept spinning for generation.

Hence, we can increase the penetration of renewable energy and thereby reducing dependency on non-renewable sources and hence it will reduce generation cost.

A precise forecasting helps the energy management company to make unit commitment decisions like to reduce spinning reserve capacity and to schedule device maintenance plan.

IV.OBJECTIVE

An accurate load forecasting will directly influence the economic operation and reliability of the system greatly. An under-forecasting of load will lead to insufficient reserve capacity preparation and in turn increases the operating cost by using expensive peaking units. Whereas in case of over prediction of load will leads to the unnecessarily large reserve capacity, which is also related to high operating cost.

Now predicting exact value of load is very complex because of the fact that electrical load depends on many factors like holidays, weekdays, season and weather of location whose load is to be predicted and other random parameters. Hence in the present work an attempt is made to develop a model which can STLF efficiently. Model is to be designed based up on historical parameters. Model is trained and tested on same. This model is developed in MATLAB/ Simulink environment with the help of neural network tool. With ANN signal pre-processing is also tried to check for the effect on closeness with actual results.

V. LITERATURE REVIEW

AbdollahkavousiFard, Haider Sawet & Faroogh Mohammadnia: in 2016 have developed a comparative study of various evolutionary short-term forecasting based on ANN. In this algorithm authors have utilized real data of load of Iran province. In this study author has generated a hybrid combination of evolutionary algorithms and ANN to forecast load. In this study, the most optimum results are obtained using modified Honey Bee Optimization(MHBMO) – ANN combination having load forecast with about 1.8%.

KishanBhushanSahay, SuneetSahu, Pragya Singh: in 2016 prepared a model to STLF for Toronto Canada using ANN. In ANN, they have utilized Back Propagation algorithm for training Neural Network. Also in BPNN three different algorithms LM, SCG and BR are used and separate results are generated based on above all three. On comparison MAPE of all three algorithmsauthors has concluded that out of all three back propagation algorithms LM and BR showing almost same results hence should not be used in forecasting load for short term.

Sharad Kumar, Shashank Mishra and ShashankGupta in 2016 developed two forecasting models ANN based and multiple regression based. Input data both weather and load data are sampled every 30 minutes. Author utilized data from 1st June 2015 to 15th June 2015 for training and testing. So, a total of 672 samples are available to develop model. Both models are separately trained and tested and their results are compared based on the amount of relevance the forecasted load is with actual value. In present study author found that ANN is better performing model than regression hence it should be preferred for forecasting short term load.

Victor Mayrink and Henrique S. Hippert in 2016 have generated a hybrid model combining a classical and a machine learning algorithm for the forecasting of short term load. Two-time series are utilized in this study by author are load and temperature of Rio De Jenerio of Brasil dated between 1 Jan 1996 to 28 Feb 1997. Data utilized are hourly data. Two models utilized are exponential smoothing and gradient boosting. In this study for forecasting residuals of all previous steps in all iterations are refined using a base learning model. Author has proposed that the hybrid model has shown a significant improvement in results than the classical approach of exponential learning.

Ni Ding, Clémentine Benoit, Guillaume Foggia, YvonBésanger and FrédéricWurtz in 2015 have developed different models of machine learning for the forecasting of load. The authors in this study have utilized real data of French distribution system. The results obtained have proven that machine learning is far more accurate than time series forecasting. Author has utilized statistical methods for the purpose of variable selection. Also, the hidden layer neurons are taken as random parameters for all models since no exact method is available for deciding its exact value. In this paper, a significant improvement is MAPE is proved from naïve model by ANN for same data.

Penghua Li, Yinguo Li, QingyuXiong, Yi Chai and Yi Zhang in 2014 have developed a hybrid quantized Elman Neural Network for the purpose of STLF. In this study author discussed the requirement of highly accurate forecasting model. According to author for every 1 % increase in forecasting error will lead to 10 million dollars increase in operating cost, which is sufficient enough motivation for forecasting. In this paper, algorithm proposed is unlike typical Elman Back propagation algorithm in which we have fixed context layer weights. Here author has now extended to hidden layer weights also thus proving to give more accurate results by understanding relation in time series in a much accurate way.

HaoQuan, Dipti Srinivasan and Abbas Khosravi in 2014 developed a LUBE model to overcome various deficiencies of traditional methods. In this study author has used PSO, which is a powerful optimization tool along with Neural Network to fulfil the objective. The results of proposed models are compared with three different and most popular forecasting models named ARIMA, ES and naïve models. Results comparison shows that the proposed model has far efficient results then the other three. Authors have tested the proposed model on data of three different countries and found that it is equally performing on all conditions.

HaoQuan, Dipti Srinivasan and Abbas Khosravi in 2013 implements Neural Network for the generation of prediction intervals. Authors have utilized lower upper bound estimation (LUBE) method and PSO for optimizing weights. The data of demand from Singapore and New South wales are used to train and test proposed model. Authors after studying concluded that this model has significant forecasting ability which can be very helpful for planning company to take decision about contingency analysis which became very crucial because of high penetration of wind and solar.

Ajay Gupta and Pradeepta K. Sarangiin 2012 developed a Generic algorithm and ANN based forecasting model. On testing the data with GA-ANN algorithm authors found GA has good capability in function optimization and thus GA has efficient optimized neural network weights and thus forecasted load with least error by finding approximate global minima. Results are developed different architecture's and results are developed for population versus error.

VI. SEGIS-ES FOR DISTRIBUTION-SCALE

SEGIS-ES is focused on developing commercial storage systems for distribution-scale PV in the market sectors shown in Table 1; specifically, PV systems designed for applications up to 100 kW that can be aggregated into multi-megawatt systems. Integrating electric energy storage into homes or commercial buildings is also a key focus of SEGIS-ES. New storage systems developed under the Program will play an important role in the development of independent microgrids – either individual buildings or communities of buildings – so microgrid-scale storage, on the order of a megawatt of distributed generation, is within the scope of this effort. Storage systems developed through SEGIS-ES will interface with SEGIS products to further enhance PV system value and economy to customers[4-10]. Products to be developed through SEGIS-ES include, but are not limited to, the following:
Battery-based systems using existing technologies that are enhanced or specifically designed for PV applications including the development of PV-Storage hybrid systems;
New energy storage system controllers that interface with SEGIS hardware to optimize battery use in order to obtain the best possible system efficiency and battery life;
Non-battery storage systems (e.g., electrochemical capacitors [ECs], flywheels) designed specifically for PV applications; and New devices that integrate into building infrastructure. SEGIS-ES does not address the following of PV modules. Development of new battery technologies, although collaboration with the DOE Office of Basic Energy Sciences Energy Frontier Research Centers' Funding Opportunity is encouraged. Utility-scale storage systems or storage at the level of large distribution feeders. Although these efforts are key to achieving high penetration of distributed generation, they will be addressed through other Program activities. PV inverters or related power conditioning devices. Non-solar-related storage system development, smart appliances, or utility portals.

Residential	Less than 10 kW, single-phase
Small Commercial	From 10 to 50 kW, typically three-phase
Commercial	From 50 to 100 kW, three-phase

Table -I: Target Market Sectors for SEGIS PV Systems.

SEGIS Tasks: Descriptions and Results-

Task 1: Conduct Feasibility Studies and Preliminary Design To address this task, the team focused on three areas: (1) interconnection standards, (2) communications, and (3) simulation model development. Based on these areas, the team worked to understand the key requirements for realizing the Grid-Smart Inverter concept. The standards issues, primarily associated with restrictive requirements of IEEE Std.1547 [4], have been identified and their resolution in favor of different, more permissive grid interconnection standards for distributed generation continues to be actively pursued. Specifically, through involvement in existing and emerging sub-committees of IEEE Std. 1547, team members continue to advocate for inverter-based distributed generation. This included two team members being present at the most recent IEEE Std.1547 Microgrid, Secondary Networks and Simulation subcommittee meetings in Las Vegas in January 2009. The FSEC team has three active balloting members of the IEEE committees and several others who have participated in previous IEEE Std.1547 ballots.

- Remote-Controlled Real Power Control
- Remote-Controlled Power Ramp Rate
- Remote-Controlled Power Factor Adjustment - The inverter can be used to source VArs, and, in the Lana‘i case, the PPA specifies a PF adjustment within the range of 0.95 leading to 0.95 lagging, in increments of 0.005, with a <0.5 second response time.

Task 2: Estimated Product Performance and Cost.

Task 3: Identify Perceived and Actual Barriers and Mitigation Plans.

VII. CONCLUSION

Solar Energy Grid Integration Systems (SEGIS) concept will be key to achieving high penetration of photovoltaic (PV) systems into the utility grid. Advanced, integrated inverter/controllers will be the enabling technology to maximize the benefits of residential and commercial solar energy systems, both to the systems owners and to the utility distribution network as a whole. It can be used with low power as well as high power photo-voltaic system. Efficiency of the proposed architecture is demonstrated for the photovoltaic system installed in educational institution. The value of the energy provided by these solar systems will increase through advanced communication interfaces and controls, while the reliability of electrical service, both for solar and non-solar customers, will also increase Advanced integrated inverters/controllers may incorporate energy management functions and/or may communicate with separate-alone energy management systems as well with utility energy portals, such as smart metering systems. Products will be developed for the utility grid of today, which was designed for one-way power flow, for intermediate grid scenarios, and for the grid of tomorrow, which will seamlessly accommodate two-way power flows as required by wide-scale deployment of solar and other distributed [11-12].

The first crucial step of any planning study is load forecasting. Forecasting refers to the prediction of the load behavior for the future. Load forecasting is important to all energy companies especially after deregulation for conducting operational planning. With continuous fluctuation in demand and supply and variation in weather behavior and energy prices increasing by peak load demands, load forecasting had become very important. A precise forecasting is very helpful in preventing system from getting over loaded and under loaded. This will make system more stable since no unexpected factor will occur which will affect generator or other electrical equipment and thus electrical system will become more reliable.

Electrical load forecasting also effects price of electricity by managing generation in the most economical way. Since the demand of load of any area is dependent on certain factors like energy pricing, level of industrialization and population, hence the modern energy market faces deep connection between electricity price and load profile.

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