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HYBRID POWER CONVERTER MODELING FOR BLDC MOTOR DRIVE USING MATLAB/SIMULINK

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Abstract: In this project Hybrid power converter modeling is presented. The application is useful for analysis and simulation of a real hybrid solar-wind-hydroelectric system connected to a public grid. Application is built on modular architecture to facilitate easy study of each component module influence. Blocks like wind model, solar model, hydroelectric model, energy conversion and load are implemented. Due to development in renewable energy technologies and continued rise in prices of petroleum products hybrid renewable energy systems are gaining more importance for supplying the power to meet the today's increasing energy demands either as a stand-alone system or as a grid connected system Voltage - RMS control is used and it is based on generating appropriate modulation coefficient by comparing output voltage and the reference signal. Smart grids (SGs) offer technological choices to have more controllable, reliable and sustainable power grids. Eco friendly and manageable energy generation is significant for sustainable development. In this study, Matlab/Simulink models of power converters which are required for smart grid simulations are presented. Pulse width modulation (PWM) technique is used to control the converters.

Key Words: Converters, Matlab, power system simulation, pulse width modulation, smart grids.

I. INTRODUCTION

II. POWER COMPONENTS DESIGN

Electrical devices work in various characteristics in terms of frequency, amplitude, and current form. Electronic power converters are used to integration of the devices on a common grid structure. Furthermore, the converters are employed as an energy control unit to increase efficiency, flexibility, and reliability of electric energy. Power converters are mainly classified in three categories: AC/AC, AC/DC, and DC/DC converters. In this section, Matlab/Simulink models of these converters and dynamic load are introduced.

A. DC/AC Converter

An inverter can be identified as electronic power equipment which converts the DC voltage to one or three phase AC voltage. Inverters can be run in grid-connected and standalone modes according to electric source and load voltages. Therefore, system voltage control has a key role to protect the power quality. Voltage controlled inverters have

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significant advantages such as cost, compact design and higher efficiency. These inverters are used in power supplies, power quality controllers, marine, renewable energy systems, and military implementations [12]. Fig.1 shows Matlab/Simulink model of voltage controlled inverter. 24 V DC voltages, which is the battery output voltage level, is used as a DC power source. R_{batt} shows the resistance of battery and wire. Presence of R_{batt} is a requirement for the model because of the fact that DC power source cannot be directly connected with a capacitance in Simulink. C_{dc} provides stable DC voltage in input of the inverter. The value of C_{dc} must be chosen accurately because it affects harmonic distortion and amplitude of the output voltage [13]. R_{cf} and C_f denote snubber resistance and capacitance, respectively. R_{cf} and C_f have significance for quality of output voltage and for protection of the inverter against to unwanted sudden alteration of the output current and voltage. The inappropriate choosing of R_{cf} and C_f can reduce the speed of simulation. Values of these components should be adjusted according to power requirements of the load.

Fig.1. Matlab/Simulink model of RMS control inverter.

R_{Lf} and L_f represent resistance and inductance values of the filter, respectively. This filter is used to provide stability of the output voltage and the current by reducing harmonic distortion resulted component frequencies which are higher than output signal. The transformer ensures galvanic isolation for the inverter. In this study, the use of transformer is necessary because of 24 V DC voltage is converted to 220 AC voltage that it is high power conversion rate. The output filter of the transformer regulates the output voltage and prevents load against to sudden change of the current. This inverter model can be used for driving linear or nonlinear and static or dynamic loads. Voltage - RMS control is used and it is based on generating appropriate modulation coefficient by comparing output voltage and the reference signal. For this purpose, the output voltage is divided to a required nominal voltage. The result is a constant value which is used to determine RMS value. After the constant value is obtained, it is multiplied with the reference signal to generate control signal. Reference signal is generated by an independent signal generator and used to generate PWM control signal. After transient state, the output signal shows the same property with reference signal. The RMS value is obtained through the result of output voltage when it is divided to nominal value of AC voltage. The control signal has same frequency with the reference signal and the output voltage.

B. DC/DC Converter

DC/DC choppers are electronic power components which convert DC voltage level to another DC voltage level. DC/DC converters are basic components for renewable energy system because of the fact that they are employed to
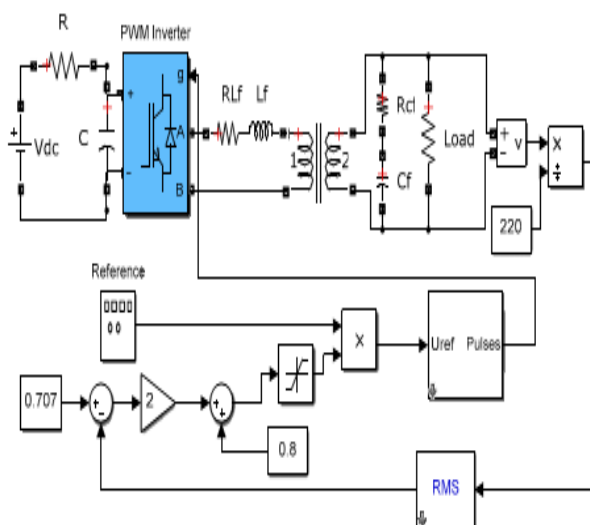
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adjust DC voltage of energy sources for voltage of loads [14]. Particularly, DC/DC choppers were commonly used for voltage stability and improvement of controllability in smart grid applications. There are two basic chopper types: buck [15] and boost for DC/DC conversion. Switched mode power supply technique is commonly used to control the output voltage of DC/DC choppers. Buck type DC/DC converter with PI controller is shown in Fig.2. Closed loop PI controller driving pulse width modulation is utilized to improve the voltage stability in the DC/DC choppers. In this method, measured output voltage is subtracted from reference voltage to obtain an error signal. Then, it is applied to PI controller and the control signal is used to generate PWM signal. The PWM signal is employed to control power switch. This control feedback aims to zero the error signal.
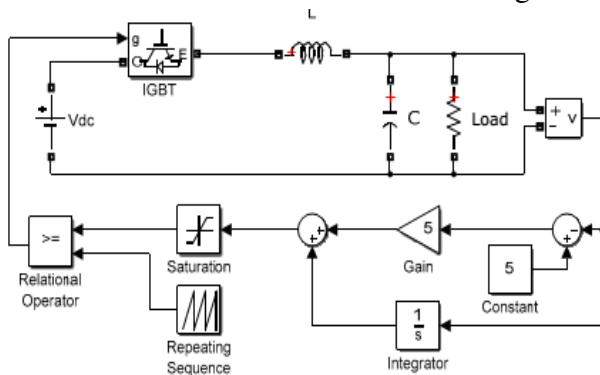

Fig.2. Circuit design of 120/5 Buck type DC/DC converter.

C. AC/DC Converter

The AC/DC converters can be designed by using controllable (IGBT, Mosfet, Thyristor, etc) and uncontrollable (diode) semi-conductor switches according to required output voltage [19]. The AC/DC converters are used in drivers, secondary power supply, chemical electrolysis and renewable energy systems. The AC/DC conversion contains three basic steps: Firstly;

AC waveform is converted to only positive or negative cycle, secondly; filtering the cycle for reducing voltage ripple and finally; using an appropriate control method to prevent the harmonic distortions and increase the efficiency of the device. The introduced DC/DC converter in the previous section can be used to control the AC/DC converter with PWM technique. The rectifying process of the AC/DC converter can be performed by the rectifier model of Simulink/Toolbox. The AC/DC converter model, which is designed in Matlab/Simulink environment, is shown in Fig.3. The rectifier block of Simulink/Toolbox is used for rectification of AC voltage and the DC/DC chopper in the previous section is utilized to filter the ripple and improve the voltage stability for the load. DC/DC chopper are utilized to control output voltage of AC/DC converter. The filter component and switching frequency can be changed according to the power rate. Buck type DC/DC converter model is used, in order to obtain lower output DC voltage than the uncontrolled rectifier DC voltage. A boost transformer will be used in front of the rectifier to increase effective value of AC voltage. The greater DC voltage is also obtained by using boost type DC/DC converter.
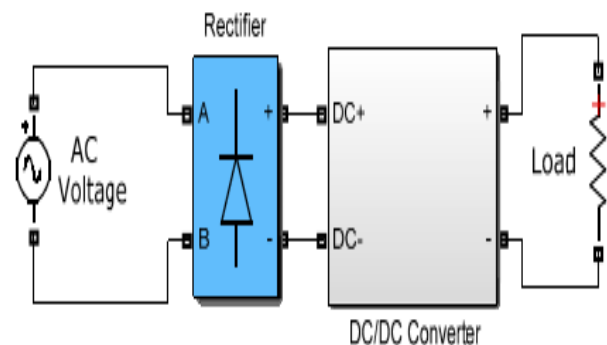

Fig.3. Matlab/Simulink model of AC/DC converter.

D. Dynamic Load

Electrical loads are analyzed in two groups: static and dynamic loads [20-21]. Due to the fact that the traditional static load models are not sufficient to represent the transient behavior of real electrical loads, there is a need for the dynamic load modeling in electrical system simulations. One of the methods is Measurement-Based Approach (MBA) where a load is statistically modeled with a long-term observation and measurement. Another method is Component Based Approach (CBA). In the CBA, the total load of the system can be obtained by summing of the load components. The load modeling in power systems has a key role to obtain realistic results. The dynamic loads can be designed by switching static load components in Matlab/Simulink simulation environment. The static loads are switched according to the dynamic load characteristic by means of switching components. In this way, the dynamic load could be designed by switching static loads, which can dynamically change total power of static load power components for each sampling time. The dynamic load models which are designed by IGBT and Breaker switches are presented in Fig.4. Both of loads have same characteristics which are defined between zero and 4000 W in five sample time intervals.
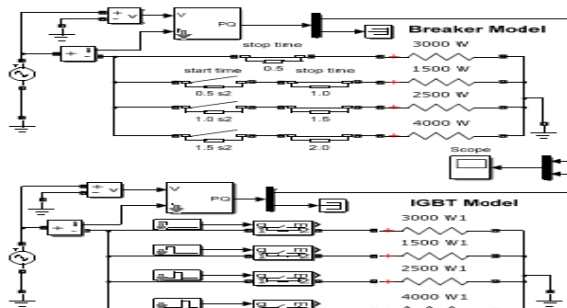

Fig.4. Dynamic load models designed by IGBT and Breaker switches.

The breaker and IGBT models have different electrical characteristics. Because of the breaker has snubber capacitor which needs reactive power and ripples occur at switching time. However, IGBT switch must be preferred in just active powered circuits which do not require compensation unit.

(II) Proposed Work: BLDC

Brushless DC motor may be described as electronically commuted motor which do not have brushes. These types of motors are highly efficient in producing large amount of torque over a vast speed range. In brushless motors, permanent magnets rotate around a fixed armature and overcome the problem of connecting current to the armature. Commutation with electronics has large scope of capabilities and flexibility. They known for smooth operation, and holding torque when stationary.

(A) Working Principle of Motor

Before explaining working of brushless DC motor, it is better to understand function of brushed motor. In brushes motors, there are permanent magnets on the outside and a spinning armature which contains electromagnet is inside. These electromagnets create a magnetic field in the armature when power is switched on and help to rotates armature. The brushes change the polarity of the pole to keep the rotation on of the armature. The basic principles for the brushed DC motor and for brushless DC motor are same i.e., internal shaft position feedback. Brushless DC motor has only two basic parts: rotor and the stator. The rotor is the rotating part and has rotor magnets whereas stator is the stationary part and contains stator windings. In BLDC permanent magnets are attached in the rotor and move the

electromagnets to the stator. The high power transistors are used to activate electromagnets for the shaft turns. The controller performs power distribution by using a solid-state circuit.

(B) Types of Brushless DC Motors

Basically, BLDC are of two types, one is outer rotor motor and other is inner rotor motor. The basic difference between the two are only in designing, their working principles are same.
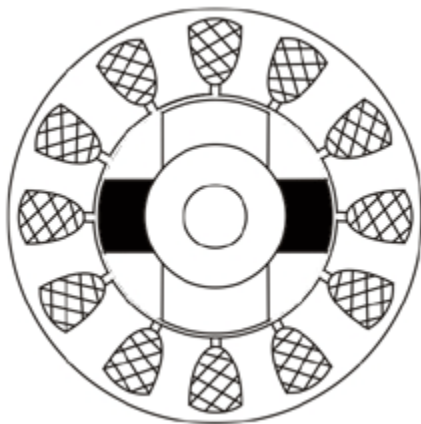
Fig 5 Inner Rotor Design

In an inner rotor design, the rotor is located in the center of the motor and the stator winding surround the rotor. As rotor is located in the core, rotor magnets does not insulate heat inside and heat get dissipated easily. Due to this reason, inner rotor designed motor produces a large amount of torque and validly used.
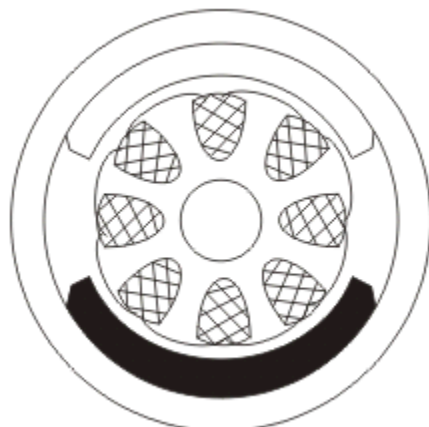
Fig 6 Outer Rotor Design

In outer rotor design, the rotor surrounds the winding which is located in the core of the motor. The magnets in the rotor traps the heat of the motor inside and does not allow to dissipate from the motor. Such type of designed motor operates at lower rated current and has low clogging torque.

(C) Advantages of Brushless DC Motor

- Brushless motors are more efficient as its velocity is determined by the frequency at which current is supplied, not the voltage.
- As brushes are absent, the mechanical energy loss due to friction is less which enhanced efficiency.
- BLDC motor can operate at high-speed under any condition.
- There is no sparking and much less noise during operation.
- More electromagnets could be used on the stator for more precise control.
- BLDC motors accelerate and decelerate easily as they are having low rotor inertia.
- It is high performance motor that provides large torque per cubic inch over a vast sped rang.
- BLDC motors do not have brushes which make it more reliable, high life expectancies, and maintenance free operation.
- There is no ionizing sparks from the commutator, and electromagnetic interference is also get reduced.
- Such motors cooled by conduction and no air flow are required for inside cooling.

(D) Disadvantages of Brushless DC Motors

- BLDC motor cost more than brushless DC motor.
- The limited high power could be supplied to BLDC motor, otherwise too much heat weakens the magnets and insulation of winding may get damaged.

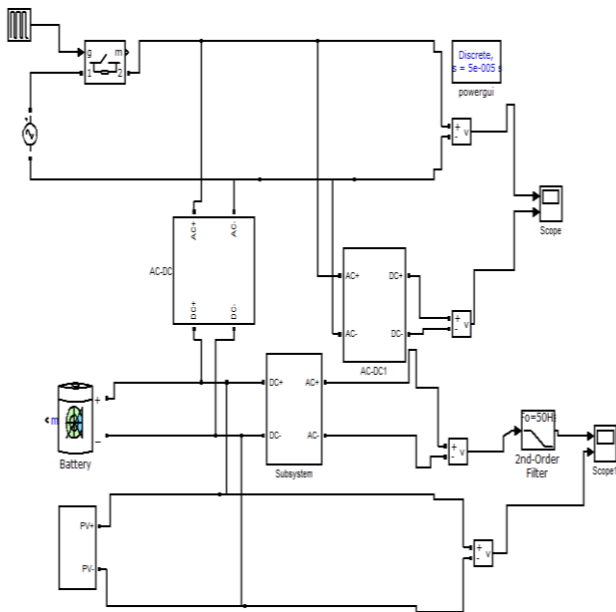## III. MATLAB/SIMULINK RESULTS
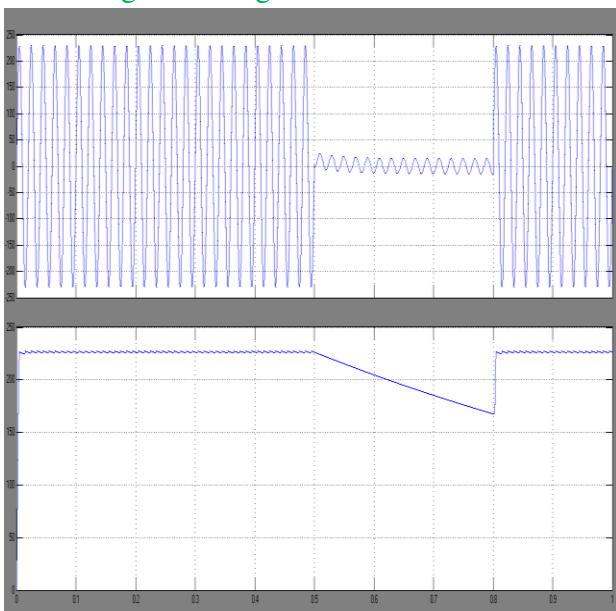

Fig.7. Microgrid Simulink model.

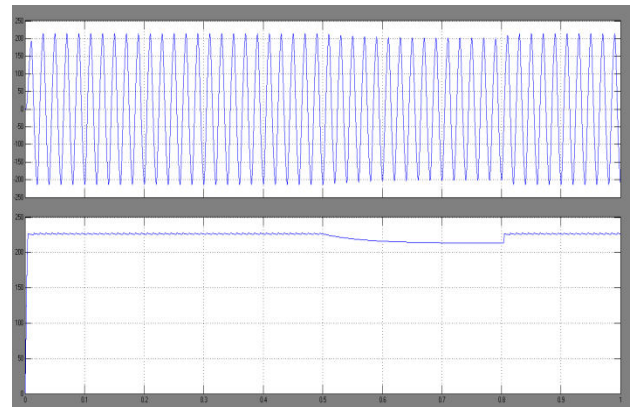Fig. 8. AC and DC load voltages for Home-1.
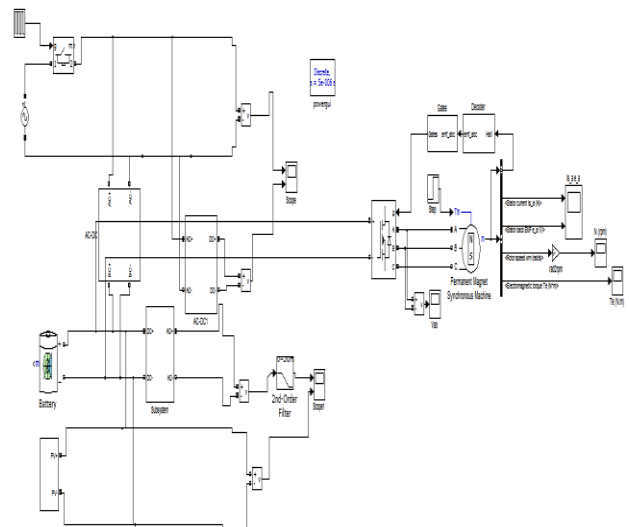

Fig. 9. AC and DC load voltages for Home-2.

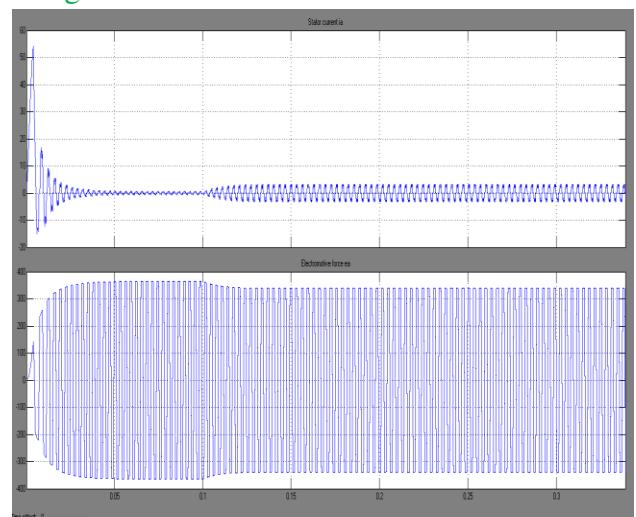Fig.10. BLDC motor drive Simulink model.

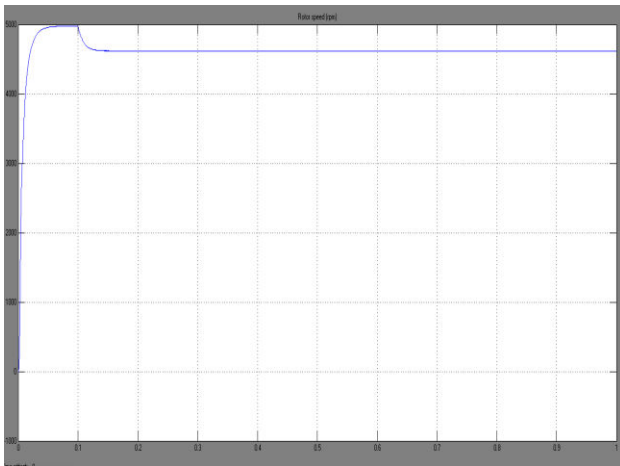FIG 11 Characteristics of Stator Current And Electromotive Force
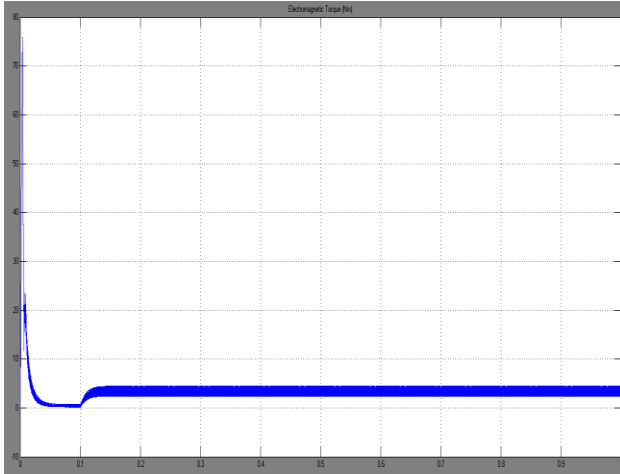
FIG 12 Characteristics of Rotor Speed Vs Time

FIG 13 Characteristics of Torque Vs Time

IV. CONCLUSION

The computer-aided design have important role in electrical engineering implementations and educations due to fact that it reduces test period and costs compared to experimental studies. Essentially, Smart grid researchers need the simulation models of the AC/DC, DC/DC, DC/AC power converters and the dynamic DC/AC loads to develop smart power systems and analyze them under various simulation scenarios. The simulation models should be designed by commonly used control techniques and their power response are consistent with the experimental studies for successful practical realization of the developed systems. In this paper, Matlab/Simulink models of electronic power converters were presented and the dynamic load models were designed by means of IGBT and breaker models of Simulink model library. As an illustrative example, the models are used for development of renewable energy micro-grid composed of DC and AC lines. In load side, two house models are tested to investigate effects of PV panel and battery integration to DC line. Short-term outage scenario was tested and simulation results numerically demonstrated that the DC bus of microgrid improves self-healing property of grid for short-term faults cases. As a consequence, power converter and dynamic load models can be effectively used in research and education studies and they can considerably reduce time and cost of design and transient analysis for smart grids. The modeling of BLDC Motor presented in this paper. The feedback signal and commutation mechanism utilizes speed, position of the rotor and stator current. All the simulation results are of theoretical aspects and can be utilized for practical implementation.

REFERENCES

[1] A. R. Khan, A. Mahmood, A. Safdar, Z. A. Khan, and N. A. Khan, "Load forecasting, dynamic pricing and DSM in smart grid: A review," Renew. Sustain. Energy Rev., vol. 54, pp. 1311–1322, 2016.

[2] M. Rastegar and M. Fotuhi-Firuzabad, "Load management in a residential energy hub with renewable distributed energy resources," Energy Build., vol. 107, pp. 234–242, 2015.

[3] G. R. Aghajani, H. A. Shayanfar, and H. Shayeghi, "Presenting a multi objective generation scheduling model for pricing demand response rate in micro-grid energy

management," Energy Convers. Manag., vol. 106, pp. 308–321, 2015.

[4] Y. Hua, M. Oliphant, and E. J. Hu, "Development of renewable energy in Australia and China: A comparison of policies and status," Renew. Energy, vol. 85, pp. 1044–1051, 2016.

[5] Z. Abdmouleh, R. A. M. Alammari, and A. Gastli, "Review of policies encouraging renewable energy integration & best practices," Renew. Sustain. Energy Rev., vol. 45, pp. 249–262, 2015.

[6] S.-Y. Huh, J. Lee, and J. Shin, "The economic value of South Korea′s renewable energy policies (RPS, RFS, and RHO): A contingent valuation study," Renew. Sustain. Energy Rev., vol. 50, pp. 64–72, 2015.

[7] S. Mekhilef, M. Barimani, A. Safari, and Z. Salam, "Malaysia's renewable energy policies and programs with green aspects," Renew. Sustain. Energy Rev., vol. 40, pp. 497–504, 2014.

[8] A. Bouraiou, M. Hamouda, A. Chaker, M. Sadok, M. Mostefaoui, and S. Lachtar, "Modeling and Simulation of Photovoltaic Module and Array Based on One and Two Diode Model Using Matlab/Simulink," Energy Procedia, vol. 74, pp. 864–877, 2015.

[9] A. Baloi, A. Pana, and F. Molnar-Matei, "Advantages of Using MatLab Simulink in Laboratory Lessons on Operating Conditions of Overhead Power Lines," Procedia - Soc. Behav. Sci., vol. 191, pp. 179–184, 2015.

[10] N. Das, H. Wongsodihardjo , and S.Islam, "Modeling of multi-junction photovoltaic cell using MATLAB/Simulink to improve the conversion efficiency," Renew. Energy, vol. 74, pp. 917–924, 2015.

[11] A. S. Martyanov, E. V. Solomin, and D. V. Korobatov, "Development of Control Algorithms in Matlab/Simulink," Procedia Eng., vol. 129, pp. 922–926, 2015.

[12] M. Fazeli, G. M. Asher, C. Klumpner, S. Member, and L. Yao, "Novel integration of wind generator-energy storage systems within microgrids," IEEE Trans. on Smart Grid, vol. 3, pp. 728-737, 2012.

[13] M. C. Trigg, and C. V. Nayar, "Matlab Simulink modeling of a single phase voltage controlled voltage source inverter," Proc. Australasian Univ. Power Eng. Conf., Melbourne, Australia, 2006.

[14] V. K. Chandna, Z. A. Jaffery, and S.K. Chaudhry, "Simulation of single phase RMS controlled voltage source inverter (VSI) for variation in Cdc, Cs and Rs," 2010 Joint Int. Conf. on Power Elec., Drives and Energy Systems (PEDES) & 2010 Power, India, 2010, pp. 1-7.

[15] K. Kayisli, S. Tuncer, and M. Poyraz, "An educational tool for fundamental dc/dc converter circuits and active power factor correction applications," Comput. Appl. Eng. Educ., vol. 21, pp. 113-134, 2013.