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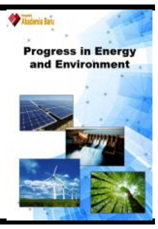

Renewable Energy Optimization Review: Variables towards Competitive Advantage in Green Building Development

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ABSTRACT

A literature review is presented in the subject of optimization solution to solve renewable energy (RE) in the green building rating system (GBRS) to: delineate the variables in optimization; consider its significant contribution to the green innovation effort; and provides competitive advantage (CA) in green building development. The paper aims to close the gap in knowledge, by using the right methodologies in optimization as a mechanism to portray how research themes can be utilized for desired CA, and to suggest future analysis for research direction. A thematic review of RE optimization literature is undertaken for disaggregating variables towards potential CA consequences in green building development. The study has reconstructed variables in RE optimization towards appropriate CA where optimization is being identified as an antecedent of green innovation while CA as a consequence of green innovation. In this regard, green innovation would serve as a conceptual bridge between optimization approach towards gaining CA. These can be achieved since various RE optimization case studies have been presented and overcome with the improvement impact on the test system, in term of power loss reduction, increased efficiency and optimal cost outcome which also obtained as key variables for the end focus. A new framework comprises of RE optimization, green innovation, and CA is proposed and linked with some of the previous optimization reviews in recent literature.

Keywords:
Competitive Advantage (CA), Renewable Energy (RE), Green Building Rating System (GBRS), Green innovation

1. Introduction

The Green Building is one of the sustainability concepts which can be well incorporated in electricity utility reduction, by increasing the efficiency of using resources such as energy, water, and materials as main focus [1-3]. From a view of maintenance, a study found that green buildings perform better than conventional counterparts in terms of energy efficiency, water efficiency and cost efficiency [4,5]. The sustainable green building energy supply has established and implemented new

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policies to improve efficiency in energy consumption and to adopt and utilize new alternatives like renewable energy (RE) system which lead beneficial for both developed and developing countries [6,7].

In fact, technological evolution in energy systems is of the essence and inevitable factor that researchers need to deal with since energy resources are also a highly important form of political and economic perspective worldwide [8]. Compared with conventional power utility generation, the technologies of RE are known to be less competitive, due to relatively highcost maintenance and their intermittency of supply [9]. However, several advantages have been discovered from RE sources, i.e. high potential approach in the reduction of carbon emissions to the atmosphere and reduction in dependency on fossil fuel resources [10]. Besides, RE also an option in avoidance of the safety problems derived from atomic power [11] in discovering the clean energy supply, resulting in more desirable to adopt RE power plants from a social point of view [12]. A critical decision on the necessity of establishing RE system, together with selecting the type of RE system and source as well as the need of a combination of RE technology is very important by governments and businesses. In terms of sustainability as indicators, main RE technologies have been evaluated by several authors, for instance, comparison of wind power, hydropower, photovoltaic and geothermal energy by [13] with consideration of the price of generated electricity, efficiency of energy conversion, greenhouse

gas emissions during the full life cycle of the technology, availability of renewable sources, water consumption, land requirements and social impacts. On top of that, [13] also concluded that wind power has the most favorable social impacts, lowest relative greenhouse gas emissions, and the least water consumption demands, but it requires high relative capital costs with more area of land. Strategies for a sustainable development of RE analyzed by [14] identified three major technological changes, i.e., efficiency improvements in energy production, energy savings on the demand side, and the replacement of fossil fuels with various sources of RE. In the same line, [15] and [16] are the example of recent studies that evaluate energy, economics and environmental impacts of RE systems. Sustainable development can be assisted by RE technologies which also provide a solution to several energy-related environmental problems. Therefore, the improvement of the said technologies via optimization algorithms in this sense, constitute a suitable tool for solving complex problems in the field of RE systems [9].

Optimization methods for solving problems found in RE systems have been proposed in many papers. The expansion of distributions networks has become a problem of primary interest, taking into account the increasing worldwide demand for energy around the world. According to [9], since investment costs of creating an RE structure is of the important element, therefore, selecting the right option among various RE system becoming a primary interest from the design and long-term planning point of view of the said energy systems. Besides, the author also describes that problem arises consist of justifying the right location patterns of energy resources and services, economic development and energy structure formulation of local policies regarding energy consumption, and analysis of interactions among economic cost, system reliability, and energy-supply security.

This study aims at reconstructing variables in green renewable energy (RE) optimization towards appropriate competitive advantage. where optimization is being identified as an antecedent of green innovation while competitive advantage (CA) as a consequence of green innovation. In this regard, green innovation would serve as a bridge between optimization approach and competitive advantage (CA).

1.1 *Renewable Energy (RE) Optimization*

1.1.1 *Unit sizing and cost optimization variables*

Optimal unit sizing is essential for efficient and economic utilization of the renewable energy (RE) sources in integrated system whereas, it assures the lowest net present cost with significant system reliability requirement for optimum operation conditions [17]. Acceptable system cost and reliability are a necessity in optimal resources-integrated system matching.

The contradiction among each other in planning issues, require an advantageous sensible tradeoff between them. Oversizing and under sizing the system components will affect the system cost and leads to failure or loss of power supply [18]. It is required to evaluate the system in terms of economics and power reliability for unit sizing and cost optimization of integrated RE system. Various authors have considered parameters such as levelized cost of energy (LCE),net present cost (NPC), payback period (PBP), annualized cost of the system (ACS), internal rate of return (IRR) etc. in cost criteria [19-21]. On the technical view, system reliability of RE is necessary to be evaluated due to highly intermittent in nature, for instance, solar and wind energy systems. Power reliability criteria indicate useful information on capability of output generated power to balance the load demand within stipulated period, considering parameter like expected energy not supplied (EENS), loss of power supply probability (LPSP), level of autonomy (LA) etc. [22-24] as summarized in Table 1.

Table 1 Summary of optimization criteria represented by various type of variables

References	Criteria	Variables	Description
Luna-Rubio, R. et al. [19]	Cost criteria	LCE	Ratio of the total annualized cost of the system (ACS) to the annual electricity production by the system. An economic evaluation tool for the energy production in an integrated system which includes all recurring and non-recurring costs over the project lifetime.
Luna-Rubio, R. et al [19]		ACS	Sum of the annualized capital cost, the annualized replacement cost, and the annualized maintenance cost of all components of the system.
Dalton et al. [20]		NPC	Life cycle cost of integrated RE system. The total NPC comprises the capital cost of the system components, the replacement cost of the component that occurs in the operation period of the plant, the cost of maintenance and fuel. NPC also considers any salvage costs of components, which is the worth remained in the system components after the operation period of the system.
Bakos and Soursos [21]		IRR	The true interest yield offered by the system during its operational period. It is also referred to as the return on investment (ROI) or the time-adjusted rate-of- return. It is evaluated by calculating the discount rate that results in the net present value (NPV) of the project to be equal to zero.
Bakos and Soursos [21]		PBP	Time in which the initial cash outflow of an investment is expected to be recovered from the cash inflows generated by the investment.
Belmili et al. [23]	Power reliability criteria	LPSP	The fraction of the deficiency energy and that required by the load.
Allan [22]		EENS	Expected energy that is not supplied to the load under the condition when the load exceeds generation.
Celik [24]		LA	Fraction of time for which the specified load can be met. It depends on the number of hours in which loss of load occurs and the total number of hours of operation.

1.1.2 *Methodologies in the optimization of renewable energy (RE)*

Various sizing methodologies have been identified in previous literature related to the field of integrated RE system-based power generation, i.e., artificial intelligence, analytical approach, multi-objective design, iterative technique, graphical construction method and probabilistic approach. Unit sizing methodologies for the integrated system are given in Fig. 1 [17,25,26].

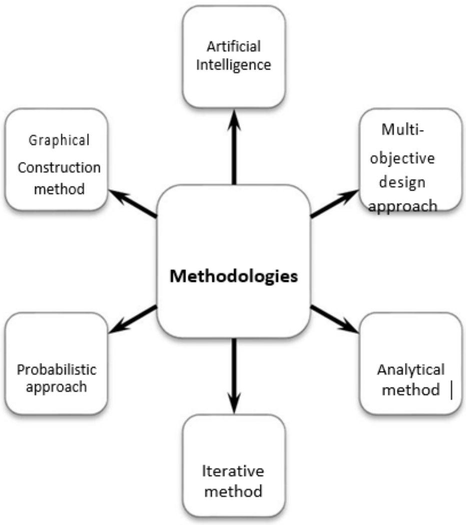

Fig. 1. Methodologies in the optimization of renewable energy (RE)

Artificial intelligence (AI) approaches as reported in literature comprises of genetic algorithms (GA), particle swarm optimization (PSO), artificial neural networks (ANN), ant colony optimization (ACO), biogeography based optimization (BBO), harmony search (HS), fuzzy logic (FL), simulated annealing (SA), or a hybrid of such techniques [25,26]. These identified algorithms can handle the non-linear variation of system components of integrated renewable energy (RE) system or intermittent nature of solar and wind energy sources and need no availability of weather data for sizing of integrated energy systems in remote sites [17].

Photovoltaic (PV)–wind-diesel optimization based integrated system has been identified by Paliwal et al., [27] to fulfill techno-socio-economic criterion. They also developed the relationship among a number of cycles, size of storage units, and replacements over project lifetime. Also, analysis for an optimal solution in PV–wind-diesel based hybrid system has been carried out by Mereietal [28] with the combination of three battery technologies i.e. vanadium redox flow type, lead–acid and lithium ion. Whereas, a novel discrete chaotic harmony search-based simulated annealing (DHSSA) algorithm by Askarzadeh [29] for optimal sizing of PV–wind–battery based integrated system and compared the obtained annual cost with discrete harmony search (HS) and discrete harmony search simulated annealing (HSSA) algorithms. A BBO algorithm for PV– wind-based system proposed by Kumar et al., [30] converges to a global optimum solution with relative computational simplicity and the results with other optimization algorithms such as GA, PSO and HOMER are compared. Minimization of cost and efficiency gained concept has been discovered by Arabali et al., [31] for an integrated SPV-wind system with battery storage using a genetic algorithm (GA) and two-point estimate method. They also calculated maximum capacity of the storage system and excess energy (EE) for different load shifting (LS) percentages. Power reliability model based on LPSP and economic model based on annualized system cost has been proposed by Yang et al., [32] and suggested the solar–

wind–battery-based system to be integrated with 3 to 5 days' battery storage since they found it was more appropriate for the required LPSP of 1% and 2% studied case. Hakimi et al. [33] used particle swarm optimization for simulation in utilizing the excess power of wind–fuel cell based system in electrolyzer where fuel cell will be filled in the deficit power when the load demand was unable to feed by generation. Kaviani et al. [34] found that yearly simulation with 1h time step offered high accuracy with approximate evaluations of reliability indices in the solar wind–fuel cell based system and discussed the impact of component outages on the reliability and system cost. Mellit et al. [35] have developed a method which uses a genetic algorithm for optimal sizing of components of solar–battery-based system.

The multi-objective design is developed via two common approaches, i.e. merging all individual objective function into a single composite in the first approach, while the second approach is to determine an entire Pareto optimal solution set. If obtained solution is dominant among various solutions in the solution space, it is well said to be Pareto optimal. Due to reducing system costs implies a rising of pollutant emissions and vice versa, deteriorating of at least one objective is needed to improve a Pareto optimal solution, regardless of any objective. Multi-objective optimization algorithm has set that identification of solutions in the Pareto optimal set as the main objective as shown in Figure 2 which represent Pareto front, dominated solution and non-dominated solutions for multi-objective design [36].

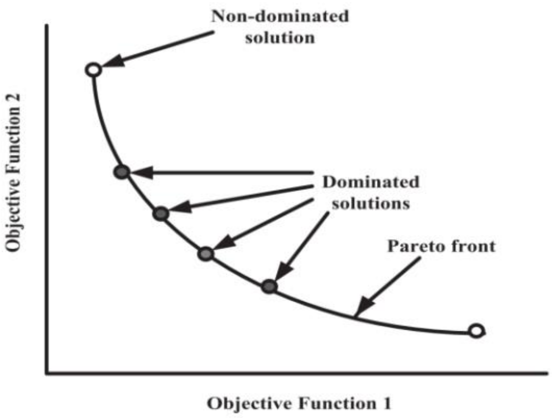

Fig. 2. Pareto optimal

A study by Maheri et al. [37] has proposed two algorithms for multi-objective optimization in wind-PV-diesel generator based system. The study also has identified two scenarios, i.e. the most cost-effective system which obtained under reliability constraint in the first scenario, while the most reliable system was created under cost constraint in the second scenario. Tant et al. [38] proposed a multi-objective optimization method in SPV with battery energy storage systems and applied the proposed system in the public low-voltage distribution grid. They also presented the isocost trade-off curves between the objectives of peak shaving and voltage control. Abbes et al. [39] developed 120 Pareto optimal set for PV-wind-based integrated system and choose a configuration that fulfills 95% of the residential electricity needed. Optimization of the mix RE system i.e. solar, wind, hydro and maximized its contribution to the peak load, while minimizing the combined intermittence at a minimum cost, has been discovered by Moura et al. [40]. The study also has considered large-scale demand response (DR) technologies and demand-side management (DSM). Bernal-Agustín et al. [41] applied Strength Pareto Evolutionary Algorithm (SPEA) to the multi-objective design of PV–wind-diesel based hybrid system for electrical energy generation.

In an iterative approach, integrated energy system performance evaluation is achieved using a recursive program until the optimum system design is achieved. Optimization model in an iterative approach also generally considers the levelized cost of energy (LCE) model for system cost and/or LPSP model for power reliability and net present value (NPV) respectively. Consideration on parameters such as rated power of wind system, the capacity of PV panels, and battery bank storage capacity have been considered by most of the authors. Due to that, the optimum configuration is one which has the lowest LCE/NPV from all the possible sets of configurations, for the desired reliability level. System cost in this method is minimized either by linear programming techniques or by linearly changing the values of the parameters. Moreover, the iterative technique does not optimize the PV area, wind turbine swept the area, PV module slope angle and wind turbine installation heights as these parameters enormously influenced system costs (LCE and/or NPV).

Many available papers in literature related to integrated system sizing are achieved using the iterative technique. For instance, Yang et al. [42] optimized the sizing of solar–wind–battery based integrated system using LPSP for system reliability assessment and the LCE for cost analysis and selected optimal configuration based on the lowest LCE. A mixed integer linear mathematical programming model (time-series) which developed by Gupta et al. [43] determined the optimal configuration, optimal operation and optimum control algorithm for hybrid energy systems. They optimized cost in such a way that resources with lesser unit cost would share the greater of the total energy demand. An algorithm for component sizing is proposed by Zhang et al. [44] specifically in PV-diesel generator based integrated system based on the optimization of the power dispatch simulations. The cost of energy (COE) is minimized which include fuel cost, capital depreciation cost, maintenance cost and emissions damage cost during optimization. While an algorithm has been presented by Li et al. [45] to decide the minimal system configuration based on energy balance.

In Analytical Method approach, the feasibility of the system can be found via characterization of integrated energy systems components by computational models. Thus, evaluation of system's performance for a set of feasible system configurations can be done within a specific size of components. Evaluation on the best configuration of an integrated energy system is performed via single or a multiple performance index comparison of the different configurations. The difference between grid-connected and stand-alone configurations in PV-battery based system was showed by Kaldellis et al. [46] by their findings of the share battery component which exceeds 27% of the system life cycle energy demand. Based on Khatod et al. [47], uncertainties which significant with wind speed and solar irradiance, Beta and Weibull distributions were taken into consideration in modeling wind speed and solar radiation. They found that the proposed method was highly efficient with lesser time and much less amount of meteorological data compared to the Monte Carlo simulation method.

Probabilistic approaches for sizing of integrated system considers the effect of the insolation and changes in wind speed for system design. In this approach, appropriate models for resource generation and/or demand are developed and finally, a risk model is created by a combination of these models. However, this optimization technique cannot characterize the dynamic changing performance of the integrated or hybrid system. Lujano-Rojas et al. [48] developed a hybrid algorithm (Monte Carlo and ANN) for to consider uncertainty related to solar radiation, wind speed, fuel prices and battery bank lifetime in solar–wind–DG based hybrid system. Tina et al. [49] evaluated impact of a tracking system on the probability density function (PDF) of PV output through the first four moments (mean, variance, skewness, and kurtosis) in solar-wind-based integrated system. They also analyzed improvement in the EIR using the two-axis tracker instead of one-axis (polar) tracker. Tina et al. [50] presented a probabilistic approach based on the convolution technique to assess the long-term performance of a considered system and developed analytical expressions to find power generated by convolution of wind generator and PV output power. Yang et al. [51] found that battery bank with an energy storage capacity of 3 days was suitable for ensuring the desired LPSP of 1% in solar– wind-based integrated system, and a LPSP of 0% can be achieved with a battery bank of 5 days' storage capacity.

In the graphical construction method, only two decision variables were considered in the optimization i.e. either SPV and battery or SPV and wind turbine. Some significant factors such as the numbers of SPV modules, SPV area, SPV slope angle, windswept area and the wind turbine installation height were completely ignored. Markvart [52] optimally designed a solar– wind-based integrated system on the basis of demand-supply criteria. Whereas, Borowy et al. [53] developed a correlation between a number of PV modules and the number of batteries.

1.1.3 *Optimization of renewable energy (RE) in a green building rating system (GBRS)*

Renewable energy (RE) exploitation is one of the most important aspects of green buildings [6]. Therefore, variable energy demands, intermittent availability of renewable resources, different technological alternatives to satisfy the different demands, and the possibility of integrating storage and energy production systems give rise to the exigency of defining criteria and strategies able to improve efficiency and energy supply, and its environmental and economic sustainability.

RE laid as part of assessment under energy category in many green building rating system (GBRS) worldwide including Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), Green Star, Green Mark, Green Building Index (GBI) and Malaysian Carbon Reduction Environmental Sustainability Tool (MyCREST) where the assessment criteria for each of this different GBRS are as shown in Table 2.

Since RE utilization is one of the most important aspects of green buildings [54], this significantly increases the utilization of RE system to the highest possible capacity into power system network. Different GBRS effect building assessment methods differently in different climates and must also represent the geographical location and climatic condition of its origin country [55,56]. Whereas as mentioned by [57], many types of research have concluded that developing countries are necessary to analyze the local situation at first, in terms of the different environmental focus and socio-economic needs, before customized and identify the adaptability of sustainable energy performance indicators in building assessment tools originated from developed countries.

GBI based on [58] for instance, was designed for the tropical climate of Malaysia. On the other option from local GBRS, i.e. MyCREST, had appeared into the mainstream and been made as a compulsory requirement by Public Work Department (PWD) for Malaysian governments' projects above RM50 million value [59].

Based on the essence of sustainable developments, the use of renewable energy (RE) such as solar photovoltaic (PV) is one of the most influentially common principles [7] and substantially significant approach towards decreasing the level of energy consumption in buildings [60] and having considered the major key component of green building-based design as the capability of electricity generation [61]. However, RE as one of various type of distributed generation (DG) can worsen the system performance [18] and lead to power losses and contribute to inefficiency of renewable energy transmitting if the proper assessment is not well considered. Due to lack of right-sizing and right-locating of RE within current GBRS assessment criteria, the innovative approach can be well developed to achieve the right parameter and justification for proper RE installation. It also gives a measure of gaining competitive advantage among GBRS developer for loss reduction and optimal cost of installation.

The green building in terms of environmental sustainability and energy efficiency outcome based is also relevantly correlates with utilizing the optimization methods and models of hybrid systems for the specific case of buildings [6]. Optimization as the solution is the procedure of finding the minimum or maximum value of a function by choosing several variables subject to a number of constraints [9]. The optimization function is called cost or fitness or objective function and is usually calculated using simulation tools [62].

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Table 2 Breakdown of assessment criteria among different GBRS

Name of GBRS Tools	BREEAM	LEED	Green Star	Green Mark	GBI	MyCREST
Origin & years introduced	UK, 1990	US, 1993	Australia, 2003	Singapore, 2005	Malaysia, 2009	Malaysia, 2015
Assessment Criteria	• ***Energy use*** • Transportation • Water • Ecology • Land use • Materials • Pollution • Health and well being	• ***Energy and atmosphere*** • Water efficiency • Sustainable sites • Materials & resources • Indoor environment quality (IEQ) • Innovation	• ***Energy*** • Transport • Water	• ***Energy efficiency*** • Water efficiency • Environment protection • Indoor environment quality (IEQ) • Innovation	• ***Energy efficiency*** • Indoor environment quality (IEQ) • Sustainable site and management • Materials & resources • Water efficiency	• ***Energy performance impact*** • Infra & maint management • Occupant & health • Lowering embodied carbon • Water efficiency factors • Waste management & reduction • Sustainable facility management • Sustainable & carbon initiatives
Developer	Building Research Establishment (BRE)	United States Green Building Council (USGBC)	Green Building Council of Australia (GBCA)	Building and Construction Authority (BCA)	Green Building Index Sdn. Bhd.	Construction Industry Development Board (CIDB) and Public Work Department (PWD)

1.2 *Innovation and Competitive Advantage of Sustainable Development*

1.2.1 *Green innovation of sustainable development*

According to [63], the definition of innovation is known as the realization of new or highly improved product or process whether to be applied in organization or a new marketing method or a new organizational method of implementation. In the context of the green building initiatives, optimization approach in renewable energy (RE) coordination significantly contributed to the innovation effort of sustainable development [64]. In order to define innovation type which occurred to decrease negative effects to the environment, different definitive words or concepts are mostly used within the literature such as; green, eco, environmental or sustainable [65].

Green innovation as the focus is defined as innovating products and production processes to reach the objectives in environmental while decreasing the ecological footprint throughout the product life cycle [66]. While [67] define green innovation included the innovation in technologies as the involvement of energy-saving, waste recycling, pollution-prevention, green product design or corporate environmental management as well as hardware or software innovation that is related to green products or processes. Whereas based on [68], green innovation facilities defined as development of environmental quality or optimum usage of natural resources which are a subgroup of general innovation facilities. The aims of green innovation as of [69] are towards energy productivity, a decrease of waste, a decrease of pollution, substitution of limited resources with sustainable resources and recycling. Green innovation is categorized into three types as in Figure 3 which also in accordance with its potential effects and application method [63,70].

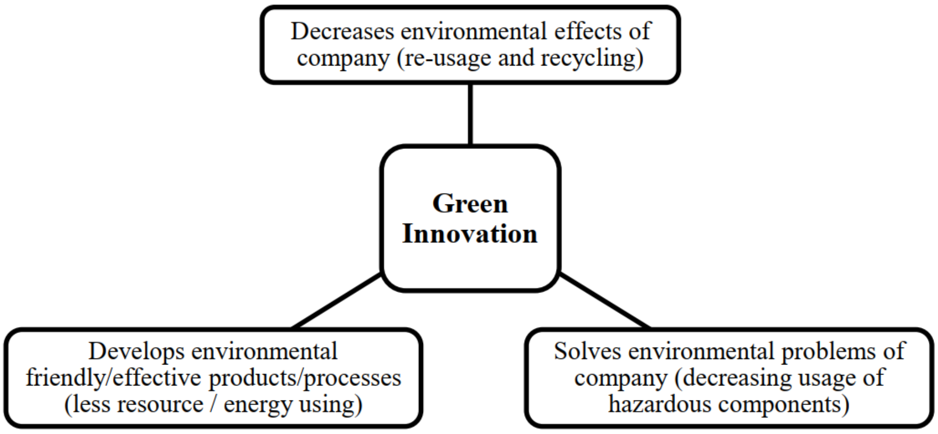

Fig. 3. Green innovation category

1.2.2 *Competitive advantage (CA)*

Related to the previous section, competitive advantage (CA) can be achieved by the company through acts of innovation including both new ways of doing things and new technologies in the broadest sense approached. CA also been created by some innovations, i.e., by serving a market segment that others have ignored or an entirely perceiving new market opportunity [71]. Not only limited to development in the environmental performance of the company, Porter [72] and also a study by [63] identified that green innovation development also provides competitive advantage (CA) as shown in Fig. 4. Consequently, according to [72] and [73], CA can be defined into two ways of which an organization can achieve over its rivals i.e. cost advantage and differentiation advantage as shown in Fig. 5.

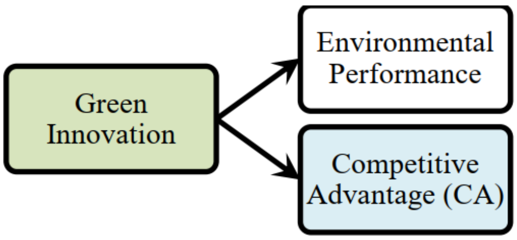

Fig. 4. Green innovation definition

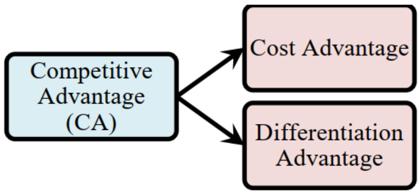

Fig. 5. Competitive advantage definition

2. Research Method

In this paper, a thematic review of RE optimization literature is undertaken for categorizing variables towards potential CA consequences in green building development. Both renewable energy (RE) costing and the technical reliability requirement is the constraints which also known as the variables and being considered in solving the right capacity and system location problem simultaneously. The selected optimization objectives and variables were reviewed and disaggregated into two (2) optimization criteria i.e. cost criteria and technical / power reliability criteria from the literature and assigned with appropriate CA consequences from the green building development perspective i.e. GBRS developer, building owner and other related stakeholder / company. Consequently, a new framework comprises of RE optimization, green innovation, and CA is proposed and linked with some of the previous optimization reviews in recent literature.

Table 3 Extracted optimization which been assigned with appropriate consequences of CA

Authors	RE System type	Differentiation or Cost Advantage?		Objective Function	Design Constraint	Outcome
		Diff	Cost			
Mellit et al. [35]	PV, battery bank	√		PV generator area	LPSP	Optimal sizing of system components method from a minimum of input data compared using Artificial neural network (ANN) was developed
Ippolito et al. [74]	PV, battery bank	√		Total generation cost, energy losses, greenhouse gas emission	Active power limit, reactive power limit, power transfer limit, voltage limit	Improvement of voltage profile was the Most suitable findings for the intermediate values of objective functions via three scenarios consideration.
Moura et al. [40]	Wind, solar, hydro	√		Renewable system utilizes to the peak load	Mix energy consumption, max potential, actual installed power, installed power yearly growth for RE technology	Considered Large-scale demand response (DR) technologies and demand-side management (DSM). The mix of the renewable system is optimized and maximized its contribution to the peak load, while minimizing the combined intermittence, at a minimum cost.

Tant et al. [38]	PV, battery bank	√	√	Voltage regulation, Peak power reduction, Annual cost	Total annual cost limit	Isocost trade-off curves between voltage control and the objectives of peak shaving for public low-voltage distribution grid is presented.
Bagul et al. [75]	PV, battery bank	√	√	System cost	Loss of power probability	Three event probability density for sizing of PV-array and battery storage technique based are developed. New technique in three events consumed less computation time, more accurate, and more closely characterized the actual distribution of daily excess energy than of two events.
Paliwal et al. [27]	PV, wind, diesel and battery		√	LCE	Number of generators, battery SOC, system health state	Techno-socio-economic criterion is formulated for the mix of sources optimal using PSO. Relationship among size of storage units, number of cycles and replacements over project life time is also been analyzed.
Askarzadeh [29]	PV, wind battery		√	Total annual cost	Number of PV panels, wind turbine and batteries	Novel discrete chaotic harmony search-based simulated annealing algorithm for integrated system optimal sizing is developed. The results with discrete HS and discrete HSSA were compared.

As discussed, the only way to sustain a competitive advantage (CA) is to upgrade it, to move to more sophisticated types [71] and with that, a new conceptual framework of optimization approach towards achieving CA in green building development is proposed as in Figure 6 to identify all the possible link from optimization variables up to the end of possible CA outcome. Related to [72] and [73], any improvement in the GBRS assessment criteria will possibly give a measure in gaining its' CA as compared to other competitors of different GBRS developer by the result of providing less capital expenditure requirement and increase efficiency of RE application for the building as well as providing higher profit in operation and maintenance of the said building on the user side. Literatures also support that green innovation which increases the resource productivity through ensuring material saving, decreasing the energy consumption, increasing waste recycling and providing less use of the resources [76] will not only decreases the negative effects on the environment but also provides CA through lowering the costs [77] and also provide technical parameter advantages. These also need to be tailored with locality used of the rating system since different GBRS effect building assessment methods differently in different climates and must also represent the geographical location and climatic condition of its origin country [55,56]. As such, this framework is proposed to be adopted as reference boundary in simulating input variables for overall RE optimization in green building development and emphasizing the competitive advantage (CA) as the end focus.

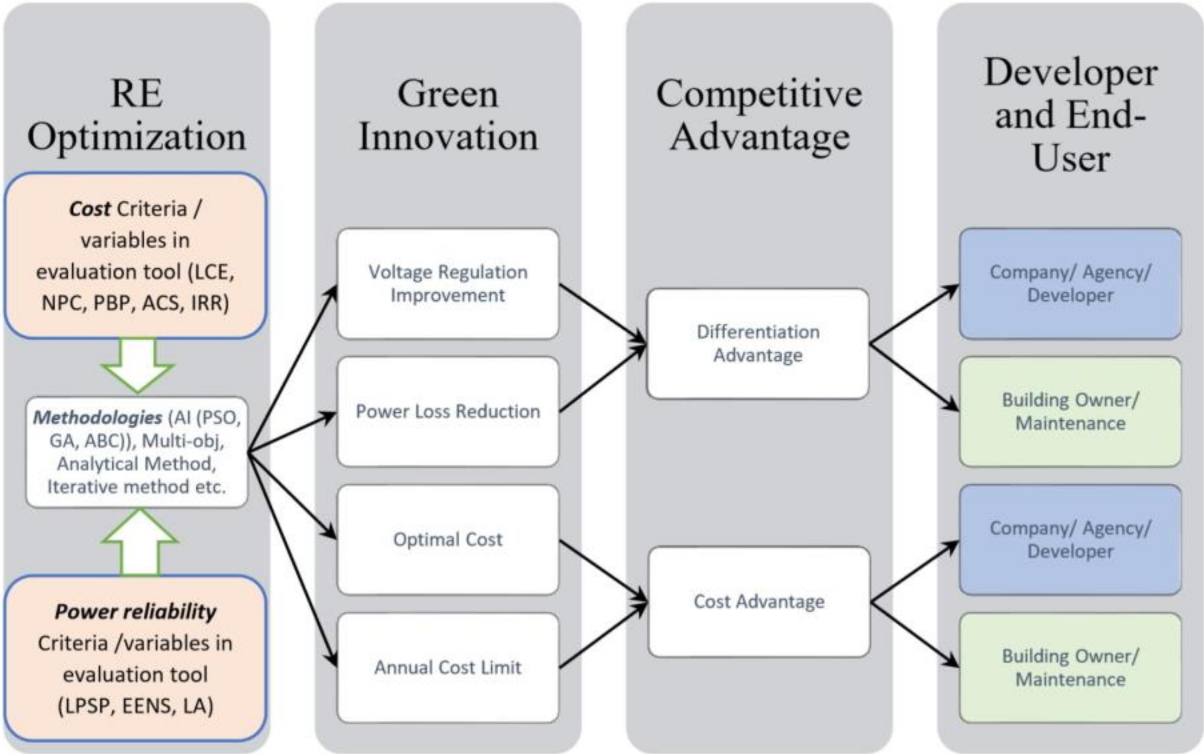

Fig. 6. Conceptual framework of the study

4. Conclusion

The overall conceptual framework of this study has defined cost variables and technical system requirement as differentiation and cost advantage respectively which also representing two variables in the optimal setting value towards gaining the competitive advantage of green building rating system. This study also has discovered wider definition and the mapping of green innovation in a sustainable development by having a specific direction in one of its' application i.e. the green building, to overcome some of issues that been identified which possible to gain the competitive advantage by companies, agencies and even the building owner in management of the said facilities. Other than that, company's key variable advantages, i.e. differentiation and cost advantage can be well adapted into sustainable development towards the improvement of its entire application by focusing on the desired key constraint.

References

[1] Lund, H., Marszal, A. and Heiselberg, P. "Zero energy buildings and mismatch compensation factors." *Energy and Buildings* 43(7) (2011): 1646-1654.
[2] Mwasha, A., Williams, R.G. and Iwaro, J. "Modeling the performance of residential building envelope: The role of sustainable energy performance indicators." Energy and buildings 43(9) 2011: 2108-2117.
[3] Ahmad, A.S., Hassan, M.Y., Abdullah, H., Rahman, H.A., Majid, M.S. and Bandi, M. "Energy efficiency measurements in a Malaysian public university." In: *Power and Energy (PECon) IEEE International Conference*, 2012.
[4] Fowler, K.M., Rauch, E., Henderson, J. and Kora, A. Re-assessing green building performance: A post occupancy evaluation of 22 GSA buildings. Prepared by: Pacific Northwest National Laboratory (PNNL), Richland, WA (US), 2010.
[5] Fauzi, M.A. and Malek, N.A. "Green Building assessment tools: Evaluating different tools for green roof system." *International Journal of Education and Research* 1(11) (2013): 1-14.

[6] Dagdougui, H., Minciardi, R., Quammi, A., Robba, M., Sacile, R. “Modeling and optimization of a hybrid system for the energy supply of a “Green” building.” *Energy Conversion and Management* 64 (2012): 351-363.
[7] Shi, L. and Chew, M.Y.L. “A review on sustainable design of renewable energy systems.” *Renewable and Sustainable Energy Reviews* 16(1) (2012): 192-207.
[8] Ma, T. and Nakamori, Y. “Modeling technological change in energy systems–from optimization to agent-based modeling.” *Energy* 34(7) (2009): 873-879.
[9] Banos, R., Manzano-Agugliaro, F., Montoya, F.G., Gil, C., Alcayde, A. and Gómez, J. “Optimization methods applied to renewable and sustainable energy: A review.” *Renewable and Sustainable Energy Reviews* 15(4) (2011): 1753-1766.
[10] Lu, Y., Wang, S., Zhao, Y. and Yan, C. “Renewable energy system optimization of low/zero energy buildings using single-objective and multi-objective optimization methods.” *Energy and Buildings* 89 (2015): 61-75.
[11] Strupczewski, A. “Accident risks in nuclear-power plants.” *Applied Energy* 75 (1-2) 2003: 79-86.
[12] Skoglund, A., Leijion, M., Rehn, A., Lindahl, M. and Waters, R. “On the physics of power, energy and economics of renewable electric energy sources - Part II.” *Renewable Energy* 35(8) (2010): 1735-1740.
[13] Evans, A., Strezov, V., and Evans, T.J. “Assessment of sustainability indicators for renewable energy technologies.” *Renewable and Sustainable Energy Reviews* 13(5) 2009: 1082-1088.
[14] Lund, H. “Renewable energy strategies for sustainable development.” *Energy* 32(6) (2007): 912-919.
[15] Hepbasli, A. “A key review on exergetic analysis and assessment of renewable energy resources for a sustainable future.” *Renewable and Sustainable Energy Reviews* 12(3) (2008): 593-661.
[16] Prakash, R. and Bhat, I.K. “Energy, economics and environmental impacts of renewable energy systems.” *Renewable and Sustainable Energy Reviews* 13(9) (2009): 2716-2721.
[17] Chauhan, A. and Saini, R. “A review on integrated renewable energy system based power generation for stand-alone applications: configurations, storage options, sizing methodologies and control.” *Renewable and Sustainable Energy Reviews* 38 (2014): 99-120.
[18] Muhtazaruddin, M.N.B., Tuyen, N.D., Fujita, G. and Jasro, J.J. “Optimal distributed generation and capacitor coordination for power loss minimization.” In: *T&D Conference and Exposition*, 2014.
[19] Luna-Rubio, R., Trejo-Perea, M., Vargas-Vázquez, D. and Ríos-Moreno, G.J. “Optimal sizing of renewable hybrids energy systems: A review of methodologies.” *Solar Energy* 86(4) (2012): 1077-1088.
[20] Dalton, G., Lockington, D. and Baldock, T. “Feasibility analysis of stand-alone renewable energy supply options for a large hotel.” *Renewable Energy* 33(7) (2008): 1475-1490.
[21] Bakos, G. and Soursos, M. “Techno-economic assessment of a stand-alone PV/hybrid installation for low-cost electrification of a tourist resort in Greece.” *Applied Energy* 73(2) (2002): 183-193.
[22] Allan, R.N. Reliability evaluation of power systems. Springer Science & Business Media, 2013.
[23] Belmili, H., Haddadi, M., Bacha, S., Almi, M.F. and Bendib, B. “Sizing stand-alone photovoltaic–wind hybrid system: Techno-economic analysis and optimization.” *Renewable and Sustainable Energy Reviews* 30 (2014): 821-832.
[24] Celik, A.N. “Techno-economic analysis of autonomous PV-wind hybrid energy systems using different sizing methods.” *Energy Conversion and Management* 44(12) (2003): 1951-1968.
[25] Bhandari, B., Lee, K.T., Lee, G.Y., Cho, Y.M. and Ahn, S.H. “Optimization of hybrid renewable energy power systems: A review.” *International Journal of Precision Engineering and Manufacturing-Green Technology* 2(1) (2015): 99-112.
[26] Iqbal, M., Azam, M., Naeem, M., Khwaja, A.S. and Anpalagan, A. “Optimization classification, algorithms and tools for renewable energy: A review.” *Renewable and Sustainable Energy Reviews* 39 (2014): 640-654.
[27] Paliwal, P., Patidar, N. and Nema, R. “Determination of reliability constrained optimal resource mix for an autonomous hybrid power system using particle swarm optimization.” *Renewable Energy* 63 (2014): 194-204.
[28] Merei, G., Berger, C. and Sauer, D.U. “Optimization of an off-grid hybrid PV–Wind–Diesel system with different battery technologies using genetic algorithm.” *Solar Energy* 97 (2013): 460-473.
[29] Askarzadeh, A. “A discrete chaotic harmony search-based simulated annealing algorithm for optimum design of PV/wind hybrid system.” *Solar Energy* 97 (2013): 93-101.
[30] Kumar, R., Gupta, R. and Bansal A.K. “Economic analysis and power management of a stand-alone wind/photovoltaic hybrid energy system using biogeography based optimization algorithm.” *Swarm and Evolutionary Computation* 8 (2013): 33-43.
[31] Arabali, A., Ghofrani, M., Etezadi-Amoli, M., Fadali, M.S. and Baghzouz Y. “Genetic-algorithm-based optimization approach for energy management.” *IEEE Transactions on Power Delivery* 28(1) (2013): 162-170.
[32] Yang, H., Zhou, W., Lu, L. and Fang, Z. “Optimal sizing method for stand-alone hybrid solar–wind system with LPSP technology by using genetic algorithm.” *Solar Energy* 82(4) (2008): 354-367.
[33] Hakimi, S. and Moghaddas-Tafreshi, A. “Optimal sizing of a stand-alone hybrid power system via particle swarm optimization for Kahnouj area in south-east of Iran.” *Renewable Energy* 34(7) (2009): 1855-1862.

[34] Kaviani, A.K., Riahy, G. and Kouhsari, S.M. "Optimal design of a reliable hydrogen-based stand-alone wind/PV generating system, considering component outages." *Renewable Energy* 34(11) (2009): 2380-2390.
[35] Mellit, A., Benghanem, M., Arab, A.H. and Guessoum, A. "An adaptive artificial neural network model for sizing stand-alone photovoltaic systems: application for isolated sites in Algeria." *Renewable Energy* 30(10) (2005): 1501-1524.
[36] Fadaee, M. and Radzi, M. "Multi-objective optimization of a stand-alone hybrid renewable energy system by using evolutionary algorithms: a review." *Renewable and Sustainable Energy Reviews* 16(5) (2012): 3364-3369.
[37] Maheri, A. "Multi-objective design optimisation of standalone hybrid wind-PV-diesel systems under uncertainties." *Renewable Energy* 66 (2014): 650-661.
[38] Tant, J., Geth, F., Six, D., Tant, P., Driensen, J. "Multiobjective battery storage to improve PV integration in residential distribution grids." *IEEE Transactions on Sustainable Energy* 4(1) (2013): 182-191.
[39] Abbes, D., Martinez, A. and Champenois, G. "Life cycle cost, embodied energy and loss of power supply probability for the optimal design of hybrid power systems." *Mathematics and Computers in Simulation* 98 (2014): 46-62.
[40] Moura, P.S. and de Almeida, A.T. "Multi-objective optimization of a mixed renewable system with demand-side management." *Renewable and Sustainable Energy Reviews* 14(5) (2010): 1461-1468.
[41] Daud, A.K. and Ismail, M.S. "Design of isolated hybrid systems minimizing costs and pollutant emissions." *Renewable Energy* 44 (2012): 215-224.
[42] Yang, H., Lu, L. and Zhou, W. "A novel optimization sizing model for hybrid solar-wind power generation system." *Solar Energy* 81(1) (2007): 76-84.
[43] Gupta, A., Saini, R. and Sharma, M. "Steady-state modelling of hybrid energy system for off grid electrification of cluster of villages." *Renewable Energy* 35(2) (2010): 520-535.
[44] Zhang, X., Tan, C.S., Li, G., Li, J. and Feng, Z. "Components sizing of hybrid energy systems via the optimization of power dispatch simulations." *Energy* 52 (2013): 165-172.
[45] Li, C.-H., Zhu, X.J., Cao, G.Y., Sui, S. and Hu, M.R. "Dynamic modeling and sizing optimization of stand-alone photovoltaic power systems using hybrid energy storage technology." *Renewable Energy* 34(3) (2009): 815-826.
[46] Kaldellis, J., Zafirakis, D. and Kondili, E. "Optimum autonomous stand-alone photovoltaic system design on the basis of energy pay-back analysis." *Energy* 34(9) (2009): 1187-1198.
[47] Khatod, D.K., Pant, V. and Sharma, J. "Analytical approach for well-being assessment of small autonomous power systems with solar and wind energy sources." *IEEE Transactions on Energy Conversion* 25(2) (2010): 535-545.
[48] Lujano-Rojas, J.M., Dufo-López, R. and Bernal-Agustín, J.L. "Probabilistic modelling and analysis of stand-alone hybrid power systems." *Energy* 63 (2013): 19-27.
[49] Tina, G. and Gagliano, S. "Probabilistic analysis of weather data for a hybrid solar/wind energy system." *International Journal of Energy Research* 35(3) (2011): 221-232.
[50] Tina, G., Gagliano, S. and Raiti, S. "Hybrid solar/wind power system probabilistic modelling for long-term performance assessment." *Solar Energy* 80(5) (2006): 578-588.
[51] Yang, H., Lu, L. and Burnett, J. "Weather data and probability analysis of hybrid photovoltaic–wind power generation systems in Hong Kong." *Renewable Energy* 28(11) (2003): 1813-1824.
[52] Markvart, T., "Sizing of hybrid photovoltaic-wind energy systems." Solar Energy 57(4) (1996): 277-281.
[53] Borowy, B.S. and Salameh, Z.M. "Methodology for optimally sizing the combination of a battery bank and PV array in a wind/PV hybrid system." *IEEE Transactions on Energy Conversion* 11(2) 1996: 367-375.
[54] Xia, C., Zhu, Y. and Lin, B. "Renewable energy utilization evaluation method in green buildings." *Renewable Energy* 33(5) (2008): 883-886.
[55] Glavinich, T.E. and Taylor, T.A. Contractor's Guide to Green Building Construction: Management, Project Delivery, Documentation, and Risk Reduction. Wiley Online Library, 2008.
[56] Shi, Q. "Strategies of implementing a green building assessment system in mainland China." *Journal of Sustainable Development* 1(2) (2009): 13-16.
[57] Hill, R., Bowen, P. and Opperman, L. "*Sustainable building assessment methods in South Africa: an agenda for research*." In: Sustainable Building, 2002.
[58] Rahardjati, R., Khamidi, M.F. and Idrus, A. "The level of importance of criteria and sub criteria in green building index Malaysia." 2010.
[59] Bahaudin, A.Y., Mohamed E., Ezanee, Mohd, N., Mohd, N., Zainuddin, Nizamuddin and Nadarajan, S. "Construction Sustainability & Awareness amongst Contractors in the Northern Region of Malaysia." *International Journal of Supply Chain Management* 6(2) (2017): 259-264.
[60] GhaffarianHoseini, A., Dahlan, N.D., Berardi, U., GhaffarianHoseini, A. Makaremi, N. and GhaffarianHoseini, M. "Sustainable energy performances of green buildings: A review of current theories, implementations and challenges." *Renewable and Sustainable Energy Reviews* 25 (2013): 1-17.
[61] Deng, S., Dai, Y.J., Wang, R.Z. and Zhai, X.Q. "Case study of green energy system design for a multi-function building in campus." *Sustainable Cities and Society* 1(3) (2011): 152-163.

[62] Bhowmik, C., Bhowmik, S., Ray, A. and Pandey, K.M. "Optimal green energy planning for sustainable development: A review." *Renewable and Sustainable Energy Reviews* 71 (2017): 796-813.
[63] Küçükoğlu, M.T. and Pınar, R.İ. "Positive influences of green innovation on company performance." *Procedia-Social and Behavioral Sciences* 195 (2015): 1232-1237.
[64] Erdinc, O. and Uzunoglu, M. "Optimum design of hybrid renewable energy systems: Overview of different approaches." *Renewable and Sustainable Energy Reviews* 16(3) (2012): 1412-1425.
[65] Schiederig, T., Tietze, F. and Herstatt, C. "*What is Green Innovation? A quantitative literature review*." In: Working Papers/Technologie-und Innovationsmanagement, Technische Universität Hamburg-Harburg, 2011.
[66] Lin, R.-J., Chen, R.-H. and Huang, F.-H. "Green innovation in the automobile industry." *Industrial Management & Data Systems* 114(6) (2014): 886-903.
[67] Chen, Y.-S., Lai, S.-B. and Wen, C.-T. "The influence of green innovation performance on corporate advantage in Taiwan." *Journal of Business Ethics* 67(4) (2006): 331-339.
[68] Rave, T., Goetzke, F. and Larch, M. "*The determinants of environmental innovations and patenting: Germany reconsidered*." In: Ifo Working Paper, 2011.
[69] Kemp, R. and A. Arundel. Survey indicators for environmental innovation, 1998.
[70] Ramus, C.A. "Encouraging innovative environmental actions: what companies and managers must do." *Journal of World Business* 37(2) (2002): 151-164.
[71] Porter, M.E. "*Competitive advantage of nations: creating and sustaining superior performance*." In: Simon and Schuster, Vol. 2, 2011.
[72] Porter, M.E. "The contributions of industrial organization to strategic management." *Academy of Management Review* 6(4) (1981): 609-620.
[73] Lin, Y.-H. and Chen, Y.-S. "Determinants of green competitive advantage: the roles of green knowledge sharing, green dynamic capabilities, and green service innovation." *Quality & Quantity* 51(4) (2017): 1663-1685.
[74] Ippolito, M.G., Di Silvestre, M.L., Sanseverino, E.R., Zizzo, G. and Graditi, G. "Multi-objective optimized management of electrical energy storage systems in an islanded network with renewable energy sources under different design scenarios." *Energy* 64 (2014): 648-662.
[75] Bagul, A., Salameh, Z.M. and Borowy, B. "Sizing of a stand-alone hybrid wind-photovoltaic system using a three-event probability density approximation." *Solar Energy* 56(4) (1996): 323-335.
[76] Bernauer, T., Engel, S., Kammerer, D. and Nogareda, J.S. "Explaining green innovation: ten years after Porter's win-win proposition: how to study the effects of regulation on corporate environmental innovation?" *Politische Vierteljahresschrift* 39 (2007): 323-341.
[77] Chang, C.-H. "The influence of corporate environmental ethics on competitive advantage: The mediation role of green innovation." *Journal of Business Ethics* 104(3) (2011): 361-370.