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DISTRIBUTED GENERATION OF POWER USING RENEWABLE ENERGY RESOURCES-A COMPARATIVE REVIEW OF GRID-CONNECTED & STAND-ALONE SYSTEM

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ABSTRACT
Off-grid power generation system has several complimentary functional applications and succinctly, it has been regarded to be an important technology to realize as its reliability, sustainability and techno-economic solution of energy. Among various decentralized generation techniques, hybrid renewable energy source (HRES) is one of the promising techniques in terms of sustainable, simplicity of operation and commissioning. The most common hybrid systems, preferably used are PV/Wind/Battery and PV/Diesel/Battery accordingly feasibility of these sources. In the recent years, HRES have been developed as new age technologies for the faster meeting the load demand in the remote area with superior combinations. Experimental investigations done by the researchers using the hybrid optimization model for electric renewable (HOMER) involved (a) study area characterization (b) resource assessment (c) load demand for the domestic, agricultural, community and commercial (d) expected different combination of RES and (e) optimization analyses in order to achieve objective function by attempting a number of combinations of RES. Based on the optimization technique the result has been evaluated with the help of different parameters as decision variables, sensitivity variable. The optimization aim was carried out in different cases regarding minimization of per unit energy cost (PUEC) and the emission of greenhouse gases (GHGs).

KEYWORDS: Green House Gases, Grid-Connected, Hybrid Optimization Model for Electric Renewable, Hybrid Renewable Energy Source, Per Unit Electricity Cost, Stand-alone.

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INTRODUCTION
The decentralized energy is characterized by generation of electrical energy closer to the load centers for meeting the local energy requirements. The implementation of decentralized energy system depends upon the extent of decentralization and it determined by the condition for the system to be operated in either GC or SA mode. Distributed generation (DG) plays an important role for rural electrification. DG uses a hybrid renewable energy source (HRES) which include conventional generators, wind turbine, solar photovoltaic, batteries, hydro power, biomass etc. The HRES reduced total net present cost (TNPC) of the overall system through proximity and tightly coupling of these systems which involves electrical power generation to utilization, though the fully decentralized energy systems are not truly desirable and also not possible due to the uncertainty of the climate conditions thereby not meeting the supply and demand of electrical power. This cost includes capital costs, replacement costs, O&M costs, fuel costs, emissions penalties, and the buying costs of power from the grid [Francois Bouffard et al., 2008].

LITERATURE REVIEW
Many Researchers have discussed the different type of technologies for power generation using decentralized system and analyzed different results in the various case studies using simulations by some software tools moreover compared with the grid connected system. They emphasized mainly the resource availability & feasibility, per unit cost of electricity, demand and losses. HRES is proposed in terms of PUEC in 83 villages of the state of Madhya

Pradesh which are categorized into five categories on the basis of resource availability. It was observed that the PUEC for all five combinations varies from Rs 4.1 to Rs 21.3 per kWh. The PUEC for only biogas was least which varies from Rs 4.1 to Rs 5.7 per kWh while for only SPV was highest which varies from Rs 16.1 to Rs 21.3 per kWh[Santos Rana et al., 1997]. The liberalized initiatives and deployment of pilot projects by government of India have been taken in different states like West Bengal, Tamil Nadu, and Karnataka and received fruitful results in terms of minimizing the losses and PUEC at the same time, it also opens the employability of the local people. They observed that the COE of the Gosaba Island, West Bengal for biomass is Rs 5.6 per kWh for domestic, Rs 6.75 per kWh for commercial and Rs 8 per kWh for industrial loads. The operating cost per unit electricity for water supply system of Odanthurai Panchayat, Tamil Nadu is Rs 5.02 per kWh for grid connected system and Rs 1.39 per kWh for the SA gasifier system. The biomass gasifier of 20 kW is commissioned in Hosahalli and Hamumanthanagara villages of Karnataka and O&M cost is calculated Rs 3.34 per kWh at full load [R. B. Hiremath et al., 2009].The authors proposed sustainable and viable techno-economic, renewable energy technology (RET) combination for generation of electricity in a village Palari in the state of Chhattisgarh (India). To achieve for the same the potential demand based on multiple combinations of RETs includes four resources, small-scale hydropower (SHP), solar photovoltaic (SPV), wind turbine (WT) and bio-diesel generators (BDG) using HOMER and COE is obtained $0.420/kWh [Rohit Sen et al., 2014]. The benefits of centralized and decentralized generation are examined for the rural distribution network with the different feeder line condition and provided an ancillary plan as distributed generation to meet the load demand and reduced distribution losses. They considered the rural areas of Northwestern India and observed that the fraction of sectioned load that is connected at any instant varies from 0.3 to 0.75 which is online load with a power factor between 0.7 to 0.95 laggings. [Shubha Singh et al., 2013]. The five methodologies namely the worksheet-based tools, optimization tools, multi-criteria decision-making (MCDM) tools, system-based participatory tools and hybrid approaches are proposed for efficient and optimal system design with analysis of the detailed viability of off-grid electrification [Subhes C. Bhattacharyya et al., 2012]. The heterogeneous investors are driving force which includes a variety of investors for different segment with investor-related factors like motives, background, resources and personal characteristics. The investors are analyzed with a multidimensional framework which includes the entrepreneurship dimension, the innovation adopted dimension and institutional dimension [Anna Bergek, et al., 2013]. The antique method utilizing electrical energy by the Hybrid Renewable Energy Source (HRES) is reverting back due to expensive grid extensions and a number of aggravating factors like the huge increase in the price of conventional fuels with unsecured availability and climate change concern with that global warming and health hazards to living organism [N.A.b.A. Razak, et al., 2010]. Table 1 illustrates the comparative description of various off grid technologies in terms of cogeneration, biomass, small and mini-hydro power, SPV, biogas and wind generation with their attribute and suitable modes. Table 2 provides the broad study domain of decentralized electricity systems.

Table 1: Comparative description of various decentralized technologies [Aqueel Ahmed Bazmi et al., 2011]

Technology	Features	Suitable mode
Co-generation	Co-generation systems with estimated average efficiency of 85%. The vital co-generation technologies are biogases co-generation, steam turbine combined heat and gas turbine combined heat.	Both Grid Connected (GC) and Standalone (SA) systems
Biomass power	The biomass requirement for small-scale applications ranges from about 5 kg/h up to about 500 kg/h which producer higher forms of gaseous fuel through gasification process.	Both GC and SA
Small and mini-hydro power	The system is classified as small-hydro if the system size varies between 2.5 and 25MW, mini-hydro typically falls below 2 MW, micro-hydro schemes fall below 500kW and Pico-hydro below 10kW capacity.	SA
Solar PV power	Stand alone SPV is not affordable due to its high initial investment, cost of generation per kWh becomes high with efficiency varies between 7 and 17%.	SA
Biogas	Biogas generally contains 60% methane and 40% carbon dioxide which is produced through anaerobic digestion of biomass and other wastes like vegetable residues, animal dung, etc.	SA
Wind power	Wind energy systems are site and season specific so for optimal	GC

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	COE, it most operates in a grid-connected mode.	

Table 2: Different Study Domain of decentralized electricity systems; Extracted from [Aqueel Ahmed Bazmi et al., 2011]

Author(s) & Year	Study domain
Ravindranath, 1993	Biomass Gasification as an environmentally sound technology for decentralizes electricity.
Ravindranath et al., 1995	A case study of biogas unit in India with their paradigm, operation and economic aspects.
Rana et al., 1998	Optimal mix renewable energy for specific energy demand for 83 villages of the state of Madhya Pradesh, India.
Stone et al., 2000	A case study of rural electrification with project investment, operational costs and impact in India.
Manolakos et al., 2001	Supply electricity and water for a remote island village with the help of simulation based software tool for optimizing the design of a HRES consisting of wind and PV.
Kolhe et al., 2002	Cost-effective feasibility of a SA solar PV system along with a diesel-powered system.
Chakrabarti et al., 2002	Feasibility study for solar energy based SPV SA system based techno economic and environmental aspects (case study, India).
Kumar et al., 2003	Optimum sizing of a stand-alone biomass plant based on agricultural residues and forest residues (case study, Canada).
Kishore et al., 2004	Profitable biomass energy technologies in the framework of clean development mechanism (CDM) with the huge potential of biomass in global climate change mitigation: a case study.
Beck et al., 2004	Difficulties faced by SA and GC systems in terms of policies which leads undervaluation of these systems.
Rabah, 2005	Improvement in the life style of poor people by practical implementation of a stand-alone SPV (case study, Kenya).
Khan et al., 2005	A potential solution of using HOMER with both renewable and nonrenewable sources of energy which helps to the problems of SA systems like low capacity factors, excess battery costs and limited capacity to store extra energy SA systems HRES system.
Santarelli et al., 2005	Hydrogen based SA system to supply electricity to residential users, integrated with renewable energy systems like SPV and micro-hydro with mathematical optimization model to minimize the total investment cost.
Kamel et al., 2005	Assessment of techno-economic parameter between hybrid solar–wind systems and diesel generator using hybrid optimization model for electric renewable (HOMER).
Silveira, 2005	Proposed CDM in promoting bio-energy technologies for sustainable development in developing countries.
Holland et al., 2006	SA systems of rural regions are assessment with significant factors for successful diffusion.
Gulli, 2006	Combined heat and power (CHP) systems is analyzed for social-cost as internal and external system costs.
Hiremath et al., 2006	A modular energy planning models with suitable combinations of HRES- a review.
Jebaraj et al., 2006	Reviews of off grid energy paradigms.
Ravindranath et al., 2006	Assessment of carbon abatement potential of bio-energy technologies (BETs) by comparison with fossil fuel alternatives.
Bernal-Agustin et al., 2006	A case study in Spain for economic analysis of the GC Solar PV system.
Faulin et al., 2006	Role of HRES in generating local employment, due to its huge potential with different RETs.
Hiremath et al., 2007	Off grid energy systems is analyzed with their total potential and installed capacities (case study, India).
Purohit et al., 2007	A feasible project under CDM of Biogases with a total CER prospective up to 26

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	million is estimated.
Walker, 2008	Estimation of the relationship between SA systems and fuel poverty (case study, UK).
Purohit, 2008	An estimation of potential for small hydro power (SHP) in India under CDM.
Adhikari et al., 2008	An outline of the CDM by their potential, opportunities and short falls for executing decentralized renewable energy projects in Thailand.
Salas et al., 2009	The electrical parameters of GC solar inverters are analyzed for applications below 10 kW.
Carlos et al., 2009	A design of GC system illustrating the factors affecting the successful completion of biomass energy projects and compare with real world data of power plants. (Thailand).
Doukas et al., 2009	The techno-economic and environmental sustainability were discussed by removal of barrier to satisfactory distribution HRES technologies.

SOFTWARE DESCRIPTIONS

Figure 1 shows the schematic diagram of HOMER with connection of different RETs such as PV, wind, battery, generator, converter. Figure 2 shows different variable as decision and sensitivity variables of different RETs such as PV, wind generator and battery. Figure 3 shows the framework of analysis as pre HOMER stages in which the load demand and its seasonal variation is to be estimated for residential, institutional, commercial, agricultural and industrial while post HOMER stage highlights the project delivery in terms of business-related dimension like financial challenges, regulatory concerns, tariff issues and selection of business model

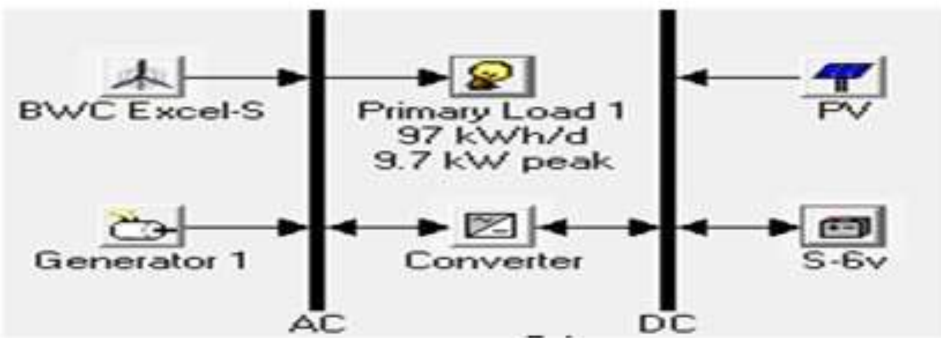

Figure 1:- Schematic Diagram of HOMER

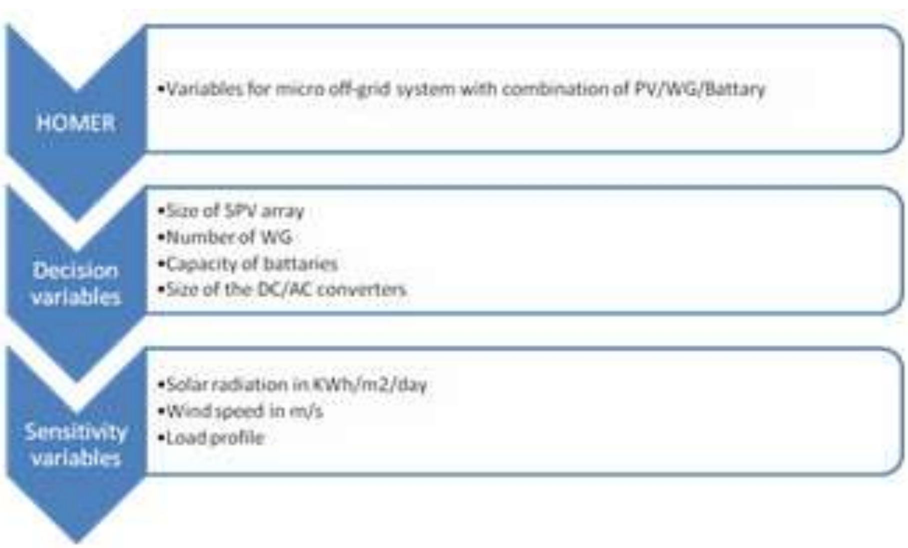

Figure 2:- Variables for off-grid system with different combination

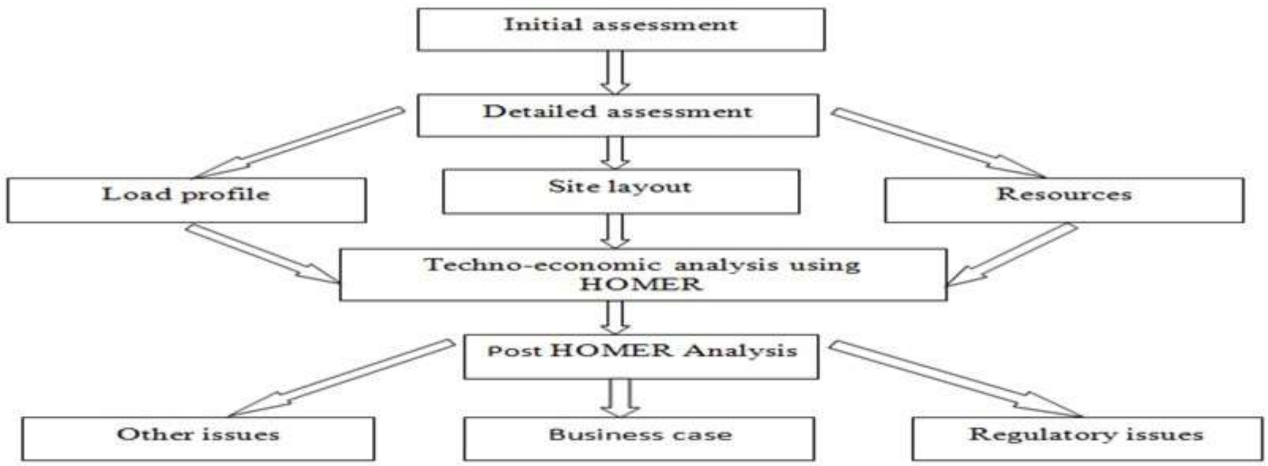

Figure 3:-Pre and post HOMER framework of analysis

CONCLUSIONS

A number of articles have been presented for both success and failure narratives of implementation for decentralized systems but most of the case studies are analyzed for isolated case. Researchers envisaged an increasing off-grid supply system, expected to make contribution to climate protection. In the mainstream media, these systems are increasingly associated with the low-carbon and locally available renewable energy resources. But in the particular context of the built environment, the emphasis is on decentralized generation with heat production. It is therefore important to realize the potential of biomass based technologies in greenhouse gases emission reduction in developed countries and their role in promoting sustainable rural development in developing countries. Being a widely spread source, biomass offers the execution of decentralized generation gaining importance in electricity markets. Distributed generation has many potential system benefits such as reduced power losses from the grid, deferring grid capacity investments, reducing emissions and costs of electricity generation. Government of India is promoting the use of solar home systems (SHS) as domestic lighting in remote and less inhabited villages. This paper revealed that hybrid technology is more beneficial as compared to single energy resource regarding less per unit electricity cost, improvement in capacity utilization factor, service reliability and global environment facility. The HOMER help to simulate the particular system and shows the optimal result with different parameters like solar radiation, wind speed, configuration of converters, inverters & batteries and monthly load profile.

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