Assessment of Rural Electrification for technology transfer in renewable energy technologies between Thailand and Ghana

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Abstract— *In the modern world, the development and progress of any nation is directly linked to the technology it can access and this is mostly transferred from a more developed nation. Transfers of technology, be it tangible assets, infrastructure, finance or skills and knowledge from transferor to transferee is thus a prime importance for growth in the economy of all sectors. Thailand and Ghana share many similarities such as all being developing nations and with similar climatic conditions. Thailand had achieved about 99% in rural electrification as of 2016 whilst Ghana had managed barely 70% even though efforts had been stepped up in both countries at almost same time. The difference has been found by research to be the technological advancement as well as prudent policies that Thailand adopted to see such growth. In view if this, there is thus the need to research into these developments to identify the possible avenues for transfer of technology and policy adaptation from Thailand to Ghana for successful advancement of rural electrification in the country. It has been identified that technologies in solar rooftop systems, solar farms, wind farms, biomass and waste to energy power technology systems hold huge potential to accelerate Ghana's rural electrification program to provide sustainable energy for all in the shortest possible time. This can be done through foreign direct investment, joint ventures and licensing operations AND South-South cooperation. Opportunities also exist in transfers of skilled personnel as well as through education and research. Projects could also be done through clean development mechanism portfolios which would yield double results for both countries.*

Keywords— **Technology transfers, rural electrification, renewable energy, solar, hydro, biomass.**

1. BACKGROUND

These Developing countries around the world, especially in Asia and Africa have been saddled with lack of access to modern forms of energy [1, 2]. This is especially prevalent in rural and remote communities of developing countries which are usually of lower population densities. The electrical load in such communities or villages are usually low and of low demand factor. The absence of modern energy supply, especially electricity tends to adversely affect the growth of the economy in such places. It has been discovered that there is a potential economic growth of more than 15 times with every dollar invested in energy supply [3, 4]. As the millennium development goals 1 & 7 spell out, poverty is linked to lack of access to basic and modern energy forms and the use of traditional inefficient fuel sources are mostly not sustainable. On this score, many efforts are being geared towards the provision of modern forms from sustainable sources of energy to all parts of each country.

Ghana and Thailand have a fair share of rural electricity poverty with the later's performance being far better than the former. Whiles Ghana is mostly patted at the back for being one of the leading countries in the sub-region with high electricity access rate [5], much is yet to be accomplished when it comes to rural electrification. The accelerated electrification measures and policies saw majority of larger towns and cities connected to the national grid electrification system in just less than two decades [6]. Most of the supply of electricity came from hydro sources and with the advent of extended drought, the weakness of this source was exposed as there was under generation forcing the country to undergo load shedding. Currently, the installed electricity generating capacity of Ghana is approximately 3650 MW which is far less than the total demand of the country [7]. This capacity is made up of about 42% of hydro sources, with the rest being thermal based [8, 9]. Renewable energy fraction is still less than 1% [10] with most installation serving rural and remote communities.

Ghana's rural electrification which began in the late 1980s and early 1990's saw the expansion and access rate from less than 25% to over 80% at present. The establishment of the National Electrification Scheme (NES) in 1989 saw the connection of 2350 communities to the national grid in ten years' time. This represented 56% of the targeted nearly 4200 communities identified to be possibly to connect over the time [11]. The NES thus established the community self-help electrification program to guide the execution of the task of electrifying communities with population more than 500 and of less than 25km from a medium or low extension grid line [9]. The government through donor funding and community participation sustained the program to its successful

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implementation. The focus on the grid extension alone by Ghana has resulted in power deficit even though there is high access rate. Ghana suffered from severe power rationing in the years 1997 & 1798, 2003, 2006 & 2007 and from 2011 to 2016 owing to the decrease in water level in the dam and short supply of crude oil for thermal options of power generation [6]. This adversely affected the GDP and the growth rate in 2016 [12].

Thailand on the other hand, has made tremendous effort to achieve an almost 100% national and rural electrification rate throughout the country [13]. The Royal Thai Government through the Electricity Generation Authority of Thailand (EGAT) instituted the National Plan for Thailand Accelerated Rural Electrification in the early 1970 which saw a rapid extension of electricity to all parts of the country [14]. This plan increased rural access rate from 10% in 1972 to more than 99% currently. This targeted people living in rural communities outside the big cities. The number of rural communities electrified in this program amounted to 64,228 by 1996 representing 98% of the entire population of rural communities. This feat was achieved through the government budgetary allocations, and soft loans from foreign and local financial institutions. Between 1977 and 1986, (representing the first two phases of the program) the Provincial Electricity Authority (PEA) is responsible for the program had borrowed and used almost USD 100 million. Cross subsidy, cost recovery and end user contribution helped the PEA to sustain the program and continue with the extension [15].

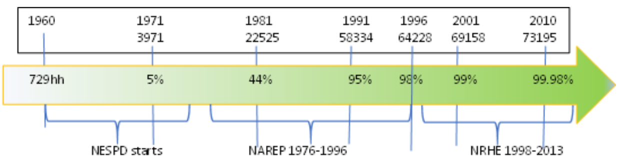

Fig. 1. Thailand RE program development (adapted from)[16].

While bemoaning the low electricity access rate in sub Saharan Africa and Africa in general as well as South-East Asia, it can be seen that Thailand has made a tremendous mark in the electricity sector worth emulating by other countries including Ghana. On this backdrop, this research is being carried out to assess the impact of renewable energy options on rural electrification in Thailand and Ghana and a possible transfer of technologies and adoption of policies between the two countries.

1.2 Renewable energy and rural electrification

In a concerted effort to increase RE penetration in Thailand's energy system to energy security and environmental impact mitigation, the Kingdom of Thailand set a target of 30% RE penetration and reduce GHG emissions by 20-25% by 2030 in the AEDP 2015. The IRENA in its country report called Outlook Report [17] has projected a further increase of 7% by 2036 if pragmatic measures are adopted and this is envisaged to bring a cost saving of more than 1.2 billion USD annually plus health and environmental gains. Over the years during the implementation of the Accelerated Rural Electrification National Plan Study, much attention was given to the integration of renewables even though majority of supply came from grid extension.

This work is mainly based on the research of literature and author contact and interview with relevant authorities involved in rural electrification in Thailand. The literature was mainly journal articles, policy and project document secured online, in library and concerned institutions. Also, documents and presentations from conferences such as the 4th ASEAN Smart Grid congress, held at SGtech, Naresuan University, Thailand, ICUE, by AIT, Thailand and other relevant resources were used. Thailand's Government policy document on rural electrification and that of Ghana were consulted for information.

2. THAILAND RE PROGRAM PARAMETERS

Successful RE programs around the world have been hinged on policies and technologies and the adoption of certified tested ones from Thailand to Ghana will certainly see the positive progress of like successes in the country. Whiles it has been found out that RE in developing countries, especially South Asia and Africa have been painfully slow; it is more disheartening to realize that it is even slower than the population growth of the rural areas, which is the recipe for worsening poverty rates. Thailand on the other hand, has been largely successful with RE, thanks to the policies and technologies with are worth transferring to other countries like Ghana. As mentioned earlier, the two components that have combined to result in the Thailand success story are the government and institutional policies and adaptable technologies of which are supported by several factors some of which are outlined in the following sections.

2.1 Institutional structures

Thailand in setting the goal to improve rural electrification from 10% in 1971, established or re-orientated institutions to oversee and execute the planned program. Whiles the EGAT was strengthened to increase capacity, the PEA was mandated and retooled to embark on the accelerated program. In this regard, the body was made more autonomous with higher degree of independence in connection with the task [13]. Similar arrangement was done by Bangladesh which established a separate Rural Electrification Authority (REA) to oversee the RE initiatives [18]. Similarly, Costa Rica also established Rural Electrification Cooperatives which saw a successful implementation of RE projects in that country. Tunisia on the other hand, delegated RE to Regional Utility Agency to execute its RE programs. Ireland's Rural Electrification Agency had its own budgetary allocations for materials and operations for RE programs and had control of planned activities of which it held itself accountable to its own targets [19].

2.2 Leadership

The successful implementation of any program, including RE largely depends on leadership and personnel or staff. Whilst the institutions are strengthened and given high degree of freedom and flexibility in decision making, the leadership must be dynamic and up to the task [20]. Thailand in deciding the RE program appointed Dr. Chulapongs Chullakesa as the first director at the office of the RE who initiated the RE program from start to finish and later assumed the position of the PEA's governor from 1993-1996 [21, 22]. A stronger supporting staff is thus required in executing the mandate of RE. The leadership should be able to motivate staff to unearth the self-dedication in them to take the task of RE. This experience was seen in Thailand's case as the staff saw themselves as laying the foundation for the future development of the nation. Whiles encouraging and motivating staff, clear career prospects and security should be set and ensured for the reliance and commitment of the staff.

2.3 The face of Politics in RE Programs.

Funding and budgetary allocations sometimes make politicians feel a sense of control over the implementation of RE programs as has been observed in many countries. There is the need thus, to insulate and separate RE programs from political interference in any country and making discussions solely the business of the tasked institutions [23]. The government provides a reporting platform and a guide. With this idea, politicians and local leaders were tasked to raise funds in support of the program, and their benefit is a speedy execution of the program and the provision of power to their constituents even before the scheduled time [22].

2.4 Selection criteria for RE program

It's been found out that RE programs cannot survive alone without the supporting factors being considered. Factors such as educational, health, water access as well as land security, dwellings of residents, road infrastructure agricultural input and income level, cultural practices [24] among others play significant roles in the success of the implementation of RE programs, less diligent assessment of these factors can spell doom for the program. In undertaking RE program, Costa Rica depended among other factors on population density, commercial development level and electricity demand level to plan and execute the RE program [25]. Thailand on the other hand, used existing business availability, income level of inhabitants, and government's planned near future intrastate in the area to model a numerical ranking for their RE planning [26]. These thus inform the load forecasting approach to determining the demand growth to enable adequate planning. In Thailand's selection model, three broader considerations were then postulated, that is;

1. "Maximizing potential benefits while minimizing project cost.

2. Integrating rural electrification into broader national development strategy.

3. Giving consideration to the social and political requirements of less stable areas" [27].

These considerations then were followed by quantitative and qualitative selection procedures for selecting the communities. The quantitative steps included number of villages in each province and district allocation, as well as the villages ranking which resulted in the number of villages to be electrified under the program at the time. The qualitative assessment involved the settlement pattern, whether dense or scattered, closeness to the distribution network and whether it's already considered in other programs, sure as distributed or off-grid network [28]. The qualitative assessment sought to certain key variables to determining the indexes for the model of selection. These included access of households to private or public source of water supply, lighting and other domestic appliances, as well as water pumping devices for agricultural purpose. Other factors such as cooking fuels used, ratio of students in various level of education, type and period of dwelling construction, baseline power demand data, overall community assessment and agricultural development assessment.

The provincial model for community selection was then computed as follows [28]:

$$(\mathrm{Si}-\mathrm{Sm}) \times \left(0.975-\mathrm{Dm}/_{\mathrm{Sx}-\mathrm{Sm}}\right)+\mathrm{Dm}=\mathrm{Di} \quad (1)$$

$$\sum_{I=1}^{27}(Di \times Vi) = 9000 \mp 50 \quad (2)$$

Out of this model, a district section model was also formulated to rationalize the community level selection, that is:

$$\mathrm{K}=\frac{\sum \mathrm{SiVi}-\mathrm{Sm}\sum \mathrm{Vi}}{\mathrm{Sx}-\mathrm{Sm}} \quad (3)$$

$$\mathrm{D}=\frac{\sum \mathrm{Ai}-\mathrm{DxK}}{\sum \mathrm{Vi}-\mathrm{K}} \quad (4)$$

$$\mathrm{Ai}=\mathrm{Vi}\left(\frac{\mathrm{Dx}-\mathrm{Dm}\times(\mathrm{Si}-\mathrm{Sm})+\mathrm{Dm}}{\mathrm{Sx}-\mathrm{Sm}}\right) \quad (5)$$

In summary, the above factors and the subsequent criteria resulted in the following factors for community selection for the RE program in Thailand:

Village ranking for final selection:

- Proximity to the grid
- Accessibility by road
- Village size
- Number of expected customers in first five years
- Potential agricultural and industrial load
- Number of commercial establishments
- Extent of public facilities.

From the foregoing, it can be seen that Thailand developed a sound and pragmatic approach to community selection and took care of prioritization in a flexible manner for effective implementation of RE program. Influential individuals were taken care of in the model to ensure reliable and effective selection.

Similar arrangement was made in the Ghana's electrification program which saw some influential community members contributing to the connection of their communities to the national grid [5]. An example is Mr Paul Addai of Addai Cutlass Company who single handed sponsored the purchase of a step-down transformer and the low-tension distribution concrete poles for the connection of his community, Ntri-Buoho in the Kwabre District of the Ashanti region in 1985 to the national grid. This exposed the once dormant community to both commercial activities and reversing rural-urban migration prevalence.

2.5 Costs Recovery

RE is just like any investment venture in which cost of capital expenditure (CAPEX) as well as operation expenditure (OPEX) must be recovered as well as profit securing some profit margin to be a security for the venture. This factor is very important for the sustenance of the program in every country which if undertaken diligently can align other elements of RE in place. Most RE programs have been found to thrive on subsidies from State or Central Government [29] or both, and when downward adjustment is made to this arrangement, it brings hardship to operators. This can create severe losses that can threaten the very sustenance of the program. Countries that have depended in foreign funding such as loans and grants find it difficult keeping their heads above the waters. The Malawian state power corporation has declined to pursue RE because of the interference of the central government in determining tariffs which the company sees as stifling. Kenyan RE program can barely move on since its source of funding is grants from bilateral donors which is incapable of supporting it [4, 27]. Most successful RE programs had depended on concessionary loans for funding the RE programs. This was the Thailand's option of funding its RE program to its success state now. Despite the flexibility of concessionary loans, they must be redeemed and ventures incapable of this should not access it. Ireland and Costa Rica used government grants and low interest loans from USAID respectively for their RE program [26, 27].

Thailand adopted varied cost recovery mechanisms to achieve success in its RE program. Among these are, the promotion of productive uses of power. The promotion was geared towards small industrial and commercial use of power in other to enhance payment of bills [22]. Thus, businesses such as already existing and new rice mills were encouraged to use electric motors instead of diesel-powered systems and individual households were encouraged to connect to power grid at the initial stages as in the example of Bolivia program [30]. Also, connection was made affordable at about 800 Baht (less than US$200) [26] and loans were provided for customers for house wiring for initial connection. Also, community leaders were tasked to distribute application forms and receive deposits for connection. Small to medium businesses like the rice mills were allowed to spread the payment of initial connection over a year and coordinated led to receive loans from banks. This approach increased the initial connection rate and subsequent recovery of cost for the progress of the program. These measures were lacking in the Ghana's program so many households remained unconnected even after an appreciable length of time after electrification.

2.6 Tariffs

As much as cost recovery is of prime importance in RE implementation programs, realistic tariffs need to be considered. Whiles low tariffs lead to under recovery and difficulty of progress, too high tariffs scare potential customers away [31] and result in slow connection rate, preventing cost savings compared to the alternatives used before electrification. A realistic power tariff ensures that the provider is able to supply sustainably the required power that is effective and also reliable. The cooperatives of Costa Rica could make marginal profits on the power charged by the country's regulatory body which is reasonably high enough [32]. These measures are seen as means of reducing barriers to obtaining power supply.

Table 1: FiT of renewable energy source power generation in Thailand and Ghana [33] [34]

		THAILAND			GHANA
Renewable resource	Category	Installed capacity/kW	FiT (Baht/kWh)	Support duration/years	FiT (Cedis/kWh)
Solar PV	Rooftop	0-10	6.85	25	
		10-250	6.4		
		250-1000	6.01		
Solar	Comm. Ground mounted	All capacity	5.66		59.7750
W2E	Integrated Waste	1000	6.34	8	
	Disposal	1000-3000	5.82	8	
		>3000	5.08	8	
	Landfill		5.6	10	69.1225
	Biomass	≤1000	5.34	20	69.1225
		>1000-3000	4.82	20	
		>3000	4.24	20	
Biogas	Liquid/solid waste		3.76	20	69.1225
	Energy crops		5.34	20	
wind			6.06	20	65.3529
geothermal					46.5817

Thailand set an attractive FiT for the renewable sector which keeps on attracting new investors to undertake projects in renewables that in the long term helps enhance RE program. Table 1 summarizes the current Fit in Thailand and compares with that of Ghana.

2.7 Community participation

The success or otherwise of a project can largely be determined by the participation and inclusiveness of beneficiary communities in decision making, planning and execution. The involvement of the community gives them a sense of belongingness and ownership of the project which ensures enhanced care and maintenance [35]. Rural electrification committees can promote access rate, education of consumers and even revenue collection after project implementation. In Ghana, community members provided unskilled labor such as tree felling, bush clearing, poles mounting and a host of others for the construction of the system which is seen to speed up execution. Experts from the community can also be drafted into the technical team of work force of the companies to enhance community participation and inclusiveness. Consumer meetings were organized in Bangladesh to explain RE to community members even before implementation. This was means to diffuse tension, rancor, litigations that may arise as a result of construction of facilities to aid for instance, right of way. Thailand used these means to educate and interact with the communities that resulted in the non-payment of right of way and possible property destruction in connection of the construction of RE systems [13] .

2.8 Prudent economic management

Careful of RE system design has been found to result in cost savings of up to 30% in CAPEX and OPEX. Initial system design must consider several parameters including customer types, area of application and the expected returns on investment. Most rural communities are sparsely populated with low density which usually have low power factor. In such cases, single phase application may just be sufficient since the load growth is not rapid due to rural urban migration. Using system design of more heavily demanded scenarios for such cases results in waste and difficulty of revenue mobilization. Bangladesh, Costa Rica and Philippines adopted the single phase line distribution system as used by the US in the 1930 for its rural electrification [21]. Thailand on the other hand, adopted material standardization for its RE program and also depended on locally made material instead of imported. The procurement cost, material handling and purchasing costs were found to be significantly low compared to other countries. Ghana on the other hand, depended largely on foreign imported materials which placed a lot of financial stress on the program. The country thus became indebted to the donor countries as connection rates were low initially [26].

3. TECHNOLOGY OPTIONS FOR EFFECTIVE TRANSFER

3.1 Grid power system

Many countries have achieved various degrees of feet in rural electrification and power expansion through the extension of the centralized or decentralized system to all parts of the country. In Thailand's effort in its RE program, the EGAT was strengthened and functioned as semi-autonomous body until it was corporatized as EGAT PLC. They had produced enough energy to sustain the RE program. Thus, the capacity by EGAT was enough for supply to MEA, and PEAs [36]. The liberalization of the power sector in 1991-1992 saw the entrance of independent power producers (IPPs), Small Power Producers, (SPPs), and very small power producers (VSPPs) to produce power and sell to EGAT and for distributed systems [37]. As of September 2018, the total generation capacity of Thailand stood at 42985 MW producing some 136385 GWh of electricity available to EGAT which is made up of both conventional and alternative energy sources. The cumulative generating capacities of various components of Thailand are shown in Figure 2. It can be seen from Figure 2 that there has been consistent growth of capacity in generation since the beginning of the new millennium.

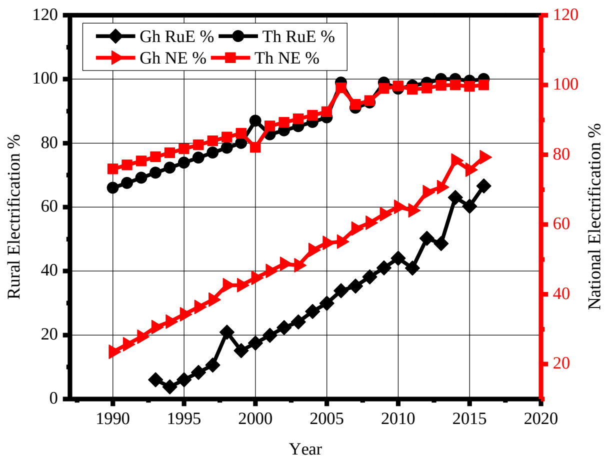

Fig. 2. Rates of Rural and National electrification in Ghana and Thailand.

3.2 Renewable energy and distributed systems

Thailand has a fairly developed renewable energy sector owing to the pragmatic measures adopted to ensure adequate penetration. It is the vision of the Thai government to increase renewable energy electricity generation from the current 7% of to 20% of total capacity. Ghana renewable capacity in the generation mix has been almost insignificant since the implementation of the RE program. At present, there is only one central grid connected RE project which is 2 MW installed capacity which makes the total contribution less than 1%. Though there are other initiatives undertaken to infuse renewables into the electrification in Ghana, there is enormous room for improvement and this can happen through transfer of technology in the renewables area from Thailand to Ghana. Ghana shares similar weather and geographical characteristics as Thailand. Table 2 outlines the climatic data of the two countries

Table 2: Climatic characteristics of Thailand and Ghana

Climate Parameter	Thailand	Ghana
Daily solar irradiation/KWhm^{-2}/day	5.13	4.37
Wind speed/m^{-1}	2.9	2.0
Temperature/ ^{0}C	28.7	26
Relative humidity	73.0	76.9
Pressure	98	99.9

From Table 2, it can be seen that the 2 countries have almost similar weather data of which renewables in these areas can well be implemented or technology in Thailand can easily be transferred to Ghana. Thailand has strengthened its industrial sector, attracting investors into the manufacturing of components of renewable energy systems. Large solar and wind manufacturing companies are producing and installing systems to support the renewable energy industry [40]. Many small and large companies are producing electricity from solar and wind that is fed into the grid and managed by EGAT [41]. Many isolated grids and individual rooftops systems are also helping communities that are difficult to be connected to the central grid, be it island or mountainous communities such as Kho Bolon Don, an island in the Satun Province in the Andaman Sea of Thailand [42]. These individual grids and projects are also helping the RE program.

Several Biomass projects are also undertaken in Thailand to generate electricity for RE. These projects are in the area of co-generation, waste to energy and biogas projects. It's been identified by research that several universities and institutions have conducted extensive research into the use of bio-resources for power and energy generation [43]. Chulalongkorn University was found to have conducted the highest number of research into ethanol production, biodiesel by Prince of Songkla, Chulalongkorn and Kasetsart Universities, Biomass by King Mongkut University of Technology, Naresuan University Kasetsart and Chulalongkorn Universities. Chiangmai University conducted the highest research in Biogas systems with Kasetsart and King Mongkut Universities making significant researches. These efforts have resulted in the trials and implementation of several Bio-resources power systems in Thailand, making tremendous contributions in that energy situation in the country. The Ministry of Energy documented that the total capacities of biomass power system were 611.76, 830.72, 1189.29 and 94.83 MW in the North, Central, Northeast and South respectively [43]. These have boosted the countries efforts in integrating alternative renewable resources in their power and energy systems.

Ghana's vegetation is rich in biomass and farm activities also produce large volumes of wastes which can be used with the right technologies to produce electricity especially for RE. Besides few larger companies such as BOPP, Juaben Mills, that produce some amount of electricity from their wastes, most biomass resources are mostly discarded, rotting and polluting the environment with GHG. There is much resources to be harnessed for power production to support the RE program. In all, the government of Ghana has earmarked 200-300 MW of medium to small hydro projects, 150-300 wind power systems, 50-100 MW Biomass and Waste to energy, 50-100 MW solar systems, 30-50 MW distributed connected to grid system in all aspects of renewables to achieve its 10% penetration of renewables in the generation mix [10, 11].

The department of alternative energy development and efficiency in Thailand has identified about 43 SHPs presently generating various capacities for grid connection and distributed systems. Most of these can be located in the northern part of Thailand where there is mountainous terrain and water bodies. Ghana, according to the renewables energy assessment reports, has 1245.2 MW potential for SHPs [44] of which there is no installed capacity currently. These numerous resources can be located along the Black Volta River basin, (about 55%), Pra River, White Volta, Tano River and the Oti River basins [45]. There are identified cascade locations along these rivers with enormous potential for SHPs.

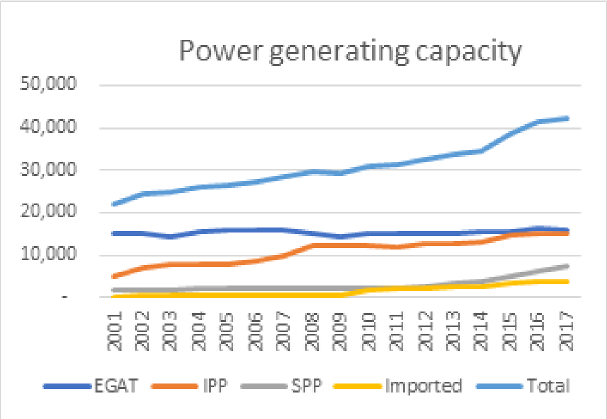

Fig. 3. Electric power generating capacity growth of Thailand Source: MoE, Thailand [38].

3.3 Models of technology transfer

Technology transfer usually occurs between developed and developing countries where the developed (Transferor) transfers to the less developed (transferee). The modes or channels through which these can happen occur includes commercial mode; in which physical or tangible assets, liquidity or entities can be traded and non-commercial, which mostly involves knowledge and skills [46].

3.4 Foreign Direct Investment

Public and private companies and institutions can take the advantage of the enabling environment prevailing in Ghana to set up power systems to provide electricity to feed the system. Various resources exist for the installation of solar farms, wind farms; waste to energy systems to take advantage of the large municipal wastes generated each day to produce electricity. The many potential mini and micro hydro sites identified could be explored by companies in Thailand to produce power for the communities' power needs. These can happen through foreign direct investment, (FDI), joint venture, Build-Operate and Maintain (BOM) or Build-Operate and Transfer (BOT) basis [46, 47]. They can also operate through local subsidiaries to establish the power systems in the renewable sector. The already existing small companies can be retooled and revamped to increase their capacities through provision of materials, injection of capital and joint operation and execution of power projects. In delivering a good return on investment to the foreign companies in Thailand, Ghana can also apart from the power security, enjoy recruitment of the local labour force and the creation of opportunities for the job markets to reduce unemployment, cross transfers of liquidity, technological and managerial skills as well as improvements in R&D for research institutions. In the same arrangement, licencing opportunities that may arise will benefit both countries by opening the frontiers of the markets for energy and other auxiliary sectors of the economy. International subcontracting and turnkey contracts can also benefit both countries where experience gained in executing these RE projects can be reinjected in local industries.

Besides the transfer of tangible assets and skills for the improvement of RE opportunities, the transfer and development of local education, institution and R&D is of utmost importance on technology transfer [48]. Many academic, professional and research institutions exist in Ghana who are engaging in various researches into the sustainable development of the Ghana energy sector. Institutions such as Kumasi Technical University, (KsTU), Kwame Nkrumah University of Science and Technology, (KNUST), Koforidua Technical University and a host of others are making modest innovations and knowledge are being churned out day by day, but they mostly lack capacity. The government of Ghana's budget for R&D is woefully inadequate to resources these bodies to undertake challenging and competitive research and innovations. This stifling constraint in terms of finance and infrastructure impede growth in research in energy matters. Thailand has several institutions dedicated to research in energy systems and are making progress with the support of the government and agencies. Naresuan University's Renewable and Smart Grid Technology, (SGtech), the first of its kind in the region is dedicated into the research of renewable energy technology and the application of these to make 'Smart Life". Other research institution and universities are well resourced to stand up to the task of exploring opportunities for sustainable energy and enhanced RE program for Thailand. Institutions in Ghana can thus collaborate with those in Thailand to engage in exchange of technology, staff, students and researchers to transfer lacking technology and skills into the country for onward application in the energy industry [48]. In doing so the frontiers of research will be wide open and a seemingly limitless infrastructural and material base made available to researchers to explore.

3.5 Clean Development Mechanisms (CDM) for technology transfer

The awareness of climate change issues prompted the adoption of the Kyoto Protocol of which Ghana and Thailand are all signatories and have rectified accordingly. There are several successful projects undertaken in Thailand in line with the CDM mechanism, with the aim of reducing GHGs and also ensuring the security of the energy in Thailand. Countries making impacts in CDM portfolios include China, India, Brazil, Chile, Colombia, Indonesia, Israel, Malaysia, Mexico, Peru, South Africa, South Korea, Thailand and Vietnam. In sub-Saharan Africa, Kenya, Rwanda, Senegal and Uganda have various degrees of portfolios in CDM projects, targeting efficiency in household energy usage [49]. Market exists in household energy efficiency, industry and agriculture and forestry, which can bring projects that, can accelerate RE programs. In biomass energy, opportunities exist for the use of agricultural residue from farming activities such as solid wastes from oil palm industry, poultry and livestock wastes to generate power for feeding into grid or as distributed system. Inefficient domestic and small industrial lighting and other energy use can be used to institute projects in Ghana that can take up a CDM portfolio. Alternative fuel use for the numerous fleets of cars and trucks such as biodiesel and bioethanol and their blends can attract a CDM portfolio in Ghana. Mini and Micro hydro potential in Ghana, million tonnes of landfills, municipal solid and liquid wastes methane flaring and power generation projects can be used for CDM financing that will boost the power generating capacity in Ghana to improve RE development.

3.6 Transfer and Adaptation of policies for RE development.

The availability of physical assets and installation can only work the in the regime of good policy framework and program action plans. Despite the numerous policies and acts of parliament in Ghana, the expected development in the renewable energy sector and the power system as a whole has not achieved the needed results [50]. Thailand achieved success though prudent policies and programs, such as a comprehensive feed-in-tariff. There is a careful breakdown of FiTs for all categories of renewables and for various capacities as well as geographical consideration as shown early on in Table 1. The action plans for Thailand's power program such as the Reconnaissance Study to assess the readiness of relevant parties to the participating members, the pre-feasibility studies of the National Plan for Thailand Accelerated Rural Electrification (AEDP) 2012-2021, Power Development Plan (PDP) 2020, Renewable Energy Development Plan (REDP) 2008-2022 [50] have all been worth of emulation. In collaboration with various institutions such as Ministry of Energy and Power, Energy Commission (EC), Volta River Authority

(VRA), Electricity Company of Ghana (ECG), Ghana can adopt these comprehensive policies into the system and the reorientation of the institutions involved in power system and the RE programs.

4. CONCLUSION

As of March 2012, Thailand RE program had connected 73348 villages out of 73360 representing 99.98% which was started from a humble beginning of 10% in 1972. Ghana has its nationwide electrification a little more than 80% with rural electrification well below 70%. Renewable energy penetration in power generation is also less than 1% yet renewable resources match that of Thailand. Thailand's success has been achieved through a 4-staged policy program instituted and executed locally, largely with local resources. Technology, logistics financial support had been locally engineered to a successful achievement of targets set. Despite Thailand being part of developing Asia and are associated with low access to electricity rate, especially, the rural sector, they stand out of the multitude. Ghana on the other hand has achieved fairly successful in electrification as compared with other nation in its sub-region, but much more is left to be achieved. Rural electrification is still low compared with urban statistics and the quality of service is lower even for the urban. There abound some 100 MW of untapped solar potential in Ghana which when harnessed can contribute to RE significantly.

Technologies lie in solar rooftops, solar farms and small systems, as well as concentrating collectors for electric power generation for rural electrification. Wind energy potential of about 3300 MW exist along the coast of Ghana and along the Ghana-Togo range that can supply more than 8000 GWh of power for RE program. Large volumes of agricultural and forest wastes as well as municipal solid and liquid wastes are available to be converted with appropriate technology to produce power to be injected into the grid for extension to all parts of the country. Technologies include biogas plant and power generation systems, landfill gas processing systems, solid waste co-generation power plants as well as modern biomass power plants.

Several researches have identified other renewable resources such as tidal, wave, ocean thermal as well as geothermal opportunities exploitable for power generation in Ghana. Thailand has demonstrated the capacities in all these field requirement and transfer of the logistical assets, technology know-how and other resources to Ghana can help achieve such feet in RE as Thailand have.

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NOMENCLATURE

NES	National Electrification Scheme
GHG	Green House Gas
AEDP	Alternative Energy Development Plan
RE	Rural Electrification
REA	Rural Electrification Authority
PEA	Provincial Electricity Authority
EGAT	Electricity Generating Authority
OPEX	Operational Expenditure
CAPEX	Capital Expenditure
IPP	Independent Power Producer
SPP	Small Power Producer
VSPP	Very Small Power Producers
MoE	Ministry of Energy
SHP	Small Hydro Power
FDI	Foreign Direct Investment
CDM	Lean Development Mechanism
PDP	Power Development Plan
EC	Energy Commission
VRA	Volta River Authority

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