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SUSTAINING THE 3e NEXUS IN GHANA ENGINEERING, ENERGY AND ECONOMIC GROWTH

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SUSTAINING THE 3e NEXUS IN GHANA: ENGINEERING,

ENERGY AND ECONOMIC GROWTH

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Executive Summary

Many countries have enjoyed economic growth as a result of the availability of reliable and sustainable supply of energy. With Ghana's anticipated accelerated economic growth under the Growth and Poverty Reduction Strategy II, and a growing population, reliable and sustainable supply of energy will remain a critical input to this economic growth. Engineers of Ghana are the drivers of Ghana's energy sector which keeps the "engine" of our nation's economy running at the accelerating speed we have experienced in recent years. This address highlights the link between engineering, energy and Ghana's economic growth, and declares that this "3e Nexus in Ghana" should be sustained to maintain Ghana's development momentum, and that engineers of Ghana pledge to champion this.

1. Significance of Energy in Economic Growth

In several countries, there has been a strong relationship between energy and economic growth. The availability of reliable and sustainable energy supply drives the growth of the economy, whilst a growing economy creates a rise in the demand of energy to support the growth. Using the national consumption of electricity as one of the key components of energy consumption in a national economy, Table 1 shows that the growing economies of countries Mauritius, Egypt, India and Brazil have been accompanied by high electricity consumption per capita.

Ghana has, since the mid-1990s, launched three development plans aimed at transforming its low-income developing country status into a middle-income one by 2015. The prevailing development plan is the Growth and Poverty Reduction Strategy (GPRS II) which forecasts an average real growth of gross domestic product (GDP) of 7-10 percent for the period 2003 to 2015, and the attainment of per capita income of US$1,000 by 2015 from less than US $400 in 2001. The drivers of the

expected economic growth according to the GPRS II are:

i) Private sector competitiveness;

ii) Human resource development; and

iii) Governance and civic responsibility.

Table 1: Growth of GDP and Energy Consumption in Selected Countries and Regions

Country /Region	GDP per Capita			Electricity consumption per capita (kilowatt-hours)		GDP per unit of energy consumption (2000 PPP US$ per kg of oil	
	US$	PPP* US$	Annual Growth Rate % 1990 -2004	1980	2003	1980	2003
	2004	2004					
Mauritius	4,889	12,02T	3.9	482	1,683	N.A.	N.A.
South Africa	4,675	11,192	0.6	3,181	4,595	4.5	3.9
Egypt	1,085	4,211	2.5	433	1,340	6.4	5.1
Cote d'Ivoire.	866	1,551	-1.1	220	209	5.2	3.8
Senegal	683	1,713	0.9	115	192	4.3	5.2
Kenya	481	1,140	-	109	154	1.8	2.1
Ghana	409	2,240	1.9	450	285	4.8	5
Benin	498	1,091	1.4	37	82	2.4	3.5
Mali I	371	998	2.5	15	38		
India	640	3,139	4	173	594	3.3	5.3
Brazil	284	8,195	1.2	1,145	2,246	7.5	6.9
Sub-Saharan Africa	731	1,946	0.3	434	522	3.2	2.7
South Asia	697	3,072	2.5	171	598	3.8	5
OECD*	28,453	27,571	1.8	5,761	8,777	3.9	5.3

*PPP - purchasing power parity (a rate of exchange that accounts for price differences across countries) Source: UNDP Human Development Report, 2006

Under the GPRS II, economic growth is expected to be led by the agricultural sector, which will provide the necessary inputs for a vibrant agro-processing industrial

sector in the medium term (by 2010). In the process, the areas of Ghana's comparative advantage in agriculture will be enhanced and transformed into competitive advantage in the sub-region. For several years, the agricultural sector has dominated the contribution to Ghana's GDP, ahead of the industry and service sectors.

The main goal of Human Resource Development under GPRS II is to ensure the development of a knowledgeable, well-trained and disciplined labour force with the capacity to drive and sustain private sector-led growth. The broad objective of good governance and civic responsibility is to empower state and non-state entities to participate in the development process and to collaborate effectively in promoting peace and stability. Measures towards attaining this objective include the promotion of an effective, responsible and accountable state machinery with improved capacity to engage the productive private sector and civil society in formulating strategies for accelerated growth and poverty reduction.

With the anticipated accelerated growth under the GPRS **II,** and a growing population, Ghana faces major challenges in providing the required energy in a reliable and sustainable manner to support this growth. Table 2 gives an indication of the growth of electricity consumption that has accompanied the growth of real GDP in Ghana from 2003 (after a drop in electricity consumption in 2002-2003).

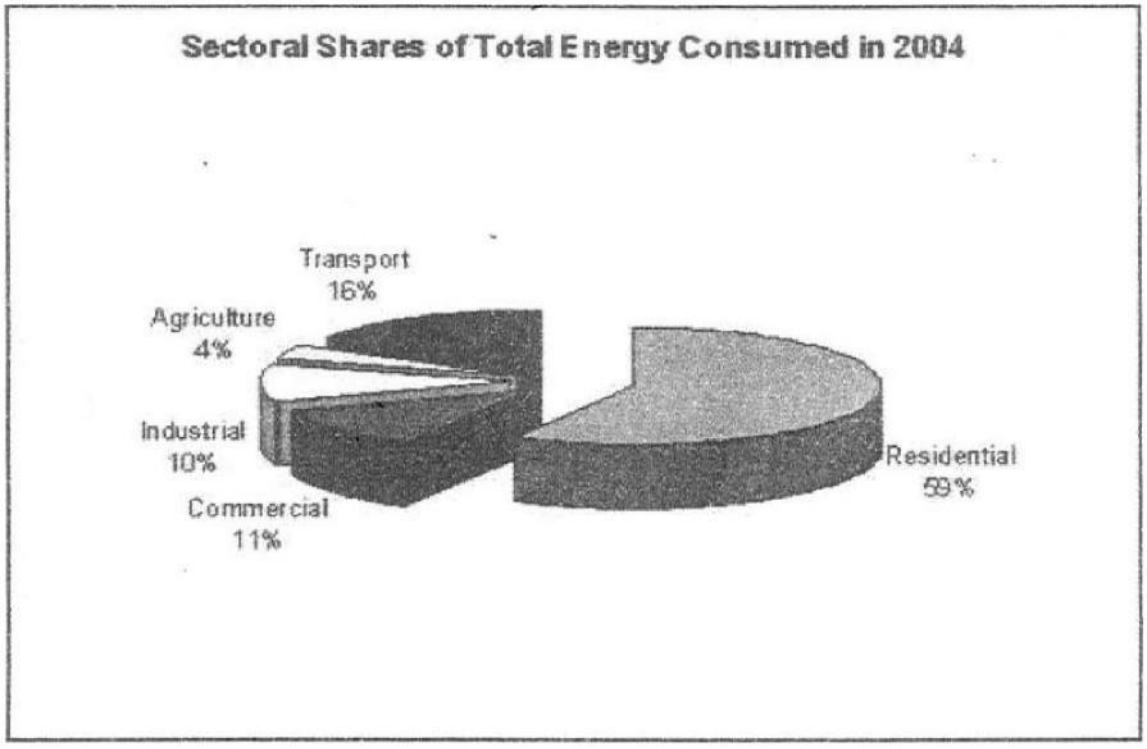
Table 2: Growth in GDP and Electricity Consumption in Ghana

Year	Real GDP growth rate, %	Real per Capita GDP growth rate, %	Total Electricity Consumption	
			'000 GWh	% rise
2000	3.7	2.1	7.4	
2001	4.2	2.3	7.70	4.05
2002	4.5	2.0	7.40	-3.90
2003	5.2	2.2	5.90	-20.27
2004	5.8	1.9	6.00	1.69
2005	5.8	2.1	6.70	11.67
2006	6.2	2.8	7.90	17.91

Source: ISSER, University of Ghana, 2006

2. Energy Situation in Ghana

Woodfuels remains the most dominant energy supplied in Ghana, with a share of 67 percent of the total energy supplied, followed by petroleum products at 27 percent and electricity at 6 percent. The residential or household sector of the economy accounts for over 50 percent of the country's energy consumption, followed by commercial enterprises and industry (see Figure 1). The significant residential sector share of the nation's energy demand is due to the high usage of woodfuels comprising mainly fuelwood (firewood and charcoal) used by households and some small-scale commercial enterprises for cooking and heating. In spite of its relatively low share of the total energy supply in Ghana, electricity supply remains a critical energy input to the nation's economy.



Source: Energy Commission, 2004

Figure 1: Distribution of National Energy Consumption

2.1 Electricity Generation

The existing power plants are the Akosombo and Kpong hydro power stations, and the Takoradi and Tema Thermal Power Stations, operated by the Volta River Authority. The Takoradi Thermal Power Station located at Aboadze, near

Takoradi, consists of two blocks of generating plants; 330 megawatt (MW) combined cycle plant and 220 megawatt single cycle plant. The installed capacity of the Tema thermal plant is 30 MW. There is also the Osagyefo Power Barge which is a 125 MW open cycle plant that may be operational in 2008. The main fuel for

the thermal power station at Aboadze has been light crude oil, but it also uses distillate oil for start-up and shut-down of the turbines. The thermal power station will switch to natural gas when it becomes available in late 2008.

Electricity generation was 7,295 GWh in 2002, dropped to 5,900 GWh in 2003 (see Table 3), but rose steadily to 8,429 GWh in 2006. In 2000, the electricity generation comprised mainly hydro-electricity (91.5 percent) emanating from the Akosombo and Kpong hydroelectric power stations. The hydro share dropped to 82.9 percent in 2005, and 66.7 percent in 2006. Whilst the hydro share of electricity generation dropped, the thermal component rose from about 8.5 percent in 2000 to about 33.3 percent in 2006. There has also been some electricity import from neighbouring la Cote d'Ivoire, and some export to Togo and Benin.

2.2 Solar Electricity Generation

Table 3: Electricity Generation in Ghana, 2002-2006

	2W2 s		21103		2051		2X5		2006	
	Gaeraion	Shale %	GaBration	Shae %	Ceneralice	912re°A	aneralion	See/	Gaeralicn	Share 7
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	87357	11.97	1,3E2	2251	53553	887	831A6	1225	1,41583	1683
Tacraci11 em										
Takcraf IUD	1,3E8	18.€9	68333	11.33	2226	303	327.72	4.83	1,3)1g	1654
Iiurrii TErnaGS	0	QM	17.83	033	-	-	-	-	-	
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1U1.	74E53	IaaCO	5,9)136	10100	6,030.04	MOO	$787.91	=CO	$42897	ma)

Source: Ministry of Energy

Solar energy provides some electricity through photovoltaic systems for vital services in remote and off-grid rural locations in the country. The solar power systems are mostly installed by public institutions in remote areas of the country, and there

are over 5000 systems, with a total installed capacity of 850 kW, generating about 2 GWh per annum (see Table 4).

Table 4: Installed Solar Power Systems		
System	**Installed Capacity, KW**	**Generation, GWh**
Rural solar home systems	450	0.70 - 0.90
Urban solar home systems	20	0.05 - 0.06
Systems for schools	15	0.01 - 0.02
Systems for lighting health centres	6	0.01 - 0.01
Vaccine refrigeration	42	0.08 - 0.09
Solar water pumps	120	0.24 - 0.25
Telecommunication	100	0.10 - 0.20
Battery charging stations -	10	0.01 - 0.02
Grid connected systems	60	0.10 - 0.12
Solar streetlights	30	0.04 - 0.06
Total	**853**	**1.34 - 1.82**
Source: Energy Commission, Ghana		

2.3 Biomass Power Generation

Some large sawmills and oil palm mills (e.g. the Benso, Twifo, Kwae Oil Palm Mills) operate combined heat and power (CHP) plants based on biomass wastes to generate steam for their operations, and some amount of electricity to supplement their grid electricity supply, as indicated in Table 5.

2.4 Energy Demand Projections

The Strategic National Energy Plan, 2006-2020 estimates that, considering the economic targets that have been set under GPRS II, the demand for woodfuels would grow to 40 million tonnes by 2015, and 60 million tonnes by 2020. Total petroleum fuel demand is projected to rise to about 3 million tonnes by 2015, and could reach 4.5 million tonnes by 2020. Electricity consumption is considered under three economic scenarios of low, moderately high and high economic growth under GPRS II. The projections under two of these scenarios are presented in Table 6. Electricity consumption is expected to would also grow from 6,900 GWh in 2000 to 20,900 GWh by 2015, at moderately hgh economic growth, with Valco Limited in operation, and will reach about 25,800 GWh by 2020.

Table 5: Power Generation Plants using Biomass

Plant Location	Installed Capacity, kW	Average Annual Production,
Kwae Oil Mills	420	1.50
Benso Oil Mills	500	1.50
Twifo Oil Mills	610	1.50
Juaben Oil Mills		

Table 6: Projected Electricity Consumption, 2008-2020

Year	Electricity Consumption at "Business as Usual" or Low Economic Growth, GWh		Electricity Consumption at Moderately High Economic Growth, GWh	
	Without Valco	With Valco	Without Valco	With Valco
2008	7,666	10862-11540	9,618	13,000
2009	8,073	11675-12354	13,161	16,660
2010	8,502	11168-12846	13,848	17,484
2011	8,904	12626-13304	14,488	18,243
2012	9,325	13108-13786	14,600	18,500
2013	9,768	13615-14294	14,990	19,500
2014	10,233	14150-14828	15,676	20,200
2015	10,721	14730-15408	16,398	20,900
2016	11,234	15321-16000	17,155	21,660
2017	11,773	15944-16623	17,951	22,598
2018	12,340	16600-17280	18,787	23,613
2019	12,934	17291-17970	19,666	24,682
2020	13,560	18036-18714	20,590	25,815

Source: Energy Commission, 2006

3.0 Engineering — Driving Ghana's Energy Sector

Several technocrats have given various definitions of engineering. One concise version is that "Engineering is the science and art of applying scientific and mathematical principles, experience, judgment, and common sense to create, maintain, sustain, develop, and apply technology for the needs and desires of society". The engineers of Ghana constantly face this challenge in their quest to contribute towards the nation's economic growth.

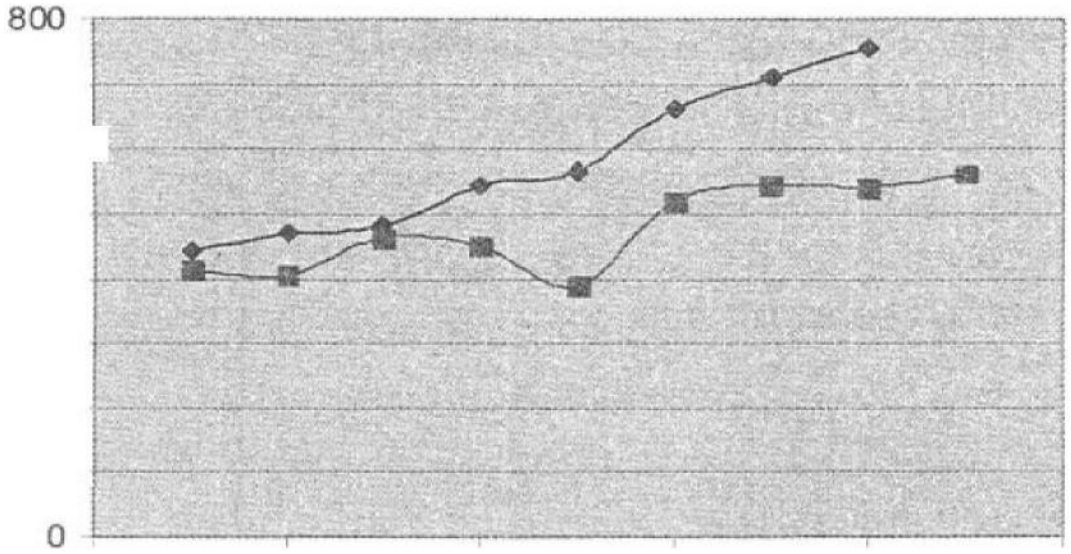
Engineering has contributed immensely to the provision of energy services for Ghana's economic growth. The energy sector is under the Ministry of Energy, and the key activities in energy generation and distribution in Ghana are based on engineering and driven by engineers. Repair and maintenance of energy supply systems are engineering activities and are driven by engineers. The key energy generation and distribution firms in the energy sector of Ghana are i) Volta River Authority; ii) Ghana Grid Company;

iii) Electricity Company of Ghana;
iv) Tema Oil Refinery;
iv) Tema Lube Oil; v) Bulk Oil Storage and Transportation;
vi) Ghana National Petroleum Company; and
vii) Oil marketing companies.

The regulatory institutions in the sector are the
i) Energy Commission;
ii) National Petroleum Authority; and
iii) Public Utility Regulatory Commission.

It is the engineers of the Volta River Authority, in close collaboration with other supporting staff, who diligently provide the professional services in electricity generation and transmission, overseeing the operation, repair and maintenance of a wide range of machinery and equipment, including turbines, generators, and transformers. Electricity transmission has now been taken over by the Ghana Grid Company.

The engineers of the Electricity Company of Ghana, working together with supporting staff, offer their professional services in the distribution of electricity to the agricultural, industrial, service sectors of Ghana. In order to have the capacity to provide these services in support of increased economic growth in Ghana, the Volta River Authority and Electricity Company of Ghana have been engaging more engineers over the years, as indicated in Figure 2.



Source: Volta River Authority (VRA) and Electricity Company of Ghana (ECG)

Figure 2:
Professional Engineers and Engineering Technicians in VRA and ECG

Engineers in a range of fields are also the key personnel involved in processing, storage and distribution at the Tema Oil Refinery Limited, Tema Lube Oil Limited, Bulk Oil Storage and Transport Limited, and the oil marketing companies. The development, installation, repair and maintenance of renewable energy systems are also undertaken by engineers. The work of the regulatory agencies - Energy Commission, National Petroleum Authority and Public Utility Regulatory Commission are also largely facilitated by engineers.

3.1 Engineering Challenges in the Expansion of the Energy Sector

The planned expansion of the energy sector of Ghana to keep pace with the economic growth involves four major activities that pose challenges to Ghanaian engineers and engineering firms: These activities are:

i) Expansion of the electricity generation, transmission and distribution facilities in 2008-2020;

ii) Transmission and distribution of natural gas from the West Africa Gas Pipeline;

iii) Design, installation, repair and maintenance of renewable energy systems (including biomass, solar and mini-hydro); and

iv) Promotion of energy efficiency and conservation.

3.2 Expansion of Electricity Generation, Transmission and Distribution

The 2008 Budget Statement clearly emphasizes the significance of energy in the nation's economic growth. Under a section with the title "Energy for Growth and

Brighter Future - Strengthening the Business Environment" it is stated that major medium and long term measures have been initiated in the energy sector which will be implemented in 2008. These measures include:

i) Operationalization of the Osagyefo Power Barge at Effasu;

ii) Execution of the Bui Hydro Electric Power Project, and

iii) Execution of (a) the Hemang and Awisam Hydro Electricity Power on the Pra River; (b) the Hydro Electric Power on Ankobra River; (c) the Tanoso Hydro Electric Power on the Tano River; and (d) the Juale Hydro River on Oti River.

There are also plans to provide electricity to 5 communities in each of the 166 Districts of the country. The Budget Statement indicates that the private sector through Public Private Partnership (PPP) will be invited to collaborate with Government to achieve these goals in the energy sector. As indicated in the Strategic National Energy Plan, 2006-2020 developed by the Energy Commission, the requirement of electricity generation is expected to reach 2,700 MW in 2012, and 3700 MW by 2020. To achieve this expansion in electricity generation three options have been highlighted in the Strategic National Energy Plan as follows:

Option 1: Thermal + renewable energy (10% of installed capacity)

Option 2: Thermal + Bui Hydro + renewable energy (10% of installed capacity)

Option 3: Thermal + Bui Hydro + nuclear energy+ renewable energy (10% of installed capacity)

Option 1 was based on electricity generation from existing hydro plants, expansion and addition of thermal plants, and renewable energy sources (constituting 10% of total generation), and did not consider generation from Bui hydro-electric project. Option 2 considered generation from all the sources in Option 1 plus generation from the Bui hydro dam, whilst Option 3 was based on the sources in Option 2 plus generation from nuclear plants. Option 2 is summarized in the Table 7.

The planned expansion of the electricity generation presents great opportunities to Ghanaian engineers. Indigenous engineering firms need to build capacity to compete favourably with international consulting firms to undertake development of specifications, installation, repair and maintenance of the various types of electricity generation, transmission and distribution systems. Our engineering firms must take advantage of the provisions of "National Competitive Tendering" and "Margin of Preference" for domestic consultants and contractors in the Public Procurement Act, 2003 (Act 663 Sections 44 and 60) in this endeavour.

3.3 Transmission and Distribution of Natural Gas

The West African Gas Pipeline Project (WAGPP) is expected to deliver the first free flow natural gas to Ghana by end of December 2007 and full pipeline

compressed gas by the middle of 2008. Major activities in this connection include the selection of a local gas distribution company, construction of a secondary gas network and the commissioning and operation of the secondary gas network.

Table 7: Electricity Generation Capacity Plan: Option 2*

POWER PLANTS	2005	2006	2007	2008	2009	2010	2011	2012
a. Akosombo Hydro	1.020	1,020	1,020	1.020	1.020	1,020	1.020	1.020
b. Kpong Hydro	160	160	160	160	160	160	160	160
c. Tapcooll	330	330	0	0	0	0	0	0
c. Tapco_gas		0	330	330	330	330	330	330
d. Tico_oll		220	0	0	0	0	0	0
d. Tico_gas		0	220	330	330	330	330	330
d. Tema diesel	30	0	0	0	0	0	0	0
d. Wind turbines				100	160	160	200	
d. Effasu Power gas Barge			125 125	125	125	125	125	
d. Tema 330 MW gas thermal			220	330	330	330		
h. 2nd Tema 330MW gas thermal					0	0		
I. Embedded Generation - gas turbine j. Bui Hydro at 200MW					200	200		
I. Biomass. solar, minihydro, etc m.Municipal solid wastes niandfill power								
Total	1,885	1,855	1,856 2,130	2,291	2,461	2,662 2,703		
VRA expected *Import*	*100*	Xry2~*0*'.*0*	*200* *0*	*0*	*0*	*0* ***0***		
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Option 2 : Thermal + Bui Hydro + 10% Renewables by instal ed capacity
Source: Strategic National Energy Plan, Energy Commission, 2004

The secondary gas network is expected to offer engineering opportunities that will

include the design, installation, repair and maintenance of pipelines, regulating and measuring equipment and power plants. Safety considerations present additional opportunities.

3.4 Renewable Energy Systems

The 2008 Budget Statement also states that the Ministry of Energy, in collaboration with other relevant Ministries and real estate developers will implement a solar programme to integrate solar fittings into new housing projects. The key areas of concern in respect of renewable energy include solar, wind, bio-fuel production and supply, and the promotion of renewable energy technologies and their efficient utilization. In this regard, the Commission is expected to fast track the passage of the Renewable Energy Law and enforcement of standards and codes for renewable energy technologies to ensure that renewable energy is integrated into the national energy mix.

Ghana has significant renewable energy resources in the form of direct solar radiation and biomass which could be developed to support national development. Ghana also has significant wind energy resource along the coastal line, particularly east of the meridian. The resources have been assessed over the past 20 years and reliable data is available particularly on the wind and solar energy resources. Some data is also available on the biomass resources for cogeneration. Indigenous engineers and engineering firms should participate fully in the development, installation, repair and maintenance of renewable energy systems The use of municipal waste in landfills for energy generation also presents engineering opportunities worth exploiting. The Volta River Authority, Electricity Company of Ghana and Independent Power Producers in the private sector are challenged to support the development of renewable energy systems and integrate them into their systems.

3.5 Promotion of Energy Efficiency and Conservation

Additionally, the Budget Statement mentions that the Energy Foundation will be re - sourced to continue assisting industries to improve their energy efficiency through energy audits, energy efficiency retrofits, and energy management training pro-grammes and workshops. The Ministry of Energy, in collaboration with its sector agencies, is also expected to establish an Energy Efficiency Enforcement Team to check illegal connections, protect energy sector physical assets and ensure adherence to Efficiency Standards. Indigenous engineering firms are encouraged to build capacity to participate fully in these programmes.

4. The Way Forward

The close connection between engineering and energy services needs to be effectively harnessed to support the nation's economic growth. This can be achieved through the pursuit of the following:

i) Capacity building in indigenous engineering firms;

ii) Facilitating innovation in the energy sector; and

iii) Regulation of engineering practice

4.1 Capacity Building in indigenous Engineering Firms

The nation requires technologically prepared engineering workforce to address the challenges posed by the planned expansion of the energy sector. Indigenous engineering firms should participate in the continuing education programmes of the Ghana Institution of Engineers, and other post-graduate training schemes to bring their engineering staff to be more aware of and better able to use new technologies in engineering practice, particularly those related to the energy sector. The benefits of such training to economic growth will be manifested in improved productivity of engineers, and increase in the speed at which the nation can adopt modern technologies to provide quality engineering services to the energy sector.

4.2 Facilitating Innovation in the Energy Sector

Many countries have experienced considerable socio-economic growth through the adoption of the knowledge-based economy which is derived from the existence of innovative engineers and scientists that mobilize a variety of factor inputs to create new products, processes and services. As Ghana aspires to upgrade its relative position in technological development to support economic growth, creating and

managing engineering innovation in the energy sector should become a key component of national policy. Research and development are indispensable inputs to innovation, and many studies have confirmed that when high investments are made in research and development, they result in considerable innovation and knowledge outputs to support national economic growth. Research institutions in the Council for Scientific and Industrial Research and the universities should be resourced by both the Government and the private sector to develop innovative technologies in renewable energy that can exploit indigenous resources to complement conventional energy supply systems.

4.3 Regulating Engineering Practice

Our nation cannot effectively engender and harness its engineering potentials to support the energy sector for economic growth without a clear-cut and enabled institutional and legal framework to regulate engineering practice in Ghana. It is therefore very important that an Engineering Council is established to regulate engineering practice in our country. Until this is done, unprofessional engineering practice will continue to put the lives of Our citizens and property at risk, with negative impact on the national developmental agenda.

The Engineering Act would restrict the creation, preparation, authorization, and provision of engineering products and services to only those registered under the

Act; and a person shall not operate an engineering firm unless that person is registered. it is expected the Act will help to improve engineering practice in the energy sector. We continue to urge the Government to expedite action on the enactment of a comprehensive Engineering Act to regulate engineering practice in our country.

5. Conclusions

As our nation endeavours to build an economy for a brighter and secure future, a strong foundation needs to be laid to propel the nation to the level of a middle income economy within the next decade. This will require higher productivity in all

sectors of the economy to increase the current growth rate from 6.4 % to at least 8 % and even higher within the next few years. Reliable and sustainable supply of energy is a critical input to this economic growth, and the engineers of Ghana are poised to provide the needed human resource to the energy sector to achieve this objective.

Engineers of Ghana are the drivers of Ghana's energy sector which keeps the "engine" of our nation's economy running at the accelerating speed we have been blessed with in recent years. This "3e Nexus in Ghana: Engineering, Energy and Economic Growth" should be sustained to maintain Ghana's development momentum, and engineers of Ghana pledge to champion this.