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Ministry of Education

NIHERST

TRINIDAD AND TOBAGO'S
ENERGY SERVICES SECTORAL INNOVATION MAPPING (SIM) STUDY

NIHERST
June 2019

TRINIDAD & TOBAGO'S **ENERGY SERVICES SECTORAL INNOVATION MAPPING (SIM) STUDY**

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Foreword

The National Institute of Higher Education, Research, Science and Technology (NIHERST) is privileged to have conducted this ground-breaking research in Sectoral Innovation Mapping (SIM) of the Energy Services Sector (ESS) in Trinidad and Tobago (T&T).

T&T is in the midst of a daunting period, characterised by depressed hydrocarbon commodity prices, low levels of production, sharp contractions in foreign exchange earnings and reduced government revenues. To avoid the consequences suffered in the 1980s and early 1990s, robust initiatives must be strategically introduced to position and strengthen the competitiveness of viable sectors of the national economy.

Closure of the Petrotrin Point-a-Pierre refinery in November 2018 ushered in a new sense of urgency to diversify the Energy Sector. This diversification should out of necessity focus on innovative practices that strengthen the export of energy services and the sale of innovations in energy-related products and processes that can be traded in markets at home and abroad.

The decision to support innovation in industry has garnered considerable interest by governments around the world. Innovation is widely considered as one of the most important drivers of competitiveness and sustained economic growth. Recalibrating T&T's economy to support innovation in the ESS requires mapping innovation in the sector and identifying the areas of weakness that hinder the optimal performance of energy services (ES) firms.

I commend the Policy, Research and Intelligence (PRI) Department of NIHERST for completing this timely and invaluable study. Specifically, I wish to thank Ms. Julie David, the Senior Policy Analyst, Mr. Richard Hector, Policy Analyst and Ms. Renée Francois Trumpet, former Research Assistant, for demonstrating a high level of commitment in completing the research and unearthing such rich information. On behalf of the Board of Governors, Executive Management and staff of NIHERST, it is my distinct pleasure to present the findings of this SIM study of Trinidad and Tobago's Energy Services Sector.

Sylvia Lalla
Acting President
NIHERST

Acknowledgements

The conduct of the Sectoral Innovation Mapping (SIM) of the Energy Services Sector (ESS) of Trinidad and Tobago would not have been possible without the support of the Ministry of Education (NIHERST's line Ministry) and the Public Sector Investment Programme (PSIP) administered by the Ministry of Planning and Development.

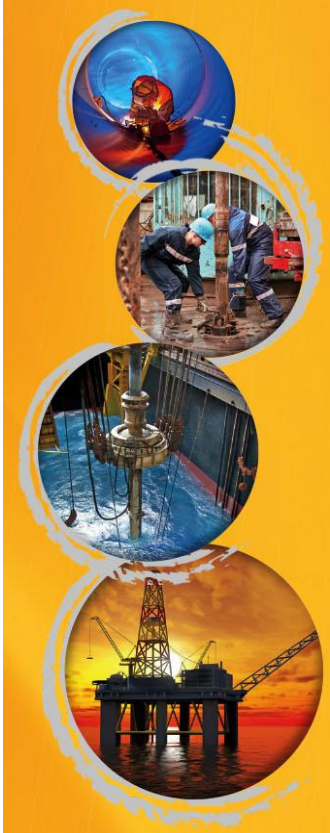
NIHERST is most grateful to the energy services sector stakeholders from industry, academia and government who supported this research and gave generously of their time as several corporate interviews extended well beyond office hours. Those persons shared valuable insights into the nature of innovation within T&T's most celebrated and competitive services sector. A list of firms, institutions and other stakeholders follows.

Sincere thanks to Anthony Paul, Chairman, Permanent Local Content Committee, Principal Consultant, Association of Caribbean Energy Specialists Limited; Anton Paul, Director, Hydrocarb Trinidad Limited; and Kevin Durham, CEO, ATOM Consultancy Limited, Chair of the Energy Institute (Caribbean) and Director at Wellbore Limited, for reviewing the manuscript and offering practical perspectives on the changing dynamics of the energy sector. These industry specialists supplemented the SIM research with relevant and current documentation.

Energy Services Firms Analytical Technologies Limited Anfield Services Limited Association of Caribbean Energy Specialists ATOM Consultancy Limited Capital Signal Company Limited Caribbean Industrial and Agricultural Chemical Service Limited Caribbean Inspection and Metallurgical Services Limited Caribbean Oceanic and Terrestrial Energy Equipment Limited Class One Systems Limited Coastal Dynamics Limited Consolidated Drilling Services Limited Delta Logistics Limited Hydrocarb Trinidad Limited Hydro Tech Limited IAL Engineering Services Limited In-Corr-Tech Limited Kennicon Engineering Limited The Kenson Group Krishna Persad and Associates L&S Surveying Services Limited Massy Energy, Production Resources Department Offshore Technology Solutions Limited Operational Support Services Company Limited Perfection Services Limited PetroCom Technologies Limited Trinidad Inspection Services Limited Trinidad Valve and Fitting Company Limited Tucker Energy Services Limited United Energy Petroleum Services Limited Wellbore Limited Well Services Petroleum Company Limited	**Upstream Operators** BG Trinidad and Tobago Limited (now Shell Trinidad and Tobago Limited) Petrotrin **Industry Associations** Energy Chamber of Trinidad and Tobago (formerly South Trinidad Chamber of Industry and Commerce) Trinidad and Tobago Local Content Chamber Trinidad and Tobago Coalition of Services Industries **Government** Ministry of Energy and Energy Industries Ministry of Trade and Industry **Supporting Institutions** exporTT EXIM Bank Royal Bank of Canada, Corporate Banking Oilfields Workers' Trade Union **Educational/Technical Training Institutions** UWI, Faculty of Engineering, Petroleum Geosciences/Chemical Engineering Department UTT, Petroleum Studies Unit NESC, Drilling Academy NESC, Welding Programme Missing from this list are several ES firms and independent researchers who have requested to remain anonymous.

Acronyms & Abbreviations

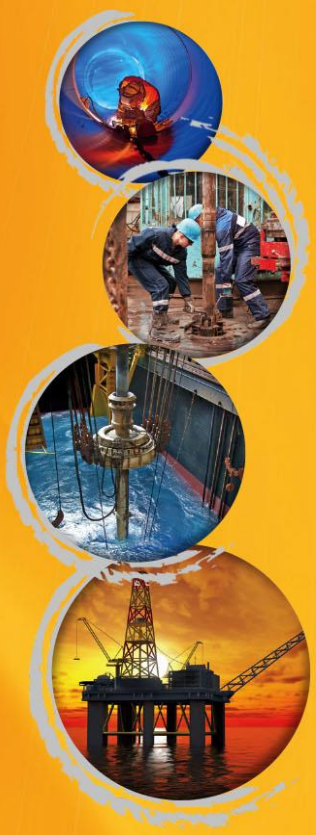
AAPGYPTT	American Association of Petroleum Geologists Young Professionals Trinidad and Tobago
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
ATL	Analytical Technologies Limited
AWS	American Welding Society
BATT	Banker's Association of Trinidad and Tobago
CAWI	Certified Associate Welding Inspector
CNC	Caribbean Nitrogen Company Limited
CSO	Central Statistical Office
CSR	Corporate Social Responsibility
ECTT	Energy Chamber of Trinidad and Tobago
EICDI	Energy Industry Competency Development Initiative
EI (C'bbean)	Energy Institute Caribbean Branch
EI UK	Energy Institute UK
EMA	Environmental Management Authority
EOR	Enhanced Oil Recovery
E&P	Exploration and Production
ES	Energy Services
ESS	Energy Services Sector
GATS	General Agreement on Trade in Services
GE	General Electric
GoRTT	Government of the Republic of Trinidad and Tobago
GSTT	The Geological Society of Trinidad and Tobago
HOS	Heads of States
HR	Human Resources
HSE	Health, Safety and Environment
HSSE	Health, Safety, Security and Environment
IADC	International Association of Drilling Contractors
IET	Institution of Engineering and Technology
IFC	International Finance Corporation
IS	Innovation Systems
IP	Intellectual Property
IPR	Intellectual Property Rights
ISO	International Organization for Standardization
LC	Local Content
TTLCC	Trinidad and Tobago Local Content Committee
M&E	Monitoring and Evaluation
MEEI	Ministry of Energy and Energy Industries



MNS	Ministry of National Security
MOA	Memorandum of Agreement
MOE	Ministry of Education
MOU	Memorandum of Understanding
MTI	Ministry of Trade & Industry
NDT	Non-destructive testing
NESC	National Energy Skills Centre
NETD	National Engineering Technician Diploma
NGC	The National Gas Company of Trinidad and Tobago
NIHERST	National Institute of Higher Education, Research, Science and Technology
NTA	National Training Agency
OEM	Original Equipment Manufacturers
OWTU	Oilfields Workers' Trade Union
OTC	Offshore Technology Conference
OTSL	Offshore Technology Solution Limited
PATW	Present Around The World (PATW) Competition
PLAR	Prior Learning Assessment and Recognition programme
PLIAP	Point Lisas Industrial Apprenticeship Programme
PRI	Policy Research and Intelligence Department
PSC	Production Sharing Contracts
PSL	Perfection Services Limited
RBC	Royal Bank of Canada
RBL	Republic Bank Limited
R&D	Research and Development
RDF	Research and Development Facility
RDI	Research, Development and Innovation
ROV	Remotely Operated Vehicle
SIM	Sectoral Innovation Mapping
SME	Small and medium-sized enterprise
STCIC	South Trinidad Chamber of Industry and Commerce
SPETT	Society of Petroleum Engineers of Trinidad and Tobago
STOW	Safe To Work
T&T	Trinidad and Tobago
TTEITI	T&T Extractive Industries Transparency Initiative
UN	United Nations
US	United States
UWI	University of the West Indies
UTT	University of Trinidad and Tobago
WTI	West Texas Intermediate

WTO	World Trade Organization

Executive Summary



The present state of the economy in T&T is a clarion call to the citizens of Trinidad and Tobago and to the players in the Energy Services Sector to support and grow what is best – the export of energy services. Locally grown energy services firms have been servicing the upstream and downstream energy sub-sectors for many years and in so doing, have developed knowledge, skills and competencies that equal and in some cases, surpass others in the global energy sector. Truth be told, in an economy as open and unprotected as T&T's economy, the competition is stiff. However, our locally grown energy services firms are resilient. Utilizing various business models and in some cases, successfully integrating into internationally reputed energy services firms, they have survived and are determined to remain open for business, operating both at home and abroad.

The conduct of the SIM study on the locally grown ESS is timely and relevant. The SIM unveils the actors, their interactions and the activities that initiate, import, modify and diffuse new technologies. The concept of the innovation system rests on the premise that an understanding of the linkages among the actors involved in innovation is key to improving the uptake of new and improved technologies to enhance performance. There are two (2) versions of innovation systems (ISs): - the narrow version focuses on extended R&D systems[1] whereas the broad version of IS focuses on extended production systems with linkages to the education system.[2] This SIM study applies the broad version.

Equally important are the framework conditions that co-exist. Examples include transparency, trust, good governance, the propensity to innovate and others that lend to a smoother performance of the industry. The absence or existence of these intangible conditions, though often perceived as trivial significantly influence the behaviours of the actors and by extension the industry.

Specifically, the findings reveal that there are two (2) types of innovations dominating the local energy landscape. These are product and process innovations. To a lesser degree, some firms have employed organisational innovations. Notwithstanding, the adoption of a new piece of equipment or technology necessitates the introduction of a new or improved production process. Both product and process innovations appear sometimes to be inextricably linked.

[1] Nelson, R. 1993. National Innovation Systems: A Comparative Study. Oxford University Press.

[2] Lundvall, Bengt-Ake. 2016. The Learning Economy and the Economics of Hope: page 86.

Locally grown energy services firms innovate for a number of reasons: either to reduce operational costs, improve the efficiency of performance, address a problem encountered by operators, or minimise the negative impact exploration and production have on the environment. This research highlights the drivers and impediments to innovation as well as, other factors obstructing the progress of the ESS.

The SIM identifies initiatives undertaken to build capacity in the sector and analyses the intensity of the interactions between actors. Criteria used to assess the linkages vary depending on the desired output from the interaction between actors.

This study has unearthed many findings. The results add to the national research resource pool which inform and support evidence-based decision-making. Equally important and following recent undertakings in the local energy landscape, it is anticipated that the SIM will inform government's efforts in diversifying the energy sector towards the exportation of energy services and energy-related innovations in products and processes.

1. INTRODUCTION

Trinidad and Tobago has a long-standing history in the oil and gas industry. The experience and expertise garnered since commercial oil production commenced 111 years ago have contributed to local personnel and services firms developing a solid reputation internationally. Notwithstanding the prolonged downturn in global hydrocarbon prices[3] as well as local production, opportunities exist for the advancement of the local energy services sector (ESS)[4] through the export of local energy services and the sale of new and improved home-grown energy-related products and processes. In essence, diversifying the energy sector is a viable and sustainable pathway for generating new reserves of foreign exchange and employment.

The Energy Services SIM study is divided into seven (7) sections with relevant appendices, figures and tables. Throughout the sections, mention is made of the different business models adopted by local ES firms. **Section 1** introduces the background, rationale for conducting the SIM research, objectives and the methodology used. **Section 2** describes the innovation systems theory and identifies the actors and the intensity of the linkages that exists between them. Within all innovation systems there are framework conditions and these are depicted in an innovation mapping diagram. **Section 3** features some of the innovations emerging from the local ESS and the drivers of innovation therein. **Section 4** reviews the impediments to innovation in the ESS. **Section 5** identifies other factors obstructing progress in the ESS. **Section 6** discusses the role of government in supporting the ESS. **Section 7** concludes the study.

[3] According to the Central Bank of Trinidad and Tobago's (CBTT) *Prices Monthly Table* reflecting WTI Crude Oil Prices and the Henry Hub Natural Gas Prices from 1991-present, the price of oil recorded in June 2014 was USD$105.2 per bbl. This price started to collapse, steeply falling to USD$30.4 in Feb 2016, and recovered slightly, recording USD$55 in Feb 2018, still below the price to which the national budget (2019) was aligned. The *Prices Monthly Table* also indicates that gas prices contracted sharply from USD$6/mmbtu in Feb 2014 to its lowest value recorded at USD$1.7/mmbtu in March 2016. Additionally, the average price of natural gas recorded in Feb 2019 (USD$2.7mmbtu), was slightly below the figure on which the national budget was predicated.

[4] The Energy Services Sector (ESS) refers to all the technical services procured by the upstream and downstream segments of the energy sector that require oil and gas sector-specific knowledge, skills and competencies (STCIC. Policy for the Development of the Energy Services Sector 2007). The local ESS can be divided into two categories of firms: contractors and local ES firms. Note that a contractor can procure the services of local ES firms for the delivery of services to upstream operators as well as render services themselves to the upstream operators. This does not hold for local ES firms that do not perform as contractors in the industry.

1.1 Background

Several countries have and continue to benefit from the experience and expertise of nationals and local energy services firms. For the upstream segment of the energy industry, **T&T's professional, technical and skilled workers are highly respected and reputed[5] for their knowledge and the supply of services rendered in geological works, directional drilling[6], well logging[7], completion[8], cementing[9], mud engineering[10], platform fabrication, platform and pipeline maintenance, inspection, logistics, and the design and conduct of practical skills training programmes.** Essentially, Trinidad and Tobago's energy services personnel have sold themselves as talented people all over the world. This small twin-island republic has produced some of the world's top drillers, petroleum and reservoir engineers, geologists, and technical trainers, many of whom occupy senior positions in major oil and gas companies. These facts are not surprising. Local services personnel began their careers at home working under very difficult conditions caused by the complex geology of local oil reservoirs.

To date, the demand for energy services stretches from South to North America, moving across to the western arm of Africa, into Europe and the Middle East. Local experts continue to demonstrate comparative levels of experience and expertise to their foreign counterparts providing advisory and operational services to overseas territories developing their oil and gas industries. Ghana, Nigeria, the Falkland Islands, and closer to home Suriname and Guyana, are beneficiaries of advice given on various approaches that can be adopted when negotiating with upstream and downstream operators, on the establishment of regulatory systems for the sector. Additionally, advice is also sought on how to stimulate local content, on the type of educational and skills training programmes needed to build the national workforce and on measures to improve health and safety standards critical for successful operations of all energy services firms.

Equally prevalent, although less publicised is the experience of T&T's energy services personnel in the development of the downstream segment of the industry. Locals have shared their expertise

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[5]Owing to the talent, knowledge and skills of locals, poaching of local energy service personnel, especially in engineering and construction services by foreign operators is endemic throughout the industry. Evidence of this practice is ongoing and can be traced back to the 1970s when AMOCO took many of the engineering and construction services personnel to outfit US energy services firms.

[6] Directional drilling is defined as the practice of controlling the direction and deviation of a wellbore to a predetermined underground target or location (www.petrowiki.org) as cited on December 12, 2018.

[7] Well Logging is the practice of creating a detailed record (known as a well log) of the geological formation during the drilling of a borehole (www.petropedia.com) as cited on December 12, 2018.

[8] Completion is the process of making a well ready to produce natural gas or oil. Completion involves installing permanent equipment, such as a wellhead, and often includes hydraulic fracturing (www.millenniumpetrocapital.com) as cited on December 14, 2018.

[9]Cementing is used to hold casing in place and to prevent fluid migration between subsurface formations (www.petrowiki.orgwwww.petrowiki.org) as cited on December 14, 2018.

[10] Mud engineering refers to the process of testing and preparing the mud at a rig (by adding various materials at the surface to change or modify its characteristics. The weight, properties and chemistry of mud must be maintained within recommended limits to suit reservoir conditions (www.glossary.oilfield.slb.com) as cited on April 2, 2019.

in the areas of plant and project management, engineering services, mechanical services, inspection and testing services, laboratory services, access services, and preventative and periodic maintenance services for downstream gas and petrochemical industries.

Currently, industry stakeholders estimate that there are approximately four hundred to five hundred (400 to 500) firms operating in the local ESS. This figure includes international energy services companies that have acquired official registration to operate in local territory. Three hundred to four hundred (300-400)[11] of these firms are also members of the Energy Chamber of Trinidad and Tobago (ECTT). Membership of the ECTT is comprised of mostly small to medium sized firms, many of which are owned and operated by T&T nationals. A few large local firms are also members each employing more than fifty-one (51) employees at any given time. Interestingly, many of these firms regardless of size, are family-owned establishments that have survived the boom and busts cycles of the industry for more than half a century.

Local small-scale firms generally do not have the physical, human nor financial resources to engage in R&D; however, owing at times to market pull factors, a handful have ventured down this pathway, conducted R&D and successfully developed innovative products and processes. (***See Section 3: Tables 1-4*** for a selected list of local innovations emerging from the ESS). In hindsight, the experiences of some of these innovative firms suggest that support is needed in the areas of intellectual property (IP) acquisition, market analysis, strategic management, negotiation, and knowledge management, as well as some measure of assistance for the commercialisation and facilitation of trade of local innovations in foreign markets. Support is also required to sensitise non-traditional consumers to innovations applicable across economic sectors.

The research shows that most local ES firms are lean in their operations with business owners in most of the small-scale firms *wearing many hats.* Succession planning, perhaps more aptly described as the transference of tacit knowledge, is frequent among family members working in local ES firms. Historically, ES firms demonstrated the ability to innovate when the price of oil plummeted (periods of busts). The 1980s best depicts this scenario. In April 1986, as the price of oil plunged to WTI USD9.75 per barrel, the costs base for international services companies increased while profits decreased. For foreign services firms, the economics dictated cessation of operations. Under these circumstances, it was the local energy services firms which worked in tandem with independent local upstream operators to innovate efficient ways to pump the oil out of the ground. Mr. Anthony Paul, an expert in the energy industry explained, "Innovation in the ES does not only take the form of new products, but also improving the way one operates and doing things one did before, more efficiently." Interestingly, many locally owned ES firms were established during this period between 1986-1999 when the price of oil collapsed and remained low. At that time, business growth for many of the small-scale firms was organic, expanding as the output and customer base increased. Local ES firms' greatest export back then and now was

[11] The Energy Chamber of Trinidad and Tobago. **2017-2018 Annual Report**: page 28.

and still is their intellectual capital. Albeit, the small size of firms suggests that their capacity to deliver is limited.

Presently, a window of opportunity for further growth has opened for T&T's ES firms. Recent oil finds in the neighbouring Caribbean state of Guyana amounting to more than five (5) billion barrels of oil denotes changing fortunes for energy services providers. The magnitude of these oil discoveries has generated massive interests in the conduct of further exploration in other Caribbean countries such as Grenada, Barbados and Jamaica. If negotiated properly with neighbouring Caribbean states, Trinidad and Tobago's economy stands to benefit from generating significant revenue and job opportunities for local ES firms. With a more coordinated and structured export-oriented model, this window of opportunity can pave a sustainable path for the survival of the local energy sector.

1.2 Rationale for Mapping the Innovation System of the ESS

The conduct of the ES SIM is both timely and relevant. In the current environment, the time is ripe to diversify the local energy sector. The focus ought to be on increasing both the export of local energy services and innovations emerging from this sub-sector. To accomplish this, one must understand the requisite support needed to stimulate innovation in the local ESS. Innovation is a *sine qua non* for the success and survival of local energy services firms. In 2018, the ESS witnessed negligible growth (4%) after contracting sharply by approximately 32% and 16% in 2016 and 2017 respectively[12]. The market continues to be characterised by relatively low hydrocarbon commodity prices, "the unabated decline in local reserves and production,"[13] and a more competitive global energy market due to the advent of shale gas and increased production from emerging oil and gas producers in developing countries[14]. To maintain the viability of local ES firms, it is critical to map the innovation system of the ESS. This innovation mapping study will determine the areas where support is most needed, identify the drivers and impediments to innovation, offer recommendations which when implemented will result in increased efficiency in service delivery of local ES firms and an increased inclination to develop innovative products and processes.

[12]Ministry of Finance. **Review of the Economy 2018**: ***"Turnaround."*** GoRTT, 2018.
[13]The Honourable Nicole Olivierre, Minister of Energy and Energy Industries. Address to the Energy Chamber's 2015 Annual General Meeting. Hyatt Regency, Port of Spain, Trinidad.
[14]The Honourable Colm Imbert, Minister of Energy and Energy Industries. Address to the Trinidad and Tobago Energy Conference and Trade Show 2017. Hyatt Regency, Port of Spain, Trinidad.

1.3 Objectives

The objectives of the ESS SIM study are:

- To identify the drivers of innovation;
- To assess the linkages that exist between/among actors;
- To detect the factors impeding innovation within locally-owned ES firms;
- To build capacity in the sub-sector to utilise and adopt specialised technologies; and
- To determine effective and feasible interventions that stimulate policy actions and support for innovation in the enabling environment.

1.4 Methodology

This SIM study comprised four (4) sequential phases: a) Preliminary Research, b) Primary Research, c) Analysis, and d) Publication and Communication of Findings.

a) The Preliminary Research phase entailed a review of the existing literature on innovation systems, background research on the history and role of ES firms in the upstream and downstream segments of the local energy sector, initiatives undertaken by the ECTT and other key stakeholders, the compilation of a stakeholder database and the presentation of the preliminary findings to the Executive Management of NIHERST.

b) The Primary Research phase included the design of questionnaires to elicit responses on innovation, and the scheduling, conduct and transcription of semi-structured interviews. Several documents informed the content of questions including the **OSLO Manual 2005 and the Bogota Manual 2001**. These publications in varying degrees, provided information on defining and measuring innovation in sectors of the economy.

   To garner primary data, a total of sixty-two (62) interviews were conducted with approximately eighty (80) persons. Of this total, forty-two (42) interviews were conducted with locally owned ES firms, the majority of which delivered upstream energy services. (***See Acknowledgments*** for a list of firms and institutions interviewed).

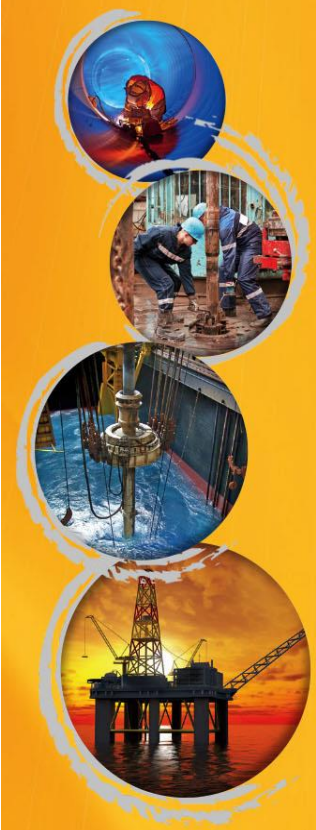
c) The Analysis phase focused on verification and assessment of data for inclusion in the Stakeholder Feedback Report and subsequently, the SIM Report. During this phase, the intensity of the linkages between key actors in the innovation system of the ESS was analysed and rated as either being strong, moderate or weak.

To determine the intensity of the linkages, factors influencing the productive intent and the degree of interface between actors were identified and each factor assigned a weight based on the level of importance in influencing the desired relationship. The scores/ratings were evaluated based on the researchers' understanding and definition of what constitutes a strong linkage between actors and industry stakeholders' perception of the ongoing interactions between actors. A percentage was calculated using the score given against the weight assigned for each linkage. The percentage of ratings is as follows:

- 70% - 100% constitutes a strong linkage
- 50% - 69% constitutes a moderate linkage
- Less than 50% constitutes a weak linkage

d) The Publication and Communication of Findings phase focused on a presentation of the Findings of the Energy Services SIM study to two (2) target audiences: first, to members of the NIHERST Executive Management Team; and second, to a wider audience comprising senior officials of the Ministry of Education, Ministry of Energy and Energy Industries, Ministry of Planning and Development, Ministry of Trade and Industry and other public and internations institutions, the Delegation of the European Union to Trinidad and Tobago, the Inter-American Development Bank (IDB), the United Nations Development Programme (UNDP), the University of the West Indies (UWI), University of Trinidad and Tobago (UTT), National Training Agency (NTA), Petrotrin (which subsequently became defunct), the ECTT, and energy services firms.

2. Sectoral Innovation System of the ESS



The Theory of Innovation Systems

The theory of Innovation Systems states that the flow of technology and information among people, enterprise and institutions is key to the innovation process.[15] This broad approach suggests that innovation takes place within complex, dynamic systems. It considers not only the realm of innovating for production but also encompasses the market elements facilitating trade in goods and services. An analysis of an industry's innovation system identifies the economic actors, as well as, the type and intensity of the interactions that exist between them. The success of the innovation system depends on the closeness of the interactions between these actors. A strong interaction or linkage constitutes a steady flow of technology and information. Further, a linkage is seen as a continuous relationship between actors with a specific productive intent. Also integral to the analysis, is a series of framework conditions which influence the behaviour and degree of interface among actors. The existence of these framework conditions though often overlooked in importance, impacts the effectiveness of the wider innovation system.

2.1 Actors and Linkages

Figure 1 maps the Innovation System (IS) of Trinidad and Tobago's Energy Services Sector (ESS). The Framework Conditions that currently exist are operating standards, political stability, visionary foresight and amicable industrial relationships. Equally important, and in short supply are trust, governance and transparency.

At a glance, the system comprises a network of five (5) categories of actors. These are Industry, the Bridging Institute, Educational/Technical Training Institutions, the Political System and Supporting Infrastructure. A description of each category follows.

- **Industry** comprises a) locally owned energy services firms and contractors, b) international energy services firms and c) the upstream and downstream operators who employ the services of ES firms. Upstream Operators include the five (5) major multinational exploration and production companies operating in T&T: BPTT

[15] Malerba, F., 1993. Italy. In: Nelson, R (ed.), National Innovation Systems. Oxford University Press,

(formerly AMOCO), Shell Trinidad Limited, BHP, EOG Resources and Perenco. Heritage Petroleum Limited incorporated in 2018 is the state-owned company

- focused on exploration, development, production, and marketing of crude oil. Independent operators include DeNovo, Range Resources and Touchstone Production, to mention a few. The National Gas Company of Trinidad and Tobago (NGC) operates in the midstream of the natural gas value chain. Downstream operators are those companies involved in the conversion of crude oil and natural gas into finished products. Such firms include Atlantic LNG, PCS Nitrogen, Methanol Holdings Limited, Methanex, Caribbean Nitrogen Company Limited (CNC), Nitrogen (2000) Unlimited, Yara Trinidad, and Phoenix Park Gas Processors Limited.

- **The Bridging Institute** is the actor charged with the responsibility of lobbying on behalf of industry stakeholders. This actor most importantly acts as a binding tie bringing actors together, thereby initiating new relationships. The research shows that currently the ECTT functions as the bridging institute for the sector.

- **Educational/Technical Training Institutions** consist of: a) local universities such as UWI and UTT that offer tertiary level programmes in petroleum geoscience, petroleum engineering, chemical engineering and other categories of engineering; b) public and privately operated technical training institutions providing post-secondary programmes in welding, fabrication, inspection, production, operations and maintenance to the energy industry, for example the National Energy Skills Centre (NESC), MIC Institute of Technology and Kenson School of Production Technology; and c) Professional Associations such as the Energy Institute Caribbean Branch[16], Geological Society of Trinidad and Tobago, the Society of Petroleum Engineers Trinidad and Tobago Section, and the American Association of Petroleum Geologists Young Professionals Trinidad and Tobago Chapter.

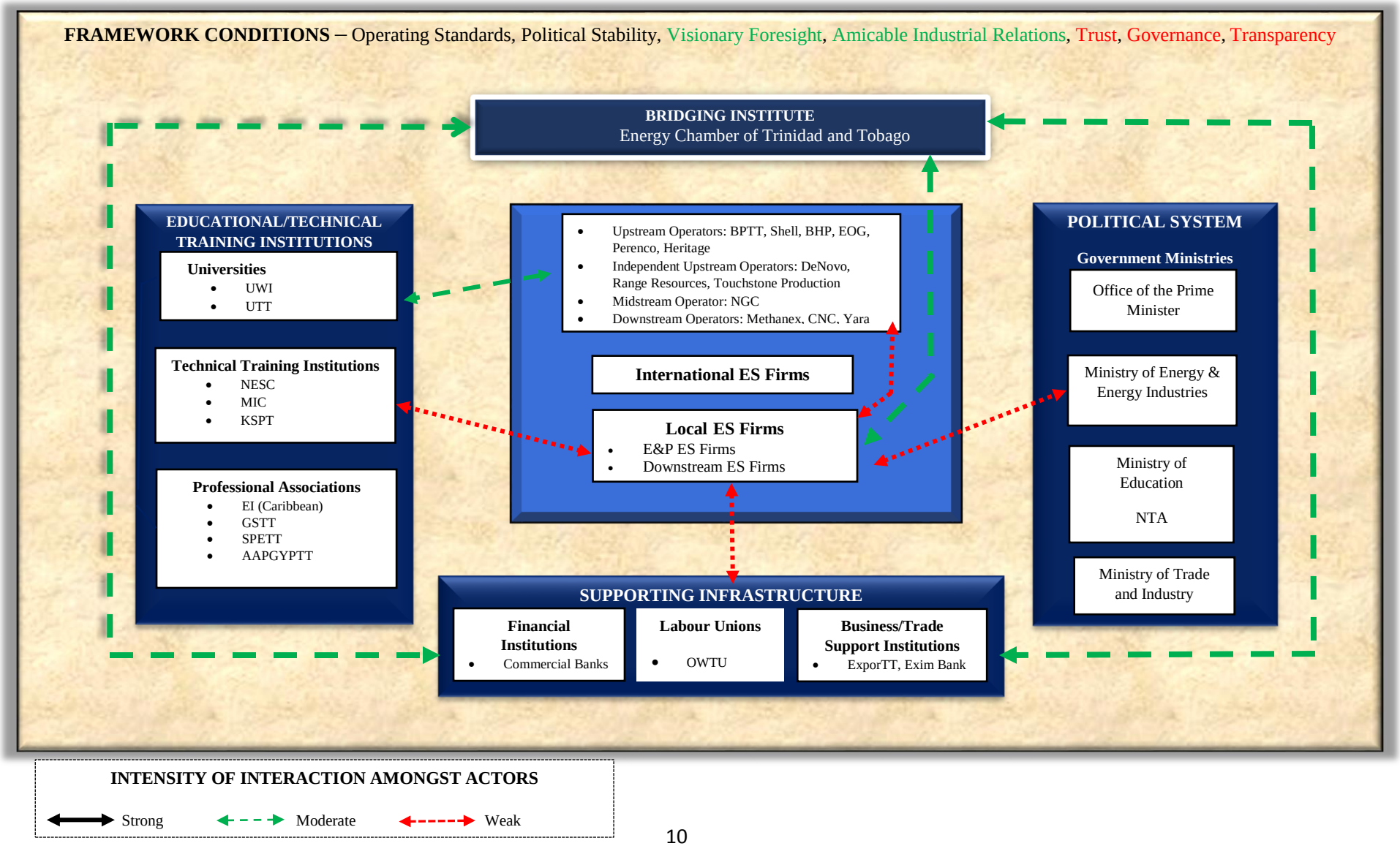
- **The Political System** encompasses the Office of the Prime Minster and Ministries and other public sector institutions mandated to provide support to all segments of the energy industry. These are the Ministry of Energy and Energy Industries (MEEI), Ministry of Trade and Industry (MTI) and the National Training Agency (NTA) which falls under the purview of the Ministry of Education. The MTI is responsible for designing a trade negotiation strategy for T&T's energy services sector. The NTA is responsible for

[16] The Petroleum Engineering Departments of UWI and UTT are elected Learning Affiliates with the Energy Institute UK (EI UK). Their Petroleum based Master's level programmes are accredited as meeting the academic requirement for Chartered Engineer's status. The respective international Accords, namely the Washington, Sydney and Dublin Accords provide global recognition of these professional titles protected by law. The EI UK is licenced by the Engineering Council UK to grant Chartered Engineer, Incorporated Engineer and Engineering Technician status to individuals who meet the stringent academic and professional work-related experience.

coordinating and regulating Tech-voc programmes and conducting surveys identifying the skills gaps in priority sectors of the economy. The NTA has also worked with the ECTT and other industry stakeholders to introduce the Prior Learning Assessment and Recognition (PLAR) Programme.

- **Supporting Infrastructure** constitutes financial institutions, labour unions, public sector business and trade support institutions inclusive of exporTT and EXIM Bank and private sector institutions that support ES firms in their bid to engage in business activity within the energy industry.

Figure 1: Innovation Mapping Diagram of the Energy Services Sector (ESS)



INTENSITY OF INTERACTION AMONGST ACTORS

Strong — Moderate — Weak

2.1.1 Moderate Linkages

A moderate linkage suggests that there is room to strengthen the relationship between these actors.

Upon analysis, moderate linkages exist between two (2) categories of actors: local ES firms and the ECTT; and upstream/downstream operators and educational/technical training institutions.

Linkage between Local ES Firms and the ECTT

The following four (4) factors were used to assess the intensity of this linkage (***See Appendix II: Table 5***):

- The development and roll out of supporting initiatives on an ongoing basis to enhance the competitiveness of local ES firms;
- The deployment of mechanisms to sensitise local ES firms to:
  - Opportunities (local and foreign);
  - Issues impeding the sector's advancement;
  - Business support services available within the enabling environment.
- Lobbying upstream and downstream operators to increase procurement of local energy services in the domestic market.
- The level of participation of local ES firms at events hosted by the ECTT.

Findings revealed that the ECTT (the Chamber) heavily emphasises capacity development, export facilitation of energy services and to a lesser extent lobbying for local content. Among its many programmes, the ECTT in 2004 introduced the STOW[17] a Health, Safety and Environmental (HSE) standard for local ES firms and became the administrator for this type of HSE certification. This organisation also supports the upgrading of skills for the sector as demonstrated by several successful programmes namely, the Energy Industry Competency Development Initiative (EICDI), several course offerings and workshops at the ECTT's Learning Centre, and the PLAR process, all of which ensures that the industry's labour force obtains the relevant skills certification. The ECTT also renders support to its members, keeping them abreast of new exploration and production (E&P) projects.

Going beyond national borders, the ECTT has facilitated the export of local energy services to foreign markets. In the recent past, in collaboration with government agencies, the ECTT organised several events inclusive of trade missions to countries such as Guyana, USA, Suriname,

[17] The Safe to Work (STOW) programme has been credited with improving the level of safety in the local industry, reducing the costs associated with complying with differing HSE requirements for operators and allowing more local ES firms to prequalify for business opportunities within the sector. It integrated the best elements of the major upstream, midstream and downstream operators' internal safety programmes. In spite of the fact that the STOW is not internationally recognised, STOW certified companies seeking to export services are better placed to comply with international HSE standards (stowtt.info/index.php?categoryid=13) as cited on April 22, 2019.

Ghana and Brazil. Business to business (B2B) transactions were facilitated for local firms following a reverse mission from Ghana. Notwithstanding, other mechanisms such as hosting of annual conferences has provided additional opportunities for networking, simultaneously raising awareness of issues impeding the advancement of the energy sector. The ECTT has also conducted sensitization workshops on some export markets, informing of different cultural and adaptive traditions. In addition to facilitating the export of energy services, the Chamber has made significant strides in lobbying government for business support services e.g. co-financing support services, which were designed initially to subsidise costs for non-energy firms.

Historically, there is a *perception* emanating from local ES firms that the Energy Chamber's support for local content development is weak. This perception is underscored by local ES firms' statements that the ECTT ought to play a greater role in lobbying for and broaching discussions on local content to increase the procurement of local energy services in the domestic market. Habitually, it has been the practice of foreign firms to access "international suppliers of inputs and services with whom they are familiar rather than [create] excessive domestic linkages. This import intensity of foreign owned services firms can many times lead to balance of payments problems for the host nation."[18] To curtail this practice, local ES firms have emphasised a role for the ECTT in lobbying both government and multinational operators to adhere to local content stipulations outlined in production sharing contracts (PSCs). From 2015 to present, the Chamber continues to host annually the Local Content Forum, and in 2017, commenced an Upstream Supply Chain Forum. At the latter event, operators identified work opportunities for local ES firms based on operators' future plans for oilfield development.

Historically, there is a *perception* emanating from local ES firms that the Energy Chamber's support for local content development is weak.

Certainly, one of the factors which proved difficult to assess was the level of participation of local ES firms at events hosted by the ECTT. Past photos and reviews tend to suggest that the complement of patrons attending these events were satisfactory.

Linkage between Upstream Operators and Educational/Technical Training Institutions

Three (3) factors were used to assess the intensity of the linkage between Upstream Operators and Educational/Technical Training Institutions (***See Appendix II: Table 6***).

- The design and implementation of relevant courses/programmes at educational/technical training institutions to equip students with the requisite skill sets and industry certification;

[18] Mytelka, Lynn K. & Barclay Lou Anne A. (2003). "*Using Foreign Investment Strategically for Innovation"* in European Journal of Development Research, Vol.16 2004, Issue 3: pp 531-560.

- The type and frequency of collaboration between upstream operators and educational/technical training institutions; and
- The conduct and transference of relevant academic research (consideration given to faculty and students' research) to upstream operators.

Several local personnel in the upstream sector were of the view that a strong linkage exists between multinational operators and universities. However, the data revealed a moderate linkage. The relationship was weakened by the weak transference of research findings from academia to industry. It is interesting to note that there is legislation supporting this close collaboration between these actors as evidenced by the Trinidad and Tobago's Petroleum Act No. 46 of 1969, amended by Act No. 4 of 2014. Section 42 (2) (g) of the Act, requires operators to "prepare, in consultation with the Minister, programmes for industrial and technical education and training, including the grant of scholarships, and carry such programmes out diligently with a view to training nationals of Trinidad and Tobago to replace foreign personnel as soon as reasonably practicable …."[19]

Industry Advisory Boards at universities also play a critical role in supporting this linkage as members drawn from industry are tasked with examining educational ideas and policies to ensure that programmes offered are aligned to the needs of industry. These actions promote greater industry/academia collaboration and support for R&D relevant to the upstream energy sector. Members of industry advisory boards are usually handpicked from the list of multinational operators in industry and from government owned institutions. These stakeholders have in great part contributed to and sanctioned UWI and UTT's petroleum sector-related programmes in petroleum geoscience and petroleum engineering.

Universities have also entered into partnerships with upstream operators for assistance in providing student scholarships, accessing sponsorship for research studies and research material (e.g. soil, oil samples and production data). Generally, collaboration in research between operators and universities has been couched under the banner of corporate social responsibility (CSR). Nonetheless, primary research from this SIM study revealed, that the Department of Chemical Engineering, UWI, was engaged in micropaleontology research, commissioned by upstream operators for use in oil and gas exploration.

2.1.2 Weak Linkages

A weak linkage indicates that the key ingredients to foster successful relationships are either weak or absent. More effort is required to strengthen the relationship between these actors.

[19] The Petroleum Act, No. 46 of 1969, Amended by Act No. 4 of 2014.

As seen in ***Figure 1***, weak linkages characterise the interactions between local ES firms and four (4) categories of actors: educational/technical training institutions, upstream/downstream operators, the Ministry of Energy and Energy Industries (MEEI) and support institutions.

Linkage between Local ES Firms and Educational/Technical Training Institutions

The following three (3) factors were used to assess the intensity of the linkage for local ES firms and Educational/Technical Training Institutions (***See Appendix II: Table 7***).

- The design and implementation of relevant courses/programmes at specific educational/technical training institutions to equip students with the requisite skill sets and industry certification;
- The type and frequency of collaboration between local ES firms and educational/technical training institutions; and
- The conduct and transference of relevant research work from academia (consideration given to the research work of students and faculty) to the ESS

T&T's energy sector is in no short supply of qualified, well-trained and skilled industry personnel who are held in high esteem and whose expertise is sought after by international energy companies operating both at home and abroad. Be that as it may, the intensity of the linkage between learning institutions identified in ***Figure 1*** and local ES firms was found to be weak.

Most graduates of UWI's and UTT's Petroleum Engineering Programmes have not demonstrated an ability to make a smooth transition from academia to industry.

The research reveals several gaps in the educational/technical training system. Most graduates of UWI's and UTT's Petroleum Engineering Programmes have not demonstrated an ability to make a smooth transition from academia to industry. Oftentimes, new recruits required at least twelve (12) months of experiential learning to understand their responsibilities. However, students graduating with a Bachelor of Science and/or Master's Degree in Engineering, in addition to completing a National Engineering Technical Diploma (NETD) from UTT, as well as graduates of Technical Vocational Institutions such as NESC, MIC and Kenson School of Production Technology, were better outfitted for the job market. Arguably, though entering industry at different levels, tech-voc graduates

… tech-voc graduates performed the best in the petroleum field operations environment and in the practical application of skills to industry.

performed the best in the petroleum field operations environment and in the practical application of skills to industry.

The NESC Drilling Academy designed and delivered experiential learning programmes conducting simulations on a functional rig and related drilling equipment. This was intended to develop students' ability to apply foundational knowledge and use critical thinking and problem-solving skills. The initial set of senior oil and gas industry instructors at the NESC also believed site visits to be instrumental in exposing students to industry problems. Such industry site visits to view specialised service areas such as open-hole logging[20] and cased-hole logging[21] were made possible through the collaborative efforts of NESC's Drilling Academy and Tucker Energy Services as well as, NESC and Wells Services Petroleum Company Limited.

Additionally, several local ES firms shared the opinion that currently, the universities' engineering programmes were diluted and lacked a broader depth of foundational knowledge compared to programmes offered in the 1960's and 1970's. Industry participants identified graduates' inability to compute simple mathematical calculations, whether working out the revolutions per minute (RPM), or the co-efficient of friction. Others spoke of graduates poor understanding, for example, of reading a Material Safety Data Sheet identifying chemicals and the exposure limits of various chemicals. Additionally, graduates demonstrated an inability to sketch a simple wellbore schematic drawing for a conventional well, or use the software applications developed by CMG[22], Petex[23] and others. In such instances, students were not comprehending the information nor were they able to apply their knowledge to solve industry problems.

[20] Open-hole logging refers to logging operations that are performed on a well before the wellbore has been cased and cemented (www.rigzone.com/training/insight.asp?insight_id=330&c_id=) as cited on April 2, 2019.

[21] Cased-hole logging involves retrieving logging measurements through the well casing, or the metal piping that is inserted into the well during completion operation (www.rigzone.com/training/insight.asp?insight_id=330&c_id=) as cited on April 2, 2019.

[22] Computer Modelling Group Ltd (CMG) is a global software technology company that engages in R&D on advanced reservoir simulation technology. CMG's software provides results for conventional, unconventional, compositional; and advanced improved oil recovery and enhanced oil recovery processes (www.cmgl.ca/about) cited on April 23, 2019

[23] Petex is a software technology company that innovates engineering models that simulate oil reservoirs, production and injection wells, and surface pipelines. Petex is the developer of Prosper which is a known steady state simulator used in the local oil and gas industry to simulate downhole and surface conditions of wells (www.petex.com/the-company/about-us/) as cited on April 22, 2019 .

Beyond the technical gaps identified, there is a common perception among many industry stakeholders that young university recruits lack the "soft skills"[24] to perform effectively in industry. There is a grave deficiency in communication, presentation, and project management skills. Most petroleum engineering graduates, do not demonstrate an appreciation for daily operational activities nor for the administrative requirements of the job. Demonstrating initiative, commitment and a willingness to go the extra mile, is limited. Significant effort is required to build professional character, confidence, commitment and initiative to ensure that young recruits are an asset to industry.

There is a grave deficiency in communication, presentation, and project management skills.

Industry practitioners who are members of the local chapter of Professional Engineering Institutions such as the Energy Institute and Institution of Engineering and Technology (IET) have attempted to provide the means to solve the communication and presentation skills deficiencies. IET UK hosts the local leg and in the past, hosted the regional Americas Present Around The World (PATW) Competition, an instrument designed to provide a forum for engineering graduates and undergraduates to prepare and partake in a competitive technical presentation arena.

It is noteworthy to mention that some tech-voc schools, such as NESC, integrated the idea of building competencies, such as a strong work ethic[25] with a cultural mind set into their drilling programme. More recently, students were held accountable for punctuality, discipline, the display of initiative and commitment and experienced a fifteen (15) day integrated HSE training component. The holistic design of the programme was in tandem with the NESC's desire to ensure that graduates, upon recruitment into industry, survived the harsh conditions encountered while working offshore, in the forest or the desert. This focus may have changed with the exit of senior personnel who were the initial architects of the programme.

[24]Unlike the technical or "hard" skills, soft skills which include effective communication skills, teamwork, dependability, adaptability, conflict resolution, flexibility, leadership, problem-solving, research, creativity and work ethics enhanced individuals' abilities to effectively perform technical work (www.indeed.com/career-advice) as cited on April 2, 2019.

[25]Five elements of a strong work ethic are dedication, professionalism, dependability, accountability and gratitude. (www.youroffice.com/5-elements-of-a-strong-work-ethic/) as cited on November 22, 2018.

Outside of formal exploration and production training, several industry stakeholders identified a need for the introduction of energy-related inspection programmes, e.g. Non Destructive Testing[26] (NDT) and Welding Engineering Technology programmes, at the university level. They explained that these programmes ought to be designed along similar lines to the programmes offered by Iowa State University in the USA and Red Deer College in Alberta, Canada. The effective application of Non Destructive Testing and other inspection techniques are integral to ensure the safe operation of assets and equipment. Without inspection services, the likelihood of failure of components and structures increases, resulting in the occurrence of catastrophic events and significant economic loss. Technical societies such as the American Society for Non Destructive Testing facilitates training and certification for local inspection firms[27].

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Deep-water[28] exploration and production has been described as "the new frontier" by energy experts. Efforts need to be concentrated on building capacity and the skill sets required for deep-water E&P services in order to support the inclusion of local service personnel in this new segment of the industry. The onus lies on the universities and training institutions to develop the appropriate course content taking into consideration the requirements for drilling at such depths. The list of skills training for curriculum development include but is not limited to: hydrate management[29], operational engineering for subsea, trouble shooting of technology for

The list of skills training for curriculum development include but is not limited to: hydrate management, operational engineering for subsea, trouble shooting of technology for deep-water E&P, flow assurance engineering and operation of topside controls.

[26]**Non Destructive Testing (NDT)** consists of a variety of non-invasive inspection techniques used to evaluate material properties, components, or entire process units. The techniques can also be utilized to detect, characterize, or measure the presence of damage mechanisms (www.inspectioneering.com/tag/nondestructive+testing) as cited on April 28, 2019.

[27] Trinidad Inspection Services (TIS) Limited, Pt. Lisas, Couva is a recipient of technical training and certification from the American Society for NDT.

[28] Exploration and production activity depths of water greater than 1000 metres (Ministry of Energy and Energy Industries) www.energy.gov.tt/for-investors/fiscal-regime/petroleum-fiscal-incentives-2014, as cited on April 2, 2019.

[29] Gas hydrate formation is composed of ice-like crystalline solids that can cause flow assurance issues and plug up subsea oil and gas flow lines. Hydrate management involves the introduction of strategies to prevent/delay the formation of hydrates. www.oedigital.com/news/450048studying-hydrate-management, as cited on April 2, 2019.

deep-water E&P, flow assurance engineering[30] and operation of topside controls[31].

Beyond the design and implementation of educational/technical training programmes, there is limited collaboration between academia and industry. Local ES firms' representation on Industry Advisory Boards at the universities, the inclusion of industry personnel as lecturers and the offering of industry internships and apprenticeships are limited.

Innovation in the local ES sector is triggered by many industry needs (***See Section 3***). These needs could be conveyed if there were adequate representation of local ES personnel on university boards. Only one of many local industry stakeholders interviewed, was invited to join UTT's current Industrial Advisory Board thereby contributing to the development of UTT's Petroleum Engineering Programme. Again, at the time of interviewing, there was one industry representative from another local ES firm sitting on UWI's Industry Advisory Board.

The frequency of collaboration between stakeholders of the local ES sector and academia is limited. The majority of lecturers in the petroleum engineering programmes at UWI and UTT are part-time lecturers who also work full-time with multinational operators in industry. They are generally knowledgeable about issues affecting the oil and gas operators; however, ill-informed about the challenges and needs of the local ESS. Of the lecturers interviewed, few gave much thought to the pool of potential opportunities for meaningful collaboration between the universities and the local ES sector.

They are generally knowledgeable about issues affecting the oil and gas operators; however, ill-informed about the challenges and needs of the local ESS.

In 2015, UWI's Faculty of Engineering introduced industry-related Capstone Projects[32] which targeted final year students. A similar initiative was undertaken at UTT, which targeted final year petroleum engineering students. At around this period, UTT requested firms within the energy sector to provide opportunities for student internships. Only a small percentage of local ES firms

[30] Flow assurance engineering involves effectively handling many solid deposits, such as, gas hydrates, asphaltene, wax, scale, and naphthenates to ensure the successful and economical flow of hydrocarbon stream from reservoir to the point of sale (www.marinetechnologynews.com/blogs/deepwater-flow-assurance-e28093-part-1-700502) as cited on April 28, 2019.

[31] Topside controls refer to a suite of equipment mounted on the host structure to communicate with the subsea infrastructure. It comprises five main components: the master control station, electrical power unit, chemical injection unit, hydraulic power unit and topside umbilical termination assembly (www.onesubsea.slb.com/control-systems/topside-controls) as cited on April 28, 2019.

[32] The Mechanical Engineering Department of the Faculty of Engineering, UWI, initiated Capstone Projects targeting undergraduate and graduate students, providing them with the opportunity to conduct experimental research and apply the theories learnt over the duration of their studies, in the design of solutions to industry-related challenges.

interviewed had responded in the affirmative, along with a handful of upstream oil and gas operators. In the case of Tech-voc, apprenticeships were assigned to students. In 2015, roughly 20%[33] of NESC's graduates had the opportunity to intern under the Point Lisas Industrial Apprenticeship Programme (PLIAP[34]) which was supported mainly by downstream operators. Upon completion of this programme, the performance of apprentices was rated relatively high.

As noted, much research has been conducted on the local energy sector. Within the recent past, UWI's research focused on:

- Determining the most effective innovative techniques for the recovery of heavy oil onshore. Such techniques include the deployment of Radio Frequency Heating;
- The quantification of natural gas hydrates; and
- The use of micropaleontology[35] in oil and gas exploration.

In the case of UTT, its research focused on:

- CO_2 sequestration, oil recovery and restoration;
- Deep-water development including opportunities for monetizing deep-water gas in T&T;
- LNG marketing and value chain; and
- Enhanced oil recovery of heavy oil offshore.

Respondents indicated that those areas of research generally focused on some of the major issues of interest to the upstream oil and gas operators and not on the issues of local ES firms. Much the same is being promoted. The Prime Minister of the Republic of Trinidad and Tobago, the Honourable. Dr. Keith Christopher Rowley in his feature address at the 2019 Energy Conference and Trade Show held in Port of Spain, Trinidad, indicated the government's intention to begin a dialogue with the major oil and gas operators and local universities, to effect a strategy to promote and finance research in technology applicable to the petroleum sector.[36] While such a strategy is a welcome initiative which could provide a fillip to the sector, the dialogue should also be extended to include Energy Services firms, given that there are several important issues warranting investigative research relating to the ES sector. The following list though not exhaustive describes areas of in-depth research, as identified by local energy services firms and educational/technical training institutions:

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[33] The data presented on the percentage of interns participating in the PLIAP was provided by an NESC Centre Coordinator.

[34] Under the PLIAP programme, graduates from Tech-voc institutions are given a two (2) year term of apprenticeship to gain industry relevant experience at energy and non-energy PLIAP partners with petrochemical producing companies and these companies' service contractors to provide these opportunities.

[35] Micropaleontology is the study of microscopic fossils, its morphology and its characteristic details. (www.micropress.org/what.html) as cited on April 2, 2019.

[36] Dr. the Honourable Keith Rowley, Prime Minister of the Republic of Trinidad and Tobago. Address at the 2019 Energy Conference & Trade Show. "Technology: Transforming the Industry. The Trinidad and Tobago Experience." February 4, 2019. Port of Spain, Trinidad.

- Risk analysis associated with shallow water flows, high ocean currents, subsurface pressures and thin pay zones[37]. The research results could provide explanations as to why some of the wells drilled in T&T's earlier deep-water campaigns failed to reach their targeted depths;
- Testing oil properties inclusive of the geochemistry and viscosity of oils and their interactions with enhanced recovery agents to reduce the buildup of asphaltenes and waxes that obstruct the flow of oil from wells;
- The design of effective completion techniques to maximize the flow from reservoirs;
- The design and implementation of methods to improve well stability for onshore and offshore wells;
- Innovating effective methods to treat and reuse water produced as a waste stream during exploration and production; and
- Identifying the challenges and opportunities that abound in deep-water developments.

What is apparent is that neither UWI nor UTT has established formal research linkages with local ES firms. Instead, much of the research is driven by the universities' capabilities rather than by the demands of the energy services industry. As a result, transference of findings from academia to the local ES industry is minimal. This does not augur well for the relationship between academia and the local ES industry. Hence, the feelings shared by some industry stakeholders and lecturers that university research on the energy sector is considered recycled, static and supportive of teaching rather than geared to relevant and practical research for use by local industry. To date research priority has not been given to the local petroleum sector and more specifically, the local energy services sector has not received the attention it deserves.

Linkage between Local ES Firms and Upstream/Downstream Operators

In assessing the intensity of the linkage between Local ES Firms and the Upstream/Downstream Operators, the following (4) factors were considered (***See Appendix II: Table 8***).

- Procurement of local energy services for upstream and downstream operations in the domestic market;
- Procurement of local energy services for upstream and downstream operations in foreign markets;
- Opportunities created for local ES firms in networking and sharing of information for future planning; and

[37]A Pay Zone, also known as a pay sand or a producing zone is a formation or a reservoir bed from where hydrocarbons are produced in exploitable quantities (www.petropedia.com) as cited on April 2, 2019.

- The frequency with which local ES firms are sensitised to local and international HSSE standards and expectations in service delivery.

The linkage between these actors was assessed to be weak. Generally, opportunities for local ES firms to service upstream/downstream operations tend to be limited[38]. Historically, the demand for local energy services increased when the price of oil plummeted. As previously mentioned in an earlier section of the study, it was in the cycle of busts and following the exit of international ES companies that local energy services providers innovated, seeking more efficient ways to extract oil out of the ground. The present scenario is far more complex. It involves issues surrounding local content, issuance of work permits and limited opportunities. Several stakeholders are of the opinion that a lack of implementation and enforcement of local content poses a major challenge for local ES firms to get work. This situation is further exacerbated by the entrance of "foreign individuals and companies [which] are often brought in to do work for which locals are fully capable and qualified." [39] (***See Section 4.1***). The research also shows that several local ES firms have built alliances with international services companies and are generally sub-contracted to provide energy services. Such arrangements appear to be built on personal relationships and past performance[40]. These work opportunities currently are few and far between.

The situation for local ES firms in the domestic market seems much more daunting when local authorities are excluded from the planning phase in the oil and gas value chain. It takes approximately five to ten (5-10) years to develop an oil field. Three to four (3- 4) of these years is usually dedicated to the planning phase which oftentimes occurs outside of Trinidad and Tobago. Most service acquisitions to be deployed in Trinidad and Tobago are therefore made outside of this host country. Multinational operators typically bundle their service contracts over multiple jurisdictions. In other words, it makes more economic sense for foreign investors to hire a few, or more likely than not one (1) contractor, to service drilling operations carried out in the Caribbean.

Most service acquisitions to be deployed in Trinidad and Tobago are therefore made outside of this host country.

As previously stated, in the past, to keep production from falling during low price periods, local ES firms were given more opportunities to service operations. It is also true that local expertise is sought after at home and abroad to do collateral damage on drilling and engineering jobs that have

[38] While the energy sector provides excellent opportunities, these are only achieved through increased local participation in the value chain. In 2004 the level of local value capture was in the 10% range and increasing this will have a significant impact on the national economy (2004 Local Content Policy of T&T, page 4).
[39] Anthony Paul. "Future of Fossil Fuels" in *Contact Magazine*. TTCIC. March 2019: page 11.
[40] A common saying among energy service providers is that "you are only as good as your last job."

gone awry, and in cases where international services firms have fallen short in meeting service demands[41]. Interestingly, in another scenario, local ES firms have also been contracted to deploy home-grown product and process innovations to solve technical problems occurring in the domestic upstream industry. Moreover, where one would have anticipated the endorsement and procurement of these successful local innovations by upstream operators to treat problems of a similar nature occurring in foreign markets, these opportunities have not yet been offered to local ES firms which unfortunately does a disservice to them.

Notwithstanding, exposure of local ES firms to foreign markets has taken off with the advent of a few trade missions. In 2011, British Gas Trinidad and Tobago (BGTT) liaised with BG Brazil to welcome a trade mission of T&T's ES firms to that country. That mission showcased an array of local energy services in drilling support, construction of offshore infrastructure, sub-sea services, operations and maintenance support and training, pipeline construction, water management services and remediation of oily waste. In addition, local experts in the oil and gas industry have ventured abroad either to provide advisory services to other governments, or have been recruited to work individually as engineers and drillers in foreign firms. The evidence shows that much more support is needed for local ES firms to access foreign markets. While as recent as February 2019, at the Energy Conference and Trade Show, a commitment was made by upstream operators to invest in E&P operations in local waters, the real opportunities for local ES firms exist in neighbouring Caribbean countries such as Guyana, Suriname and French Guiana, to name a few, where the outlook for oil production is very promising.

… the real opportunities for local ES firms exist in neighbouring Caribbean countries such as Guyana, Suriname, French Guiana, to name a few, where the outlook for oil production is very promising.

Since 2008, major upstream operators like bpTT and SHELL[42] have held quarterly contractor meetings with contracted ES firms to improve communications with these firms, gain a better appreciation of their challenges and promote compliance with HSSE standards and legislation governing the industry. Industry stakeholders explained that in the past, bpTT created positions within its organization to facilitate operational support for contracted ES firms and subsequently, held these contracted firms accountable for their performance.

Given the nature of the energy industry, local ES firms attest that the most effective method of selling an innovative product and process to an operator involves identifying and directly

[41] "While local services providers have comparative levels of experience and expertise as their foreign counterparts, they do not have the same capacity." Notes from interview with respondent on January 23, 2019.
[42] As of 2016, British Gas Trinidad and Tobago (BG TT) was acquired by SHELL Trinidad and Tobago Limited.

approaching key decision makers within those firms as well as, the major ES contracting firms. International fora, such as the annual Offshore Technology Conference (OTC) held in Houston, Texas, present opportunities for local ES firms to network and transact meetings with operators, technology suppliers and other potential business partners. Those networking opportunities afford services firms a platform to showcase employee capabilities and innovations. In most instances, the onus is on locally owned ES firms to understand the modus operandi of the operators and network with key decision-makers. By way of example, a local firm seeking to sell quality solutions to solve technological problems associated with drilling would attempt to establish a relationship with the drilling superintendent on a rig, then convincingly demonstrate to him that the local ES firm can deliver quality services.

Linkage between Local ES Firms and Ministry of Energy and Energy Industries (MEEI)

The following four (4) factors were considered in assessing the intensity of the linkage between local ES firms and the MEEI (***See Appendix II: Table 9***).

- MEEI's development and implementation of initiatives that enhance the competitiveness of local ES firms operating in domestic and foreign markets;
- MEEI's formulation of policy and strategy to articulate a clear strategic pathway for stakeholders in the energy services sector;
- MEEI's knowledge of the services and innovations offered by local ES firms; and
- MEEI's performance as a regulator with specific reference to the issuance and renewal of licences (e.g. E&P, Refining, Pipeline, Export, Marketing, Transportation licences), collecting financial obligations from licensees, establishing a national petroleum register.

Several industry stakeholders have remarked that the MEEI should play a more substantial role in strategically managing and positioning T&T as a hub for regional and extra-regional energy services. Albeit the ECTT currently serves as the only voice of the ESS and presently takes the lead in developing and implementing strategies to advance the sector, deficiencies exist in the enabling environment that can only be addressed by a government institution such as the MEEI, with the relevant authority and capacity to mitigate and eliminate those challenges. These deficiencies include:

- the absence of strong governance and coordination of the ESS ;
- the absence of enforcement mechanisms to support local content;
- poor track record in the issuance and renewal of licences as mandated in the National Petroleum Act #46 of 1969;
- poor collection of taxes and royalties from licensees;
- the absence of a national petroleum registry as made mandatory in the National Petroleum Act #46 of 1969;

- a mishandling of funds collected under the PSCs that should be directed to R&D activities of benefit to the local sector;
- the absence of a well-coordinated export-oriented model for the ESS; and
- the absence of fiscal incentives for ES firms to engage in innovation.

Although the MEEI is responsible for the development and implementation of policy initiatives for the petroleum sector, the Ministry has adopted a hands-off approach in articulating a clear strategic pathway for stakeholders in the ESS. Attempts have also been made by other public sector institutions to invite the MEEI to participate in the formulation of strategic interventions for the ESS; however, the willingness of the MEEI to participate has not always been forthcoming.

The MEEI is the sole regulator of the energy sector, with the authority to engage in a series of activities with petroleum stakeholders. The responsibilities of the Energy Minister and currently his Ministry as articulated in Trinidad and Tobago's Petroleum Act No. 46 of 1969, and as amended by Act No. 4 of 2014, include enforcement of regulations, the issuance and renewal of licences (E&P, Export, Pipeline, Refining, Marketing, Transportation) for all stakeholders engaged in oil and gas activities, approval of PSCs, granting of ancillary rights, the collection of taxes and other financial obligations from the licensee, monitoring the status of the environment, as well as, all operations and the establishment of a national petroleum registry of stakeholders in the industry.

There is wide consensus among stakeholders that the execution of several of these responsibilities is weak, particularly in the collection of taxes and royalties owed to the state, enforcement of compliance with regulations and the establishment of a national petroleum registry. Strengthening these areas would not only assist in securing much needed finance for the economy and for R&D activities with respect to upgrading and advancing the sector, but it would also give the state stronger leverage in regulating the use of its resources and in providing support in strategic areas of benefit to local industry stakeholders.

The establishment of a national petroleum registry by the MEEI featuring ES firms offering technical services within the domestic market and abroad is essential. The ECTT has a database which is populated by its member companies which currently offer or have demonstrated the potential to offer technical services along the entire value chain to CARICOM countries. This database however is inadequate since it does not capture all the stakeholders in the industry. A national petroleum registry would in fact capture information about services and areas of technical expertise of several local ES firms which are not members of the Chamber.

The establishment of a state driven coordinating unit under the MEEI's Energy Research and Planning Division to provide policy support and treat with issues pertinent to the ESS should be made a priority.

MEEI's current organisational structure does not include divisions or units that

directly support the growth and development of the local ESS. MEEI's respondents in this study were generally uninformed about some of the high priority issues impacting the local ESS and many innovations developed by local ES firms. The establishment of a state driven coordinating unit under the MEEI's Energy Research and Planning Division to provide policy support and treat with issues pertinent to the ESS should be made a priority.

Linkage between Local ES Firms and Public Business Support/Trade Related Institutions

Four (4) factors were used to assess the intensity of the linkage between local ES firms and public business support/trade related institutions (***See Appendix II: Table 10***).

- The development and roll out of relevant business support/trade facilitation services to enhance ES firms' competitiveness and entry into export markets;
- ES firms' usage of business support/trade facilitation services;
- ES firms' awareness of the available suite of business support/trade facilitation services; and
- Business support/trade facilitation organisations' knowledge of the challenges and trade related needs of local ES firms.

As illustrated in ***Figure 1***, the linkage between local ES firms and business support/trade related institutions of the public sector is weak. Within the enabling environment, there are only three (3) public institutions offering some measure of support for local ES firms. These are exporTT, EXIM Bank and the MTI.

Although relevant, these support services lack the level of customisation needed to have a significant impact on local ES firms.

At exporTT, local ES firms are eligible to participate in the Co-Financing facility, the Research and Development Facility (RDF), Export Market Research and Export Capacity Building/Training Programmes. Although relevant, these support services lack the level of customisation needed to have a significant impact on local ES firms. To date, the service most used by local ES firms is the Co-financing facility which provides financial support in the sum of TTD$20,000 to assist ES firms in offsetting expenses incurred for trade show participation, translation services for export-related documentation, and the adoption of industry specific certifications and standards.

Somewhat of a teaser, a loophole exists in the RDF facility which is not open to ES firms. ES firms whose R&D efforts are directed towards the introduction/development of innovative energy-based solutions that can be applied in both the energy and non-energy sectors, can participate. Thus far, only one of the local ES firms interviewed was successful in receiving RDF financing. Surprisingly, this grant funding facility does not provide support for a range of critical activities in the conduct of R&D. These include the purchase and upgrade of equipment/software and training to build the skills required to operate the equipment needed to develop innovations.

Consequently, few local ES firms endeavoured to participate in the RDF. Many remained skeptical about collaborating and sharing information about their innovations with external parties, having experienced trust issues relating to theft and infringement of their innovative ideas and intellectual property.

Local ES firms require more in-depth assistance in selected areas such as: writing of grant funding proposals, developing business plans and export strategies for various markets, business networking skills, understanding non-tariff barriers, taxation issues, trade agreements, and the cultural nuances of different markets.

Beyond the RDF, the Export Market Research facility is less frequently used. This is primarily because exporTT's Market Research Centre currently lacks the HR capacity to undertake the meticulous level of market intelligence/research needed by local ES firms. With only one export officer to support all services sectors in identifying the demand, market access limitations, cultural preferences and norms of potential ES export markets, delivery services of a more customised nature become onerous. Likewise, the Export Capacity Building/Training Programme is least utilized by local ES firms. These programmes are structured in a generic manner to cover companies across a wide range of sectors. While in many instances the subject matter is relevant, workshops lack the necessary level of detail. Local ES firms require more in-depth assistance in selected areas such as: writing of grant funding proposals, developing business plans and export strategies for various markets, business networking skills, understanding non-tariff barriers, taxation issues, trade agreements, and the cultural nuances of different markets. It is also worth noting that only a handful of local ES firms were familiar with some of the business support services offered by exporTT and even fewer accessed other facilities.

"Historically, financial institutions in T&T have been risk averse to funding innovative activities in the energy industry and this is counterintuitive to stimulating innovation."

Accessing suitable financing for innovative activities within the ES sector has been problematic. Mr. Richard Small, Principal Consultant of Class One Systems Ltd explained, "Historically, financial institutions in T&T have been risk averse to funding innovative activities in the energy industry and this has been counterintuitive to stimulating innovation." Primary sources of R&D financing utilized by local ES firms originated from firms' internal cash flows, internally generated equity and loans from banks. Most local ES firms sourced their loans from the Royal Bank of Canada (RBC) and Republic Bank Limited (RBL). Only a handful of firms were successful in securing finance either from the EXIM Bank, or international financing institutions such as the International Finance Corporation (IFC), or local grant funding agencies. Financial institutions such as Citibank continue to fund projects valued no

less than USD 5 million, mainly courting large companies and corporate groups. Generally, the banks that have shown a keen interest in assisting local ES firms, have made concerted efforts to understand the industry and in the case of RBC, has leveraged the expertise of its international branches that have been the leading financiers of the North American hydrocarbon sector.

RBC in its efforts to support the ES sector identified the following factors when lending to ES firms[43]:

- Multiple long-term contracts with major upstream and downstream operators;
- Healthy revenue streams demonstrated by the firm's ability to service debt payments;
- Diversified service lines spanning the E&P cycle which allow an ES firm to withstand cyclical swings in the industry;
- Strong reputations and strategic alliances with industry stakeholders;
- Long term relationships with financial institutions augurs predictability of cash flows; and
- The ability to raise debt and equity financing is critical to the success of any company in the sector. Up to 2015, there was no platform which facilitated small corporates in securing equity financing.

Alternatively, there are a few challenges banks must consider when designing financing facilities. These include[44]:

- Lengthy lags between delivery services and receiving full payment from oil and gas operators- ES firms usually received payments approximately six (6) months after the delivery of services from operators;
- The cyclical nature of work and the relatively short period to deliver services, sometimes three to six (3-6) months usually results in fluctuating cash flows; and
- Specific instances in which local firms may not receive written contracts, and where they do exist are usually for a short term.

It is worth noting that in some oil-based economies, financial sectors have been more facilitative in designing specialised financing facilities to assist their domestic ES firms.

It is worth noting that in some oil-based economies, financial sectors have been more facilitative in designing specialised financing facilities to assist their domestic ES firms. An example is the Diamond Bank of Nigeria which, in the early 2000s, collaborated with the International Finance Cooperation and a major multinational operator to establish a revolving credit facility for Nigerian ES firms. In order to access this facility, ES firms had to be employed

[43] Presentation entitled "*Financing in the Energy Sector*" by Marc Jardine, Vice President Cooperate Banking, RBC Merchant Bank, to the Energy Chamber of Trinidad and Tobago on November 24, 2015, Trinidad.
[44] Ibid

by multinational operators and undergo several training programmes that were geared towards improving the recipient firms' competitiveness. In T&T, consideration should be given to the design and implementation of similar programmes to support local ES firms.

3. Innovation in the ESS

The **Oslo Manual 2005** provides clear definitions of what constitutes an innovation and the different types of innovations. An innovation is a new or a significantly improved product, process, service or system introduced by a firm. More specifically, product innovations are goods or services that are new or have been significantly altered with respect to either their physical characteristics or functional uses. Process innovations are new or significantly improved production or delivery methods. With process innovations, changes have been made either to equipment, software or techniques. Organisational innovations are new organisational methods in either a firm's business practices, external relations or workplace organisation. **Section 3** focuses on these three (3) types of innovations which characterise the local ESS – product and process innovations and organisational innovations – and the drivers of innovation.

3.1 Product and Process Innovations

A review of the existing literature suggests that T&T is the country of origin of several technological innovations which have been utilised in the local oil and gas sector. In spite of this, industry stakeholders have indicated that there are still several innovations developed by local ES firms which have not been well-documented.

Product and process innovations were the two dominant types of innovations developed in the local ESS. These tended to be closely associated and can be viewed as a natural concomitant of each other. In other words, the adoption of new and/or improved equipment and technologies invariably necessitated the introduction of new and or significantly improved production processes and vice versa. Another characteristic of some innovations was their intersectionality i.e. innovations were applicable across industries.

Tables 1-4 identify and briefly describe notable product and process innovations developed either locally or in partnership with global associates, adopted and diffused into the local oil and gas sector. These lists of innovations in use within the local ESS are by no means exhaustive.

Table 1: Product Innovations Developed by Local ES Firms

Local ES Firms	Innovation	Service	Description
Analytical Technologies Limited (ATL)	Indigenous Bacterium	Disaster Planning and Recovery	ATL cultivated an *indigenous bacterium* for the biodegradation of oil in contaminated soils. ATLs *indigenous bacterium* is more resilient than bacterium cultured in foreign environments. Its application therefore reduces the costs and time incurred with rectifying damages caused by oil spills.
IAL Engineering Limited	Casing Hanger	Well Services - Drilling	IAL's *Casing Hanger* designed in collaboration with a major international energy services firm is that portion of a well head assembly that supports the casing string when it is lowered into the well bore.
Perfection Services Limited (PSL)	Tubular Pipe Transport Rack System	Cargo carrying units/ Shipping	The *Tubular Pipe Transport Rack System* allows companies installing pipes in the drilling phase of exploration to stack the pipes in the order of utilisation. Companies utilising the rack system save space on the ships and significantly reduce the time taken to install pipes for drilling operations.

Table 2: Product Innovations Developed by International Energy Firms that have been Modified and/or Tested by Local ES Firms

Local ES Firms	Innovation	Service	Description
Offshore Technology Solutions Limited (OTSL)	Modification of an Inspection "eye ball" ROV	Underwater Inspection	OTSL collaborated with a small US based firm to *modify an inspection (eyeball) ROV* to perform most of the functions of a work class ROV. Modifications were made to cut costs since work class ROVs are significantly more expensive than eye ball ROVs.
PetroCom Technologies Trinidad Limited	Smart Pumper	Well Services – Drilling	The *Smart Pumper* platform is a cost-effective automation and monitoring system developed by New Horizon Exploration (an independent oil and gas operator). It can be used to manage any type of well-site operation in real time using the internet. PetroCom Technologies Trinidad Limited collaborated with New Horizon to conduct initial tests for this innovative device.
	Seisnetics Technology	Well Services – Seismic Data	PetroCom Technologies introduced *Seisnetics*, a 3D seismic processing software to analyse and interpret seismic data for the oil and gas industry.

Table 3: Process Innovations Developed by Local ES Firms

Local ES Firm	Innovation	Service	Description
Hydrocarb Trinidad Limited	Emulsion & Effluent Treatment Process	Oil Storage/ Refining	Hydrocarb's *Emulsion & Effluent Treatment Processes* treats with breaking very tight emulsions and separates dissolved solids from associated produced fluids in the Petroleum Industry. Further, the *Emulsion & Effluent Treatment Process* can be universally applied to numerous industrial applications to remedy the processing of slop oil[45] for all industries to meet international saleable product & effluent discharge standards.
	Tar Sands Bitumen Removal and Fluidization Process	Oil Sands Extraction	Hydrocarb's *Tar Sands Bitumen Removal and Fluidization Process* fluidizes the bitumen without the evolution of carbon dioxide and satisfies global refinery standards for crude oil. In addition, Hydrocarb successfully conducted tests on samples of Tar Sands from Petro-Canada's Alberta fields and Trinidad's Oil Sands.[46]
	Pipe-Cement Interface Bond Enhancer	Well Service	The *Pipe-Cement Interface Bond Enhancer* is a process developed by Hydrocarb Trinidad Limited to enhance the efficiency and longevity of a well and/or well system through the use of a coating in the creation of a bond between the pipe and other surfaces within a drilling and/or well system.[47]

[45] Slop Oil and Sludge Oil is reclaimed petroleum waste mixtures of oil, chemicals and water derived from a wide variety of processes in refineries or oil fields (www.solisoil.com/index) as cited on December 4, 2018.
[46] Hydrocarb Trinidad Limited Energy and Environmental Technology Commercialisation Opportunities. Unpublished document. July 2010.
[47] Ibid

Table 4: Process Innovations Introduced in the Domestic Sector by Local ES Firms and Developed by International Energy Firms

Local ES Firms	Innovation	Service	Description
Offshore Technology Solutions Limited (OTSL)	The Coiled Pipe Reel System	Well Services - Drilling	The *Coiled Pipe Reel System* adopted and deployed by OTSL is a polyethylene tube unspooled from a reel that replaces the traditional rigid drill pipe in drilling operations. This method reduces the time taken to lay the oil pipes and also reduces drilling costs.
Trinidad Inspections Services Limited	Rope Access	Inspection/ Maintenance	*Rope access* is a technique which applies rope work allowing workers access to difficult to reach locations on work platforms without the use of scaffolding. Trinidad Inspection Services Limited uses this cost-effective technique to inspect platforms in the oil and gas sector

3.1.1 Analysis of Product and Process Innovations in the Local ESS

Although the list of **Product Innovations Developed by Local ES Firms** featured in ***Table 1*** is incomplete, it is true to say that many of the innovations are used to improve the delivery of well services, disaster planning and recovery services and inspection and maintenance services of the oil and gas value chain. Additionally, only a small percentage of product and process innovations introduced by local ES firms originate in T&T. Most technological innovations used in the local oil and gas landscape originate overseas, with local ES firms either becoming the sole agents or the first to import, and if need be, modify the product or process innovation for use in E&P operations.

Understandably, it is the large multinational oil and gas operators and oil field services firms such as Schlumberger, Baker Hughes, Halliburton and Weatherford, which dedicate extensive resources to research and as a result, are among the global leaders in the development of extraction technologies for the sector. Rather than reinvent the wheel, local ES firms involved in R&D have concentrated their efforts on innovating technologies, which they cannot access, and as observed, in niche areas where opportunities exist for improving existing technologies.

Irrespective of whether innovations originate overseas or in T&T, all must be assessed to ensure that the product, process or service conforms to specified requirements. In most cases, multinational operators seeking to use locally developed innovative technologies would require that these technologies meet the recommended ISO or API standards specified for the product. Compliance with international standards pose many advantages, as local innovations adhering to international standards can have easier access to foreign markets. Likewise, local firms have an opportunity to improve their level of competitiveness, thereby reducing delivery time and saving the extra costs incurred by mandatory testing and recertification procedures for entering into new markets. To date, only a few local ES firms have ventured the way of manufacturing and/or modifying new technologies/equipment that adhere to international industry standards. Again, owing to significant costs, even fewer local ES firms conducted R&D due to the fact that the value of available work in the domestic market is insufficient for serious consideration to be given to the manufacture of sophisticated equipment or the development of prototypes. This challenge best explains why many local ES firms resort to the importation of technologies and equipment for use in their field operations.

…the value of available work in the domestic market is insufficient for serious consideration to be given to the manufacture of sophisticated equipment or the development of prototypes.

Twenty-one percent (21%) of the local ES firms interviewed indicated that they conducted some measure of R&D at a stage in the company's history. Whether those efforts were generally

classified as R&D, many explained that when the need arose, they developed innovative solutions to resolve problems, particularly one-off problems. In most instances, firms did not establish formal research and development departments in their structure. There appeared to be a myriad of arrangements in existence. In one scenario, local ES firms entered joint arrangements for example, with foreign firms which offered technical know-how to conceptualize innovative solutions; in another scenario, some firms recruited researchers; others commissioned foreign experts to modify equipment to meet the client's needs; and yet others collaborated with foreign-based firms to manufacture integrated products. It is well noted from our data that at no time did local ES firms consult with local universities or local research institutions for assistance in bringing their innovative ideas to fruition.

3.2 Organisational Innovations

A handful of local ES firms introduced new organisational methods in their daily business practices to enhance efficiency of operations and increase productivity. These organisational innovations manifested themselves in different forms. For some firms, organisational innovations translated into the installation of new software applications; for others, the introduction of new systems. The following examples of organisational innovations were identified:

- The introduction of *inventory management software* which permitted one local ES firm to monitor inventory levels and pinpoint the location of its equipment at all times, whether in the field or in the workshop. The software also allowed for documents tracking relating to the inspection status of equipment.

- The introduction of a new *inventory management system* with the primary objective of improving the provision of real time information on the delivery and status of equipment and services to internal and external clients. This organisational innovation resulted in significant savings in time and money.

- The installation of a system of *stockpiling a wide variety of difficult to source materials* on an as needed basis. Utilised by a large ES firm, this system enabled the firm to build and deliver specialised products and services to its clients in a relatively shorter period of time, offering not only cost and time savings but also strengthening its reliability and efficiency of operations.

- The introduction of an *internal human resource scheme* to increase productivity and reduce absenteeism. Another local ES firm in the business of selling engineering services, introduced this scheme which allowed the company to establish production targets for every job function and reward workers who met set targets. Structured on a point system, this organisational innovation linked points to rewards. In other words, upon successful

completion of an assignment, a worker was either given a percentage share of the profits earned by the firm or household items valued according to the point system. This innovation had the greatest impact on mid-level staff with minimum to no buy-in from employees operating at lower levels of the organisation.

3.3 Key Drivers of Innovation in the ESS

Whatever the reason or combination of reasons, innovation in the local ESS appeared to be driven at the individual, team and organisational levels. Based on innovative activities described in ***Tables 1-4***, key drivers of innovation in the ESS were as follows:

- The existence of persons in authority positions who possessed the knowledge, skills and leadership abilities to choose the right problems to solve;
- The existence of a team environment that capitalised on the creative process;
- The presence of a climate fostering the generation of ideas and experimentation; and
- Long term relationships with overseas industry partners which facilitated access to cutting-edge technologies.

Innovating to Resolve Technical Problems in Industry

Technical problems occur quite frequently in the daily tasks of upstream operations. The study revealed that it was usually services firms with sustained good long-standing relationships with operators that were invited back to be the first responders to a call for service. Primary research shows that most of these services firms exhibited characteristic traits of executive personnel functioning at the top tier of authority, very knowledgeable of both the issues to be addressed and the possible technologies available to resolve a problem. An intimate and in-depth understanding of the mechanics underpinning the available technologies, coupled with the presence of a team environment supportive of the creative process, local ES firms successfully innovated solutions and earned significant revenue by delivering innovative services.

According to Wellbore Limited's Chief Operating Officer, Kevin E. Durham, "A significant factor that must be considered in resolving technical problems is to front-end [load] operations, with the ability to deploy good, sound scientific practice (applying API, ASTM and IP standards) as opposed to 'best practice', and coupled with operations and engineering excellence standards." Furthermore, Wellbore's COO insists, "There is a need to develop proper standard operating procedures and have end-users properly trained and current with this good practice."

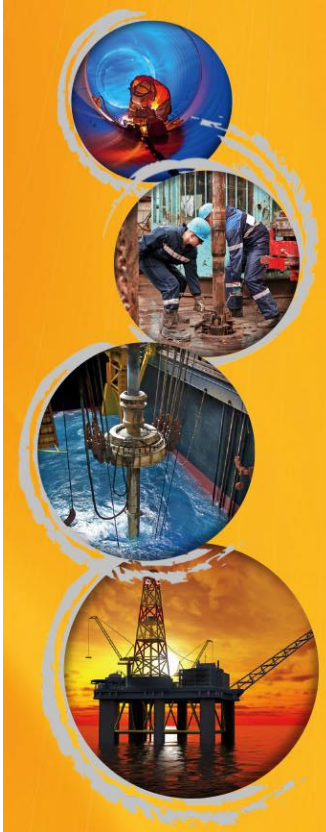
Surviving in an Unfavourable Economic Climate

On the heels of the recent sharp decline in oil prices came the directive to reduce fees charged for energy services. Under such circumstances, upstream operators and multinational services providers who would have subcontracted work to local ES firms, mandated that services fees be reduced and revised to fall within specific price ranges. Unfavourable economic conditions forced local ES firms to innovate efficiencies in the delivery of quality services. With reduced demand and reduced prices, it was critical for the survival of local ES firms to become more cost effective in the delivery of services. In some cases, those firms relied heavily on well-established relationships with overseas industry personnel in order to gain access to cutting edge technologies, which not only gave them an advantage over other services providers, but also kept business buoyant in lean times.

Generating New Revenue Streams

Some firms innovated new products and processes with the intention of generating new revenue streams for their company. At the helm of these firms were visionary leaders who adopted very strategic approaches to diversifying their range of products and services. Common to their strategies was relevant background research identifying trends and challenges, a thorough understanding of current technologies and thereafter, inventing new technologies to reduce environmental degradation. In these scenarios, those involved were highly skilled and knowledgeable, encouraged a team environment supportive of the creative process, and one that fostered the generation of ideas and experimentation.

4. Impediments to Innovation in the ESS



…the pathway to innovation in the ESS is both risky and never smooth.

While the benefits of innovation are substantial, several industry stakeholders have expressed that the pathway to innovation in the ESS is both risky and never smooth. As previously noted, only a small percentage of local ES firms have attempted to innovate. Upon further investigation, this research uncovered several contributing factors impeding innovation within the local ESS. Innovations are limited by the lack of opportunity resulting from the absence of enforcement of local content, financial constraints, the small size and composition of the domestic market, cultural nuances that suggest "foreign is better", and resistance to technological change.

4.1 The Lack of Opportunity Resulting from the Absence of Enforcement of Local Content

Research studies indicate that many oil & gas exporting economies of developed and developing countries have formulated local content policies, installed and enforced local statutes to capture and retain more market value for domestic firms in their national economies. Further, the success of enforcement of local content has varied across countries such as Norway, Canada, the United Kingdom, Brazil, Ghana, Nigeria and Venezuela.

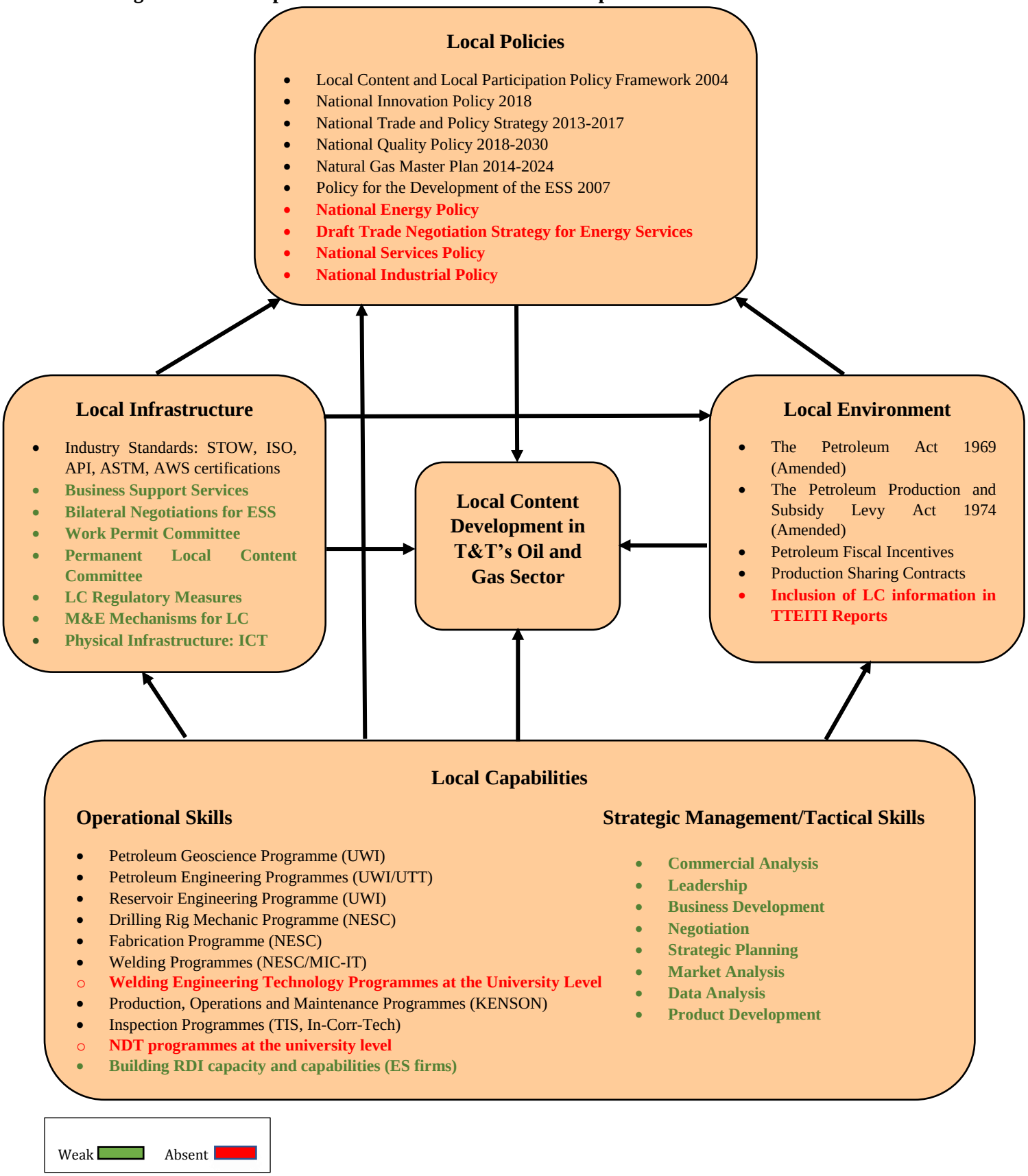
There is wide acceptance of the view that if local ES firms are to be firmly established and build credibility in the market, then a necessary condition for this is an increase in the level of local content and local participation in the domestic energy sector. Without job opportunities at home, local firms have struggled to build a strong track record and to obtain endorsements which are considered immediate returns on investment and a *sine qua non* for admission into foreign markets.

In the Trinidad and Tobago context, while legislation and stringent regulations exist, the absence of enforcement on the part of successive governments has negatively impacted local content and by extension the opportunity to innovate in the sector. Under these circumstances, local ES firms struggle to win contracts. Their struggles have been further exacerbated by a perceived bias, skewed in favour of awarding contracts to foreign ES firms. Foreign ES firms clinch many lucrative opportunities and are paid relatively much more for services rendered in areas where local ES firms are fully capable and qualified. Furthermore, as stated: *"… other work that can and should be done here is sent overseas, thus facilitating revenue*

leakage, transfer pricing and tax avoidance. …"[48] Some stakeholders allude to the existence of a "robust" Local Content Policy formulated in 2004, which as indicated by stakeholders and the current Minister of MEEI, Senator the Honourable Franklin Khan[49], needs to be revised and strengthened. ***Figure 2: A Conceptual Model for Local Content Development in T&T's Oil and Gas Sector*** illustrates four (4) critical components that must be considered to effect local content. These components include: local policies, local environment, local capabilities, and local infrastructure.

[48] Anthony Paul. "The Future of Fossil Fuels" in *Contact Magazine*. TTCIC. March 2019: page 11.
[49] Senator the Honourable Franklin Khan, Minister of Energy and Energy Industries. Address to the Spotlight on Energy, "Our Oil, Our Gas and Our Future", Conference 2018. Hyatt Regency, Port of Spain, Trinidad.

Figure 2: A Conceptual Model for Local Content Development in T&T's Oil and Gas Sector



Local Policies

Local policies inform the requisite target audience of specific plans for treating with different types of policy-related issues within a country. These types of policies set parameters which guide stakeholders' actions regarding what they can and cannot do within the selected space. ***Figure 2***, identifies a series of coordinated local policy interventions that are required to help actualize local content. These, in addition to the *National Energy Policy*, *Draft Trade Negotiation Strategy for the ESS*, the *National Services Policy* and the *National Industrial Policy* which are at various stages of development are all integral to enhancing the competitiveness of local ES firms and strengthening their participation in industry.

Within recent years, T&T's local content policy experts have been at the forefront of local content policy developments in several countries including Ghana, Nigeria, and Guyana. Nonetheless, this twin-island republic is yet to get it right domestically. It is noteworthy that some of the aforementioned countries have made further headway than T&T in implementing local content policy initiatives.

Others stated that it was "outdated, ineffective and in urgent need of review."

This study identified opposing views on the strength of the current local content policy. Some industry stakeholders describe the existing *Local Content and Local Participation Policy Framework 2004*, authored by a GoRTT appointed Permanent Local Content Committee, as robust but not impactful due to non-implementation. Others stated that it was "outdated, ineffective and in urgent need of review."[50] Another group labelled the policy as **"**toothless" and "a brochure" that allows oil and gas operators to find ways and means to "circumvent local content." The general sentiment however, was that the *Local Content and Local Participation Policy Framework (2004)* was an attempt to placate local stakeholders and deemed to be ineffective for the following reasons:

a) Local participation targets were not established for action by upstream/downstream operators;
b) Neither an action plan nor strategy was prepared in tandem to guide local content policy implementation; and
c) The absence of a monitoring and evaluation (M&E) framework to determine the extent to which local content statutes were adhered to and whether the desired impact was achieved.

… The general sentiment however, was that the *Local Content and Local Participation Policy Framework (2004)* was an attempt to placate local stakeholders …

[50] Ibid

Notably, one factor warranting the attention of local content policy makers is the practice of multinational upstream operators' adoption of regional strategies when procuring energy services. As previously mentioned in ***Section 2***, typically, contracts awarded in different hydrocarbon provinces situated within the same region and involving similar types of services are "bundled" to one contractor or a group of international services contractors. Albeit, the bundling of contracts may be more economical for the multinational upstream operators. However, those manoeuvres have made it more difficult for the local energy services firms to win contracts in the domestic industry. To counteract this, the implementation and enforcement of local content statutes and moral suasion can influence operators to adopt local strategies for the T&T industry and at the onset, local ES firms in T&T's oil field development plans can be solicited.

Again, industry stakeholders commented that local content policy instruments for T&T's energy industry ought to be geared towards creating a level playing field and driving greater export competitiveness of local ES firms rather than being too onerous and punitive. T&T's energy industry and economy are heavily dependent on investments made by major upstream operators to maintain and or possibly boost production levels in the medium to long-term. Also, as an oil province that has experienced declining reserve-replacement ratios and production levels from mature oil fields, T&T must compete with new and emerging oil producing countries for investment. The sector must be weary of local content policy statutes which may be too stringent, likely to discourage foreign direct investment, and reduce the competitiveness of the domestic sector. On the other hand competitiveness-driven local content regulations are more likely to maintain an investment friendly climate through the introduction of the following[51]:

- Minimum local content targets;
- Minimum targets for growing the competitiveness of suppliers;
- Full, fair and reasonable access to opportunities for local firms; and
- Tender evaluation criteria for major contracts to drive supplier development.

… attempts to strengthen local content in the domestic energy industry will not be as effective as envisaged if "strong political will" is absent and a colonial or cultural mind-set that "*foreign is better*" persists.

Moreover, it is highly likely that attempts to strengthen local content in the domestic energy industry will not be as effective as envisaged if "strong political will" is absent and a colonial or cultural mind-set that "*foreign is better*" persists. Therefore, T&T's ES firms, nationals and institutions must develop a strong sense of self-belief. Policy makers must also possess a clear vision for the development of the energy services sector, articulating policies that guide the behaviours and actions of upstream and

[51] Ibid

downstream operators. Regulations must also be established and enforced assigning full authority to a local agency to monitor and evaluate the implementation of local content policies.

Local Environment

The local environment significantly influences the level of interaction existing between local policies, local infrastructure and local capabilities. Within the environment, governance mechanisms and the legislative backing to support institutional capacity to initiate policy making, planning and the regulation of local content and local participation are featured. Petroleum sector legislation (inclusive of the Petroleum Act No. 46 of 1969, and as amended by Act No. 4 of 2014 and the Petroleum Production and Subsidy Levy), production sharing contracts (PSCs) and petroleum incentives of the T&T government impact the development of local content. These and other variables influence the business development and investment environments of the energy sector.

In practice weak regulatory capacity and governance systems prevail. Transparency and accountability as prescribed by the Petroleum Act No. 46 of 1969 and as amended by Act No. 4 of 2014 and enforcement of regulations are absent. Research from this study further indicates that even in instances where local content policies in other hydrocarbon producing countries seemed to be comprehensive, their limited effectiveness were attributed to the non-existence of supporting legislation for local content. In the absence of legislation, upstream and downstream operators are not legally bounded to implement local content policy initiatives. With reference to the Nigerian experience, the introduction of local content policies without appropriate local content legislation led to local content policies being implemented on a discretionary basis and in a questionable manner[52]. While there are local content provisions in T&T's Petroleum Act and in the PSCs, enforcement of sanctions in favour of local content within the energy sector is sorely lacking.

Currently, the TTEITI is responsible for promoting transparency and accountability in the management of T&T's hydrocarbon resources. This agency reports on the harmonization of payments made by oil, gas and mining companies against government receipts[53]. However, in the local environment, local content disclosures are absent from transparency reports. T&T should follow suit like other EITIs in capturing more vital information such as, the commitments of upstream and downstream operators, data on local and expatriate employment, and procurement and capacity building programmes for local contractors and services firms, to support informed decision-making on the way forward.

[52] Kazzazi, Abolfazl, and Behrouz Nouri. 2012. *A Conceptual Model for Local Content Development in Petroleum Industry.* Growing Science Ltd.

[53] Trinidad and Tobago Extractive Industries Transparency Initiative. 2018. *Trinidad and Tobago EITI Report 2016: Champagne History, Mauby Reality, Adjusting to the new Paradigm*, TTEITI.

Local Capabilities

Local capabilities constitute education, skills and enterprise development, transfer of technology and know-how and the conduct of R&D, all of which are relevant to the needs of operators and ES firms.[54] Building local content capabilities means ensuring that the actors within the ES Innovation System are equipped with the requisite skill sets to increase local value added along the entire energy industry value chain. ***Figure 2*** illustrates that there are two types of skill sets critical to the growth of successful innovative local ES firms - operational and strategic management skills. Many ES professionals and skilled workers have acquired operational skills, having graduated from local universities and technical training institutions where the emphasis in teaching was and continues to be on building the scientific, technological and engineering capabilities of students. However, stakeholders argue that less of an effort is made at the university level to develop the RDI capacity for the energy sector. Again, increasing local value added requires deepening not only operational skills but also strategic management skills.

Fostering a cadre of local firms demonstrating skills in strategic management, though necessary, is weak. Local ES firms need to engage in activities on the higher end of the energy industry value chain. Strategic activities such as the establishment of joint ventures, mergers and acquisitions, equity partnerships can promote the growth and competitiveness of local firms. Much thought has been shared that mastering these strategic management skills can only be acquired through experience. Current business programmes at local tertiary level institutions were designed to teach students the rudiments of the various fields of business study rather than develop the human capacity to function at strategic levels.

Local Infrastructure

The analysis of the local infrastructure focuses on the elements deemed essential to enhance the efficiency and competitiveness of the local energy sector. These elements include the receipt of certification for appropriate industry standards, the availability of relevant business support services, the enactment of bilateral trade negotiations between the GoRTT and other hydrocarbon producing countries, effective efforts of the Work Permit Committee, the Permanent Local Content Committee (PLCC) and the MEEI in promoting, implementing and enforcing local content and local participation. Equally important as an element under the local infrastructure component is the provision of an upgraded physical infrastructure, particularly the ICT infrastructure. Data

[54] Kazzazi, Abolfazl, and Behrouz Nouri. 2012. *A Conceptual Model for Local Content Development in Petroleum Industry.* Growing Science Ltd.

provided on the performance of these elements determine the policy interventions required to support the local infrastructure of the ESS.

The acquisition of relevant certification of appropriate industry standards is essential for local ES firms seeking to prequalify for contracts in the energy industry. The STOW, while only relevant within the domestic sector, serves as an intermediary HSE standard. The ECTT's STOW Implementation Board is responsible for ensuring that the systems and business support services for compliance, monitoring and evaluation of HSE requirements developed under the STOW are established and functioning as intended[55]. In addition to implementing the STOW, local ES firms striving to export energy services and establish a presence in international markets should direct their efforts towards upgrading internal management systems through the acquisition of international industry standards such as ISO, API, ASTM and AWS.

There is a limited suite of services offered by business support/trade related institutions within the public/private sectors for local ES firms. As previously mentioned in ***Section 2***, some semblance of assistance is offered in the areas of financial services, capacity building workshops/training sessions and market intelligence/export market research. Certainly the conduct of a comprehensive export market research exercise is needed prior to entering into bilateral negotiations for the ESS. Energy cooperation agreements, bounded by MOUs between the GoRTT and foreign governments facilitate the export of energy services mitigating market access limitations for local ES firms.

The MEEI is represented on the Work Permit Committee which is chaired by the Immigration Division of the Ministry of National Security. Ideally, work permits are issued to upstream and downstream operators for foreign nationals that possess knowledge and skills that are either not available or in limited supply locally. Operators are required to demonstrate how they intend to fill these positions upon the expiration of contracts. Several industry stakeholders have lamented that some multinational operators have sidestepped that process. These operators utilise new job titles for positions that involve similar duties and responsibilities to those jobs performed by local personnel in possession of the requisite skill sets and knowledge. The completion of an updated job classification[56] for T&T's Energy Sector is necessary to reduce such occurrences. The Work Permit Committee must also exert a greater effort to ensure that initiatives aimed to address the transfer of technology, knowledge and skills from foreign workers to local personnel are instituted by both operators and foreign ES firms, in a timely manner.

Additionally, locally owned ES firms operating in different segments of the sector have demonstrated varying levels of expertise and share of activity. There are segments in which foreign firms dominate and others in which local ES firms capture a greater share of the sub-sector. As observed, most offshore drilling services are performed by foreign-owned services firms while

[55] The Energy Chamber, STOW Website (stowtt.info/index.php?categoryid=8) as cited on April 25, 2019.

[56] A Job classification is a system for objectively and accurately defining and evaluating the duties, responsibilities, tasks, and authority level of a job (https://www.managementstudyguide.com/job-classification.htm) as cited on April 12, 2019.

local ES firms supply a greater portion of inspection services for upstream and downstream segments of the sector. To increase local participation, the reconstituted Permanent Local Content Committee (PLCC) should first consider identifying sub-sectors in which local firms have capacity and currently supply energy services, and those sub-sectors where the potential of local ES firms to supply competitive energy services exist. At this juncture, interventions ought to be made to increase local firms' participation thereby engendering a greater share of local content in the industry.

A review of the literature suggests that local energy services firms stand to benefit significantly from competitiveness-driven local content regulations rather than protectionist-driven regulations. The benefits of protectionist-regulations appear short-lived, and in fact contravene core World Trade Organisation (WTO) principles which call for contracts to be awarded fairly, based on international competition, acknowledging price, quality and delivery[57].

There is consensus that MEEI has not effectively monitored the implementation of local content targets outlined in production sharing contracts (PSCs). Industry stakeholders remarked that a well-defined and effective system to monitor, measure and audit local content targets is missing from the infrastructure supporting local content development. The introduction of such a system is necessary and will require strengthening the regulatory, capacity and governance systems of the MEEI and other relevant ministries and state agencies in capturing information of this nature. There is a perception that this is the "core issue that has plagued the industry and led to the slide"[58]

Industry stakeholders remarked that a well-defined and effective system to monitor, measure and audit local content targets is missing from the infrastructure supporting local content development

4.2 Other Impediments to Innovative Activities

As articulated in earlier sections, local ES firms innovate to solve practical problems encountered while conducting E&P operations for oil and gas; to generate new revenue streams; and to sustain a firm's operations. As observed, the local environment in Trinidad and Tobago does not appear to lend itself as a ready market for new innovations. In addition to the lack of opportunity resulting from the absence of enforcement mechanisms supportive of local content, financial constraints, the composition and small size of the domestic market, cultural nuances such as "*foreign is better*" and resistance to technological change are also impediments to innovation in the ESS.

[57] Presentation entitled "Strategic Recommendations for T&T's Local Content Policy: Improving the National Bottom Line" by Zaffar Khan and Rene Marcellin, at the Revenue Management in Hydrocarbon Economies Conference on June 21, 2012.
[58] Anthony Paul. "The Future of Fossil Fuels" in TTCIC *Contact Magazine*, March 2019: page 11.

4.2.1 Financial Constraints

The pathway to innovation is risky business. There are no guarantees that an innovation once introduced into the market will bring significant returns to an investment. Funding schemes to support energy services innovations are virtually non-existent in the local setting. Most of the financing as articulated in this study is sourced via internal cash flows, internally generated equity, soft loans from family and friends and to a much lesser extent from commercial banks. In most instances, local ES firms embarking on RDI have encountered difficulty accessing finance from commercial banks. Banks usually assess requests for funding purely based on risks and finances. Oftentimes, they require loans to be fully collateralized with tangible assets. As previously stated in ***Section 2***, these restrictions naturally have been counterintuitive to innovation.

Financiers are generally not willing to approve loans for firms awarded short term contracts. This scenario can be very problematic for local energy services firms. Work for these stakeholders tends to be cyclical for relatively short periods between 3-6 months. The duration of one contract as well as the revenue earned cannot support the investments required to develop an innovation. In instances where financing from commercial banks has been accessed, this is owed to established personal relationships with banking personnel. Good cash flows, a diverse clientele obtained through servicing various operators and a track record of timely loan repayments are some of the core factors considered by banks when evaluating prospective loan applicants. Again, local ES firms have expressed repeatedly the need for banks to be more apprised of the work they do in order to improve the capacity of the bank to assess the credit worthiness of innovative projects for which they may seek funding.

4.2.2 Small Size and Composition of the Domestic Market

Currently, there are a few multinationals and several independent operators conducting E&P operations in Trinidad and Tobago. Most of these operators have been in T&T for a very long time, irrespective of the mergers and acquisitions that have taken place. Over this long period, these operators have established systems that work and the networks on which they rely for services. The introduction of an innovative breakthrough that could possibly be disruptive[59] to their systems, costly in adoption [60] and requires the retraining of staff, oftentimes has been met with resistance and limited success. With limited opportunities available, undoubtedly, the small size and composition of the domestic market has proven to be an impediment to innovation for local ES firms.

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[59] A disruptive innovation is one that displaces established products, firms and alliances creating a new market and value network (https://www.investopedia.com/terms/d/disruptive-innovation.asp) as cited on April 12, 2019.
[60] Technology switching costs can be very steep especially when the innovations proposed are not compatible with the existing infrastructure as articulated by Richard Small during an interview on November 11, 2015.

Although the challenge is very real especially for firms introducing disruptive technologies, finding a buyer or markets to sell the innovation is not impossible. The key to success in the local environment is planning which requires undertaking market intelligence research, networking to build relationships and ascertaining the needs of operators and international services providers who want to be at the forefront of technological changes. Of equal importance, finding the right business model that works for the given innovation is critical to its success in the local environment.

Some local ES firms have adopted inorganic approaches to selling their innovations. Some have integrated into the supply chain of international services providers; others have sought to enter joint venture partnerships with international investors and industry stakeholders gaining access to their partners' technologies, expertise and market opportunities; and still others, particularly those firms with resources, have acquired foreign ES companies in order to penetrate new markets.

4.2.3 Cultural Nuance: "Foreign is Better"

There is a common misconception that the technologies - equipment and processes produced by locally owned ES firms - are of an inferior quality compared to the technologies of foreign ES firms. Although many local ES firms have complied with the requisite international industry standards and have proven that their goods and operational processes are higher than or on par with their international counterparts, multinational upstream and downstream operators and other companies registered locally have demonstrated repeatedly their preference for services to be delivered by foreign ES firms. In most cases foreign energy services are priced at significantly higher costs. The cultural nuance *foreign is better* becomes more apparent when local industry stakeholders shared instances of companies with operations in the local territory showing preference for purchasing equipment from an international ES firm, and that foreign services firm having sourced the finished products directly from local ES firms. Rather than engage in trading directly with a local ES firm that manufactured the equipment, local and foreign companies felt more comfortable sourcing the equipment at higher prices from foreign-owned services companies which repackaged and rebranded the equipment with an international logo.

4.2.4 Resistance to Technological Change

Albeit the uptake of new and significantly improved technologies has facilitated the streamlining and automation of processes leading to improvements in productivity and profit margins, some companies within the domestic sector have resisted technological change. Several industry stakeholders identified Petrotrin (now defunct) as one of the most notable transgressors. Technologies that automated production processes such as the Smart Pumper did not gain the traction expected due to clients' fears that such technologies may render jobs within the sector,

obsolete. Dialogue among ES firms proposing technological solutions, their clients and labour unions, becomes absolutely necessary in determining the extent to which job scopes and duties will be altered. Certainly, strategies to retool personnel and temper unjustified calls for higher wages when employees' jobs scopes are altered, should be deployed.

Furthermore, decisions on technological change generally tend to be the responsibility of the executive management of ES firms. Some local ES firms have not viewed investments in innovation as imperative for their companies' success nor have they seen the need to alter processes and strategies that have proven successful over the years. These firms refuted the need to innovate on the basis that, technological advancements made within their spheres of interest over the years were inconsequential, thereby leaving intact dated processes related to the performance of services.

5. Other Factors Obstructing Progress in the ESS

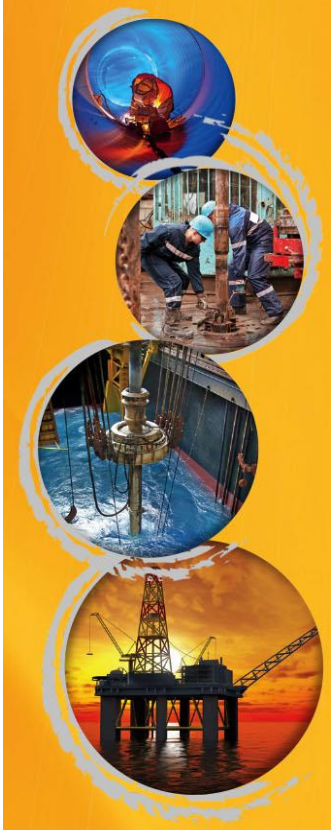
The presence of other factors within the enabling environment obstruct progress of local ES firms. These are as follows:

- **Bandwidth limitations** – Notwithstanding the uptake of new and improved technologies, it is rare for some ES firms to receive the quality of internet service needed. In Fyzabad and other remote areas in southern Trinidad where oil fields are located, bandwidth limitations negatively affect some firms in their operations either when downloading information, participating in video conferencing and/or in their procurement process vis-à-vis submission of tenders online.

- **Staff Retention** - Many small and medium sized ES firms have difficulty in retaining most of their graduates/recent hires for more than a year due to poaching activities of upstream and downstream operators and major international ES firms. These firms offer more attractive remuneration packages. Small and medium sized ES firms encounter setbacks when, after having made substantial investments in equipping their staff with the requisite skills, they face abrupt staff exits due to more lucrative offers.

- **Unstable Industrial Environment –** Instability in the industrial environment can stymie the performance of workers. As a worker's performance wanes so too does productivity. In the oil and gas sector, the role of the trade union is critical in maintaining a stable industrial relations climate. Representative associations such as the Oilfield Workers Trade Union (OWTU) act in the interest of their membership and the wider working class to ensure fair treatment of workers. Fair terms and conditions of work are governed by industrial relations principles, practices and legislation and facilitate a stable work environment which supports the employment relationship between the employer and employee. Further, in instances where disruptive technologies have displaced workers, the onus is on the OWTU to lend support to those displaced, sensitizing them to the importance of innovative upgrades to industry and offering assistance where needed to retool workers for continued relevance.

- **Under-Resourced Public Institutions such as the MEEI, the Environmental Management Authority (EMA) –** The MEEI is a critical stakeholder in this industry and must outfit itself with the cadre of skilled and seasoned professionals to carry out its responsibilities as outlined in the National Petroleum Act. Its current under-resourced status has negatively impacted the ESS. The EMA has made positive strides within recent years in demanding that companies comply with more rigorous environmental standards. Companies were required to adopt more advanced and environmentally friendly



technological solutions. However, the EMA is faced with a series of internal challenges which limit its effectiveness and hinder the work of local ES firms.

6. Role of the Government in Supporting the ESS

The conduct of an ES SIM study would be incomplete without consideration being given to the role of government in supporting this sub-sector of the energy industry. The ESS is a critical component in the drive to sustain and diversify the industry. Government must therefore make deliberate overtures to know this sub-sector and the many services and innovations local ES firms have to offer. To be successful in sustaining and diversifying the industry a holistic approach should be adopted. The relevant arms of government should fully understand their tasks and the impact each institution will have on what is to be achieved.

Responsibilities of Government

Through its ministries and state agencies, GoRTT must articulate the strategic direction for the energy industry. The country's overseas missions must also be strategically situated. These missions as arms of government have a primary and continuing facilitative role in promoting local energy services exports and paving the way for new business opportunities to be afforded local ES firms in foreign markets. As the country's top negotiator at high-level meetings, it is the head of government and in the case of Trinidad and Tobago, the Prime Minister who needs to champion and promote the local ESS in new development plans with the head of other oil and gas countries and other emerging players in energy. The onus is also on T&T's government as a national upstream and midstream operator to endorse the innovations and services of local ES firms. In hindsight, these are some of the key roles and responsibilities that have been realised by governments of successful oil and gas economies supporting domestic energy services firms.

The Current Local Setting

Research indicates that sporadic initiatives are not set into a cohesive plan of action for the sub-sector. Further, a lack of continuity in the government's strategy and a shift in policy direction over time, averted promising initiatives with potential opportunities for local ES firms in emerging oil provinces on the western arm of Africa. Industry stakeholders identified these as major factors that decelerated the progress of negotiations undertaken by the NGC on a potential investment to build a Gas Processing Facility for Ghana's Jubilee Field (ECTT 2016). That investment was expected to set in motion many opportunities for T&T's ES firms.

In 2016, the MEEI supported the reconstitution of the Permanent Local Content Committee whose mandate was to action the recommendations of the *2004 Local Content and Local Participation Policy and Framework*. The policy however,

appears to be written at a high level and does not articulate a clear action plan for developing the local ES sector. As previously mentioned in ***Section 4***, it fails to detail activities, set targets or articulate a code of behaviour for industry stakeholders. Inadvertently omitted from the policy is a public sector authority to monitor and evaluate policy implementation.

In 2016, MTI was also tasked with the responsibility of formulating a Trade Negotiation Strategy for the ESS. Subsequently, a committee comprising representatives of the main actors in the ESS was convened to guide the development of this strategy. In 2019, this initiative seems to have been relegated to the backburner. Notwithstanding, if government is of the firm belief that "the country is well poised to service the industry requirements emanating from the development of emerging hydrocarbon economies in the Caribbean"[61], then this strategy needs to be completed, thereby giving priority to sensitizing and guiding local ES firms in mitigating trade barriers. One such barrier identified as a deterrent to trade in energy services is the absence of a double taxation treaty between Suriname and Trinidad and Tobago. Local energy services firms conducting business in Suriname are required to pay taxes both to the Surinamese and Trinidad and Tobago governments.

As sole owner of the NGC and its main subsidiaries, the government is best positioned to play a pivotal role in expanding T&T energy services into regional and international markets. To grow the international portfolio and diversify revenue streams, NGC has signed several Memoranda of Understanding (MOUs) and has pursued international partnerships with selected state owned energy companies in Ghana, Venezuela, Mozambique and Tanzania. Arguably, while midstream services can benefit immensely from these agreements, local energy services firms can also benefit particularly from opportunities arising in pipeline construction and fractionation projects. In 2019, a Memorandum of Agreement (MOA) was executed between Trinidad and Tobago and Guyana. Another MOA is being prepared between T&T and Grenada. Under these agreements, Trinidad and Tobago is expected to provide technical expertise and experience to these neighbouring CARICOM states in the development of their hydrocarbon resources[62]. While all these initiatives are necessary and welcomed, they are conducted in a piecemeal manner. Government needs to take a more active and coordinating role in supporting services and innovations of local ES firms through engagement and strategic planning.

An export-oriented model that is worth pursuing with the support of government is the formation of a "T&T Inc." that draws on the strengths of local ES firms contracted or subcontracted to service overseas operations as well as, service national midstream and upstream operators such as NGC and Heritage Petroleum Company Limited respectively, bidding for opportunities abroad.

[61] Feature Address of Dr the Honourable Keith Rowley, Prime Minister of Trinidad and Tobago. 2019 Energy Conference and Trade Show, Port of Spain, Trinidad.
[62] Ibid

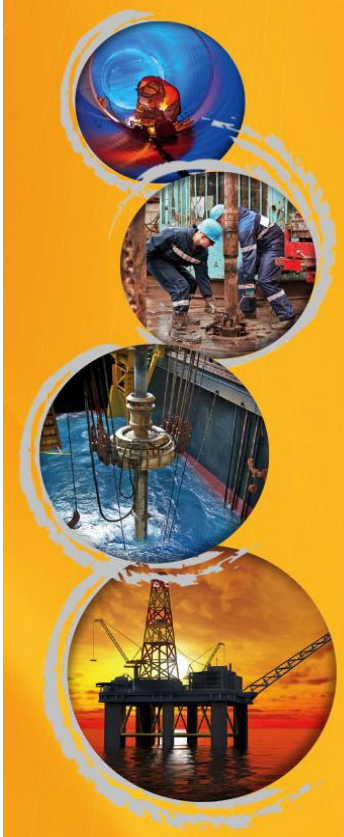
7. Conclusion

The recent discovery of significant oil reserves in neighbouring Guyana and other oil finds in Suriname, French Guiana and Venezuela open up a myriad of opportunities to grow the export of T&T's energy services and stimulate the adoption of high valued innovative technologies developed in part or whole by local ES firms. These positive developments present opportunities for the local sector to provide assistance in developing indigenous capabilities in services, skills, enhancement of infrastructure and natural gas industries. Trinidad and Tobago's energy services personnel are highly reputed and respected, having sold themselves as talented and capable in supplying advisory, technical, and capacity building services all over the world. Less known globally are their innovative products and processes, tested and tried by operators in the local market. The import and adoption of these innovative technologies by international operators and services companies can generate significant revenue for the local economy. As with most competitive industries, missed opportunities in the energy sector, will certainly be seized as another country's gain.

In T&T's Energy Services Sector, innovation takes place at the individual, team and organizational levels. It is generally driven by visionary leaders in industry with expert knowledge and the ability to choose the right problems to solve. In most instances, these visionary leaders become part of a team environment that capitalises on the creative process. Some leaders encourage within their firms a climate that fosters the generation of ideas and experimentation; others, rely on trusting relationships with overseas partners which allow access to cutting edge technologies.

In the local setting, there are more impediments to innovation than there are drivers. Conducting RDI in the ES sector is very expensive and financial constraints can be problematic stalling the innovation process. The lack of opportunity also impedes local ES firms' participation in innovative activities. Without a ready market, engaging in innovation is too risky a business. Many local ES firms also argue that this lack of opportunity is caused by the absence of enforcement of local content. Other challenges include the small size and composition of the domestic market, cultural nuances that "*foreign is better*", and resistance to technological change.

Local ES firms innovate for various reasons. Some out of necessity, as being more efficient in operations is fundamental to survival. Others innovate, possibly envisioning an opportunity to tap into a new source of available revenue. The innovative activities of these firms aim to solve problems encountered by upstream/downstream operators; and there are those firms that innovate to minimize the negative impact of oil and gas exploration and production on the



environment. Stimulating growth in innovation in the local ESS is no easy task. It requires the effort of all actors identified in the ES Innovation System.

It is evident from the study that moderate and weak linkages exist between the five (5) categories of actors identified in the ESS Innovation System. The analysis suggests that in most instances, the linkages between actors are weak, the common denominator being an intermittent flow of technology and information. In comparison, a strong linkage is usually characterised by a continuous relationship nurtured by the free flow of technology and information yielding a productive intent. These irregular flows and in some instances, the lack of connectivity between actors have resulted in the absence of constructive dialogue and collaboration, a lack of awareness, the need for more relevance, and a dilution of what ought to be more targeted support.

Under these circumstances and with a clearer understanding of the environment that prevails, the ESS SIM study paves a way forward with an Action Plan. Private and public sector stakeholders are charged with responsibilities for strengthening the ESS Innovation System. The success of a strengthened and robust Innovation System depends on commitment and decisive action on the part of all stakeholders to build on the existing competencies and experience of local ES firms; the design and roll out of relevant business and trade support services; strengthened governance of the sector; trade in energy services; the development of alternative funding mechanisms to support innovations; the collection of ES data to improve and inform decision-making and the roll out of an export-oriented model that supports the growth .

In spite of the deterrents to innovation, the environment within which ES firms operate is very dynamic. The recommendations contained in the Action Plan supports the current context and government's efforts to seek redress for its dependence on export earnings solely from the production and export of oil and natural gas. Diversifying the energy sector and attracting investments in alternative sources of revenue is aligned to the *National Development Strategy of Trinidad and Tobago*. The ESS SIM study is a living document, to be updated periodically, perhaps every five (5) years, to maximise its relevance and ensure that activities outlined in the Action Plan are measured and would have achieved their desired goals.

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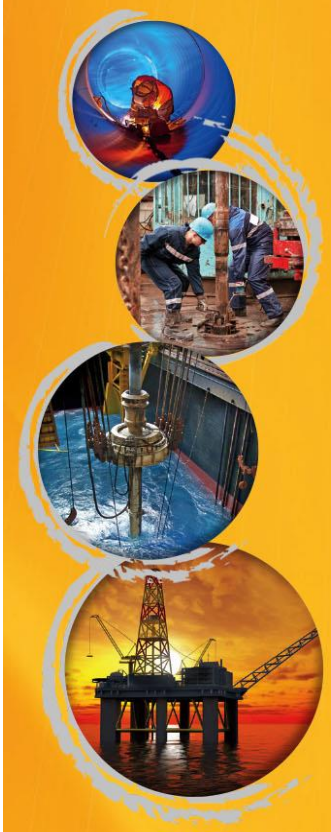

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Appendix I

Action Plan for the Energy Services Sector of Trinidad and Tobago

Themes	Activities	Intended Outputs	Intended Outcomes	Responsible Agencies
Building Capabilities (competencies and experience) for the Energy Services Sector	The introduction of new Associate and Bachelor's degree programmes in welding and non-destructive testing at UTT and COSTATT respectively	Associate and Bachelor's degree programmes in welding and non-destructive testing approved and operational	Increased pool of certified and skilled personnel in welding and NDT testing for the energy sector	MOE UTT COSTATT NTA Industry stakeholders in inspection and welding
	Expansion of the Point Lisas Industrial Apprenticeship Programme to provide a greater number of NESC, MIC and YTEPP students with experiential learning	An increase in the number of apprenticeships offered to graduates of NESC, MIC and YTEPP to approximately 35%	Expansion of the Point Lisas Industrial Apprenticeship Programme to provide a greater number of apprenticeships for students of NESC, MIC and YTEPP	MOE MEEI NESC MIC YTEPP
	The conduct of a Survey on the Energy Services Sector periodically (skills matching every 5 years) by the NTA	The survey findings will determine: • Current job vacancies within the ESS • Requisite competencies (knowledge and skills) of industry	The supply of the active labour force meets the labour demands of industry	NTA ES firms ECTT
Provision of a relevant suite of business and trade support	Design, deploy and market customised business and trade support services for the ESS	A suite of relevant business and trade support services	Increased uptake and use of customised business and trade support services by ES firms	ExporTT EXIM Bank MTI ECTT IPO

Themes	Activities	Intended Outputs	Intended Outcomes	Responsible Agencies
services for the ESS				
	The establishment of compulsory national standards and quality control methods for services such as non-destructive testing (NDT)	Compulsory national standards for services such as NDT are articulated and operationalised	Improved safety, quality and standards for NDT services in the local ESS The effective coordination of standards development in the energy sector	NTA Industry stakeholders in inspection and welding TTBS
	Hosting workshops to sensitise: • Banking institutions to the financial challenges encountered by ES firms • ES firms to available funding facilities offered by the local Banking Sector	Workshops conducted The exchange of relevant information documented	Improvement in the design and targeting of financial support services in the ES industry	ECTT BATT EXIM Bank
Provision of alternative funding sources for innovations in the ESS	Establishment of a database identifying the available funding schemes to support innovations from the ESS	A database created and fully operational	An increase in the number of ES firms accessing eligible funding schemes for their innovations	MEEI PLCC
Strengthening governance of the ESS	Provision of governance and coordination of the ESS by MEEI and a state-driven coordinating unit under the MEEI's Energy Research	A strategic direction articulated in a plan of action by the MEEI	Improvement in the performance of the ESS	A state-driven coordinating unit under the MEEI's Energy Research and Planning Division

Themes	Activities	Intended Outputs	Intended Outcomes	Responsible Agencies
	and Planning Division			
	Establishment of a national petroleum registry that includes ES firms	A national petroleum registry established	Increased employment opportunities and income for ES firms Improved decision-making for the ESS through the collection of relevant data Increased collaboration between local ES firms and other stakeholders	MEEI ECTT Registrar General CSO
	Data collection and reporting on local content and local participation articulated in TTEITI's Annual Reports	Annual TTEITI Reports prepared and published with data on: • Upstream/downstream oil and gas operators' implementation of local content requirements • Local and expatriate employment levels in the Energy sector • Procurement of services from local ES firms • The value of contributions to education and technical training institutions by	Strengthened transparency in the implementation of local content requirements Improvement in identifying problems/solutions for the sector	TTEITI MEEI ECTT Upstream/ Downstream Operators

Themes	Activities	Intended Outputs	Intended Outcomes	Responsible Agencies
		upstream/downstream operators		
	The conduct of a job classification survey for the energy sector	A current job classification report for T&T's energy sector	Increased transparency in the issuance process of work permits for the Energy Sector Increased uptake of the active local labour force into the vacancies identified in the sector	MEEI MNS ECTT
Building a viable export-oriented energy services sector	Open dialogue/negotiate agreements with Heads of States (HOS) of oil and gas economies	Memorandum of Agreement with oil and gas producing countries	Increased support and endorsement from government	OPM MEEI MoFA MTI
	Establishment of T&T Missions and recruitment of commercial attaches in missions where agreements with HOS are signed	Facilitation of new trade and business transactions in the oil and gas sector	Building of T&T brand, making new connections, stimulating trade and business opportunities for local firms	MEEI MoFA MTI ECTT
	Conduct of market intelligence research targeting consumers of energy services in overseas markets	Identification of new markets and barriers (tariff and non-tariff) impeding access to targeted markets	Improvement in the use of resources and increasing the likelihood of success	MEEI exporTT ECTT Overseas T&T Missions
	Prepare National Energy Policy	Cabinet approved National Energy Policy	Clear strategic direction set for stakeholders in the industry	MEEI

Themes	Activities	Intended Outputs	Intended Outcomes	Responsible Agencies
			Increased opportunities for energy services	
	Prepare a Trade Negotiation Strategy for Energy Services	A Trade Negotiation Strategy is developed and approved by the Cabinet	Increased awareness of how to treat suppliers and consumers of energy services	MTI
	Formation of a company "T&T Inc." that coordinates the services of local ES firms ready to export to overseas markets	The establishment of a registered company that coordinates the relevant services of local ES firms	Increased job opportunities for export ready local ES firms servicing large scale E&P projects Increased revenue streams	MEEI ES firms
Strengthening the collection of data on the ESS	Identifying data collection sets that are not readily available but are critical to an improved performance of the ESS	Data of relevant ESS baseline indicators identified and available	Improved decision-making for the ESS	CSO CBTT MEEI
	Establish a focal point/unit for the collation and analysis of energy sector data	Focal point/unit identified and approved	Increased use of production data, seismic data, subsurface data, and process and plant operations data for decision-making	CSO MEEI MOE

Appendix II

To determine the intensity of the linkage between specific actors, a percentage is calculated using the score given against the weight assigned for each linkage. The percentage of ratings is as follows:

- 70% - 100% constitutes a strong linkage
- 50% - 69% constitutes a moderate linkage
- Less than 50% constitutes a weak linkage

Table 5: Linkage between Local ES Firms and the Energy Chamber of Trinidad and Tobago (ECTT)

Factors Considered	Score	Weight
The development and roll out of supporting initiatives on an ongoing basis to enhance the competitiveness of local ES firms	5	8
The deployment of mechanisms to sensitise local ES firms to: ➢ Opportunities (local and foreign); ➢ Issues impeding the sector's advancement; ➢ Business support services available within the enabling environment	6	8
Lobbying upstream and downstream operators to increase procurement of local energy services in the domestic market	2	8
The level of participation of local ES firms at events hosted by the ECTT	6	8
Total	19 (59%)	32 (100%)

Table 6: Linkage between Upstream Operators and Educational/Technical Training Institutions

Factors Considered	Score	Weight
The design and implementation of relevant courses/programmes at educational/technical training institutions to equip students with the requisite skill sets and industry certification	6	8
The type and frequency of collaboration between upstream operators and educational/technical training institutions	6	8
The conduct and transference of relevant academic research (consideration given to faculty and students' research) to upstream operators	2	5
Total	14 (67%)	21 (100%)

Table 7: Linkage between Local ES Firms and Educational/Technical Training Institutions

Factors Considered	Score	Weight
The design and implementation of relevant courses/programmes at specific educational/technical training institutions to equip students with the requisite skill sets and industry certification	5	8
The type and frequency of collaboration between local ES firms and educational/technical training institutions	2	8
The conduct and transference of relevant research work from academia (consideration given to the research work of students and faculty) to the ESS	1	5
Total	8 (38%)	21 (100%)

Table 8: Linkage between Local ES Firms and Upstream/Downstream Operators

Factors Considered	Score	Weight
Procurement of local energy services for upstream and downstream operations in the domestic market	4	8
Procurement of local energy services for upstream and downstream operations in foreign markets	2	8
Opportunities created for local ES firms in networking and sharing of information for future planning	3	5
The frequency with which local ES firms are sensitised to local and international HSSE standards and, expectations in service delivery	3	5
Total	12 (46%)	26 (100%)

Table 9: Linkage between Local ES Firms and the Ministry of Energy and Energy Industries

Factors Considered	Score	Weight
MEEI's development and implementation of initiatives that enhance the competitiveness of local ES firms operating in domestic and foreign markets	1	5
MEEI's formulation of policy and strategy to articulate a clear strategic pathway for stakeholders in the energy services sector	1	5
MEEI's knowledge of the services and innovations offered by local ES firms	1	5
MEEI's performance as a regulator with specific reference to the issuance and renewal of licences (E&P, Refining, Pipeline, Export, Marketing, Transportation licences), collecting financial obligations from licensees, establishing a petroleum register	3	8
Total	6 (26%)	23 (100%)

Table 10: Linkage between Local ES Firms and Public Business Support/Trade Related Institutions

Factors Considered	Score	Weight
The development and roll out of relevant business support/trade facilitation services to enhance ES firms' competitiveness and entry into export markets	3	8
ES firms' usage of business support/trade facilitation services	2	5
ES firms' awareness of the available suite of business support/trade facilitation services	2	5
Business support/trade facilitation organisations knowledge of the challenges and trade related needs of local ES firms	2	5
Total	9 (39%)	23 (100%)

Appendix III

Key Performance Indicators for the ES Sector of Trinidad and Tobago

Focus Area	Indicator
Demographics	No. of registered Energy Services (ES) firms
	No. of registered ES firms in operation
	No. of ES firms exporting services
Volume of activity in the ESS	Foreign Direct Investment into the Energy Industry
	Total depth of exploratory and developmental drilling on land and sea
	Foreign Direct Investment into the Energy Industry
Revenue Generation	Contribution of the Petroleum Support Services to GDP
	Value of Energy Services exports
Volume of Innovative Activity	No. of innovative products and services introduced by ES firms
	No. of innovative production processes introduced by ES firms
	Research, Development and Innovation (RDI) Expenditure in the ESS
	No. of patents and other IPRs e.g. industrial designs filed by local ES firms
	No. of patents and other IPRs e.g. industrial designs granted to local ES firms
Employment	No. of technicians employed by the ESS
	No. of engineers (by function e.g. geosciences, petroleum engineering, reservoir engineering, chemical engineering,) within the ESS
	No. of technologists employed within the ESS
	No. of firms/individuals providing technical advisory services
Education	Annual Tertiary education graduates in petroleum related programmes
	Annual Technical/vocational education graduates in petroleum related programmes
Provision of Business Support/Trade Facilitation Services	No. of ES firms attending trade missions
	No. of ES firms benefiting from Export and Capacity Building Programmes
	No. of ES firms approved for grant funding from public sector institutions.
	No. of ES firms approved for funding from international donor agencies.
Industry Standards	No. of ES firms with certification (e.g. STOW and ISO 9001)

Appendix IV

Contribution of Petroleum Support Services to GDP (2013-2018)

	2013r	2014r	2015r	2016r	2017r	2018p
GDP (Current Prices) TTD	**3,218.7**	**2,801.2**	**2,913.8**	**1,971.0**	**1,651.7**	**1,716.8**
% Change	**32.7**	**(13)**	**4**	**(32.4)**	**(16.2)**	**3.9**
% Contribution	**1.8**	**1.6**	**1.8**	**1.4**	**1.1**	**1.1**

Source: Ministry of Finance, Review of the Economy 2018, "Turnaround"

Appendix V

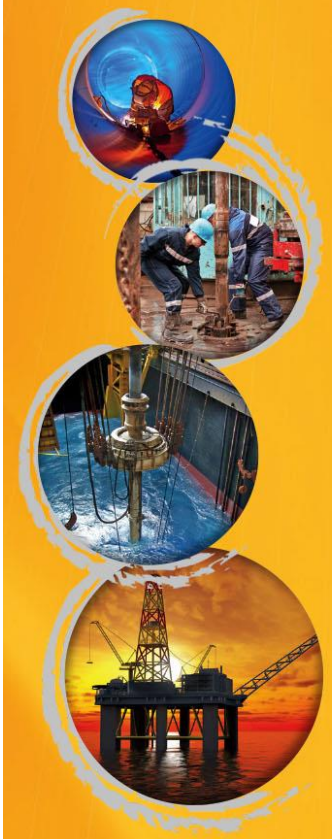
Introduction

The Policy, Research and Intelligence (PRI) Department of NIHERST embarked on executing the second phase of the Energy Services Sectoral Innovation Mapping (SIM) study namely, the conduct of Primary Research. A total of sixty-two (62) interviews were conducted with approximately eighty (80) persons, using semi-structured questionnaires. Where clarification was required to gain a more comprehensive understanding of the changing dynamics in both the domestic and global oil and gas industries, further contact was made with stakeholders via e-mail and telephone discussions.

A Stakeholder Feedback Report was generated from this primary research phase of the ES SIM project. This phase lasted for approximately six (6) months. The responses captured were provided by actors from industry, educational/technical training institutions and public and private sector institutions which were selected from a database collated during Phase One, the preliminary research phase of this project. Questions posed to interviewees aimed to glean a profile of each institution, their endeavours at home and views on the viability of the industry, ES firms' linkages with other actors in the innovation system, their engagement with innovation in the sector, and the challenges faced in the industry

All responses were captured under the following eight (8) themes:

- The viability of the ESS/Exporting energy services to emerging oil and gas producing countries;
- Accomplishments within the ESS;
- The concept of innovation in the ESS;
- Drivers of Innovation;
- Impediments to Innovation;
- Challenges encountered in the ESS;
- Building capabilities in the ESS; and
- Standing in the Future.



The Viability of the ESS/Exporting Energy Services to Emerging Oil and Gas Producing Countries

Virtually all stakeholders expressed confidence in the viability of the domestic energy services sector. Several interviewees expressed that T&T's petroleum sector has been in existence for more than one hundred (100) years and were of the

opinion that this sector occupied by four to five hundred (400-500) firms will be around for many more years. They explained that it is the oil and gas sector that drives the national economy. Other sectors are dependent on it and if the oil and gas sector fails to perform, other sectors will suffer. ES personnel believed that the viability of the sector is dependent on how well it is managed by the Ministry of Energy and Energy Industries (MEEI). They believed that this Ministry plays a pivotal role in setting a strategic direction for this sub-sector and positioning the country as a hub for regional and extra-regional energy services. Stakeholders also spoke very openly about the opportunity to use the oil and gas sector as a platform from which to diversify, using business technology, business systems and procedures from oil and gas to strengthen other industries.

Stakeholders also believed that so long as the energy sector exists, so too will the need for energy services. The export of energy services has the potential to be a niche market. Stakeholders explained that this market could not develop without strengthening the local energy services sector. As will be explained under the section titled *Challenges Encountered in the ESS*, lack of enforcement of local content is problematic for the sector. Local ES firms do not have sufficient opportunities to hone their skills at home before going abroad. And if the price of oil remains low over an extended period of time, the demand for oil and gas services would fall. As indicated, there are many opportunities abroad for local energy services firms. Stakeholders explained that foreign countries such as Papua New Guinea, and French Guiana revealed a preference to recruit the services of firms from developing countries rather than those of developed countries.

Energy services personnel explained that exporting local energy services can earn much needed foreign exchange, as well as generate and retain employment in the oil and gas sector. Reference was made to the lost opportunity when negotiations undertaken by the NGC to build a Gas Processing Facility for Ghana's Jubilee Field ceased. Many lamented that with no real plan for the sub-sector, a lack of continuity in government strategy coupled with ongoing shifts in policy direction stymied the project.

Accomplishments within the ESS

T&T's ES firms have developed a rich pool of knowledge and mastered a wide range of skills and competencies. Industry stakeholders boasted of the following accomplishments as well as, innovations of the local energy sector:

- T&T has produced some of the world's top drillers, geologists, petroleum and reservoir engineers and technical trainers. This high level of proficiency in these respective fields is due in part to working under very complex geological conditions. T&T is situated at the intersection of three (3) tectonic plates and therefore the nature of the rock strata is complex.

- Local ES firms' greatest export is their intellectual capital. Trinidadians have been working in oil fields worldwide, making a difference for the markets in which they operate. These

nationals and services companies adapt very well to foreign cultures and are highly regarded for their expertise. Nationals hold senior positions in major oil and gas companies and have been at the forefront in terms of developing policies particularly, local content policies in emerging oil and gas countries. According to one stakeholder "*our local personnel are willing to share their knowledge. They are open in sharing information. This helps build relationships*."

- In the early 1960's, Trinidadian engineers built the largest offshore platform in the world, at that point in time, in Guapo, South Trinidad.

- Prior to the commencement of offshore drilling, T&T's energy sector personnel developed and implemented deviated drilling techniques, providing access to oil fields that started near the coast and continued offshore. Today, local personnel in ESS are highly reputed worldwide for their skills in directional drilling. They can be found in Norway, Antarctica, Falkland Islands to name a few.

- Local ES personnel constructed platforms used by major upstream operators in offshore oil and gas production – for example, the construction of bpTT's Juniper Platform and Cannonball Fc, the Oil Bird and Poinsettia Facilities.

Several innovations were discussed during interviews and the purpose of these innovations thus far. Mention was made of the *Smart Pumper*, an automated and monitoring system that can manage well sites situated in remote areas. PetroCom Technologies Trinidad Limited spoke of their work with foreign firm New Horizon to run the initial tests for this device. This ES firm also introduced *Seisnetics Technology* to the local setting. This type of software locates with precision oil and gas findings in frontier and mature basins. Another ES firm Hydrocarb Trinidad Limited introduced three (3) innovations an *Emulsion and Effluent Treatment Process* that breaks up tight emulsions and separates solids from fluids, the *Tar Sands Bitumen Removal and Fluidization Process* that fluidizes bitumen and the *Pipe Cement Interface Bond Enhancer* that coats the surfaces within a drilling and /or well system enhancing the longevity of the well.

Other innovations shared included an *Indigenous Bacterium* cultivated by Analytical Technologies Limited (ATL) for the biodegradation of oil in contaminated soils. Offshore Technology Solutions Limited (OTSL) spoke of the modifications made to an *inspection eyeball remotely operated vehicle (ROV) to perform work functions.* IAL Engineering Limited indicated that they collaborated with an international energy services firm to design a *Casing Hanger* which is that portion of a well head assembly that supported the casing string when lowered into the well bore. Perfection Services Limited introduced their *Tubular Pipe Transport Rack System* which allowed companies during the exploration phase to stack the pipes in the order of utilisation.

Other innovations introduced by local ES firms and developed by international firms were the *Coiled Pipe Reel System* introduced by OTSL. This innovation is a polyethylene tube which replaces the traditional rigid pipe in drilling operations. Another innovation adopted and deployed by Trinidad Inspection Services Limited is the *Rope Access Technique* which gives workers access to hard to reach areas on work platforms. In essence, this technique replaces scaffolding. Despite the long list of innovations developed, industry stakeholders were of the view that the pathway to innovation is risky and never smooth. Stakeholders believed that there are still many innovations which to date are either not known or not well documented.

The Concept of Innovation in the ESS

Some firms expressed that an innovation is not an invention. They indicated that innovations in the ESS manifested themselves in various forms, for example, the development and sale of a new product and/or process or simply an improvement in the way a firm operates to do things more efficiently.

Stakeholders further explained that innovations spawned in the energy services sector can be used in other sectors and vice versa. An example of this scenario shared by one stakeholder was the use of a surveyor's instrument designed for one industry but also applied in Forensic Science to map crime scenes.

Another stakeholder remarked that *"innovations are commercialized solutions that respond to current or future problems within industry*." Interviewees all appeared to share the notion that while there is need to innovate, there are challenges in the system.

Drivers of Innovation

Many ES firms stressed that an overarching attribute that stimulates a company's innovative efforts is the vision possessed by their firms' executive management and senior personnel. Among those interviewed, senior managers acknowledged the benefits derived from firms' having the absorptive capacity to innovate. They claim that this innovative capacity is demonstrated when personnel developed an intimate working knowledge of the mechanics that underpin existing technical operations and used that knowledge to develop and or modify technologies and processes. They further explained that the capacity to innovate extends well beyond academic qualifications. Having the wherewithal to innovate is developed and sharpened over time, especially when firms are forced to solve problems encountered. Even in instances in which local firms lacked the requisite human and financial resources to develop innovations, they indicated that they were able to conceptualize innovative ideas and partner with local researchers and foreign ES companies to move their ideas from the stage of conceptualisation to innovative solutions.

Another common viewpoint shared, was that innovation within the ESS is driven by the needs of firms. Several reasons were given by ES firms for engaging in innovative activities. These firms spoke of the need to: make operations more effective and cost efficient, which allowed some firms to survive periods of downturn; problem solve technical challenges encountered by clients; integrate new technologies to make things function more efficiently, almost to optimal levels; innovate only if the technology needed is unavailable; and in few cases, take advantage of opportunities to generate new revenues streams.

Having the right attitude and knowing how to deal with failure also drives one to be persistent in innovating a new product or process. One stakeholder shared his opinion that the way failure is viewed militates against the many attempts required to innovate. He explained, "*to succeed, one must stumble along the way, it does not happen on the first shot. Everyone wants quick results and is not prepared to work hard to see things come to fruition*." Another seasoned stakeholder further explained the issue well: "*unsuccessful attempts should be seen as a learning curve, as failure is essential to innovation and perseverance is a key element in relation to overall success. To be truly innovative one must be able to learn from failure. However, the stigma attached to failure in T&T is counterproductive to innovation*."

As noted, some local ES firms made a concerted effort to be pioneer implementers, original equipment manufacturers (OEMs) or agents of new technologies sold to firms in domestic and regional markets. These early adopters indicated that they diligently monitored international market trends to know future demands for oil and gas services as well as, watched the entrance of high technology instruments in the global market, to assess ways in which these foreign technologies could be modified and applied to improve local operations. The acquisition of crucial industry certifications and standards provided micro and small sized ES firms with a competitive advantage over other similarly sized ES firms in the domestic market.

Impediments to Innovation

Several stakeholders spoke about the operating environment in which their firms must exist. The relatively low hydrocarbon commodity prices experienced post 2014 ushered in a "new normal" which has negatively impacted the demand for energy services and the price operators wished to pay for these services. They explained that the demand for their services has reduced and in low price environments, operators have made it clear that they want low costs in proposals/bids put forward by local ES firms. Stakeholders indicate that firms have also been asked to reduce prices on ongoing projects. Under these circumstances of reduced opportunities, local ES firms have expressed that they feel less incentivized to invest in innovation. Again, stakeholders conveyed that cost is becoming an important factor in their clients' shrinking budgets and this militates against companies bringing on new technologies.

Only a few of the many locally owned energy services firms interviewed had much to share of their involvement in executing the research and development required for product and processes

innovations. Several others articulated that the small size of the domestic market did not lend itself to the extensive R&D required by the industry. The costs and risks involved in undertaking innovative projects are high. Alongside these factors, local ES firms believe that they are not globally recognized for their R&D efforts, nor even for those technological innovations that are widely used internationally. Further, stakeholders pointed out that, technologies developed for the energy industry are required to undergo significant testing to ensure accuracy in performance of the intended works and that requirements of industry standards set by associations such as the American Petroleum Institute (API) must be met. As a consequence of these aforementioned factors, they state that firms would rather purchase technologies/equipment developed by international energy companies rather than invest in R&D efforts in-house.

Looking inwardly, others have argued that they are too small in size to develop new products and processes. Their firms do not possess the appropriate resources to conduct R&D. For some of these companies, their efforts are better directed towards becoming the agent or the sole distributor for a new technology. According to one such firm. "*Timing is everything. Small companies have a window of eighteen (18) months to sell a new technology. Big operators do not purchase new technologies on impulse. They must see the benefit to include this cost in their next budget cycle*. *Big companies tend to go directly to the local ES firm's supplier abroad in an attempt to take away the business*." Introducing a new technology to operators in the domestic market is costly due to the fact that before introduction, these firms need "*to conduct research, send money to acquire the technology, train and certify their personnel in the use of the technology*." Additionally, they need "*to test the technology to ensure it meets the requirements of their clients*." They lose considerable investment when larger companies capture potential opportunities.

The switching costs associated with adopting disruptive technologies also stifled ES companies' innovative efforts. Stakeholders were of the opinion that marketing innovations to existing operators is significantly less effective, when the technologies being marketed are incompatible with the operators' existing infrastructure and consequently, likely to incur high switching costs. In this scenario, ES firms needed to propose "*disruptive*" technological solutions before upstream and downstream operators made significant investment decisions.

Stakeholders also explained that the colonial mind-set of "*foreign is better*" has also stymied the ESS's innovative progress. Companies indicated that once this mind-set prevails, local ES firms will continue to face several challenges. In many instances, international ES firms were awarded the most lucrative contracts, while many local ES firms were either sub-contracted or given opportunities only when international ES firms were unable to service upstream operators' requirements. One stakeholder described the example of firms operating in the domestic sector and displaying a preference for purchasing at much higher prices, equipment bearing the branding of a prominent multinational ES firm, rather than purchasing at significantly lower prices, the same items from the original manufacturer which in this case was a local energy services firm. This occurred frequently, despite consumers knowing that the original manufacturer was a local firm which sold the equipment over to the multinational ES firm.

Moving an idea to an innovation is a costly process. In this regard, ES firms expressed their challenges in accessing adequate finance to realise their innovations. They shared that local financial institutions were unwilling to finance their innovations and provided limited insurance coverage. One industry stakeholder remarked that T&T's banks suffer from "*energy phobia*." Local financial institutions were found to be highly risk averse and assess requests for funding based solely on risks and finances. Innovation presented a substantially higher risk and financial institutions were reluctant to provide financing. Consequently, many firms in the nascent stage of development would not qualify for loans. Banks required loans to be fully collateralized with tangible assets. Banks also wanted to see long term contracts for services firms as well as, workman's compensation which were difficult to attain from upstream operators. These restrictions namely, limited available resources, were counter-intuitive to innovation. Several local ES firms remarked that innovations generally were self-funded or funded through soft loans acquired from family members and friends.

ES firms were also of the opinion that banks ought to be but were not fully apprised of the nature of work in the ESS and therefore there was an inherent misunderstanding of the equipment (hardware and software) used in oil and gas operations. While contracts in the energy industry can be termed as very lucrative, these contracts were short and sporadically awarded. As one stakeholder expressed, "*work is cyclical for a relatively short period of time - 3-6 months. Having a contract of 3-4 months [duration] is short, for financiers to be willing to approve loans."* Additionally, a single contract neither lasted nor earned significant revenue to generate the requisite investments for an innovation. Local services firms also lamented that there were no specific funding facilities streamlined to assist the ESS in RDI.

Establishing personal relationships with banking personnel was also highlighted as a key factor in securing financing. It was noted that when ES firms successfully introduced innovations to their clients, their credentials improved and over time, financial institutions were more inclined to approve loans and invest in those ES firms' pipeline projects. Key assessment criteria such as good cash flows, a diverse clientele obtained through servicing various sector stakeholders and a track record of timely loan repayments, were factors that positively contributed to the willingness of banks to provide funding after proven success. Local ES firms expressed the need for financial institutions to have more in-depth knowledge of ES firms' operations and in the process, expand the criteria for assessment, taking into consideration the client firm's proven technology in the analysis.

Stakeholders also articulated that the paucity of opportunities for local ES firms resulted from the lack of enforcement of local content. Local firms expressed that before exporting their services regionally and/or internationally, their preference would be to develop a strong track record and endorsement of their expertise at home. Without sufficient opportunities locally, the export desire cannot be realised. According to industry stakeholders, understanding local content does not mean excluding foreigners, but maximising the use of locals. Trinidad and Tobago could be described as having one of the most open economies in which foreign firms have gained entrance, registered

themselves locally and then were able to access opportunities. The same has not applied in the case of local firms trying to penetrate into foreign markets. Again, stakeholders remarked that the term "local" cannot simply refer to "having one or a few Trinidadian nationals working in a company" or "the registering of a foreign owned company locally." This was considered barely adequate and not a true reflection of what's intended by the term "local." Guided by the Procurement Act, some stakeholders have defined local content as "*the value of money spent on any good or service that stays within the local economy. The percentage of this is measured in a dollar value*."

While other stakeholders have argued that "*local content is often ignored in spite of the fact that it is part of the Production Sharing Contract and government needs to be more assertive in negotiating PSCs, enforcing local content, and using language that does not lend itself to ambiguity*." Others retort that "*for local content policies to work, T&T government must have a strong belief in the ability of local services providers to supply quality services, and must have the strength to stand up to MNCs and foreign entities who do not understand what local firms are able to do and doubt our quality*." As previously mentioned, start-up companies that do not have the track record need local content to access opportunities on smaller jobs.

Challenges Encountered in the ESS

Industry stakeholders were of the opinion that not enough has been done to strategically position and safeguard the general body of local energy services companies. Of those interviewed, the following issues were seen as challenges encountered in the energy services sector. The first challenge presented was the *poaching of employees*. Local services firms expressed their frustrations at constantly having to retrain new staff as larger firms were better able to offer more attractive remuneration packages. In many instances, these small and medium-sized firms made substantial investments in their new recruits, equipping them with the requisite skills for the task at hand, only to have them clipped away at short notice. On the other hand, young graduates were of the belief that employment with internationally acclaimed companies was better for their careers in the long term.

Several local firms complained about insufficient resources to market their companies and services. Firms also spoke out strongly about *feeling financially exposed*. According to those firms, work was cyclical for relatively short periods of three (3) to six (6) months. While many firms claimed competence in delivery of energy services, they did not have the equipment in-house and therefore would need to import these assets to perform services. As previously mentioned, these local firms felt unfairly treated as financiers were unwilling to approve loans for short contractual periods.

Another challenge which was frequently encountered was the unavailability of data to make informed decisions. The MEEI which is the repository for energy sector data (geological, seismic and production) has not made this type of data publicly available. Without the information, local firms were unable to reduce uncertainty, minimise risks, and increase production. Firms were also vocal about the MEEI's weak execution of several of their responsibilities as outlined in the

National Petroleum Act. According to one stakeholder, the MEEI is weak in the collection of taxes and royalties owed to the state, enforcement of compliance with regulations and establishment of a national registry.

Another challenge includes the resistance of firms to technological change. It has taken a lot of endorsement from different organisations to get new technologies adopted. And still, as local firms attested, the government appeared to have more confidence in the 'foreigner' than their own. Foreign was always seen as better. One stakeholder shared his experience with Petrotrin explaining that this operator was a major transgressor resisting technological change.

A sensitive challenge, but one that is worth mentioning is the granting of work permits to foreigners who should possess knowledge and skills that are not available locally. In some instances, local personnel working for the upstream operator have complained that, on several occasions they were given tasks to perform that were originally assigned to foreign workers. They performed these tasks effectively because they possessed the same qualifications and skill sets as foreigners who were granted permission/approval to work legally in T&T via a work permit. Local personnel were remunerated at a lower rate despite getting the job done effectively. Some interviewees were of the opinion that the big upstream operators have sidestepped the process. To ensure that work permits are given to worthy applicants, they have suggested that some form of training which ensures transference of knowledge is agreed to, as a condition upon issuance of a work permit. The MEEI is also of the opinion that updating the job classification for the energy sector would leave little room for operators to find loopholes in the work permit system.

Building Capabilities in the ESS

Most stakeholders agreed that tech-voc graduates transitioned more smoothly into industry. Staff of the NESC explained that this scenario was particularly true for welding and fabrication graduates, many of whom quickly found employment in Atlantic LNG, Damus and Weldfab. According to that stakeholder, "*60% of Damus welders and fabricators were graduates of the NESC.*" Other firms such as Lennox Petroleum and JSL also have shown interests in recruiting graduates from the NESC's Drilling Academy.

To further the discussion, an NESC lecturer tried to identify a reason for this smooth transition from classroom to the workplace. He explained that a concerted effort had been made to help students achieve a balance between theory and experiential learning. Students were allotted a certain amount of time outside the classroom. He reminded the interviewers that NESC students were being trained to construct and maintain plants and therefore it was necessary to give them much experience working on the rig floor. According to this lecturer, without a close relationship with industry, opportunities for NESC students to work in the field would be very hard to come by. He recalled that in the past, students were trained on Rig 152 of Wells Services Petroleum Limited. Others had the opportunity to train under Tucker Energy Services on open hole logging and log hole casing, specialty services of this ES firm. Trinidad Cement Limited also contributed to sharing industry knowledge with students through the delivery of presentations on cementing technologies currently used in the industry.

In recapping the raison d'etre for the establishment of the NESC, one interviewee considered the NESC's Drilling Academy as a fully integrated open access drilling academy. He further explained that there were four (4) open access drilling academies worldwide. The NESC was the only one (1) in the Caribbean, Central and South America. The other three (3) were located in Texas, Aberdeen in Scotland and Aeroglen in Australia. The NESC, despite its many achievements, was still viewed as a third-tier educational institution when compared to UWI, UTT and others, and while it was mainly funded by the state, it also operated as a profit-making entity. The NESC was established to build capacity for the downstream sector while the Drilling Academy was introduced to build capacity to service the upstream sector. This interviewee's experience had shown him that the inherent risks and the loss of life on the rig floor could be significantly reduced when graduates entered the workforce with experience and a high level of knowledge and skill. He remarked that when plants shut down for maintenance, with downtime averaging twenty-four (24) days, NESC graduates have been frequently called upon to service this segment of the sector.

A similar scenario of students transitioning smoothly into industry has not happened for local universities UWI and UTT. Their lecturers complained that insufficient field work hampered the practical application of what was learnt. Students ought to have gone on field trips, collecting samples of rock when cutting took place to construct the Highway to Point Fortin. The rocks there were similar to what could be found when drilling for oil. Lecturers felt that greater collaboration was needed between industry and university to assist the latter in understanding the challenges of the local industry. This sentiment was shared by several university lecturers from UWI and UTT. As one UWI lecturer explained, in the Petroleum Studies Unit at UWI, there are two (2) full-time lecturers and eighteen (18) part-time lecturers who work mostly for the upstream industry. These part-timers are encouraged by industry to lecture at university. However, the limited number of full-time lecturers negatively impacted the volume of research that could be conducted by the Petroleum Studies Unit and the work interests of the part-time lecturers explained why the research was skewed to meet the needs of upstream operators.

All stakeholders agreed that the universities should play an active role in solving some of the technical problems encountered in today's energy industry. They feared that less of an effort is made at the university level to develop RDI capacity for the local sector. University research was said to be supportive of teaching. Remarks were made that the research was static, recycled, not geared to relevant and practical research for use by local industry. Professors explained that the research efforts at UWI have been focused on the extraction of heavy oil onshore and oil from tar sands using radio frequency heating. Another professor further explained that enhancing the recovery of heavy oil entailed the injection of a nutrient to support the growth of bacteria indigenous to the wells. The bacteria then secreted a liquid that reduced the viscosity of the oil and subsequently lowered the tension between the rock water and oil so that an additional 3-5% of oil could be recovered. For the MSc in Petroleum Engineering at UTT, the research conducted was company specific with attempts made to plug gaps in the sector. Research at UTT was being conducted on CO_2 sequestration, CO_2 oil recovery, CO_2 restoration, deep water development, LNG marketing and value chain.

Several stakeholders were of the opinion that although funding had been received from operators namely BP, REPSOL, BHP, MEEI, and Trinity Exploration and Production plc, research had not been moving forward at the expected pace, given Trinidad and Tobago's long tenure in this sector. Several stakeholders shared the view that no concerted effort had been mounted by government or the private sector to identify areas in which research work should be focused. The lack of proper facilities such as advanced equipment and a fully functional lab at UWI also made the effort to conduct research less pronounced. One lecturer reminisced about the 1960's when T&T's petroleum industry, was leading the world in research on microscopic fossils. He recalled the existence of the geological services laboratory at Pointe-a-Pierre under TEXACO and the push to innovate and develop. He opined that when state owned companies came into the fold, things changed. There was no longer that push to innovate. He felt that his experience in the industry which dated back to 1998, and much of what is being done presently in the industry, suggested that things have not advanced much. They were carried out the same way as they were done in the 1960s.

Funding research was not without problems. One lecturer recalled that while at times operators would donate an annual grant, there was no support in terms of projects on which to work. In other instances, materials would be shared with the universities with specific intentions of building the capabilities of workers in the upstream industry. Several professors demonstrated knowledge about the research needs and challenges of the upstream operator. One operator they claimed wanted to conduct research to identify and understand thinly bedded pay zones while others encountered challenges such as the presence of asphaltenes and waxes which obstructed the flow of oil, and the treatment, handling and reuse of water. Generally, it was felt that faculty from both UWI and UTT were not familiar with the research needs of local ES firms.

Much discussion stirred concerning factors influencing the design of curricula for degree programmes relevant to E&P operations. Stakeholders agreed on the following factors:

- *Input from industry*. In fields such as the Geoscience Programme offered at UWI, one professor emphasized that students were being prepared to work in the upstream industry and not conduct research. The curriculum though broad, was developed in collaboration with industry. Other lecturers explained that once every semester, based on feedback from graduates and scenarios in industry, changes to the curricula were discussed and approved. Both UWI and UTT maintained Industrial Advisory Boards/Councils comprised mostly of operators tasked with the responsibility to ensure that the curricula remained relevant to the needs of upstream industry.

- *International Accreditation is seen as important*. Without foreign accreditation, there was no way to determine whether UWI, UTT or even NESC's programmes were meeting or exceeding minimum standards of quality. Stakeholders from academia explained that the Petroleum Engineering Departments of UWI and UTT remained elected learning affiliates to the Energy Institute UK (EI UK) and the Geological Society of London. The universities' petroleum-based Master's level programmes were accredited as meeting the academic requirements for Chartered Engineer's status. The respective international accords namely, the Washington,

Sydney and Dublin Accords, provided global recognition of these professional titles protected by law. They further explained that the EI UK was licenced by the Engineering Council UK to grant Chartered Engineer, Incorporated Engineer and Engineering Technician status to individuals who met the stringent academic standards and professional work-related experience. One lecturer felt it necessary to communicate that the Drilling Academy of NESC was also aligned to the Washington and Sydney Accords. All three (3) institutions UWI, UTT and NESC remained accredited by the International Association of Drilling Contractors (IADC).

- *International partnerships have kept programmes at local learning institutions relevant.* One NESC lecturer pointed out that a significant amount of knowledge was shared between the NESC and its foreign counterparts. He further explained that the Drilling Academy of NESC had maintained its linkages with PETEX Learning and Assessment Centre of the University of Texas. Through this partnership, the NESC programmes were made more robust with the provision of interactive on-line training courses and resources relevant to industry operations. Likewise, the lecturer conveyed that the welding programme also had affiliations to Canada's Red Deer College and the Northern Alberta Institute of Technology (NAIT) with whom much knowledge had been exchanged.

Stakeholders also agreed that the universities were much more linked to the multinational operators than to local ES firms. These multinational firms have contributed in many ways through funding for research; funding for field trips made to a donor's research facilities; or the provision of computer hardware and software licences. As mentioned, a few of the main foreign energy service firms continued to offer internship opportunities for final year university students.

Similarly, tech-voc schools were not to be left behind. As one stakeholder shared, they too have had their interface with industry and were generally kept abreast of industry requirements. These discussions have contributed to the development of the NESC curriculum. It was indicated that 20% of the best students were selected to participate in the PLIAP programme in partnership with Point Lisas Industrial Estate.

Another area of discussion under the theme building capabilities that peeked the interests of stakeholders was that of building a culture of innovators. For many of the stakeholders interviewed, their belief was that it all started in the classroom. Stakeholders found unity in the view that a direct approach to innovation was needed, and agreed that the curricula ought to be designed to encourage students to think critically, problem solve and develop soft skills needed by industry. Additionally, many spoke about the aptitude of today's student. There was general consensus that students lacked a sense of inquiry and failed to demonstrate initiative. Lecturers believed that students' concern was really about passing exams and getting the information they needed to do so. Virtually no interest had been shown in wanting to identify new and or improved techniques in how to find oil. It was shared that university graduates, very seldom, thought outside the box. Additionally, it was felt that the science-based subjects taught at the CXC and CAPE levels did not sufficiently prepare students to make a smooth transition to training for a technician's job. It was suggested that students needed to be taught how to think on their own. Another

suggestion was for students to work in multidisciplinary teams, an approach which has often led to innovations. Mention was also made of the STEM IQ which was relatively low in Trinidad and Tobago and the fact that STEM was a major requirement for technological innovation which should commence at the primary school level.

Another issue placed on the table was the gap in experienced personnel. Several stakeholders explained that resourcing adequate academic staff to teach full-time at the universities was problematic. According to those stakeholders, academia competed with industry. Not many PhD qualified engineers from engineering industries would be interested in teaching. Industry continued to pay more and the attraction remained great. On the other hand, in the Geosciences faculty at UWI, most of the senior staff were nearing the age of retirement. There was a real need in this instance for succession planning.

The demand for new skills has also arisen. One professor spoke of the need for sedimentologists. Several others spoke of the need to build capabilities for deep water exploration. In this regard, many stakeholders believed that engineering courses would have to be tailored to deep water E&P operations. As one lecturer explained, deep water presented different challenges, for example, remaining stationary to conduct well construction and drilling amidst ocean currents; or dealing with the unexpected high and low pressures encountered while drilling at different oceanic depths. Tech-voc lecturers advocated the introduction of energy related inspection programmes at the university level.

Standing in the Future

To gain an insightful view of how stakeholders view the future, it is necessary to allow them to project the many possibilities they foresee, unrestricted by how things are today. A recap of the many discussions highlighted that the viability of the local energy services sector lies in the export of energy services to emerging oil and gas economies; building partnerships with foreign counterparts in foreign territories to service their oil and gas operations either through the integration of local services firms into global value chains or the formation of joint venture partnerships with host country firms. Another preferred business model is the formation of a "T&T Inc." comprising local ES firms, subcontracted to work alongside midstream and upstream operators like NGC and Heritage Petroleum Company Limited respectively, bidding for opportunities abroad.

These models are in fact business practices that have been honed by multinational operators and their home-grown energy services firms. Several stakeholders felt very strongly that it is the responsibility of government to take the lead, establish and instruct the missions to market the local expertise and scan the environment to initiate new business. As one stakeholder recalled "*When a foreign operator comes to a country to do business, it is supported by its country of origin. Companies and countries go hand in hand. When BHP, one of the world's largest mining companies came to Trinidad and Tobago in 2001, the Australian High Commission moved from Barbados to T&T. Again, when REPSOL came to T&T, a Spanish Embassy was established in Trinidad. When a foreign company and its country enter a host country, they usually bring with them services providers from their home jurisdiction."* Certainly, as another stakeholder

confirmed, all this happens after "*the Head of Government has spoken to another Head of Government. Firms must come in under the support of government to government*." The brand as many stakeholders proudly stated is T&T Brand which must be effectively marketed and managed, in order to take advantage of opportunities to service operators overseas. To stand in the future, means that government has recognised the need to install a system to monitor, measure and audit local content targets formulating appropriate policy instruments that are geared towards creating a level playing field for actors in the industry.

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