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## **Assessment of E&P Technology in Nigeria**

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## **Preface**

This report is part of a study addressing technological and institutional aspects of the development and utilisation of offshore petroleum resources in Nigeria. Norway and Nigeria have signed a memorandum of understanding on private sector development in the Nigerian upstream oil and gas industry. One of the objectives of the cooperation is to increase local content in the Nigerian industry. As a first step Norad and the Norwegian Ministry of Petroleum and Energy (OED) has funded an Intsok study on local content and how to improve the capabilities of Nigerian supply and service companies. The study will also assess potential for cooperation between Norwegian and Nigerian enterprises. Intsok / OED has commissioned SNF to undertake the study jointly with Rogaland Research and Kragha and Associates in Nigeria.

## **Résumé**

The report is based on an assessment expert workshop designed for collective handling of complex problems and issues. This part of the overall project had focus upon the prospects of E&P technology and competence requirements related to the Nigerian upstream oil and gas industry, with a view to assess the status of technology and competence requirements applied for E&P operations (exploration, field development, production) and to identify areas with the largest potential for Nigerian local short and mid term contribution.

Different methods such as structured assessment and ranking against multiple criteria were supported by techniques like brainstorming and collective consensus building to arrive at an evaluation of a representative range of E&P technologies.

## **Thanks to contributors.**

The project would like to acknowledge the assistance of Mr. Moses Kragha and Associates in the organising of the expert workshop on E&P technology assessment set up in Lagos November 6, 2002. This acknowledgement also extends to all the 15 experts who dedicatedly worked through a series of assignments on various aspects of E&P technologies pertaining to the ambition of increasing local content.

Stavanger, 10 January 2003

Jan Erik Karlsen, project leader

## Contents

1	INTRODUCTION .....	4
1.1	Background of the project .....	4
1.2	Definition of ‘local content’ .....	4
2	TECHNOLOGY ASSESSMENT .....	5
3	EXPERT WORKSHOP ARRANGEMENT .....	5
3.1	Objective for the Technology assessment workshop .....	5
3.2	Scope for the Technology assessment workshop .....	5
3.3	Working mode .....	6
4	RESULTS .....	6
4.1	Business critical technologies .....	7
4.2	Potential for increased local content – total view .....	8
4.3	Potential for increased local employment .....	9
4.4	Potential for increased local manufacturing .....	10
4.5	Current state of local competence .....	10
4.6	Potential for development of local expertise .....	11
5	DISCUSSION .....	12
5.1	Local content by added value – candidate technologies .....	12
5.2	Value potential of local content .....	13
5.3	Critical emergent technologies .....	14
5.4	Competence gap - Areas most critical for competence development .....	15
5.5	R&D .....	17
6	CONCLUSIONS .....	17
	APPENDIX A – LIST OF PARTICIPANTS (EXPERT PANEL) .....	19
	APPENDIX B – TECHNOLOGY INVENTORY .....	19

# 1 Introduction

## 1.1 Background of the project

The project was established to address technological and institutional aspects of the development and utilisation of offshore petroleum resources in Nigeria.

### Objective:

1. Assess the enabling environment for private sector development in the Nigerian upstream petroleum industry
2. Recommend ways and means of increasing and improving the capabilities of Nigerian supply and service companies
3. Assess areas of co-operation where the Norwegian business community can enhance employment, revenue generation and other development effects

**Client:** Intsok

**Donors:** NORAD (Norwegian Agency for Development Cooperation), OED (Norway Ministry of Petroleum and Energy)

### Methods:

- Supply and Value Chain analyses
- Technology assessment and foresight analyses
- Policy assessment
- Gap analyses
- Expert assessment
- Comparative case studies

**Project organisation:** International consortium constituted with Nigerian / Norwegian partnership of SNF, Kragha & Associates and RF.

**Time frame:** Pilot study (August 2002- February 2003)

## 1.2 Definition of 'local content'

“The quantum of composite value added to, or created in the Nigerian economy without compromising quality, health, safety and environmental standards”

**“Value added”:**           - *Human*; as % of total employment, per skills level  
                                  - *Material and services*; stated as % of total price

E.g. 100% value added for:

- All manufacture in Nigeria with Nigerian raw materials
- Consultancies by Nigerians
- Leased equipment from 100% Nigerian companies

E.g. for non-Nigerian goods sold by 100% Nigerian companies, value added =

- finishing in Nigeria or,
- % of amount over and above that paid to the overseas supplier

## 2 Technology assessment

This part of the overall project had focus upon the present status and future prospects of E&P technology and competence requirements related to the Nigerian upstream oil and gas industry, with a view to:

- Assess the status of technology and educational/competence requirements applied for E&P operations (exploration, field development, production);
- Identify areas with the largest potential for Nigerian local short term contribution;
- Assess trends and forecasts for Nigerian mid term E&P activities.

By *technology* is meant the whole complex of knowledge, skills, routines, competence, equipment and engineering practices which is necessary to design and produce a product, process or service.

The technology assessment was organised prior to the policy gap analysis workshop in order to list and rank E&P technologies conducive to increasing Nigerian local content in the upstream sector.

## 3 Expert workshop arrangement

### 3.1 Objective for the Technology assessment workshop

The workshop took place on 6<sup>th</sup> November 2002 with 15 experts attending (see Appendix A).

The purpose of the technology assessment workshop was to evaluate E&P technologies with respect to

- current level of competence;
- criticality for contribution to new field discoveries and developments;
- potential for impact on local content in the Nigerian E&P industry.

### 3.2 Scope for the Technology assessment workshop

Prior to the workshop and as basis for the expert assessment, an inventory of proven E&P technologies applicable for the Nigerian context was prepared. The main focus was towards exploitation of the frontier deep sea blocks, as it is believed these will contribute most in the upcoming era of Nigerian E&P development.

The technology inventory was organised along field lifecycle phases (*Exploration, Field development and Production*) and grouped into 17 major technology areas. The technology

areas were further detailed into 117 functionally oriented specific technologies. An overview of the technology inventory is included in appendix B.

In the expert workshop the technology areas and specific technologies would be evaluated and ranked against the following set of criteria:

1. To what extent the technology is critical for improving **discovery** and **cost-effective exploitation** of Nigerian petroleum reserves in the future.
2. To what extent the technology area can contribute to **improved HSE standards** (e.g. personnel safety and external environment protection).
3. Current **competence** in the Nigerian environment (universities, R&D institutions, local industry) relative to leading international competence.
4. To what extent their application can contribute to new **Nigerian employment**, both directly and indirectly
5. Realistic potential for increased share of **locally manufactured equipment** from Nigerian supply and service industry
6. To what extent they offer realistic development potential for **local expertise** (personnel) within Nigerian supply and service industry as well as Operator companies

The score for each technology against each criterion was made on a scale from 1 (low) to 10 (high).

### 3.3 Working mode

Against the criteria set out above, the expert panel would through a series of steps:

- a) set up in pairs, rank all the 17 technology areas against criteria 3-6 and reach consensus;
- b) set up in pairs, for each technology area, pick at least 5 critical and prioritised specific technologies, rank those against all 6 criteria and reach consensus ;
- c) set up in three groups, for each technology area, rank at least 5 critical technologies against all 6 criteria and reach consensus ;
- d) group presentations of results.

The time available became somewhat limited due to delayed start, thus item c) had to be reduced in scope to ranking by technology area level rather than on specific technologies.

## 4 Results

The material produced during the expert workshop has been analysed, and the results are presented below, organised by ranking criterion or combination of criteria (target areas).

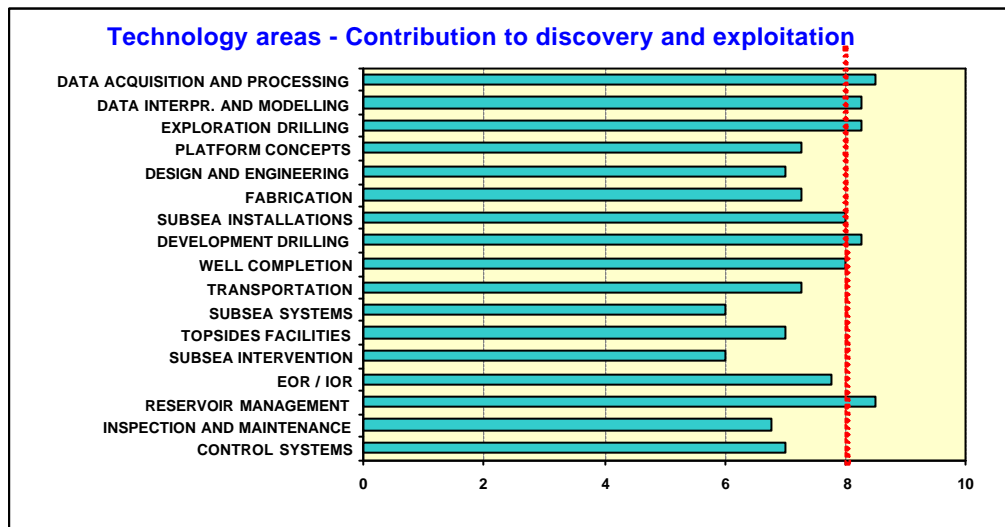
Firstly, the consensus judgement by the three five-person groups is applied to identify the most important technology areas for each target area. In the diagrams below a red line has been drawn to highlight the top scoring technology areas.

Then, for each target area, the pair consensus evaluation of specific technologies is utilised to find the most dominant specific technologies within the prioritised technology areas. Details from the pair wise evaluation of specific technologies will be issued in full as a separate report.

Below is included a discussion of the findings, as well as some outline technology based strategies for increased local content.

## 4.1 Business critical technologies

Based on criterion 1 the panel was asked to evaluate technologies on their criticality for economically successful exploration and exploitation of petroleum resources. The overall ranking identified 7 technology areas which received an average rating of 8 or above:



The specific technologies which were judged most critical within the 7 technology areas were:

### *Data acquisition and processing*

- Integrated seismic acquisition / processing / inversion
- High resolution seismics
- Logging while drilling

### *Data interpretation and modelling*

- 3D modelling
- 3D visualisation
- Integrated interpretation for risk assessment and uncertainty management

### *Exploration drilling*

- MWD
- Ultra deep water drilling (>1500 m)
- Coring
- Production testing monitoring

### *Subsea installations*

- Manifolds
- Pipelines
- Umbilicals

### *Development drilling*

- Multilateral wells
- Formation damage prevention
- Drilling & completion fluids
- Coring

### *Well completion*

- Casing
- Sand control / Screens
- Cementing
- Perforations

### *Reservoir management*

- High resolution reservoir models
- Fluid characterisation (PVT testing)
- Cased / Open hole logging
- Inflow control
- Downhole electrical and fiberoptic sensors

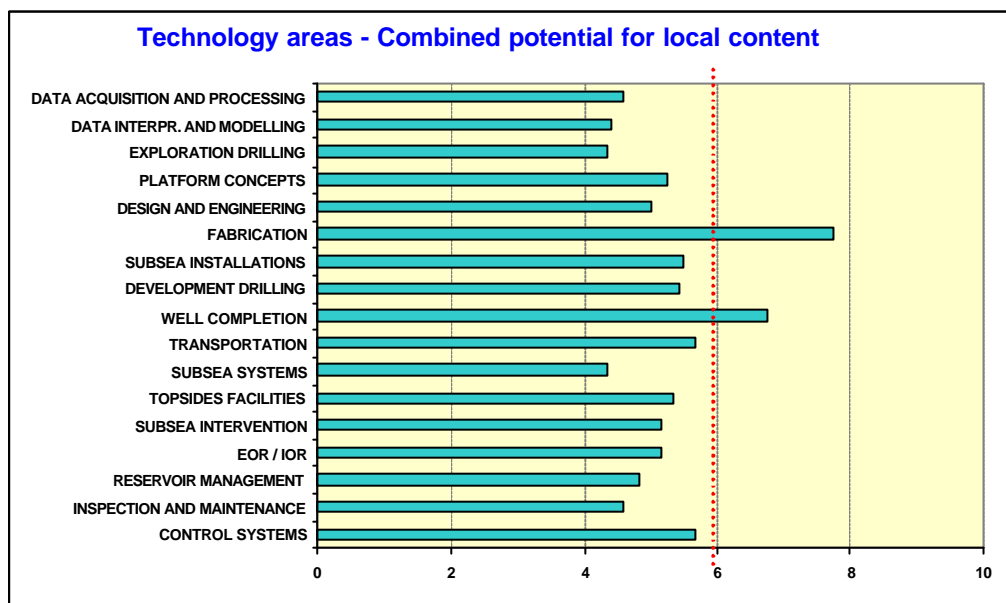
The prioritised areas reflect the big challenges in green field operations; exploration mapping and drilling in first time areas and potential high risk / high cost deep water developments.

## 4.2 Potential for increased local content – total view

Based on criteria 4, 5 and 6, the technology areas were assessed with respect to their overall potential for increased local content. Applying the scores for the criteria for

- Employment,
- manufacturing and
- expertise growth

the technology areas ranking for combined local content potential, were:



The specific technologies which were judged most important within the top two technology areas were:

*Fabrication*

- Structures
- Topsides incl. Quarters

*Well completion*

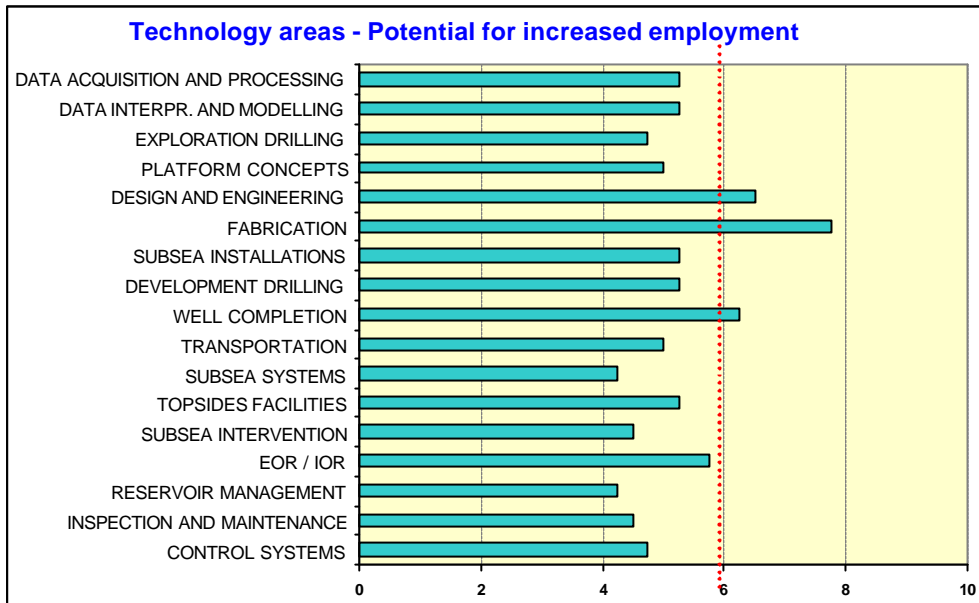
- Casing
- Sand control / Screens
- Cementing
- Perforations

Fabrication scored high across the board, and reflects an area with high value added potential based on ‘old’ expertise.



### 4.3 Potential for increased local employment

Based on criterion 4 the panel was asked to evaluate technologies against their potential for more local employment (skilled labour).



The three highest rated technology areas and their key technologies with highest employment potential were:

*Design and engineering (all disciplines)*

- Mechanical
- Process
- Electrical
- Instrumentation
- Structural

*Fabrication*

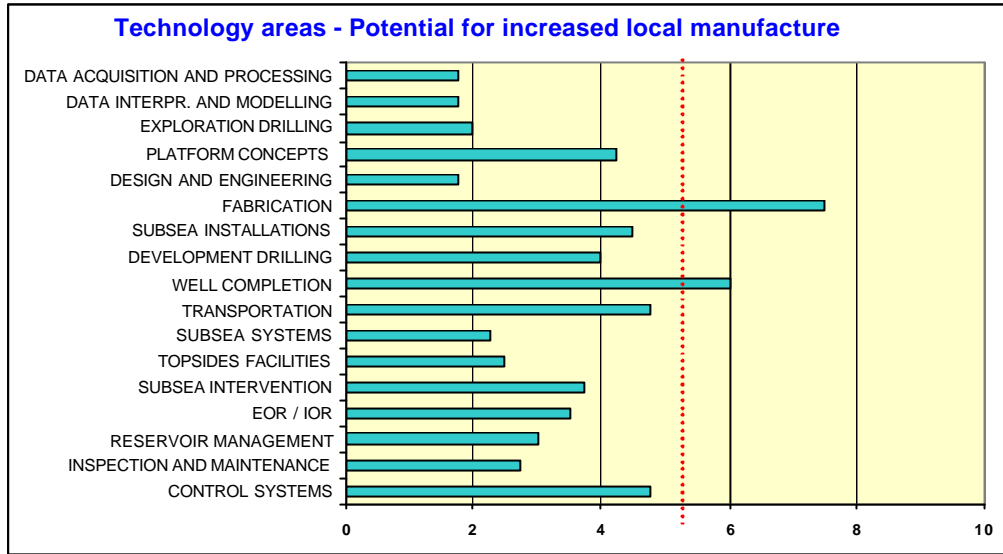
- Structures
- Drilling rigs

*Well completion*

- Casing
- Sand control / Screens
- Cementing
- Perforations

## 4.4 Potential for increased local manufacturing

Technology areas with highest potential for more local manufacturing of equipment



The specific technologies within the two areas with highest potential for Nigerian made equipment, were

*Fabrication*

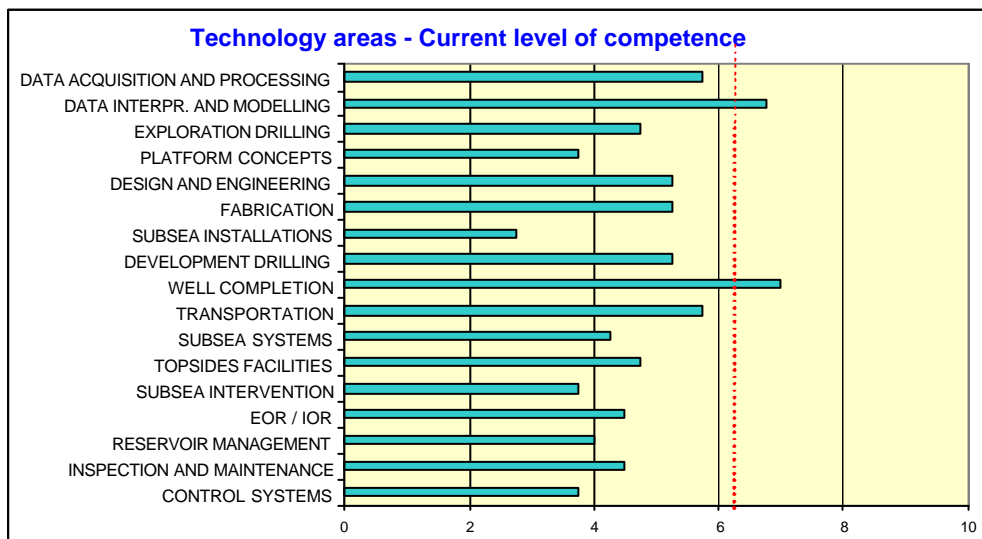
- Structures
- Topsides incl. Quarters

*Well completion*

- Casing
- Sand control / Screens
- Cementing
- Perforations

## 4.5 Current state of local competence

The technology areas were rated for current competence in the Nigerian environment (universities, R&D institutions, local industry) relative to leading international competence.



Within the top two areas where current competence were regarded to be highest, the specific technologies with highest standing were:

*Data interpretation and modelling*

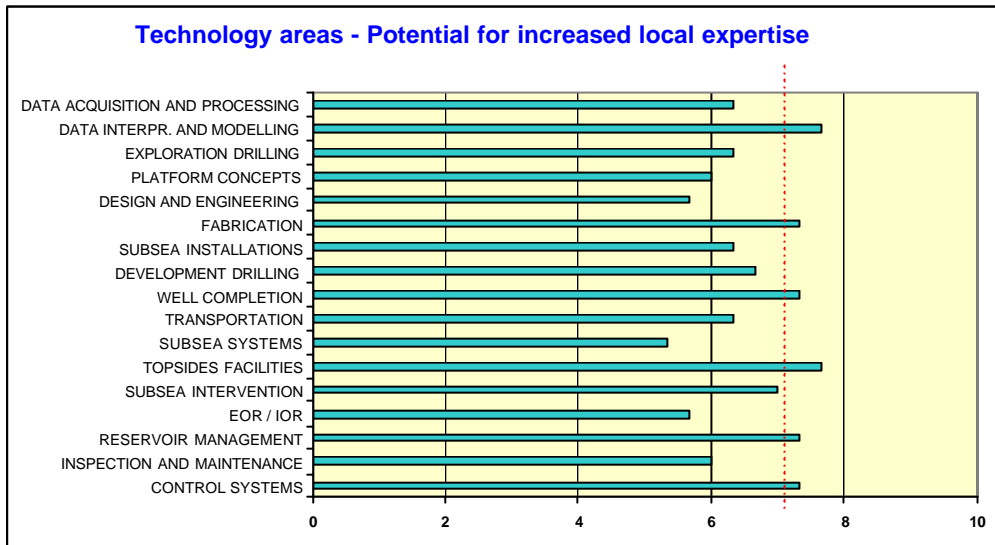
- 3D modelling
- "Integrated interpretation for risk assessment and uncertainty management"

*Well completion*

- Casing
- Sand control / Screens
- Cementing
- Perforations

## 4.6 Potential for development of local expertise

This section covered ranking of technologies with respect to potential for local expertise development, i.e. to what extent there is high development potential for local personnel within supply and service industry as well as operator companies.



The technology areas with highest score represent areas with a good personnel base in place, where focussed training with highest success rate will raise skills levels, and where one realistically can talk about a transition from competence to expertise.

*Data interpretation and modelling*

- 3D modelling
- 3D visualisation
- "Integrated interpretation for risk assessment and uncertainty management"

*Topsides facilities*

- Produced water handling
- Produced water injection/discharge
- Fluids handling

*Fabrication*

- Structures

*Reservoir management*

- High resolution reservoir models
- Fluid characterisation (PVT testing)

*Well completion*

- Casing
- Sand control / Screens
- Cementing
- Perforations

*Control systems*

- Remote reservoir control
- Production monitoring
- Remote processing control

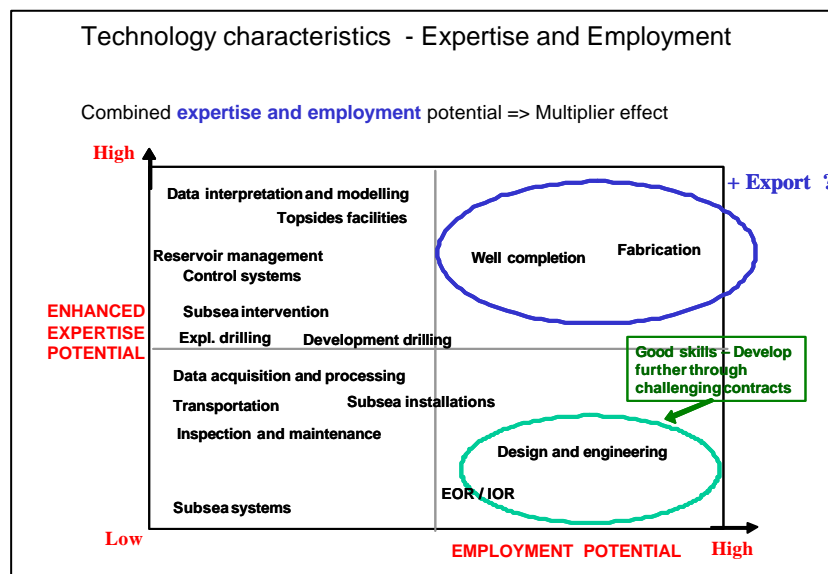
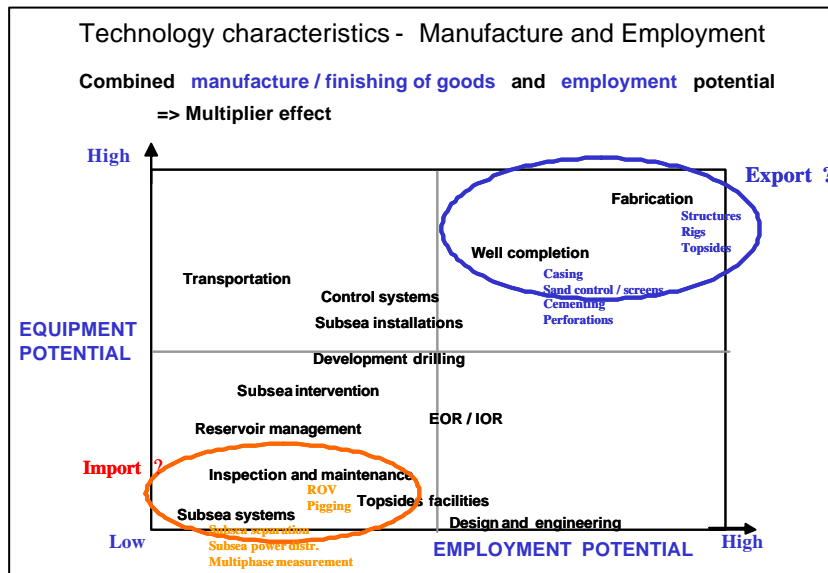
## 5 Discussion

### 5.1 Local content by added value – candidate technologies

All technology areas were judged to have some scope for higher local content, however the scope has different characteristics dependent upon which efforts are involved. I.e. some technology areas are characterized by highly specialised skills but low in terms of manpower requirements, whilst other demand high numbers in manpower of less specialised labour. Also, the efforts vary in duration from intensive project work to longer duration operational tasks.

Thus, there are several factors that come into the equation when assessing potential for added local content in terms of money value.

The three local content criteria applied in the workshop, namely increased components of Nigerian employment, equipment and expertise, are not mutually exclusive of each other. Two technology areas which scored high on all three criteria were Well Completion, which encompasses a wide range of services and facilities, and Fabrication.



Thus **Well completion** and **Fabrication** stand out as two areas which will count strongly and where increased local content may be achievable in the short and medium term, given that certain prerequisites are put in place.

In relative West African context Nigeria can be seen as an industrial nation, with emphasis on the petroleum sector. Its long history of petroleum activity gives basis for further development, and one route for qualified E&P expertise and capacity may be export to other West Africa nations.

Nigeria is still a low cost nation compared to other locations which supply E&P expertise and capacity and, given reputation for quality and reliability, Nigeria could be highly competitive base for well services as well as fabrication and yard services.

Other technology areas were rated lower for local content in the short and medium term. This can be a function of an already well developed base for local deliveries, a required high level of novel expertise or special equipment, or low expected total value. However, these technologies will become contributors in the longer term and must also be present in the development horizon for local content.

## 5.2 Value potential of local content

In some technical areas such as data interpretation and well services, Nigeria has strong competence and adequate workforce, whilst numbers in terms of manpower are relatively low. Further strengthening of local expertise in interpretation and analysis work is a valid option for more ownership of strategic decision processes, but has limited direct effect on monetary added value when compared to the higher employment numbers and increased raw material value which can be achieved through fabrication contracts executed at local yards and mechanical industries.

The combination of employment and finishing of goods is key to increased local content. One example of high percentage ‘value added’ is when a low value steel plate is imported and turned into equipment within Nigeria. Fabrication is seen as a major contributor through such transformation or refinement of raw material into high capex capital assets.

In order to be more specific on further prioritisation, we will project candidate technologies against planned investment and expenditures. This should give an indication as to revenue potential (equipment and labour based) in the various disciplines so that the technology areas with highest local value potential can be addressed in more detail with respect to implementation measures.

Regarding equipment transactions the definition of local content states:

“E.g. for non-Nigerian goods sold by 100% Nigerian companies, value added =

- finishing in Nigeria or,
- % of amount over and above that paid to the overseas supplier”

The first clause, i.e. ‘finishing in Nigeria’ must be a more important criterion than sole price increase, which also can be obtained exclusively through preferential contracts to

“commission agents”. The ‘finishing in Nigeria’ will also have a solid employment component.

### 5.3 Critical emergent technologies

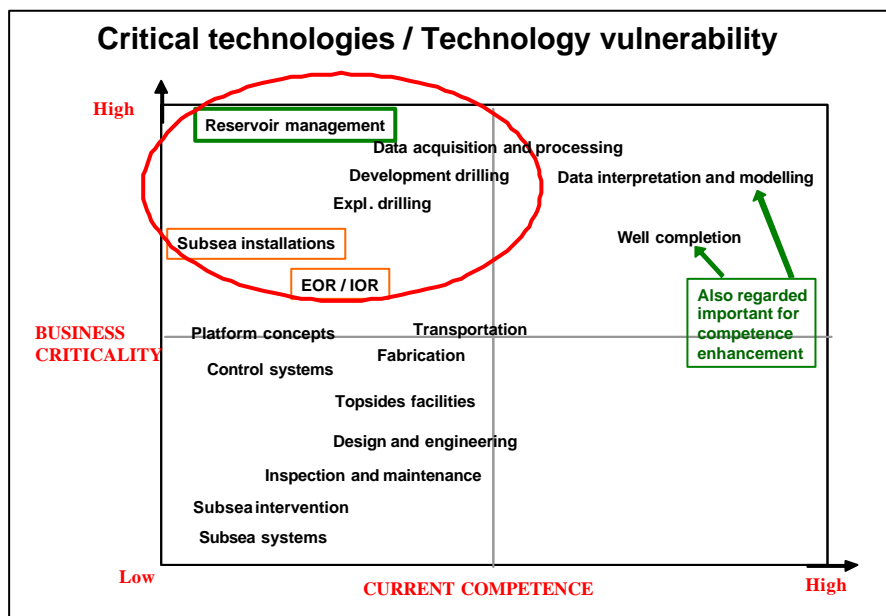
The technology areas that were seen most critical for upcoming E&P business in Nigeria (per criterion 1) correspond largely with the technologies that were highlighted in similar technology assessments made for the European Commission and for the Norwegian Research Council. Thus, the Nigerian expert panel’s views were in line with the international expertise assembled for those two exercises.

Most known onshore and offshore prospects have been developed, and the early ones are approaching tail end production. Thus one common underlying factor in the nature of new E&P developments in Europe and most other major petroleum producing regions is that the next era for developments are in less accessible areas, such as very deep waters.

These challenges require new solutions which are still regarded as new or emergent, and the most novel technology developments are still not ready for the market or are applied only to limited extent. For Nigeria it can be anticipated that such equipment and expertise will be imported and not be a significant contributor to local content in the foreseeable future.

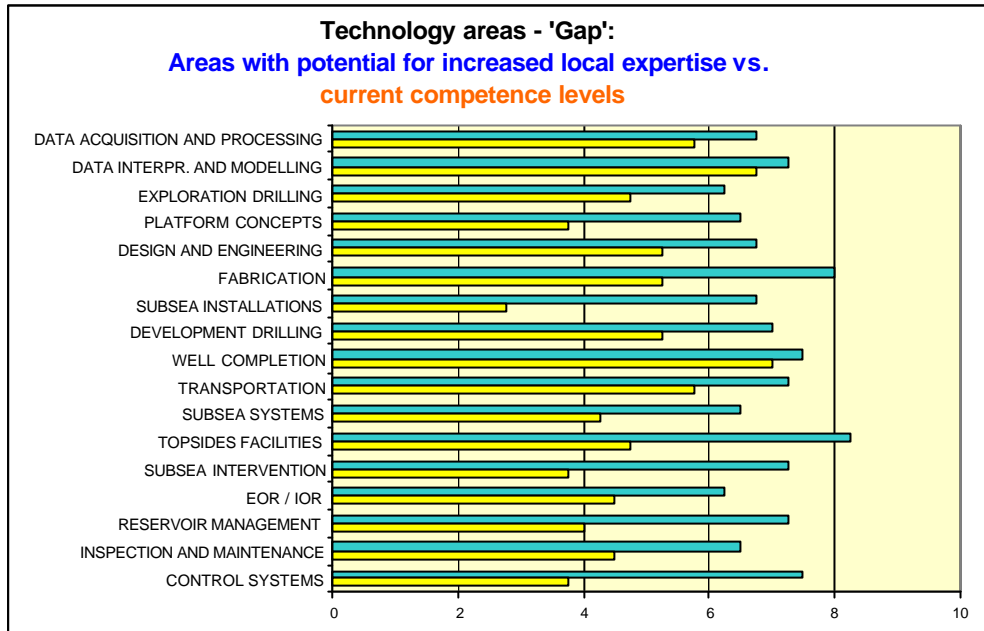
A comparison of current competence with the most critical technologies is shown below. Reservoir management was projected to have good potential for skills enhancement with Nigerian content, whilst challenges within Sub sea installations and EOR / IOR technology were regarded less likely to be handled by local resources in the short / medium term.

Data acquisition and Drilling in deep waters were also critical areas ranked with relatively low Nigerian competence today, which also had limited success potential for short / medium term local competence build-up.

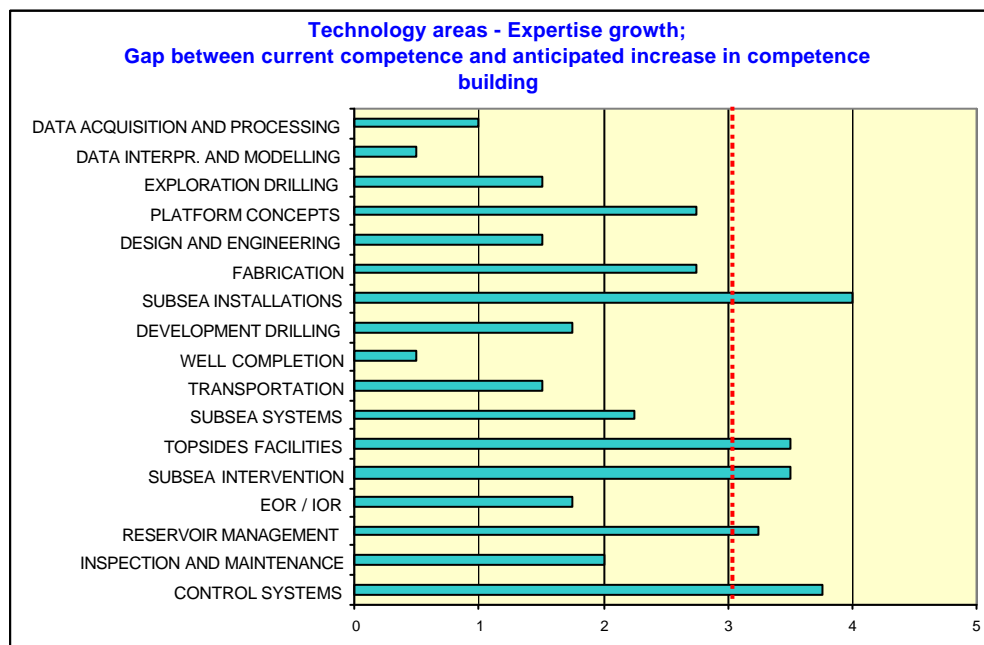


## 5.4 Competence gap - Areas most critical for competence development

When comparing the panel’s assessment of areas with potential for increased local expertise with current competence levels, the gap identifies areas where short / medium term competence enhancement is both critical and possible.



By showing the difference between the evaluations for the two criteria, the most potential areas for raised competence levels come out as:



Small gaps reflect an understanding that current competence levels are adequate for the challenges ahead, whilst big gaps identify critical and realistic potential for raised focus in local industry as well as in the R&D / education sector

Within the highlighted areas the technologies with highest gap between current competence levels and what can be achieved in the short to medium term, are:

*Subsea installations*

- Manifolds
- Pipelines
- Umbilicals
- Composite materials
- Subsea installations protection

*Topsides facilities*

- CO<sub>2</sub> / H<sub>2</sub>S control
- Fluids handling

*Subsea intervention*

- Subsea installation intervention
- Downhole water shutoff

*Control systems*

- Remote reservoir control

*Reservoir management*

- High resolution reservoir models
- 4D seismic
- Inflow control
- Downhole electrical and fiberoptic sensors
- 3D visualisation

The top rated technology areas in this valuation were Sub sea installations, Reservoir management and Control systems represented by Remote reservoir control. Lowest rated were Well completion services.

**Sub sea installations:** Sub sea applications have been taken in use on a broad scale for recent developments in other parts of the world. The first installations are just being developed for Nigerian waters. Design and fabrication is highly specialised and current experience and competence in Nigeria is low. However, sub sea systems and installations will be central for all new deep sea operations, and the competence gap clearly expresses this as an area where local skills needs to be developed.

The panel did not score sub sea technology amongst the most important areas with short / medium term scope for local content increase. This reflects that current basis is weak in this area and that it may take more time to develop skills and manufacturing capacity that will count in a local content context.

**Reservoir management:** Scored highest on the ‘business’ ranking, i.e. was seen as one of the two most critical technology areas for cost effective exploitation of petroleum resources.

Existing fields have largely been characterised by strong water drive and naturally flowing wells, and although there has been regular well maintenance, there has been limited focus on production optimisation. During recent years the older segments have received attention with reservoir stimulation efforts, and there is an increased focus on enhanced recovery.

The gap identifies a critical need for competence increase, and combined with a relatively strong knowledge and experience base, reservoir management is an area where the panel sees good potential for short / medium term enhancement of local expertise.

**Control systems:** A strong trend in the industry goes towards more remote operation of facilities and functions, which has an impact on both safety and cost through reduced platform or site manning. At the moment there is limited use of remotely operated installations in Nigeria, but the general knowledge of process control and production monitoring is good and serves as basis for increased local expertise content.

However, the specific area of remote reservoir monitoring and control is an edge technology, where the gap is big and where local content contribution will be limited in the short / medium term.

**Well completion:** To a large extent represented by technologies which have been required and in place from the early days of petroleum production. The techniques have evolved



over the years and the execution of many disciplines is carried out by trained local staff. Basic well completion technology is one area with strong local involvement, with high criticality for the future business, and high potential for local content growth on all criteria.

The small gap in this comparison reflects a strong local basis and there does not seem to be need for a radical competence lift to fit the anticipated demand for services. Although it is not given that familiar well completion techniques can be extrapolated to fit the deep sea environment, a shift to more local content is still foreseen by developing expertise from current competence and practice.

Given the strong position and growth potential, well completion services, equipment and personnel may also constitute an important area for potential export to other countries in the region.

## 5.5 R&D

R&D activities are to some extent carried out at Nigerian institutions, both independent and in collaboration with the E&P industry. However, the efforts are fragmented and probably initiated on an ad-hoc basis. The study identifies some technology areas where a concerted and coordinated approach will benefit all stakeholders (state, industry, individuals).

Objectives: Competence development, technology knowledge and potential new developments in a long term perspective.

## 6 Conclusions

The nation and the industry must be realistic about where the local content policy has most potential for realisation. The technology assessment has identified technology areas with characteristics that make them suitable for local growth, with potential for deliveries both to domestic projects and for export to other countries in the region.

It would be over ambitious to aim at short term proficiency in emergent fields such as edge sub sea technology, whilst more established services such as construction, well logging, cementing and onshore mud rehabilitation should be possible to expand by local contractors from today's knowledge and experience. To accelerate local deliveries it may be applicable to introduce gap closing measures as to

- avoid unnecessary low-bid strategies,
- invoke contract strategies that demand split of specialist work and local work,
- avail funding for new establishments,
- build capacity for local finishing,
- discourage the role as non value added, transaction handling “commission agents”,
- facilitate geographical clustering of complementary industries and services to aid cooperation and coordinated bidding for complex contracts.

In the longer perspective, cost efficiency and competition on equal terms will be the environment that will develop a healthy and growing industrial environment. However, in an interim build-up period certain discriminating measures are deemed necessary to establish a base for further organic growth.

Important ingredients in the transition to stronger local representation will be education, training and certification of the personnel that will make up for successful achievements.

Prioritised measures should result from the combined analysis of the project activities (comparative study, contracts information from operators and suppliers, policy assessment and technology assessment) and will be concretised in the final presentation.

## Appendix A – List of participants (Expert panel)

Dr. G.S. Ihetu	GSI consulting
Chief C.J. Ikelionwu	Tinomek consulting
Axel Destremau	Schlumberger
W.A. Akinsipe	DPR
M.J Orife	Versa-Tech
O.M. Otabor	SPE
D. Osinusi	Mansfield/Reslink
Prof. J.C. Igbeka	University of Ibadan
Prof. G.K. Falade	University of Ibadan
T.M Gbugu	NAPIMS
Sola Oyinola	Schlumberger
Engi.U.J Otokpa	NAPIMS
A Shehu	NAPIMS
Dr. O.A.Lalude	Omega Petroleum
O. Olaosebikan	NAPIMS

## Appendix B – Technology inventory

### 17 TECHNOLOGY AREAS:

#### Exploration and Appraisal

1. *Data acquisition and processing*
2. *Data interpretation and modelling*
3. *Exploration drilling*

#### Field Development

4. *Platform concepts*
5. *Design and engineering*
6. *Fabrication*
7. *Subsea*
8. *Development drilling*
9. *Well completion*

#### Production

10. *Transportation*
11. *Subsea systems*
12. *Topsides facilities*
13. *Subsea intervention*
14. *EOR / IOR*
15. *Reservoir management*
16. *Inspection and maintenance*
17. *Control systems*

## 117 SPECIFIC TECHNOLOGIES:

### Exploration and Appraisal

#### 1. *Data acquisition and processing*

- Multi component seismic
- Integrated seismic acquisition / processing / inversion
- High resolution seismics
- Specialised seismic processing
- Downhole seismics
- Seismics while drilling
- Logging while drilling

#### 2. *Data interpretation and modelling*

- 3D modelling
- 3D visualisation
- Handling of large data volumes
- Integrated data models (shared earth model)
- "Integrated interpretation for risk assessment and uncertainty management"

#### 3. *Exploration drilling*

- Slimhole drilling
- HP HT drilling
- MWD
- Geo steering
- Ultra deep water drilling (>1500 m)
- Downhole analysis
- Continuous data to shore
- Coring
- Production testing monitoring

### Field Development

#### 4. *Platform concepts*

- FPSOs
- TLP, Mini TLPs
- Wellhead platforms

#### 5. *Design and engineering*

- Mechanical
- Process
- Electrical
- Instrumentation
- Structural

#### 6. *Fabrication*

- Structures
- Process
- Topsides incl. Quarters
- Mooring systems
- Risers
- Drilling rigs

#### 7. *Subsea installations*

- Manifolds
- Pipelines
- Umbilicals
- Composite materials
- Artificial seabed
- Subsea installations protection

#### 8. *Development drilling*

- Expert drilling systems
- Underbalanced drilling
- Slim wells
- Coiled tubing operations
- Monobore / Monodiameter wells
- Multilateral wells
- HP HT wells
- Lost circulation prevention
- Formation damage prevention
- Drilling & completion fluids
- Ultra long horizontal wells
- Long reach wells
- Coring
- MWD
- Low cost rigs for slim wells

#### 9. *Well completion*

- Casing
- Sand control / Screens
- Expandable screens
- Cementing
- Perforations
- External casing packers
- Openhole zone isolation
- Multifunctional wells

## Production

### *10. Transportation*

- Offshore loading systems
- Pipelines
- Multiphase inhibitors
- Friction reduction additives
- Hydrate prevention

### *11. Subsea systems*

- Subsea separation
- Subsea power distribution
- Downhole pumping and separation
- Downhole gas compression
- Multiphase measurements
- Subsea water injection

### *12. Topsides facilities*

- Compact processing
- Produced water handling
- Produced water injection / discharge
- CO<sub>2</sub> / H<sub>2</sub>S control
- Fluids handling

### *13. Subsea intervention*

- Well intervention / workovers
- Pipeline intervention
- Subsea installation intervention
- Downhole water shutoff

### *14. EOR / IOR*

- Chemical methods
- Water or Gas injection
- WAG/SWAG injection
- CO<sub>2</sub> injection
- Steam injection
- Foam injection
- Artificial lift

### *15. Reservoir management*

- High resolution reservoir models
- Fluid characterisation (PVT testing)
- Logging equipment
- Formation testing
- 4C seismic
- 4D seismic
- Cased / Open hole logging
- Inflow control
- Scale inhibition
- Downhole electrical and fiberoptic sensors
- Cableless downhole sensors
- Continuous reservoir monitoring
- Vertical Seismic Profile
- Massive parallel computing
- 3D visualisation

### *16. Inspection and maintenance*

- ROV's
- Pigging
- Corrosion prevention

### *17. Control systems*

- Remote reservoir control
- Production monitoring
- Remote processing control
- Condition monitoring
- Positioning systems
- Workprocess and workflow management
- Decision support systems