Jan Erik Karlsen & Christian Quale

Assessment of E&P Technology in Nigeria, Detailed technologies ranking

Report RF – 2003/057

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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.

This report supplements the report 2003/027 “Assessment of E&P Technology in Nigeria” and includes graphs showing the ranking of all specific technologies against the evaluation criteria.

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, 4 February 2003

Jan Erik Karlsen, project leader
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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 6th 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 A.
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 in the expert workshop was analysed with the main findings presented in report RF–2003/027 “Assessment of E&P Technology in Nigeria”.

The main report aggregated information to technology **area** level. This report includes the ranking of each individual technology as it resulted from the pair consensus evaluation of the most dominant technologies within each technology area.
5 Expert assessment of specific technologies

The graphs show the pair wise ranking of all technologies against the evaluation criteria. The participants were asked to apply scores to at least 5 specific technologies within each technology area. With 7 pairs applying a scale from 0 to 10, the maximum score for a specific technology is 70.

The scoring was distributed amongst the technologies within each technology area. Thus, in areas with many specific technologies listed, the individual technology receives generally lower score levels. The relative ranking within the technology area is here more important than the absolute score for a certain technology.

5.1 Ranking on Criticality, HSE and Current Competence criteria

The graphs in this section show the technology’s scores against criteria 1, 2 and 3, i.e. the panel’s view on

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. To what extent the technology area can contribute to improved HSE standards (e.g. personnel safety and external environment protection).

1. Data acquisition and processing

1.1 Criticality for E&P business

1.2 Potential for HSE impact

1.3 Current local competence level
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 & uncertainty mgmt

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

4. Platform concepts

- FPSOs
- TLP, Mini TLPs
- Wellhead platforms
5. Design and engineering

- **Criticality for E&P business**
- **Potential for HSE impact**
- **Current local competence level**

6. Fabrication

- **Criticality for E&P business**
- **Potential for HSE impact**
- **Current local competence level**

7. Subsea installations

- **Criticality for E&P business**
- **Potential for HSE impact**
- **Current local competence level**
8. Development drilling

- Expert drilling systems
- Underbalanced drilling
- Slim wells
- Coiled tubing operations
- Monobore / Mono-diameter wells
- Multilateral wells
- HP HT wells
- Lost circulation prevention
- Formation damage prevention
- Drilling and 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

10. Transportation

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

Assessment of E&P Technology in Nigeria - 10 - Detailed technologies ranking
11. Subsea systems

12. Topsides facilities

13. Subsea intervention
17. Control systems

<table>
<thead>
<tr>
<th>Category</th>
<th>Criticality for E&amp;P business</th>
<th>Potential for HSE impact</th>
<th>Current local competence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote reservoir control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production monitoring</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Remote processing control</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Condition monitoring</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Positioning systems</td>
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<td></td>
<td></td>
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<tr>
<td>Workprocess and workflow management</td>
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<td></td>
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<tr>
<td>Decision support systems</td>
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</tr>
</tbody>
</table>

Assessment of E&P Technology in Nigeria - 13 - Detailed technologies ranking
5.2 Ranking on Local Content criteria

The graphs in this section show the technology’s scores against criteria 4, 5 and 6, i.e. the panel’s view on

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

---

**1. Data acquisition and processing**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Increase employment</th>
<th>Increase manufacturing</th>
<th>Increase expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multicomponent seismic</td>
<td>40</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Integrated seismic acquisition / processing / inversion</td>
<td>50</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>High resolution seismic</td>
<td>60</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Specialised seismic processing</td>
<td>70</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Downhole seismics</td>
<td>80</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>Seismics while drilling</td>
<td>90</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>Logging while drilling</td>
<td>100</td>
<td>80</td>
<td>90</td>
</tr>
</tbody>
</table>

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**2. Data interpretation and modelling**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Increase employment</th>
<th>Increase manufacturing</th>
<th>Increase expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D modelling</td>
<td>30</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>3D visualisation</td>
<td>40</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Handling of large data volumes</td>
<td>50</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Integrated data models (shared earth model)</td>
<td>60</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>Integrated interpretation for risk assessment &amp; uncertainty mgmt</td>
<td>70</td>
<td>60</td>
<td>50</td>
</tr>
</tbody>
</table>
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

4. Platform concepts

- FPSOs
- TLP, Mini TLPs
- Wellhead platforms

5. Design and engineering

- Mechanical
- Process
- Electrical
- Instrumentation
- Structural

Assessment of E&P Technology in Nigeria - 15 - Detailed technologies ranking
6. Fabrication

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

Increase employment  Increase manufacturing  Increase expertise

7. Subsea installations

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

Increase employment  Increase manufacturing  Increase expertise
### 8. Development drilling

<table>
<thead>
<tr>
<th>Technologies</th>
<th>Increase employment</th>
<th>Increase manufacturing</th>
<th>Increase expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert drilling systems</td>
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<tr>
<td>Underbalanced drilling</td>
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<tr>
<td>Slim wells</td>
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<td></td>
<td></td>
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<tr>
<td>Coiled tubing operations</td>
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<tr>
<td>Monobore / Mono-diameter wells</td>
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<tr>
<td>Multilateral wells</td>
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<td></td>
<td></td>
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<tr>
<td>HP HT wells</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lost circulation prevention</td>
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<td></td>
<td></td>
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<tr>
<td>Fracture damage prevention</td>
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<td></td>
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<tr>
<td>Drilling and completion fluids</td>
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<td></td>
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<tr>
<td>Ultra long horizontal wells</td>
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<td></td>
<td></td>
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<tr>
<td>Long reach wells</td>
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<td></td>
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<tr>
<td>Coring</td>
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<tr>
<td>MWD</td>
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<td></td>
<td></td>
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<tr>
<td>Low cost rigs for slim wells</td>
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</tr>
</tbody>
</table>

### 9. Well completion

<table>
<thead>
<tr>
<th>Technologies</th>
<th>Increase employment</th>
<th>Increase manufacturing</th>
<th>Increase expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casing</td>
<td></td>
<td></td>
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<tr>
<td>Sand control / Screens</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expandable screens</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cementing</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Perforations</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>External casing packers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Openhole zone isolation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multifunctional wells</td>
<td></td>
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</tr>
</tbody>
</table>

Assessment of E&P Technology in Nigeria  - 17 -  Detailed technologies ranking
16. Inspection and maintenance

- ROVs
- Pigging
- Corrosion prevention

Increase employment
Increase manufacturing
Increase expertise

17. Control systems

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

Increase employment
Increase manufacturing
Increase expertise
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
   - Seisims 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. Topside facilities
   ➢ Compact processing
   ➢ Produced water handling
   ➢ Produced water injection / discharge
   ➢ CO₂ / H₂S 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
   ➢ CO₂ 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