



esg

energy
services
group

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Capability Statement

On

Consultancy Services

for

Enhanced Oil Recovery

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Introduction

Energy Services Group Ltd. (ESG) provide management and advisory services spanning the upstream oil and gas business cycle, including exploration sub-surface analysis, field development planning, drilling, production, project management, facilities engineering and support services including late life asset management and decommissioning. ESG staff are seasoned, highly trained and motivated professionals, each with many years experience with international operating companies. ESG are independent, and specialize in the delivery of objective solutions to meet client needs, safely and efficiently. Consequently, the client is assured of receiving the highest quality, most cost effective solutions to meet its program objectives.

Integrated Service

ESG specialize in providing an integrated service and we work closely with our clients to ensure their objectives are clearly understood and our interests are aligned. We consider our clients to be our partners. Our strength is in providing expertise in technical and commercial disciplines to the oil and gas industry at reasonable cost. We believe innovation and best industry practice are the keys to unlocking value throughout the life of the asset, from exploration and appraisal, through development and production, to decommissioning.

Philosophy

ESG's philosophy is to utilize people with exceptional talents and skills, working together to provide exceptional results. ESG's pool of expertise includes world-class geoscientists, engineers and commercial analysts. ESG's staff assigned to a client's project can draw on the collective backing of the full expertise and knowledge base of the company.

The combination of knowledge, skills and experience within ESG spans the entire spectrum of the upstream energy industry. Our strength is in taking on the most challenging problems and providing innovative solutions, using all the disciplines we have in house or third party.

One of our unique strengths is in risk and reliability-based technologies, where we apply rigorous quantitative risk assessment techniques to design, evaluation and analysis. Combining this with our expertise in optimization, we provide optimal, pragmatic, and cost-effective design solutions to enhance performance and maximize productivity.

ESG offers a specialised **Enhanced Oil Recovery (EOR)** consulting service as part of our Enhanced Field Development Planning capabilities, which are as follows:

- **Full Field Review:** principally subsurface reservoir and surface assessment.
- **Field Development Plan:** includes all aspects of the life of asset development, including reservoir assessment, pressure maintenance and secondary recovery (excluding EOR), well and completion design and Artificial Lift; surface facilities: offshore jackets and topsides (if relevant), gathering system, process and pipelines, oil/gas storage and export facilities; Cost Estimation, Capex and Opex budget, economic evaluation and risk assessment; operating philosophy, abandonment and decommissioning, HSE philosophy and requirements, HR field organisation.
- **EOR:** the evaluation, design, planning and implementation of the Enhanced Oil Recovery processes, i.e. gas, thermal and chemical; such as Water Alternating Gas Injection (WAG), Steam Injection and CO₂ Injection.
- **Enhanced Field Development Plan:** this combines the standard Field Development Plan with Enhanced Oil Recovery (as described above).

ESG staff have experience in all aspects of planning and operations management and supervision, integrity inspections, documentation and training. Each of the company's personnel has over 25 years experience with international operating oil companies in both offshore and onshore situations in over 40 countries worldwide.

Company's Capability

Knowledge Base

ESG's staff and associates have Enhanced Oil Recovery (EOR) assessment, design, planning and project management, most of it gained through many years experience with major oil companies. We can conduct and project manage the following types of EOR applications:

- Hydrocarbon gas injection
- CO₂ injection
- Water Alternating Gas Injection (WAG)
- Steam injection for heavy oil EOR, including steam flood, cyclic steam injection and Steam Assisted Gravity Drainage (SAGD)
- In-situ combustion
- Chemical Flooding, including surfactant mecellar polymer flooding and alkaline flooding

ESG staff have particular expertise in Heavy Oil EOR, including steam injection, having conducted projects in Kuwait, Albania and Canada (see Experience).

This knowledge base encompasses all the technical and commercial aspects of the application of EOR as an integral part of field development planning. We understand the full field life cycle and have experienced staff in-house to provide the associated subsurface analysis and surface facilities design. We are comfortable with uncertainty and risk and are able to use key decision-making tools to assess the value of reducing uncertainty and mitigating risk. We recognize the need for trade-offs in order to provide an optimized EOR solution. Throughout project planning and implementation, the EOR team can call on the expertise of ESG's Subsurface, Drilling and Facilities Engineering & Construction departments. Most importantly we understand the need to underpin all the technical and commercial disciplines with a commitment to health, safety and the environment.

Services

ESG has an extensive knowledge base and experience which enables us to offer complete integrated EOR services. These services may form part of a green field Enhanced Field Development Plan (EFDP) prior to development, or as in incremental project later in the life of the asset in order to maximize reserves recovery and asset value. We can undertake the EOR study and subsequent project implementation either in-house or at the client's offices.

Our services include the following components:

Pre-project Planning

- Preparation of an overall project strategy, policies and procedures
- Cost-Time-Resource (CTR) preparation
- Preparation of a project schedule for the EFDP project

EOR Screening Study

An EOR screening study is typically a high-level review of the reservoir and fluid properties to determine which, if any, EOR processes are suitable for the field. The outcome is often a "go" or "no-go" recommendation which can be supported by a screening economic evaluation, if required.

- Compilation of available technical and economic data and preparation of a data base

- High level review of the reservoir model
- High level review of the existing reservoir simulation and history match
- Identify appropriate EOR process
- Screening economic assessment
- EOR Screening Study Report

EOR Detailed Study & Pilot Design

The EOR detailed study and associated coreflood studies provide a detailed assessment of the EOR process on reservoir performance and its economic viability. It includes the design of a Pilot Project which is normally conducted to test the EOR process on a limited number of wells.

- Design and supervision of special coreflood studies to optimize oil recovery for different EOR processes and reservoir conditions
- Conduct reservoir simulations using results of special coreflood studies
- Optimize EOR process for reserves recovery and reservoir conditions
- Cost estimation of all drilling and facilities
- Economic evaluation of Pilot project, including optimization and sensitivity analysis
- Conduct risk and uncertainty assessment
- BOD for injector well and well surveillance for the pilot project
- Design pilot project for the optimum EOR process, including well design and facilities
- EOR Detailed Study Report and Pilot Design Report

Project Management of EOR Pilot Implementation

The EOR Pilot Project is implemented typically on a limited number of existing or new wells in order to assess the reservoir performance for the selected EOR process. Reservoir and well performance are monitored during the Pilot. The outcome is an assessment of the EOR process and a "go" or "no-go" recommendation for full field design and implementation.

- Project management (PM) of injector well drilling and completion
- PM of facilities engineering, construction, installation, hook-up and commissioning for the EOR delivery process, well surveillance and pipelines
- Compilation and analysis of well surveillance data
- End of Project EOR Pilot Evaluation report and recommendation for full field implementation

EOR Full Field Design

The EOR Full Field project is designed and fine tuned using the results of the Pilot. The work includes an economic and risk assessment to demonstrate the commercial viability of the project and mitigate the key risks.

- Reservoir simulation for the full field implementation with results of Pilot Study
- History match the simulation
- Optimize EOR process for reserves recovery and reservoir conditions
- Design of all injector and producer wells
- Design of Full Field Well Surveillance
- PM of Engineering design of all EOR facilities (EOR process, pipelines & offshore structures, if any)
- Cost estimation of all drilling and EOR facilities
- Economic evaluation, including optimization and sensitivity analysis
- Conduct risk and uncertainty assessment
- EOR Full Field Design Report (either as a standalone report or as part of the EFDP)

Project Management of Full Field Implementation

During EOR Full Field implementation the EOR Project is implemented across the entire field. Reservoir and well performance are monitored to ensure that oil productivity and injection rates of the EOR medium (gas, steam or chemicals) are optimized.

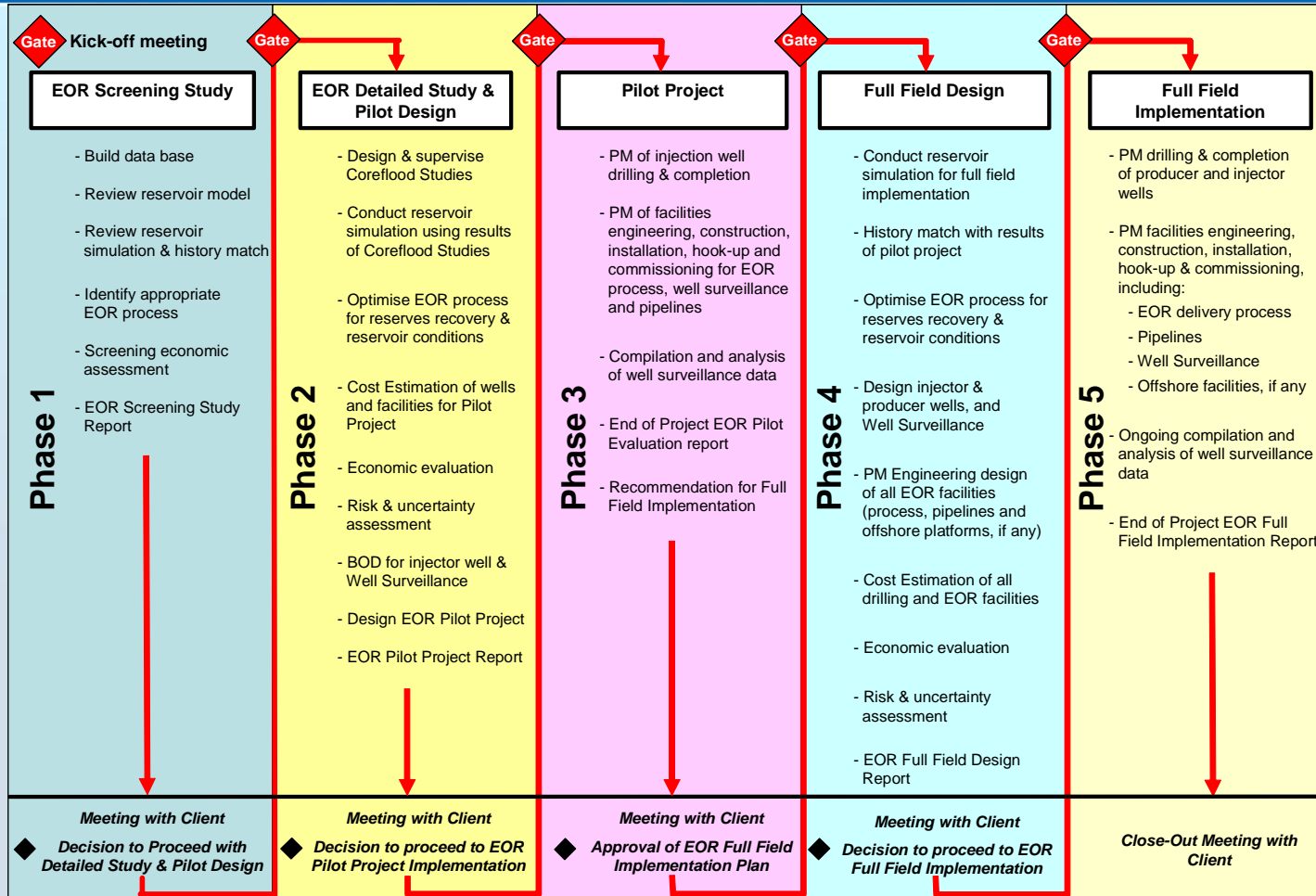
- PM of injection and production well design, drilling and completion
- PM of facilities engineering, construction, installation, hook-up and commissioning, including EOR delivery process, well surveillance, pipelines and offshore facilities
- Compilation and analysis of well surveillance data
- End of Project EOR Full Field Implementation Report

Capability & Methodology

ESG can provide EOR consulting services for any size of oil field development, onshore or offshore, in any geographical location. The standard methodology for preparation of an EFDP, Pilot project and Full Field EOR project is outlined above. However as each project is distinct and different we first determine the client's specific needs through project initiation meetings at which the key objectives and deliverables for the project are defined; and the Cost, Time and Resource components are discussed and agreed.

ESG's overall workflow for EOR is shown in the following diagram. This generic workflow is a starting point and will be tailored to the requirements of the client and the specific field under consideration.

EOR Work Flow



Generic Work Flow for EOR projects

ESG use a gated project management method, whereby entry to each phase of the project is dependent on completion of all deliverables for the preceding phase and the client's approval, which is normally obtained at a technical review meeting.

Software

ESG has licenses for or, is experienced in using, a range of workstation- and PC-based software applications which can be used for field review and development projects. These include:

- Geological well log correlation Kingdom suite (SMT)
- Seismic interpretation and mapping Kingdom suite (SMT)
- Seismic stratigraphic interpretation OpendTect SSIS (DGB Earth Sciences)
- Material balance MBAL (Petroleum Experts)
- Well modelling PROSPER (Petroleum Experts)
- Lift curve generation PROSPER (Petroleum Experts)
- System modelling GAP (Petroleum Experts)
- PVT analysis PVTp (Petroleum Experts)
- Pressure transient analysis Saphir (KAPPA Engineering)
- Numerical well modelling Saphir (KAPPA Engineering)
- Rate transient analysis Topaze (KAPPA Engineering)
- Rapid numerical simulation Rubis (KAPPA Engineering)
- Reservoir simulation Eclipse (Schlumberger)
- Pipeline design and analysis PIPESIM (Schlumberger)
- Process design and modelling HYSYS (Aspen Tech)
- Well planning WELLPLAN (Landmark)
- Casing Design STRESSCHECK (Landmark)
- Tubular Design WELLCAT (Landmark)

Other software can be rented on an as-required basis.

Project Management

ESG operate a rigorous and comprehensive project management procedure for all its EOR projects. Our goal is to bring projects on time and under budget. ESG has a proven track record and its approach to effective project management includes the following:

- Chairing regular project team meetings and monitoring progress against agreed time-lines
 - Maintaining action list and verifying follow through
 - Developing and maintaining timelines and gantt charts
 - Maintaining critical issues and roadblock list and assuring timely resolution of issues
- Providing full range of technical support from other ESG departments throughout the project, including drilling, facilities engineering and HSE.
- Coordinating with the client's existing contractors and suppliers for cost information
- Assuring adherence to client's approved procedures
- Assuring optimum reporting and communication between Project Team Members and Project Manager and Client.

Project Schedule

The project schedule, together with milestones and deliverables are agreed with the client prior to the start of the study. The project schedule is then updated on a weekly basis so that any critical issues can be identified and discussed with the client.

Project milestones are agreed at the outset to identify gates in the project work flow which cannot be passed without the client's approval. These are often associated with deliverables which are presented to the client as reports and/or presentations at technical review meetings. This process ensures that the client is kept fully informed of project progress and remains in full control of the project.

Meetings

Two types of meetings are normally held:

- Regular Update Meetings are held, usually either weekly or monthly depending on the location of the project team. Technical issues of the work are presented and discussed, administrative and any critical issues are identified and resolved with the client.
- Technical Review Meetings are held at key points during the project to present substantive pieces of work to the client, often as a prerequisite for proceeding to the next phase of work. The project schedule is reviewed at each meeting and any recommendations for additional studies and optional work are made. The final meeting is the Close-Out Meeting where final project deliverables are submitted to the client.

Any key decisions and action points made during the meetings are recorded and followed up for review at subsequent meetings.

Progress Reports

A report is submitted to the client on a weekly basis in order to monitor project progress. This highlights the work done in the past week, the work to be done in the coming week, any changes to the schedule and any highlights any critical issues.

Training

A key element of the EOR project, and the technical studies that underlie it, is the provision of training for the client's staff. This is particularly important to enable technology transfer and the build up of experience and capability within the client's organization. Effective training includes technical fundamentals, problem solving and operational practice. Training can be provided either as formal courses or as on-the-job, where the client's staff actively participate in the project.

ESG can provide customized training programs in the following main technical areas that underlie the EOR project:

- EOR concept design and optimization
- Reservoir simulation of different EOR processes
- Design and analysis of Coreflood studies
- Well Surveillance for EOR projects
- Economic evaluation of EOR projects

ESG's courses are customized to suit client requirements and address client gaps in the most effective manner. Blending theory, practice and discussion in the right proportions, our courses succeed in elevating the understanding and competence of a wide cross-section of participants. In keeping with our philosophy, our courses go beyond the traditional approaches, and several special problems, current trends and research activities are discussed.

Classroom multimedia training is used along with practice sessions with relevant software and problem-solving tools. Several examples are also used in the class to illustrate and disseminate key concepts and problem solving skills. Detailed manuals and software products (where appropriate) are a standard part of an ESG training program. Continuing training programs are also available.

Organization

ESG will use its own vastly experienced resources to support a dedicated EOR Project Team consisting of ESG in-house and associate personnel. ESG's experienced staff include the following:

Name	Discipline	Overall Years Experience
Paul Baron	Petroleum Engineering EOR Specialist/Project Manager	28
Paul Rhodes	Facilities Engineering/Project Manager	20
Aavo Taal	Production Geology	27
Ge Hoogeworst	Geophysics	32
Serdar Kaya	Geomodelling	17
Andrew Stocks	Petrophysics	37
Paula Pedler	Reservoir Engineering	20
Hugh Kane	Facilities Engineering	25
Jim Bonini*	Process Engineering	14
Howard Wigg	Production Technology & Completions Engineering	34
David Eyre*	Corrosion Engineer	27
Wayne Longstreet	Well Engineering	45

* Staff provided through associates

The dedicated Project Team normally consists of the following positions:

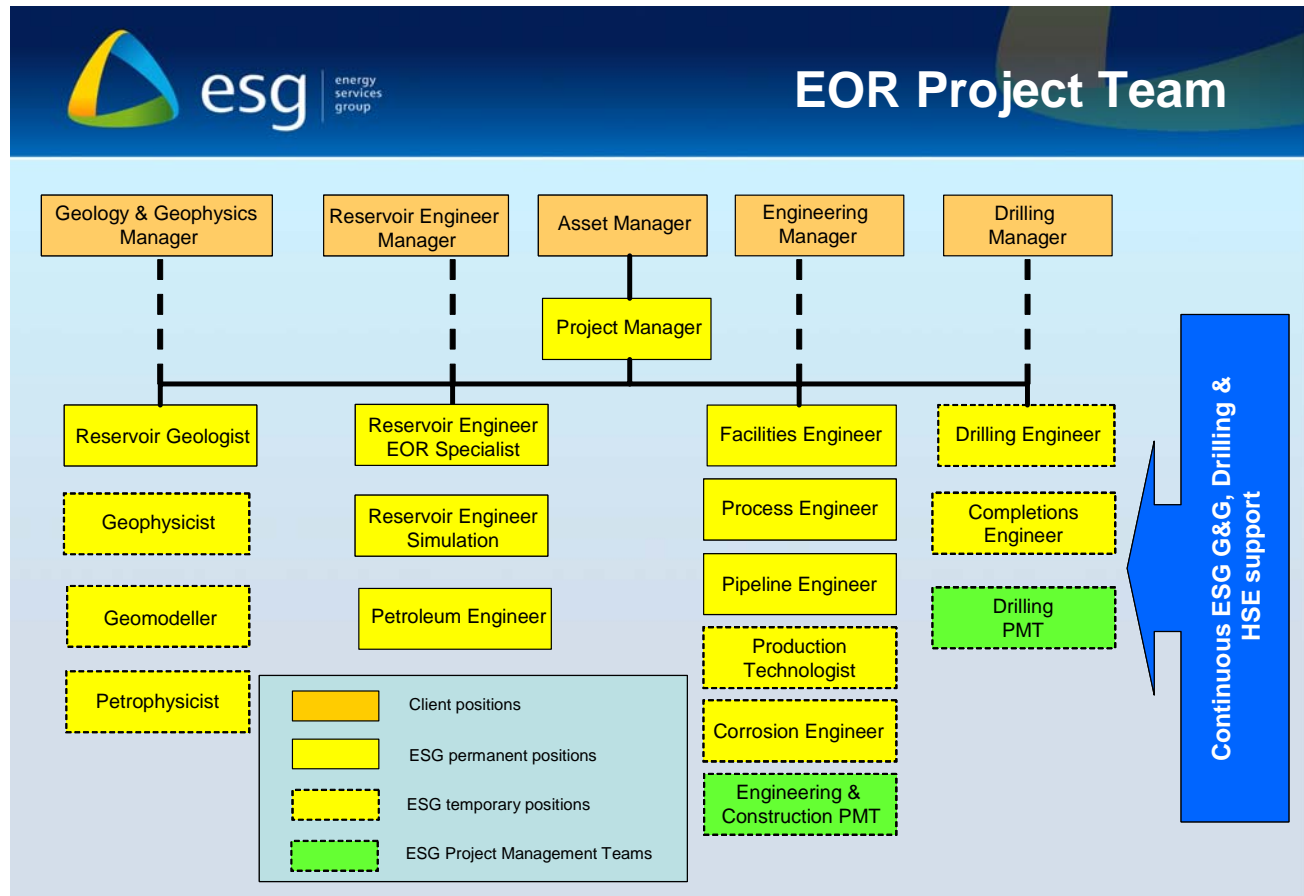
- Project Manager*
- Facilities Engineer*
- Reservoir Geologist*
- Process Engineer*
- Geophysicist (as required)
- Pipeline Engineer*
- Reservoir Geomodeller (as required)
- Production Technologist (as required)
- Petrophysicist (as required)
- Corrosion Engineer (as required)
- Petroleum Engineer EOR Specialist*
- Drilling Engineer (as required)
- Reservoir Engineer – Simulation*
- Completions Engineer (as required)

*Members of the Core Team of permanent staff

In addition to these positions in the EOR Core Team, ESG can provide Project Management Teams for Project Engineering & Construction and Drilling to manage the implementation phases of the EOR project: Pilot Project and Full Field Implementation Project

ESG assign staff to a project as and when required. The staff varies according to the size and needs of each project and is agreed with the client prior to the start of the project. There is generally a core

team of permanent staff and a number of temporary staff (marked "as required" in the list given above). It is only through the use of such expertise and assistance that a project schedule, process and timely work-flow will be successfully applied and managed to meet each project's needs. The reporting structure of this EOR Project Team is outlined in the figure below:



ESG's Project Manager will be a senior General Manager of ESG and will report directly to the client's designated Asset Manager. All other ESG staff report to the ESG Project Manager. There is also a very important functional link between ESG staff and their counterparts in the client's organisation (shown as dashed lines in the above chart). This is essential for direct, open communication at all technical levels between the client's technical staff and the EOR Project Team. ESG's Project Team is supported at all times by ESG's other departments, particularly G&G, Drilling and HSE.

ESG's Project Team can be located either in the client's offices or in ESG's offices in Dubai.

Experience

ESG's staff have conducted a number of EOR projects for several clients, some of which are ongoing.

Company/Operator	Date	Project
KOC	2008-09	Heavy oil network modelling and steam supply EOR project, part of the integrated field development plan of the 8-10 Billion bbl Lower Fars Heavy Oil Field, Kuwait.
KOC	2008	Evaluation of EOR options for North Kuwait fields.
ADNOC	2007	Technical review of gas injection and recycling EOR projects of all major fields in Abu Dhabi.
Novus Petroleum	2003-2004	Subsurface and commercial components of the Zarghun South integrated field development plan, Pakistan
BP	2003	Engineering, Implementation & Commissioning of debottlenecking modifications to improve the Heavy Oil production process and sand control measures on Harding Field, UK North Sea.
Premier	2001-2003	Integrated reservoir development plan for a large heavy oil re-development in Albania.
BP	1988-91	Technical studies, design of Pilot Project and field tests on 11 Billion bbl West Sak Heavy Oil field, North Slope Alaska

Contact Information

ESG operates from its Head Office in Dubai, UAE. It has also established country offices and representation in Turkmenistan and Malaysia.

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