Kingdom of Saudi Arabia

Strategic Priorities for Oil and Gas Technology Program

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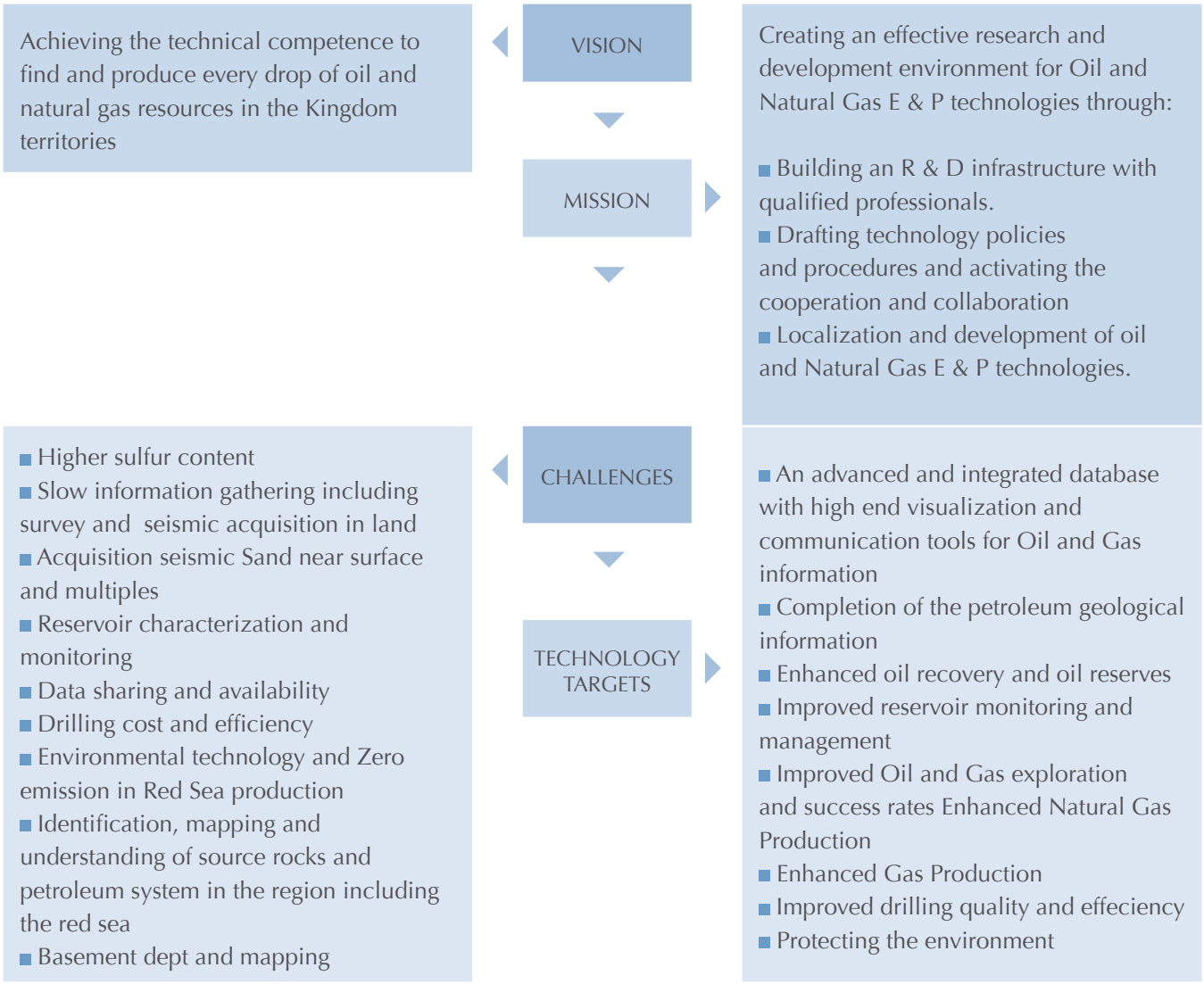
Executive summary

This document outlines a strategy that will guide oil and gas research and development in the Kingdom of Saudi Arabia for the next twenty years. Its development required the cooperation of many stakeholders in the exploration and production industry. These stakeholders helped to establish a vision, a mission, values, and strategic objectives that will focus oil and gas research and development in the Kingdom. Each of the strategic objectives has a set of performance measures that will help gauge the success of the Kingdom in implementing this strategy.

Technology target areas were defined using a strengths, weaknesses, opportunities, and threats (SWOT) analysis. This analysis took inputs from many professionals representing nearly all of the oil and gas companies and universities in the Kingdom of Saudi Arabia. These individuals helped define the technology target areas by outlining the challenges that the Kingdom faces and expects to face in the future.

Figure 1 shows the vision, mission, challenges, and resulting technology target areas. For each technology target area, groups of professionals were selected to carry out more detailed planning.

Figure 1: Vision, Mission, Challenges, and Technology Target Areas



In order to ensure the successful implementation of this strategy, a system was designed to monitor its implementation and to allow for periodic updates. All components of this strategy are aimed at creating value within the Kingdom and the vision is to excel in technologies that will help discover and produce every drop of oil and gas within the Kingdom of Saudi Arabia in an environmentally friendly manner.

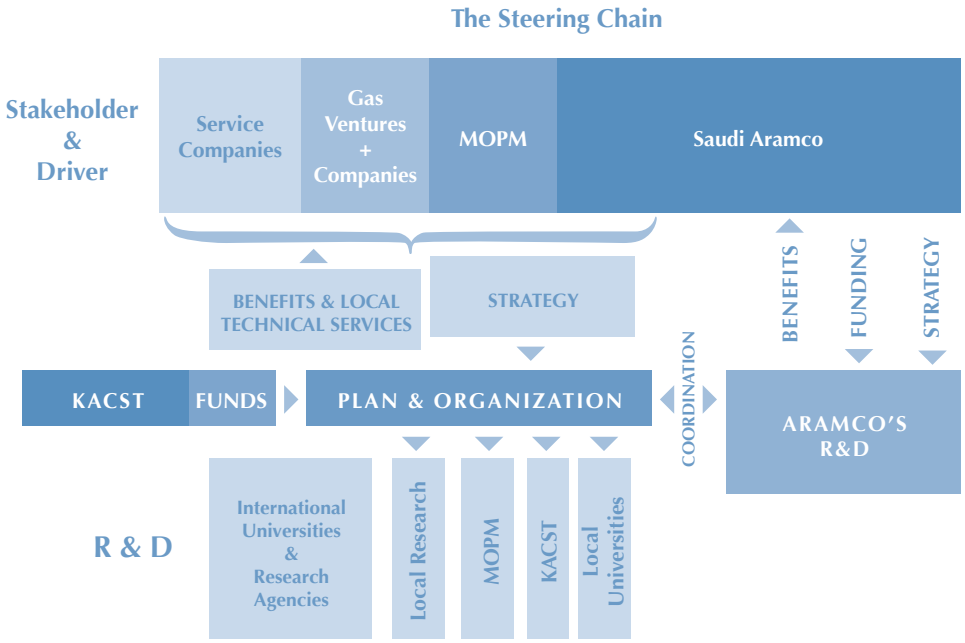
Introduction

The development of this strategic plan began following the approval of a national plan for science and technology in the Kingdom of Saudi Arabia (KSA). The King Abdulaziz City of Science and Technology (KACST) was directed to manage this national plan and it covered many different technology areas. Specifically, the plan focused on 11 strategic and advanced technologies ranked in the order of their importance. Oil and gas was ranked second, emphasizing its importance to the future of the Saudi economy.

Stakeholders

Many stakeholders were involved in the development of this strategic plan. Key stakeholders include Saudi Aramco, the Ministry of Petroleum and Mineral Resources (MoPM), gas ventures, and service companies for upstream oil and gas sectors. The planning process provided all stakeholders with an opportunity to share their ideas. Figure 2 is a schematic showing the relationships among the stakeholders.

Figure 2: Relationships among Oil and Gas Stakeholders



Introduction

To encourage stakeholder participation, a website for the plan was constructed.
The website address is: http://www.ept2025.com

The oil and gas program formed a strategy team with representatives from Saudi Aramco, KACST, MoPM, and several universities. The team was responsible for directing the development of the oil and gas strategic plan. The team met six times for a full day meetings and discussed a wide range of issues. The team also communicated with each other by e-mail and the chat room available at the plan web page. The strategy team is listed in table 1.

Table 1: Strategy Team

Name	Institution	Position
Tariq AlKhalifah	KACST	Director
Abdulrahman AlQuraishi	KACST	Assistant Director
Abdulaziz AlKaabi	Saudi Aramco	Member
Saleh Almulhim	Saudi Aramco	Member
Iessa Mahfis	MOPM, Eastern Branch	Member
Majed Badah	MOPM, Eastern Branch	Member
Abdulaziz AlMajed	King Fahad University for Petroleum and Minerals	Member
Abdulaziz ibn Laboun	King Saud University	Member
Emad AlHomadhi	King Saud University	Member
Hassan Naji	King Abdulaziz University	Member
Mahmoud AlOsaimi	MOPM, headquarter	Member
Abdullah AlSabti	KACST	Project Manager
Emad AlMushaqigh	KACST	Team Secretary

Strategy Development

The strategy development process began with a review of the oil and gas R&D experiences of technologically mature countries such as Norway and Canada. Some of the references analyzed in this review are shown in Figure 3.

Figure 3: Oil and Gas Strategy References

Following a review of other countries initiatives, the status of oil and gas R&D in the Kingdom of Saudi Arabia was analyzed. SRI international was contracted to benchmark worldwide institutions in upstream oil and gas and to provide an analysis of the relative standing of the KSA in oil and gas R&D as measured by publications and patents status.

The oil and gas program next carried out a strengths, weakness, opportunities, and threats (SWOT) analysis. The program distributed a questionnaire requesting information on strengths, weakness, opportunities, and threats to a large number of professionals in the Kingdom. A workshop was then held dedicated to the SWOT analysis. The head of the Norwegian Oil and Gas technology strategy (OG21) attended this workshop to provide additional insights based on their experience.

This workshop included more than 40 people representing nearly all companies, research institutes, and universities working in upstream oil and gas R&D in Saudi Arabia. Later, an additional questionnaire was distributed to specify the latest technologies and projects needed for the kingdom.

This was followed by another workshop that defined the technology target areas of importance and discussed the attendees willingness to participate in technology target

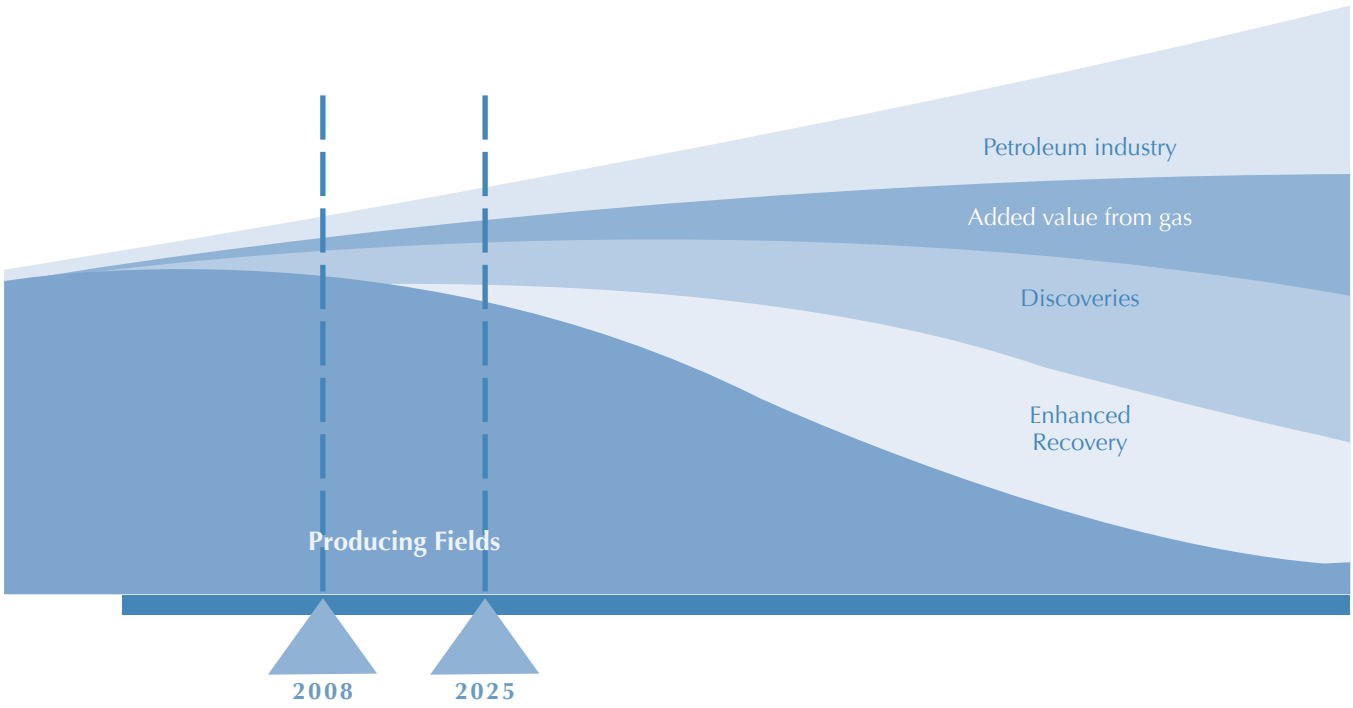
groups responsible for preparing the detailed technology target areas plans.

This process led to the development of this document, which outlines the strategy for upstream oil and natural gas technology development and localization. This strategic plan describes the initiatives needed to achieve the strategic goals and discusses the implementation process of the plan.

Strategy Timeframe

Although this strategy concentrates on the next 20 years, this plan develops a vision for the next 100 years. It is important to look out this far because, as shown in Figure 4, value from oil and gas production will diminish without the added value from enhanced recovery, new discoveries of oil and natural gas, and the supporting industry. New technologies supporting these potential added values include focusing efforts on the refining and petrochemical industries as we expect that Saudi Arabia will dominate the oil business for a significant period of time to come. However, refining and petrochemicals R&D is covered by another strategy that was developed by the petrochemical institute at KACST.

Figure 4: Future Challenges as Value from the Oil and Gas Sector Increases



Analysis of Oil and Gas Publications and Patents

Oil and gas exploration and production is a multidisciplinary field that relies on devices, instruments, and materials developed in fields such as information technology, electronics, mechanics, and advanced materials. The overall field, "oil and gas," as well as sub-topics, were defined in close consultation with KACST researchers and other KSA stakeholders.

The KSA oil and gas program identifies three sub-topics-petroleum geology, petroleum engineering, and geophysics-relevant to KSA strategic priorities. KACST researchers provided detailed lists of keyword terms that were used to develop search queries for publication and patent databases.[1] The scope of this study was restricted to only recent publication (2002-2006) and patent (2002-2006) activity in these fields.

There is general agreement that publications and patents strongly correlate with scientific research capacity, although publication and patent counts alone do not fully represent the quality or scope of research. Nonetheless, publication and patent activity have long been used as indicators for knowledge creation and research output.[2] Several indicators are presented below, including forward citations (the frequency at which publications and patents are cited by others), which is as a measure of impact, and co-authoring relationships, which are an indicator of scientific collaboration. Together, these indicators provide measures of collaboration, globalization, and the impact of science and technology research in fields related to the KSA oil and gas program.

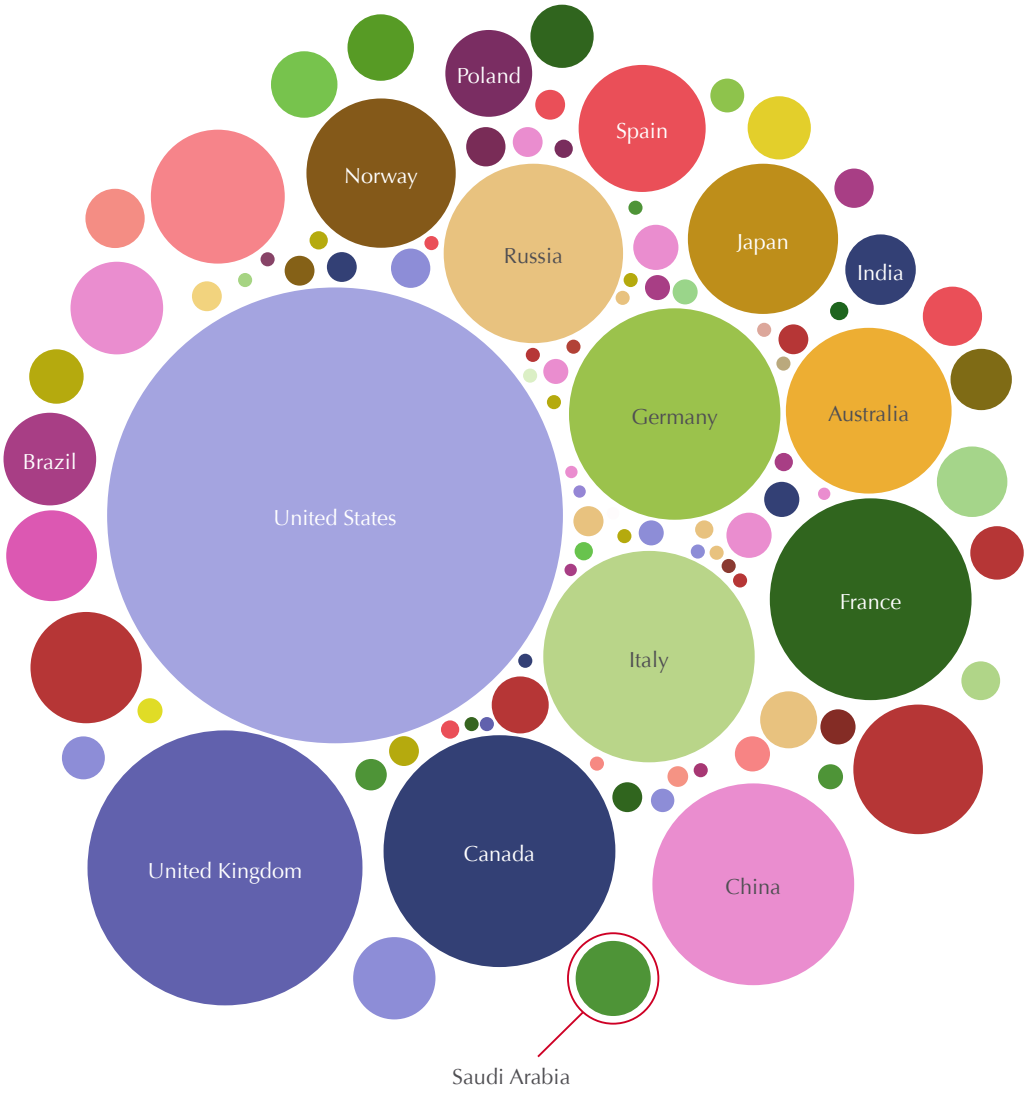
1 ISI Web of Science and Delphion were queried for scientific publication and U.S. patent application data, respectively. The ISI Web of Science is a database of peer-reviewed articles in major scientific journals from around the world. Delphion is a searchable database of global patent activity, including the U.S. Patent and Trademark Office (USPTO). The USPTO is one of the world's major granters of patents and it has been argued that the U.S. market is so large that most important inventions from around the world are patented there.

2 Seminal research in the use of publications as a measure of scientific productivity includes A.J. Lotka, "The frequency distribution of scientific productivity," Journal of the Washington Academy of Sciences, vol 16 (1926); D. Price, Little Science, Big Science, (New York: Columbia university Press, 1963); J.R. Cole and S Cole, Social Stratification in Science, (Chicago: The University of Chicago Press, 1973); J. Gaston, The reward system in British and American science, (New York: John Wiley (1978); and M.F. Fox, "Publication productivity among scientists: a critical review," Social Studies of Science, vol 13, 1983.

Global Oil and Gas Publication Activity

Between 2002 and 2006, there were 3523 articles published worldwide in oil and gas fields related to KSA oil and gas research priorities.[3] As shown in Figure 6, the United States was the world's largest producer of related articles, generating 1137 articles over this time period. The United Kingdom was second, producing 428 articles followed by Canada and Italy with 307 and 258 articles respectively. Saudi Arabia was the 21st largest producer of publications, producing 33 articles.[4]

Figure 5: Oil and Gas Publication (2002-2006)



3 Throughout this section, "oil and gas" refers only to the subset of oil and gas-related research defined by the KSA oil and gas program.

4 A publication is assigned to a country if any of the publication's author's affiliations are located in that country. Because publications often have multiple authors, a single publication may be assigned to multiple countries. Aggregate figures, such as total global publication output, count each publication only once, but adding up sub-totals may yield a result larger than the reported total due to multiple counting.

As shown in table 2, Petroleum Geology accounts for more than half of oil and gas publications from 2002 to 2006, with Petroleum Engineering (889) and Geophysics (803) splitting the remainder.

Table 2: Oil and Gas Sub-Topics (2002-2006)

Sub - Topic	Publications
Petroleum Geology	1867
Petroleum Engineering	889
Geophysics	803

Benchmark Country Publication Impact

Average publication impact is calculated as the number of citations of articles from a particular country divided by the total number of articles published by authors from that country. For instance, a country that published 50 articles that were cited 100 times would have an average publication impact of two. Table 3 presents publication and citation counts for benchmark countries.[5] Between 2002 and 2006, Australia had the highest average publication impact of all countries at 5.10 followed by Germany (4.71), and the United States (4.44). The average publication impact for Saudi Arabia was 0.61 with 20 citations of 33 articles.

5 Benchmark countries include global leaders in terms of total petrochemical technologies publication output in addition to a list of specific countries provided by KACST.ISI Web of Science and Delphion were queried for scientific.

Table 3: Oil and Gas Publication Impact (2002-2006)

Country	Publications	Total Citations	Average Impact
Australia	150	765	5.10
Germany	253	1191	4.71
USA	1137	5049	4.44
Netherlands	90	365	4.06
New Zealand	100	392	3.92
Spain	97	380	3.92
Japan	131	512	3.91
UK	428	1607	3.75
Norway	123	432	3.51
Canada	307	1043	3.40
France	235	757	3.22
Italy	258	730	2.83
Peoples R China	239	627	2.62
Russia	182	260	1.43
Saudi Arabia	33	20	0.61

Oil and Gas Research Organizations

Oil and gas R&D publications are produced at more than a thousand research institutions in nearly 100 countries. As shown in table 4, the three institutions producing the largest number of publications related to oil and gas R&D are the Russian Academy of Sciences (131), Stanford University (94), and the University of Texas (79). In petroleum engineering, the top three organizations are Stanford University, Institut Français du Pétrole (IFP) and University of Calgary. In geophysics, the top three organizations are the U.S. Geological Survey (USGS), the University of Texas, and the Russian Academy of Science. Finally, in geology, the top three organizations are the Russian Academy of Science, the Chinese Academy of Science and the USGS.

Table 4: Global Oil & Gas R&D Organizations (2002-2006)

Organization	Publications	Total Citations	Average Impact	Geology	Petroleum Engineering	Geophysics
Russian Acad Sci	131	186	1.42	103	5	23
Stanford Univ	94	340	3.62	31	54	10
Univ Texas	79	273	3.46	28	28	25
US Geol Survey	79	571	7.23	43	4	32
Chinese Acad Sci	74	245	3.31	55	0	19
CNR	53	109	2.06	42	0	11
Univ Alberta	50	109	2.18	20	30	1
Inst Francais Petr	45	59	1.31	9	36	1
Univ Calgary	44	88	2.00	4	33	7
Univ London Imperial Coll Sci Technol & Med	43	129	3.00	11	25	7
Texas A&M Univ	38	82	2.16	14	29	2
Inst Geol & Nucl Sci	37	158	4.27	31	0	6
Univ Tokyo	33	189	5.73	10	2	21
China Univ Geosci	33	119	3.61	28	1	4
Heriot Watt Univ	32	52	1.63		0	0

International Collaboration and Publication Impact

For countries with a similar level of publication activity, those with a high level of international collaboration also tend to produce publications with a high level of impact. In this study, international collaboration is calculated as the average number of countries represented per publication, based on authors' addresses. Figure 6 plots a country's level of international collaboration (horizontal axis) against the average impact of its publications (vertical axis). Australia, Germany and the Netherlands, which show significant international collaborative activity, also tend to produce papers with a higher average impact.

KSA Collaboration Activity

As shown in table 5, authors affiliated with KSA institutions collaborated on more than one article with authors from: the United States (5 publications) and France (2). KSA-affiliated authors collaborated on individual publications with authors from: Australia, Canada, Malaysia, Norway, UAE, and the United Kingdom.

Figure 6: Oil and Gas Collaboration and Publication Impact (2002-2006)

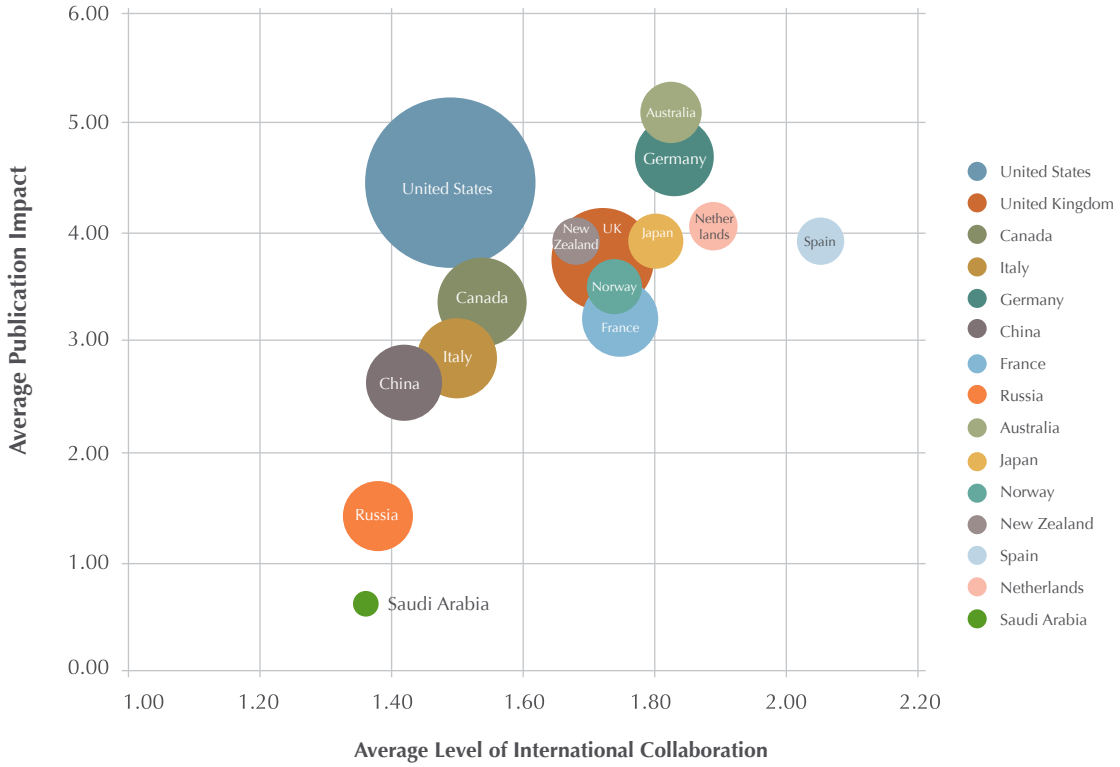


Table 5: KSA Publication Collaborators (2002-2006)

Country	Name of Publications
United States	5
France	2
Australia	1
Canada	1
Malaysia	1
Norway	1
United Arab Emirates	1
United Kingdom	1

Oil and Gas Journals

Table 6 presents journals with a significant level of publication activity related to KSA oil and gas sub-fields from 2002-2006.

Table 6: Oil and Gas Journals (2002-2006)

	Journal	Publications
Geophysics	Geophysics	108
	Earth And Planetary Science Letters	73
	Geochimica Et Cosmochimica Acta	60
	Journal Of Geophysical Research-Solid Earth	51
	Organic Geochemistry	34
	Chemical Geology	34
	Geophysical Prospecting	31
	Geophysical Journal International	30
	Tectonophysics	29
	Chinese Journal Of Geophysics-Chinese Edition	27

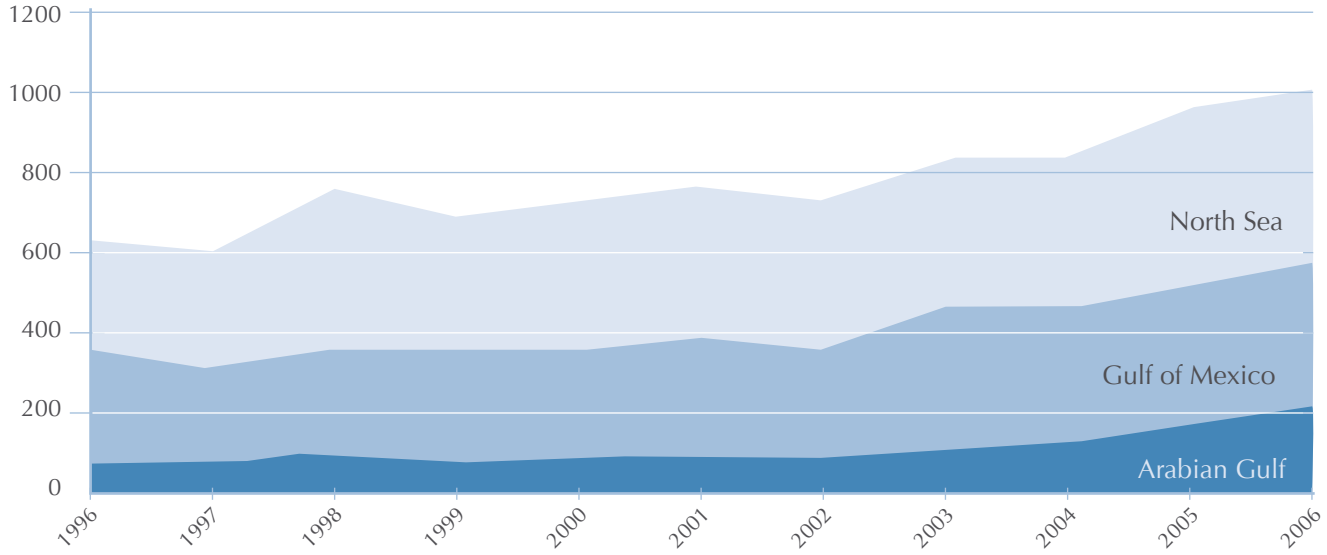
	Journal	Publications
Geology	Sedimentary Geology	246
	Geology	170
	Journal Of Sedimentary Research	143
	Geomorphology	132
	Acta Petrologica Sinica	107
	Sedimentology	105
	New Zealand Journal Of Geology And Geophysics	70
	Stratigraphy And Geological Correlation	69
	Cretaceous Research	66
	Rivista Italiana Di Paleontologia E Stratigrafia	57
Petroleum Engineering	Journal Of Petroleum Science And Engineering	188
	Journal Of Canadian Petroleum Technology	136
	Spe Reservoir Evaluation & Engineering	115
	Spe Journal	86
	AAPG Bulletin	65
	Petroleum Science And Technology	57
	Spe Drilling & Completion	42
	Oil & Gas Science And Technology-Revue De L'Institut Français Du Petrole	42
	Petroleum Geoscience	40
	Spe Production & Operations	21

Regional Publication Trends

The previous subsections examined publication data using a keyword-based approach. SRI International also performed an analysis of regional oil and gas publications using a journal based approach. For this analysis, all articles in ISI-indexed journals related to oil and gas R&D were included. This analysis compared the number of oil and gas publications that are focused on three regions: the Arabian Gulf, the Gulf of Mexico, and the North Sea. The results are shown in Figure 7.

	Arabian Gulf	North Sea	Gulf of Mexico	Global
Petroleum Engineering	339	650	652	27.142
Petroleum Geophysics	855	2638	3341	93.981
Total	**1194**	**3288**	**3993**	**121.123**

Figure 7: Oil and Gas Publication Trends



Despite the fact that the Arabian Peninsula contains the majority of the world's oil reserves, oil and gas research, as measured by the number of publications, focuses less on the Arabian Gulf than on the North Sea and the Gulf of Mexico. This is particularly noticeable in the fields of petroleum geology and geophysics in which the Arabian Gulf produces less than one percent of global R&D publications.

The challenges in the Arabian Gulf region are as significant, if not more significant, than those faced by the Gulf of Mexico and North Sea. The relatively poor quality of seismic data and the highly fractured and complex reservoirs in the region pose major challenges. These challenges present opportunities for the Arabian Gulf countries, and specifically Saudi Arabia, to develop new technologies.

Oil and Gas Patent Activity

Between 2002 and 2006, there were 461 oil and gas related patent applications filed with the United States Patent Office. As shown in table 7, the majority of these (327) listed at least one inventor from the United States. Other countries with a significant number of inventors include: Japan (60 patents), the Netherlands (34 patents), and the United Kingdom (27 patents). Two oil and gas related patent applications listed an inventor from Saudi Arabia. These patent applications are not cited by any other patent applications.

Table 7: Oil and Gas Patents (2002-2006)

Rank	Country	Petroleum Engineering	Geophysics	Petroleum Geology	Total
1	United States	56	240	31	327
2	Japan	8	51	1	60
3	Netherlands	2	31	1	34
4	United Kingdom	2	25	0	27
5	Germany	1	21	1	23
6	France	0	19	2	21
7	Canada	1	14	4	19
8	Italy	1	6	0	7
9	Norway	0	4	0	4
10	Australia	0	3	0	3
10	Russia	0	3	0	3
10	Ukraine	0	3	0	3
13	Brazil	0	2	0	2
13	China	0	2	0	2
13	Israel	0	2	0	2
13	Republic of Korea	0	2	0	2
13	Saudi Arabia	0	1	1	2

Strategic Components

This strategy includes a vision, a mission, values, strategic objectives, and challenges. Together these components will guide the future of the local oil and gas R&D program.

Vision

Achieving the technical competence and superiority to find and produce all the oil and natural gas resources in the Kingdom's territories.

Mission

Creating an effective research and development environment for oil and natural gas exploration and production technologies through:

- An R&D infrastructure with qualified professionals.
- Policies and procedures facilitating the collaboration between research institutes (universities and industry).
- Localization and development of oil and natural gas exploration and production technologies to solve problems, improve quality, and reduce cost.

Values

- Openness: open and shared information environment.
- Cooperation: exchange information and ideas through cooperative work.
- Humbleness: recognizing that what you have always requires improvement.
- Truth: delivering accurate and precise information.
- Dedication: to follow tasks to the end.
- Competition: the kind that promotes the work spirit and enthusiasm.

Strategic Components

Strategic Objectives

The following objectives were designed so that the KSA will be able to achieve the strategic vision and mission by 2025. Each objective is followed by a corresponding performance measure.

1. Improved data availability, openness, visualization, and access for research

- The availability of all acquired geological, geophysical and petroleum informations digitally with instant access.

2. Improved human resources quality, quantity, and education

- Increase in local Ph.D. holders in E&P disciplines by 1000 percent (or 1000).

3. Improve oil recovery and proven reserves

- Increase oil in place to 900 billion barrels and obtain a recovery rate of 70 percent by 2025 (Aramco objective).

4. Reduced exploration and production cost

- Reduce the cost of onshore barrel by 20 percent and offshore barrel by 50 percent.

5. Improve and increase efficiency of oil and natural gas exploration and drilling operations

- Cut the time needed for land acquisition and drilling operations by a 50 percent.

6. Reduced well pollution and emission

- No harmful pollutants emission from Red Sea wells and reduce emission from onshore and gulf wells to a minimum.

7. Complete the geological information needed for oil and gas upstream R&D

- Complete all missing petroleum geology information.

8. Development and localization of technology services for oil and gas

- The availability of at least 50 percent of the technology services (i.e. software) locally.

The performance measures were developed so that projects can be easily evaluated in regards to how they contribute to the strategic objectives.

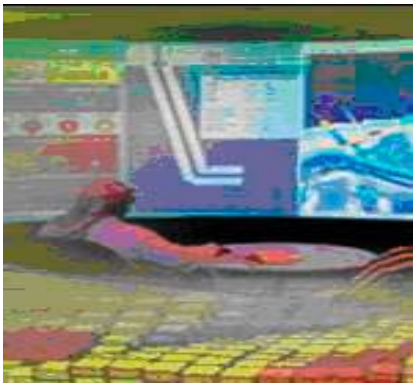
Challenges

The following is a list of some challenges identified by stakeholders:

- Education of young people on the importance of oil and gas technologies.
- Higher sulfur content in petroleum.
- High water-to-oil ratio.
- Slow information gathering, including survey and seismic acquisition in land.
- Seismic acquisition in areas covered with sand and characterized by near surface complexities and multiples.
- Reservoir characterization and monitoring.
- Data sharing and availability.
- Subsalt exploration and production.
- Drilling in deep water and old and complicated formations.
- Environmental and zero emission technologies.
- Identification, mapping, and understanding of source rocks and petroleum system in the region, including the Red Sea.
- Basement depth and mapping.
- Unayzah formation heterogeneity.
- Improved oil recovery.
- Exploration in new frontier areas such as the Red Sea and Rubaii alkhali.
- Mapping the top of large reservoirs.
- Detection and mapping of fractures in carbonate reservoirs.
- Deep inter-well resistivity measurements.
- In-situe wettability characterization.
- The problem of condensate banking in gas wells.
- Oily water disposal.
- Upstream waste management.
- Water down hole and online separation.
- Pore network modeling.
- Well monitoring systems.
- Well testing analysis in highly permeable layers.
- Sand production from unconsolidated formations.
- Dealing with reservoirs characterized with high salinity and temperature.

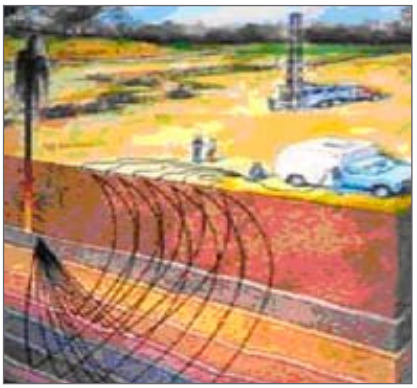
Technology Target Areas

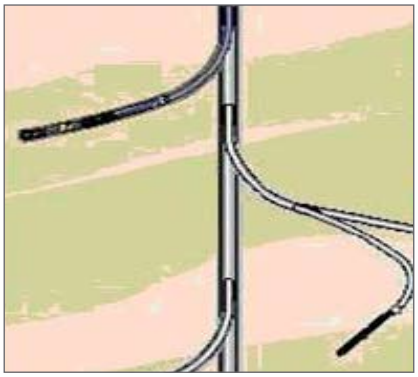
The oil and gas program, together with stakeholders, identified eight technology target areas (TTAs) that will be the focus of Saudi Arabian oil and gas R&D in the future. These technology targets were developed by identifying technology gaps in high-priority areas. The eight technology target areas and more focused secondary technology areas are listed below.



- An advanced and integrated database with high end visualization and communication tools for oil and gas information:
  - Development of data storage, compression, and monitoring capabilities (i.e. database).
  - Capabilities in data format upgrade and adaptation to our needs (i.e. new data formats).
  - Development of analysis, visualization, and integration tools (i.e. user interface).
  - Improved data accessibility through better communication and structure (i.e. internet access).
  - Advancements in data openness and sharing systems (i.e. access regulations).
- Completion of the petroleum geological information:
  - Mapping, modeling, and describing the sedimentary basement (i.e., improved gravity interpretation)
  - Better understanding and characterization of the petroleum systems including the source rock (i.e., seismic data interpretation).
  - Improved description of important and complicated formations including onaiyza formation (i.e., improved well information).
  - Improved fault and fracture description and direction in carbonate formations (i.e., azimuthal anisotropy).

Technology Areas





- Completion of the geological maps and their integration and coherency (i.e., remote sensing interpretation).

■ Enhanced oil recovery (EOR):

- Improved injection and production systems in carbonate reservoir.
- Determine the proper enhance recovery methods for existing reservoirs.
- Reduce water-oil ratio.

■ Reservoir modeling, monitoring and management:

- Improved reservoir modeling and simulation (i.e. parallel simulation), modeling and simulation tools.
- Enhanced reservoir monitoring and attributes extraction (i.e. 4-D seismics, deep diagnostics and sensing).
- Enhancements in real-time and remote monitoring of changes in giant reservoirs (i.e. passive seismic, nanotechnology, wireless technology).
- Improved information and attribute integration for reservoir simulation (i.e. well-seismic integration), modeling and simulation input data.
- Fracture and fault detection and mapping in carbonate reservoir (i.e. azimuth anisotropy).

■ Improved oil and gas exploration success rates especially in the Rubaii Alkhali and the Red Sea:

- Improved efficiency and quality of land acquisition (i.e., land streamers).
- Solving near surface seismic problems (i.e., datuming and inversion).
- Solving seismic multiple related problems (i.e., full waveform inversion).
- Improved seismic imaging (i.e., prestack depth migration).
- Development of unconventional methods for exploration and data integration (i.e., remote sensing).

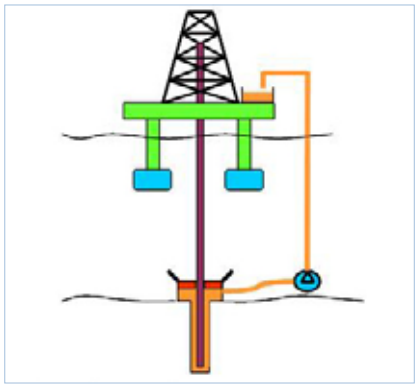
■ Oil and natural gas production:

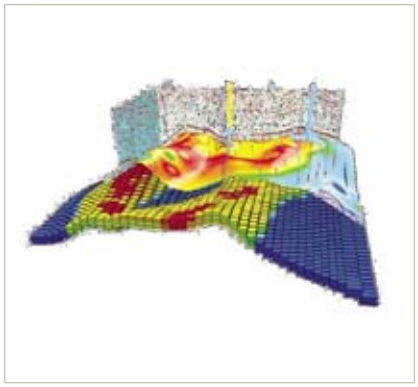
- Solving the problem of gas condensate in producing wells.
- Oil and gas reservoir stimulation.
- Production free of pollutants.

■ Improved drilling operations (quality and efficiency):

- Reduce drilling cost and drilling completion through developing efficient drilling systems (i.e., new cutting methods and drilling fluids).
- Complete drilling and consequences monitoring systems (i.e., drilling sensors and advanced drilling components).

Technology Areas





- Improved drilling in deep water and through formations in old and hard layers (i.e., ultra extended reach drilling).
- Improved drilling in high temperature, high pressure and high productivity formations.

- Protecting the environment:
- Improved monitoring systems and methods for emission from wells (i.e., water real-time sensors).
- Enhanced production standards to avoid emission.
- Improved carbon dioxide capture, and sequestration.
- Production and injection related hazard assessment (i.e., passive seismic, InSAR).

The technology target areas were defined to provide guidance to those implementing the oil and gas strategic plan. Each technology target area includes an objective, a background and a description. The phases of implementation for a technology target area are:

- Theoretical development.
- Laboratory testing and modifications.
- Development/further development of equipment.
- Testing of prototypes.
- Qualification.
- Pilot/demonstration.

The time required to develop a technology target is estimated to be six to ten years. Therefore, secondary goals (technologies) have been identified under each technology target area. Where technology development is fairly advanced, the demonstration phase may be the only one remaining. Secondary goals can be developed considerably earlier, possibly within two years for some technologies.

The technology target areas have not been ranked by priority, but it is assumed that a plan of execution will contain criteria for ranking based on the contribution of each technology target to the strategic objectives.

Additionally, eight technology target teams will be formed comprised of three to five professionals from both industry and academia to draft a detailed

plan for each target area and to lead the technology development during the plan execution phase in these areas.

Technology Initiatives and Priorities

The technology initiatives required to meet this plan's strategic objectives fall into two categories: technology prioritization and technology transfer.

Technology Prioritization

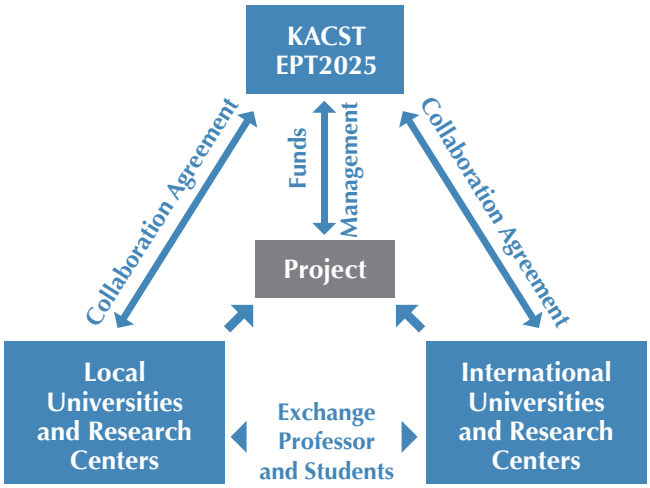
Following a model used by Saudi Aramco, technologies will be prioritized according to their compliance with the strategic objectives (impact), to their probability of success, and to their required resources. While Saudi Aramco>s objectives are focused on oil in place and recovery, the objectives in this plan include elements related to enhancing local content. Therefore, the oil and gas program weighs the criteria with impact weighted more heavily than the probability of success and required resources as follows:

- Impact (50 percent).
- Probability of success (25 percent).
- Required resources (25 percent).

Technology Transfer Models

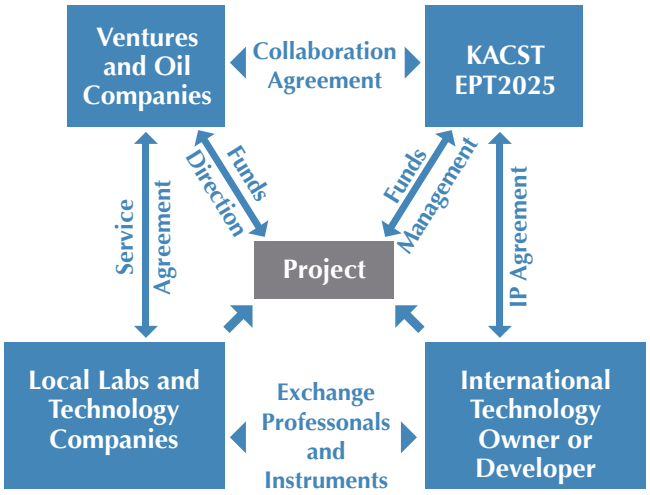
We use two models for technology transfer, both of which include the exchange of professionals and students between the technology owner or developer and a local entity. The first model applies to the case of transferring basic or applied research that is of strategic importance. The receiving party in this case is a local university or research center. In this model, KACST funds projects that allow Saudi graduate students and scientists to join international institutions. (Figure 8)

Figure 8: Basic/Applied Research Technology Transfer



The second model is concerned with transferring developed technologies or products that require minimal to moderate development for application locally. As a result, it includes an additional component corresponding to the end user. (Figure 9)

Figure 9: Developed Technologies/Products Technology Transfer



Like the first model, the project is managed and funded by KACST. However, there is also a collaboration agreement between KACST and the end user (e.g. Aramco, SRAK, TAQA). The end user may also contribute funds and provide direction for the project. In return, the end user gets a preferential service agreement that guarantees access to the developed product or service. An IP agreement is arranged between KACST and the international owner or developer of the technology, which provides the local entity with the right to locally use and develop the technology.

Key Technologies

Table 8 lists some specific technologies within each technology target area. The technologies and target areas in this table are not ranked but will be prioritized according to the methodology discussed previously.

Table 8: Technology Target Areas and Underlying Technologies

	Technology Target Area (TTA)	Technologies
TTA1 -	**An advanced and integrated database with high end visualization and communication tools for oil and gas information**	
TTA1-1	Development of data storage, compression, and monitoring capabilities	■ Wavelet transform and wave packet technology ■ Integrated Databases
TTA1-2	Capabilities in data format upgrade and adaptation to our needs	■ CFP format and HDF format ■ New data formats
TTA1-3	Development of analysis, visualization, and integration tools	■ Coherency cubes ■ e-drilling ■ Rate of penetration (ROP) modeling and optimization ■ Data integration ■ 3-D visualization and rendering ■ User interface
TTA1-4	Improved data accessibility through better communication and structure	■ Data bank technologies ■ Internet access
TTA1-5	Advancements in data openness and sharing systems	■ Internet friendly access regulations ■ Access regulations
TTA2 -	**Completion of the petroleum geological information**	
TTA2-1	Mapping, modeling, and describing the Sedimentary basement	■ Improved Gravity interpretation ■ Deep seismics ■ Regional earthquake seismology ■ Basin modeling
TTA2-2	Better understanding and characterization of the petroleum systems including the source rock	■ Seismic data interpretation ■ Seismic while drilling ■ Managed pressure drilling

Technology Areas

	Technology Target Area (TTA)	Technologies
TTA2-3	Improved description of important and complicated formations including Onaiyza formation	■ Logging at bit ■ Seismic while drilling ■ Improved well information ■ Data integration for high resolution modeling
TTA2-4	Improved Fault and fracture description and direction in Carbonate formations	■ Azimuthal anisotropy ■ Seismic while drilling
TTA2-5	Completion of the geological maps and their integration and coherency	■ Remote sensing interpretation
TTA3 -	**Enhanced oil recovery (EOR)**	
TTA3-1	Improved injection and production systems in carbonate reservoir	■ Smart fluids ■ Water/CO2 injectivity pilot ■ CO2 flooding ■ Wettability characterization and alteration ■ Smart proppant ■ Non-damaging stimulation fluids ■ Acoustic energy for heavy oil production ■ Cost efficient chemicals
TTA3-2	Determine the proper enhance recovery methods for existing reservoirs	
TTA3-3	Field screening for proper enhance recovery methods	■ Gas based EOR ■ Water based EOR ■ Thermal ■ Microbial
TTA3-4	Reduce water-oil ratio	■ In well separation methods ■ Chemical and microbial polymer shutoff ■ Smart fluids ■ Down hole water control ■ Smart wells
TTA4 -	**Reservoir modeling, monitoring and management**	
TTA4-1	Improved reservoir modeling and simulation	■ Finite difference and finite element modeling ■ Advanced computing and Linux clusters ■ Parallel simulation ■ Pore scale modeling ■ Virtual intelligence ■ Near borehole mechanics simulation ■ Fluid flow modeling ■ Basin modeling

Technology Areas

	Technology Target Area (TTA)	Technologies
TTA4-2	Enhanced reservoir monitoring and attributes extraction	■ 4-D seismic ■ Deep diagnostics and sensing ■ Tracers
TTA4-3	Enhancements in real-time and remote monitoring of changes in giant reservoirs	■ Passive seismic ■ Wireless technology ■ Intellipipe ■ Nanoscope concept ■ Down hole robotics and sensors ■ Nanotechnology ■ Down hole fluid analyzer ■ Multi phase flow metering
TTA4-4	Improved information and attribute integration for reservoir simulation and modeling	■ Well-seismic integration ■ Seismic while drilling ■ Borehole seismic integration ■ Integrated modeling ■ 3-D visualization
TTA4-5	Fracture and fault detection and mapping in Carbonate reservoir	■ Azimuth anisotropy ■ Coupled geo-mechanical and reservoir simulation of naturally fractured reservoirs
TTA5 -	**Improved oil and gas exploration and success rates especially in the Rubaii alkhali and Red Sea**	
TTA5-1	Improved efficiency and quality of land acquisition	■ Land streamers
TTA5-2	Solving near surface seismic problems	■ Wave-equation Datuming and near surface modeling ■ High resolution seismic ■ Radar technology
TTA5-3	Solving seismic multiple related problems	■ Wave equation inversion ■ SMRE
TTA5-4	Improved seismic imaging	■ Wave equation migration and velocity estimation ■ Prestack depth migration
TTA5-5	Development of unconventional methods for exploration and data integration	■ Remote sensing based mapping
TTA6 -	**Oil and Natural Gas Production**	
TTA6-1	Solving the problem of gas condensate in producing wells	■ Smart fluids

Technology Areas

	Technology Target Area (TTA)	Technologies
TTA6-2	Oil and gas reservoir stimulation	■ Acidizing ■ Hydraulic fracturing ■ Non-damaging stimulation fluids ■ Smart fluids and proppants
TTA6-3	Production free of pollutants	■ Oil in water acoustic monitoring ■ Down hole water control ■ Down hole gas oil separation process (GOSP)
TTA7 -	**Improved drilling operations**	
TTA7-1	Reduce drilling cost and drilling completion through developing efficient drilling systems	■ Advanced drilling fluids (smart fluids) ■ Microholes ■ GEOSTEERING - Low cost 3D rotary steerable systems ■ Logging at bit ■ Novel drill bits ■ Slim hole drilling ■ Down hole sand control ■ Nano composite materials for drill pipe and bit construction ■ Intelligent completion applications
TTA7-2	Complete drilling and consequences monitoring systems	■ Drilling Micro sensors ■ Advanced drilling components ■ Intellipipe wireless transmission ■ Mud logging sensors ■ e-drilling ■ ROP modeling ■ Inclination and logging at bit ■ Electrical drill pipe ■ Leak detection tools

Technology Areas

	Technology Target Area (TTA)	Technologies
TTA7-3	Improved drilling in deep water and through formations in old and hard layers	■ Ultra extended reach drilling ■ Managed pressure drilling ■ Lightweight drilling fluids and cement, ■ Lightweight risers ■ Torque reduction ■ Through tubing rotary drilling ■ Slim hole re-entry ■ Coiled tubing (CT) drilling ■ Flexible composite drill pipe ■ Laser drilling and perforation ■ Slim hole drilling
TTA7-4	Improved drilling in high temperature, high pressure and high productivity formations	■ Managed pressure drilling ■ Lightweight drilling incompressible fluids and cement ■ Lightweight risers ■ Torque reduction ■ Through tubing rotary drilling ■ Slim hole re-entry ■ CT drilling ■ Multi-lateral drilling and completion ■ Precise pore pressure prediction ■ Well testing while drilling ■ Smart wells
TTA8 -	**Protecting the environment**	
TTA8-1	Improved monitoring systems and methods for emission from wells	■ Real-time sensor systems ■ Cuttings management ■ Water treatment and water based fluids ■ Sonic leak detection systems for oil and gas pipelines ■ Photo acoustic oil in water monitoring ■ Microorganisms for oil spill removal ■ Microbial desulphurization
TTA8-2	Enhanced production standards to avoid emission	
TTA8-3	Improved carbon dioxide capture and sequestration	■ Advanced capturing and compression technologies ■ Local sources and sinks screening ■ Monitoring for leak detection

Technology Areas

	Technology Target Area (TTA)	Technologies
TTA8-4	Production and injection related hazard assessment	■ Passive seismic ■ DINSAR ■ Integrated geo-mechanical and fluid flow modeling

Strategic Initiatives

This section describes the initiatives that will be undertaken to achieve the strategic objectives. These initiatives fall into seven categories: infrastructure, finance, human resources, coordination and cooperation, laws and regulations, strategic research trends, and localization. These were obtained based on the output of the conducted SWOT analysis (see appendix C).

Infrastructure

This initiative will develop the KSA R&D infrastructure to support the strategic objectives by:

- Initiating new outstanding academic programs and developing current available ones (graduate and under-graduate programs).
- Establishing centers of excellence in universities and research institutes.
- Starting and supporting incubators that find and commercialize innovative technologies.
- Starting and developing advanced specialized laboratories.
- Constructing an organizational structure that will manage and guide R&D operations on the national level.
- Developing a national database for oil and gas exploration and production technical data to support R&D activities.

Finance

There are two kinds of financial initiatives that will be undertaken. First, there are those that deal with how existing money is spent. Second, are those that deal with securing future funds.

Efficiently Using Existing Funds

Initiatives that deal with how existing money is distributed include:

- Utilizing current assigned budget in developing infrastructure (buildings,

laboratories, equipments, academic chairs…etc).

- Utilizing current assigned budget in the quantitative and qualitative development of human resources through recruitment, financial motivations, fellowships for students and researchers, and supporting training and qualification programs for the R&D staff.
- Supporting and funding activities that assist R&D activities (data bases, periodical meetings, workshops, societies…etc).

Securing Future Funds

Initiatives that deal with securing future funds include:

- Proposing allocating part of foreign investments taxes in oil and gas industry to national R&D activities in the same field.
- Enhancing financial returns from studies and consultation that are provided to beneficiaries.
- Proposing a way to benefit from private grants and donations.
- Encouraging national mega companies that could benefit from R&D in oil and gas to take part in funding these activities.
- Securing continuous governmental funding.

Human Resources

There are three types of human resources initiatives that will be undertaken. The first relates to filling current shortages by attracting foreign researchers. The second aims to attract local manpower over the medium term. The final type of initiative aims to improve educational opportunities for future researchers. Individual initiatives are listed by type below.

1. Compensating current shortages in research staff by attracting outstanding foreign researchers by:

- Providing an attractive research environment and financial motivations.
- Exploiting the conservative environment of the kingdom to attract regional researchers.
- Supporting academic programs and accepting foreign students in graduate studies
- Proposing amendments to immigration and foreign recruitment laws to eliminate any obstacles to attracting foreign researchers.

2. Attracting local manpower to oil and gas R&D activities by:

- Arranging educatory programs for talented students.

- Providing financial awards for outstanding students in related academic fields.
- Approving a new attractive salary structure for researchers that ensure keeping outstanding staff from moving to another industry sector.
- Adopting new laws and regulations that ensure high quality R&D activities and providing financial incentives for outstanding researchers.
- Attracting local researchers from other fields (math, physics, and engineering) to participate in oil and gas R&D activities.
- Supporting current academic programs and starting new programs (in other universities).

3. Developing current and future human resources by:

- Providing enough scholarships for graduate students in local and international universities.
- Establishing specialized training programs for researchers and research assistants and technician.
- Providing fellowship for highly performing researchers in outstanding research institutes.
- Improving academic and graduate programs.

Coordination and Cooperation

To ensure a successful R&D program, there has to be an effective system for coordination and cooperation between the industry and research sectors and between research entities themselves. The following two types of initiatives will be undertaken to achieve this.

- Coordination and cooperation among research entities:
  - Conducting joint research projects.
  - Exchange of experience and expertise.
  - Establishing periodic meetings, workshops and conferences.
  - Enhancing the role of current scientific societies and establishing new ones.
- Coordination and cooperation between industry and research sectors:
  - Enhancing the established cooperation between the industry and some research institutes and encouraging the same for other institutes.
  - Encouraging the industrial sector to participate in funding R&D activities.
  - Exploiting the similarities in the gulf environment to promote cooperation of the industry and research sectors and to create a future market for R&D products in the gulf.
  - Utilizing the presence and interest of international oil companies and laboratories in the region to establish an internal and external R&D alliance through which funds and profits are shared.

Laws and Regulations

Initiatives will be undertaken that will propose amendments to laws and regulations that obstruct R&D activities related to:

- Researcher's salary structure.
- Immigration, foreign recruitment and foreigner salary structure.
- Performance evaluation and quality control.
- Rights and laws governing intellectual property.
- Industry support of local R&D activities through funds and information.
- Removal of unjustified or unnecessary confidentiality on technical data.

Localization

This initiative will direct and concentrate localization efforts in:

- Technologies stated in the research trends.
- Services of a technology nature.
- Products.
- Knowledge and consultation capabilities.
- Advanced education and training capabilities.

Exploration and Production Technologies 2025

Within KACST, a department will be created called the Saudi Exploration and Production Technologies 2025 (EPT2025) that will manage, oversee, revise, and organize the implementation of this strategy. EPT2025 will have a manager and a secretariat.

Mandate

EPT2025 will be a KACST department that facilitates innovation, technology development, technology transfer and research & development to solve existing problems, and improve the financial, environmental, and quality performance of the Saudi Arabian upstream oil and gas industry. EPT2025 will facilitate collaboration in all aspects of oil and gas R&D. EPT2025's role includes:

- Facilitating the localization and transfer of new technology for application in the Saudi upstream oil and gas industry.
- Acting as a matchmaker between those that have problems or opportunities and those that have potential technology or research solutions.
- Bringing stakeholders together to identify areas where technology or research will make a difference and launching specific projects to address those challenges.
- Promoting industry participation in the resulting initiatives and assisting with securing funding from a variety of sources.
- Providing a forum for the exchange of information and the creation of partnerships that are of mutual benefit to all involved and improve industry performance.
- Facilitating consensus for input to government on strategy and priorities regarding innovation, technology development and research in upstream oil and gas.

Organization and Implementation of the Strategy

The strategy outlined in this document provides direction and focus. However, successful implementation of the technology strategy requires:

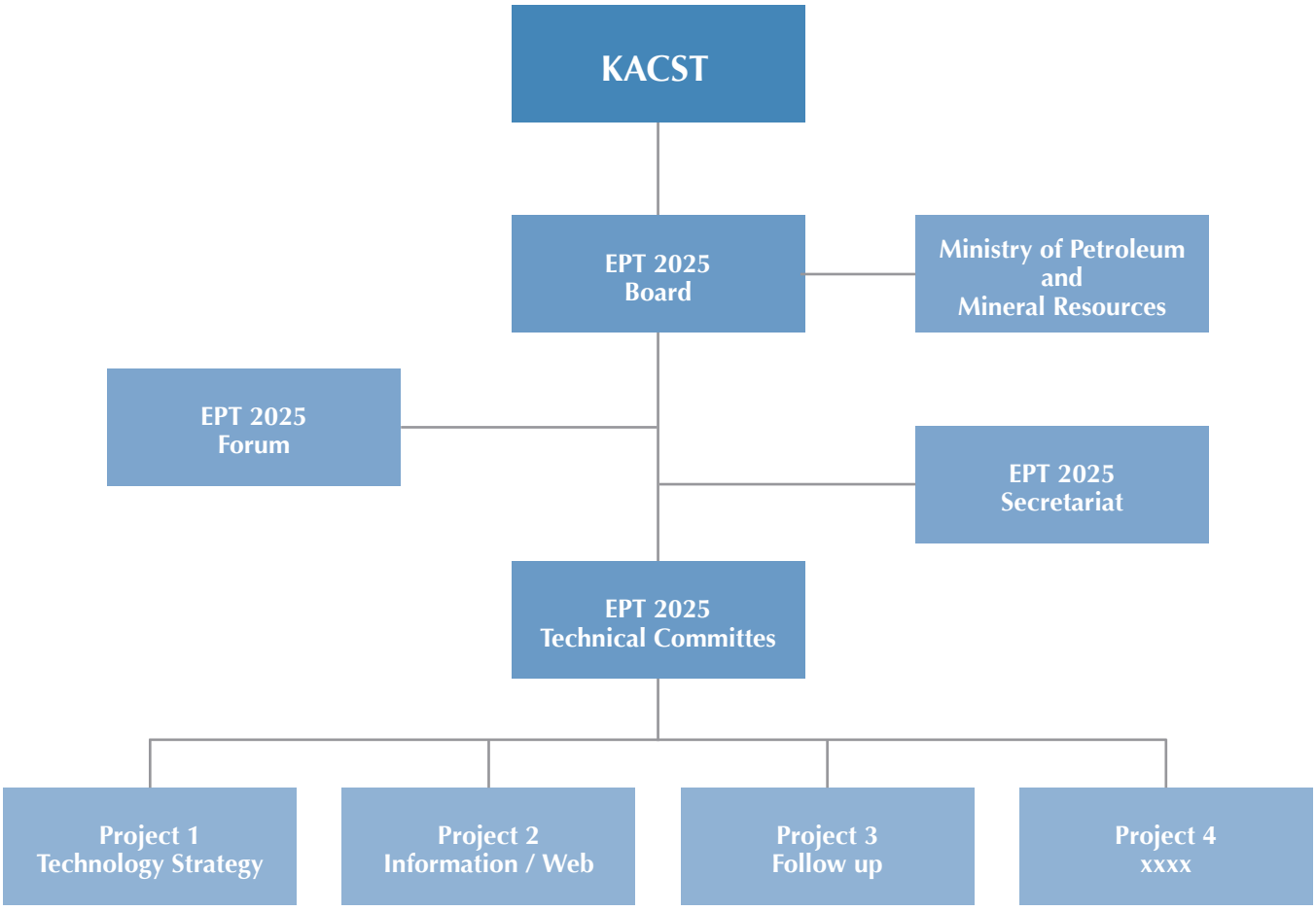
- Sufficient support in the industry and the public sector.
- A plan of action.
- Sufficient human and financial resources to implement proposed measures, and to follow up the strategy.
- A capable follow up structure.

Thus, to implement this strategy, it is important to establish a single organization to develop and improve already established networks (like those in the universities) and organizational structures (like that in Aramco). EPT2025 will link these structures, ensure cooperation, and provide overall coordination of technology development in the oil and gas sector to maximize return on investment.

Organization

EPT2025 will be organized through a secretariat/working group and a board that has a direct link to KACST. Its connection to the oil and gas sector will be through the EPT2025 Forum. A schematic form of the organization is illustrated in Figure 10.

Figure 10: Schematic Oil and Gas Organization



Strategy Oversight and Management

EPT2025 will serve as a catalyst for initiating R&D projects in time-critical areas with relevant participants from the sector.

Implementation

EPT2025's implementation of the technology strategy will be aided by the strong support it enjoys among stakeholders. This support will be gathered by allowing a broad representation of stakeholders on the EPT2025 Board, and by allowing a comprehensive round of comments on drafts of this strategy document. KACST and MOPM resources will ensure top-level support from the oil companies.

The strategy will be introduced through the various research programs under the direction of KACST and through its use in the development of technology strategies by companies and universities. Publicity for the technology strategy and information about activities related to EPT2025 will primarily be disseminated through the website at http://www.ognpksa.org.

The stakeholders will work together to define secondary goals and plans under each technology target area and to identify in more detail the technology gaps and needs that can help achieve their overall objectives. Proposals for projects may be submitted by one or more research/academic institutes in co-operation with one or more oil companies to bridge the gap between academia and industry.

To achieve an efficient, powerful system for implementing and following up the strategy, and for EPT2025 to be more of significant contributor, it has been proposed that the major oil companies be responsible for co-ordinating one or more of the technology target areas. The oil companies would work with the EPT2025 secretariat, forming a core group/technical committee. The participants in this core group will be responsible for:

- Surveying relevant technological developments in the areas in question, from strategic research to demonstration.
- Surveying the technology gaps and research needs in the area in consultation with the oil and gas sector.
- Drawing up action plans for technology development in the area.
- Initiating and promoting technology development projects in the area.
- Being a driving force behind the funding of relevant technology development projects.
- Keeping track of technological developments in the area, following up the strategy and informing relevant participants in the sector.
- Ensuring the co-ordination of overlapping activities, and exploiting synergies.
- Establishing and operating an electronic meeting place in the relevant area.

EPT2025 will provide strategic input to the program committees.

Strategy Review

This strategy and corresponding implementation plans will be reviewed and updated annually. A comprehensive review will take place every five years. This update will require the same amount of effort needed to develop this initial strategy. Updates will be suggested and studied by the EPT2025 Forum and must be approved by the EPT2025 Board.

Funding

Implementing the strategy described in this document will require considerable effort over a period of five to ten years. This will only be the beginning of long-term

efforts as it is expected that initiatives undertaken in this strategy will last beyond 2025. KACST, the oil companies, and the supplier industry must work together to support these efforts.

The formation of EPT2025 will allow existing oil and gas R&D funding to be used more effectively. However, more government funding is necessary as a catalyst to achieve the desired <push>. Without the government funding and incentives, it is doubtful that the industry will be able to develop technology fast enough to take advantage of the window of opportunity presented by the challenges in oil and gas R&D.

The supplier industry has fewer funds available for R&D investment than the oil companies due to lower profitability. At the same time, considerable technology development tasks should be transferred to the local supplier industry. As oil prices are high, local oil companies are executing larger and larger projects requiring quick supplier response, which increases the cost of supplier services. This creates an opportunity to develop technology enhanced local suppliers at a lower cost.

The local supplier industry has limited opportunities to strengthen its R&D efforts and should focus on enhancing its competitiveness. This is largely taking place today as markets and technological needs are shifting away from Saudi Arabian needs. The supplier industry cannot handle long-term R&D needs specific to the KSA. This strengthens the argument for doing research and development in supplier activities and to help develop these technologies for new supplier companies. Funding and guidance for this will be predominantly provided by the government through KACST. However, we envision that this strategy will also help direct funding that oil companies and other entities may wish to provide.

Project Evaluation

Projects that support this strategy will be considered through a yearly request for proposals (RFP) that will be distributed and announced on the EPT2025 website every September. Proposals will be due in January of the following year. The technology target groups for each technology target area will develop the request for proposals for their relevant areas. The RFP should fit the vision and objectives developed for each technology target area.

The technology target groups will evaluate the received proposals. The evaluation will be based on how much each proposal contributes to the strategic objectives outlined in this document.

Table 9: Strategic Objectives, Technology Target Areas, and Stakeholder Support

Type	Objective	Technology Target Areas	Stakeholder Support
DataAvailability and Access	The availability of all acquired geological, geophysical and Petroleum info digitally with instant access	1	Ministry of Petroleum and Minerals, KACST, and the Saudi Geological society
Human Resources	Increase in local Ph.D. holders in E&P disciplines by 1000 percent (or 1000)	All	EPT2025, KACST, the ministry of higher education, and universities
Enhanced Oil Recovery	Increase Oil in place to 900 billion barrels and obtain a recovery rate of 70 percent by 2025	3, 4	EPT2025, Aramco, MoPM, and the universities
Reduced Cost of Exploring and Production	Reduce the cost of an onshore barrel by 20 percent and an offshore barrel by 50 percent	3, 5	EPT2025, Aramco, service companies, and universities
Efficient and Improved Exploration and Drilling	Cut the time needed for land acquisition and drilling by a 50 percent	5, 7	EPT2025, Aramco, service companies, and universities
Reduced Well Pollution and Emissions	Eliminate emissions from Red Sea wells and reduce emissions from onshore and gulf wells	8	EPT2025, Aramco, MoMP, and universities
Geological Information for Upstream R&D	Complete all missing Petroleum geology information	1	EPT2025, MoMP, and universities
Technology Services for Oil and Gas	The availability of at least 50 percent of the technology (i.e. software) services locally	All	EPT2025 and KACST

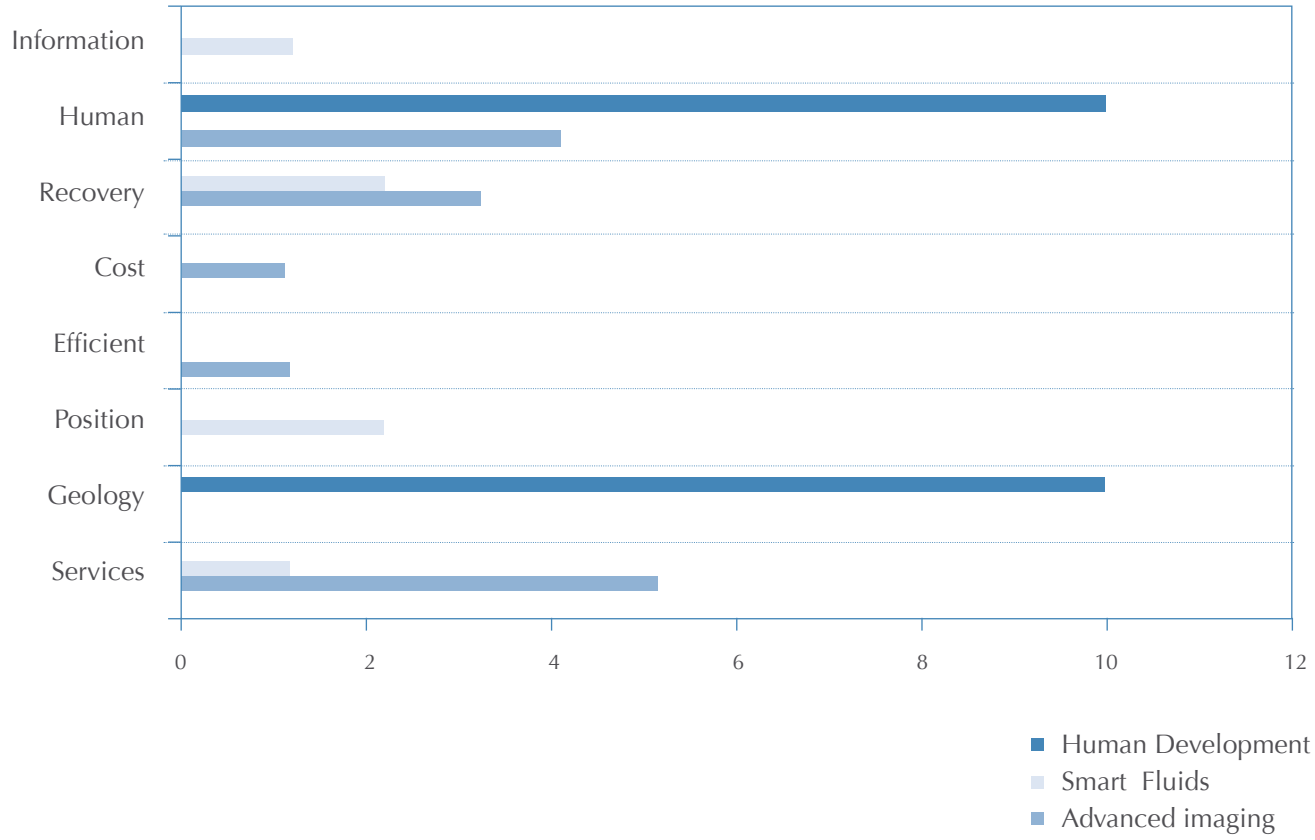
Project Evaluation

As an example, three oil and gas projects were evaluated:

- Advanced Imaging dedicated to advanced processing and imaging of seismic data for better exploration and reservoir description. This project would help four potential scientists obtain their PhD in advanced imaging from abroad.
- A purely scientific project on Smart Fluids.
- Human development: a project to develop ten graduates in the field of petroleum geology.

The evaluation of these three projects with regards to each strategic objective is shown in Figure 11. Each of the three projects was weighted based on how much they contribute to each objective.

Figure 11: Example Evaluation of Three Projects with Regards to Strategic Objectives



Final remarks

The development of this plan has been a joint effort with companies like Saudi Aramco, SRAK, LUKSAR providing significant contributions. This strategic plan will be followed by an implementation plan describing how to achieve the stated objectives. The plan will detail spending and project priorities as well as a structure for quality control and risk management.

Appendix A: SWOT Analysis

Table A-1: Policy Related SWOT Analysis Table 1

	Strengths:	Weaknesses:
	1. The current availability of funds and support 2. Increased focus on upstream R&D strategic planning 3. Underutilized local university professors in R&D	1. Lack of long term funding commitment and well structured support for R&D activities 2. Lack of focus and direction 3. Inefficient and insufficient infrastructure to support research activities 4. Insufficient cooperation and coordination between involved sectors and researchers 5. Shortage of qualified specialists (quality and quantity) 6. Departure of scientists to better pay jobs (inside & outside) 7. Weak academic and research programs 8. Shortage of young researchers and technicians 9. Weak incentives for R&D professionals 10. Lack of accountability and quality control in R&D activities 11. Lack of international R&D alliances 12. Lack of technology incubators to transform innovations to commercial realities 13. Nonexistent or insufficient number of centers of excellence

Appendix A: SWOT Analysis

Threats:	Initiative #	Factors	Initiative #	Factors
1. Committed ongoing funding resources for R&D activities	1	S1 S2 T5	21	W3 W5 W6 W7 W8 W9 W10/ T2
2. Government regulations and strict immigration laws	2	S1 S2 T6	22	W2 W7 / T3
3. Confidentiality policy set by data owners limiting information and raw data sharing	3	S1 T7	23	W10 / T4
4. Lack of confidence in national researchers and national research centers	4	S2 T1	24	W1 / T5
5. Instability of oil and gas prices and the consequent affect on R&D funding and interest	5	S2 T2	25	W11 W9 / T8
6. Low interest by students in joining the related fields	6	S1 S2 T3	26	W4 W12 W13 / T9
7. Seeking investment return in a short period by oil companies	7	S2 T8	27	W2 W7/T11
8. Inadequate enforcement of intellectual property regulations	8	S3 T4	28	O9 /T3 T4
9. Technology monopoly and secrecy				
10. The increasing interest in alternative fuels				
11. International environmental policy and regulations				
12. The international geopolitics				

Appendix A: SWOT Analysis

Opportunities:	Initiative #	Factors	Initiative #	Factors
1. Government Interest and public appetite for scientific development and achievement 2. HC being the main national income 3. The position of Kingdom as a leading oil producer 4. Presence of vast amount of upstream E&P data and cases (onshore, offshore) 5. Huge current and unexplored potential oil and gas reserves with desire and need to improve reserves and recovery 6. New exploration activities targeting new frontier areas 7. New exploration activities for free gas by international companies 8. Industry eagerness for using and applying the latest upstream technologies 9. Recent industry desire to cooperate with local R&D centers 10. Presence of promising current and future markets for R&D products in the gulf countries 11. General lack of focus and investment on onshore technologies 12. Underpaid and underappreciated scientists in third world countries 13. Stable oil and gas governmental policy 14. Easily accessible excellent outcrop geological information	9	S1 S3 O4 O5 O6 O7 O12	13	W1 W3 W5 W8 W9 W12 W13 / O1 O2 O3
	10	S1 S2 O13	14	W2/O4 O5 O6 O7
	11	S3 O11	15	W2/ O8
	12	S1 S2 S3 O8 O9	16	W5 W6 W7 W8 / O13
	13	S1 O14	17	W11 / O14
			18	W4 / O9
			19	W14 / O7
			20	W12 W13 / O8

Appendix A: SWOT Analysis

Table A-2: Technical SWOT Analysis Table 2

Strengths:	Weaknesses:
1. Good modeling tools and computer capabilities 2. Oil recovery as compared to others 3. Number of wells and possible info 4. Long history of exploration and production 5. Low relief and simple structure at depth 6. Oil in shallow waters, no deep drilling 7. Generally highly porous reservoirs 8. Generally large oil fields 9. Oil production and examples 10. Amount of oil exploration and seismic data 11. The latest software and solutions are present 12. Available funds	1. Higher sulfur content 2. Water production 3. Slow information gathering including survey and seismic acquisition in land 4. Acquisition seismic sand and near surface and multiples 5. Reservoir characterization and monitoring 6. Data sharing and availability 7. Subsalt exploration and production 8. Drilling cost and efficiency 9. Environmental technology and zero emission in Red Sea production 10. Identification, mapping and understanding of source rocks and petroleum system in the region including the red sea 11. Basement depth and mapping 12. Onaiza formation heterogeneity 13. Red Sea and Rubaii alkhali Exploration 14. Gas exploration and production 15. Mapping the top of large reservoirs 16. Detection and mapping of fractures in carbonate reservoirs 17. Deep inter-well resistivity measurements 18. In-situe wet-ability characterization 19. The problem of condensate banking in Gas wells 20. Oily water disposal 21. Upstream waste management 22. Water downhole and online separation 23. Pore network modeling 24. Well monitoring systems

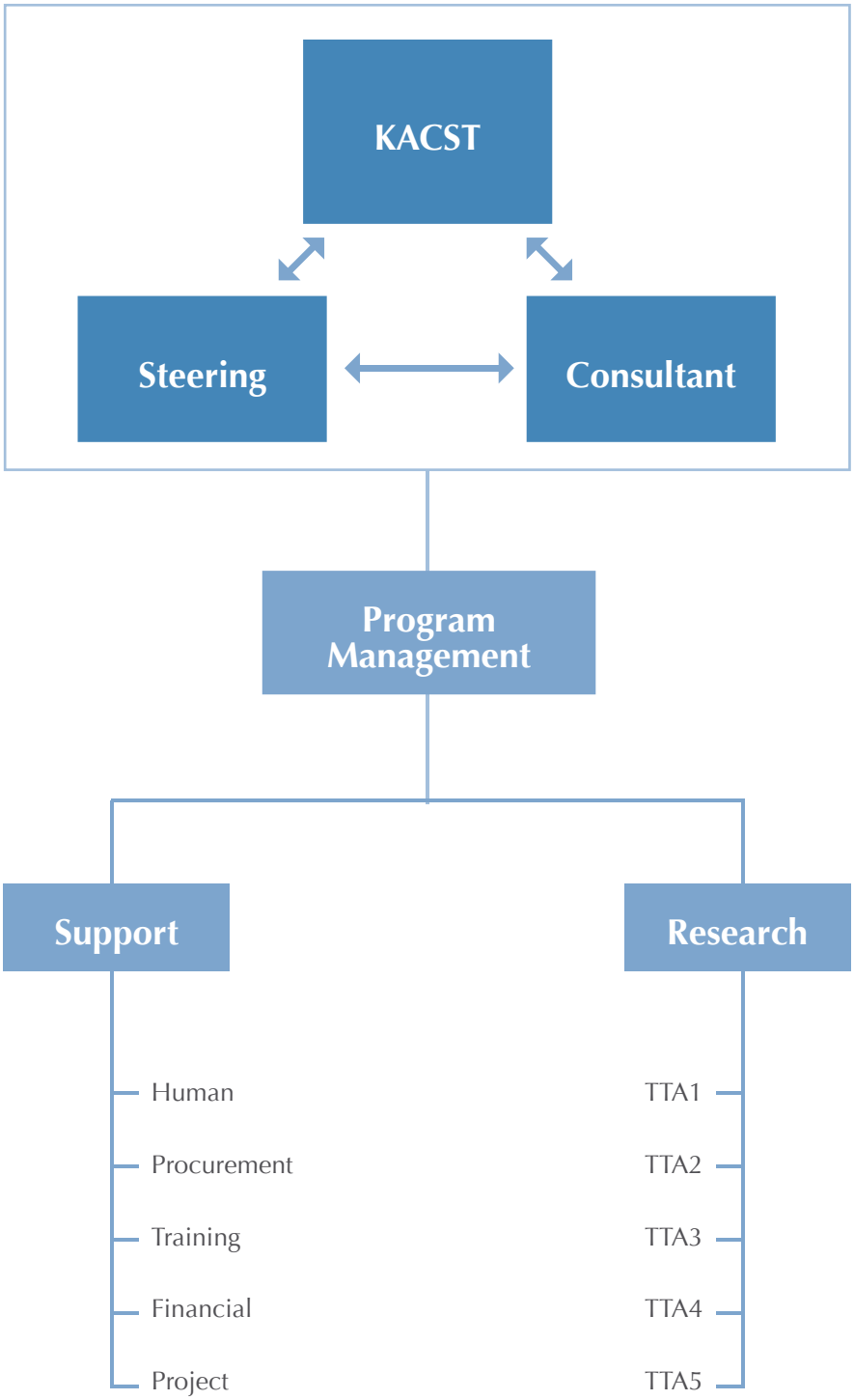
Appendix A: SWOT Analysis

Threats:	Initiative #	Factors	Initiative #	Factors
1. Technology monopoly and secrecy 2. International environmental policy and regulations 3. Lack of scientists in some technologies 4. Lack of continuity of funding resources for R&D activities 5. Hiring regulations	1	S1 S3 S8 S12 T1 T3	15	W1-W24/ T1 T3 T5
	2	S8 T4	16	W1 W2 W3 W4 W8/ T2
	3	S4 S5 S6 T2	17	W1-W24 / T4

Opportunities:	Initiative #	Factors	Initiative #	Factors
1. Available funds for research 2. High number of wells and corresponding info 3. Good coverage of exploration data 4. Weak environmental regulations 5. Presence of vast amount of data and examples 6. Good modeling tools and computer capabilities 7. Easily accessible excellent outcrop geological information 8. Significant hydrocarbon reserves 9. Coordination between various local entities 10. Collaboration with international research entities 11. A plan to organize efforts 12. University research capability 13. Aramco facilities and researches 14. Ministry support 15. Collaboration with service companies	4	S1 S2 O8 O10 O12 O15	9	W1 W2 W22/ O1 O4 O8 O10 O12 O13
	5	S5 S6 S7 O7 O15	7	W6/O1 O2 O3 O5 O6 O11 O14
	6	S8 S9 S10 O12 O14 O15	8	W10 W11 W12/ O1 O2 O3 O6 O7 O12 O14
			11	W3 W4 W7 W13 / O1 O3 O10 O12 O13
			10	W5 W15 W16 W18 W23/ O1 O2 O4 O6 O8 O9 O12 O13
			13	W8 W22 W24/ O1 O2 O7 O14 O15
			12	W14 W19/ O1 O12
			14	W9 W20 W21/ O1 O11 O12 O14

Appendix B: Proposed Organizational Structure

Figure B-1: Proposed Organizational Structure



Appendix C: Strategic Initiatives Process

This appendix explains the process that was undertaken to develop the strategic initiatives. The process involved extracting primary initiatives after performing the SWOT analysis (Table A-1) and categorizing these initiatives according to administrative themes (HR, coordination & cooperation, etc.). Primary initiatives were then rephrased in order to consolidate initiatives.

Table C-1: Strategic Initiative, SWOT, and Themes

#	S T	Initiative	Themes
1	S1 S2 T5	Utilizing current assigned budget to make plans for a sustainable funding	Financial
2	S1 S2 T6	Providing financial and mental motivators to attract students to relevant fields of studies and developing a strategy to attract students	Financial, HR
3	S1 T7	Concentrating on long term researches and limiting funds of short term research to benefiting companies	Financial, Coordination
4	S2 T1	Utilizing current interest in R&D and strategic planning to secure a continued future funding	Financial
5	S2 T2	Proposing the change of recruitment and procurement laws and regulations utilizing current interest in R&D strategic planning	Laws
6	S1 S2 T3	Utilizing financial funding and interest in R&D to establish a data base that support research activities	Coordination
7	S2 T8	Providing proposals that address intellectual property rights and enforcement	Laws
8	S3 T4	Utilizing currently wasted manpower in the researchers sector to accomplish outstanding researches and increase the confidence in local researchers	Laws, Coordination, HR
#	**S O**	**Initiative**	
9	S1 S3 O4 O5 O6 O7 O12	Utilizing current assigned funds and available manpower to benefit from available data in performing research projects in new frontier area exploration (onshore and offshore), gas exploration and enhanced recovery	Res. Trends
10	S1 S2 O10 O13	Utilizing current assigned funds to develop a detailed long term plan to exploit researchers from developing countries and those who want to live in the Kingdom	HR, Laws
11	S3 O11	Exploiting the resemblance of geological conditions of the Gulf in conducting joint researches and creating a local future market for advanced E&P technologies	Coordination

Appendix C: Strategic Initiatives Process

12	S1 S2 S3 O8 O9	Directing resources within a long term plan to produce advanced technologies that support increasing demands of oil industry	Res. Trends
#	**W O**	**Initiative**	
13	W1 W3 W5 W8 W9 W12 W13 / O1 O2 O3	Having oil and gas as the primary resource for the country and being the greatest producer and exporter in the world imply a greater concern in developing infra structure of R&D in oil and gas E&P (funding, HR, infrastructure)	Infrastructure, Financial, HR
14	W2/O4 O5 O6 O7	Directing researches towards exploration and production technologies in new frontier areas (Red Sea & Rub Alkhali) while concentrating on discovery of new fields and enhancing available ones	Res. Trends
15	W2/ O8	Exploiting current industry interest in applying state of the arts technologies to direct R&D activities to fill future demands of industry	Res. Trends
16	W5 W6 W7 W8 / O10 O13	Utilizing the attracting environment of the Kingdom to Muslims to attract outstanding researchers to support R&D and academic activities	HR, Laws
17	W11 / O14	Utilizing the stability of oil industry policy of the Kingdom in establishing international R&D alliance	Coordination
18	W4 / O9	Utilizing the current cooperation between the industry and specific research entities to enhance cooperation between research centers and researchers	Coordination
19	W14 / O7	Utilizing the presence of international gas ventures to enhance international cooperation in R&D activities	Coordination
20	W12 W13 / O8	Exploiting current industry interest in applying state of the arts technologies to establish excellent centers and incubators	Coordination, Infrastructure
#	**W T**	**Initiative**	
21	W3 W5 W6 W7 W8 W9 W10/ T2	Proposing the amendments of laws and policies that obstruct developing scientific research as foreign recruitment and administrative laws	Laws
22	W2 W7 / T3	Re-evaluating the confidentiality of technical data in the industry to help in the formulation of the strategy and to enhance research and academic programs	Coordination, Laws

23	W10 / T4	Establishing standards for quality assurance in the research to gain more confidence from the industry in local R&D activities	Laws, HR
24	W1 / T5	Securing a sustainable and continued funding of the R&D sector mitigating the instability in oil prices	Financial
25	W11 W9 / T8	Enhancing and enforcing IP laws to motivate researchers and cooperate with international entities	Laws, Coordination, HR
26	W4 W12 W13 / T9	Enhancing cooperative research activities to produce technologies that will break monopoly	Coordination
27	W2 /T11	Directing R&D activities to environmentally friendly technologies. (CO_2 sequestration, waste water management… etc)	Res. Trends
#	**O T**	**Initiative**	
28	O9/ T3 T4	Utilizing the current cooperation between industry and specific research institutes to break down confidentiality and enhance confidence in local researches	Coordination

Appendix C: Strategic Initiatives Process

Primary Initiatives

The following is the formulation of the initiatives after rephrasing:

Infrastructure

- Extracted from (20+13): Having oil and gas as the primary resource for the country and being the greatest producer and exporter in the world imply a greater concern in developing infrastructure of R&D in oil and gas E&P including:
  - Academic programs (graduate and undergraduate).
  - Excellence centers.
  - Incubators.
  - Well equipped laboratories.

Financial

- Extracted from (2+13): Utilizing current assigned funds to support R&D by:
  - Motivating researchers.
  - Fellowship and scholarship to students.
  - Equipping laboratories.
  - Funding high priority researches.
  - Training.
  - Funding academic programs (research chairs…etc).
- Extracted from (1+4+24): Making a plan for securing a sustainable funding through:
  - Available governmental funds.
  - Grants and donations.
  - Financial returns from studies and consultation that are provided to beneficiaries.
  - Foreign investments taxes in oil and gas industry.

Future Research Trends

- Extracted from (27+15+14+12+9): Directing researches and current and future resources through:
  - Coordination and cooperation with industry to define research trends.
  - Concentrate on technologies that suit our local conditions and needs.
  - Concentrate on non-traditional new frontiers (Red Sea and Rub Alkhali).
  - Gas exploration and production technologies.
  - Environmentally friendly technologies (CO_2 sequestration, waste water management…etc).

Appendix C: Strategic Initiatives Process

Human Resources

- Extracted from (2): Enhance the enrolment of talent gifted students to academic fields related to oil and gas E&P technologies through:
  - Arranging educatory and public awareness programs.
  - Industry provided scholarship.
  - Allocating enough opportunities of scholarship for graduate studies.
  - Improving the salaries and compensations for researchers and R&D staff.
- Extracted from (13): Utilizing available funds in developing HR through:
  - Training and scholarship.
  - Fellowship.
  - Attracting salaries.
  - Financially motivating outstanding researchers.
- Extracted from (10+16): Compensate the shortage of manpower by foreign recruitment through:
  - Amendment of recruitment laws.
  - Good salaries and attracting research environment.
  - Enhancing graduate studies in universities and providing seats for foreign students.
- Extracted from (8+23): Establishing standard and regulations for R&D activities and exploiting wasted human resources by applying standards to control quality.

Coordination and Cooperation

- Extracted from (3): Coordination with industry in sharing the support of research.
- Extracted from (6+22+28): Establishing a technical database that includes all information needed to support researchers while taking in account confidentiality of some information.
- Extracted from (11+17+18+19+26+28): Establish local and international R&D alliance through which support and benefits are shared between all parties through:
  - Utilizing what currently is available of cooperation between industry and some research institutes and spreading the experience to other institutes.
  - Exploiting the resemblance of research environment of the Gulf in conducting joint researches and creating a local future.
  - Utilizing the presence and interest of international oil companies and laboratories in the region to establish an internal and external R&D alliance through which funds and profits are shared.

Laws and Regulations

- Extracted from (5+7+8+21+23+25): Proposing amendments of laws and regulations that obstruct R&D activities that are elated to recruitment:
  - Immigration, foreign recruitment and foreigner salary structure.
  - Performance evaluation and quality control.
  - Procurement.
  - Rights and laws governing intellectual property.
  - Industry support of local R&D activities by funds and information and removal of unjustified or necessary confidentiality on technical data.

Appendix D: Stakeholders and Participants

Stakeholders

Private Sector

Table D-1: Private Sector Stakeholders

Department	Company	Comments
EXPEC-ARC	Saudi Aramco	Dedicated to advanced research and development in exploration and production
The exploration divisions	The four Gas ventures	
Development divisions	Services companies, ARGAS, Schulumberger, and more	Carbonate research center, Dhahran
Development divisions	Alkhafji joint operations	
Development divisions	Saudi Chevron Company	

Universities

Table D-2: University Stakeholders

Department	University
Petroleum Engineering and Earth Sciences Departments	King Fahad University for Petroleum and Minerals
Petroleum Engineering and Geology Departments	King Saud University
Earth Sciences College	King Abdulaziz University

Ministries and Agencies

Table D-3: University Stakeholders

Department	Organization
The Ministry branch in the Eastern region	Ministry of Petroleum and Mineral Resources

Research Centers and Institutions

Table D-4: Research Center and Institution Stakeholders

Department	Center and Institute
Oil and Gas Center	Research Institute at King Fahad University
Dhahran Carbonate Research Center	Schulumberger

Appendix D: Stakeholders and Participants

Workshop Participants

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- Abdulbari Arefi
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- Dr. Eissa Shokir
- Dr. Mohammed M. Amro
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- Dr. Ali Sahin
- Mr. Yahya Shinawi, MOPM, Dhahran
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