Abu Dhabi Energy Policy

-Energy Problems Plaguing Abu Dhabi and Their Implications for Japan-

Takashi Matsumoto*

Summary

In January 2013, United Arab Emirates Energy Minister Mohamed bin Dhaen Al-Hamli expressed his concern that the Emirate of Abu Dhabi was lagging behind schedule in expanding its crude oil production capacity and would become a net natural gas importer in the near future. A crude oil production expansion plan, published by Abu Dhabi National Oil Corporation in March 2009, called for boosting the capacity to 3.5 billion barrels per day by the end of 2017. In response to rapid growth in demand for natural gas mainly for electricity generation, Abu Dhabi has launched projects to develop non-associated gas at offshore oil fields along with high-sulfur gas resources and has begun to import gas from neighboring countries.

But Abu Dhabi has crude oil development problems including a possible delay in development due to a concession renewal problem for ADCO (Abu Dhabi Company for Onshore Oil Operations), as well as a financial resources shortage at ADMA-OPCO (Abu Dhabi Marine Operating Company) for underground gas injection to maintain oilfields. While Abu Dhabi promotes large-scale high-sulfur (sour) gas development projects, there are problems to be solved in regard to pricing of sulfur as a by-product and toxic gas measures. In a bid to make up for natural gas supply shortages, Abu Dhabi plans to introduce nuclear and renewable energy for the electricity generation sector that accounts for most of gas demand. It has come up with a plan to cover 25% of electricity demand with nuclear power generation and 7% with renewable energy power generation by 2020. The plan calls for building four nuclear reactors to achieve the 25% target. As for renewable energy, however, the existing plan covers only one-fifth of the 7% target. In a bid to secure oil exports that provide most of Abu Dhabi's revenues, the emirate is planning to ship crude oil from and build an oil refinery and an LNG receiving station in the neighboring UAE Emirate of Fujairah.

These energy problems plaguing Abu Dhabi have the following implications for Japan:

(1) Even if Abu Dhabi proceeds with natural gas development, the gas supply-demand balance for the entire UAE may fail to be improved, with net gas imports continuing to expand. Therefore, Abu Dhabi could reduce or terminate contracted LNG exports to Japan in the future. Japan will have to take measures (finding alternative LNG supply sources) responding to the reduction or termination.

(2) While crude oil development in Abu Dhabi is expected to be delayed, additional output is likely

* Senior Coordinator, Global Energy Group 1, Strategy Research Unit, IEEJ

to be exported mainly to Asian countries. While Japan's oil demand is expected to gradually decline, Japan will have to secure a certain share of total Japanese oil imports from Abu Dhabi oil, from the viewpoint of energy security, given that the UAE is paving the way for crude oil and petroleum products to be exported from Fujairah without passing through the Strait of Hormuz.

(3) Abu Dhabi and the UAE plan to expand nuclear and renewable energy facilities, indicating opportunities for academic, commercial and other cooperation between the UAE and Japan. Given such cooperation, we should take into account the UAE as an attractive future market for sales of Japanese products.

1. Introduction

On January 9, 2013, the United Arab Emirates' Energy Minister Mohamed bin Dhaen Al-Hamli[1] made the following points at a local energy forum:

i. The plan to expand the crude oil production capacity to 3 million barrels per day by the end of 2012 has lagged behind schedule.

ii. A crude oil pipeline bypassing the Strait of Hormuz has been constructed but has yet to launch full operation.

iii. If domestic energy demand continues to expand at the present pace, the country will become a net natural gas importer in the near future.

Particularly, the third point attracted attention as an indication of a serious gas supply crisis in the UAE and as the first official remark admitting that even an oil and gas producing country has failed to have domestic resources satisfy domestic demand.

Media reports fell short of specifying whether Energy Minister Hamli was talking about the entire UAE or the Emirate of Abu Dhabi alone. Given that the UAE Constitution established in June 1996 provides that each emirate has rights (to own and dispose) its own natural resources, the federation has been viewed as having no energy policy or oil/energy law. Therefore, my understanding is that the minister was talking about the Emirate of Abu Dhabi.

This paper answers the following questions and analyzes the implications of Abu Dhabi's energy problems for Japan:

(1) Will natural gas development make smooth progress?

(2) Will crude oil production capacity expansion make smooth progress?

(3) How will other energy development projects affect energy supply and demand?

(4) Will the structural dependence on natural gas be reformed to achieve energy self-sufficiency as a result?

(5) How can the present energy policy be viewed through answers to the above questions?

[1] In a cabinet reshuffle in March 2013, Al-Hamli was replaced by Mubadala Oil & Gas Deputy Chief Executive Suhail Al-Mazroui as energy minister.

2. UAE energy conditions

2-1 Major energy indicators

According to the BP Statistical Review of World Energy published in 2012, the UAE had 97.8 billion barrels in crude oil reserves and 6.1 trillion cubic meters in natural gas reserves at the end of 2011. These respective reserve sizes are the seventh largest in the world. The reserves-to-production ratio is 80.7 years for crude oil and more than 100 years for natural gas. According to the UAE country report published by the U.S. Energy Information Administration in January 2013, however, the Emirate of Abu Dhabi has 94% or more of the UAE's rich crude oil and natural gas reserves. Dubai accounts for only 4% of the UAE crude oil reserves. Of the UAE natural gas reserves, Sharja accounts for 4% and Dubai for 1.5%. Therefore, Abu Dhabi commands the core of UAE energy policy and supply/demand for both oil and natural gas.

UAE energy resources (at 2011-end)

	Reserves	Production	Recoverable reserves
Crude oil	97.8 b. bbl	3.22 m.bpd	80.7 years
Natural gas	6.1t. m^3	51.7 b. m^3	100 years or more

Source: BP Statistical Review of World Energy, June 2012 Edition

According to the International Energy Agency's Energy Balances of Non-OECD Countries 2012, the UAE as a whole has already posted net natural gas imports, which emerged in 2008 when the Dolphin Pipeline entered full operation after its completion in 2007.

Among primary energy supply, natural gas constitutes a percentage more than four times greater than that of oil, accounting for 81% of overall primary energy supply. The UAE thus lopsidedly depends on natural gas.

UAE's primary energy mix (2010)

(Unit: Mtoe)

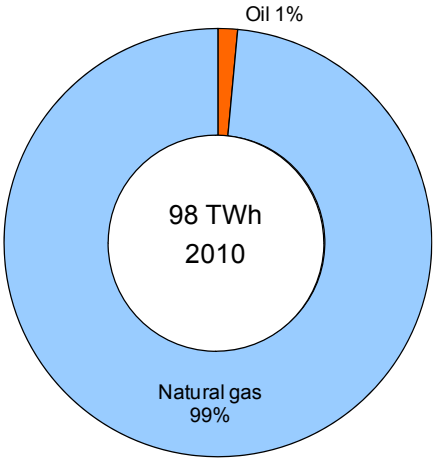
	Oil	Natural gas	Coal	Nuclear	Hydro	Renewable	Total
Domestic output	113	43	0	0	0	0	176
Imports	18	14	1	0	0	0	33
Exports	140	7	0	0	0	0	147
Primary supply	12	51	1	0	0	0	62
Share (%)	19%	81%	1%	0%	0%	0%	100%

Source: IEA, Energy Balances of Non-OECD Countries 2012 Edition

2-2 Electricity demand outlook

Natural gas is provided for generating electricity. The UAE depends on natural gas for 99% of electricity generation. In 2010, electricity output totaled 98 billion kilowatt-hours, about one-tenth of Japan's power output. Given that the population of the UAE stands at slightly more than 5 million, per capita electricity consumption in the UAE turns out to be about two times as much as the Japanese level.

UAE power generation mix (2010)

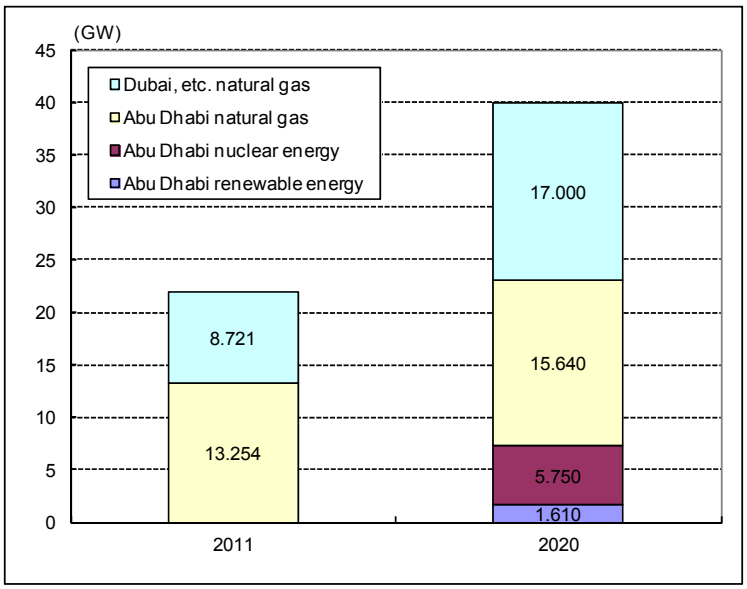


Source: IEA, Energy Balances of Non-OECD Countries 2012 Edition

As electricity consumption increased at an accelerating pace from 40 billion kWh in 2000 to 60 billion kWh in 2005 and to about 100 billion kWh in 2010, the UAE plans to expand its power generation capacity. The present plan calls for expanding the capacity to 40 gigawatts in 2020 from about 22 GW at the end of 2011. The increase of 18 GW amounts to the capacity of about 18 nuclear reactors.

If the UAE depends mostly on natural gas for the expansion, natural gas demand will double. In Abu Dhabi that has a strong sense of crisis about this possibility, Masdar Chief Executive Officer Sultan Al-Jaber[2] in January 2013 stated that the emirate had a plan to increase renewable energy's share of electricity supply (23 GW in power generation capacity) to 7% and nuclear energy's share to 25% by 2020.

UAE power generation capacity plan



Source: Prepared from various information

[2] Al-Jaber became minister of environment in the March 2013 cabinet reshuffle.

An estimate of the UAE's natural gas demand in 2020 based on the Al-Jaber remark indicates that natural gas supply may have to increase about 1.5-fold from 2011 to cover 68% of electricity demand in Abu Dhabi and 100% of such demand in the other emirates. This means that natural gas demand may expand from about 60 billion cubic meters (about 6 billion cubic feet per day) in 2011 to about 90 billion m^3 (about 9 billion cf/d) in 2020.

3. Past and ongoing gas development projects in Abu Dhabi

The growing natural gas demand in the UAE has been discussed above. The following covers past and ongoing gas development projects undertaken by Abu Dhabi that plays a major role on the supply side.

3-1 Past gas development projects

Abu Dhabi's natural gas development had centered on associated gas from oil fields until the 1970s. Then, natural gas demand had been almost absent, with most associated gas left to flare. When liquefied natural gas exports started in 1977, however, Abu Dhabi began to pay attention to developing non-associated gas in the Khuff layer at offshore oil fields. In the 1990s when domestic natural gas demand increased, Abu Dhabi began to develop non-associated gas at onshore oil fields as well.

Past gas development projects

Project name	Phase	Period	Outline
Offshore Khuff layer gas development	Phase 1 Abu Al Bukhoosh	1990-1992	Non-associated gas output totaling 320 million cf/d was transported via pipeline to Das Island for processing into LNG.
	Phase 2 Abu Al Bukhoosh	1997-2004	Non-associated gas output expanded to 540 million cf/d.
	Umm Shaif	1994	Non-associated gas output totaling 600 cf/d was processed into LNG at Das Island.
OGD (Onshore Gas Development)	OGD-1	1991-1996	Thamama zone gas development. Expanding Habshan gas refining capacity. Expanding gas injection capacity. Expanding NGL recovery to 5,300 tons per day.
	OGD-2	1996-2001	Thamama zone gas development. Constructing pipelines from Habshan to Magtaa and Ruwais. Expanding gas refining capacity further to 3 billion cf/d.
	OGD-3	2003-2008	Thamama zone gas development at the Bab oil/gas field. Expanding Habshan gas processing capacity further to 4.31 billion cf/d.
AGD (Asab Gas Development)	AGD-1	1996-2001	Thamama zone gas development at the Asab oil/gas field. Expanding associated gas recovery from 730 million cf/d to 1.56 billion cf/d.
	AGD-2	2003-2008	Constructing an Asab gas processing and NGL recovery plant. The plant was to process 743 million cf/d in gas and turn out 4,700 tons per day in NGL and 1,700 tons per day in ethane.

Source: Prepared from various information

These gas development projects allowed Abu Dhabi to increase natural gas output by more than 2 billion cf/d and almost double UAE natural gas supply.

3-2 Natural gas imports

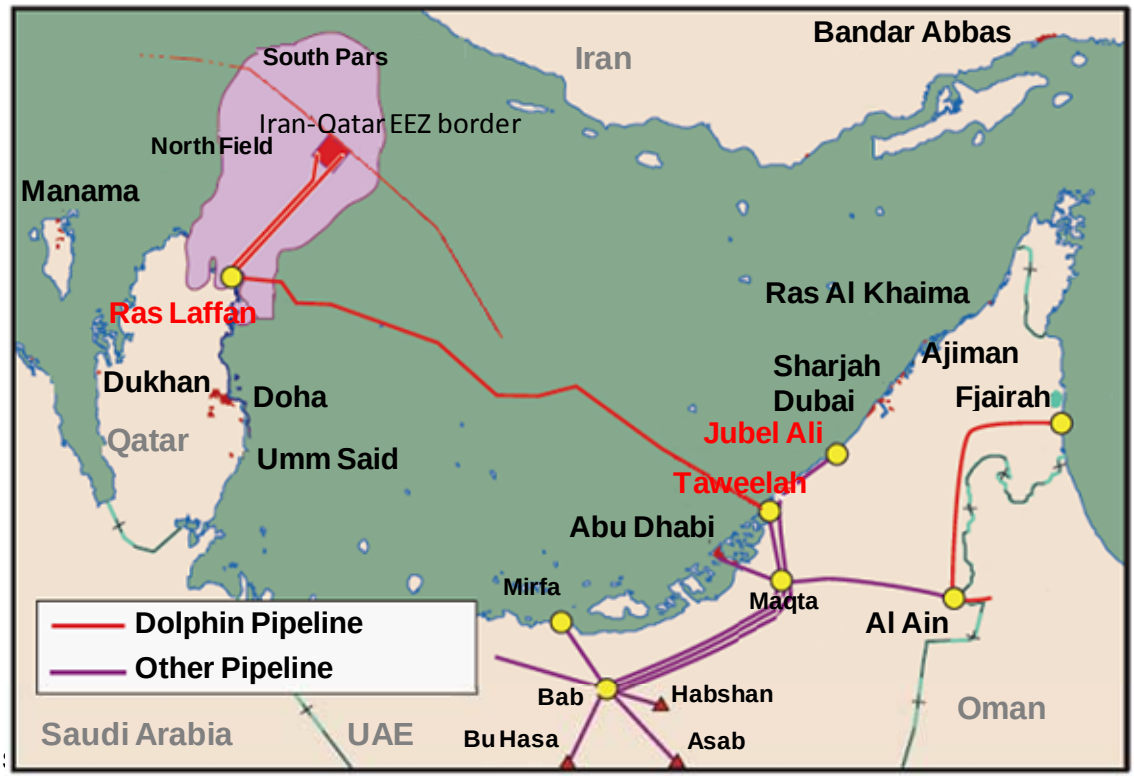
As the abovementioned projects alone failed to cover natural gas demand growth, however, a natural gas import project was launched. This was the so-called Dolphin Pipeline Project.

Dolphin Energy, as the operating body for the project, was founded by UAE Offset Group (UOG), set up in March 1999, TotalFinaElf and Enron. UOG was later transformed into Mubadala Development. Occidental invested in Dolphin Energy in 2002 as Enron failed. As a result, Dolphin Energy has been 51% owned by Mubadala Development and 24.5% each by Total and Occidental.

Dolphin Energy launched pipeline construction in the first half of 2001 under an initial plan to complete the pipeline in early 2003. In July 2007 or about four years behind schedule, the company completed the 370-kilomter natural gas pipeline between Ras Laffan in Qatar and Taweelah in the UAE with a gas transportation capacity of 3.2 billion cf/d, with the construction investment totaling about $3.5 billion.

The natural gas import project consisted of two phases -- the first phase for 2 billion cf/d in natural gas imports from Qatar and the second phase for boosting the imports by 1.2 billion cf/d to 3.2 billion cf/d. But Qatar declared a moratorium on its North Field gas field in April 2005, forcing the second phase to be frozen. In the end, the present contract covers about 2 billion cf/d in imports over 25 years to 2032.

Dolphin Pipeline



3-3 High-Sulfur Gas Development Projects

As Abu Dhabi was inviting various industries to diversify its economy, demand for gas

for power generation was expected to substantially increase. The freeze on the second phase of the Dolphin Pipeline Project prompted Abu Dhabi to launch two types of natural gas development projects. One of the two is high-sulfur gas development.

Earlier, Abu Dhabi had subjected gas with a hydrogen sulfide content of 10% or less to development in consideration of technical and cost problems. In order to respond to rapid growth in domestic gas demand, however, it concluded it had no choice but to develop high-sulfur (sour) gas that has a higher hydrogen sulfide content and is difficult to develop. In 2006, it made a decision to develop sour gas.

Sour gas development plans emerged first in the 1990s. As high domestic gas demand growth was then already expected to cause a future gas shortage, Abu Dhabi considered sour gas development at the Bab and Shah onshore and Hail offshore oil/gas fields. As the Dolphin Project launched in 1999 was expected to allow Abu Dhabi to get cheaper Qatari gas, however, Abu Dhabi shelved the sour gas development once.

But Qatar declared a moratorium on the North Field gas field in April 2005, leading the Dolphin Project's second phase (for increasing imports through the pipeline by 1.2 billion cf/d) to be frozen. At the same time, demand for gas mainly for power generation in Abu Dhabi was expected to expand substantially due to economic and population growth. Therefore, Abu Dhabi had no choice but to develop sour gas to satisfy growing domestic demand. Then, natural gas prices were rising to improve the profitability of sour gas development, backing up the development.

- Shah sour gas development project

The Shah gas field is located in an inland area 180 kilometers south-southwest of Abu Dhabi. As a result of bidding in 2007, the $10 billion project started, with Abu Dhabi National Oil Company holding a 60% stake in the project and ConocoPhilips owning the remaining 40% stake. Great expectations were placed on the first sour gas development project in Abu Dhabi to respond to growing domestic gas demand. As ConocoPhilips offered to withdraw from the project in 2010, ADNOC selected Occidental of the United States as developer of the gas field in February 2011.

Sour gas from the Shah gas field includes a hydrogen sulfide content of 23% and a carbon dioxide content of 10%. The project is designed to separate 500 million cf/d in natural gas and 50,000 barrels per day in natural gas liquids and condensate from 1 billion cf/d in sour gas. The first phase of the project calls for digging 32 production wells including 20 planned to launch production by the end of 2014.

- Bab sour gas development project

The Bab gas field is located in an inland area 150 km southwest of Abu Dhabi. While bids for the Bab gas field developing project were invited along with those for the Shah project in 2007, it was difficult for most relevant companies to make bids due to difficulties in developing the gas field below the Bab oil field and environmental constraints in the area close to populated Liwa. No successful bidder was chosen then.

Through bidding in May 2012, Shell won the Bab project over Total. Reports then said

Shell offered to sell sulfur in its plan, while Total planned to put sulfur back into the ground.

Sour gas output from the Bab gas yield reportedly includes a hydrogen sulfide content of 30-50% and a carbon dioxide content of 15%. While sour gas output under the project is expected at 1 billion cf/d, no natural gas recovery volume estimate has been specified.

➢ Hail sour gas development project

The Hail gas field is located in an offshore area 100 km west of Abu Dhabi. Bidding for the Hail gas development was scheduled for May 2012 along with that for the Bab gas development. Cosmo Oil Co. was awarded a concession for crude oil development at the formation in 2011. Total, Shell and ExxonMobil, which were invited to make bids for the Hail gas development, have reportedly been embarrassed by the concession issue and environmental problems (the shallow gas field is relatively close to the shoreline).

As sour gas from the Hail formation reportedly includes a hydrogen sulfide content of 14-15%, Hail sour gas may be easier to handle than Bab or Shah sour gas. The Hail project aims at producing 400-600 million cf/d in sour gas.

Ongoing high-sulfur gas development projects

Project name		Period	Outline
High-sulfur gas development projects 【1 billion cf/d】	Shah sour gas - H2S: 23% - CO^2: 10%	2007-	ConocoPhilips withdrew from the project after making a successful bid → Occidental was employed as developer. The $10 billion project will produce 500 million cf/d in natural gas and 50,000 barrels per day in NGL and condensate from 1 billion cf/d in sour gas. Production is set to start in late 2014 (instead of 2012 as initially planned).
	Bab sour gas - H2S: 50% - CO^2: 15%	2012-	In April 2013, Shell made a successful bid. The more-than-$10 billion project will produce natural gas, NGL and condensate from 1 billion cf/d in sour gas.
	Hail sour gas - H2S: 15%	2012-	Bidding is underway. Total, Shell and ExxonMobil indicated their interests in the project, though embarrassed by the gas field's conflict with an ADOC concession. The project will produce natural gas from 400-600 million cf/d in sour gas.

Source: Prepared from various information

Abu Dhabi plans to finally produce a total of 3 billion cf/d in sour gas at the Shah and Bab onshore and other gas fields to expand natural gas output by about 1 billion cf/d. But sour gas development has the following problems:

(1) Profitability of sour gas development projects changes greatly depending on sulfur sales prices.

The sour gas refining process produces sulfur as a by-product. Sulfur prices plunged from a $750-800 per ton range in the middle of 2008 to a $40-50 range at the end of the year. At the end of 2012, sulfur sales prices in the Middle East were as low as $140-150, according to British fertilizer consultant Ferticon. Therefore, sour gas development projects are greatly affected by sulfur sales prices.

Gas available for sale is far less than sour gas output, working to boost cost per sale unit.

(2) Environmental conservation must be taken into account for sour gas development sites.

Efforts to minimize adverse effects on the environment cost more money and time for the Bab project near the populated city of Liwa and the Hail project in a shallow area close to the shoreline.

(3) Gas development should be designed to refrain from affecting crude oil production.

As gas layers are just below oil layers, any wrong gas development methods may damage oil layers. Therefore, gas developers must exercise prudence.

Among Abu Dhabi's neighboring countries, Iran has produced 18 million cf/d in sour gas with a hydrogen sulfide content of 25% at the Bangestan gas field in the Southwest for processing in Amak (since 2007). In Saudi Arabia as of November 2011, Saudi Aramco and Shell were assessing a facility to process sour gas turned out at the Kidan gas field in the Southwest close to Qatar. They plan to complete the assessment by the end of 2013. These projects are smaller than the Shah or Bab project. Therefore, the Shah and Bab projects will reportedly serve as the first test for future sour gas development.

3-4 Integrated Gas Development (IGD)

The other type of natural gas development is integrated gas development (IGD).

Although earlier natural gas development projects were implemented on a one-company-for-one-region basis, an IGD project integrates crude oil and natural gas development. For the first IGD project that will link an offshore oil/gas field to an onshore gas facility, crude oil development and gas refining/sales companies signed an EPC (engineering, procurement and construction) contract worth more than $10 billion in July 2009. The project has been divided into three packages for their simultaneous implementation.

The project will recover 1 billion cf/d in high-pressure gas from the Khuff and Areaj layers at the Umm Shaif oil field operated by offshore oil developer ADMA-OPCO (Abu Dhabi Marine Operating Company). Under Package 1, offshore gas refining/sales company ADGAS will sweeten the gas at a facility on Das Island. Under Packages 2 and 3, onshore gas refining/sales company GASCO will lay a pipeline to transport sweetened gas from Das Island to an onshore gas facility in Habshan, which will refine sweetened gas and separate natural gas for sales.

The submarine pipeline under Package 2 was completed in October 2010. Package 3 was published as 90% complete as of September 2012. As Package 1 has lagged behind schedule, however, full natural gas production is expected to be delayed beyond the third quarter of 2013. The project is designed to expand natural gas output by 1 billion cf/d.

Under the project, the gas processing capacity in Habshan will increase by 2 billion cf/d from the present level by 2014.

A problem involving the project is that ADMA-OPCO will have to get alternative gas for natural gas that has been used for maintaining the bottom hole pressure at the oil field and will no longer be available for that purpose in the future.

IGD Project

Project name	Package	Period	Outline
IGD (Integrated Gas Development) 【1 billion cf/d】	Package 1	2009-	Constructing a gas facility on Das Island
	Package 2	2009-2010	Constructing a 117 km submarine pipeline from Das Island to the shoreline, with a transportation capacity of 1.1 billion cf/d
	Package 3	2009-	Constructing a 90 km onshore pipeline and a gas facility in Habshan

Source: Prepared from various information

Under a candidate IDG project now subject to assessment, ADNOC, Wintershall and OMV launched a plan in July 2012 to dig three delineation wells at the Shuwaihat gas field for three-dimensional oil and gas exploration. If assessment results are favorable, the project may shift to the production development stage.

Another ongoing gas development project

Project name	Period	Outline
Shuwaihat gas field development (25 km west of Ruwais)	July 2012-	- ADNOC, Wintershall and OMV have signed a technological assessment contract, digging three delineation wells at the Shuwaihat gas field for three-dimensional oil and gas exploration. - ADNOC plans to shift to the production development stage if assessment results are favorable.

Source: Prepared from various information

3-5 Natural gas supply-demand balance in Abu Dhabi in 2020

BP Statistical Review of World Energy 2012 gave the entire UAE's natural gas production as about 5 billion cf/d in 2011. Based on recoverable reserve shares, Abu Dhabi is estimated to account for 94% or 4.7 billion cf/d of the production. In addition, Abu Dhabi is expected to produce 2 billion cf/d under the IGD and sour gas development projects. Therefore, Abu Dhabi can be expected to produce up to 6.8 billion cf/d in natural gas in 2020.

Based on Abu Dhabi's natural gas power plant capacity, the emirate's natural gas demand in 2020 is estimated at 4.5 billion cf/d. In 2020, Abu Dhabi may thus produce about 1.5 times more natural gas than domestic demand. To achieve such production surplus, however, Abu Dhabi will have to build nuclear plants and spread renewable energy power generation as planned. Unless Abu Dhabi proceeds with gas development projects steadily while diversifying electricity sources, the emirate could become a net natural gas importer.

4. Abu Dhabi's crude oil production capacity expansion projects

Coming next are crude oil production capacity expansion projects. Abu Dhabi's crude oil development started even before the UAE's independence in 1971. More than 50 years have passed since Abu Dhabi launched crude oil production. In order to maintain and expand crude oil output, Abu Dhabi tried to hold down a production decline and increase crude oil recovery rates at existing operational oil fields, instead of developing untapped oil fields. Specifically, Abu Dhabi has produced pure water for injection into oil fields and put associated gas turned out on crude oil

production back into oil fields to maintain oil field pressures. But putting associated gas back into oil fields is now interpreted as not contributing to effective use of resources. Abu Dhabi is now required to take new measures (including injection of carbon dioxide into oil fields) to maintain pressures.

Under the circumstances, Abu Dhabi came up with a plan in March 2009 to boost its crude oil production capacity to 3.5 billion barrels per day by 2017. Progress toward the target is reviewed below on a company-by-company basis.

4-1 ADMA-OPCO

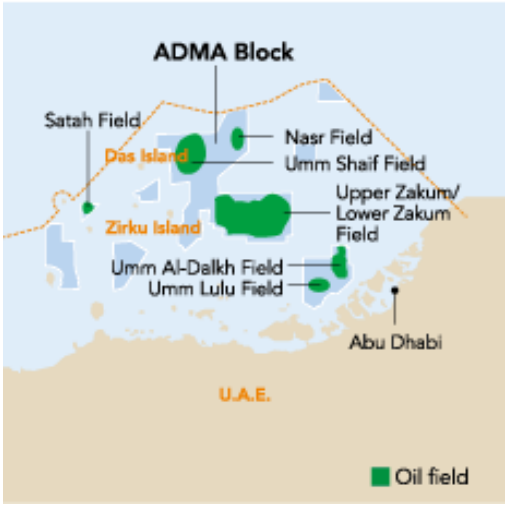
Abu Dhabi Marine Operating Company (ADMA-OPCO) has set a target of boosting its oil production capacity from 1.1 million bpd at present to 1.75 million bpd in 2020. It controls a wide range of offshore oil fields including Umm Shaif (120 km northwest of Abu Dhabi) and Zakum (80 km northwest of Abu Dhabi). Digging of the first well at the Umm Shaif oil field started in 1958. The Zakum oil field was found in 1963. In 2000, ADMA-OPCO began to inject gas into the major oil fields to extend their service lives and maximize crude oil production.

Later, ADMA-OPCO decided to develop new oil fields under Abu Dhabi's crude oil output expansion plan. As for a four-package project to develop the Um Al-Lulu oil field (20 km northwest of Abu Dhabi) and the Sarb oil field (120 km northwest of Abu Dhabi), a series of bidding procedures was completed by the end of March 2013. Under the initial version of the plan, construction will start in the third quarter of 2013.

At the Nasr oil field (120 km northwest of Abu Dhabi), ADMA-OPCO already confirmed about 25,000 bpd in crude oil output under its early production scheme by 2012. Bidding is going on for technical documents. ADMA-OPCO plans to select a successful bidder in early 2014.

The three oil fields are expected to allow ADMA-OPCO to increase crude oil output by 300,000 bpd.

Locations of offshore oilfields



Source: INPEX website

In addition, ADMA-OPCO plans to increase crude oil output by 100,000 bpd by redeveloping the Umm Shaif and Zakum oil fields now in operation. A challenge for the immediate future will be how to secure financial resources for gas injection into these oil fields to maintain oil layers in connection with the IGD project, as mentioned above.

In addition, ADMA-OPCO plans to increase crude oil output by 100,000 bpd by redeveloping the Umm Shaif and Zakum oil fields now in operation. A challenge for the immediate

future will be how to secure financial resources for gas injection into these oil fields to maintain oil layers in connection with the IGD project, as mentioned above.

In the future, ADMA-OPCO is expected to tackle untapped oil fields and take measures for expanding production at existing operational oil fields toward achieving the 2020 production capacity target of 1.75 million bpd for 2020.

ADMA-OPCO's new oil field development

Oil field	Production target	Investment	Outline
Umm Al-Lulu	105,000 bpd (2014)	- $500 million - $650 million	- Package 1: Wellhead tower, pipeline, etc. - Package 2: Intensive production facilities (gas processing platform, oil separating facility, utility, accommodation)
Sarb	100,000 bpd (2017)	- $300 million - $500 million	- Package 3: Wellhead tower, platform, etc. - Package 4: Major process plant
Nasr	25,000 bpd 65,000 bpd (2017)	- More than 1 billion?	- Phase 1: Test production facilities - Phase 2: Oil wells, wellhead tower, pipeline, generator, platform, utility, accommodation, etc.

Source: Prepared from various information

4-2 ZADCO

Zakum Development Company (ZADCO) has set a target of expanding crude oil production capacity from 500,000 bpd at present to 750,000 bpd in 2015. It controls offshore oil fields including the Upper Zakum oil field in a layer above the Zakum oil field (80 km northwest of Abu Dhabi), the Umm Al-Dhalk oil field (20 km northwest of Abu Dhabi) and the Satah oil field (180 km northwest of Abu Dhabi). Upper Zakum crude began to be shipped from Zirk Island in 1983.

In order to maintain oil layer pressures, ZADCO has injected water into the Upper Zakum oil field since 1984, into the Umm Al-Dhalk oil field since 1986 and into the Satah oil field since 1998. It has also injected overhead gas into the Satah oil field since 1988.

Based on Abu Dhabi's crude oil production expansion plan, ZADCO decided to dig new production wells at Upper Zakum. Instead of digging offshore production wells one by one, its Upper Zakum production expansion project adopts a new approach where production wells are dug on four reclaimed islands.

ZADCO's crude oil expansion projects

Oil field name	Output expansion target	Investment	Outline
Upper Zakum	1st phase 100,000 bpd (2015)	- $800 million - $1.2 billion	- EPC 1: Offshore construction (240 km submarine pipeline, 128 km fiber cable, revamping seven wellhead platforms, etc.) - EPC 2: Onshore production facility construction (four crude processing trains, flare tower, measurement systems, revamping Zakum Central Complex)
	2nd phase 100,000 bpd (2016)	- $2 billion	- Bidding procedures are going on for constructing permanent production facilities.
Zirk Island production equipment expansion	1 million bpd	Undecided	- Bidding procedures are going on for two crude processing trains, gas treatment plant, etc. The target year for their completion is 2017.

Source: Prepared from various information

ExxonMobil Abu Dhabi President Morten Mauritzen in November 2012 reported that digging of the first well under the production expansion project would start in several weeks (in early December), ahead of the EPC 1 and 2 bidding. ZADCO is also enhancing crude oil and gas production equipment on Zirk Island for future output expansion.

4-3 ADCO

Abu Dhabi Company for Onshore Oil Operations (ADCO) has set a target of expanding crude oil output from 1.3 million bpd at present to 1.8 million bpd in 2017. ADCO controls all of Abu Dhabi's onshore oil fields including the Bab oil field (150 km southwest of Abu Dhabi, found in 1960, production launched in the same year), the Bu Hasa oil field (200 km southwest of Abu Dhabi, found in 1962, production launched in 1965), the Asab oil field (185 km south of Abu Dhabi, found in 1965, production launched in 1973), the Shah oil field (230 km south of Abu Dhabi, found in 1966, production launched in 1983) and the Sahil oil field (120 km south of Abu Dhabi, found in 1967).

In order to maintain oil layer pressures, ADCO has injected water into the Bu Hasa oil field since the 1980s, into the Bab oil field since the 1990s and into the Asab and Sahil oil fields since the mid-2000s.

Based on Abu Dhabi's crude oil production expansion plan, ADCO divided its oil fields into four groups -- the southwestern group including Bu Hasa and Huwaila, the northeastern group including undeveloped oil fields like Rumaitha and Dhabiya, the southeastern group including Asab, and the Bab oil field alone -- and prepared production expansion plans for these groups.

ADCO crude oil production expansion projects

(Unit: 1,000 bpd)

Area	Oil field	At present	2012-end	2016-end	2017-end
Bu Hasa	Bu Hasa/Huwaila	560	560	560	560
	Bida Al-Qemzan	0	20	20	51
Bab & Gas	Bab	300	380	420	450
North East Bab	Rumaitha/Shanayel	40	48	70	80
	Dhabiya	70	70	100	130
South East Asset	Shah	50	70	70	70
	Asab	290	340	340	345
	Sahil	55	100	100	100
	Qusahwaira	0	30	30	50
	Mender	0	0	0	16
Total		1,365	1,618	1,710	1,852

Source: PIW, April 30, 2012

While ADCO has specified field-by-field production expansion projects, whether these projects could be implemented as planned is uncertain. This is because oil multinationals that hold concessions at oil fields have a great matter of concern other than the production expansion. The matter is the renewal of concessions expiring in January 2014. The present concession holders are concerned that they would fail to recover upfront investment in the production expansion unless their concessions are renewed.

4-4 ADCO concession renewal

The ADCO concessions originate from a concession agreement signed between Abu Dhabi and Petroleum Development (Trucial Coast) Ltd. [3] on January 1, 1939. Geological exploration started in February 1950. In 1962, Petroleum Development (Trucial Coast) Ltd. was renamed Abu Dhabi Petroleum Company (ADPC). Taking advantage of the then resources nationalism[4], ADNOC acquired a 25% stake in ADPC on January 1, 1973, and expanded the stake to 60% on January 1, 1974. Under an Emiri Decree on October 8, 1978, ADPC was reorganized into Abu Dhabi Company for Onshore Oil Operations (ADCO) to control overall operations subject to the concessions.

The oil multinationals that held the concessions in 1939 have remained unchanged. They were Anglo-Persian Oil Company (BP at present), Compagnie Française des Pétroles (Total at present), Anglo-Saxon Petroleum Co. (Shell at present), and a predecessor of ExxonMobile and Partex (owned by Calouste Sarkis Gulbenkian).

The 70-year-old consortium may change when the concessions expire and are renewed in January 2014. In June 2012, ADNOC conducted a pre-qualification of bidders to limit the number of qualified bidders to 10. Then, BP and Partex were dropped from the qualified bidder list. The reported candidates for new participants in the consortium are Occidental (U.S.), CNPC (China), KNOC (South Korea), INPC (Japan), Statoil (Norway), Eni (Italy) and Rosneft (Russia). With

[3] Petroleum Development (Trucial Coast) Ltd. was one of the wholly owned subsidiaries founded by Turkey Petroleum Company (renamed Iraq Petroleum Company in 1929) to expand into the Middle East.

[4] In the resources nationalism movements, countries tried to control and develop their own natural resources in line with a resolution adopted by the United Nations in 1962 on “Permanent Sovereignty over Natural Resources.”

support from British Prime Minister James Cameron, BP has managed to restore its qualification and is set to submit bidding documents by the end of September 2013 following the final qualification in March 2013. Cited as reasons for dropping BP in the pre-qualification are BP's lack of safe operation consciousness as indicated by the crude oil spill accident in the Gulf of Mexico, BP's sale of concessions (to such firms as Russia's TNK-BP) to raise money for compensations for the accident, and Britain's condemnation of the UAE's detainment of citizens calling for freedom of speech in 2011. But the real reasons remain unknown.

After bidding documents are submitted in September 2012, ADNOC will have to screen these documents and make a decision on successful bidders before the Supreme Petroleum Council's screening and decision. As these procedures were unlikely to be completed by the January 2014 expiration of the concessions, ADNOC asked the SPC to tentatively extend the deadline for one year. But the SPC has reportedly turned down the request[5], leaving the ADCO concession renewal problem in the balance.

The SPC has thus specified its plan to renew the concessions as originally scheduled. In a past case, however, the renewal of concessions for gas refining and sales company GASCO was settled in March 2009 after the original renewal deadline of October 2008, leading a contract retroactive to the original deadline to be signed upon the settlement. This approach could be adopted for the ADCO case as well. While the nominal concession renewal schedule may remain unchanged, the effective renewal may be delayed.

Bidders for their part see difficulties regarding the deadline. While ADNOC has reportedly asked them to submit ADCO oil field development plans, new bidders have no detailed data about the oil formation. In this sense, the bidding is viewed as favorable for the present concession holders. This is because an oil company may generally take at least one or two years to make an oil development plan based on oil formation data. ADNOC has also requested bidders to present plans for enhanced oil recovery using carbon dioxide. It may be dangerous for bidders to prepare CO_2-using EOR plans without tests using pilot plants. There is also an economic efficiency problem. No decision has been made on who would purchase CO_2 for injection into oil fields or how much CO_2 purchases would cost.

ADNOC is also expected to revise financial conditions for the concessions, as indicated by bidding documents distributed to bidders in late March 2013. At present, concession holders pay 20% of monthly income as royalty and an 85% tax on the remainder and a 1% margin is guaranteed to them. After the revision, however, the royalty will remain unchanged with the tax rate being raised slightly to eliminate the 1% margin guarantee, according to a report[6].

[5] MEES, May 17, 2013
[6] PIW, April 8, 2013

Candidate bidders for ADCO concessions

	Company name	Stake	Other concession/equity stakes (%)	Invited on March 26
Present concession holders	ADNOC	60.0%		
	BP	9.5%	ADMA(14.67%), ADGAS(10%)	△→○
	Total	9.5%	ADMA(13.33%), ABK(75%), GASCO(15%), ADGAS(5%), FERTIL(33.33%)	○
	Shell	9.5%	GASCO(15%)	○
	ExxonMobil	9.5%	ZADCO(28%)	○→ Absence
	Partex	2.0%	GASCO(2%)	△→×
Candidates for new concession holders	Occidental(U.S.)		* Shah gas field development (40%)	○
	CNPC(China)		* Implementing joint research in untapped blocks	○
	KNOC(South Korea)		Two onshore blocks (40%), one offshore block (40%)	○
	INPEX(Japan)		ADMA(12%), ZADCO(12%)	○
	Statoil(Norway)		* A MOU signed for exploration, development and production at a deepsea gas field	○
	ENI(Italy)			○
	Rosneft(Russia)			○

Source: Prepared from various information

Candidate bidders for ADCO concessions include those that already have some concessions in Abu Dhabi or invested local companies. From the 11 candidates, ADNOC is expected to select those meeting the following conditions for recommendation to the SPC:

(1) Companies with CO_2-using enhanced oil recovery technology

(2) Companies from countries that stably procure crude oil from Abu Dhabi

(3) Companies from countries that would provide military forces in emergency

The present concession holders may be discouraged from expanding crude oil production capacity as the uncertain period is to be extended for one year, with financial conditions changing for the worse.

5. Other energy projects in Abu Dhabi

Abu Dhabi has various energy projects in addition to oil and gas projects.

5-1 Nuclear power plant construction

In December 2006, the Gulf Cooperation Council decided on a joint plan for using nuclear technology for peaceful purposes harmonized with international standards and systems. In response, the UAE began to consider using nuclear energy at an international nuclear symposium in November 2008. In 2009, the UAE enacted a nuclear energy law, created the Emirates National Energy Corporation (ENEC) and the Federal Authority for Nuclear Regulation (FANR) and started nuclear plant construction.

In bidding for nuclear plant construction in December 2009, a South Korean consortium including KEPCO made a successful $20.4 billion bid for constructing two nuclear reactors.

Although the Fukushima Daiichi nuclear power plant accident occurred in March 2011, FANR Director General William D. Travers made no change to the UAE's nuclear plant construction plan, saying the FANR would closely watch developments regarding the Fukushima

nuclear accident, completely figure out the details of the accident and utilize lessons learned from the accident for its nuclear plant plan. The first reactor's construction has continued as originally planned.

The nuclear power plant construction plan calls for completing four nuclear reactors by 2020. Their total power generation capacity of 5.6 GW meets Abu Dhabi's plan to cover 25% of its electricity demand with nuclear power generation.

Nuclear plant construction plan

Construction site	Braka close to the border with Saudi Arabia
Capacity	1.4 GW x 4 (=5.6 GW)
Year for starting operation	1st reactor: 2017
	2nd reactor: 2018
	3rd reactor: 2019
	4th reactor: 2020

Source: Prepared from various sources

The ENEC has a tentative plan to build 14 nuclear reactors with a total capacity of 20 GW in the future. The plan might include a program given by the Emirate of Dubai in November 2010 to cover 20% of its electricity demand with nuclear power generation by 2030. But no specific move has been seen in regard to this plan.

5-2. Masdar renewable energy development

The UAE launched the Masdar Initiative in January 2008 to prepare an economic development program for building a sustainable society based on advanced energy technologies (including photovoltaic and solar thermal energy, wind power, hydrogen, and carbon capture and storage) to respond to long-term structural changes in energy supply and prepare for the depletion of domestic oil and natural gas resources.

Image of a completed Shams 1 plan

Under a specific plan for the Masdar Initiative, a 100 MW solar thermal power generation plant (Shams 1) costing $600 million started operation in March 2013 in Madinat Zayed 120 km southwest of Abu Dhabi. The plant is designed to cover electricity demand at 20,000 ordinary homes.

In parallel, a similar Noor 1 solar power generation facility is under construction. Noor 2 and 3 facilities are also being considered for the future.

A CCS plan is also going on to collect CO_2 from aluminum and other plants for injection into the ground. ADNOC is now considering how to price CO_2.

5-3 TAQA's waste-to-energy plant project

Abu Dhabi National Energy Co. (TAQA) is implementing an $850 million waste-to-energy plant project. TAQA received documents for pre-qualification by April 15 and is

now screening these documents.

The project is designed to collect 1 million tons in solid waste annually for generating 100 MW in electricity.

The renewable energy power generation capacity using the solar thermal plant and the waste-to-energy plant is now limited to 300 MW. In order to achieve Abu Dhabi's target of using renewable energy to generate 7% of electricity supply, the capacity will have to be expanded to five times the present size.

5-4 Fujairah utilization plans

Energy facilities are being constructed in Fujairah, the capital city of the Emirate of Fujairah, located outside the Strait of Hormuz or on the Indian Ocean side. These facilities are designed for securing energy supply even in the event of emergency and for promoting Abu Dhabi's energy policy.

➢Hormuz-bypassing pipeline

Abu Dhabi used funds from International Petroleum Investment Company (IPIC) for a 370 km crude oil pipeline from the onshore oil field area of Habshan to Fujairah with a transportation capacity of 1.5-1.8 million bpd at a total cost of $4.2 billion from 2008. Crude output at onshore oil fields now stands at about 1.3 million bpd compared with the capacity. The pipeline is capable of shipping all onshore crude output planned at 1.8 million bpd for 2017 from Fujairah. Since the pipeline construction was completed in mid-2012, the pipeline is now under commissioning ahead of its imminent delivery to ADNOC[7]. Another pipeline is under consideration for shipping crude oil from offshore oil fields of ADMA-OPCO and ZADCO.

➢ Fujairah LNG import terminal

Abu Dhabi founded Emirates LNG as a joint venture of IPIC and Mubadara Development in 2012 to promote a project for replacing Abu Dhabi's natural gas supply to Fujairah with LNG imports. Under Phase 1, Emirates LNG plans to complete a facility capable of receiving 4.5 million tons per year in LNG (or 600 million cf/d in natural gas) by 2014. Phase 2 for a similar capacity is under consideration, although no time schedule has yet to be specified.

➢Fujairah refinery

Abu Dhabi is promoting a project for constructing a 200,000 bpd oil refinery using IPIC funds. As the pipeline is ready to transport crude oil to Fujairah, Abu Dhabi may be planning to build an oil refinery in Fujairah for petroleum products exports. The oil refinery construction costing $3.5 billion is planned to end in 2016.

➢ Fujairah oil terminal

[7] A Dow Jones Newswires report on April 24, 2013, stated that 6 million bbl in crude oil was shipped from Fujairah in April.

The Emirate of Fujairah has led Gulf Petroleum owned by the emirate's royal family to construct petroleum products tanks. Gulf Petroleum completed the $130 million first phase of the tank construction project in January 2013, providing a storage capacity of 412,000 kiloliters (about 2.5 million bbl).

6. Conclusion

Having reviewed various energy projects by Abu Dhabi, in the following, I summarize answers to the questions given at the outset.

(1) Will natural gas development make smooth progress?

The answer to the question is that it may not necessarily do so.

This is because Abu Dhabi's gas development projects include sour gas projects that it cannot promote without overcoming hurdles regarding sulfur prices, environmental measures and adverse effects on crude oil production.

(2) Will crude oil production capacity expansion make smooth progress?

The answer to this question is that it may be difficult for Abu Dhabi to achieve the target production capacity of 3.5 million bpd by 2017.

This is because there are various problems to be solved. ADMA-OPCO has a financial resources problem regarding a switch from associated gas to CO_2 for increasing oil layer pressures. ZADCO has adopted a new production well digging method. Prior to the ADCO concession renewal in 2014, the present concession holders face a risk of failing to recover upfront investment for the capacity expansion unless their concessions are renewed. ADNOC has already requested the SPC to extend the present ADCO concessions for one year. This means that the period where the present concession holders are reluctant to expand the crude oil production capacity amid uncertainties over the concession renewal may be prolonged, increasing the chances of them failing to achieve the capacity expansion target by the existing deadline. Another problem is that if there is any newcomer among the concession holders after the renewal, gaps between the concession holders' experiences with local oil fields may work to delay the production capacity expansion project.

(3) How are other energy development projects?

The conclusion is that it may be difficult to achieve the renewable energy development target.

While the present plan calls for securing a renewable energy power generation capacity of 1.6 GW by 2020, only 0.1 GW has been completed, 0.1 GW is under construction and 0.1 GW is in the pre-bidding stage. The total is limited to 0.3 GW or one-fifth of the target. It may be very difficult to make the remaining 1.2 GW operational in seven years.

Meanwhile, nuclear power plant construction is likely to make progress as planned, allowing four nuclear reactors (with a total capacity of 5.6 GW) to be completed by 2020. But a

long-term plan calling for a total of 14 reactors may be difficult to achieve due to the difficult selection of construction sites and massive investment.

The utilization of Fujairah is expected to make further progress since Fujairah is not only vital for Abu Dhabi but also geographically important for other countries facing the Arabian Gulf.

(4) Will Abu Dhabi turn a net natural gas importer?

The conclusion is that Abu Dhabi has no natural gas supply problem for the immediate future.

Statistically, the entire UAE's natural gas production totaled about 5 billion cf/d in 2011. Based on recoverable reserve shares, Abu Dhabi is estimated to account for 94% or 4.7 billion cf/d of the production. In addition, Abu Dhabi is expected to produce an additional 2 billion cf/d under the IGD and sour gas development projects.

Meanwhile, Abu Dhabi's natural gas demand in 2020 can be projected at 4.5 billion cf/d, based on the natural gas power generation plant capacity. The present natural gas output is thus enough to satisfy demand in 2020. But this estimate is based on an assumption that nuclear plant construction and renewable energy development will make progress as planned. If Abu Dhabi fails to steadily develop gas resources while diversifying electricity sources, it may turn a net natural gas importer.

(5) How can the present Abu Dhabi energy policy be viewed through answers to the above questions?

- Securing revenues

Abu Dhabi gives top priority to securing revenues by maximizing oil exports. To this end, it is implementing various projects to expand oil production. The Abu Dhabi Economic Vision 2030, published in November 2008, views crude oil as set aside for exports and natural gas for domestic consumption including power generation.

- Securing and diversifying electricity supply

Abu Dhabi is required to expand electricity generation capacity as demand has been expanding for electricity for sea water desalination and other uses in line with economic and population growth over recent years. Therefore, the Abu Dhabi Water & Electricity Authority has taken leadership in planning to boost the total electricity generation capacity to 23 GW by 2020. In response, the ADNOC group and Masdar have attempted to develop sour gas and use CO_2 instead of gas for injection into oil fields for expanding the natural gas production capacity and using natural gas more efficiently. Since there may be a limit on the dependence on natural gas for electricity generation, Abu Dhabi is seeking to introduce and expand new electricity sources such as nuclear and renewable energy through the ENEC's nuclear plant construction, Masdar's solar thermal power generation and TAQA's waste-to-energy plant project.

- Ensuring energy and national security

From the viewpoint of energy security, Abu Dhabi plans to utilize Fujairah at a geographically advantageous location outside the Strait of Hormuz for ensuring stable exports even in the event of emergency. At the same time, Fujairah may be utilized for ensuring stable LNG imports.

From the viewpoint of national security, Abu Dhabi must defend its oil and gas fields as its key assets. In attracting foreign investment in oil and gas field development, therefore, Abu Dhabi may give priority to companies from (1) countries with strong military forces, (2) countries helping Abu Dhabi secure oil export destinations and (3) countries with advanced oil and gas development technologies. Abu Dhabi is expected to consider these points in selecting companies to hold renewed ADCO concessions.

7. Analysis

Lastly, I would like to analyze the implications for Japan of energy problems facing the Emirate of Abu Dhabi and the emirate's relations with Japan.

(1) Natural gas problems

Abu Dhabi's natural gas supply-demand balance has no problem for the immediate future (through around 2020). But the entire UAE is expected to see its net natural gas imports expanding despite natural gas development to expand domestic output. While Japan has a contract to purchase 4.3 billion tons per year in LNG from Abu Dhabi until 2019, Abu Dhabi can be expected to reduce or terminate contracted LNG exports to Japan in the future. Therefore, Japan will have to take measures (finding alternative LNG supply sources) responding to the reduction or termination.

(2) Crude oil and petroleum products problems

Abu Dhabi's crude oil production capacity is expected to gradually increase, even though somewhat behind schedule. Among Japanese companies, Japan Oil Development Co. has concessions at large oil fields of ADMA-OPCO and ZADCO. In addition, Abu Dhabi Oil Co., Inpex ABK Ltd. and United Petroleum Development Co. are engaged in production at small and medium-sized oil fields. Therefore, Japan's public and private sectors should strive for ensuring safe oil field operations and development to help Abu Dhabi achieve relevant plans.

Abu Dhabi's future crude oil export destinations are expected to include Asian countries where oil demand is likely to expand. For Japan, Abu Dhabi is the second largest oil supplier after Saudi Arabia. While Japan's oil demand is expected to decline gradually in the future, Japan should maintain a certain volume of imports from Abu Dhabi in line with overall oil imports from the viewpoint of energy security at a time when the UAE is paving the way for crude oil and petroleum products to be exported from Fujairah without passing through the Strait of Hormuz.

(3) Nuclear and renewable energy problems

Abu Dhabi plans to cover 25% of its electricity demand with nuclear energy and 7% with

renewable energy by 2020. The entire UAE is considering building a total of 14 nuclear reactors in the future, with the Emirate of Dubai planning to cover 20% of its electricity demand with nuclear energy by 2030. There is a market for Japan to offer its products or knowhow. During his visit to the UAE in early May, Prime Minister Shinzo Abe signed a bilateral nuclear cooperation agreement, paving the way for Japan-UAE nuclear business cooperation.

As mainly Masdar has promoted renewable energy development projects including solar thermal power generation, basic opportunities exist for Japan to expand commercial and academic cooperation with the UAE. Given such cooperative relations, Japan should view the UAE as a very attractive future market for Japanese products.

Contact: report@tky.ieej.or.jp