2014
세아 Fellowship 공모
우수연구논문집

SEAH

Technology Management
Economics and Policy Program

Seoul National University
IEPP
International Energy Policy Program

ITPP
Seoul National University

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E-Government Education and Training for Rural Areas: End-User Skills

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Chapter 1 Background Introduction

1.1 Overall introduction

Education has become the key element in the knowledge economy of the 21st century. Over the past two decades, the objectives of the public sector investment into information technology and e-government have evolved from increasing the quality and efficiency of internal government operations, through delivering better public services and making them available across traditional and electronic channels, to facilitating administrative and institutional reform, engaging citizens in policy- and decision-making processes, and (more recently) directly supporting policy and development goals within and across the health, education, economy, security and other sectors. In order to respond to such objectives, contributions from an increasing range of actors including political and government leaders, public managers, agency staff (management, technical and service-level), business and non-profit partners, citizens and others are required. To this end, however, the actors should understand their roles, possess competences (knowledge, skills and attitudes) required to fulfill the responsibilities associated with their roles, and be able to work together and across different roles. However, rapid changes in technology and lack of the trained and skilled human resources in this area may cause to fall further behind and face difficulties in catching up in the use of emerging technologies. Building

capacity in ICT for e-Government initiatives will allow for better delivery of services and more efficient cost-effective government operations.

The mini-track always focus on the acquisition, utilization and continued development of the competences required from various actors and roles involved in planning, development and usage of public sector information technology and e-government. Of interest are enquiries and cases related to: actors and their responsibilities and roles; training, apprenticeship and capacity building; body of knowledge, learning innovation, technology and gaming; assessment methods, certification and others. End user training program usually include both general and specialized end user skills. Specialized end user skills include communication, statistics, economics, research and analysis, operational research, and finance and personal skills. General end-user skills include operational data management and basic IT. In this project the focus is on the general end-user skills that will support the e-Government Master Plan of the nation which the Federal Government of Nigeria contracted to the Korea International Cooperation Agency (KOICA) on the 20th February, 2014.

This project is aimed at organizing an E-Government Education and Training from the end-users perspective in at list five (5) selected Rural Areas in Nigeria to promote and support the National e-Government master plan development as part of the global best practices obtained world over. The remainder of the study is organized in the following way; the next section presents a general overview of the study area, we then present the objectives of the study followed by the statement of need, and we then present the target group and the expected results, we then present the Basic Computer Skills Curriculum followed by a brief description of some sponsors partners, we then present the cost analysis, followed by an implementation plan, then some challenges and possible ways of overcoming them, and then the conclusion.

1.2 Overview of Nigeria

The Federal Republic of Nigeria is a federal constitutional republic comprising of 36 states with Lagos as the largest city and its Federal Capital Territory, Abuja. The country is located in West Africa at 9°4′N 7°29′E, it covers an area of Total 923,768 km^2 (32nd) 356,667 sq mi with Water (%) 1.4 and shares land borders with the Republic of Benin in the west, Chad and Cameroon in the east, and Niger in the north. Its coast in the south lies on the Gulf of

Guinea in the Atlantic Ocean.

The site of numerous ancient kingdoms and empires, the modern political state of Nigeria has its origins in the British colonization of the region during the late nineteenth to early twentieth centuries; it emerged from the combination of two neighboring British protectorates: (the Southern Nigeria Protectorate and Northern Nigeria Protectorate). During the colonial period, the British set up administrative and legal structures whilst retaining traditional chiefdoms. Nigeria achieved independence in 1960, but plunged into civil war several years later. It has since alternated between democratically-elected civilian governments and military dictatorships, with its 2011 presidential elections being viewed as the first to be conducted reasonably freely and fairly (Nossiter, 2011).

Nigeria is often referred to as the "Giant of Africa", due to its large population and economy (Holmes, 1987). With approximately 177,155,754 (7th) inhabitants, with a density of 188.9/km2 (71st) 489.3/sq mi, Nigeria is the most populous country in Africa and the seventh most populous country in the world (Library of Congress – Federal Research Division, 2008). The country is inhabited by over 500 ethnic groups, of which the three largest are the Hausa, Igbo and Yoruba.

Figure 1-1 Map of Nigerian showing the 36 states

Figure 1.1 is the map of Nigeria showing the 36 States including the federal capital territory[1]. According to the World Bank (2014), Nigeria has been identified as a regional power in Africa. Its economy GDP (PPP) in 2014 became the largest in Africa, worth Total $521.359 billion (30th), Per capita $2,997, and GDP growth rate of 5.4% as at 2013 estimate. The GDP (nominal) 2014 estimate Total $316.035 billion (38th), Per capita $1,816 and overtook South Africa to become the world's 26th largest economy (World Bank, 2014). Furthermore, the debt-to-GDP ratio is only 11 percent (8 percent below the 2012 ratio), and Nigeria is expected to become one of the world's top 20 economies by 2050 (World Bank, 2014). The country's oil reserves have played a major role in its growing wealth and influence. Nigeria is considered to be an Emerging market by the World Bank. It is also a member of the MINT group of countries, which are widely seen as the globe's next "BRIC-like" economies. It is also listed among the "Next Eleven" economies set to become among the biggest in the world. Nigeria is a member of the Commonwealth of Nations, the Africa Union, OPEC, and the United Nations among other International organizations.

According to National Literacy Survey (2010), conducted by the National Bureau of Statistics in Nigeria estimates the adult literacy rate as 56.9%, with huge variations between regions (urban 74.6 % and rural 48.7%,) and sex (male 65.1% and female 48.6%) (NBS, 2010). Accordingly the population pyramid showing the age and sex structure of Nigeria is shown in Figure 1.2. In addition the percentage of population in each age group and the sex ratio can be seen as presented in Table 1.1.

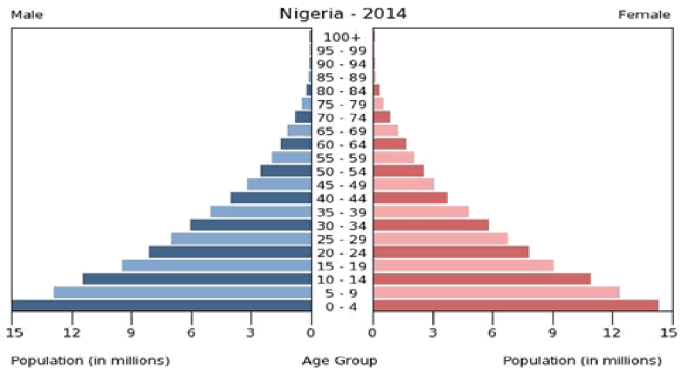

Figure 1-2 Population pyramid showing age and sex structure of Nigeria
(Source: CIA world fact book, 2014)

[1] http://www.babcecilschools.org/website/wp-content/uploads/2012/12/Map-of-Nigeria-and-its-States.jpg

Table 1-1 percentage population by age group and sex ratio

Age range	% of population	Sex		Sex ratio
		Male	Female	
0-14 years	43.2	39,151,304	37,353,737	1.05
15-24 years	19.3	17,486,117	16,732,533	1.05
25-54 years	30.5	27,697,644	26,285,816	1.05
55-64 years	3.9	3,393,631	3,571,301	1.04
65 years & over	3	2,621,845	2,861,826	0.85
Total population	100	177,155,754		1.01
Urban population	49.6% of total population			

(Source: CIA world fact book, 2014)

Chapter 2 Objectives and Outcome

2.1 Concept Idea

This project will organize an E-Government Education and Training from the end-users perspective in at list five (5) selected Rural Areas in Nigeria to promote and support the National development of the e-Government master plan as part of the global best practices obtained world over, through training course with an appropriate course curriculum in order to make understanding and awareness of e-government for everyday life.

2.2 Objectives

- Develop an understanding of some Basic Computer Skills and vocabularies
- Understand some basics of MS Word Exercises and Excel Exercises
- Be able to successfully develop and use the power point
- Develop an understand of how to navigate the Internet
- Learn features and advantages of the e-Government Program
- Be able to successfully use some applications functional flow and a basic understanding of some platform requirements
- Some basic understanding of navigation, and initial login

Be able to successfully complete and submit: Tax Exemption Card Applications and DMV Applications (Vehicle Registration, Replacement Plate and Driver License Application)

2.3 Statement of Need

Due to the bilateral agreement between Korean Government and Nigerian Government on e-Government mater plan contracted to the Korea International Cooperation Agency (KOICA) on the 20th February, 2014 and the expectation of Nigeria to become one of the world's top 20 economies by 2050, e-Government has become one of the top national priorities in Nigeria. This project will support the National e-Government master plan development, create awareness within the Rural Areas and prepare a readiness for the adoption of the e-Government amongst the Local community, thereby bridging the digital divide of rural communities.

2.4 Target Group

The target group will be covering the villagers of all age range with the individual's appropriate courses, most especially the project will focus on the market women and the retirees. Market women have no knowledge of ICT and the Internet, they constitutes about 9.4% of the population and nevertheless will have to pay their taxes. They need some basic understanding of ICT to be able to cope with e-Government adoption. For the retirees, most of them have little or no knowledge of ICT and the Internet; due to the fact that they never had such privilege before their retirement as the Internet was not popular during their time, they constitute about 3.1% of the population and are the less privileged.

2.5 Expected Results

The expected results is seen in terms of the social impact as this project is aimed at developing the basic skills of the less privileged persons within the community especially market women and retire. It is expected that the ideas will create an awareness of e-Government and prepare the local people for the adoption of the service when it is deployed. The project can be replicated to cover the entire rural Areas of the country.

2.5.1 Short Term Outcomes

- IT literacy and reduction of the internal digital divide
- Improved access to government operations and services (payment of tax and tax exemptions, application of driver's license and other payments)
- Increased access to and quality of education
- Better delivery of and access to health services

2.5.2 Long Run Outcomes

- Improved education management capacity
- Improved health management capacity
- Improved social security and public safety
- Improved social welfare and quality of the environment
- Integration and coordination of social and economic policy

Chapter 3 Main Project

3.1 Basic Computer Skills Curriculum

Here we will like to present the lesson modules covering basic computer skills developed by computer teachers. We will provide Lessons (handouts), Teacher Guides, Vocabulary Lists and Activities. Some computer skills may have several lessons associated with them and some lessons may cover several computer skills. The lessons are grouped by computer task and skill. Rather than rigidly defining a day-by-day curriculum, teachers can pick and choose lessons and activities that suit their classroom needs and student's pace. We highly recommend incorporating keyboarding practice into the curriculum. Using a keyboarding program such as Mavis Beacon every day will help the students feel comfortable on the keyboard. Also two good websites for practicing mouse skills are Mousarobics and Mouse Exercises.

3.2 Table of Contents

Table 3-1 syllabus for the basic computer training program

No	Syllabus	Target Group
1. Very Basic Computer Skills		
	Visuals for teaching very basic computer skills: using a mouse and turning a computer on and off. Content: • How to turn on the computer • How to turn off the computer • Mouse skills • Mouse visual aid • Mouse skills vocabulary	Suited for low NRS levels (no or minimal reading and writing skills) or for students with little to no computer experience
2. Computer Vocabulary		
	Activities to teach everyday computer vocabulary includes: computer parts, toolbar, font, highlight Content: • Basic definitions (Basic Computer and Windows Terms: student dictionary) • Basic definitions matching game • Computer vocabulary • Vocabulary matching game 2 • About your computer (understanding your computer)	Suited for low NRS levels (no or minimal reading and writing skills) or for students with little to no computer experience
3. Opening and Saving Files		
	Navigating windows to open and save files. Content: • Find a file (file on your floppy) • Open a file from your disk • Save a file (Save a New File) • Using folders (Create a Folder, Save a New File in a Folder, Find a File in a Folder, Delete a File in a Folder)	Suited for low NRS levels (no or minimal reading and writing skills) or for students with little to no computer experience
4. Skills and Activities Practice		
	Activities created to help students practice skills such as font attributes (bold, italics), spacing, cut-and-paste, and tables. Content: • Font attributes (b-i-u form: bold, italicize, and underline, examples) • Cut and paste (123 cut and paste, cut and paste letters, directions, order clothes, order cut and paste, reading numbers cut and paste, story, words cut and paste) • Spacing (123 space, ABC space, ABC tab) • Editing (ABC delete capital, ABC delete small, delete practice, directions, story, words and sentences) • Tables (class tables, farmers table, form, month tables, sorting words, word search)	Suited for low NRS levels (no or minimal reading and writing skills) or for students with little to no computer experience

No	Syllabus	Target Group
5. MS Word Exercises		
	Step-by-step instructions with graphics designed to introduce learners to various aspects of MS Word. Content: • What is Microsoft Word? • Exercise 1: Typing and Editing (Using the toolbar, Highlighting text, Copy and Paste functions, Font and Font size, Common keyboard operations, Bold, Italics, Underline) • Exercise 2: Editing and Formatting (Basic keyboard keys, Formatting text, Cut and Paste, Saving to a disk, Using the undo button) • Exercise 3: Spell Check • Exercise 4: Spell Check • Exercise 5: Spell Check • Exercise 6: Editing and Spell Check (Microsoft Word format) | Practice (Microsoft Word format) • Exercise 7: Editing and Formatting | Formatting Practice (Microsoft Word format) • Exercise 8: Tables (How to insert a table, How to use shading, Moving the cursor in a table) • Exercise 9: Columns and Indenting (Changing alignment, Columns, Indenting) • Exercise 10: Bullets and Clip Art (Formatting bullets, Inserting pictures, Using lines and borders) • Copying and Pasting Images (Copying and pasting pictures from the Internet, Formatting and resizing your picture) • Microsoft Word: Using HELP 98 2000 Version (Accessing the Help Menu, Searching for a help topic, Browsing Help Contents) • Microsoft Word: Using HELP XP Version (Accessing the Help Menu, Searching for a help topic, Browsing Help Contents)	NRS levels range from Low Intermediate and High Intermediate Basic Education to Low Adult Secondary
6. Excel Exercises		
	Step-by-step instructions with graphics designed to introduce learners to various aspects of MS Excel Content: • Explanation of Excel Cursors (select mode, click and drag, auto fill, resizing) • Exercise 1, Basic: Entering Information • Exercise 1: Entering Information (Understanding rows and columns, Typing and editing text in a cell, Formatting text in a cell, Using the series fill handle) • Exercise 2, Basic: Making Lists • Exercise 2: Making Lists (Moving from one cell to another, Entering	

No	Syllabus	Target Group
	information in cells, Removing a hyperlink, Center and merge, Sort ascending, Deleting a row or column) • Exercise 3, basic: Budgets • Exercise 4: Adding Totals and making a spreadsheet • Exercise 5: Making Charts (Using AutoSum, Using the fill handle to copy formulas, Using AutoFormat, Using the Chart Wizard to create a pie and bar graph) • Exercise 6: Budgets (creating a monthly budget with: separate columns for expenses and income, totals for the expenses and income, a bar graph that compares monthly expenses with monthly income) • Exercise 7: Making Charts (making tables and graphs in Microsoft Excel)	
7. Internet		
	Lessons and activities on using the internet are presented where these lessons refer to Internet Explorer as the browser. Many activities can be completed regardless of the browser. Content: • What is the internet? (Who made the internet, what is the World Wide Web? (www), MODEM, browser, email, spam or junk mail, chat, URL, Web address ending, link, search engine) • Go to a website on the internet • Internet directions: Mapquest • Exercise 1 (How Can I Access the Internet?) • Exercise 2 (Look ups) • Exercise 3 (How to use search engines) • Exercise 4 (Search Engine Practice) • Internet job search (Job search, submit resume, upload documents) • Online dictionaries and encyclopedias • Internet dictionary (how to use online dictionary) • Metro Transit website (how to use the TRIP PLANNER) • Publish your own recipe (create a class cookbook)	Suitable for NRS level Low Adult Secondary
8. PowerPoint		
	Step-by-step instructions with graphics designed to walk students through the creation of a PowerPoint presentation. Content: • PowerPoint for 2000 (Entering Text, Using Microsoft Clipart, Using Internet Clipart, Formatting Your Presentation, how to use ANIMATION) • PowerPoint for XP (Entering Text, Using Microsoft Clipart, Using Internet Clipart, Formatting Your Presentation, how to use ANIMATION)	Suitable for NRS level Low Adult Secondary

No	Syllabus	Target Group
	• Sample presentation (PPT)	
9. Introduction to e-Government		
	Step-by-step lessons with graphics designed to introduce learners to an introductory and general overview of e-government with various applications functional flow and platforms Content: • Overview of e-Government Program • Applications functional flow • Platform requirements • Navigation, and • Initial login	Suitable for NRS level Low Adult Secondary
10. Activating the Program		
	Step-by-step lessons with graphics designed to introduce learners to how they can open and manage an e-government account Content: • Requesting a Login and Password • Account Request Form • Changing your Password • Requesting a New Service	Suitable for NRS level Low Adult Secondary
11. E-Government Tax Applications		
	Step-by-step lessons with graphics designed to introduce learners to how they can successfully complete a tax payment or apply for a tax exemption Content: • Tax Exemption Card • Exemption from Utilities Tax • Other Tax Payments	Suitable for NRS level Low Adult Secondary
12. E-Government FRSS Services		
	Step-by-step lessons with graphics designed to introduce learners to how they can successfully apply and complete payment for driver's license and vehicle registration Content: • Vehicle Registration • Vehicle Title • Replacement Plates • Application for Driver License • Application for Non-Driver ID	Suitable for NRS level Low Adult Secondary

Chapter 4 Sponsors Partners

4.1 The Internet Society (ISOC)

This is an international, non-profit organization founded in 1992 to provide leadership in Internet related standards, education, and policy. It states that its mission is "to promote the open development, evolution and use of the Internet for the benefit of all people throughout the world". The Internet Society has its headquarters in Reston, Virginia, United States, (near Washington, D.C.), and offices in Geneva, Switzerland. It has a membership base of more than 130 organizations and more than 55,000 individual members. Members also form "chapters" based on either common geographical location or special interests. There are over 90 chapters around the world.

4.1.1 Mission

Their mission is to promote the open development, evolution, and use of the Internet for the benefit of all people throughout the world. To help achieve this mission, the Internet Society:

- Facilitates open development of standards, protocols, administration, and the technical infrastructure of the Internet.
- Supports education in developing countries specifically, and wherever the need exists.
- Promotes professional development and builds community to foster participation and leadership in areas important to the evolution of the Internet.
- Provides reliable information about the Internet.
- Provides forums for discussion of issues that affect Internet evolution, development and use in technical, commercial, societal, and other contexts.
- Fosters an environment for international cooperation, community, and a culture that enables self-governance to work.
- Serves as a focal point for cooperative efforts to promote the Internet as a positive tool to benefit all people throughout the world.
- Provides management and coordination for on-strategy initiatives and outreach efforts in humanitarian, educational, societal, and other contexts.

With these strategic underpinnings in place, the Internet Society has identified and

undertaken a number of projects to demonstrate its commitment to the mission. Many of these have been initiated by Chapters or as a result of individual and organizational member desires. Others have been undertaken through the efforts of the Trustees, and Internet Society staff in Reston, Geneva, and around the globe[2].

4.1.2 Who they are

The Internet Society is a global cause-driven organization governed by a diverse Board of Trustees that is dedicated to ensuring that the Internet stays open, transparent and defined by you. They are the world's trusted independent source of leadership for Internet policy, technology standards, and future development.. More than simply advancing technology, they work to ensure the Internet continues to grow and evolve as a platform for innovation, economic development, and social progress for people around the world. With offices around the world, they work to ensure that the Internet and the web that is built on it:

- **Continues to develop as an open platform that empowers people** to share ideas and connect in new and innovative ways
- **Serves the economic, social, and educational needs** of individuals throughout the world – today and in the future

4.1.3 Partnerships and Expertise

Backed by more than 65,000 members and supporters, 100 Chapters around the world, as well as more than 145 Organization members, the Internet Society achieves change through partnership and expertise in policy, technology and communications. By working with a range of partners from non-profit agencies, local and global NGOs, academia, technologists, local councils, federal policy and decision makers, business and more, they want to make sure that your voice, expertise, and imagination can continue to develop one of the greatest tools of our lifetime.

[2] http://www.internetsociety.org/who-we-are/mission

4.2 US Agency for International Development (USAID)

The United States Agency for International Development (USAID) is the United State federal government agency primarily responsible for administering civilian foreign aid. USAID seeks to extend a helping hand to those people overseas struggling to make a better life, recover from a disaster or striving to live in a free and democratic country. There works is to end extreme global poverty and enable resilient, democratic societies to realize their potential. It operates in Africa, Asia, Latin America and Europe.

4.2.1 Who they are

President John F. Kennedy created USAID in 1961 by executive order to implement development assistance programs in the areas authorized by the Congress in the Foreign Assistance Act. The Congress updates this authorization through annual funds appropriation acts, and other legislation. Although technically an independent federal agency, USAID operates subject to the foreign policy guidance of the President, Secretary of State, and the National Security Council. On 3 April 2014 the Associated Press published findings of an investigation showing how USAID engineered a program involving the creation of a Twitter-like communications network called ZunZuneo aimed at giving a platform to political dissent to spark reform[3].

4.2.2 Assistance to Foreign Countries

U.S. foreign assistance has always had the twofold purpose of furthering America's interests while improving lives in the developing world. USAID carries out U.S. foreign policy by promoting broad-scale human progress at the same time it expands stable, free societies, creates markets and trade partners for the United States, and fosters good will abroad. Spending less than 1 percent of the total federal budget, USAID works in over 100 countries to:

- Promote broadly shared economic prosperity;
- Strengthen democracy and good governance;
- Protects human rights;
- Improve global health,

[3] www.United_States_Agency_for_International_Development

- Advance food security and agriculture;
- Improve environmental sustainability;
- Further education;
- Help societies prevent and recover from conflicts; and
- Provide humanitarian assistance in the wake of natural and man-made disasters[4].

4.2.3 What they do

In an interconnected world, instability anywhere around the world can impact us here at home. Working side-by-side with the military in active conflicts, USAID plays a critical role in our nation's effort to stabilize countries and build responsive local governance; they work on the same problems as our military using a different set of tools. They also ease the transition between conflict and long-term development by investing in agriculture, health systems and democratic institutions. And while USAID can work in active conflict, or help countries transition from violence, the most important thing they can do is prevent conflict in the first place. This is smarter, safer and less costly than sending in soldiers.

USAID extends help from the American people to achieve results for the poorest and most vulnerable around the world. That assistance does not represent a Democratic value or a Republican value, but an American value; as beneficiaries of peace and prosperity, Americans have a responsibility to assist those less fortunate so they see the day when their assistance is no longer necessary. USAID invests in ideas that work to improve the lives of millions of men, women and children by:

- Investing in agricultural productivity so countries can feed their people
- Combating maternal and child mortality and deadly diseases like HIV, malaria and tuberculosis
- Providing life-saving assistance in the wake of disaster
- Promoting democracy, human rights and good governance around the world
- Fostering private sector development and sustainable economic growth
- Helping communities adapt to a changing environment
- Elevating the role of women and girls throughout all our work[5].

[4] http://www.usaid.gov/who-we-are

4.3 Intel cooperation

Intel Learn Program is empowering youth around the world, it is designed especially for young learners in developing countries, and the Intel Learn Program extends learning beyond the classroom with an engaging, project-centered approach. Intel Learn is an informal education program that teaches youth the skills they need to succeed in our increasingly knowledge-based economy, with a focus on technology literacy, problem-solving, critical thinking, and teamwork.

From Argentina to the Ukraine, Intel Learn has enriched the lives of more than one million learners in 15 countries to date. Taught in community technology centers, typically as an after-school program, Intel Learn is administered in partnership with local governments, communities, and nonprofit organizations.

Their goal is to ensure the effective use of technology in learners between the ages of eight and 25. Students all around the world are using Intel Learn to gain new skills—and discovering new paths into their future.

In terms of opening Doors for Bright Young Minds, Intel Learn Program is helping youth from underserved communities develop their problem-solving, collaboration, and technology skills—and giving them the tools to build connections to a brighter future[6].

4.4 World Bank

The World Bank is a United Nations international financial institution that provides loans to developing countries for capital programs. The World Bank is a component of the World Bank Group, and a member of the United Nations Development Group. The World Bank's official goal is the reduction of poverty. According to its Articles of Agreement, all its decisions must be guided by a commitment to the promotion of foreign investment and international trade and to the facilitation of capital investment[7].

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[5] http://www.usaid.gov/what-we-do

[6] http://www.intel.com/content/www/us/en/education/k12/intel-learn.html

[7] http://www.worldbank.org/

4.4.1 World Bank Institute

The World Bank Institute (WBI) creates learning opportunities for countries, World Bank staff and clients, and people committed to poverty reduction and sustainable development. WBI's work program includes training, policy consultations, and the creation and support of knowledge networks related to international economic and social development.

The World Bank Institute (WBI) can be defined as a "global connector of knowledge, learning and innovation for poverty reduction". It aims to inspire change agents and prepare them with essential tools that can help achieve development results. WBI has four major strategies to approach development problems: innovation for development, knowledge exchange, leadership and coalition building, and structured learning. World Bank Institute (WBI) was formerly known as Economic Development Institute (EDI), established on March 11, 1955 with the support of the Rockefeller and Ford Foundations. The purpose of the institute was to serve as provide an open place where senior officials from developing countries could discuss development policies and programs. Over the years, EDI grew significantly and in 2000, the Institute was renamed as the World Bank Institute. Currently Sanjay Pradhan is the Vice President of the World Bank Institute.

4.4.2 Global Development Learning Network

The Global Development Learning Network (GDLN) is a partnership of over 120 learning centers (GDLN Affiliates) in nearly 80 countries around the world. GDLN Affiliates collaborate in holding events that connect people across countries and regions for learning and dialogue on development issues.

GDLN clients are typically NGOs, government, private sector and development agencies who find that they work better together on sub-regional, regional or global development issues using the facilities and tools offered by GDLN Affiliates. Clients also benefit from the ability of Affiliates to help them choose and apply these tools effectively, and to tap development practitioners and experts worldwide. GDLN Affiliates facilitate around 1000 videoconference-based activities a year on behalf of their clients, reaching some 90,000 people worldwide. Most of these activities bring together participants in two or more countries over a series of sessions. A majority of GDLN activities are organized by small government agencies and NGOs[8].

4.5 African Development Bank

The African Development Bank Group (AfDB) is a multilateral development finance institution established to contribute to the economic development and social progress of African countries. The AfDB was founded in 1964 and comprises three entities:

- The African Development Bank,
- The African Development Fund and
- The Nigeria Trust Fund.

The AfDB's mission is to fight poverty and improve living conditions on the continent through promoting the investment of public and private capital in projects and programs that are likely to contribute to the economic and social development of the region. The AfDB is a financial provider to African governments and private companies investing in the Regional Member Countries (RMC). While it was originally headquartered in Abidjan, Cote d'Ivoire, the Bank's headquarters moved to Tunis, Tunisia, during the civil war in Cote d'Ivoire[9].

4.5.1 Functions

The primary function of AfDB is making loans and equity investments for the socio-economic advancement of the RMC. Other functions of the AFDB are to:

- Provides technical assistance for development projects and programs.
- Promotes investment of public and private capital for development.
- Assists in organizing the development policies of RMCs.

The AfDB is also required to give special attention to national and multinational projects which are needed to promote regional integration.

4.5.2 Mission & Objective

The overarching objective of the African Development Bank (AfDB) Group is to spur sustainable economic development and social progress in its regional member countries (RMCs), thus contributing to poverty reduction. The Bank Group achieves this objective by:

- Mobilizing and allocating resources for investment in RMCs; and

[8] http://www.gdln.org/about

[9] http://www.afdb.org/en/about-us/

- Providing policy advice and technical assistance to support development efforts.

In 2000, all multilateral development institutions have agreed on a same set of objectives, called the Millennium Development Goals (MDG).

4.5.3 Millennium Development Goals

- Eradicate extreme poverty and hunger
- Improve maternal health
- Achieve universal primary education
- Combat HIV/AIDS, malaria and other diseases
- Promote gender equality and empower women
- Ensure environmental sustainability
- Reduce child mortality
- Develop a global partnership for development. Source (http://www.afdb.org/about-us/mission-objective/)

4.6 New Partnership for Africa's Development (NEPAD)

The New Partnership for Africa's Development (NEPAD) is an economic development program of the African Union. NEPAD was adopted at the 37th session of the Assembly of Heads of State and Government in July 2001 in Lusaka, Zambia. NEPAD is a merger of the Millennium Partnership for Africa's Recovery Programme (MAP) and the Omega Plan. The merger was finalized on 3 July 2001. Out of the merger, the New Africa Initiative (NAI) was born. NAI was then approved by Organization of African Union's Heads of State and Government Summit on 11 July 2001. Its policy framework was finalized on 23 October 2001, forming NEPAD, the New Partnership for Africa's Development. NEPAD aims to provide an overarching vision and policy framework for accelerating economic co-operation and integration among African countries[10].

[10] http://www.nepad.org/about

4.6.1 What is NEPAD?

- It is a holistic, comprehensive integrated strategic framework for the socio-economic development of Africa. The NEPAD provides a vision for Africa, a statement of the problems facing the continent and a programme of action to resolve these problems in order to reach the vision.
- It is a plan that has been conceived and developed by African leaders.
- It is a comprehensive integrated development plan that addresses key social, economic and political priorities in a coherent and balanced manner.
- It is a commitment that African leaders are making to African people and to the international community, to place Africa on a path of sustainable growth.
- It is a commitment African leaders are making to accelerate the integration of the African continent into the global economy.
- It is a framework for a new partnership with the rest of the world.
- It is a call to the rest of the world to partner Africa in her own development on the basis of her own agenda and programme of action.

4.6.2 NEPAD'S Goals and Priorities

NEPAD's goals are threefold:

- To promote accelerated growth and sustainable development,
- To eradicate widespread and severe poverty, and
- To halt the marginalization of Africa in the globalization process.

These goals translate into six concrete sectorial priorities:

- First, bridge the Infrastructure Gap (this priority is tackled along four different angles - bridging the Digital Divide, Energy, Transport, Water and Sanitation).
- Second, build human resources (this priority regroups four missions - reduce poverty, bridge the education gap, reverse the Brain Drain and improve health).
- Third, develop a strong and sustainable agriculture.
- Fourth, ensure the safeguard and defense of the environment.
- Fifth, spread and favor culture across the continent. and
- Sixth, finally, develop science and technology.

The implementation of NEPAD is expected to bring about economic growth and development, increased employment, a reduction in poverty and inequity, the diversification of productive activities, enhanced international competitiveness and increased exports, and finally an increased integration of the African continent[11]

4.7 Korea International Cooperation Agency (KOICA)

The Korea International Cooperation Agency (KOICA) was established in 1991 by the South Korean Ministry of Foreign Affairs and Trade as the amazing governmental organization for Official Development Assistance (ODA) to enhance the effectiveness of Korea's grant aid programs for developing countries by implementing the government's grant aid and technical cooperation programs[12].

4.7.1 Mission

The Korea International Cooperation Agency was founded as a government agency on April 1, 1991, to maximize the effectiveness of Korea's grant aid programs for developing countries by implementing the government's grant aid and technical cooperation programs. In the past, development cooperation efforts were focused mainly on meeting the Basic Human Needs (BHNs) of developing countries and on fostering their Human Resource Development (HRD). However, the focus has now broadened to promoting sustainable development, strengthening partnerships with developing partners, and enhancing the local ownership of beneficiaries. Additionally, global concerns such as the environment, poverty reduction, and gender mainstreaming, have gained significant importance in the international community.

Due to the continuously changing trends in development assistance efforts and practices, KOICA is striving to adapt to these changes by using its limited financial resources effectively in areas where Korea has a comparative advantage. In particular, Korea has the unique experience of developing from one of the poorest countries in the world to one of the most economically advanced, as recently demonstrated by Korea's entry into the OECD DAC (Development Assistance Committee) on November 25, 2009. The know-how and

[11] http://www.au.int/en/NEPAD

[12] http://www.koica.go.kr/

experience Korea gained from this transition are invaluable assets that allow KOICA to efficiently support the sustainable socio-economic development of its partner countries and to offer them hope for a better world.

4.7.2 Activities and Project

The project aid program, which supports the construction of schools, hospitals, vocational training centers, and other indispensable facilities, has become one of the leading programs of KOICA. Alongside such physical aspects, KOICA also offers training and expertise to comprehensively support the development of partner countries.

In selecting projects, KOICA places special attention on areas where Korea's expertise and experience can make important contributions. These areas include

- Education and vocational training,
- Health and medical care,
- Public administration,
- Agriculture and fisheries, and
- Information and communication technology (ICT).

To further expand the effectiveness of this program, KOICA plans to introduce a sector-wide approach and strengthen the monitoring and evaluation of the program.

4.7.3 Major Policy Directions

- Increasing the volume of ODA and the ration of grant aid.
- Implementing a result-based management system that meets the needs of partner countries.
- Implementing Korea's development experience and comparative advantages into develop cooperation projects.
- Encouraging the Civil Society Organizations and the private sector to join KOICA's projects.
- Maintaining the 'Selection and Focus' Principle.
- Expanding untied aid.
- Strengthening capacity for ODA implementation.

4.7.4 Training Programme

KOICA's training program supports the Human Resources Development (HRD) of partner countries and plays a critical role in narrowing the knowledge gap between developed and developing countries. This program aims to share important technical skills and knowledge as well as to build capacities for sustainable development. To meet this goal, KOICA invites technicians, researchers, and policy makers for training and education in Korea, and shares Korea's development experience and knowledge. The training program strives to help developing countries design their own effective development policies and use suitable technologies.

4.7.5 Civil Society Cooperation

KOICA's CSO program is designed to provide assistance for civil society organizations that conduct overseas development assistance activities with the objectives of reducing poverty and promoting welfare. This civil society-based cooperation program complements Official Development Assistance implemented at governmental-level projects, while KOICA also supports projects in regions where such projects are unlikely to take place on an intergovernmental level and projects with emphasized focus on on-site concerns, which include those aimed at improving living conditions (i.e. education, medical service, and income generation) of local residents in developing countries.

4.7.6 Multilateral Cooperation

Multilateral systems provide the best prospects for an inclusive process to set the "rules for international conduct" and a forum to promote values important to Korea, including democracy, human development and social justice. To promote aid effectiveness and harmonize with the international community, KOICA is continuing to strengthen its network with multilateral organization through contributions, joint programs, joint evaluation of projects, and joint training courses. By collaborating with multilateral organizations, so called 'multi-bi assistance', KOICA expects to diversify ODA delivery channels. Grant aid represents over 60% of multilateral assistance.

Table 4-1 Summary of the potential funders/sponsors

Name	Website/ contact	Headquarter
The Internet Society (ISOC)	http://www.internetsociety.org	Reston, Virginia, United States, (near Washington, D.C.)
U.S. Agency for International Development (USAID)	http://www.usaid.gov	Washington
Intel cooperation	http://www.intc.com/	Santa Clara, California
World Bank	http://www.worldbank.org/	Washington
African Development Bank	http://www.afdb.org	Tunis, Tunisia
New Partnership for Africa's Development (NEPAD)	http://www.nepad.org/	Lusaka, Zambia
(KOICA)	http://www.koica.go.kr/	Jongno District, Seoul

Chapter 5 Project Implementation

5.1 Cost Analysis

Here we will like to present the cost analysis of the project as it will be implemented. Since it is the same project that will be carried out in five (5) different rural areas, the same cost will apply for the five different areas. However, we shall present the cost of carrying out the e-government training in one rural area and later multiply this by the number of areas selected for the training. The various amounts allocated to the cost items here are tentative; they were given according to what is prevailing currently in the Nigeria market, just to have a rough estimate of the pilot project as well as the main project and are subject to change due to the dynamic nature of the market and the time of implementation.

Table 5-1 Unit items cost

Category	Description	Unit Amount	Unit Cost (USD)	Total
Labor				
	Project Manager	1	2000	2000
	Instructors	5	1500	7500
	Project team	3	3000	9000
Materials/Equipment				
	Laptop computers	30	500	15000
	Stationery (printing ink and papers)	2	250	500
	Prepare training hand-outs	25people	5×10days× 2	25000
	Software		10000	10000
	Standby generator	1	500	650
	Fuel for generator	200ltrs petrol	1	200
	Projector	5	900	4500
	Screen	5	200	1000
	Printer	5	200	1000
	Multitap adapter	31	10	31
Meetings				
	Venue	5 class rooms	313×10days	15650
	Tea Breaks (coffee & snacks)	31 people/ 10days	5×10days	1550

Category	Description	Unit Amount	Unit Cost (USD)	Total
	Meals (lunch)	31 people/ 10days	10×10days	3100
	Participant Remuneration	25 people	1000	25000
	Accommodation (instructors and manager)	6	80×10days	4800
	Accommodation (project team)	3	100×14days	4200
Local and Overseas Travel				
	Project Team Local travels across communities	3	500	1500
	Economic class (Return ticket) oversea travels	3	2500	7500
Communication and Internet				
	Internet Bundles (5GBMTN Fastlink internet modem)	30 people	95	2850
	Cellphone Credit project team	3	100	300
1St One Month Preparation				
	First month project team initial arrangements/preparations	3	2000	6000
	Meals Project team	3	10×30days	900
	Accommodation	3	100×30days	9000
Miscellaneous				
	For the entire pilot period	Project team	2000×3	6000
Subtotal (for the pilot survey)				$164731
Total for the Entire project (6 Month duration)		5	164731	$823655
10% Contingency				$823655.5
Gran Total				$906020.5

5.2 Project time line

The entire project time line shall be six (6) month for the entire duration. First we shall need one (1) month for the preparation of logistics, mobilization of the instructors/participants and participant's registration. The pilot project will take two (2) weeks duration and if it is successful, then we can go for the main 2nd phase of the project. The 2nd phase project is a replication of the pilot project in four (4) additional selected local areas and the time period for the preparation and the main training shall be one (1) month each.

5.3 Implementation Strategy

For the sake of implementation, the project will be carried out in phases. We intend to first of all carry out a pilot project in one (1) of the Rural Areas to access the feasibility of the project and then the project can be replicated in other selected areas. There are three options or strategies by which the project can be successfully implementation to suite the Nigerian context.

5.3.1 Implementation strategy one

Train the participants and allow them to go with the Laptops: this will allow the participants to use the laptops to re-train themselves and also train their pears within the community and as such, what they have learned will be remembered. But it will be more costly to the project team because they have to spend same amount in all the selected Rural Areas.

5.3.2 Implementation strategy two

Train the participants and collect back the Laptops: This will be cost effective to the side of the project team as they can use the same laptops to carry out the second phase of the project. They can use the laptops for the training of at the second selected Rural Area. But the participants are at disadvantage because they may not be able to retain what they have been thought and they cannot pass on the knowledge to others because they have no access to computer and the internet.

5.3.3 Implementation strategy three

Train the participants, collect the laptops and build a Telecentre after the training: A public place where people can access computers, the Internet, and other digital technologies that enable them to gather information, create, learn, and communicate with others while they develop essential digital skills. It will act as a community support to the Local community, participants can always go there to learn more, improve on their skills and can be of help to other pears. But it will be even more costly to the project team because they need to establish the basic infrastructure for the center.

5.4 First Stage Implementation

The first phase will be the pilot project that will be carried out in one (1) of the rural areas. In this case, we will like to carry out the pilot survey at New Karu Local Government Area in Nasarawa State. New karu is close in proximity to the Federal Capital Territory of Nigeria. It has an area of 2,640 km². Karu local government has its headquarters in New Karu town. According to the 2006 census, the population of mainly New Karu town was 205,477, It was originally built to house the capital's civil servants and lower income families, even though it is close in proximity to the Federal Capital Territory they still has no running water or good sanitation system and are still facing the challenge of bad road and lack of electricity.

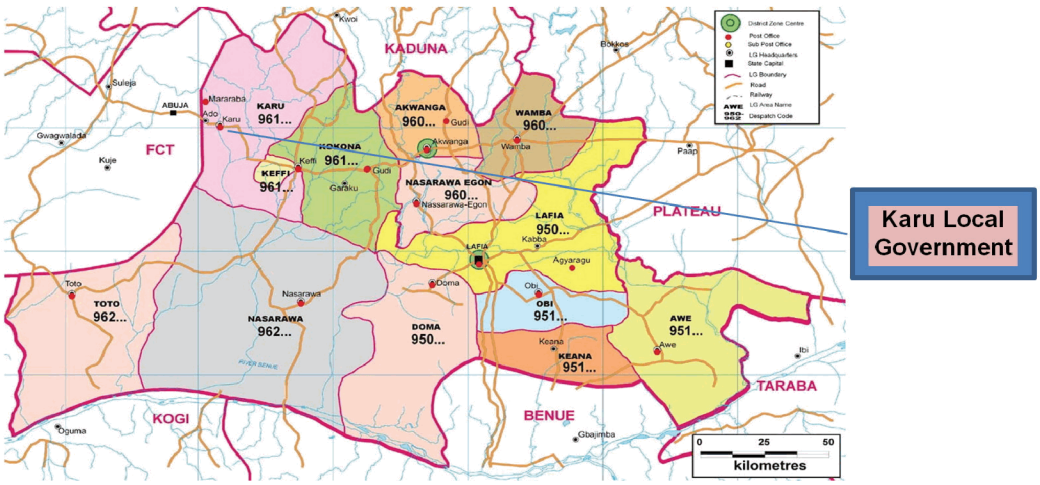

Figure 5-1 Map of Nasarawa State showing Karu Local Government

5.5 Second Stage Implementation

The second phase will be the main project that will be carried out in four (4) other rural areas as a replication of the pilot project depending on the success outcome. In this case, we will select the areas to be covered based on the geographical location of North-West, North-East, South-West and South-East areas in other to represent the entire population of the country. Accordingly, the main project shall be carried out in the following areas: For the North-Western Nigeria, we select Bakura Local Government Area in Zamfara State; for the South-Western Nigeria, we select Ifelodun Local Government Area in Osun State; for the South-Eastern

Nigeria, we select Uzo-Uwani Local government Area in Enugu State; and for North-Eastern Nigeria, we select Alkaleri Local Government Area in Bauchi State.

5.6 Implementation Issues and Challenges

The implementation of the project even though will be beneficial to the community cannot be without some challenges. The challenge of getting the participants to attend the program may be a task we have to look into. One of the major challenges that the participants will face after the training will be internet access; they may be reluctant to continue paying for their Internet subscription since they may not have immediate need of it. Also, is the challenge of electricity because, most of the Rural Areas are still face with electricity problem.

5.6.1 How to solve the problem

One way to solve these problems is through awareness, since the entire community has a certain level of loyalty to their village heads, we can use the village heads to create awareness within the local community and mobilize them for the program. Another way is to go through the Local Government Council Area and collaborate with them to assist in the mobilization and other logistics. Also incentives will be provided to each of the participants in for of Remuneration at the end of the training program.

Chapter 6 Conclusion

We developed an e-Government education and training program for the end users in five Rural Areas in Nigeria to prepare them for the adoption of the e-Government master plan presently been developed by the Korean International Cooperation Agency (KOICA) contracted to them on the 20th February, 2014. We develop a full curriculum that will be used for the training in a total period of six month. As for the implementation, this program has been designed to be carried out in two phases; a pilot project to be carried out in one Rural Area (Karu Local Government Area in Nasarawa State) and the main project that will follow the success of the pilot project in four additional selected Rural Areas.

We also presented some possible challenges that we may face on implementation of the project and suggested some ways that these challenges can be overcome. Also, we present an analysis of the rough estimate of the total cost of the project as at what is currently prevailing in the Nigerian market and a brief overview of some potential funders/sponsors. This training program will be highly important as a contribution to the community in terms of social benefits to the community and in strengthening the relationship between the two countries.

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Utilization of sulfur waste from sour gas and crude oil production in Turkmenistan

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Utilization of sulfur waste from sour gas and crude oil production in Turkmenistan

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ABSTRACT

Possessing huge hydrocarbon reserves, Turkmenistan is among major oil and natural gas producing countries.

Large quantities of by-product sulfur or so-called sulfur waste are being produced and released as a result of the removal of hydrogen sulfide from the oil and gas.

Lack of local markets and economic considerations limit the traditional outlets of by-product sulfur and the build-up of excess sulfur is becoming potential economic and environmental liability.

In this paper it is tried to look into the issue of utilizing waste sulfur. By the word "utilizing" we do not merely mean eco-friendly conservation, but also production of the value added goods from exploiting it.

Therefore, the aim is to learn about contemporary techniques of environment-friendly ways of waste sulfur conservation, to have an understanding of the up-to date technologies in this field, to find out the nomenclature of the potential value-added products that can be produced by utilization of hydrogen sulfide and potential markets (both domestic and foreign) for them.

To sum up, I believe that current research would contribute to the issues of the improvement of environmental protection and value-addition potential of the oil and gas sector of Turkmenistan.

Keywords: waste sulfur, hydrogen sulfide, utilization, value-added product, crude oil, sour gas

INTRODUCTION

In addition to water, oil, and NGL removal, one of the most important segments of gas processing involves the removal of sulfur and carbon dioxide. Natural gas from some wells contains significant amounts of sulfur and carbon dioxide. This natural gas, because of the rotten smell provided by its sulfur content, is commonly called "sour gas". Sour gas is undesirable because the sulfur compounds it contains can be extremely harmful, even lethal to breathe. Sour gas can also be extremely corrosive. In addition, the sulfur that exists in the natural gas stream can be extracted and marketed on its own.

Hydrogen sulfide (H_2S) is a smelly, corrosive, highly toxic gas. Besides its other bad habits, it also deactivates industrial catalysts. H_2S is commonly found in natural gas and is also made at oil refineries, especially if the crude oil contains considerable number of sulfur compounds.

Because H_2S is such an obnoxious substance, it is converted to non-toxic and useful elemental sulfur at most locations that produce it.

Sulfur exists in natural gas as hydrogen sulfide (H_2S), and the gas is usually considered sour if the hydrogen sulfide content exceeds 5.7 milligrams of H_2S per cubic meter of natural gas.[1] The process for removing hydrogen sulfide from sour gas is commonly referred to as 'sweetening' the gas.

Sulfur can be sold and used if reduced to its elemental form. Elemental sulfur is a bright yellow powder like material, and can often be seen in large piles near gas treatment plants. In order to recover elemental sulfur from the gas processing plant, the sulfur containing discharge from a gas sweetening process must be further treated. The process used to recover sulfur is known as the Claus process, and involves using thermal and catalytic reactions to extract the elemental sulfur from the hydrogen sulfide solution.

To sum up, there is a huge potential in terms of waste sulfur in the country, especially after the supergiant "Galkynysh" field has been put in operation. In case if conserved volumes of waste sulfur is processed and added value, such as manufacturing fertilizers and other products it will contribute to the improvement of environmental protection and increase productive capability of the sector. Therefore, my main research question will be the following: *How to*

[1] www.naturalgas.org/naturalgas/processing-ng/

utilize and add value to the waste sulfur obtained in the sour gas and crude oil production for the benefit of the sector and a country?

The main methodology for this research is assumed to be a case study.

The outline of the paper will be as follows:

1. Background and linkage to country strategy;
1.1 Situation analysis;
1.2 Chemical industry of Turkmenistan;
2. Sulfur and its utilization techniques in environmental friendly manner;
3. Learning about technologies and techniques for the value-added goods production from hydrogen sulfide;
4. Analyzing world, regional and domestic markets for the sulfur value-added products and their future prospects;
5. Conclusions and recommendations.

1. Background and Linkage to Country Strategy

1.1 Situation Analysis

The Constitution of Turkmenistan states a responsibility of the government to conserve the nature. Protection and rational use of natural resources is a fundamental principle of the state policy.

From the first days of independence of Turkmenistan the law-making process was directed on creation of a proper legislative system responding to the international standards in the ecology sphere. There have been adopted the following regulatory acts of Turkmenistan:

- Law on nature conservation (1991);
- Sanitary Code of Turkmenistan (2009);
- Law on state specially protected natural territories (1992);
- Law on mineral wealth (1992);
- Forestry Code of Turkmenistan (1993);
- Law on protection and sustainable use of flora (1993);

- Law on standardization and metrology (1993);
- Law on state environmental assessment (1995);
- Regulations on implementation of the state environmental impact assessment (1996);
- Law on hydrocarbon resources (2008);
- Law on protection of atmospheric air (1996);
- Regulations on State Commission of Turkmenistan on climate change issues (1997);
- Law on protection and sustainable use of fauna (1997);
- Law on prevention and liquidation of emergency (1998);
- Law on hunting and conduction of hunting (1998);
- Regulations on State Commission to ensure implementation of Turkmenistan's obligations under UN Environmental Conventions and Programs (1999);
- Water Code of Turkmenistan (2004);
- Decree to establish the State Commission on CDM (2009);

National Climate Change Strategy was adopted 15 June 2012 and has become an important step for the further encouraging of activity in the area of climate change, as well as a necessary condition for Turkmenistan's sustainable social and economic development. At the national level the Strategy proposes to establish National Clean Climate Fund.

As a party to the primary UN conventions on nature conservation aimed at protection the environment and preventing the ecological disasters of natural and anthropogenic character, Turkmenistan demonstrates interest and willingness to participate in decision making process on environmental global problems for present and future generation. A strong evidence of this is joining of Turkmenistan to the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol signed and ratified accordingly in 1995 and 1998 and others.

Majority of the energy resources in Turkmenistan are concentrated in the oil and gas sector. The most important of them is the natural gas with its reserves much greater than the other important hydrocarbon resource – oil. By the proven reserves country is the second after Russian Federation among CIS countries.

Extraction, preparation and transportation of natural gas in Turkmenistan are implemented by State Concerns "Turkmengas" and "Turkmenoil".

The operation of the oil and gas enterprises globally is inevitably accompanied with sulfur

release during production and processing.

Therefore, a problem of environmental friendly utilization of sulfur in order to diminish or even totally cope with its negative effects and instead use it in the way it can bring value to the economy is of the important issues.

Underlying principles of development of the oil and gas sector of Turkmenistan are incorporated in the National Program of the President of Turkmenistan "Strategy of economic, political and cultural development of Turkmenistan until 2020" and in the "Program of development of the oil and gas industry until 2030". According to these documents, priority measures on development of the natural gas sector of Turkmenistan are the accelerated development and putting into operation of oil and gas fields explored and prepared for development, large – scale application of new techniques and high technologies.

Turkmenistan gas extraction is planned to increase up to 250 billion cubic meters and oil to 110 million tons by 2030.[2]

Priority measures on the development of the oil and gas transportation infrastructure are the reconstruction of the operating oil and gas transportation system, expansion of oil and gas main pipelines for domestic as well as export supplies. Further importance will be given to increasing technological and economic efficiency of the production cycle as a whole: geological survey, exploration, development of oil and gas fields and transportation of hydrocarbons.

Turkmenistan is second largest dry natural gas producer in Eurasia, behind Russia. Public investment and the start of production at one of the world's largest natural gas fields (Galkynysh) even more boosted its economy in 2013.

According to BP's 2013 Statistical Review, total primary energy consumption in Turkmenistan was about 1.05 quadrillion Btu in 2013. Natural gas consumption accounted for approximately 76%, and consumption of petroleum products represented the remaining 24%.

Turkmenistan had 600 million barrels of proven crude oil reserves as of January 2014, according to *Oil and Gas Journal* (OGJ). In 2013, total oil production was around 260,000 barrels per day (bbl/d), of which 11% was from national gas plant liquids. Recent production growth has come from Dragon Oil's offshore Cheleken block and Eni's onshore Nebit Dag field.

Turkmenistan has two oil refineries, the Seidi and Turkmenbashi, with a total crude oil

[2] Oil and gas complex of Turkmenistan, www.oilgas.gov.tm

distillation capacity of 237,000 bbl/d. According to IHS Energy, the refineries typically operate at around 50% of capacity, with foreign oil companies exporting their share of crude oil. (EIA, 2013)

Table 1. Turkmenistan oil production and consumption 2001-2013[3]

Oil (million tons)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Production	8.0	9.0	10.0	9.6	9.5	9.2	9.8	10.3	10.4	10.4	10.7	11.0	11.4
Consumption	3.8	3.9	4.4	4.3	4.3	4.1	4.6	5.1	4.6	4.8	4.9	6.1	6.3

Table 2. Turkmenistan natural gas production and consumption 2001-2013[4]

Natural gas (bcm)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Production	46.4	48.4	53.5	52.8	57.0	60.4	65.4	66.1	36.4	42.4	59.5	62.3	62.3
Consumption	12.5	12.9	14.2	15.0	16.1	18.4	21.3	20.5	19.9	22.6	25.0	26.4	22.3

Table 3. Crude oil refining capacity in the Caspian region

Country	Number refineries in operation	Crude capacity (1,000 bbl/d)
Azerbaijan	2	399
Kazakhstan	3	345
Russia	40	5,500
Turkmenistan	2	237
Uzbekistan	3	224
Iran	9	1,451

Source: IHS Energy

1.2 Chemical Industry of Turkmenistan

Turkmenistan intends to develop a national chemical industry which will be strategically important for Turkmen national economy. Turkmenistan's chemical industry is one of the fastest growing sectors of the national economy, having enormous resource potential. A key

[3] BP Statistical Review of world energy, 2014
[4] BP Statistical Review of world energy, 2014

project in this field is the construction of a mining and processing complex for the production of potash in the Lebap province, which will become the largest one in Central Asia. The complex's capacity is planned to be 1-1.5 million tons per year. The project is being implemented by "Belgorkhimprom" JSC (Belarus).[5]

Turkmenistan is also working on the development of a large project envisaging the establishment of major gas, chemical, and petrochemical industries in the next ten years. Works on the utilization of associated petroleum gas and extraction of liquefied natural gas, synthetic fluids, and electricity are of great importance as well. Another important issue is the development of domestic gas processing industry for the production of ammonia, carbamide, and carbon build-up of production of liquefied natural gas, on which there is a steadily growing demand in the world market.

Turkmenistan has also started the construction of a new sulfuric acid production workshop with a capacity of 500,000 tons per year at a chemical plant in the city of Turkmenabat. A consortium of the Japanese Mitsui Engineering and Shipbuilding Co., Ltd and Turkish Rönesans Türkmen Insaat Sanaýi we Tijaret Anonim Sirketi are charged with the design and turnkey construction of this facility at the order of "Turkmenhimiya" State Concern. A certain part of the project is expected to be financed by a loan from the Japan Bank for International Cooperation (JBIC).[6]

Recently, the President of Turkmenistan during his working visit to Balkan province, took part in the official ceremony of laying the founding stone of a carbamide plant with the capacity of 1,155 million tons of chemical fertilizer per year in the town of Garabogaz. Providing highly efficient agricultural fertilizers is of great importance for enhancing productivity of crops that are crucial to ensure the country's abundance of food and development of fodder stock for animal husbandry and poultry. This plant will enable Turkmenistan to export its products to the world markets more efficiently.[7]

Strategy of development of the chemical industry for the last years is directed on the maximum use of own raw materials, demand satisfaction of other branches of economy, expansion of an export potential of branch, sustainable development of agriculture.

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[5] www.turkmenistan.ru

[6] www.turkmenistan.ru

[7] www.turkmenistan.ru

Special attention is given to expansion of mineral fertilizers manufacture in relation with high demand in domestic market for increase of efficiency of agricultural production.

Resource possibilities of the country allow production all kinds of mineral fertilizers in volumes completely providing internal needs of the country, and also considerably increase a branch export potential.

Simultaneously with the program of increasing the volume of nitric fertilizers, the State concern "Turkmenhimiya" works on development of release of potash fertilizers.

There are 13 deposits with showings of potassium salts located in territory of Turkmenistan. All of them are located on southeast of Turkmenistan. According to stocks of potassium ores estimation and on studying degree three deposits are mostly interesting for working out: Garlyk, Karabil and Tubegatan deposits. Total stocks of potassium ores of these deposits are preliminary estimated in 2,8 billion tons.[8]

As to phosphoric fertilizers operating capacities on their manufacture satisfy needs of domestic market in this kind of production. For the further increase in capacities of manufacture of phosphoric fertilizers works on development of stocks of local phosphorites are conducted. Now performed exploration work for variety of phosphorites, conducted work under confirmation of their stocks, developed the technology of their enrichment and processing.

Also during visit of the President of Turkmenistan to Japan are signed the Framework agreement with the company «Sojitz Corporation» on construction of factory on manufacture of caustic soda, chlorine, hydrochloric acid and sodium hypochlorite in Turkmenistan and the License agreement on delivery of technology with the company «Asahi Kasei Chemicals» («Japan). As raw materials on the given manufacture will be used a table salt manufactured by industrial complex "Guvlyduz".

Important part in mineral and raw-material base creation acts the gulf of Garabogazgol - the largest in the world deposit of sulphate of sodium and other useful minerals. This is the unique deposit in the world where in a usual environment proceeds a crystallization of various salts in industrial scale.

According to the Program of development of chemical branch of Turkmenistan at production association "Garabogazsulfat" is planned carrying out of modernization of facilities,

[8] www.summitdownloadportal.org

restoration of a raw-material base and complex development of a mineral and raw materials of a gulf of Garabogazgol. Mineral resources of a gulf are a perennial source of raw materials for manufacture of variety magnesian, sodium salts, compounds of bromine, boron and lithium.

Building of the new railway roads, connecting of Kazakhstan and Iran, and also building of a new gas pipeline along coast of Caspian Sea will even more improve an infrastructure of factory and its investment appeal.

Among the nonfuel minerals produced in Turkmenistan are bentonite, bischofite, bromine, epsomite, gypsum, iodine, kaolin, lime, quartz sands, salt, sodium sulfate, and sulfur. According to the Government, Turkmenistan has more than 160 deposits of solid minerals and significant resources of hydrominerals—in particular, iodine-bromine brines; surface brines of Kara-Bogaz-Gol Bay; and brines of oil, gas, and sulfur deposits (Ministerstvo Ekonomicheskogo Razvitiya Rossiyskoy Federatsii, 2012).

2. Sulfur and Its Utilizations Techniques in Environmental Friendly Manner

Let's start from broadly understanding what sulfur is and its characteristics.

Sulfur has been known and used since ancient times for several medicinal and industrial uses. In modern times, most sulfur is used to generate sulfuric acid, which is a component of a wide variety of industrial processes, particularly the production of fertilizers.

Because of this, sulfuric acid (and hence sulfur) consumption often has been regarded as a good indicator of a nation's industrial development.

In the past, sulfur was mined from surface occurrences in several geologic environments and was used in relatively small amounts. Over time, the uses of sulfur and sulfuric acid expanded, as did the need for larger quantities of these commodities. Sulfur is now mined from underground deposits; a much larger quantity, however, is recovered as a by-product from a number of industrial processes.

Sulfur resources are abundant and widespread, but prevailing prices and extraction technologies constrain the extent to which they can be classified as reserves. At present, sulfur

can be economically mined from very few deposits. Most of the sulfur that is currently produced comes from natural gas and petroleum deposits, making it difficult to formulate reliable reserve data.

Recovery of elemental sulfur from natural gas processing and petroleum refining first overtook sulfur mining as the dominant source in the United States in 1982, and its importance has increased steadily since that time. Recovered sulfur dominates the world markets. In 2003, mined sulfur was less than 3% of total elemental production worldwide.

Barker (1983) describes sulfur sources as follows:

- Combined sulfur—sulfur that occurs in nature combined with other elements, commonly referred to as sulfides and sulfates;
- Cupriferous pyrites—pyrite containing minor amounts of copper sulfides. The most common is chalcopyrite, a sulfide of copper and iron with the formula CuFeS2 or CumFenS(m+n).
- *Hydrogen sulfide (H2S)—a colorless, flammable, toxic gas that may occur in petroleum and natural gas*
- Involuntary sulfur—sulfur produced as a by-product in response to legislative or process mandates;
- Native sulfur—sulfur that occurs in elemental form in nature;
- Nonferrous metal sulfides—copper, lead, zinc, nickel, and molybdenum sulfides that are processed for their metal content;
- Organic sulfur—complex organic sulfur compounds that occur in petroleum, coal, oil shale, and tar sands;
- Pyrites—metallic-looking sulfide minerals of which iron pyrites (pyrite) is the most common, and includes marcasite, and pyrrhotite;
- Sulfate sulfur—sulfur combined as SO4 −2 as contained in anhydrite, gypsum, and many other minerals;
- Voluntary sulfur—elemental sulfur;

The type of sulfur concerning our interest is recovered sulfur, which is elemental sulfur produced as a by-product of natural gas processing, petroleum refining, water gas, and other fuel gases. Large quantities of sulfur are present in natural gas and petroleum as hydrogen sulfide and

organic compounds from which elemental sulfur is commonly recovered.

The principal sources of recovered sulfur are hydrogen sulfide in sour natural gas and organic sulfur compounds in crude oil. Recovery is mainly in the elemental form, although some is converted directly to sulfuric acid. Smaller quantities of sulfur are recovered from oil sands, oil shale, and coal, although oil sands are increasing in importance in Canada. The introduction of stricter environmental controls, combined with increased market demand for lighter petroleum products, a trend toward refining heavier, sourer crudes, and increased use of sour gases led to the availability of greater quantities of recovered sulfur, commonly at a substantially lower price than Frasch sulfur. Recovered sulfur producers usually incur additional transportation costs because many of the production facilities are far from major consumers, but their product is always price competitive. Because it is an involuntary by-product, the cost of production attributed to recovered sulfur is more a question of accounting practices. Sulfur in oil occurs as organic sulfur compounds such as mercaptans (thiols), alkyl and aryl sulfides and disulfides, thiophenes, and complex condensed aromatic heterocyclic sulfur compounds, which must be converted to hydrogen sulfide before the recovery of sulfur. Sulfur in natural gas is mainly in the form of hydrogen sulfide, which must be removed from the gas at the wellhead because of its toxicity, corrosiveness, and chemical activity. Hydrogen sulfide forms in high-temperature diagenetic settings (such as in deep oil and gas reservoirs) through the thermal maturation of crude oil and through thermochemical sulfate reduction. Thermochemical reduction of sulfate by hydrocarbons is probably responsible for the bulk of the hydrogen sulfide found in this setting (Machel 1992).

Elemental sulfur is also present in high-temperature hydrocarbon reservoirs as a result of oxidation of contained hydrogen sulfide by sulfate and other processes. The elemental sulfur generally occurs as disseminated droplets of liquid sulfur. Large quantities of sulfur also may be present as polysulfides or dissolved in the hydrocarbon fluids. Lowering of reservoir temperature and pressure (as in a well string) can result in exsolution of elemental sulfur and plugging of rock formations and production equipment. Ruckmick, Wimberly, and Edwards (1979) call such occurrences thermogenic.

Sulfur in crude oil is recovered during the refining process, and the amount of sulfur recovered depends on the sulfur content of the crude, the amount of crude processed, the

refining process, and the products. Refineries in the past were equipped to remove the sulfur only from the lighter refinery products, and much of the sulfur in the crude oil remained in the refinery emission gases or the residual fuel oils and was ultimately emitted to the atmosphere when these oils were burned. Environmental restrictions now limit the quantity of allowable emissions and severely reduced the sulfur content of most finished products from petroleum refineries. The amount of sulfur recovered is increasing because of the increasing use of heavier and sulfur-rich crudes and more recent requirements to recover most of the sulfur content of the crude oil.

The organic sulfur compounds in crude oil must be removed from the refinery feed and converted to hydrogen sulfide by a hydrogenation process before the sulfur can be recovered. The sulfur in natural gas is already present as hydrogen sulfide, separable from the hydrocarbon gases by a variety of processes (Hyne1982; Anon. 1987b, 1987c).

A process developed by C.F. Claus in Germany in 1883 converts hydrogen sulfide from both sources to elemental sulfur. Over the years, the Claus process has been improved and modified to fit a variety of situations, so that it has become known as the modified Claus process. The basic process is now used in hundreds of sulfur recovery units with different configurations throughout the world, collectively referred to simply as Claus plants. Anon. (1986c) gives an excellent overview of the Claus process in its various forms.

The process was based on the following reaction in which hydrogen sulfide is burned to yield elemental sulfur and water:

$$2H_2S + O_2 \rightarrow 2S + 2H_2O$$

Only under ideal conditions does this reaction happen exactly as described. Modern Claus reactors incorporate a two-step process that takes advantage of the following reactions:

$$2H_2S + 2O_2 \rightarrow SO_2 + S + 2H_2O$$
$$2H_2S + SO_2 \rightarrow 3S + 2H_2O$$

In the first step of the process, insufficient oxygen is present to convert all the H_2S to SO_2,

thus also causing elemental sulfur and water to be formed. In the second stage, the reaction product SO_2 from the first reactor mixes with additional H_2S, completing the formation of elemental sulfur and water, usually with the aid of a catalyst.

The sulfur condenses and is removed in molten form from the reaction vessel and stored until shipping or use onsite.

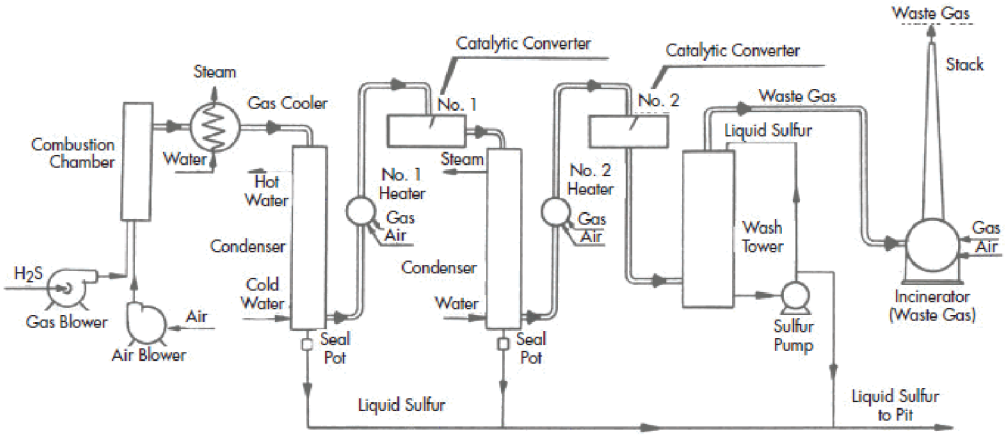

Figure 1. Simplified flowsheet, double-contact sulfuric acid plant[9]

Figure 1 shows the Claus process in a generalized flow sheet. The efficiency of the Claus process for sulfur recovery from gas streams containing H_2S depends on the concentration of the H_2S being treated. The modifications to the process have improved the recovery of sulfur, although not all the sulfur is recovered. Typical sulfur recovery efficiency at Claus plants is 90% to 96% for a two-stage reactor and 95% to 98% for a three-stage reactor. If the depleted process gas is within acceptable limits, it is then incinerated in the final stage of the Claus process to oxidize all the remaining sulfur compounds, and the remainder, or tail gas, is emitted into the atmosphere. Usually, however, the tail gas must undergo further processing to remove as much of the sulfur as technically possible to meet environmental requirements. In the United States, 99.9% recovery efficiency is required at sulfur recovery plants with a capacity of at least 20 tonnes per day (tpd). Amine-based tail gas treatment is the most common tail gas process in the United States, where sulfur compounds in the tail gas are converted to H2S, separated, and

[9] Source: Barker (1983)

recycled to a Claus plant. Other developed countries have similar requirements. Canada requires sulfur recovery of 98.5% at 50-tpd plants and 99% for 2,000-tpd operations. The European Union (EU) mandates 98.5% sulfur recovery. Germany, a member of the EU, has set higher standards of 99.8% for 20- to 50-tpd plants and 99.5% for those with larger than 50-tpd capacity. Japanese operations must recover 99.8% of sulfur; and Taiwan has the highest standard at 99.95% recovery.[10]

Table 4. Basic forms of sulfur

Lump	Advantages of lump sulfur include the easiness of preparation technology, consisting of the spill and the solidification of liquid sulfur on the tarmac and then cracking sulfur blocks up to 3 m, stacking and loading on trucks. The main drawback is the loss of up to 3% during excavating operations.
Granular	It consists of homogeneous particles with a diameter of 1 to 5 millimeters. The presence of particles smaller than this quantity of sulfur and dust is not allowed. Granulated sulfur is convenient for consumption and transportation, basically does not form dust during loading - unloading operations.
Liquid	Liquid sulfur benefits from increasing demand compared to other forms. This is particularly true for large consumers and relatively short transportation distances (800-1000 miles), when the cost of energy to maintain the sulfur in a molten state is lower compared to melting it in the final use destination.

Source: http://www.n-trading.ru/business/products/?id=9

Sulfur compounds are highly environment pollutants. The main source of pollution by sulfur compounds is the burning of coal and oil. SO2 accounts for 96% of sulfur emitted into the atmosphere, while the rest is H_2S, CS_2, COS, etc.

Currently, the production of sulfur outpaces consumption, and the trend is projected to be persistent at least until 2015 - 2020 years.

This is due to the production of associated (regenerative) of sulfur in the processing of ever-increasing amounts of sulfur-containing hydrocarbon feedstock (gas, oil) and a deeper cleaning of sulfur refined products, exhaust and flue gas by-product coke, metallurgical and

[10] www.segemar.gov.ar/bibliotecaintemin/LIBROSDIGITALES/.../068.pdf

energy industries, which is dictated by the tightening of the requirements for the protection of the environment.

Sulfur is a poor conductor of heat and electricity, as well as poorly soluble in water.

The sulfur in liquid form is primary with respect to the other forms. However, the costs associated with the storage, transportation, unloading, and also with the accumulation of static electricity during transportation, are quite high. At the same time, the purity of the product in the case of liquid sulfur much higher relative to other commodity forms.

Lump sulfur produced by filling and solidification of liquid sulfur followed by milling of formed blocks. Drawbacks related to cultivation and storage of lump sulfur is possible losses, air pollution and moisturization of product. The more convenient and safer way to store is granulation of sulfur, despite the fact that process of granulation (air, water or fluidized-bed granulation) is a costly affair.

3. Learning About Technologies and Techniques for the Value-Added Goods Production From the Hydrogen Sulfide

Natural gas containing hydrogen sulfide is passed through the absorbent, resulting in a concentrated hydrogen sulfide.

The next step is obtaining high purity elemental sulfur, which is then sent to consumers in liquid, granular or block form. For environmental reasons, the production of marketable lump sulfur in the coming years is expected to be ceased or minimized.

Approximately 90% of the sulfur produced globally are processed and then consumed in the form of sulfuric acid. Then nearly 65% of sulfuric acid is used for the production of phosphate and complex fertilizers. Another 11-12% is used in other areas of agriculture: the production of ammonium sulfate and other sulfur-containing fertilizers, pest control, and various chemicals. Remaining 23-24% is used for the needs of the mining industry (leaching of copper and other ores), chemical complex (manufacture of synthetic rubber and rubber products, dyes, synthetic fibers, and so on), the oil industry (preparation of drilling fluids in oil refining alkylation) and pulp paper industry (sulphite and sulphate pulping).[11]

The most promising application area of sulfur is the production of innovative building materials for the construction of industrial facilities, as well as road construction. This is primarily sulfur cement, sulfur concrete and its products, as well as sulfur asphalt concrete.

Sulfur added construction materials possess high strength characteristics, increased wear, corrosion and chemical resistance, low permeability, highly resistant to sudden temperature changes. Moreover they are cost-effective and environmental-friendly. These conclusions are based on the experience of the application of these materials, dating back to the 1970s in the US, Canada, France and Poland. Today sulfur concrete and sulfur cement widely used in Japan and South Korea. (www.gazpromsera.ru)

3.1 Sulfur Concrete

Sulfur concrete used in the construction of buildings and structures where strictest requirements in terms of resistance to aggressive environments, frost and weather and impermeability exist, such as industrial, agricultural objects and storage facilities for bulk and liquid materials.

The most promising areas for the application of sulfur concrete:

- Road surface elements (plates, paving tiles, face drafts, road barriers);
- Structures subject to saline aggression (floors, drain pans, foundations);
- Engineering structures (collector rings, sewers, treatment plants);
- Studies confirm the superior performance of designs based on sulfur concrete: Damped creep loading level to 0.5Rn;
- Temperature and shrinkage deformation - in the range (20-30) x10-ZMM/mm are observed only in the first day on cooling;
- Fits to the climatic conditions of Norilsk, Moscow, ***Ashgabat*** (Co - 0.7-0.85);
- Stable thermal engineering indicators, high thermal resistance in walls;
- High corrosion resistance when exposed to oils, acids and salt solutions, harsh climatic and atmospheric conditions;
- Ability of rapid solidification and gaining commercial form. Hardening of the mixture can occur at negative temperatures or under water as a result of cooling;

[11] www.gazpromsera.ru

- Sulfur concrete can be used for concreting in winter (up to -40 ° C) and under water (fresh and saline waters). (www.gazpromsera.ru)

Meanwhile, demand for basic production of sulfur stabilized, and in some areas tends to decrease due to the introduction of new technologies.

Sulfur concrete is a composite material, which includes a sulfur binder, inert fillers and excipients. Since the main difference from similar sulfur concrete based on Portland cement is the presence of sulfur binder, we should mention the properties of the sulfur. Sulfur is one of the most common non-metals in nature having the ability to form compounds with virtually all chemical elements. Sulfur and its compounds can occur in all states (solid, liquid and gaseous). From the standpoint of physical characteristics of the sulfur - a crystalline solid, stable in two modifications: orthorhombic (density 2.07 g/cc.) and monoclinic (density 1.97 g/cc.).

Sulfur concrete has been actively studied in North America in the 1970. Its advantages with respect to the traditional concrete based on Portland cement have been identified already at that time. Thus, it was found that in contrast to cement it has some special properties such as low water absorption, water and corrosion resistance, and fast accumulation of a high strength.

Positive and negative qualities of sulfur concrete are summarized in the Table 2.

Table 5. Assessing the quality of sulfur concrete

Positive properties	Negative properties
High strength	Low thermal resistance
Corrosion resistance	
Low water absorption	
Watertightness	
Frost-resistance	
Fast solidification	
Solidification in the cold weather	
Recyclability	
Low shrinkage	

Source: “Astrakhangazprom” LLC

In the table 6, we can see the comparative description of the main parameters of these types of concrete.

Table 6. Comparative characteristics and properties of sulfur and Portland cement concretes

Property name (test)	Sulfur concrete	Concrete
Moisture resistance	1,0	0,8
Chemical resistance (Acid)	84%	23%
Frost resistance (at 100% humidity)	300	50
Demolition,%	3%	17%
Compressive strength, Mpa	55-65	15-25
Flexural strength, Mpa	10-15	6-9
Tensile strength, Mpa	5-7	3-4
Solidification time, h.	0,3	24

Source: Journal of Ceramic Processing Research (http://jcpr.kbs-lab.co.kr/english/)

It should be noted that the properties of sulfur concrete to a greater extent depend on the process and quality control, and raw material input at all stages of production.

Sulfur concrete as a construction material is known since the 17th century.

In 1921, Bacon and Davis published a paper in which he described the properties of sulfur and its use in the manufacture of building materials. Active research sulfur binders began in the 1970s in North America and environment-friendliness of sulfur concrete was proven. The increase in hydrocarbon production in 1980-90s had led to an increase in sulfur production as a by-product of oil and gas and it paved the way for major oil and gas companies to search the methods of its utilization. It resulted in the emergence of are innovations regarding the production and use of concrete on the basis of sulfur binder.

Almost every major manufacturer possesses a patent on the technology of production. Over time, after expiration of patents the invention has become available for mass use.

Table 7. Major US patents related to sulfur concrete and its production process

Patent Number	Patent Title	Date published
4025352	"Production of sulfur concrete"	1977
4188230	"Sulfur concrete, solution and similar materials"	February 1980
4391869	"Modified sulfur cement"	July 1983
5004799	"Granular modified sulfur concrete"	1991

Source: collated by author on the basis of media revision

The technology of preparation of granulated sulfur concrete emerged in the United States. Its emergence was determined by the need of manufacturing concrete at any time and any place (due to the need to maintain a certain temperature of the solution its use was limited geographically and in terms of time). Technology for production of sulfur concrete granules requires placing ready mixture into the unit, where the concrete is exposed to the high pressure gas or water, which contributes to the formation of granules. For further use, in according with the patent, it is only necessary to heat the pellets up to the melting point 140-1500C. Commercial production of sulfur concrete (and products based on it) was first established by Canadian company StarCrete in 1975, which in an alliance with Sulfur Innovations Ltd has developed a technology for the production of concrete on the basis of the modified sulfur. According to this technology, molten sulfur and the modifier is mixed with pre-warmed aggregates and fillers, forming sulfur concrete mixture. At present, StarCrete products are widely used for the manufacture of corrosion-resistant structures for the protection and repair of concrete floor coatings in chemical and food industries, etc. (www.newchemistry.ru)

Figure 2 shows the generalized version of sulfur concrete production technology.

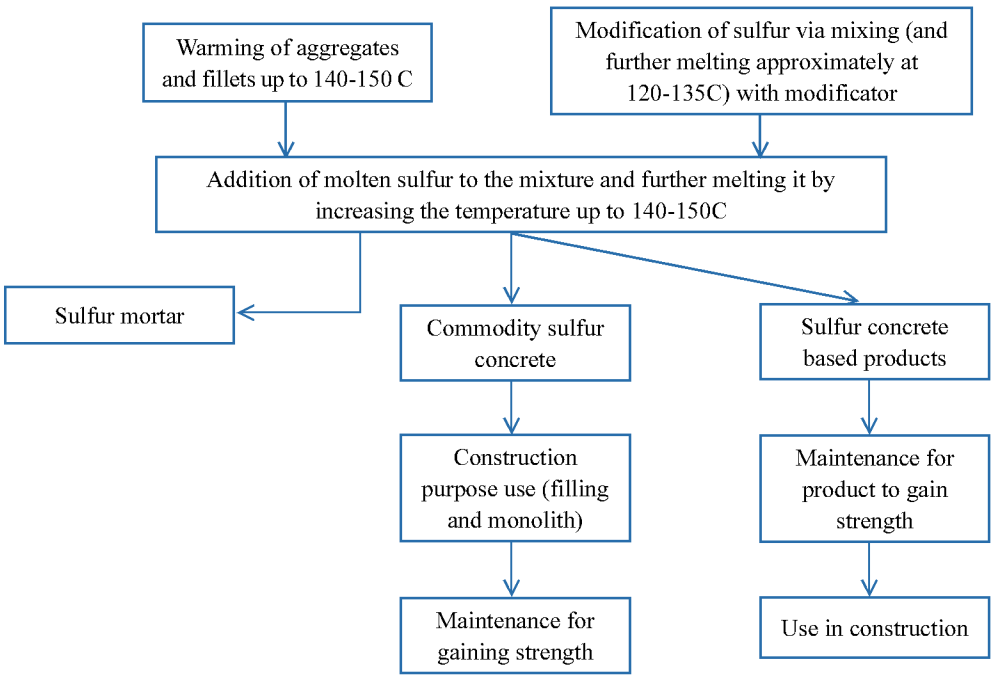

Figure 2. Generalized version of sulfur concrete production technology.[12]

The most significant difference between the production technology of sulfur concrete and cement analogue is abandoning the use of water in the manufacturing process.

Regarding the equipment necessary for the production of sulfur concrete is almost same with cement the only difference being the need to maintain a high temperature in the mixer.

"Astrakhangazprom" LLC in alliance with Ministry of construction of Russia developed technology to produce sulfur cement and concrete. Heavy oil residue and sulfur in a ratio of 5/95 are exposed to the electromagnetic field.

Technical sulfur, sulfur-containing waste is may be used for the sulfur cement production. Dense rocks, artificial and natural porous materials, production waste (crushing of screenings and sedimentary rocks) are used as inert fillers and excipients.

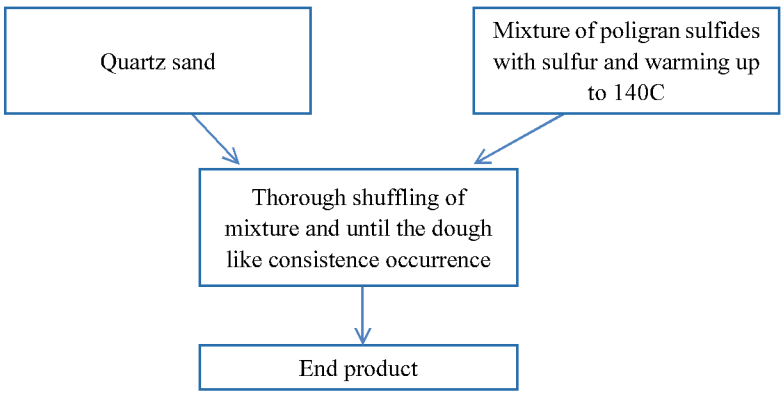

Figure 3. Technology of production of sulfur concrete developed in innovation center "Chemical Technologies and Equipment" (Bashkortostan, Russia)

3.2 Sulfur Asphalt

Sulfur asphalt - an innovative pavement with a three percent sulfur content of the binder.

Sulfur asphalt differs with zero moisture permeability, high wear resistance and low susceptibility to erosion even in chemically aggressive environments. When producing relatively cheap sulfur asphalt, sulfur modifier replaces 50% of expensive bitumen, which not only reduces end product price, but also improves physical properties of the asphalt pavement.

Sulfur additives into the asphalt mix, improve compaction of mixture, and allow reducing the thickness of the pavement, to slow down the aging process of the pavement, improve the

[12] www.newchemistry.ru

quality of road construction and repair work. Sulfur asphalt can be stack at any time of year and the weather.

This wide range of commodity forms reflects the different origins of sulfur (natural, associated, etc).

Sulfur asphalt is an asphalt mixture based on sulfur bitumen. Sulfur bitumen - a binder, in where up to 40% of the bitumen is replaced by sulfur.

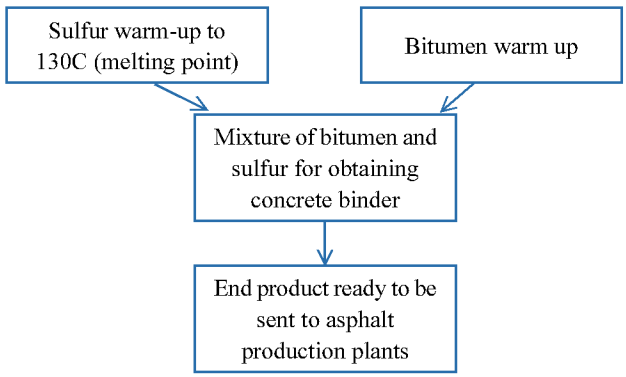

Figure 4. Schematic diagram of the sulfur asphalt production.[13]

Table 8. A complete list of sulfur based products and applications

Blocking agents (medicine);	Cellophane;	Pulp and paper industry;
Fertilizers;	Plastics based on cellulose nitrate;	Photography;
Foods;	Viscose;	Plate glass;
Binder for construction;	Galvanized;	Resins;
Film;	The skin;	Petroleum products;
Asphalt;	Fire-fighting;	Detergents;
Pigments;	Explosives;	Soap;
Fungicides;	Food preservatives;	Soda;
Insecticides;	Matches;	Steel;
Water treatment;	Tires;	Rechargeable batteries;
Solvents;	Paints;	Textiles;
Medicines;	Plastics;	Synthetic fiber;
Clay;	Mechanical rubber goods;	

[13] Source : Academy of Industrial Market conjectures (Академия Конъюнктуры Промышленных Рынков)

More than 90% of the world's sulfur is converted into sulfuric acid. Thus, more than 56% of the world consumption of sulfuric acid is used in the production of phosphoric acid and phosphate fertilizers. About 10% of the world consumption of sulfuric acid and sulfur is used in manufacture of various agrochemicals (insecticides, fungicides, herbicides, feed), and 11% is claimed in the manufacture of a wide range of chemicals, and 3% in the industry of plastics and rubber products, and 2% in the pulp and paper industry 6% in oil refining, 2% in the production of pigments and 7% in the mining industry for the leaching of ores.

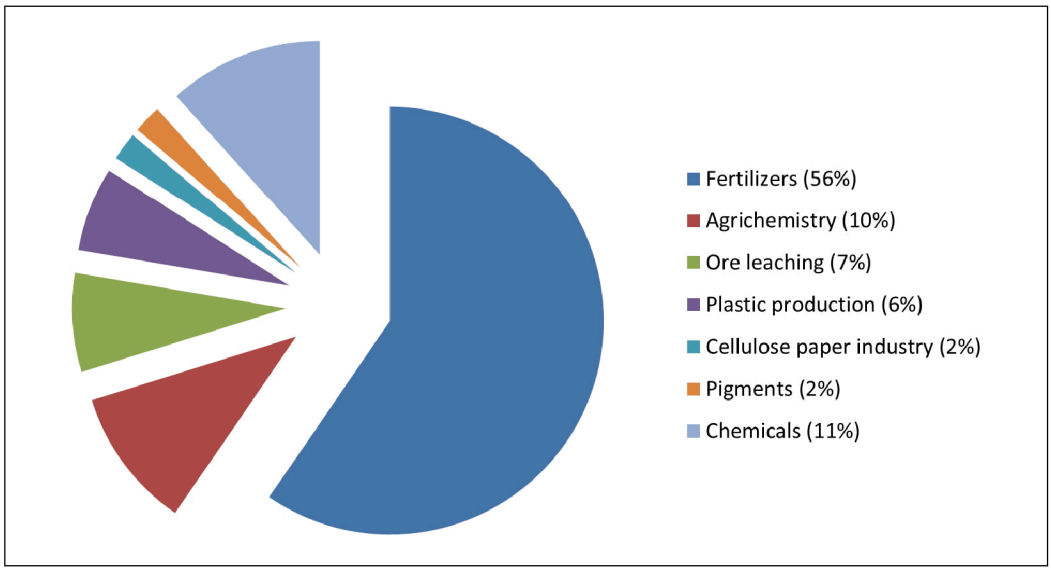

Figure 5. Share of global sulfur consumption by industries.[14]

Seasonality of demand for phosphate fertilizers leads to the need to store large amounts of sulfur during periods of low demand.

At the first glance the most attractive segments for consumer sulfur can seem phosphate fertilizers and agricultural chemistry.

Phosphate fertilizers produced from phosphoric acid which, in turn, prepared from phosphate rock and sulfuric acid. Production of phosphoric acid, followed by the production of phosphate fertilizers is the most large-capacity segment of sulfuric acid consumption. A more detailed examination of the segments of production of phosphoric acid and phosphate fertilizers

[14] Source: ICIS Pentasul

we can identify factors that make them less attractive for oil and gas companies. Viability of phosphoric acid production fertilizers is dependent on availability of company's own sources of raw material - phosphate rock. Oil and gas companies do not have access to such sources, which makes this segment is not attractive in terms of new production. Therefore, currently oil and gas companies sell sulfur to producers of phosphoric acid and fertilizers. During the periods of sharp rise in demand for phosphate fertilizers and sulfur it becomes much more profitable for the oil and gas companies selling it, rather than processing into other products. For instance, in 2007-08 world prices for sulfur increased from 60-90 USD to 450-600 USD per ton.[15] Those producers possessing large sulfur reserves in storage were in advantageous position. Availability of storage and sulfur in them allows producers to wait for more favorable market situation and sell sulfur during periods of high demand. With significantly excessive sulfur supply prices are kept at a low level and in this case the absence of storage tanks forces the manufacturer to process it into other products with high demand. An alternative to construction of sulfur storages is involvement of phosphoric acid or phosphate fertilizer producer in the business, which allows guarantee the sale of certain amount of sulfur.

In addition to well-established segments of consumption of sulfur, there are emerging other large areas:

- Sulfur-bitumen binder for asphalt mixtures;
- Asphalt concrete mix on sulfur-bitumen binder;
- Binder for concrete mixtures;
- Concrete sulfuric binder (sulfur concrete);

According to the US Geological Survey in 2009, the volume of world cement production amounted to 2.8 billion tons, consumption of bitumen for road construction around 100 million tons. Currently, these segments can only be considered as potential competitors in the construction of sulfur binder, as a market for the latter is in its early infancy.

In the long run, one of the factors driving the demand for sulfur in construction may be an increase in energy prices. High energy intensity of cement clinker production process determines the high energy costs in its overall cost.

When considering these segments from the perspective of sulfur processing oil and gas

[15] www.newchemistry.ru

companies should resort to the experience of Shell- the largest supplier of sulfur in Canada. Shell has developed several solutions based on sulfur, including Shell Thiocrete and Shell Thiopave. Shell Thiocrete is a sulfur-based binder. Raw material supplied in the form of liquids or granules. The company stresses the fact that the material contains less carbon, which makes Shell Thiocrete more environmentally friendly compared Portland cement. To date, the use of sulfur binder in road construction is experimental. Shell developed and patented a unique product - granulated sulfur binder under the brand name Shell Thiopave. Unlike the sulfur melt, Shell Thiopave introduced into asphalt mix in the dry state, thereby reducing the emission of sulfur vapor and to avoid eye damage. The additive improves process by allowing the mixture at lower temperatures than the production of conventional asphalt mixture. The solid form of Shell Thiopave simplifies material turnover. (www.newchemistry.ru)

Figure 6. Shell Thiopave granules

Another segment of consumption of sulfur and sulfuric acid - agrochemicals. According to various estimates the global market of plant protection products is has risen from 2.8 to 3.4 million tons. Oil and gas companies are not engaged in recycling of sulfur through the production of agricultural chemicals. However, oil and gas companies offer various brands of sulfur producers RTI, agrochemical, and pharmaceutical enterprises. Also worth mentioning is the commodity market of sulfuric acid. The main products in the commodity market of sulfuric

acid are produced in non-ferrous metallurgy and refining of waste gases. The main supplier of technology for the production of sulfuric acid from sulfur-containing raw materials is the company Haldor Topsoe. (www.newchemistry.ru)

Table 9. Application of sulfur concrete in developed countries in Europe, North America and South-East Asia

Scope of Use	Advantages with respect to the sulfur concrete cement analog
Precast concrete (foundation slabs, curbs, slabs for flooring and roads, prefabricated for sewerage and port facilities and tramway sleepers, transmission line poles, etc.).	High strength, which provides finished products sulfur concrete, short-term set of grade strength and recyclability.
Disposal of waste (number of acids, salts, heavy metals and radioactive waste with low levels of radioactivity).	Low sulfur concrete porosity prevents polluting wastes to penetrate into the environment.
Paving (airports, roads in areas with low temperatures), concrete floor (chemical plants, food production).	Highly resistant to acids, salts and other chemical elements and compounds, as well as resistance to abrasion and corrosion.

Source: Websites of foreign manufacturers and suppliers of sulfur

If divided all building construction, which is used in the manufacture (or use) for sulfur concrete prefabricated and monolithic, the list of areas you use this building material is as follows.

Table 10. The use of sulfur concrete in monolithic and prefabricated construction

Prefabricated elements	Monolith
Foundation blocks, traveling (especially airfield plates) and tramway sleepers, sewer pipes, curbs, electric poles, paving and wall tiles, gutters, etc.	Ground floor on the chemical (including the production of mineral fertilizers) and food production, disposal of hazardous waste (salts, acids, nuclear waste), sewers, port construction, bridges, tunnels, oil rigs, etc.

Source: Websites manufacturers and suppliers of sulfur

Table 11. Test Interactions sulfur concrete with chemical compounds

Substance	The presence of interaction with sulfur concrete
The copper salt of sulfuric acid	None
Magnesium chloride	None
Muriatic acid	None
Nitric acid	None
The zinc salt of sulfuric acid	None
Citric acid	None
Nickel sulfate	None
A mixture of nitric acid and citric	None
Boric acid	None
Citric acid	None
Wastewater	None
Hydrofluoric acid	None

Source: «Sulfur Polymer Cement Concrete» Idaho National Engineering Laboratory

Figure 7. The result of the impact of 10% hydrochloric acid on concrete (sulfur - left, cement - right)

The most active consumers of sulfur concrete in the US are chemical plants (production of acids, salts and fertilizers), steel mills, agricultural products processing factories and food enterprises. They use sulfur binder based concrete mainly to fill the floors. In this case, the feature that gives it the advantage is the sulfur concrete corrosion and chemical resistance. High

strength and abrasion resistance are also important regarding one of the promising field for sulfur concrete - paving (usually in the form of plates), subject to high loads (this is particularly true for airports and roads in areas with difficult climatic conditions). Today the largest producers of sulfur concrete in the world today are the companies Shempruf Concrete (USA) and Starcreat (Canada).

Table. 12 shows comparative performance data marks Shempruf sulfur concrete Concrete STARcrete ^{TM} and relative to Portland cement.

Table 12. Comparative characteristics of sulfur concrete, manufactured by leading companies throughout North America and Portland cement.

Characteristics	STARcrete^{TM}	Chempruf Concrete	Portland cement
Compressive strength	62 Mpa	41,4-69 MPa	25-30 MPa
Tensile strength	7,4 MPa	6-10 MPa	3-4 MPa
Density	2400 kg. / m^3	2300-2500 kg. / m^3	2400 kg. / m^3
The percentage of water content	0,1-0,2%	0,1%	6%
Thermal conductivity	0,4 W / (m * C0)	0,2-0,5 W / (m * C0)	0,8-1 W / (m * C0)

Source: data from the manufacturer's websites (www.chemprufconcrete.com, www.starcrete.com)

4. Analyzing World, Regional and Domestic Markets for the Sulfur Value-Added Products and Their Future Prospects

Sulfuric industry has traditionally been one of the branches of large-scale mining industry. Sulfur production has shifted from countries with mineral resources, to countries processors. The main part of sulfur was released as a byproduct of gas (France, Canada) and oil (USA, Germany), and non-ferrous metals (UK, US, Germany). Sulfuric industry consists of a chain of production: sulfur-containing raw materials - elemental sulfur - sulfuric acid. The economic efficiency of sulfur on the basis of different raw materials is variable and depends largely on the type and quality of raw materials. With a negative impact on the environment sulfur compounds occupy one of the first places among the pollutants. Their formation and release into the atmosphere, mainly from burning coal and oil. Thus 96% of sulfur released to the atmosphere in the form of SO_2, the rest is accounted for by the number of sulfate, H_2S, CS_2, COS and other

compounds. Elemental sulfur adversely affects the human health as a dust irritating the respiratory mucosa and cause eczema. Sulfuric industry relies on advanced and diversified resource base. Sulfur-containing raw materials are oil, natural gas, sulfur ore, coal, tar sands, sulphide ores of non-ferrous metals, pyrite, and so on. Production of sulfur based on several types of raw materials, competition between them has escalated in recent years. The most important are the following types of materials: - natural gas. Largest reserves of gas sulfur have Russia, Canada, Saudi Arabia, Iran, Iraq, UAE, Kazakhstan; - Largest reserves of sulfur in the oil allocated Saudi Arabia, Iraq, Kuwait, UAE, Iran, Iraq, Mexico, Venezuela, Russia. (http://ukrchem.dp.ua)

Table 13. Assessment of recoverable world reserves of sulfur-containing raw materials

	brimstone	pyrites	Oil	Gas	Sulphide ores	other	Total, mln. tons
Total	+	+	+	+	+	+	20000
Canada	-	+	+	+	+	+	8000
Venezuela	-	-	+	+	-	+	4000
Russia	+	+	+	+	+		2000
Saudi Arabia	-	+	+	+	-	+	1000
United States	+	+	+	+	+	+	600
Iraq	+	-	+	+	-	-	600
China	+	+	-	-	+	+	500
Chile	+		-	-	+		350
Poland	+	+	-	-		+	300
Spain	+	+	-	-	+	+	300
Iran	+	+	+	+	-	-	250
Kuwait	-	-	+	+	-	-	200
Kazakhstan	-	-	+	+	+	-	200
Mexico	+	-	+	+	+	-	170
UAE	-	-	+	+			150
South Africa	-	+	-	-	+	+	100
Japan	+	+	-	-	+	-	70
France	+		+	-	-	-	20

Source: “Mineral Commodity Summaries”.

Three fourth of the global sulfur total reserves is concentrated in Canada, Venezuela, Russia, Saudi Arabia. In general, the global sulfuric industry can be divided into 2 sectors on the forms of sulfur production: specialized and "side". Specialized sector focuses exclusively on the extraction of sulfur from pyrite deposits. Most of the native sulfur ores are concentrated in Iraq (about 335 million tons), United States (200 million tons), Chile (100 million tons) and Mexico (100 million tons). Large deposits of sulfur ores are known in Poland, Ukraine, Russia (Samara Region - Vodinskoe, Kamennodolskoe, Kamchatka - Maletoyvayamskoe), Turkmenistan (Magdanly). In Japan, there are significant reserves of sulfur of volcanic origin. The main producing countries are the United States, Mexico and Iraq. (http://ukrchem.dp.ua)

Table 14. The sulfur content in selected oilfields

Oilfield	Location	Reserves (mln.tons)
Abkayk	Saudi Arabia	34
Kirkuk	Iraq	50
Bolivar	Venezuela	103
Big Burgan	Kuwait	161
Saffaniya	Saudi Arabia	83

Source: http://ukrchem.dp.ua

Production of sulfur from oil, until recently, was concentrated in the US, Japan and Western Europe. However, their share in recent years is rapidly decreasing due to the increase of sulfur production from this raw material in the Middle East (Kuwait, Saudi Arabia), Latin America (Mexico, Venezuela) and in Asia (China, India, the Republic of Korea, Taiwan). Another important source of sulfur - natural gas. World proven reserves of natural gas contain 3-3.5 billion tons of sulfur. The main natural gas fields with a high content of hydrogen sulfide are in Russia, Canada, Mexico, the US, Kazakhstan, Uzbekistan, France, Iran. In the middle of the first decade of the XXI century, major sources of sulfur are oil and natural gas (amounting to about 60%). Production of gaseous sulfur was higher than oil, but the latter showed the best growth dynamics of production. Qualitative structure of sulfur production is gradually changing: the primary production of natural sulfur is reduced and almost all sulfur is now produced as a byproduct of oil and gas processing, non-ferrous metallurgy, production of sulfur

from pyrite is negligible (7%) and remained mainly in China. Currently, the vast majority of all forms of sulfur produced as a byproduct. In particular, about 98% elemental sulfur is produced at refineries and gas in the purification of hydrocarbons. In the late '90s - the first half of the 2000s, production of sulfur in the world were quite stable at 56-58 million tons (1997 - 56,940,000. 2000 - 58.1 million tons.). In 2000-2008, according to the US Geological Survey, the growth of the global sulfur production was 17.4%, in 2008 it increased by 1%, and in 2009 - was reduced as a result of the crisis to 2.4%. The volume of world production of sulfur-containing products (sulfur, sulfuric acid and pyrite) in 2012 amounted to 85.4 million tons, of which the share of elemental sulfur accounted for more than 50 million. The main importers of sulfur today are China (32%), North and South Africa (24%), the US (10%), South America (7%) and India (6%). Leading exporter of sulfur is Canada, followed by Russia, Saudi Arabia, UAE, Germany, Iran, Japan and Poland. (http://ukrchem.dp.ua)

Table 15. Global production of sulfur in all forms (thousand tons)

	2006	2007	2008	20011	2012
Total (rounded figures)	65700	68400	69000	80000	85400

Source: Proceedings of the US Geological Survey.

Geography of sulfuric industry over the years has remained relatively stable. Sulfur in some regions increased due to the opening and development of natural sulfur deposits, in others - through the development of its associated technologies of extraction. The values of the various sources of sulfur have changed significantly. Tightening in the developed world environmental standards enhances interest in recovering sulfur from oil, with desulfurization equipment installation is carried out not only in developed countries but also in developing countries. The rapid development of ferrous and nonferrous metallurgy contributes to the production of sulfur from flue gases.

Top 25 countries account for over 92% of its global production. Among individual countries leaders traditionally been the United States, Canada (10 million tons of sulfur each), Russia and China (production by 6.0-8.5 mln tons / year), Japan (3.5 million. Tons), Saudi Arabia (more than 2.3 million. tons), Kazakhstan, Mexico, Poland, the United Arab Emirates (at 1.5 million.

tons), Germany, France, South Korea, Chile, Iran (more than 1 million. tons). In the last decade, sulfur production was shifted to countries that do not have their own mineral resources. An important feature of the modern world sulfuric industry is a low attachment to the place of extraction of raw materials. Therefore, many industrialized countries that are major producers, serve both large importers. In 2001-2005 about 30% of sulfur was produced from imported raw materials, and this figure is growing steadily. Structure of the world production of sulfur in the last 10 years has changed somewhat. For example, the US share decreased from 15.7% in 2004 to 12.8% in 2011, Canada - from 13.8% to 10.3%. Gradually increasing the proportion of China (from 10.3% in 2004 to 13.9% in 2011), which in 2011, according to some industry sources, the first time was the leader for the production of sulfur, and Saudi Arabia (the release of an elementary sulfur - from 3.5% to 4.8%). (http://ukrchem.dp.ua)

Table 16. Geographical structure of world production of sulfur in all forms,%

Continent	2011	2012
North America	37,2	27,8
Asia	29,2	30,0
Europe	13,6	11,0
CIS	13,7	14,8
South America	3,5	6,1
Africa	1,6	7,2
Australia and Oceania	1,2	1,4

Source: http://ukrchem.dp.ua

In the last decade due to the growth of energy consumption in the world there was a need to develop new oil and gas fields, including those with high sulfur content. Increasing volumes of production of sulfur-containing hydrocarbon feedstock (gas, oil) and a deep cleaning of sulfur refined products, exhaust and flue gas by-product coke, metallurgical and energy industries lead to the accumulation of world reserves of elemental sulfur. Major World stocks sulfur concentrated mainly in Canada, the USA, France, Kazakhstan, Iraq and Iran. The volume of unclaimed sulfur in some years, according to the US Geological Survey reaches 20-21 million tons.

At a chemical plant in the city of Turkmenabat in Lebap region of Turkmenistan started construction of a new plant for sulfuric acid production capacity of 500 thousand tons per year, wrote on Monday, the newspaper "Neutral Turkmenistan". Turkmenabat chemical plant - a single complex for the production of phosphate fertilizers and sulfuric acid. Its main products - ammonium superphosphate. Plant to date - the only production base for this valuable fertilizer, highly demanded in agriculture of Turkmenistan.

The main raw materials for the production of phosphate fertilizers used sulfuric acid, synthetic ammonia and phosphate rock.

It is believed that in the next five years will remain the main producers of oil and gas producing countries in the Middle East, CIS, East Asia and North America. In Russia, Kazakhstan and Turkmenistan, as well as in the Middle East sulfur production volumes will grow as mining (speech, in particular, the implementation of projects growth at existing fields and development of new resources, rich in sulfur content). The main consumers of sulfur will remain the United States, China, Russia, Morocco, Tunisia, India, China and Brazil.

As we can observe from the Figure 8 until the 2019 sulfur recovery from the oil and gas production will reach more than 2 million tons. This volume can have a dangerous impact on the environment, therefore should be approached with caution either by conserving it in an environment friendly way of adding value to it in the form of sulfur extended products and selling in the domestic as well as regional or international markets.

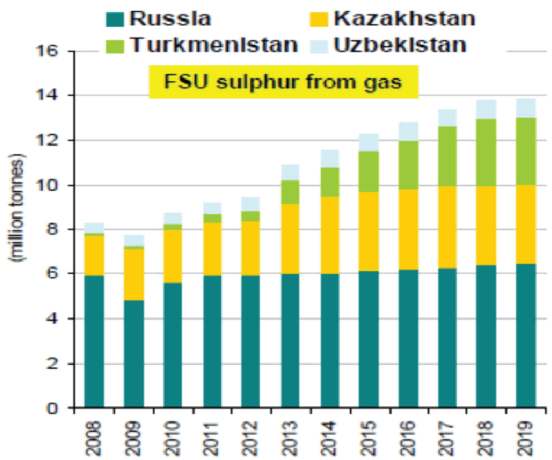

Figure 8. Gas-Recovered Sulfur Production[16]

The import side, the biggest importing countries is China, in 2012 imports amounted to 10 million tons. Furthermore, Brazil as a new type of sulfur and sulfur resources in the consumer market, fertilizer production increased significantly, so the future of Brazil's sulfur imports will also grow. For the future sulfur market, in 2013 the overall market oversupply of sulfur, the main importing countries of Morocco, China's demand will affect the entire international market trend. 2013 global sulfur supply remained stable, but the decline in demand led to market in the doldrums. Long-term, global sulfur production capacity is increasing, such as Russian, Turkmen gas projects will contribute to these areas and supply of sulfur will be greater than the growth rate of demand growth rate.

Now the global sulfur market is very calm, turnover is not busy. Sulfur market demand in downturn and prices continue to fall. At present, China Port Sulfur stocks nearly 2.5 million tons, short-term import demand will decrease. China's sulfur price has dropped 900 yuan / ton, or 125 U.S. dollars / ton, the international sulfur market have a huge impact.[17] Equally noteworthy is that India imports is still relatively low, traders postpone getting goods to fight international suppliers of cheap. Seen in this light, it is expected the next few months sulfur prices will decline, but long term, because the presence of rigid demand, next year will gradually return to international sulfur prices reasonable level.

Sulfur is a byproduct of oil and other commodities, thus influencing their price movements mainly to changes in demand. First, the global sulfur market, used for the production of industrial sulfuric acid sulfur accounted for 45%, of which the production of fertilizers accounted for more than 60%. Sulfur prices, demand changes directly affect the changes in global fertilizer demand, but also by the impact of phosphate fertilizer demand, therefore, sulfur and phosphate fertilizer production to maintain a high degree of correlation. Secondly, China as the world's largest importer of sulfur, which imports and import prices on the global sulfur market, has played an important role. While China imports 74% of sulfur for the production of phosphate fertilizers its imported sulfur showed an increasing trend in the number, which is the domestic fertilizer production capacity expansion, strong global demand for fertilizer.

[16] Source: IFA, 2011;BSC, April, 2010

[17] www.crugroup.com/

5. Conclusion and Recommendations

Sulfur is both a by-product and an important commodity on the world market; hence, it must be managed rather than treated as a waste product. Potential adverse effects associated with sulfur management can be mitigated through a combination of industry best practices and regulatory requirements applied on a facility-specific basis.

Potential issues associated with sulfur management include groundwater and surface water contamination, soil acidification, emergency incidences, odours, aesthetics, and dusting.

The following recommendations can be given in terms of environmental protection aspect of the issue:

1. Increase knowledge and understanding regarding concerns and impacts (positive and negative) associated with the storage and handling of elemental sulfur: development of a monitoring and reporting program for environmental outcomes such as selection of indicators for air, water, and soil (e.g., sulphate and pH) and identification of science based objectives. Development of a program to consult with local residents and other stakeholders on sulfur management;
2. Require facility operators to pursue elemental sulfur management measures that reduce or avoid the need for long-term elemental sulfur storage: Development of guidelines for regulatory applications related to solid sulfur storage such as description of storage required including form, amount, location, and duration, rationale for storage requirements and alternatives explored. Development of associated evaluation tools for regulators to use when reviewing sulfur handling and storage applications;
3. Manage the handling and storage of elemental sulfur to reduce the potential for adverse effects.

The most environmentally friendly form of recovered sulfur conservation is in granulated form. Nevertheless, it is of the most costly options.

As we have seen in previous chapters, recovered sulfur can be utilized in wide variety of spheres of the economy of a country. In the case of Turkmenistan in my opinion 3 potential areas for the usage of sulfur is first of all to produce phosphate fertilizers, which are of high demand within the country, as a result of considerable portion of population is employed in agricultural sector, where wheat and cotton production is prevailing. Therefore, a part of the by-product

sulfur can be converted into sulfuric acid in the Turkmenabat chemical plant which is expected to have 500,000 ton annual sulfuric acid production shop soon after the reconstruction will be held.

Owing to the fact that, presently construction is booming in Turkmenistan, sulfur concrete is going to be of high demand as well. In this context on of the technologies of the companies has been presented can be utilized in the territory of Turkmenistan.

Finally, road construction is on the rise in Turkmenistan as well. Sulfur –extended asphalt technology can be used to produce more efficient and less costly asphalt with addition of sulfur binder.

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Energy Security Evaluation In South East Asian Countries

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Energy Security Evaluation In South East Asian Countries

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I. Background

Energy security has been grown as one of the important goals of energy policy of many countries in recent years. Concerns about energy security first arose in the early 1970s in Europe, Japan and the United States, when the first oil crises revealed the vulnerability of developed economies to oil price shocks which then leads to the creation of the International Energy Agency (IEA) within the OECD. Furthermore, the European Commission (2006, 2008) stated that the three pillars of the European Union's energy policy are efficiency, sustainability and security of energy supplies. The growing importance of energy security comes at a time when several Southeast Asian economies such as Vietnam, the Philippines, Indonesia, Cambodia, Laos and Myanmar are just embarking on their economic takeoff and require large amounts of energy. Addressing the energy security situation in the region may provide opportunities for the neighboring countries to secure energy supply.

A number of researches have been reported in the literature discussing about conceptualization of energy security. However the energy security term is not clearly defined. There is no common interpretation of the energy security (Cecchi et al., 2009). According to Loschel (2010), the concept of security of energy supply, or in short form energy security, seems to be rather blurred. Other authors, Kruyt et al., (2009) and Mitchell (2002), also claim that the concept is elusive.

Similar to the others, Chester argues that the concept of energy security is slippery or difficult to define. Hence, not many researches have been made to clarify the concept of energy security (Chester, 2010).

This paper aims to build a quantitative assessment of energy security that is practical for application to the case of Southeast Asian countries. It is intend to include a set of indicators that cover dimensions of energy security regarding the availability of energy and economics related data of the countries in this region. Each of the indicators will be normalized into 0 to 1 scale, to allow multiple indicators to be synthesized into composite scores which will eventually be use to calculate their corresponding dimensions as well as the overall energy security index. This paper is structured as follows: the first section provides background and introduction regarding energy profile in Southeast Asian countries. The next section explains the method of the study. Section 3 contains the result an analysis, followed by policy implications and conclusions in the last section.

II. Introduction

In order to put the Southeast Asia region energy consumption into perspective, Table 1 provides some key energy indicators for ASEAN member countries. An economic revival coupled with ongoing urbanisation and industrialisation has driven brisk growth in ASEAN energy use since the Asian Financial Crisis of 1997-1998, which induced a sharp slump in energy consumption. Energy demand growth continued even through the more recent global economic crisis. Per capita primary energy demand growth was averaging 3.6% per year from 2000-2011. ASEAN primary energy demand in 2011 was around 550 million tonnes of oil equivalent (Mtoe), 4.2% of global demand. It is likely that this share will rise. On the other hand ASEAN energy use on a per-capita basis is low, at about half of the global average, and it is home to almost 600 million people, of which more than one-fifth do not have access to electricity.

Table 1. Key energy indicators for ASEAN

	Unit	1990	2000	2011	2000-2011
GDP (MER)	$ billion	788	1 261	2 185	5.10%
GDP (PPP)	$ billion	1 225	1 966	3 413	5.10%
Population	million	444	522	597	1.20%
Primary energy demand	Mtoe	223	373	549	3.60%
Primary energy demand per capita	toe	0.5	0.7	0.9	2.30%
Primary demand/GDP (MER)	toe/$1 000	0.28	0.3	0.25	-1.50%
Net oil trade	mb/d	0.7	-0.3	-1.9	18.70%
Net gas trade	bcm	46.8	68.7	62.1	-0.90%
Net coal trade	Mtce	0.4	37.8	219.6	17.40%
Energy-related CO2 emissions	Mt	368	715	1 166	4.50%

Notes: MER = market exchange rate; PPP = purchasing power parity.
Source (IEA ,2013)

As Southeast Asian countries in transform into a larger energy consumer and interact more within global energy markets, their governments will be increasingly confronted by challenges to secure energy supply. Energy security promises to become an elevated priority as reliance on oil imports rises across the region. Hence, the governments of Southeast Asian countries need to ensure that energy supplies are affordable, in order to support continued economic growth and development. Another major policy is to remove barriers to energy efficiency and cleaner sources of energy, especially in the context of the region's fast-rising energy demand, the expanding role of coal in its energy mix and its growing urban population.

Southeast Asia's primary energy mix is dominated by fossil fuels, with oil, natural gas and coal making up more than three-quarters of demand. There has been continuing trend towards more consumption of coal and natural gas, replacing oil in power generation and industry, and traditional biomass in the residential sector. However, oil remains the dominant fuel, with demand currently at 4.4 million barrels per day (mb/d), and a 37% share in the primary energy mix. Natural gas is second at 21% of the primary energy mix with demand around 141 billion cubic metres (bcm) (which is comparable to current gas demand in China). Coal consumption

has been rising at double-digit rates since 1990, tripling its share of the energy mix to 16%. Renewable energy currently accounts for 12% of the primary energy mix, made up mainly of hydro, geothermal and biomass power, co-generation technologies and solar photovoltaic (PV). Traditional biomass' share is about 12% of total demand (bringing the share of renewables in total to 24%).

Electricity demand in Southeast Asia increased by about a factor of five between 1990 and 2011 to 712 terawatt-hours (TWh). However, on a percapita basis ASEAN electricity demand remains low compared with developed countries.

III. Literature Review

a. Definition of energy security

Despite the high importance of energy security in policy, many researchers argued that the definition of energy security is not clearly defined. Winzer (2012) finds that concern about risks is a general agreements among authors. However, according to Gnansounou (2008), the number of threats that are caused by or have an impact on the energy supply chain is huge. Hence, the main reason for difference between energy security concepts is on how the authors select which threats they use in their analysis. Studies on energy security focus on different risk sources or choose different impact measures.

According to Winzer (2012), the focus can be categorized into four groups.

- First, definitions of energy security that focuses on the continuity of commodity supplies.
- Second, definitions of energy security that focuses on the impact measure to the continuity of service supplies.
- Third, definitions of energy security that focuses on the continuity of the welfare or the economy.
- Fourth, definitions of energy security that focuses on the impacts on the environment or the society.

Based on a review of security of supply literature, the common concept behind all energy security definitions is the absence of, protection from or adaptability to threats that are caused

by or have an impact on the energy supply chain (Winzer, 2012). Individual authors limit their concept of energy security along one or several dimensions due to the difficulty of measuring all of those threats at once. One dimension focuses on the sources of those threats (technical, human and natural). Another dimension focuses on the scope of the impact of those threats. These are measured in terms of continuity of commodity supplies, service supply, the economy and the environment and society. Many authors further limit their concept of energy security by distinguishing between secure and insecure levels of continuity based on the speed, size, duration, singularity and sureness of the threat.

b. Dimensions of energy security

The concept developed by the IEA (2014) is representative of many of energy security concepts: "the uninterrupted physical availability at a price which is affordable, while respecting environment concerns". This definition can be synthesized into three energy security dimensions: availability (the uninterrupted physical availability), affordability (a price which is affordable), and acceptability (respecting environment concerns). As with the IEA's definition of energy security being representative of many other definitions, the three indicators (or variations on them) are found in most energy security indicator sets. While there is no universally agreed upon definition of energy security, many dimension sets conform to the three IEA-derived dimensions or can be considered variations on them.

Table 2. Energy security dimensions

Author(s)	Dimensions
The World Energy Council has three sustainability objectives (the three 'A's) (WEC, 2007).	Accessibility to modern, affordable energy for all; availability in terms of continuity of supply and quality and reliability of service; and accep tability in terms of social and environmental goals.
The Asia-Pacific Energy Research Center provide four rather similar dimensions called the four 'A's (APERC, 2007):	Availability refers to the availability of oil (and other fossil fuels) and nuclear energy; Accessibility considers the barriers to accessing energy resources; Affordability of energy (limited to fuel prices, price projections, and infrastructure costs); and Acceptability surrounding environmental issues dealing with coal (carbon sequestration), nuclear, and unconventional fuels (biofuel and oil sands).

Hughes and Shupe (2011)	Reworked APERC's four 'A's to be more in line with the IEA definition, dividing availability into changes in current (or short-term) conditions (Availability) and changes to long-term conditions (Accessibility),
Kruyt et al. (2009)	extended the work by Jansen et al. (2004) on the social stability of an energy supplier to Acceptability
Sovacool and Mukherjee (2011)	Divided APERC's four 'A's into five dimensions: Availability, Affordability, Technology Development, Sustainability, and Regulation
Sovacool and Brown (2010)	Energy security has four dimensions : Availability, Affordability, Energy and economic efficiency, and Environmental stewardship.
von Hippel, Suzuki, Williams, Savage, and Hayes (2011)	According to this definition, energy security is composed of six dimensions: energy supply, economic, technological, environmental, social and cultural, and military and security.
Vivoda (2010)	Built on the work of Von Hippel et al. by adding further 5 dimensions: demand management, efficiency, human security, international, and policy. Vivoda further deepened the 6 dimensions of Von Hippel et al. by adding 10 "attributes" to them (as well as introducing another 34 attributes with his own five dimensions).

Hence in general, all of those dimensions offered by the above authors actually can be draw down into four dimensions of energy security: availability, accessibility, affordability and acceptability. Most of the dimensions and objectives are captured in the IEA's definition of energy security. One exception is the IEA's apparent omission of accessibility, which can be considered as part of availability in that for an energy flow to be accessible, it must be available; if access to an energy flow is problematic, this is reflected in its availability. Although the World Energy Council seemingly omits affordability as an objective, it is mentioned in the definition of accessibility.

c. Indicators of energy security

- Simple Indicator

  These are common measurements that allow understanding of the results or attributes of the activities performed within an industry's supply chain (OECD, 2008). The single indicators are often linked to measurable outcomes during a specific period. For an

indicator to be useful and effective, it has to be relevant to the objectives of the industry. It also has to be clearly defined to ensure the proper collection of information about it. It must be easy to understand and use and be comparable with the performance of similar. The simple indicators are often linked to measurable outcomes during a specific period. Information about single indicators can be found in publicly annual statistical reports or databases.

- Diversification Indicator

  In an extensive cross-disciplinary review of the literature on measures of diversity, Stirling (1998) identifies a number of effective dual-property measures combining variety and balance, yet finds no metric in the literature that also captures disparity. He concludes that the characterization of disparity is inevitably subjective and ultimately depends on the choice of particular performance criteria. He shown that the Shannon diversity index is the most attractive simple index reflecting both variety and balance in an even way, and inclusion of disparity remains cumbersome.

- Composite Indicator

  A composite indicator is formed when individual indicators are compiled into a single index, on the basis of an underlying model of the multi-dimensional concept that is being measured.

IV. Methodology

a. Data

Data are collected from ASEAN Center for Energy, ADB, US Energy Information Administration, International Energy Agency, BP Statistical Review, and data available in Sovacool (2011).

b. Methodology

- Selecting core dimension and indicator:

  The dimension selection developed by gathering the concepts from other works available

in the literature review, eliminating the duplicate dimensions and selecting for inclusion only those aspects that can be applied to Southeast Asian countries, given their data availability.

Table 3. Dimensions and indicators

Dimension	Indicators	Definition
Availability	Total primary energy supply percapita	Supply of crude oil, natural gas, coal, hydro and other renewables
	Population with high quality connections to the electricity grid	Percentage of population with reliable grid connection compared to all people in the country
	Self sufficiency	Percentage of TPES over TPEC
Stability of Supply	Average reserve to production ratio for the four primary energy fuels (coal, gas, and oil)	Ratio of proven recoverable reserves over production of those reserves
	Energy resources and stockpiles	Reserves of of coal, oil and gas divided by TPEC
	Supply Security (coal, oil, gas)	Domestic and world production diversity indices (diversification index calculated using Shannon-Wienner Index method)
Affordability	Retail price of 100 liters of unleaded gasoline	Price of gasoline inclusive of all taxes and subsidies.
	Per capita energy subsidies	Total gov't expenditure on direct/indirect energy subsidy divided by population
	Households dependent on traditional fuels	Percentage of population that relies on solid fuels, i.e. biomass, wood, charcoal, agricultural waste, dung and coal.
	Stability of electricity prices	Percentage of retail electricity price changed every 5 years
Efficiency	Energy intensity	TPEC over GDP PPP 2005 US$
Environmental impact	Per capita energy-related carbon dioxide emissions	Annual tons of CO2 emission from fuel combustion divided by total population
Affordability	Retail price of 100 liters of unleaded gasoline	Price of gasoline inclusive of all taxes and subsidies.

- Calculation

  Since the indicators have different unit measurement, it is necessary to convert them to a standard unit on 0 to 1 scale, with 0 expressing the poorest result and 1 the best. The steps are as follows:

  - Begin with calculating a composite score for each indicator.
  - Normalize the score into 0 to 1 scores.
  - The normalized scores of indicators then summed according to their respective dimensions. The score of each dimension is the average of their respective indicators.
  - The scores of each dimension are put together to obtain an overall energy security index (ESI).
  - The score of a dimension and ESI is a simple average of the dimensions, reflecting equal value attached to each dimensions.

V. Results and Analysis

a. Availability

Three indicators represent this dimension: total primary energy supply per capita, population with connection to electricity grid, and self sufficiency. Brunei Darussalam always scores the highest for both 2005 and 2010. This is due to its abundance oil and gas and small population; hence their total primary energy supply per capita is very high. Brunei also has 100% electrification ratio. Brunei scores are far above its neighboring countries. The bottom three is Myanmar, Laos and Cambodia due to their relatively poorer performance in the three indicators. In 2011, there are 66% of population in Cambodia does not have access to electricity; the numbers are 51% and 22% for Myanmar and Laos. These countries' per capita energy consumption also very low. Per-capita consumption in Myanmar, for example, is 33 times lower than in Brunei Darussalam. Indonesia also has a relatively score despite of its abundant energy resources. This is due to its large population and geographical condition that make total primary energy supply per capita, population with connection to electricity grid scores low.

Table 4. Availability dimension

Country	2005	Country	2010
Brunei	0.87	Brunei	0.87
Singapore	0.67	Singapore	0.67
Malaysia	0.56	Malaysia	0.58
Thailand	0.52	Thailand	0.50
Philippines	0.44	Philippines	0.46
Vietnam	0.39	Vietnam	0.45
Indonesia	0.32	Indonesia	0.35
Laos	0.24	Laos	0.28
Cambodia	0.16	Cambodia	0.16
Myanmar	0.15	Myanmar	0.13

b. Supply Stability

Three indicators represent this dimension: Average reserve to production ratio for the four primary energy fuels (coal, gas, and oil), Energy resources and stockpiles and Supply Security (coal, oil, gas). Singapore scores the lowest for both years because it relies almost entirely on energy imports to meet its domestic energy needs. Singapore's total primary energy supply (TPES) in 2011 was 20 587 kilotonnes of oil equivalent (ktoe). On the other end, Indonesia which is rich in energy resources compared to its neighboring countries scores the best. Surprisingly Thailand out performed Brunei, Malaysia and the Philippines in this dimension. This might be because the nature of the index calculation. Domestic production and reserve ratio of Thailand can be higher than other richer in natural resources countries such as Malaysia and Brunei Darussalam, due to their low domestic production. Again in this category, Laos, Cambodia and Myanmar performs poorer compared to other countries.

Table 5. Supply stability dimension

Country	2005	Country	2010
Indonesia	0.69	Indonesia	0.63
Thailand	0.52	Thailand	0.42
Malaysia	0.42	Malaysia	0.37
Philippines	0.33	Brunei	0.24

Brunei	0.28	Vietnam	0.23
Vietnam	0.24	Laos	0.20
Myanmar	0.09	Philippines	0.16
Cambodia	0.01	Myanmar	0.06
Laos	0.00	Cambodia	0.01
Singapore	0.00	Singapore	0.00

c. Affordability

This dimension represented by four indicators: retail price of 100 liters of unleaded gasoline, per capita energy subsidies, households dependent on traditional fuels and stability of electricity prices. Singapore scores the best in this dimension because it does not subsidize its energy sector, does not depend on traditional fuels and has a more stable electricity price. Similar to previous dimensions the group of Malaysia, Thailand, Brunei Darussalam, the Philippines and Indonesia has similar scores. And Vietnam along with Cambodia, Myanmar and Laos are the lowest performer group. The middle group have a relatively energy infrastructure compared to the bottom group.

Table 6. Affordability dimension

Country	2005	Country	2010
Singapore	0.87	Singapore	0.80
Malaysia	0.84	Malaysia	0.73
Thailand	0.72	Thailand	0.71
Brunei	0.66	Brunei	0.66
Philippines	0.64	Indonesia	0.64
Indonesia	0.56	Philippines	0.63
Vietnam	0.55	Cambodia	0.46
Cambodia	0.44	Vietnam	0.46
Myanmar	0.39	Myanmar	0.43
Laos	0.37	Laos	0.39

d. Efficiency

This dimension only has one indicator, which is energy intensity that means the share of

energy consumption over GDP. The scores show that Cambodia need less energy to increase its GDP by 1 unit compared to other Southeast Asian countries. Brunei performance is degraded in 2010 compared to that of 2005. This is due to its energy consumption grows faster than it GDP. Philippines and Myanmar improve from 0.56 and 0 in 2005 to 0.86 and 0.95 in 2010. Other countries performances are more or less follow the same pattern.

Table 7. Efficiency dimension

Country	2005	Country	2010
Brunei	1.00	Cambodia	1.00
Cambodia	0.74	Myanmar	0.95
Laos	0.63	Philippines	0.86
Philippines	0.56	Laos	0.62
Myanmar	0.50	Indonesia	0.57
Vietnam	0.41	Vietnam	0.54
Indonesia	0.39	Malaysia	0.48
Malaysia	0.31	Brunei	0.44
Thailand	0.22	Thailand	0.43
Singapore	0.00	Singapore	0.00

e. Environmental Impact

One indicator represents this dimension that is per capita energy-related carbon dioxide emissions. Brunei Darussalam, which consumes more fossil fuel, scores the lowest compared to Laos that scores the highest in this dimension. Laos has large hydropower potential; hence it consumes less fossil fuel and emits less CO_2 compared to more fossil fuel intensive economy such as Singapore, Malaysia, Thailand and Indonesia.

Table 8. Environmental impact dimension

Country	2005	Country	2010
Laos	1.00	Laos	1.00
Cambodia	0.99	Myanmar	1.00
Myanmar	0.99	Cambodia	0.99
Philippines	0.96	Philippines	0.97

Vietnam	0.94	Vietnam	0.95
Indonesia	0.90	Indonesia	0.92
Thailand	0.77	Thailand	0.83
Malaysia	0.57	Malaysia	0.65
Singapore	0.23	Singapore	0.52
Brunei	0.00	Brunei	0.00

f. Overall Energy security index

The overall energy security performance shows not much improvement of energy security among Southeast Asian countries during 2005 and 2010. The Philippines scores the same between 2005 and 2010, but drop from top performer to second place due to Indonesia's increasing energy security score. The scores of Malaysia, Thailand, Cambodia, Laos, Singapore and Vietnam are slightly improved. In contrast, Brunei's performance plunged from 0.56 in 2005 to 0.44 in 2010. This is primarily affected by the poor performance in environmental dimension where Brunei produce the most per capita energy related CO_2 emission.

Table 9. Overall energy security index

Country	2005	Country	2010
Philippines	0.58	Indonesia	0.62
Indonesia	0.57	Philippines	0.62
Brunei	0.56	Thailand	0.58
Thailand	0.55	Malaysia	0.56
Malaysia	0.54	Cambodia	0.53
Vietnam	0.51	Vietnam	0.53
Cambodia	0.47	Myanmar	0.51
Laos	0.45	Laos	0.50
Myanmar	0.43	Brunei	0.44
Singapore	0.35	Singapore	0.40

VI. Conclusion

The index method approach has been used in this study to evaluate energy security in Southeast Asian countries. The result shows that the energy security situation does not much change between 2005 and 2005. The highest performance score in both years are 0.58 and 0.62. This means although one country performs the best, there is still a room to improve the energy security level. In this study the top performer countries only achieve 60% of the full potential to be energy secure country. From the result Myanmar is the most improved country by increasing 4.4%. On the other hand Brunei degrades the most by 21%.

There are still many rooms to improve this study in the future. For example weighing the indicators based in their importance in the system. Another one is to find what factors that caused energy security performance better than others. Alsoaccording to studies in the the literature review that determining dimensions and indicators are a crucial part of developing and conceptualizing the evaluation tools, improvement in conceptualization stage might improve the result provide a more reliable insight.

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