The Association of Academies of Sciences in Asia (AASA)

TOWARDS A SUSTAINABLE ASIA

ENERGY

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With 22 figures

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Author

The Association of Academies of Sciences in Asia (AASA)

KAST Building, 7-1, Gumi-Dong
Bundang-Gu
Seongnam-Shi
Gyunggi-Do, 463-808
Republic of Korea
E-mail: aasa@kast.or.kr

ISBN 978-7-03-029008-3
Science Press Beijing

ISBN 978-3-642-16680-8 e-ISBN 978-3-642-16681-5
Springer Heidelberg Dordrecht London New York

Library of Congress Control Number: 2010937229

Cover design: Huabin Huang

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

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Project Team of "Sustainable Development in Asia" of the AASA

Project Co-Chairs

Yi Wang	Institute of Policy and Management, CAS
Namık K. Aras	Turkish Academy of Sciences

Group Coordinators

Energy

Luguang Yan	Institute of Electrical Engineering, CAS
Seung Mo Oh	Seoul National University

Environment and Climate Change

Gensuo Jia	Institute of Atmospheric Physics, CAS
Woojin Lee	Korea Advanced Institute of Science and Technology

Natural Resources

Lei Shen	Institute of Geographic Sciences and Natural Resources Research, CAS
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Culture

Baichun Zhang	Institute for the History of Natural Science, CAS
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Andrei V. Tabarev	Russia Institute of Archaeology & Ethnography

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Zhenyu Wang	Bureau of International Cooperation, CAS
Shaofeng Chen	Institute of Policy and Management, CAS
Yu Chen	Bureau of International C ooperation, CAS
Weiwei Liu	Bureau of CAS Membership, CAS
Mingqi Pan	Institute of Policy and Management, CAS

Thematic Report of the AASA Project "Sustainable Development in Asia"

TOWARDS A SUSTAINABLE ASIA: ENERGY

Lead Authors

Luguang Yan	Institute of Electrical Engineering, CAS, China
Seung Mo Oh	School of Chemical and Biological Engineering, Seoul National University, Rep. of Korea
Changgang Huang	Institute of Electrical Engineering, CAS, China

Contributors

Indral K. Perera	Sabaragamuwa University of Sri Lanka, Sri Lanka
M.Shamsher Ali	Bangladesh Academy of Sciences, Dhaka; Southeast University Bangladesh, Bangladesh
Volkan S. Ediger	İzmir University of Economics, Turkey
Alvin B. Culaba	Center for Engineering and Sustainable Development Research, Philippines
Bundit Fungtammasan	King Mongkut's University of Technology Thonburi, Thailand
Harsh Gupta	National Geophysical Research Institute, India
Hassan Zohoor	The Academy of Sciences of IR Iran, Iran
Yee Cheong Lee	Federation of Asian Scientific Academies and Societies, Malaysia
Mahmood Yaghoubi	The Academy of Sciences of IR Iran, Shiraz University, Iran
Muhammad Yahaya	University Kebangsaan Malaysia, Malaysia
Rishi K. B. Shah	Center for Renewable Energy, Nepal
Oktay Kerimov	National Academy of Science, Azerbaijan
Andrei G. Korzhubaev	Trofimuk Institute of Petroleum Geology and Geophysics, Siberian Branch of the Russian Academy of Sciences, Russia
Saran Solongo	Institute of Physics and Technology, Academy of Sciences of Mongolia, Mongolia

Reviewers

Yi Wang	Institute of Policy and Management, CAS, China
Namık K. Aras	Turkish Academy of Sciences, Turkey

Abbreviations

AASA	Association of Academies of Sciences in Asia
GDP	gross domestic product
IAC	InterAcademy Council
IAP	InterAcademy Panel
IGCC	integrated gasification combined cycle
PV	photovoltaic
tce	tons of coal equivalent
toe	tons of oil equivalent

Foreword

Asia is not only the largest and most populated continent in the world, but also the region with the most diverse development models and most dynamic economies. In the past half century, Asia has been witnessing rapid economic growth and playing an increasingly more important role in world's political and economic arena. At the same time, Asia has developed the commonly-called "Asia Model", which has attracted worldwide attention. The Asia Model shows a new way for the developing nations or late-development countries on how to realize industrialization and modernization. All these achievements are made by Asian countries with a focus on the advantages of their late development, re-examination of their internal cultural values, active absorption of modern S&T and management experiences and constant exploration and innovation.

These social progresses have made great contributions to the realization of the UN Millennium Development Goals and have played a pioneering and demonstration role on what can be accomplished in today's world. However, Asia is facing big challenges. The most prominent one is that the rapid development of Asian economies is based on large input of production factors at the huge expense of natural resources and environment, which has been sharpening the conflicts in population, resources, environment, socio-economic development. The sustainable development in the region is being severely threatened and challenged. The rethinking and questioning of the Asia Model in the international community is growing especially in the era of post Asia Financial Crisis and Global Financial Crisis.

It is not only a common challenge for the governments of Asian countries, but also a common task for the Asian scientific communities to cope with the resources and environment crisis and to seek a new way of sustainable development in Asia. AASA, as a non-governmental and regional international scientific organization with 26 member academies, is mandated to initiate and conduct investigation on issues concerning S&T, economic and social development. As early as April 2007, AASA proposed to initiate a project on "Sustainable Development in Asia" (SDA) within AASA framework in the hopes to provide consultation and advice for national and regional governments in Asia and relative international organizations. This study proposal was approved at AASA board meeting held in Russia in August 2007 with the Chinese Academy of Sciences as the initiator. The project covers environment, energy,

resources and culture with the establishment of four working groups among AASA member academies.

Soon after, the SDA project was officially launched and implemented at different levels. The efforts include the clarification of the research content, emphasis, structure and division of tasks. Various meetings at the working level and international workshops have been held to coordinate the research activities and project progress: the first international workshop under this project was held in February 2008; the AASA Workshop on Sustainable Energy Development in Asia in November 2008; the AASA Workshop on Agricultural Culture and Asian Sustainable Development in August 2009; and the AASA Workshop on Environment and Resources in September 2009.

With the joint efforts of AASA member academies, the SDA project has now come up with a series of studies including four thematic reports, namely, "Towards a Sustainable Asia: Energy", "Towards a Sustainable Asia: Environment and Climate Change", "Towards a Sustainable Asia: Natural Resources", and "Towards a Sustainable Asia: The Cultural Perspectives" . Based on these four reports, a synthesis report has also been written entitled: "Toward a Sustainable Asia: Green Transition and Innovation". All these reports have looked deeply into the common issues and challenges for the Asian sustainable development from different perspectives.

The synthesis report is an integration and extension of the four thematic reports. It aims at the major resource and environmental challenges and issues in Asia in the general context of the challenges of financial crisis and climate change, and in line with green transition and innovation in Asia. Of its major findings, it includes: the diagnosis of key resource and environmental issues in Asia, such as water, minerals, land resource, environmental pollution, eco-degradation, energy and environment and climate change, the revelation and reflection of the diverse, different, complicated and severe nature of resource and environmental issues in Asia, the systematic analysis of the main driving forces and future trends of resource and environmental changes in Asia, the empirical analysis and discretion of current evolution of the relationship between environment and development in Asia with the establishment of theoretical and conceptual models, the initiation of principals, strategic framework, focus and advice for promoting the green development of Asia on the basis of summarizing Asia's advantages and disadvantages.

The synthesis report differs from other similar reports. It focuses more on the combination of theoretical and empirical research in the evolution of environment and development, on the combination of trends analysis in time series and comparative study at spatial scale, and on the combination of Asia's integrated analysis and regional and national differences. Besides, attempts have been made here on the innovative modeling of the evolutionary and theoretical relationship between environment and development, analysis of the driving

forces in environmental evolution, and utilization of newly developed composite index to conduct empirical research of Asia's environment and development relation in the evolution.

We hope the reports will be of good value to the facilitation of the green development in Asia, providing advice on dealing with the shortage of conventional resources, environment pollution and climate change, fostering new economic growth and enhancing Asia's competitive advantages. This is the first time that AASA has ever undertaken such a study, and it surely leaves grounds for more detailed study and analysis of various issues and challenges that Asian countries face in the future.

The SDA project is sponsored by AASA. I want to give my special thanks to all AASA member academies for their consistent support, advice and assistance, without which, the accomplishment of such an internationally interdisciplinary scientific project would be impossible. My thanks also go to all the members in the working groups, especially Professors Namık Aras and Yi Wang, co-chairs of this study, without whom, efficiency and quality of the study would not be guaranteed. I also need to thank United Nations Environment Programme (UNEP), InterAcademy Council (IAC) and InterAcademy Panel (IAP) etc. for providing us the references and various advice and inspirations. Last but not the least, I want to express my thanks to all friends and the institutions that have rendered us encouragement and assistance all the way along.

The SDA project features with a wide range of fields and a huge amount of data, some of which are still in their early stage of development. Any comments or suggestions from our friends and various international institutions are warmly appreciated.

Prof. Jinghai Li

President

The Association of Academies of Sciences in Asia (AASA)

September 20, 2010

Preface

Vision of the Association of Academies of Sciences in Asia (AASA) is to provide a forum to discuss and provide advice on issues related to science and technology and the application of technology for national development. During the year 2008, two workshops were organized by AASA in Beijing. These workshops were devoted to sustainable energy development in Asia. This report was based on presentation paper and meeting discussion. The whole project is coordinated by Prof. Wang Yi from the Chinese Academy of Sciences and Prof. Namik K. Aras, the secretary general of AASA, from the Turkish Academy of Sciences. The energy group work is coordinated by Prof. Yan Luguang from China and Prof. Seung Mo Oh from Republic of Korea.

Yan Luguang, Seung Mo Oh, Alvin B. Culaba, Andrei G. Korzhubaev, Bundit Fungtammasan, Harsh Gupta, Hassan Zohoor, Huang Changgang, Indral K. Perera, Lee Yee Cheong, M.Shamsher Ali, Mahmood Yaghoubi, Muhammad Yahaya, Oktay Kerimov, Rishi K. B. Shah, Saran Solongo and Volkan S. Ediger participated in the writing of this report. Indral K.Perera made a contribution to amending English writings.

This report is inevitable to be imperfect due to the limitation of knowledge and time of the Study Group. Comments and corrections are welcomed.

Study Group on Energy

August 2010

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1 Introduction

The Association of Academies of Sciences in Asia (AASA) is a non-profit organization, established in 2000, comprising 26 Academies. The vision of AASA is to provide a forum to discuss and provide advice on issues related to science and technology and the application of technology for national development. Since its establishment, AASA has held many symposia, conferences and scientific meetings. Based on several proposals from member academies, it was decided in April 2007 to organize a new project termed as "Sustainable Development in Asia", covering four main areas: energy, environment, natural resources and social & cultural development. The whole project is coordinated by Prof. Wang Yi from the Chinese Academy of Sciences and Prof. Namik K. Aras, the secretary general of AASA, from the Turkish Academy of Sciences. The energy group work is coordinated by Prof. Yan Luguang from China and Prof. Seung Mo Oh from Republic of Korea.

During the year 2008 two workshops were organized in Beijing. The first workshop was held during February 25-26 and was devoted to the whole project "Sustainable Development in Asia", including the four groups—energy, environment, natural resources and social development & culture, 27 experts from 10 countries attended, 8 papers related to energy from 8 countries were presented (see Appendix A). From the information exchange and discussion that followed it was clear that the energy situation and conditions are quite different in different Asian countries. So to make a more reliable report for sustainable energy development in Asia, it was suggested that every country should provide a national report concerning its energy situation, perspective, main features, challenges and opportunities, policies and sustainable development suggestions. Based on these national reports a summary report for the whole of Asia was to be formulated. As such, it was decided to organize a second workshop in winter 2008 devoted entirely to sustainable energy development in Asia.

Since the InterAcademy Council (IAC) had carried out a sustainable energy study in 2005-2007 and published a report entitled "Lighting the Way: Toward a sustainable energy future" in October 2007, Nobel Laureate Steven Chu pointed out that "This report represents the convergence of some of the

best minds and top institutions in the world to establish the necessary direction for governments, scientists, engineers, and industry—indeed society as a whole—to secure clean, sustainable energy required for our prosperity" and that it can serve as some basis for our future work for Asia. Accepting this proposal, the IAC and InterAcademy Panel (IAP) very actively supported to organize this second workshop. This second workshop was held during November 17-18, 2008, and was attended by 31 experts from 11 countries, who presented 15 papers and 3 papers from the first workshop from Russia, Mongolia and Azerbaijan were also included. Thus representing totally 14 national reports from 14 countries. On behalf of IAC, Prof. Dato Engr. Lee Yee Cheong presented the IAC report "Lighting the Way: Toward a sustainable energy future" (see Appendix A). On the basis of all reports and discussions held after each presentation, a half day special session devoted to discuss the content and organization of the final report was held. At this discussion, it was decided to organize a study panel with 17 members to provide maximum possible material and data, mobilize all AASA member-countries to provide their national reports with all necessary data, information and suggestion, and also to collect all possible statistical data and suggestion from official publications. A small group was assigned to plan and write the draft report "Sustainable Energy Development in Asia", the first draft report was sent to all panel members to get their comments, modifications and opinions. After amendments based on the comments and opinions, the present report—the second draft report was prepared. Finally the complete report will be sent to Prof. Yi Wang and Prof. Namik K. Aras and the project office to form the synthesis report and to organize the necessary peer review.

2 General Situation of Energy Development in Asia

There are many publications with statistical data of the energy development in the world, in Appendix 3 we have presented in 6 tables the current data for 2005-2007, including the area, population, GDP, the primary energy consumption and its structure, the primary energy production and its balance with consumption, the electricity generation, installed capacity and its structure for all 48 Asia countries. Since Russia is located such that a part of it belongs to Asia and the remainder to Europe, it is difficult to separate the corresponding data for Asia and Europe, so the data cited for Russia, refers to the entire country and as such, the figures may include those belonging to the European part of Russia.

From Appendix B, it can be seen that the total land area of Asia is 48.9 Mkm^2, it is 32.7% of the total earth land area (149.5 Mkm^2); the total population of Asia in 2007 was 4,108 millions, it is 62.3% of the total world population (6,596 millions); the total GDP of Asia in 2007 was 14,713 billion US dollars, it is 27.1% of the world GDP(54,347 billion US dollars); the GDP per population in Asia was 3,582 US dollars/person in 2007,it is 43.5% of the world average(8,240 US dollars/person); the total energy consumption in 2006 was 5,290 Mtoe in Asia, it is 44.7% of the world consumption(11,844 Mtoe). The energy consumption per unit GDP in 2006 was 0.417 toe/k US dollars in Asia. It is 170% of the world average (0.246 toe/k US dollars). Per capita energy consumption in Asia is 1.30 toe/(person·year), it is 71.4% of the world average(1.82 toe/(person·year)). Figures 2.1-2.4 illustrate respectively the world population, GDP, energy consumption, per capita energy consumption and their distribution among different countries.

Geographically, Asia is divided into 6 regions, i.e.: East Asia, South-East Asia, South Asia, West Asia, Central Asia and North Asia. The East Asia has 5 countries (China, DPR of Korea, Republic of Korea, Mongolia and Japan) with a total area of 11.76 Mkm^2 (24.0% of that of Asia), 1,525 M population (37.1% of the total population of Asia), 8,630 Billion US dollars GDP (58.7% of the Asia GDP) and 2,702 Mtoe energy consumption (51.1% of the Asia energy consumption). South-East Asia has 11 countries (Vietnam, Lao PDR,

Cambodia, Burma, Thailand, Malaysia, Singapore, Indonesia, Philippines, Brunei and Timor-Leste), with a total area of 4.51 Mkm^2 (9.2% of that of Asia), 574.8 M population (14.0% of the total population of Asia), 1,261 Billion US dollars GDP (8.6% of the Asia GDP) and 396 Mtoe energy consumption (7.5% of the Asia energy consumption). South Asia has 7 countries (India, Pakistan, Sri Lanka, Bangladesh, Nepal, Bhutan and Maldives) with a total area of 4.5 Mkm^2 (9.2% of that of Asia), 1,496 M population (36.4% of the total population of Asia), 1,427 Billion US dollars GDP (9.7% of the Asia GDP) and 531 Mtoe energy consumption (10.0% of the Asia energy consumption). West Asia has 16 countries (Afghanistan, Iran, Turkey, Cyprus, Syria, Lebanon, Jordan, Iraq, Kuwait, Saudi Arabia, Yemen Arab Republic, Oman, United Arab Emirates, Qatar, Bahrain and Israel), with a total area of 6.8 Mkm^2 (14.0% of that of Asia), 295 M population (7.2% of the total population of Asia), 1,907 Billion US dollars GDP (13.0% of the Asia GDP) and 703 Mtoe energy consumption (13.3% of the Asia energy consumption). Central Asia has 8 countries (Turkmenistan, Uzbekistan, Kirgizstan, Kazakhstan, Tajikistan, Armenia, Azerbaijan and Georgia) with a total area of 4.2 Mkm^2 (8.6% of that of Asia), 76 M population (1.86% of the Asia population), 197 Billion US dollars GDP (1.34% of The Asia GDP) and 191 Mtoe energy consumption (3.6% of the Asia energy consumption). North Asia is Russia with a total area of 17.1 Mkm^2 (34.9% of that of Asia), a population of 141.4 M (3.4% of that of Asia), GDP is 1,291 Billion US dollars (8.8% of that of Asia), energy consumption is 768 Mtoe (14.5% of that of Asia). The countries in each of the above regions have close similarities, though different regions are quite diverse.

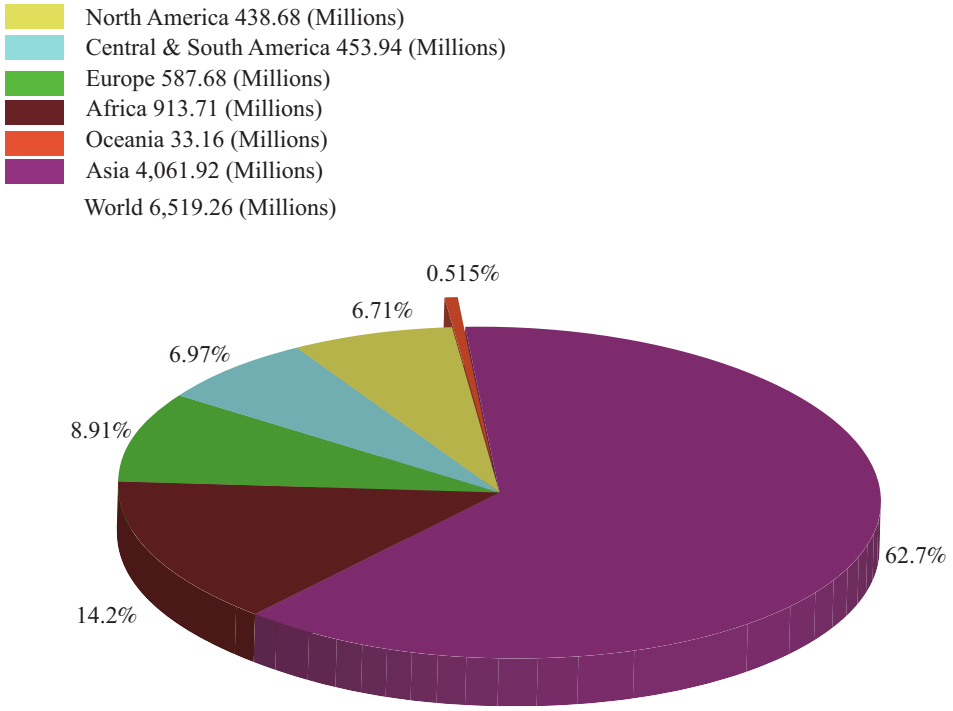


Figure 2.1 Percent and value of world population in 2006

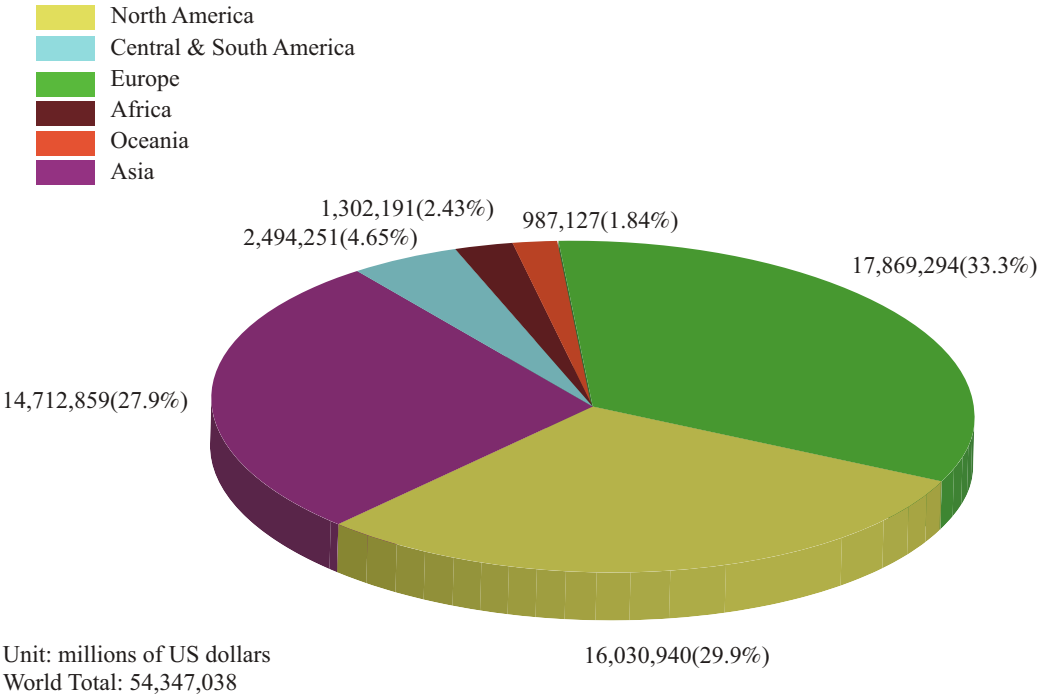


Figure 2.2 World GDP and it's distribution in 2007

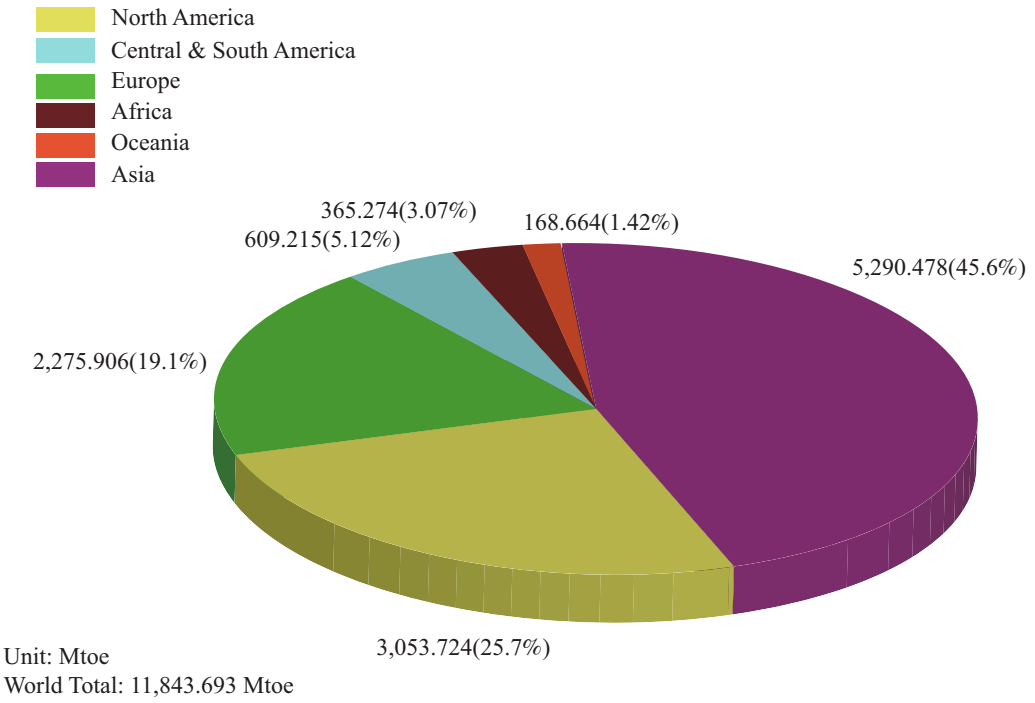


Figure 2.3 Percent of world energy consumption in 2006

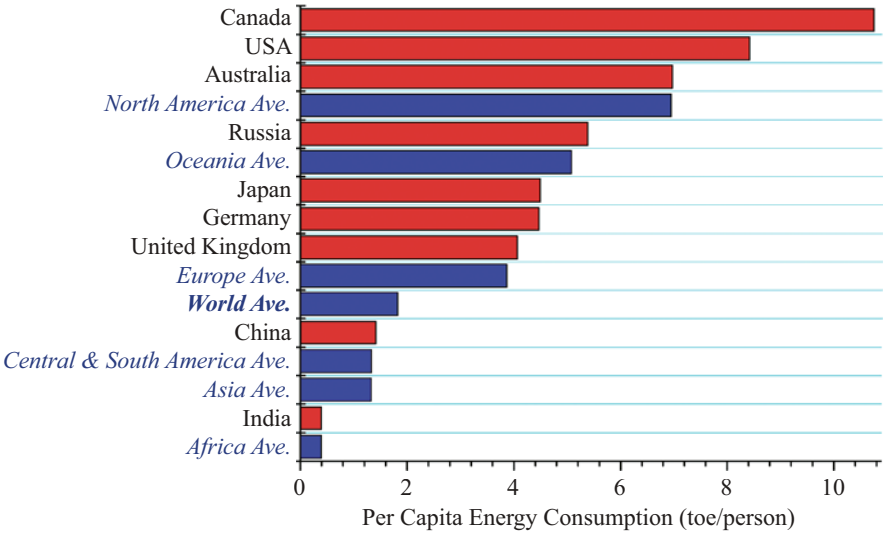
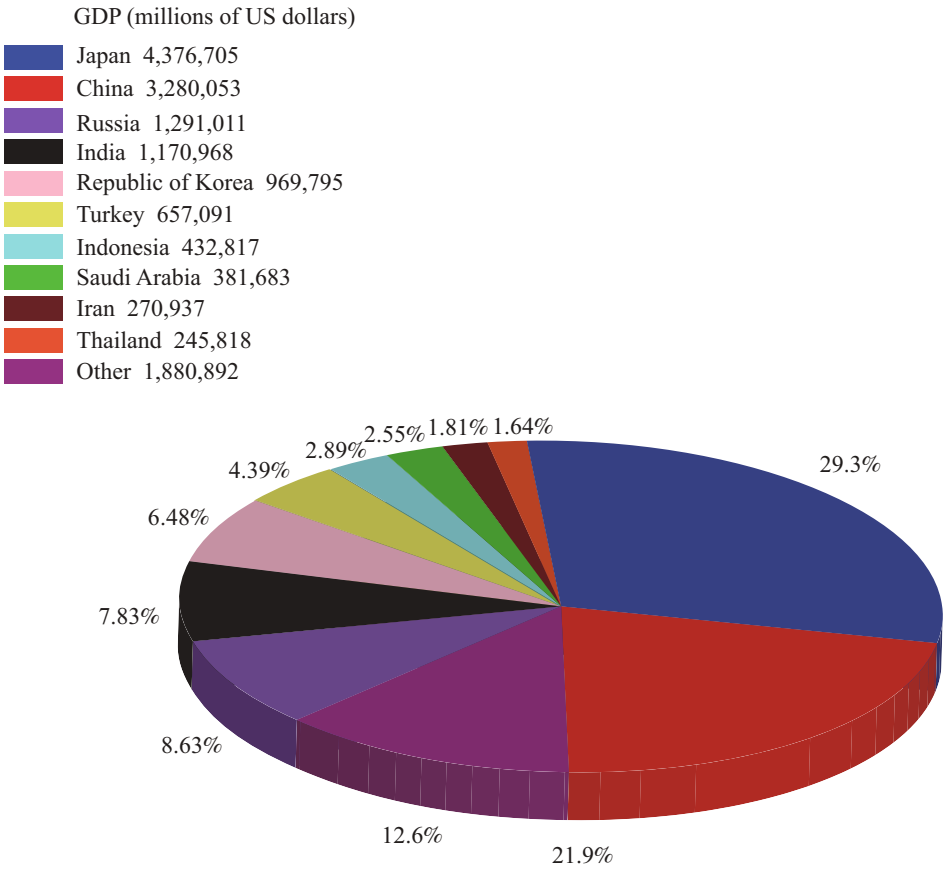


Figure 2.4 Per capita energy consumption of world in 2006

The economic development level of every country can be determined by its GDP and per Capita GDP values. Figures 2.5-2.7 present the corresponding curves for 2007. It can be seen that Japan, China, Russia, India and Republic of Korea have a total GDP of over 1,000 Billion US dollars, the sum of their contribution reaching 74.1% of the total GDP of Asia, the total contribution



Asia Total GDP in 2007: 14,712,859 (millions of US dollars)

Figure 2.5 Asia total GDP in 2007 and it's distribution

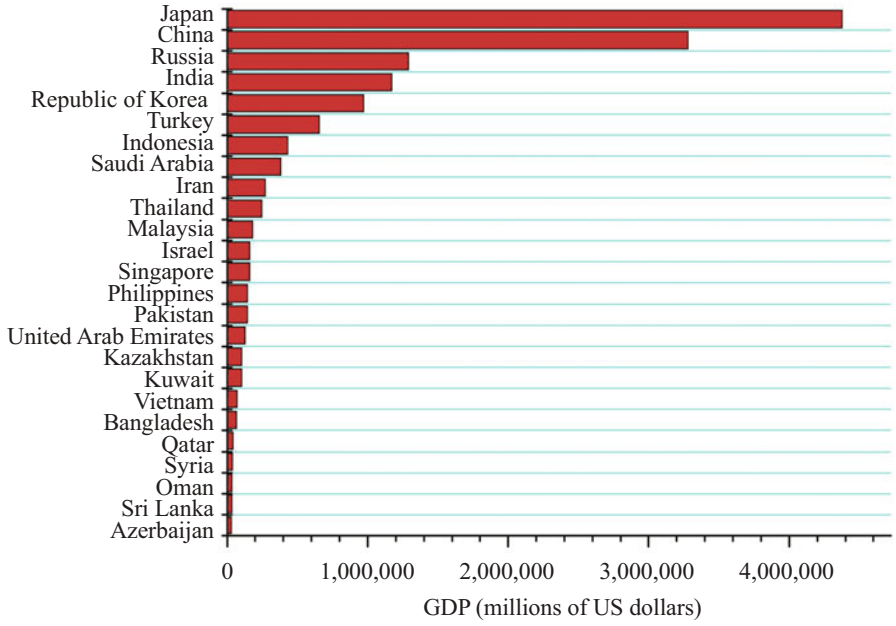


Figure 2.6 GDP in 2007

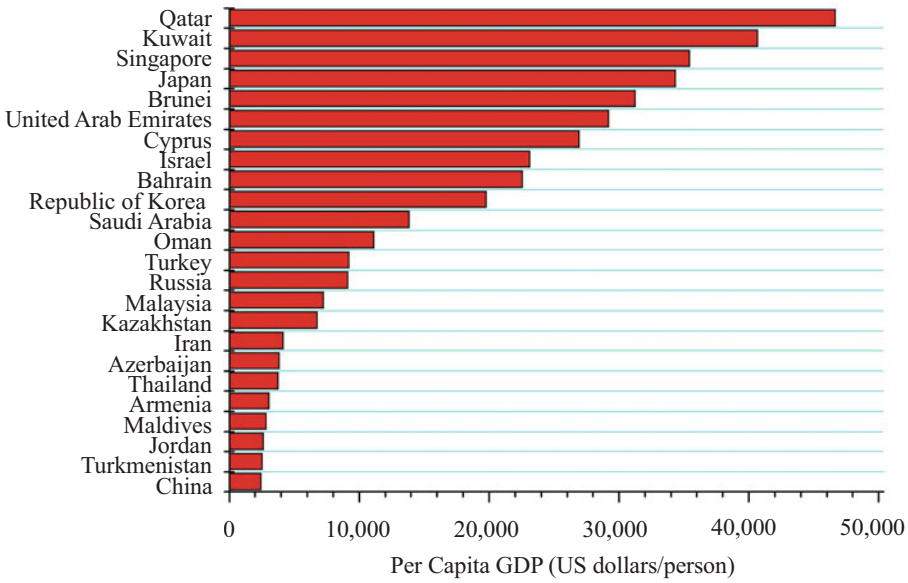
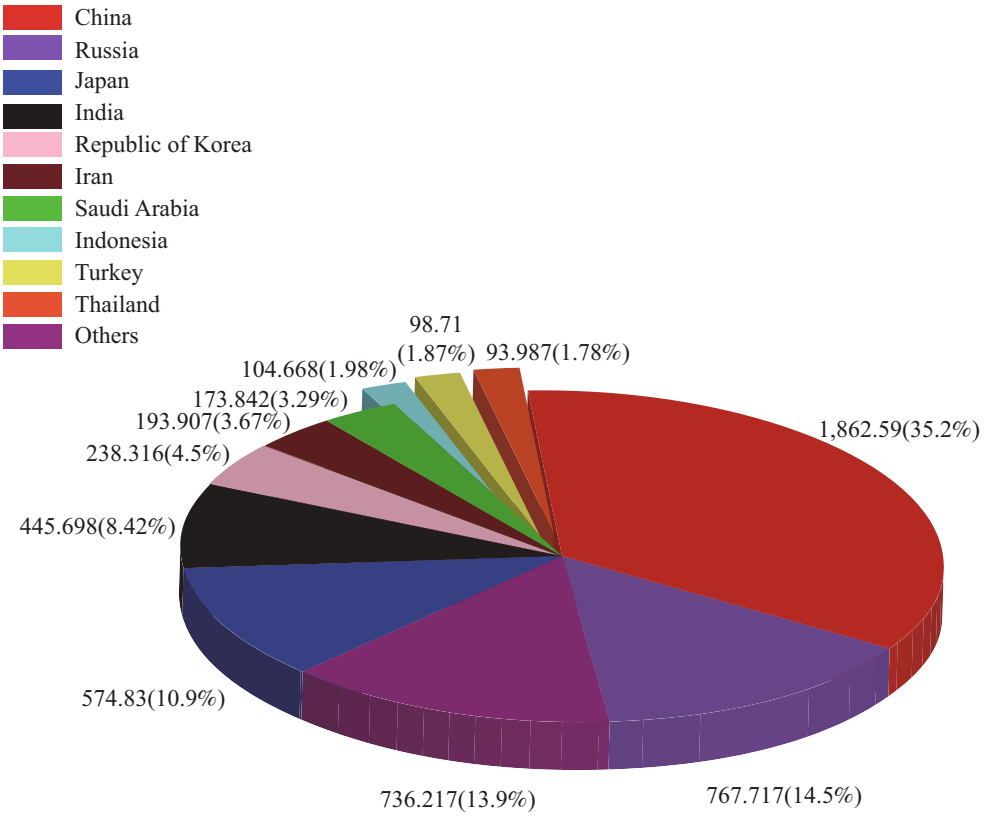


Figure 2.7 Per capita GDP in 2007

from the next five countries Turkey, Indonesia, Saudi Arabia, Iran and Thailand is 13.3% , while the remaining 38 countries have only 12.6% . Only 10 countries have per Capita GDP over 20 kilo- US dollars/person, they are Qatar, Kuwait, Singapore, Japan, Brunei, United Arab Emirates, Cyprus, Israel, Bahrain and Republic of Korea. The well developed countries like Japan, Republic of Korea and Russia are always in the front both for total GDP and per Capita GDP. Large developing countries like China, India and Indonesia are very important with their large GDP. Some small countries with quite good resources and economical conditions, as Qatar, Kuwait, Singapore, Brunei, United Arab Emirates, Cyprus, Israel and Bahrain have per Capita GDP from 20 kilo-US

dollars/person to 46 kilo- US dollars/person.

Figures 2.8-2.12 present the energy consumption situation of the Asian countries and their energy structure. It can be seen that the four large countries China, Russia, Japan, and India consumed 1,862-446 Mtoe primary energy in 2006, their sum being 67.2% of the total energy consumed in all the Asian countries. Their average energy consumption per person was 1.36 toe/person, which was 104% of the entire Asian average (1.30 toe/person) and was 72% of the average of the whole world (1.82 toe/person). The energy consumption per GDP varies widely, from about 0.03 toe/ kilo- US dollars (Cambodia) to 3.24 toe/ kilo-US dollars (Uzbekistan).It depended on many factors such as available resources, economical and technological development level, etc. But for all countries the most important parameter is the reduction of the energy consumption per GDP. The average Asia value was 0.42 toe/ kilo- US dollars which is 70% higher than the world average (0.25 toe/ kilo-US dollars).



Unit: Mtoe
Total Energy Consumption in Asia 2006: 5,290.478 Mtoe

Figure 2.8 Asia primary energy consumption in 2006

The primary energy structure in Asia is similar to the whole world, i.e., up to now, the fossil energy still remains the main energy resource, for the whole world, the fossil energy percentage being 86.8% (coal—27.2%, oil—36.6%, gas—23%), for Asia—91.5% (coal—37.5%, oil—31.7%, gas—22.3%),

the special features for Asia is that: the coal percentage is about 10% higher, the hydro, nuclear and renewable percentage is about 5% lower than that for the whole world. The energy structure for each country is highly dependent on the availability of the relevant resource. The import-export reality, for example, coal is still the main resource for China (70.5%), India (53.4%), Mongolia (72%) and DPR of Korea (83.2%), gas is for Russia (55%) and many other central Asian and West Asian countries with good resources, oil is for the resources-rich countries. For west Asian and some countries that rely on imports, oil is still the main used energy source, as for Japan (46.1%), Republic of Korea (47.1%), Iraq (94.3%), Saudi Arabia (60.6%) etc.

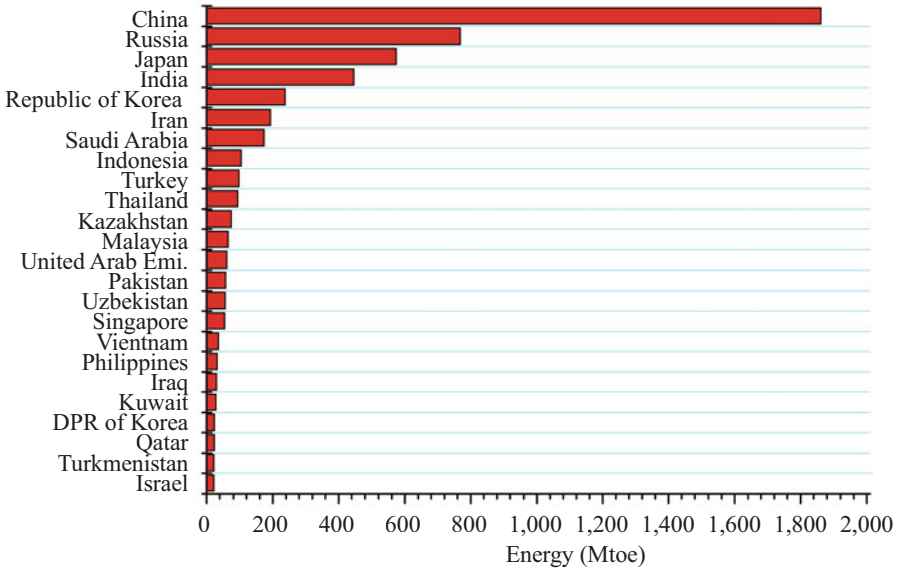


Figure 2.9 Asia energy consumption in 2006 (Top 24)

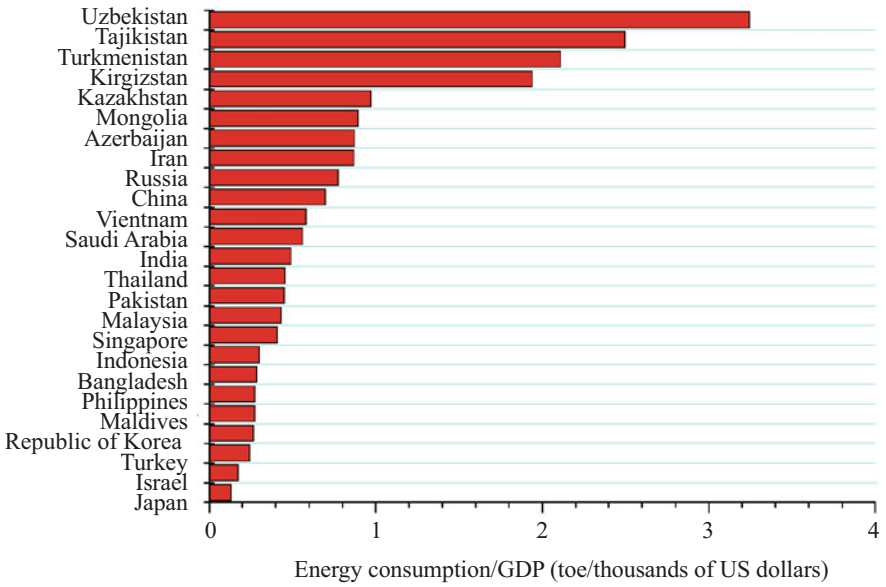
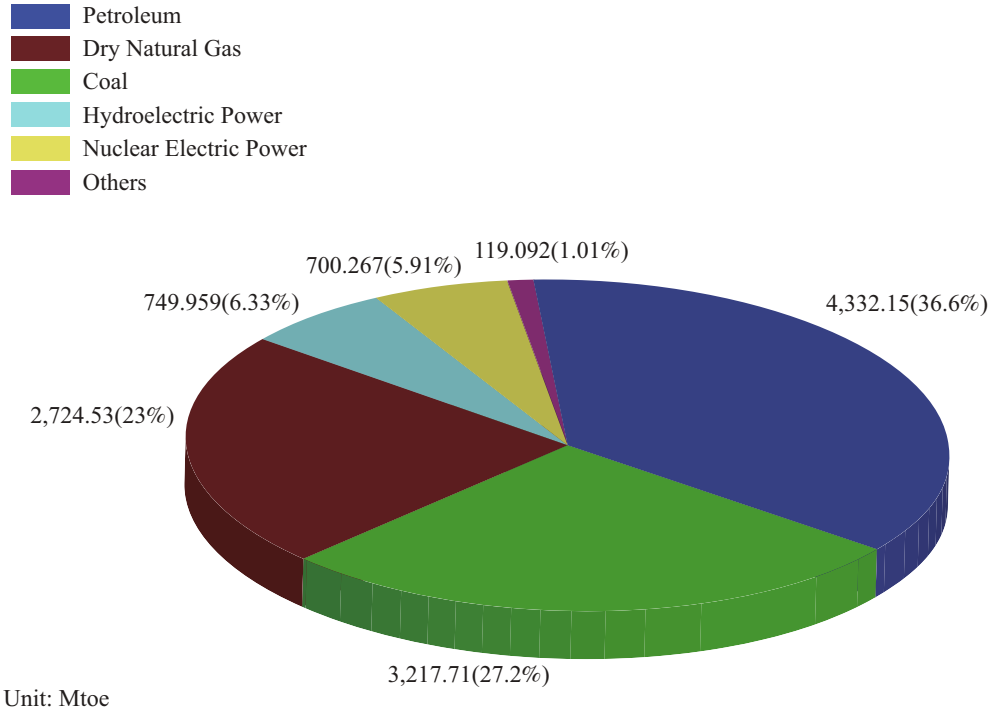
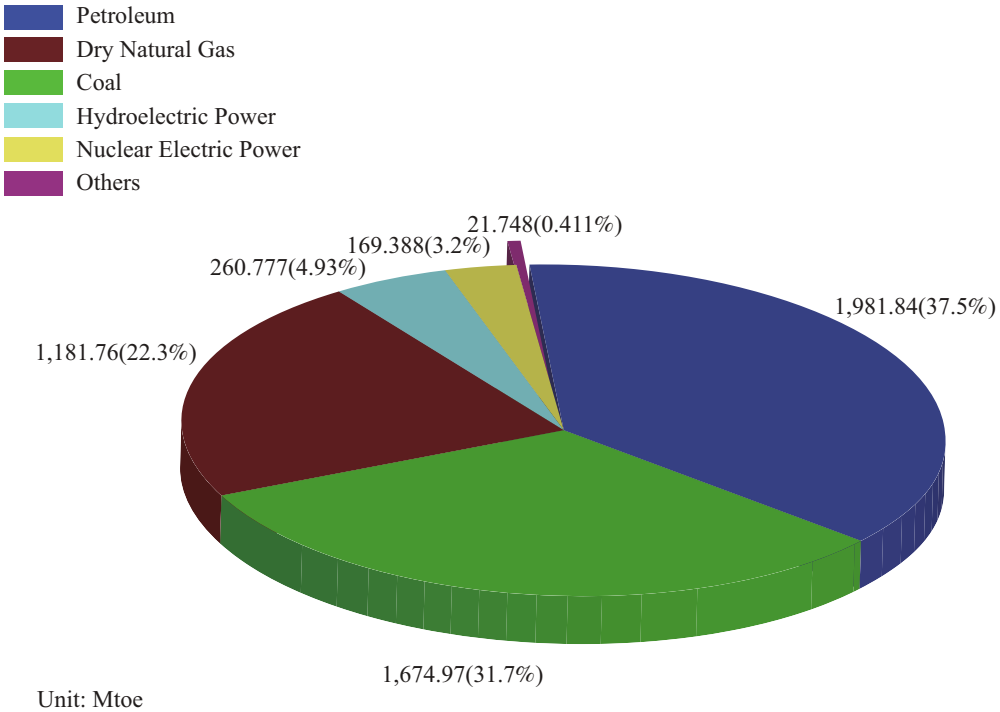


Figure 2.10 Energy consumption/GDP in 2006



Unit: Mtoe
Total Energy Consumption of World in 2006:11,843.693 Mtoe

Figure 2.11 World energy structure in 2006



Unit: Mtoe
Total Energy Consumption in Asia 2006:5,290.478 Mtoe

Figure 2.12 Asia energy structure in 2006

Figures 2.13-2.14 present the situation of the energy production minus energy consumption and the values of (production–consumption/consumption)

for different Asian countries that existed in 2005. They reflect the energy import and export situation for these selected countries. It can be seen that 16 countries mainly in the North, West and Central Asia are energy exporting, and 13 countries in the East, South-East and South Asia are mainly importing energy, the resource that we cite as the commodity that is exported and imported are mainly concentrated on oil and gas. The other 19 countries rely on their own production. The largest oil and gas exporting countries in 2005 were Russia (565 Mtoe), Saudi Arabia (475 Mtoe), Iran (145 Mtoe), United Arab Emirates (133 Mtoe), Kuwait (125 Mtoe), Indonesia (100 Mtoe). The largest energy importing countries in 2005 were Japan (465 Mtoe), Republic of Korea (196 Mtoe), India (113 Mtoe) and China (97 Mtoe). Some West Asian countries export energy at the rate of 2-7 times higher than their own consumption, while Japan, Republic of Korea and some small countries import more than 40% of their energy requirement from outside.

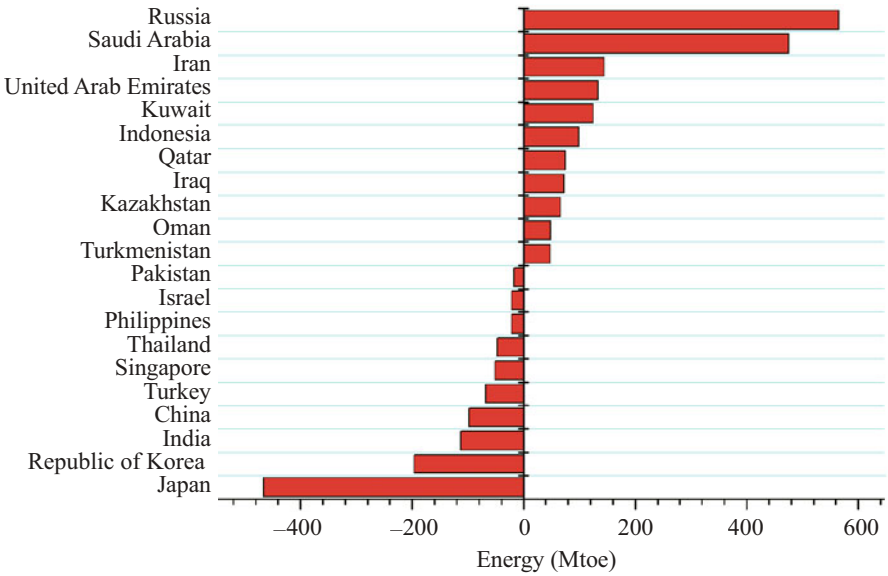


Figure 2.13 (Energy production–energy consumption) in 2005

Electric energy can be considered as the main secondary energy source for practical use. The total installed power capacity in 2006 in Asia was 1587 MkW, which is approximately 40% of the world capacity (4,012 MkW), while the total generated electricity in Asia was 7,447 Billion kW·h, which is 41% of the world generation (18,015 Billion kW·h). Figures 2.15-2.17 present the 2006 data for total installed capacity, installed capacity per capita and the generated electricity per capita for Asian countries. The installed capacity in China was 517 MkW. While in Japan—251MkW, in Russia—218 MkW, and in India—144MkW, a figure higher than 100MkW. The sum of these four countries accounts for 71% of the total Asian capacity. The installed electricity per capita and the generated electricity per capita for most countries are similar to each other. In front are the small countries with rich resources in West Asia and South-East Asia and the well developed countries. For instance, for these two parameters, Kuwait has the

highest values such as 4.5 kW/person and 18,500 kW·h/person, while India has almost the lowest of 0.13kW/person and 630 kW·h/person. The world average was 0.6 kW/person and 2,800 kW·h/person respectively, and the average values for Asia are 0.4 kW/person and 1,800 kW·h/person respectively, i.e. about 2/3 of the world averages.

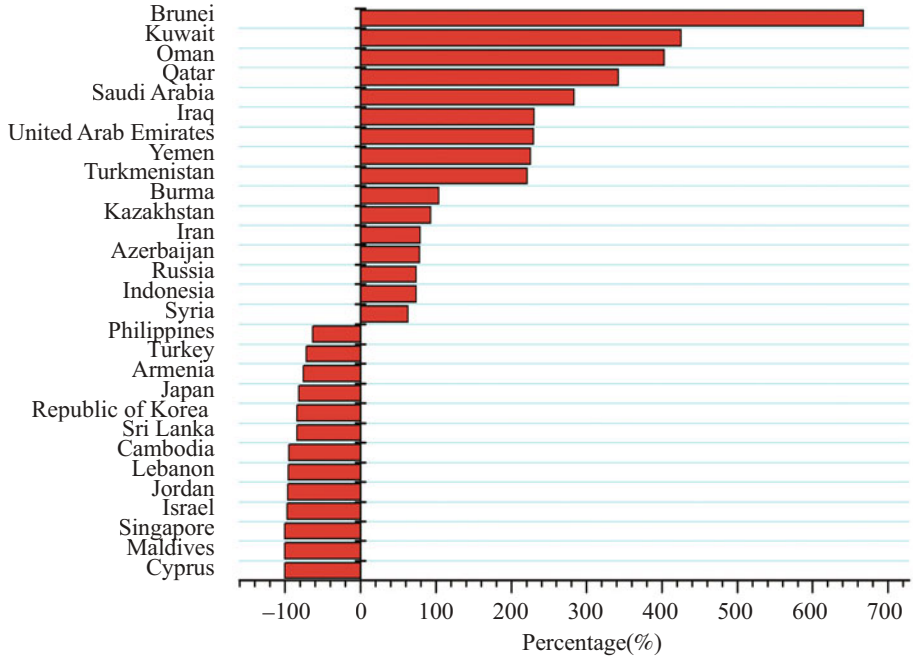


Figure 2.14 (Production–consumption)/consumption in 2005

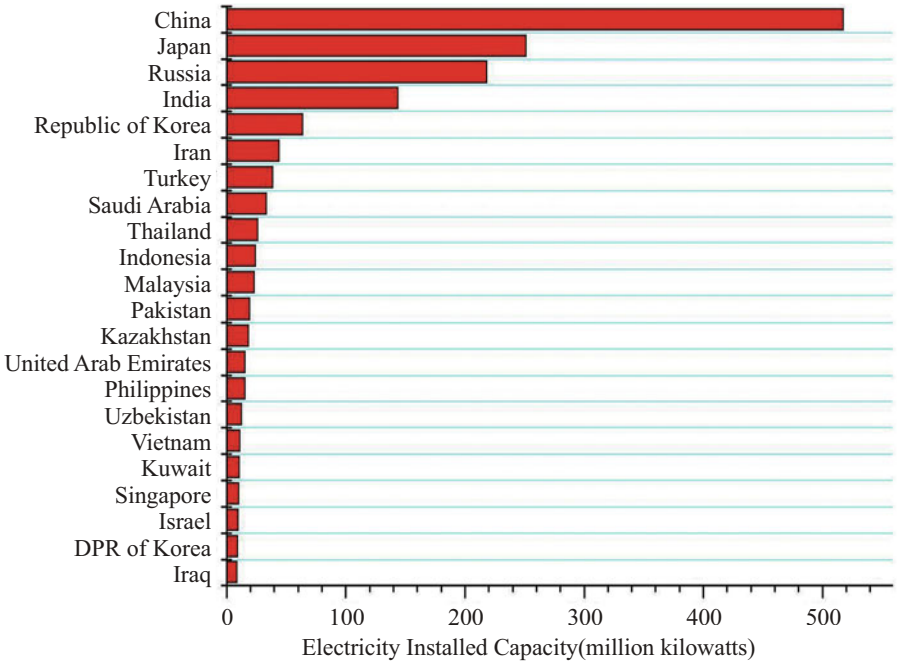


Figure 2.15 Total electricity installed capacity in 2006 (top 22)

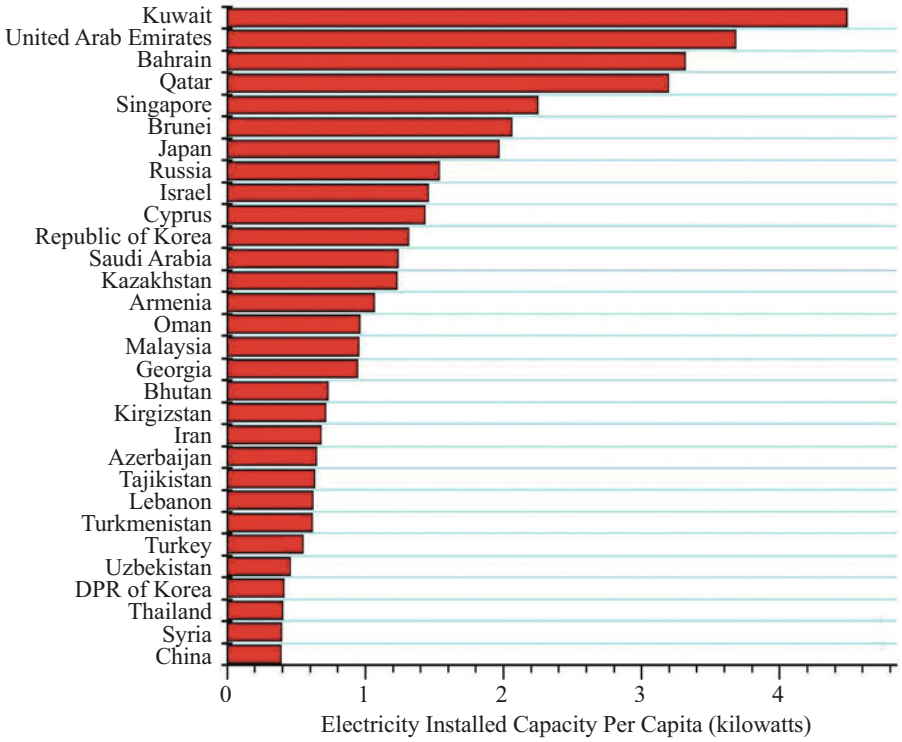


Figure 2.16 Electricity installed capacity per capita in 2006 (top 30)

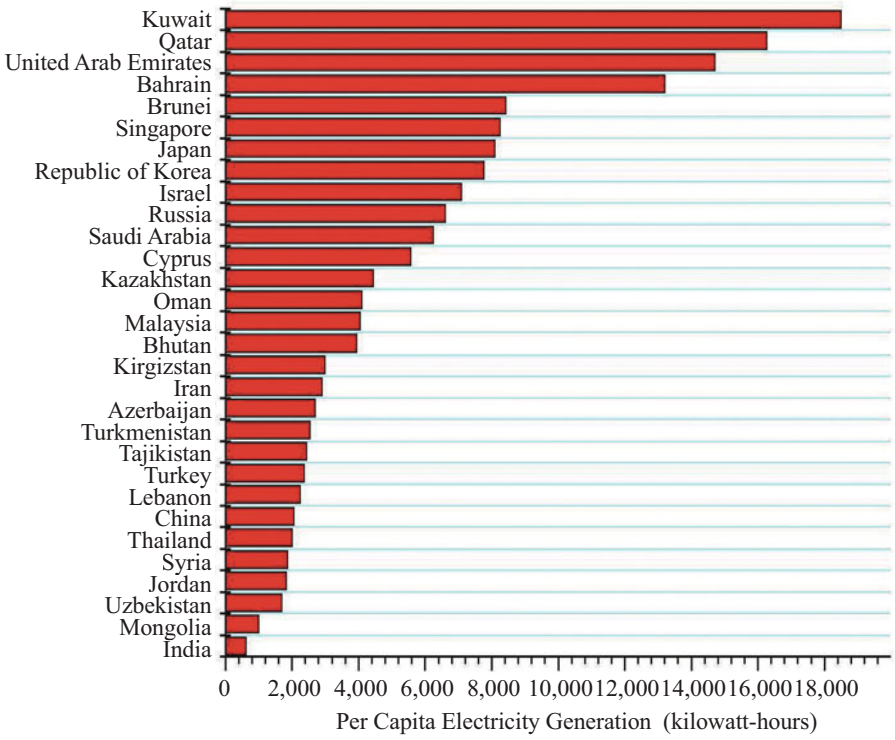
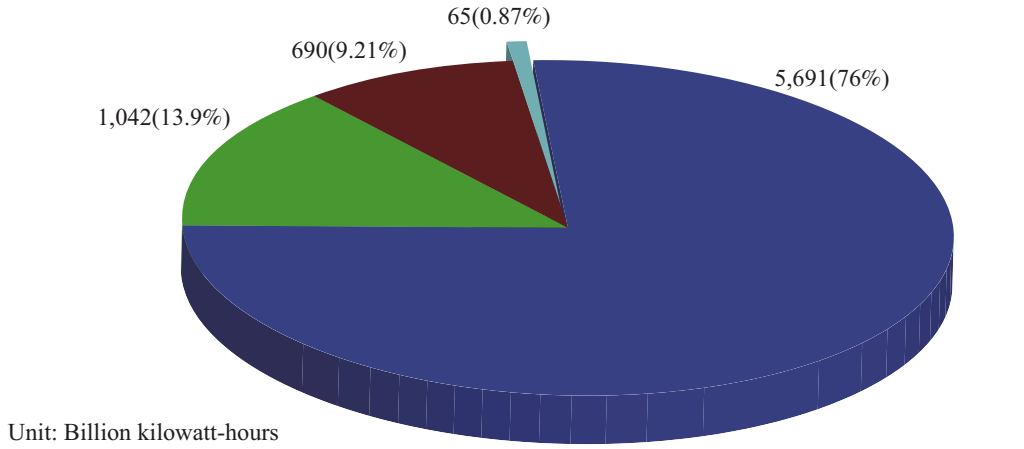


Figure 2.17 Per capita electricity generation in 2006 (top 30)

Figure 2.18 shows the electric energy structure in Asia, 2006. The electric energy structure for the world in 2006 comprised : fossil energy thermal stations—66.3%, hydroelectric stations—16.6%, nuclear stations—14.8%, non-

hydro renewable stations—2.3%, and the corresponding values for Asia are: 76%, 14.0%, 9.1% and 0.9%. The installed power capacity structure for Asia in 2006 is: fossil energy thermal stations—70.4%, Hydroelectric stations—18.6%, nuclear stations—9.0%, non-hydro renewable stations—2.0%.



Country	Fossil	Hydro	Nuclear	Renewable
China	2,225	431	55	6.2
India	566	112	16	9.5
Japan	634	85	288	26
Russia	620	174	144	3.1

Unit: Billion kilowatt-hours

Figure 2.18 Electric energy structure in Asia, 2006

Figures 2.19-2.20 present the per capita CO_2 emission from energy consumption in the year 2006 for some countries in the world. The CO_2 emission per capita of Australia was 20.58 Metric Tons/(capita·year), USA –19.78 Metric Tons/(capita·year), Germany–10.4 Metric Tons/(capita·year), Japan–9.78 Metric Tons/(capita·year), China–4.58 Metric Tons/(capita·year), India–1.16 Metric Tons /(capita·year), and the world average was 4.48 Metric Tons/(capita·year). The CO_2 emission per capita for most of the developed countries was found to be higher than those of developing countries. Figure 2.21 shows the per capita CO_2 emission for some countries during the period of 1980-2006. It can be seen that developed countries maintain a high CO_2 emission for a long period of time. On the other hand, the population in Asia was over 60%of the world population and the economic development was much faster, it has been found that the rate of CO_2 emission was much higher in the recent years. As such, the Asian CO_2 emission from energy consumption is a very important indicator for the global warming.

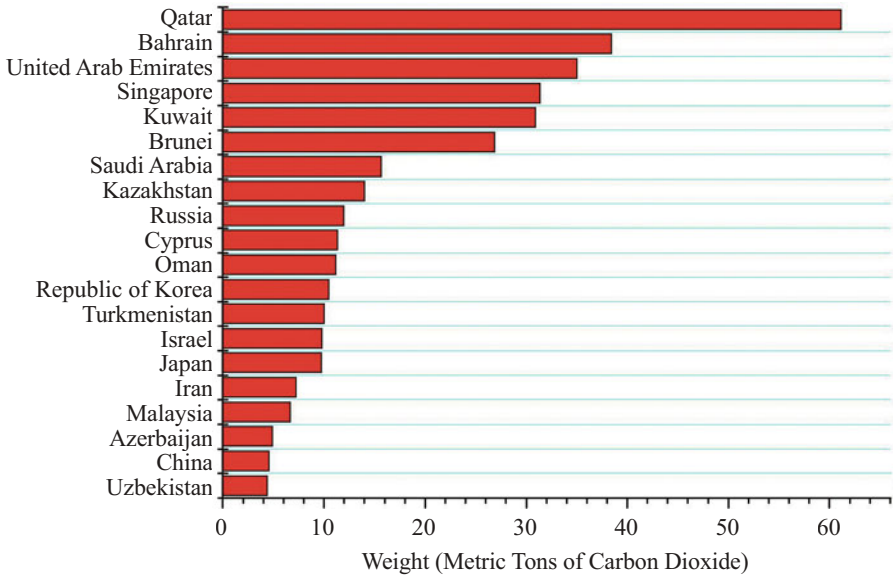


Figure 2.19 Per capita carbon dioxide emissions from the energy consumption (Asia top 20)

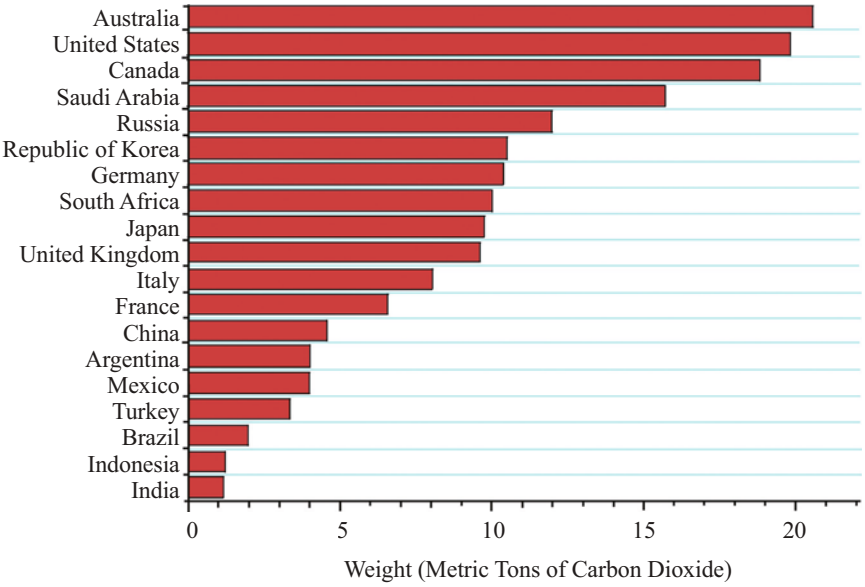


Figure 2.20 Per capita carbon dioxide emissions from the energy consumption (attendee countries of G20 Summit in London 2009)

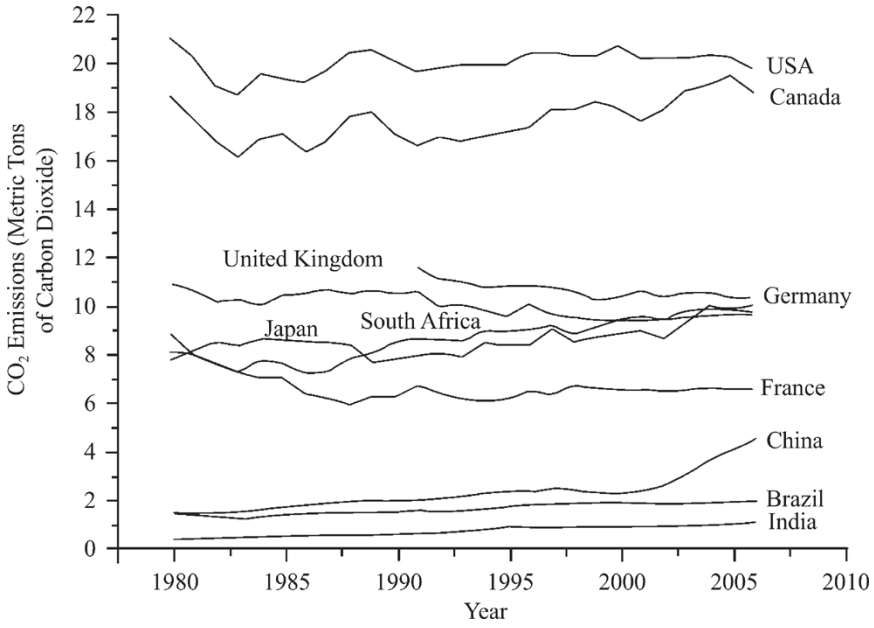


Figure 2.21 Per capita carbon dioxide emissions of selected countries from 1980 to 2006

3 Main Features

The main features of the Asia energy development approach may be summarized as below:

(1) **As an important part of the world, the development tendency should be almost identical to that of the whole world.** Figure 3.1 presents the changes in the world primary energy structure during the 1850-2007 period and estimation for 2050. It is clear that the 20th century is a fossil energy century for the whole world. Recently, the world primary energy structure is 86.8% fossil energy (petroleum 36.6%, dry natural gas 23%, coal 27.2%), hydro electric power 6.33%, nuclear electric power 5.91% , others 1.01%(Figure 2.11). For Asia fossil energy is 91.5%(petroleum 31.7%, dry natural gas 22.3%, coal 37.5%), hydro electric power 4.93%, nuclear electric power 3.2% , others 0.4%(Figure 2.12). The Asia fossil energy percentage is 5% higher, coal percentage is 10% higher, while the hydro and nuclear power are 4% lower than those of the whole world. So the pollution and climate change problems caused by energy consumption alone are more serious in Asia, and such, the needs for energy structure change to establish a future energy sustainable system is more urgent in Asia.

(2) **Since most Asian countries are developing countries with quite fast industrialization, urbanization and motorization development, its energy consumption is growing swiftly**. The energy consumption per capita in 2006 in Asia was 1.30 toe/(person·year), i.e. 71.5% of the world average 1.82 toe/(person·year) (Figure 2.4). It is fast approaching the world average value, and as such, to ensure a reliable energy supply for its future development, it is more important and difficult for Asia than for the rest of the world.

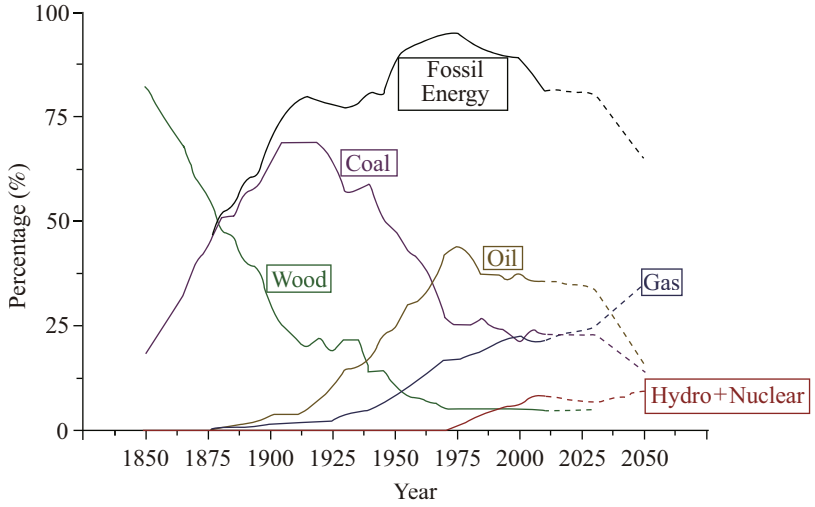


Figure 3.1 World primary energy structure (1850-2050)

(3) **Due to the large differences of the development stage, energy resource, area and population etc. the energy condition is very different for different countries. Each country needs to define its development strategy in accordance with its real situation.** For example, Japan, Russia and Republic of Korea are well developed countries in Asia, with a total population of 320 M (8%of that in whole of Asia) and as energy consumption of 1,582 Mtoe (30%of that in whole of Asia), average energy consumption per capita is 5.0 toe/(person·year). (3.8 times higher than the Asian average). The Russia consumption entirely relies on the inner production with an annual 565 Mtoe oil and gas export, Japan and Republic Korea have very limited resources internally and more than 80% of the consumption relies mainly oil and gas on import. For energy imports alone, Republic of Korea spent more money than what they gained from semiconductor and automobile export. The large developing countries with population over 100 M persons in 2006 included China(1,314 M), India(1,112 M), Indonesia(232 M), Pakistan(162 M), and Bangladesh(147 M), with a total population of about 3000M (74% of that of whole Asia), and a total energy consumption of 2,492 Mtoe(47% of that of whole Asia), their average consumption per capita was 0.83 toe/(person·year) (~64% of the average of whole Asia average). Due to the large area and population their energy consumption relies mainly on their own resources, with less than 30% imports to cover the resource and production deficit. The other 40 middle and small countries have a total population of 740M persons(18% of that of the total Asia population), and they consumed 1,190 M toe energy(23%of that of the whole Asia), and as such, accounted for a average consumption per capita of 1.6 toe/(person·year). (124% of the Asia average). Some west Asian countries have quite rich oil and gas resources, each of them exported over 70 Mtoe energy per year to the world. Good examples are, Saudi Arabia (476 Mtoe), Iran (147 Mtoe), United Arab Emirates (133 Mtoe), Kuwait (126 Mtoe), Qatar (77 Mtoe), and Iraq (70 Mtoe) (Figure 2.13). Some least developing countries,

like Nepal and Sri Lanka still mainly use the traditional biomass. So the energy development will be quite different for different countries in accordance with their real situations.

(4) **Relatively high percentage of people is still in energy poverty and without electricity.** Today an estimated 2-3 billion people use coal, charcoal, firewood, agriculture residues or dung as their primary fuel, roughly 1.6 billion people world-wide live without electricity, a large percentage of these people is in the developing countries of Asia. The provision of modern forms of energy to such poor people could generate multiple benefits, and as such, top priority must be given to solve the global poverty in the future energy development process.

(5) **The energy efficiency is still quite low (Figure 2.10), in 2006 the average energy consumption per GDP for whole Asia is 0.42 toe/10^3 US dollars, which is almost 70% higher than the world average(0.25 toe/10^3 US dollars).** If the energy efficiencies of China, which has 0.7 toe/10^3 US dollars, and India, which has 0.5 toe/10^3 US dollars, are considered, it can be seen that there are 3 and 2 times higher than world average, and also 5.3 and 3.7 times higher than the lowest value of Asia (Japan, 0.13 toe/10^3 US dollars). Energy efficiency depends on many factors, mainly: economical structure of the whole society, energy saving in industry, transportation and building, technology improvements and innovations etc. To improve the situation, governments of every country should develop and implement corresponding policies and regulations to achieve higher energy efficiency for a great variety of processes, services and products. The science and technology community should step up its efforts to research and develop new and low-energy technologies.

(6) **With the fast increase of the fossil energy consumption the environment protection and climate change problem become more serious.** Coal and oil burnings are the major source of pollution and CO_2 emission. Pollution of air, water and solid waste has serious influence on the environmental conditions and public health, as CO_2 as green house gas emission causes global warming. Due to pollution caused by such processes air quality in many Asian cities has dropped below the required air quality standards, many lands have been converted into deserts or are affected by acid rain, leading to the pollution of a lot of the existing water systems. Due to the green house gas emission the earth's surface temperature has already increased by about 0.4 ℃ from 1960 to 2000. The related effects of the temperature rise had already caused serious concern among the people. Although the CO_2 emission per capita is much higher in developed countries than for developing countries, where for example (Figures 2.19-2.21) in 2006, USA had 19.78 Metric Tons CO_2/(person·year), Japan—9.78 Metric Tons CO_2/(person·year), China—4.58 Metric Tons CO_2/(person·year), India—1.16 Metric Tons CO_2/(person·year), with the world average being 4.48 Metric Tons CO_2/(person·year). The Asian countries are mostly developing countries, but the Asian population is over 60% of that of the world population and the economic development has become much faster in recent years. Although CO_2

emissions in Asian countries, which are mostly developing countries, are much lower than those of developed countries, leaders and people in Asia are paying increasing attention to environmental protection and climate change. However practical efforts to solve the problems are at their initial stages.

(7) **Advanced technology research, development and application are very important for future energy development.** The necessary and the associated activities to change the energy structure, and thereby enhance the energy efficiency with significant energy saving, which would also ensure environment protection and reduce climate change problems associated with energy consumption and to guarantee a reliable and sustainable energy supply, are receiving increasing attention and support from government, industrialists and scientists, and also from almost all established institutions established for energy management, research and development. But these efforts should be further strengthened. There is a wide technological gap between the developed and developing countries in Asia, which reinforces the need for intra-Asian international cooperation.

4 Main Challenges

Based on the presentation and discussion at two of our workshops (Appendix A) and the collected data of the energy situation of Asian countries for 2006-2007 (Appendix B), the energy development in Asia is facing many challenges, of which some are listed below:

(1) **To provide an adequate, reliable and a sustainable energy supply to meet the fast growing energy needs.** Reliable energy supply is the basis for healthy and fast social and economic development for every country. Therefore, special attention should be diverted to the extension of basic energy services to the people who currently lack access to modern forms of energy to solve the global poverty problem. It is estimated that the global energy demand will be about 60% higher in 2030 than 2000, while the average demand per capita in Asia will approach in 2030 the world average (presently is 71.5%). The total Asia demand will be 2.2 times higher than today, i.e. almost 11.9 billions toe, which is quite a big challenge. Sustainability depends on many factors such as: the available primary energy resources, the production capability, the environment protection, the climate change, the import and export possibility etc. so its strategy and policies may be different for different countries.

(2) **To guarantee the energy security mainly with the oil supply.** Many Asian countries have neither any or sufficient oil resources and production capabilities and as such they have to import quite a large quantity of oil from outside. For example, Japan imported annually 230 Mt, China—230 Mt (including 50 Mt for Taiwan), Republic of Korea—100 Mt, India—80 Mt, Singapore—40 Mt, Thailand—30 Mt, the total sum being about 32%of the total Asian oil production(2,210 Mt)and 18% of the total world oil production(4,000 Mt). Due to the rapid development of transportation the oil consumption in the Asian countries grew very quickly, but due to limited resource and production capability the world oil production will increase slowly and after 2030 it may even being to decrease, so oil supply security will become the first energy security problem for the world. Many effective measures should be taken to solve this problem and thereby reduce future geopolitical conflict and economic vulner-

ability.

(3) **To reduce pollution from energy consumption and improve the environment protection.** Over 90% of the used primary energy is fossil energy. Many important pollutants appear with fossil energy combustion in air, water and land. The air quality in the cities drops to a relatively lower value, even below the minimum standard requirement. Many lands were affected by acid rain and can even get transformed to a desert, water is polluted by many harmful materials, their influence on the living condition and health of the people becoming more and more un-acceptable. Although environment protection receives much more attention in all countries, up to now only particle and SO_2 emissions are under active control. Activities relating to the control of fine particle, mercury, ozone, NO_X and others had just begun. Following the experience of advanced countries the protection work with detailed measurement, the quality standard establishment and practical control should be strengthened.

(4) **To reduce the CO_2 emission caused by energy consumption and the possible global warming.** The green house gas CO_2 emission in the world is due mostly to the use of fossil fuel. Coal is still the main resource for power generation in this century, and it generates almost twice as much CO_2 per unit of energy supplied than natural gas. Recently the coal percentage in Asia was found to be 37.5% in the primary energy structure, which is about 10%higher than in the world. With the sharp increase of the energy consumption, the CO_2 emission becomes much more serious. The CO_2 capturing and sequestering technology development is just under discussion and small scale research and development work have just started. The global warming consideration may be the main factor to limit the future use of fossil energy in Asia, and it is necessary to aggressively pursue efforts to develop advanced coal technologies and the carbon capture and storage technology.

(5) **To establish the future sustainable energy development system with significant changes in the primary energy structure.** The world energy situation has already entered into a new phase to establish gradually the sustainable energy development system with significant reduction of the fossil energy percentage and large increase of non—carbon nuclear and renewable energy percentage. Asia will follow the same path but with more difficulties. For this purpose Asia may need to work in a more coordinate and effective manner in five different areas as listed below: ① Based on the development of high—efficiency, clean and low—carbon emission technologies, to continue the active utilization of coal within the allowable limits of the resource, environment and climate change allowable limits. ② Use all possible resources in the development of alternative oil sources and ensure the reduction of transportation, which is heavily dependent on oil and thereby ensure a sufficient oil supply. ③ On the basis of available resources, as much as possible to develop hydro and nuclear power. ④ Large scale development and application of non-hydro renewable energy, mainly solar, wind and biomass ener-

gies. ⑤ Actively support research and development of the future novel energy resources, mainly, nuclear fusion and methane hydrate. Hopefully, the basis for this sustainable system could be formed during the first half of this century.

(6) **To enhance the energy efficiency with significant energy saving.** The average energy consumption per GDP in Asia is almost 70% higher than the world average, the difference between different countries being quite high. For instance Japan has 0.13 toe/10^3 US dollars GDP, Uzbekistan has 3.2 toe/10^3 US dollars GDP. The enhancement of the energy efficiency is very important to reduce the total energy consumption and to slow down the increase of the energy demand for every country. Although many governments in Asia had already paid attention to adjust its economical structure, to establish strict regulation for energy saving approaches in different areas and to mobilize people to save energy in their daily lives, in order to have significant results, and to ensure that all these efforts are continued for a long time.

(7) **To strengthen the research, development and application of the advanced technology and the cooperation among Asia countries.** It is well recognized that for future sustainable development we need to improve existing technologies to a high degree, and to innovate and develop new technologies to create an entirely new basis for new industry. Most Asian countries established recently their institutions for technology research, development and management, for training high level experts and for organization of effective international cooperation. Though the related work has just begun, such activities should be strengthened in the future.

(8) **To form the development strategy and policies in different countries.** Though the conditions are quite different for different countries in Asia, energy development has very close relation with many important areas of the whole country, such as practical needs, primary energy resources, industrial production capability, environment protection, global warming, import and export situation etc. In particular, the capacity to deliver the policy and regulatory reforms that are required for such development would be a critical challenge for each country. Based on its real situation every country needs to study its own development strategy, to form its own development program, to define the necessary policies and regulations to guide its own development. The corresponding work should be strengthened.

Since Asia is still in the fast developing stage, for future development it could adopt the world's best practices and technologies for infrastructure expansion, new infrastructural projects (power plants, transportation, residential buildings and new industries) and in effect Asia could adopt the most efficient technologies. Such an approach would provide Asia with many good opportunities to overcome the above challenges and to create a global revolution in the way we produce and use energy.

5 Main Recommendations

For the present situation, based on the main features and the main challenges of the energy development in Asia, the probable main recommendations for future sustainable energy development in Asia are:

(1) **To establish a sustainable energy system for Asia is the main objective and guide line for the future development.** Sustainability means the exploitation of natural resource for the generation of energy within acceptable levels of global resource depletion and environmental pollution, but without destroying the ecological balance of the earth. The system could provide sufficient, reliable energy to cover the necessary consumption requirement. This approach will significantly reduce the fossil energy dependence and will lead to a large increase of non-carbon nuclear and renewable energy percentage. Each country should establish its own energy indicators for sustainable development, and formulate strategies that will continuously improve them.

(2) **High priority should be given to the energy saving and the enhancement of the efficiency to reduce as high as possible the total energy consumption requirement.** All countries should develop and implement policies and regulation to achieve significant energy saving and greater energy efficiency for all processes, service and products. The main areas that should be targeted for energy saving are industry, transportation, building and commercial establishments. It is especially important to enhance the dissemination of technology improvement and innovation between industrialized and developing countries, so that the developing countries can adopt cleaner and more efficient technologies as their industrialized counterparts.

(3) **Active high-efficiency, low pollution and low carbon emission utilization of coal should be further developed and strengthened.** As the world's most abundant fuel, coal will continue to play an important role in the world's energy mix, though at present, its utilization cause serious pollution and generates almost twice as much CO_2 per unit of supplied energy than natural gas. Although in the process of the establishment of a sustainable energy system the coal percentage in the world primary energy supply will decrease gradually, the utilized quantity of coal will still increase in the coming decades, as many

coal fired power station will be constructed and put into operation in Asia. Coal can only be used as an energy resource, within the allowable limits of environment and climate change. So it is important to continue and strengthen the development and application of the advanced high-efficiency, clean and low-carbon emission technologies, such as IGCC (Integrated Gasification Combined Cycle), pollution measurement and control, carbon capture and storage etc. For pollution measurement and control for coal consumption, besides the particle and SO_2 measurements, the other important pollutants such as O_3, Hg and NO_X etc should also be measured and controlled. The carbon capture and storage activities have just started in Asia, mainly at the discussion and preparation stage, it is necessary to develop regulation and introduce a price signal for carbon emission to accelerate the development of biomass and other renewable energy technologies. The development of the potential retrofit technologies for post-combustion carbon capture at existing pulverized coal plants and the most efficient technologies for the new coal plants should get more attention and support for experimental studies and also for the demonstration of their reliability, safety and economic performance, so that global warming will not be the main factor limiting the utilization of coal.

(4) **Provision of a reliable oil supply to overcome the most critical energy security problem in Asia.** As mentioned before, many Asian countries lack sufficient oil resource and the production capabilities and as such, they have to import a large quantity of oil. With the rapid development of transportation, the oil consumption also increases very fast. But, as the world oil production is expected to reach its maximum in 2020-2030, the competition for oil supply has the potential to become a source of growing geopolitical tension and economic vulnerability. To guarantee a reliable oil supply, it is needed: ① To reduce the oil consumption especially for transport system development by improving the automobile, train, ship and aircraft energy efficiency and by developing electric cars, trains and maglev to use electric energy instead of oil. ② To develop alternative to replace oil for transportation needs, such as extracting oil from unconventional sources (tar sands and shale oil), coal and gas liquefaction and biomass fuels. ③ To use other resources to replace oil, such as compressed natural gas, hydrogen etc. Although most of these methods already exist, but to play an import role to replace oil, they should be developed to be of large scale production and application.

(5) **On the basis of available resources, hydro and nuclear power should be developed as much as possible.** As sustainable, low-carbon resources, hydro and nuclear power plants generate no CO_2 and conventional air pollution emission during operation, and as such, they have already become large scale energy resources in the world. In Asia in 2006 the total installed capacity of hydropower (Russia not included) was 212GW and nuclear power was 103GW, i.e. 18.6% and 9% respectively of the total Asian installed capacity of power. To solve the present situation of pollution and global warming associated with fossil energy utilization and to form the future sustainable energy system,

priority should be given to the large and fast development of hydro- and nuclear power in the near future. In places where large hydropower deployment may not be acceptable, small to medium alternatives such as run-of- river type schemes should be explored. Hopefully, all Asian countries will use their hydro resources to build hydro-plants where the ecological condition and emigration will allow. Presently, in Asia only countries such as Russia, Japan, Republic of Korea, China, India, Pakistan and Armenia have nuclear plants. Large scale nuclear power development is still facing the problems associated with plant safety, capital cost, waste management and weapon proliferation. As such, it is needed to solve all these problems to encourage more countries to have nuclear power and to enhance its significance for energy supply. The present nuclear power plants uses pressurized water reactor, and the natural uranium resource are also limited. As such, for future large scale development of nuclear power it is needed to strengthen the fast breeder development and thorium resource application study.

(6) **Wind power to be developed as the second large scale renewable energy resource after hydro-energy, with its already matured technology and industry, good economic performance and with its bright large scale commercialization in the near future.** Since 1980's grid connected wind farms started to provide power to the network and by 2007 the total installed capacity had already reached 94 GW in the world, with a contribution of 14GW from Asia (India—7.8GW, China—5.9GW). The importance of the rapid development of wind power is already well recognized by Asian countries and many new large wind farms are under construction. To promote its fast and large scale development, it is needed to strengthen the detailed wind resource measurement, to develop 5-10MW large units with good quality and reliability. To reduce further capital investment and energy cost to improve its economical performance, to enhance the network regulation capability to overcome its unstable drawback, its development should be coordinated with the whole power system development.

(7) **The development of the contribution of solar energy, which is, even at present, one of main renewable energy resource to a relatively large scale, in future sustainable energy system with a good basis for small scale heat and power application.** Heat application for cooking, heating, drying, air conditioning and building methods for energy saving etc should be increased significantly to provide a large percentage of the total energy supply. Power application should become an important partner in the whole power system. There are two types of solar power. They are solar photovoltaic and solar thermal. The development of PV's (PhotoVoltaic) Power has been very rapid in the recent years and in 2007 the world total installed power reached 12.6GW, PV cell production reached 4GW. China and Japan produced 2GW through PV cell. PV power has the advantage of being used for different power supply regions ranging from kW to GW. It possess low maintenance, including stand alone power (<100kW) for remote area without any electricity supply. In the provision of

grid connected building integrated power (<5MW) for distributed network in the cities and large scale concentrated plant (up to 10GW) in the desert area, the possible market is very wide. For its future large scale development it is needed to reduce its capital investment and energy cost significantly, to develop new high efficiency PV cells and to have privileged policies and the demonstration of project supported by the government and also power systems. The principle of solar thermal power is similar to the usual coal-fired plant, and it has advantages for large scale application, such as: ① In industries where boiler, turbine, and generator already exist. ② Energy can be stored in thermal state to overcome the non-continuous solar resource problem. ③ The boiler can be used even for gas or coal burning to generate continuous power. Three solar thermal systems (trough, tower, and disk) already have demonstration plants in operation, but for large scale application there is still a lot of development and commercialization work to be done.

(8) **The growth of the role and significance of Biomass, which was the main energy resource for mankind for a very long time in the rural areas of many Asian countries, before the active utilization of fossil energy in the process of forming the new sustainable energy systems.** Biomass can be used to provide heat and power. It is the only renewable energy which can be converted into liquid fuel for transportation. The use of agriculture and forest residues and city wastes, for the generation of biomass power, in both liquid and solid fuels forms are already in commercialization stages. Due to the difficulties of resource collection and transportation the unit power plants have capacities less than 50MW, and the fuels are used locally. For large scale development, it is needed to have more concentrated resources, the energy crops should be grown significantly, taking into account that there is considerable scope to increase the yield of energy crop production using biotechnology and good agricultural practices. Processing biomass to increase energy density such as palletizing and torrefaction can reduce transport cost substantially, and therefore should be promoted. New commercial methods for producing liquid fuels should get more attention and support to be matured as soon as possible to avoid the conflicts between biofuel production and food production.

(9) **The strengthening of long-term perspective advanced research and development work in the energy field.** For example: ① Fusion is the most important future sustainable energy resource on earth. Japan, China, Republic of Korea and India has already been working in the area of fusion research for a long period of time and hopefully a fusion power station may appear in Asia very early. ② The energy potential of gas-hydrates is estimated to be twice the energy contained in the world total fossil fuel reserves. Very large reserves of this resource has already been discovered in Asia (India, Japan, China) and with innovative scientific and technological developments its utilization as a energy resource can meet the future energy demand and reduce the environmental and geo-hazards. The related work has already started and should be strengthened with continuous stable support. ③ Hydrogen is the new potential energy carrier

for the future, it can be used for power generation, as a transport fuel and can be produced by solar, biomass and fossil energy. Study on the production, storage, transportation and application of hydrogen has already started and should be stably continued. ④ In accordance with the available resources, the geothermal, tidal and ocean energy are also important for related countries. ⑤ For effective energy utilization the improvement of the energy storage technologies (pumped hydropower, compressed air, chemical batteries) and the development of the new technologies (superconducting magnetic storage, redox flow cell, and supercapacitor) are also important.

(10) **The need to organize studies to define their development strategies, program and privileged policies relevant to each country in accordance with their real situation.** As a basis for the practical research, development, industrialization and application work. The international exchange and cooperation, especially among Asian countries, should be highly encouraged.

6 Concluding Remarks

Asia is entering the phase of establishment of the future sustainable energy system. Sustainability means to provide sufficient, reliable energy to cover the necessary, rapidly increasing consumption requirement with available natural resources within acceptable levels of global resource depletion and environment pollution, but without destroying the ecological balance of the earth. It is necessary to reduce gradually the dependence on the fossil energy percentage and thereby enhance the reliance on low carbon nuclear and renewable energy percentage.

Based on the two AASA workshops on sustainable energy development in Asia, and the collected statistical data, this report presents the general information about the present energy development in Asia, the analysis of the main features, the main challenges and provides some main recommendations for the near future development.

We hope that this report will help the leaders, science and technology communities and all people working in the energy field of all Asian countries to go forward with more confidence and courage.

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Appendix A

List of the Energy Related Papers Presented at 1st Workshop and 2nd Workshop in Beijing

1st Workshop (Feb.25-26, 2008)

(1) Yan Luguang (China): "Study on the Energy Sustainable Development in China for First Half of 21st Century".

(2) Seung Mo Oh (Republic of Korea): "Energy Policy and R&Ds in Korea".

(3) Christopher C. Bernido (Philippines): "Natural & Human Resources".

(4) Harsh Gupta (India): "Emerging Energy Resources in India".

(5) Oktay Kerimov (Azerbaijan): "Azerbaijan: Science, Economy, Power Industry & Environment".

(6) Saran Solongo (Mongolia): "Sustainable Development in Asia: Mogolia".

(7) A.G. Korzhubaev (Russia): "The forecast of development of the oil and gas industry of Russia and Prospect of export of oil and gas to the Asia Pacific".

(8) Hassan Zohoor (Iran): "Status of Energy in Iran".

2nd Workshop (Nov.17-18, 2008)

(1) Dato Lee Yee Cheong (Malaysia, IAC Representative): "Lighting the Way: Toward A Sustainable Energy Future, (Summary of IAC Report)".

(2) Xavier Chen (BP China): "World Energy Developments and Challenges for Asia".

(3) Wang Yi (China): "Briefing on the AASA Project 'Sustainable Development in Asia'".

(4) Yan Luguang (China) : "Consideration of the Energy Sustainable Development in China".

(5) Hassan Zohoor (Iran): "Status of Energy in Iran".

(6) Volkan S. Ediger (Turkey): "National Energy Report of Turkey: Energy Situation, Challenges, and Policies for Sustainable Development".

(7) Indral K. Perera (Sri Lanka) : "Development of Alternative Energy Sources with Special Emphasis to The Current Situation in Srilanka".

(8) Rishi K. B. Shah (Nepal): "Energy Structure of the Nation and the Prospects of Renewable Energy Resources Potential for Sustainable Development against the Conventional Energy—Challenging Task Ahead for Nepal".

(9) Bundit Fungtammasan (Thailand): "Sustainable Energy Development in Thailand: Recent Acheivements and Future challenges".

(10) M. Shamsher Ali (Bangladesh): "Energy Mix Policy And Sustainable Energy Development Issues of Third World Countries".

(11) Seung Mo Oh (Republic of Korea): "Energy Policy and R&Ds in Korea".

(12) M. Yaghoubi (Iran): "Studies of Environmental Compatible Buildings Using Domed Roof Architectures for Passive Cooling in Hot Arid Regions of Iran".

(13) H. K. Gupta (India): "The Indian Scenario of Gas Hydrates".

(14) Muhammad Yahaya (Malaysia): "Sustainable Energy Development and Strategies for Malaysia".

(15) Alvin B. Culaba (Philippines): "The S&T Challenges in the Philippine Energy Sector".

Appendix B

Tables for Statistic Data of Energy Situation of Asia Countries

Table B1 All Asia country basic statistic data : area-population-GDP-energy consumption-energy intensity (2006-2007)

No	Country in Asia	Area (sq. km)	GDP (millions of US dollars)		Population (millions)		GDP/Population (US dollars/person)		Energy Consumption 2006 (Mtoe)	Energy Consumption/ GDP (toe/ thousands of US dollars)
			2006	2007	2006	2007	2006	2007	2006	2006
1	Afghanistan	647,500	8,399	11,627	31.06	31.89	302.7	364.6	0.443	0.052
2	Armenia	29,743	6,406	9,177	2.98	2.97	2,130.4	3,089.9	5.113	0.798
3	Azerbaijan	86,600	20,122	31,248	8.07	8.12	2,374.6	3,848.3	17.567	0.873
4	Bahrain	665	12,914	16,041	0.70	0.71	17,451.4	22,593.0	12.255	0.949
5	Bangladesh	144,000	61,961	67,694	147.37	150.45	429.3	449.9	18.753	0.302
6	Bhutan	47,000	927	1,096	0.66	0.67	1,432.8	1,635.8	0.759	0.818
7	Brunei	5,770	6,400	11,562	0.37	0.37	16,797.9	31,248.6	4.474	0.699
8	Burma (Myanmar)	678,500	NA		46.99	47.37			5.966	
9	Cambodia	181,040	7,193	8,628	13.76	14.00	501.2	616.3	0.235	0.033

Continued

No	Country in Asia	Area (sq. km)	GDP (millions of US dollars)		Population (millions)		GDP/Population (US dollars/person)		Energy Consumption 2006 (Mtoe)	Energy Consumption/ GDP (toe/ thousands of US dollars)
10	China	9,596,960	2,668,071	3,280,053	1,313.97	1,321.85	2,033.9	2,481.4	1,862.586	0.698
11	Cyprus	9,250	15,418	21,277	0.78	0.79	20,154.2	26,932.9	3.060	0.199
12	Georgia	69,700	7,550	10,176	4.66	4.65	1,702.0	2,188.4	3.372	0.447
13	India	3,287,590	906,268	1,170,968	1,111.71	1,129.87	816.6	1,036.4	445.698	0.492
14	Indonesia	1,919,440	364,459	432,817	231.82	234.69	1,634.0	1,844.2	104.668	0.287
15	Iran	1,648,000	222,889	270,937	65.03	65.40	3,223.1	4,142.8	193.907	0.870
16	Iraq	437,072	NA		26.78	27.50			31.345	
17	Israel	20,770	123,434	161,822	6.87	6.99	17,535.7	23,150.5	21.561	0.175
18	Japan	377,835	4,340,133	4,376,705	127.52	127.43	34,022.9	34,346.0	574.830	0.132
19	Jordan	92,300	14,176	15,832	5.91	6.05	2,537.8	2,616.9	7.733	0.545
20	Kazakhstan	2,717,300	77,237	103,840	15.23	15.28	5,045.5	6,795.8	74.978	0.971
21	DPR of Korea	120,540	NA		23.11	23.30			23.937	
22	Republic of Korea	98,480	888,024	969,795	48.85	49.04	18,340.8	19,775.6	238.316	0.268
23	Kuwait	17,820	80,781	102,095	2.42	2.51	31,081.6	40,675.3	28.663	0.355
24	Kirgizstan	198,500	2,695	3,505	5.21	5.28	518.3	663.8	5.225	1.939
25	Lao PDR	236,800	3,404	4,008	6.37	6.52	590.5	614.7	0.600	0.176
26	Lebanon	10,400	22,722		3.88	3.93	5,603.5		5.132	0.226

Continued

No	Country in Asia	Area (sq. km)	GDP (millions of US dollars)		Population (millions)		GDP/Population (US dollars/person)		Energy Consumption 2006 (Mtoe)	Energy Consumption/ GDP (toe/ thousands of US dollars)
27	Malaysia	329,750	148,940	180,714	24.40	24.84	5,780.3	7,275.1	64.735	0.435
28	Maldives	300	915	1,049	0.36	0.37	2,715.1	2,835.1	0.251	0.274
29	Mongolia	1,564,116	2,689	3,894	2.91	2.95	1,040.2	1,320.0	2.407	0.895
30	Nepal	147,181	8,052	10,207	28.29	28.90	291.1	353.2	1.708	0.212
31	Oman	212,460	24,284	35,729	3.10	3.21	9,258.1	11,130.5	13.874	0.571
32	Pakistan	803,940	128,830	143,597	161.74	164.74	810.2	871.7	57.962	0.450
33	Philippines	300,000	116,931	144,129	89.47	91.08	1,382.3	1,582.4	32.071	0.274
34	Qatar	11,437	42,463	42,463	0.89	0.91	51,283.8	46,662.6	22.856	0.538
35	Russia	17,075,200	986,940	1,291,011	142.07	141.38	6,932.3	9,131.5	767.717	0.778
36	Saudi Arabia	2,149,690	309,778	381,683	27.02	27.60	13,081.3	13,829.1	173.842	0.561
37	Singapore	692.7	132,158	161,347	4.49	4.55	30,083.8	35,460.9	54.028	0.409
38	Sri Lanka	65,610	26,967	32,354	20.72	20.93	1,363.9	1,545.8	5.509	0.204
39	Syria	185,180	34,902	38,081	18.88	19.31	1,790.2	1,972.1	20.435	0.585
40	Tajikistan	143,100	2,811	3,712	6.94	7.08	422.6	524.3	7.023	2.498
41	Thailand	514,000	206,247	245,818	64.63	65.07	3,186.6	3,777.7	93.987	0.456
42	Timor-Leste	15,007	356	395	1.06	1.09	346.0	362.4	0.000	0.000
43	Turkey	780,580	402,710	657,091	70.41	71.16	5,521.5	9,234.0	98.710	0.245

Continued

No	Country in Asia	Area (sq. km)	GDP (millions of US dollars)		Population (millions)		GDP/Population (US dollars/person)		Energy Consumption 2006 (Mtoe)	Energy Consumption/ GDP (toe/ thousands of US dollars)
44	Turkmenistan	488,100	10,496	12,933	5.01	5.10	2,143.4	2,535.9	22.134	2.109
45	United Arab Emirates	83,600	129,702	129,702	4.27	4.44	27,977.1	29,212.2	62.164	0.479
46	Uzbekistan	447,400	17,178	22,308	27.31	27.78	647.2	803.0	55.730	3.244
47	Vietnam	329,560	60,884	71,216	84.40	85.26	723.9	835.3	35.415	0.582
48	Yemen Arab Republic	527,970	19,057	22,523	21.47	22.23	880.9	1,013.2	6.742	0.353
World		510,072 ,000	48,244,879	54,347,038	6,519.26	6,595.77	7,400.4	8,239.7	11,843.693	0.246
Asia		48,854,449	12,674,873	14,712,859	4,061.92	4,107.61	3,120.4	3,581.9	5,290.478	0.417
Source		https://www.cia.gov	http://www.worldbank.org		http://ceq.hss.doe.gov				http://eia.doe.gov	

Note:
1. Area is sum of land area and water area, not land area only
2. NA=Not available

Table B2 Six Asia regions' basic statistic data :
area-population-GDP-energy production and consumption-electricity generation (2005-2006)

Region	Country	Area		GDP 2007		Population 2007		Primary Energy Production 2005		Primary Energy Consumption 2006		Electricity Generation 2006	
		Value (sq. km)	Percent in Asia (%)	Value (millions of US dollars)	Percent in Asia (%)	Value (millions)	Percent in Asia (%)	Value (Mtoe)	Percent in Asia (%)	Value (Mtoe)	Percent in Asia (%)	Value (billion kilowatt-hours)	Percent in Asia (%)
East Asia	China	9,596,960	19.64	3,280,053	22.29	1,321.85	32.18	1,593.38	27.02	1,862.586	35.21	2,717.50	36.49
	Japan	377,835	0.77	4,376,705	29.75	127.43	3.10	103.371	1.75	574.83	10.87	1,032.70	13.87
	DPR of Korea	120,540	0.25			23.3	0.57	22.227	0.38	23.937	0.45	21.72	0.29
	Republic of Korea	98,480	0.20	969,795	6.59	49.04	1.19	37.876	0.64	238.316	4.50	379.73	5.10
	Mongolia	1,564,116	3.20	3,894	0.03	2.95	0.07	2.083	0.04	2.407	0.05	2.93	0.04
	Total	11,757,931	24.07	8,630,447	58.66	1,524.57	37.12	1,758.937	29.83	2,702.076	51.07	4,154.58	55.79
South-East Asia	Brunei	5,770	0.01	11,562	0.08	0.37	0.01	21.95	0.37	4.474	0.08	3.1	0.04
	Burma	678,500	1.39			47.37	1.15	12.924	0.22	5.966	0.11	5.96	0.08
	Cambodia	181,040	0.37	8,628	0.06	14	0.34	0.011	0.00	0.235	0.00	1.16	0.02
	Indonesia	1,919,440	3.93	432,817	2.94	234.69	5.71	234.749	3.98	104.668	1.98	125.67	1.69
	Lao PDR	236,800	0.48	4,008	0.03	6.52	0.16	0.607	0.01	0.6	0.01	1.64	0.02
	Malaysia	329,750	0.67	180,714	1.23	24.84	0.60	98.227	1.67	64.735	1.22	99.08	1.33

Continued

Region	Country	Area		GDP 2007		Population 2007		Primary Energy Production 2005		Primary Energy Consumption 2006		Electricity Generation 2006	
		Value (sq. km)	Percent in Asia (%)	Value (millions of US dollars)	Percent in Asia (%)	Value (millions)	Percent in Asia (%)	Value (Mtoe)	Percent in Asia (%)	Value (Mtoe)	Percent in Asia (%)	Value (billion kilowatt-hours)	Percent in Asia (%)
South-East Asia	Philippines	300,000	0.61	144,129	0.98	91.08	2.22	12.403	0.21	32.071	0.61	53.93	0.72
	Singapore	692.7	0.00	161,347	1.10	4.55	0.11	0	0.00	54.028	1.02	37.08	0.50
	Thailand	514,000	1.05	245,818	1.67	65.07	1.58	44.296	0.75	93.987	1.78	130.68	1.75
	Timor-Leste	15,007	0.03	395	0.00	1.09	0.03	4.629	0.08	0	0.00		
	Vietnam	329,560	0.67	71,216	0.48	85.26	2.08	48.857	0.83	35.415	0.67	54.28	0.73
	Total	4,510,560	9.23	1,260,634	8.57	574.8	13.99	478.653	8.12	396.179	7.49	512.58	6.88
South Asia	Bangladesh	144,000	0.29	67,694	0.46	150.45	3.66	12.847	0.22	18.753	0.35	22.94	0.31
	Bhutan	47,000	0.10	1,096	0.01	0.67	0.02	0.537	0.01	0.759	0.01	2.62	0.04
	India	3,287,590	6.73	1,170,968	7.96	1,129.87	27.51	295.624	5.01	445.698	8.42	703.32	9.44
	Maldives	300	0.00	1,049	0.01	0.37	0.01	0	0.00	0.251	0.00	0.22	0.00
	Nepal	147,181	0.30	10,207	0.07	28.9	0.70	0.608	0.01	1.708	0.03	2.66	0.04
	Pakistan	803,940	1.65	143,597	0.98	164.74	4.01	39.841,72	0.68	57.962	1.10	90.41	1.21
	Sri Lanka	65,610	0.13	32,354	0.22	20.93	0.51	0.862	0.01	5.509	0.10	8.32	0.11
	Total	4,495,621	9.20	1,426,965	9.70	1,495.93	36.42	350.319,72	5.94	530.64	10.03	830.49	11.15

Continued

Region	Country	Area		GDP 2007		Population 2007		Primary Energy Production 2005		Primary Energy Consumption 2006		Electricity Generation 2006	
		Value (sq. km)	Percent in Asia (%)	Value (millions of US dollars)	Percent in Asia (%)	Value (millions)	Percent in Asia (%)	Value (Mtoe)	Percent in Asia (%)	Value (Mtoe)	Percent in Asia (%)	Value (billion kilowatt-hours)	Percent in Asia (%)
West Asia	Afghanistan	647,500	1.33	11,627	0.08	31.89	0.78	0.21	0.00	0.443	0.01	0.92	0.01
	Bahrain	665	0.00	16,041	0.11	0.71	0.02	12.266	0.21	12.255	0.23	9.23	0.12
	Cyprus	9,250	0.02	21,277	0.14	0.79	0.02	0	0.00	3.06	0.06	4.37	0.06
	Iran	1,648,000	3.37	270,937	1.84	65.4	1.59	327.902	5.56	193.907	3.67	189.9	2.55
	Iraq	437,072	0.89			27.5	0.67	103.528	1.76	31.345	0.59	29.98	0.40
	Israel	20,770	0.04	161,822	1.10	6.99	0.17	0.677	0.01	21.561	0.41	48.7	0.65
	Jordan	92,300	0.19	15,832	0.11	6.05	0.15	0.277	0.00	7.733	0.15	10.87	0.15
	Kuwait	17,820	0.04	102,095	0.69	2.51	0.06	154.213	2.61	28.663	0.54	44.75	0.60
	Lebanon	10,400	0.02		0.00	3.93	0.10	0.261	0.00	5.132	0.10	8.76	0.12
	Oman	212,460	0.43	35,729	0.24	3.21	0.08	60.576	1.03	13.874	0.26	12.77	0.17
	Qatar	11,437	0.02	42,463	0.29	0.91	0.02	96.282	1.63	22.856	0.43	14.41	0.19
	Saudi Arabia	2,149,690	4.40	381,683	2.59	27.6	0.67	642.801	10.90	173.842	3.29	169	2.27
	Syria	185,180	0.38	38,081	0.26	19.31	0.47	32.531	0.55	20.435	0.39	35.29	0.47
	Turkey	780,580	1.60	657,091	4.47	71.16	1.73	26.848	0.46	98.71	1.87	167.94	2.26
	United Arab Emirates	83,600	0.17	129,702	0.88	4.44	0.11	191.27	3.24	62.164	1.18	62.76	0.84
	Yemen Arab Republic.	527,970	1.08	22,523	0.15	22.23	0.54	21.072	0.36	6.742	0.13	5.02	0.07
	Total	6,834,694	13.99	1,906,903	12.96	294.63	7.17	1,670.714	28.33	702.722	13.28	814.67	10.94

Continued

Region	Country	Area		GDP 2007		Population 2007		Primary Energy Production 2005		Primary Energy Consumption 2006		Electricity Generation 2006	
		Value (sq. km)	Percent in Asia (%)	Value (millions of US dollars)	Percent in Asia (%)	Value (millions)	Percent in Asia (%)	Value (Mtoe)	Percent in Asia (%)	Value (Mtoe)	Percent in Asia (%)	Value (billion kilowatt-hours)	Percent in Asia (%)
Central Asia	Armenia	29,743	0.06	9,177	0.06	2.97	0.07	1.182	0.02	5.113	0.10	5.61	0.08
	Azerbaijan	86,600	0.18	31,248	0.21	8.12	0.20	29.809	0.51	17.567	0.33	21.83	0.29
	Georgia	69,700	0.14	10,176	0.07	4.65	0.11	1.68	0.03	3.372	0.06	7.12	0.10
	Kazakhstan	2,717,300	5.56	103,840	0.71	15.28	0.37	137.989	2.34	74.978	1.42	67.76	0.91
	Kirgizstan	198,500	0.41	3,505	0.02	5.28	0.13	3.821	0.06	5.225	0.10	15.62	0.21
	Tajikistan	143,100	0.29	3,712	0.03	7.08	0.17	4.255	0.07	7.023	0.13	17.01	0.23
	Turkmenistan	488,100	1.00	12,933	0.09	5.1	0.12	69.092	1.17	22.134	0.42	12.83	0.17
	Uzbekistan	447,400	0.92	22,308	0.15	27.78	0.68	62.46	1.06	55.73	1.05	46.66	0.63
	Total	4,180,443	8.56	196,899	1.34	76.26	1.86	310.288	5.26	191.142	3.61	194.44	2.61
North Asia	Russia	17,075,200	34.95	1,291,011	8.77	141.38	3.44	1,328.466	22.53	767.717	14.51	940.64	12.63
	Total	17,075,200	34.95	1,291,011	8.77	141.38	3.44	1,328.466	22.53	767.717	14.51	940.64	12.63
Asia		48,854,449	100.0	14,712,859	100.0	4,107.61	100.0	5,897.378	100.0	5,290.478	100.0	7447.4	100.0
Source		https://www.cia.gov		http://www.worldbank.org		http://ceq.hss.doe.gov		http://www.eia.doe.gov		http://www.eia.doe.gov		http://www.energy.gov/energysources	

Note :
1. Area is sum of land area and water area, not land area only
2. NA=Not available

Table B3 Primary Energy Consumption and Its Structure in 2006

No	Country	Primary Energy	Petroleum		Dry Natural Gas		Coal		Hydroelectric Power		Nuclear Electric Power		Geothermal, Solar, Win & Wood and Waste Electric Power	
		Value (Mtoe)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)
1	Afghanistan	0.443	0.241	54.5	0.019	4.2	0.021	4.8	0.162	36.5	0	0.0	0	0.0
2	Armenia	5.113	2.402	47.0	1.511	29.6	0.033	0.6	0.451	8.8	0.716	14.0	0	0.0
3	Azerbaijan	17.567	6.432	36.6	10.540	60.0	0	0.0	0.594	3.4	0	0.0	0	0.0
4	Bahrain	12.255	1.687	13.8	10.568	86.2	0	0.0	0	0.0	0	0.0	0	0.0
5	Bangladesh	18.753	4.679	25.0	13.362	71.3	0.367	2.0	0.344	1.8	0	0.0	0	0.0
6	Bhutan	0.759	0.062	8.1	0	0.0	0.042	5.5	0.655	86.4	0	0.0	0	0.0
7	Brunei	4.474	0.752	16.8	3.722	83.2	0	0.0	0	0.0	0	0.0	0	0.0
8	Burma	5.966	2.153	36.1	2.883	48.3	0.106	1.8	0.823	13.8	0	0.0	0	0.0
9	Cambodia	0.235	0.223	94.5	0	0.0	0	0.0	0.013	5.3	0	0.0	0	0.2
10	China	1,862.586	373.937	20.1	52.553	2.8	1,312.633	70.5	107.957	5.8	13.965	0.7	1.542	0.1
11	Cyprus	3.060	3.027	99.0	0	0.0	0.033	1.1	0	0.0	0	0.0	0	0.0
12	Georgia	3.372	0.728	21.6	1.315	39.0	0.012	0.4	1.317	39.1	0	0.0	0	0.0
13	India	445.698	136.611	30.7	36.009	8.1	237.782	53.4	28.142	6.3	4.789	1.1	2.364	0.5
14	Indonesia	104.668	62.770	60.0	22.044	21.1	14.116	13.5	2.384	2.3	0	0.0	3.354	3.2
15	Iran	193.907	85.855	44.3	102.274	52.8	1.247	0.6	4.501	2.3	0	0.0	0.030	0.01

Continued

No	Country	Primary Energy	Petroleum		Dry Natural Gas		Coal		Hydroelectric Power		Nuclear Electric Power		Geothermal, Solar, Win & Wood and Waste Electric Power	
		Value (Mtoe)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)
16	Iraq	31.345	29.546	94.3	1.679	5.4	0	0.0	0.120	0.4	0	0.0	0	0.0
17	Israel	21.561	12.681	58.8	0.857	4.0	8.013	37.2	0.007	0.03	0	0.0	0.002	0.01
18	Japan	574.830	265.117	46.1	90.608	15.8	116.728	20.4	21.245	3.7	73.846	12.8	7.287	1.3
19	Jordan	7.733	5.620	72.7	2.099	27.1	0	0.0	0.013	0.2	0	0.0	0.001	0.01
20	Kazakhstan	74.978	12.150	16.2	28.963	38.6	31.940	42.6	1.924	2.6	0	0.0	0	0.0
21	DPR of Korea	23.937	0.897	3.7	0	0.0	19.913	83.2	3.126	13.1	0	0.0	0	0.0
22	Republic of Korea	238.316	113.618	47.7	32.478	13.6	55.887	23.5	0.859	0.4	35.326	14.8	0.147	0.06
23	Kuwait	28.663	17.003	59.3	11.660	40.7	0	0.0	0	0.0	0	0.0	0	0.0
24	Kirgizstan	5.225	0.713	13.7	0.724	13.9	0.397	7.6	3.391	64.9	0	0.0	0	0.0
25	Laos	0.600	0.155	25.8	0	0.0	0.047	7.8	0.398	66.4	0	0. 0	0	0.0
26	Lebanon	5.132	4.822	93.9	0	0.0	0.139	2.7	0.172	3.4	0	0.0	0	0.0
27	Malaysia	64.735	26.341	40.7	30.189	46.6	6.717	10.4	1.487	2.3	0	0.0	0	0.0
28	Maldives	0.251	0.251	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
29	Mongolia	2.407	0.675	28.1	0	0.0	1.731	72.0	0	0.0	0	0.0	0	0.0
30	Nepal	1.708	0.855	50.1	0	0.0	0.190	11.1	0.662	38.8	0	0.0	0	0.0

Continued

No	Country	Primary Energy	Petroleum		Dry Natural Gas		Coal		Hydroelectric Power		Nuclear Electric Power		Geothermal, Solar, Win & Wood and Waste Electric Power	
		Value (Mtoe)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)
31	Oman	13.874	3.828	27.6	10.046	72.4	0	0.0	0	0.0	0	0.0	0	0.0
32	Pakistan	57.962	19.324	33.3	26.212	45.2	4.099	7.1	7.644	13.2	0.685	1.2	0	0.0
33	Philippines	32.071	16.318	50.9	1.915	6.0	6.104	19.0	2.463	7.7	0	0.0	5.272	16.4
34	Qatar	22.856	4.564	20.0	18.292	80.0	0	0.0	0	0.0	0	0.0	0	0.0
35	Russia	767.717	145.920	19.0	422.496	55.0	114.903	15.0	43.452	5.7	40.062	5.2	0.886	0.12
36	Saudi Arabia	173.842	105.307	60.6	68.522	39.4	0.013	0.01	0	0.0	0	0.0	0	0.0
37	Singapore	54.028	47.858	88.6	6.165	11.4	0.005	0.01	0	0.0	0	0.0	0	0.0
38	Sri Lanka	5.509	4.472	81.2	0	0.0	0.074	1.3	0.963	17.5	0	0.0	0	0.01
39	Syria	20.435	14.073	68.9	5.356	26.2	0.006	0.03	1.000	4.9	0	0.0	0	0.0
40	Tajikistan	7.023	1.624	23.1	1.190	16.9	0.045	0.6	4.163	59.3	0	0.0	0	0.0
41	Thailand	93.987	50.133	53.3	28.985	30.8	12.152	12.9	1.969	2.1	0	0.0	0.748	0.8
42	Timor-Leste	0	0		0		0		0		0		0	
43	Turkey	98.710	34.646	35.1	28.781	29.2	24.208	24.5	10.960	11.1	0	0.0	0.114	0.12
44	Turkmenistan	22.134	5.251	23.7	16.884	76.3	0	0.0	0.001	0.003	0	0.0	0	0.0

Continued

No	Country	Primary Energy	Petroleum		Dry Natural Gas		Coal		Hydroelectric Power		Nuclear Electric Power		Geothermal, Solar, Win & Wood and Waste Electric Power	
		Value (Mtoe)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)	Value (Mtoe)	Percent (%)
45	United Arab Emirates	62.164	21.951	35.3	40.212	64.7	0	0.0	0	0.0	0	0.0	0	0.0
46	Uzbekistan	55.730	7.654	13.7	45.384	81.4	1.122	2.0	1.569	2.8	0	0.0	0	0.0
47	Vietnam	35.415	13.298	37.5	5.261	14.9	11.010	31.1	5.846	16.5	0	0.0	0	0.0
48	Yemen Arab Republic	6.742	6.742	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
World		11,843.693	4,332.147	36.6	2,724.528	23.0	3,217.708	27.2	749.959	6.3	700.267	5.9	119.092	1.01
Asia		5,290.478	1,674.966	31.7	1,181.758	22.3	1,981.839	37.5	260.777	4.9	169.388	3.2	21.748	0.4

Source:
U.S. DOE. http://www.energy.gov/energysources. 2009-05-10

Table B4 Oil, gas and coal production in Asia countries in 2007

No	Country	Oil		Gas		Coal	
		QBtu	MTon	TCF	Gm^3	MST	MTon
1	Afghanistan	0	0	NA	NA	0.10	0.094
2	Armenia	0	0	0	0	0	0
3	Azerbaijan	1.807	45.543	0.345	9.764	0	0
4	Bahrain	0.075	1.893	NA	NA	0	0
5	Bangladesh	0.013	0.320	0.554	15.691	0	0
6	Bhutan	0	0	0	0	0.06	0.056
7	Brunei	0.351	8.840	NA	NA	0	0
8	Burma	0.046	1.172	NA	NA	0.88	0.801
9	Cambodia	0	0	0	0	0	0
10	China	8.001	201.636	2.446	69.230	2,803.93	2,543.167
11	Cyprus	0	0	0	0	0	0
12	Georgia	0.002	0.054	0.000,4	0.010	0.01	0.006
13	India	1.459	36.757	1.119	31.681	528.50	479.35
14	Indonesia	2.019	50.875	1.978	55.967	179.92	163.18
15	Iran	8.407	211.859	3.952	111.83	1.40	1.269,8
16	Iraq	4.432	111.684	NA	NA	0	0
17	Israel	0.000,2	0	NA	NA	0	0
18	Japan	0.012	0.307,6	0.132	3.727	0	0
19	Jordan	0.000,04	0.001	NA	NA	0	0
20	Kazakhstan	2.920	73.577	0.985	27.864	103.19	93.592
21	DPR of Korea	0	0	0	0	37.29	33.822
22	Republic of Korea	0	0	0.014	0.390	3.18	2.885
23	Kuwait	5.325	134.198	NA	NA	0	0
24	Kirgizstan	0.002	0.054	0.001	0.0180	0.35	0.313
25	Laos	0	0	0	0	0.34	0.309
26	Lebanon	0	0	0	0	0	0
27	Malaysia	1.223	30.823	2.278	64.462	0.74	0.675
28	Maldives	0	0	0	0	0	0
29	Mongolia	0	0	0	0	8.55	7.757
30	Nepal	0	0	0	0	0.01	0.012
31	Oman	1.522	38.347	0.851	24.086	0	0
32	Pakistan	0.137	3.464	1.088	30.782	5.15	4.672
33	Philippines	0.053	1.337	NA	NA	2.69	2.436
34	Qatar	1.794	45.198	2.112	59.765	0	0

Continued

No	Country	Oil		Gas		Coal	
		QBtu	MTon	TCF	Gm^3	MST	MTon
35	Russia	20.254	510.396	23.064	652.72	346.68	314.436
36	Saudi Arabia	18.814	474.103	2.680	75.856	0	0
37	Singapore	0	0	0	0	0	0
38	Sri Lanka	0	0	0	0	0	0
39	Syria	0.854	21.524	NA	NA	0	0
40	Tajikistan	0.001	0.015	0.001	0.032	0.09	0.081
41	Thailand	0.492	12.399	0.897	25.385	20.11	18.235
42	Timor-Leste	0.153	3.848	0	0	NA	NA
43	Turkey	0.089	2.254	0.032	0.892	84.17	76.342
44	Turkmenistan	0.351	8.848	2.432	68.840	0	0
45	United Arab Emirates	5.498	138.557	NA	NA	0	0
46	Uzbekistan	0.127	3.193	2.302	65.152	3.64	3.299
47	Vietnam	0.692	17.450	NA	NA	44.24	40.127
48	Yemen Arab Republic	0.666	16.783	0	0	0	0
	World	156.065	3,932.829	NA	NA	7,036.25	6,381.881
	Asia	87.591	2,207.310	49.263	1,394.15	4,175.22	3,786.925

Note:
1. NA=Not available
2. 1×10^6 (Btu) = 0.025,2 (toe), 1 Quadrillion (10^{15}) Btu = $0.025,2\times 10^9$ (toe) = 25.2×10^6 toe
3. 1 cubic foot =0.028,3 cubic meter, $1TCF=10^{12}\times0.0283$ cubic meter =28.3 Gm^3
4. 1 short ton =2000 pounds =0.907 ton

Source:
U.S. DOE. http://www.energy.gov/energysources. 2009-05-12

Table B5 Energy production ,consumption and their balance in 2005

No	Country	Primary Energy Production			Primary Energy Consumption			Energy Balance (Production–Consumption)		Percent of Primary Energy Import or Export (Production-Consumption)/ Consumption (%)
		(10^{15} Btu)	(Mtoe)	(Mtce)	(10^{15} Btu)	(Mtoe)	(Mtce)	(Mtoe)	(Mtce)	
1	Afghanistan	0.008	0.210	0.300	0.019	0.480	0.686	–0.270	–0.385	–56.20
2	Armenia	0.047	1.182	1.689	0.193	4.857	6.938	–3.675	–5.250	–75.66
3	Azerbaijan	1.183	29.809	42.584	0.663	16.720	23.885	13.089	18.699	78.29
4	Bahrain	0.487	12.266	17.523	0.458	11.550	16.500	0.716	1.023	6.209
5	Bangladesh	0.510	12.847	18.353	0.693	17.467	24.953	–4.620	–6.600	–26.49
6	Bhutan	0.021	0.537	0.767	0.019	0.480	0.685	0.057	0.082	11.95
7	Brunei	0.871	21.950	31.358	0.114	2.861	4.087	19.090	27.270	667.21
8	Burma	0.513	12.924	18.462	0.252	6.343	9.062	6.580	9.401	103.740
9	Cambodia	0.000,4	0.011	0.016	0.009	0.215	0.306	–0.203	–0.291	–94.83
10	China	63.229	1,593.380	2,276.257	67.093	1,690.742	2,415.346	–97.363	–139.089	–5.76
11	Cyprus	0	0	0	0.121	3.048	4.354	–3.048	–4.354	–100
12	Georgia	0.067	1.680	2.400	0.148	3.737	5.339	–2.057	–2.939	–55.04
13	India	11.731	295.624	422.319	16.205	408.363	583.376	–112.740	–161.057	–27.61
14	Indonesia	9.315	234.749	335.356	5.362	135.126	193.037	99.623	142.319	73.73
15	Iran	13.012	327.902	468.432	7.261	182.987	261.410	144.916	207.022	79.19
16	Iraq	4.108	103.528	147.897	1.244	31.339	44.770	72.189	103.127	230.35
17	Israel	0.027	0.677	0.967	0.853	21.495	30.707	–20.818	–29.740	–96.85
18	Japan	4.102	103.371	147.673	22.572	568.805	812.578	–465.434	–664.906	–81.83

Continued

No	Country	Primary Energy Production			Primary Energy Consumption			Energy Balance (Production–Consumption)		Percent of Primary Energy Import or Export (Production-Consumption)/ Consumption (%)
		(10^{15} Btu)	(Mtoe)	(Mtce)	(10^{15} Btu)	(Mtoe)	(Mtce)	(Mtoe)	(Mtce)	
19	Jordan	0.011	0.277	0.396	0.288	7.269	10.384	–6.992	–9.988	–96.19
20	Kazakhstan	5.476	137.989	197.127	2.839	71.537	102.195	66.452	94.931	92.89
21	DPR of Korea	0.882	22.227	31.753	0.937	23.617	33.739	–1.390	–1.986	–5.89
22	Republic of Korea	1.503	37.876	54.108	9.276	233.757	333.938	–195.881	–279.830	–83.80
23	Kuwait	6.120	154.213	220.305	1.164	29.329	41.898	124.885	178.407	425.81
24	Kirgizstan	0.152	3.821	5.458	0.207	5.208	7.440	–1.387	–1.981	–26.63
25	Laos	0.024	0.607	0.866	0.029	0.719	1.027	–0.112	–0.160,1	–15.60
26	Lebanon	0.010	0.261	0.373	0.237	5.966	8.523	–5.705	–8.150	–95.62
27	Malaysia	3.898	98.227	140.324	2.546	64.165	91.664	34.062	48.660	53.09
28	Maldives	0	0	0	0.011	0.266	0.380	–0.266	–0.380	–100
29	Mongolia	0.083	2.083	2.975	0.090	2.279	3.256	–0.196	–0.281	–8.62
30	Nepal	0.024	0.608	0.869	0.065	1.632	2.332	–1.024	–1.463	–62.73
31	Oman	2.404	60.576	86.537	0.477	12.032	17.188	48.544	69.349	403.47
32	Pakistan	1.581	39.841,72	56.917	2.252	56.762	81.089	–16.920	–24.172	–29.81
33	Philippines	0.492	12.403	17.719	1.336	33.677	48.109	–21.273	–30.390	–63.17
34	Qatar	3.821	96.282	137.546	0.863	21.757	31.082	74.524	106.463	342.52
35	Russia	52.717	1,328.466	1,897.808	30.293	763.392	1,090.560	565.074	807.249	74.02
36	Saudi Arabia	25.508	642.801	918.287	6.657	167.746	239.638	475.055	678.650	283.20

Continued

No	Country	Primary Energy Production			Primary Energy Consumption			Energy Balance (Production–Consumption)		Percent of Primary Energy Import or Export (Production-Consumption)/ Consumption (%)
		(10^{15} Btu)	(Mtoe)	(Mtce)	(10^{15} Btu)	(Mtoe)	(Mtce)	(Mtoe)	(Mtce)	
37	Singapore	0	0	0	2.023	50.982	72.832	–50.982	–72.832	–100
38	Sri Lanka	0.034	0.862	1.231	0.213	5.361	7.659	–4.500	–6.428	–83.93
39	Syria	1.291	32.531	46.472	0.791	19.943	28.490	12.588	17.983	63.12
40	Tajikistan	0.169	4.255	6.0792	0.279	7.040	10.058	–2.785	–3.979	–39.56
41	Thailand	1.758	44.296	63.280	3.626	91.364	130.520	–47.069	–67.241	–51.52
42	Timor-Leste	0.184	4.629	6.613	NA	NA	NA	NA	NA	NA
43	Turkey	1.065	26.848	38.355	3.739	94.211	134.588	–67.363	–96.233	–71.50
44	Turkmenistan	2.742	69.092	98.703	0.854	21.531	30.758	47.562	67.945	220.90
45	United Arab Emirates	7.590	191.270	273.243	2.303	58.039	82.912	133.232	190.331	229.56
46	Uzbekistan	2.479	62.460	89.228	2.156	54.326	77.609	8.133	11.619	14.97
47	Vietnam	1.939	48.857	69.796	1.225	30.872	44.103	17.985	25.694	58.26
48	Yemen Arab Republic	0.836	21.072	30.103	0.256	6.462	9.231	14.610	20.871	226.09
World		460.139	11,595.510	16,565.010	462.798	11,662.500	16,660.720	–66.996	–95.708	–0.57
Asia		234.024	5,897.378	8,424.824	200.311	5,047.856	7,211.221	844.893	1,206.990	
Source		U.S. DOE. www.eia. doe.gov	Calculated[1]	Calculated[2]	U.S. DOE. www.eia. doe.gov	Calculated[1]	Calculated[2]	Calculated[1]	Calculated[2]	Calculated

Note:
1. 1 Quadrillion (10^{15} Btu = 25.2 Mtoe
2. 1 Quadrillion (10^{15} Btu = 36.0 Mtce

Table B6 Asia electricity installed capacity (2007) and electricity generation (2006)

No	Country	Electricity Installed Capacity by Type, in 2007					Electricity Generation by Type, in 2006				
		Conventional Thermal (GW)	Hydroelectric (GW)	Nuclear (GW)	Geothermal, Solar, Wind, and Waste (GW)	Total (GW)	Conventional Thermal (billion kilowatt-hours)	Hydroelectric (billion kilowatt-hours)	Nuclear (billion kilowatt-hours)	Geothermal, Solar, Wind, and Waste (billion kilowatt-hours)	Total (billion kilowatt-hours)
1	Afghanistan	NA	NA	0	0	NA	0.27	0.65	0	0	0.92
2	Armenia	1.775	1.052	0.376	0	3.203	1.39	1.80	2.42	0	5.61
3	Azerbaijan	NA	NA	0	0	NA	19.46	2.38	0	0	21.83
4	Bahrain	2.767	0	0	0	2.767	9.23	0	0	0	9.23
5	Bangladesh	5.015	NA	0	0	NA	21.57	1.38	0	0	22.94
6	Bhutan	NA	1.488	0	0	NA	0	2.62	0	0	2.62
7	Brunei	NA	0	0	0	NA	3.10	0	0	0	3.10
8	Burma	NA	NA	0	0	NA	2.67	3.29	0	0	5.96
9	Cambodia	NA	0.013	0	0	NA	1.11	0.05	0	0.002	1.16
10	China	484.050	128.57	7.572	3.369	623.561	2,225.06	431.43	54.85	6.16	2,717.50
11	Cyprus	1.134	0	0	0	1.134	4.37	0	0	0	4.37
12	Georgia	1.688	NA	0	0	NA	1.85	5.26	0	0	7.12
13	India	NA	34.654	3.900	7.761	NA	565.81	112.46	15.59	9.45	703.32
14	Indonesia	NA	NA	0	0.890	NA	109.82	9.53	0	6.33	125.67

Continued

No	Country	Electricity Installed Capacity by Type, in 2007					Electricity Generation by Type, in 2006				
		Conventional Thermal (GW)	Hydroelectric (GW)	Nuclear (GW)	Geothermal, Solar, Wind, and Waste (GW)	Total (GW)	Conventional Thermal (billion kilowatt-hours)	Hydroelectric (billion kilowatt-hours)	Nuclear (billion kilowatt-hours)	Geothermal, Solar, Wind, and Waste (billion kilowatt-hours)	Total (billion kilowatt-hours)
15	Iran	NA	NA	0	0.048	NA	171.80	17.99	0	0.12	189.90
16	Iraq	NA	NA	0	0	NA	29.50	0.48	0	0	29.98
17	Israel	10.487	NA	0	0.005	NA	48.67	0.03	0	0.01	48.70
18	Japan	174.282	22.199	49.467	7.670	253.618	633.68	84.90	288.26	25.86	1,032.70
19	Jordan	2.180	NA	0	0.002	NA	10.82	0.05	0	0.003	10.87
20	Kazakhstan	NA	NA	0	0	NA	60.07	7.69	0	0	67.76
21	DPR of Korea	NA	NA	0	0	NA	9.23	12.49	0	0	21.72
22	Republic of Korea	46.596	1.585	17.716	0.284	66.181	234.40	3.43	141.31	0.59	379.73
23	Kuwait	NA	0	0	0	NA	44.75	0	0	0	44.75
24	Kirgizstan	NA	NA	0	0	NA	2.06	13.55	0	0	15.62
25	Laos	NA	NA	0	0	NA	0.05	1.59	0	0	1.64
26	Lebanon	NA	NA	0	0	NA	8.08	0.69	0	0	8.76
27	Malaysia	NA	NA	0	0	NA	93.13	5.95	0	0	99.08
28	Maldives	NA	0	0	0	NA	0.22	0	0	0	0.22

Continued

No	Country	Electricity Installed Capacity by Type, in 2007					Electricity Generation by Type, in 2006				
		Conventional Thermal (GW)	Hydroelectric (GW)	Nuclear (GW)	Geothermal, Solar, Wind, and Waste (GW)	Total (GW)	Conventional Thermal (billion kilowatt-hours)	Hydroelectric (billion kilowatt-hours)	Nuclear (billion kilowatt-hours)	Geothermal, Solar, Wind, and Waste (billion kilowatt-hours)	Total (billion kilowatt-hours)
29	Mongolia	NA	0	0	0	NA	2.93	0	0	0	2.93
30	Nepal	0.057	NA	0	0	NA	0.02	2.65	0	0	2.66
31	Oman	3.323	0	0	0	3.323	12.77	0	0	0	12.77
32	Pakistan	NA	NA	0.462	0	NA	57.32	30.55	2.55	0	90.41
33	Philippines	NA	NA	0	1.983	NA	34.15	9.84	0	9.94	53.93
34	Qatar	NA	0	0	0	NA	14.41	0	0	0	14.41
35	Russia	NA	NA	23.242	0.094	NA	619.65	173.65	144.30	3.05	940.64
36	Saudi Arabia	NA	0	0	0	NA	169.00	0	0	0	169.00
37	Singapore	NA	0	0	0	NA	37.08	0	0	0	37.08
38	Sri Lanka	NA	NA	0	0.003	NA	4.47	3.85	0	0.002	8.32
39	Syria	NA	NA	0	0	NA	31.29	4.00	0	0	35.29
40	Tajikistan	NA	NA	0	0	NA	0.37	16.64	0	0	17.01
41	Thailand	23.339	3.476	0	0.003	26.818	119.83	7.87	0	2.99	130.68
42	Timor-Leste	0	0	0	0	0	0	NA	0	0	NA

Continued

No	Country	Electricity Installed Capacity by Type, in 2007					Electricity Generation by Type, in 2006				
		Conventional Thermal (GW)	Hydroelectric (GW)	Nuclear (GW)	Geothermal, Solar, Wind, and Waste (GW)	Total (GW)	Conventional Thermal (billion kilowatt-hours)	Hydroelectric (billion kilowatt-hours)	Nuclear (billion kilowatt-hours)	Geothermal, Solar, Wind, and Waste (billion kilowatt-hours)	Total (billion kilowatt-hours)
43	Turkey	27.379	13.063	0	0.123	40.565	123.78	43.80	0	0.36	167.94
44	Turkmenistan	NA	0.001	0	0	NA	12.83	0.003	0	0	12.83
45	United Arab Emirates	NA	0	0	0	NA	62.76	0	0	0	62.76
46	Uzbekistan	10.841	1.710	0	0	12.551	40.39	6.27	0	0	46.66
47	Vietnam	7.820	4.580	0	0	12.400	30.92	23.36	0	0	54.28
48	Yemen Arab Republic	1.132	0	0	0	1.132	5.02	0	0	0	5.02
World		NA	NA	377.005	125.913	NA	11,943.04	2,997.06	2,660.26	414.31	18,014.67
Asia		803.865	212.39	102.735	22.235	1,141.226	5,691.16	1,042.17	690.28	64.867	7,447.40

Source:
U.S. DOE. http://www.energy.gov/energysources. 2009-05-20