Chapter 1: Introduction.

1.1. Preliminary Remarks.

Since they first started to use stone tools, humans have been dependent on mineral resources contained in or on the earth. This dependence has increased as we have evolved to our present industrialized status, to the point today where our livelihood is utterly dependent on mining. However, mining cannot be sustainable because the deposit is finite and is eventually exhausted.

Future global perspective will depend on energy and mineral resources that are safe, reliable, and environmentally sound. However, most countries continue to use fuels that are non-renewal and technologies that pose significant hazards to the environment and human health.

Therefore, there is a pressing need in the new century to adopt sustainable energy and mineral options, especially in the face of mounting evidence of global warming linked to fossil fuel use, environmental impacts from mining activities and the persisting threat of nuclear accidents, unresolved problems of radioactive waste disposal, and the spector of nuclear weapons proliferation associated with continued use of nuclear power.

1.1.1. Worldwide/Global Environmental Impact of Mining Activities.

From the industrial revolution onwards the main origins of international confliction and environmental impact have been the fast growth of population and rapid increasing demand of energy and mineral resources in accordance with the expeditious development of science and technology.

Centuries of uncontrolled exploitation of nature and international wars to preoccupy the resources have played havoc on our planet Earth. The phenomenal advance of science and technology has placed enormous pressure on the earth's resources to meet the frightening increasing requirements of human beings. Many environmentalists are predicting the demise of all humanity unless the earth's ecological trauma is quickly alleviated.

Particularly, the mining industry from exploration and extracting to refining and transporting has left very serious impacts on all the creatures and environment by polluting fresh air and water, spewing almost half of all toxic emissions from all the industries in some countries, threatening nearly 40 percent of the world's undeveloped tracts of forest, and consuming about 10 percent of world energy.

Such mining activities have resulted in the depletion of mineral resources, desertification and deforestation, climatic changes, droughts and floods and other natural problems threatening all human beings and their environment on this earth. These environmental problems are being compounded to even more alarming proportions by the more rapidly increasing requirements for energy and mineral resources year by year.

1.1.2. Global Environmental Impact of Nuclear Plants.

Nuclear plants, nuclear waste, and nuclear weapons raise substantial public concern in the current world. In particular, many risky decisions regarding nuclear plants may impose serious risks on future generations that require a different kind of consideration of the danger to people living today.

The energy issue dominated the early days of nuclear power. Arguments were made that the world has only a finite amount of petroleum and natural gas so that uranium must be used for energy generation. Even though fission's future was very doubtful, because of concerns about apprehensive nuclear technology, high cost, reactor accident risks, radioactive waste management, and potential links to the spread of nuclear weapons.

There is a technical stigma attached to nuclear plants so that trying to site a new nuclear plant leads to substantial public opposition. The uncontrolled and mistaken use of such nuclear technology in mining and industry can cause heavy pollution on vast areas of land and rivers as shown at the Chernobyl nuclear accident in Russia.

In particular, nuclear waste sites have seriously generated substantial public opposition all over the world. Radioactive waste is generally categorized as low-level waste (LLW), trans-uranic waste (TRU), and high level waste (HLW). HLW has led to requirements for a 10,000 year isolation which is based on inter-generational equity arguments.

We have a responsibility to handle the nuclear plants wisely, not only for the present but also for the future. This is not a technical mandate but an ethical one of long-standing. Traditional risk analysis based on natural science and engineering has difficulty incorporating such nuclear plants, which are moral values and not easily quantifiable.

So, the critics of nuclear plants argue that nuclear waste may become a problem in many hundreds, perhaps thousands of years. The International Atomic Energy Agency (IAEA) has stressed that its responsibility today is to manage the nuclear waste to protect human health and environment in the present and in the future without imposing undue burdens on future generations.

Nuclear plants generate large amounts of electricity. This is a serious social problem because it requires the overconsumption of large amounts of electricity in order to recover the large sunk costs for the construction of nuclear plants and provide the incalculable large amounts for the management of nuclear waste and finally the dismantling of nuclear plants. This has been a cardinal source to promote an anthropocentic extravagant life rather than a theocentric temperate life to meet final profit targets for nuclear plants.

1.1.3. Climate Change from GHGs Emissions.

The climate change is just one indicator of the threats we face as a rigorous alarm from the Creator, God of grace. It is obviously our urgent duty to heal the climate change caused by human beings.

Ironically, climate change accompanied with disasters is more unfavourable to the socio-economically weak, who are usually less responsible for the advent of climate change and have less ability to cope with the impact of climate change. In particular, most of Africa would be hit the hardest if climate change continues in its current course.

It is necessary for us to make it clear that while the earth is dying with the environmental degradation, we are indulging ourselves in overdevelopment and overconsumption so much beyond the carrying capacity of the earth.

We should recognize that if we do not act urgently to recover it, the true cost of our failure will be borne by succeeding generations. This is the moral challenge of our generation. We should therefore set a road-map to a more secure climate future. We cannot rob our children of their future.

1.1.4. Advanced Countries and Developing Countries.

As a result of the unethical international policies for energy and mineral development of advanced countries in the northen hemisphere, to develop overseas petroleum, uranium and other mineral resources through using the loose environmental legal system of developing countries, those living in the third world are not only fighting for their own survival, but battling with the growing disparity between the North and their own poorer South. The wealthier Northern countries face new pressures as they depend on the resources of the poorer South, while the South wants to have a say in the management of its own resources. As the divide increases, the crisis intensifies.

Additionally, non-Christians have criticised the biblical doctrine of creation, particularly its teaching on dominion, for being the root cause of environmental disasters brought about by Western Christian countries. The arrogant attitude towards nature that this has bred, is, in the opinion of critics, responsible for the indiscriminate way in which our earth's resources have been exploited purely for their consumption. Eco-feminists extend the focus to male-dominion pointing out that both oppression of nature and oppression of women could be traced back to this same root.

1.1.5. Christian Insights and Perspectives.

With such grave concerns about the environmental impact of energy and mineral development, we are challenged by the urgent task of coming to grips with root issues. Dealing with superficial symptoms will not be sufficient. Getting to root issues will turn out to be an absorbing theological discussion. Restoring, even reinterpreting biblical doctrines will help the Church to face the challenge as God's people. Theology is not merely for our academic indulgence but a motivation for actions.

1.2. Environmental Impact of Energy and Mineral Development in Korea.

Korea has needed a great deal of energy and mineral resources to meet the increasing demand for her rapid economic development. In order to meet the need for mineral resources, she has developed domestic mining activities, with the exception of coal, gold and limestone and has made an effort to develop overseas ones.

After going through the serious energy shortage as a result of the oil shock in 1973 and 1979 by OPEC, she has developed nuclear power plants. However most western countries have suspended and/or decreased the development of plants after the serious impact of the nuclear accidents at Three-Mile-Away Island in America and Chernobyl in Russia.

In her energy and mineral development drive to meet the rapidly increasing requirements of energy and mineral resources, Korea confronts some serious environmental and ethical problems at the moment.

1.2.1. Pollution from Closed Mines.

Once a mine reaches the end of its operational lifetime and dumping activities cease, ground-water is contaminated by acid water drainage and eventually flows into rivers and dams. Adjacent soils are polluted with heavy metals such as cadmium and lead, which come out of abandoned mine sites.

According to a report from a Korean newspaper on September 5, 2006, there are 936 closed mines in Korea. Some adjacent soil from these abandoned mine sites are seriously contaminated so that vegetables, rice and corn produced in those areas in 2005 contained lead and cadmium at a much higher level than the international standard approved by the International Food Regulatory Commission.

1.2.2. Pollution from Limestone and Coal Mines.

Korea has abundant reserves of limestone, dolomite, calcareus marl and hard coal (anthracite) which are the main materials for various cements, iron-manufactured solvents and briquette. However, limestone and coal mines bring about serious air pollution with dust coming from mining activities. Most of the roofs at Taebaeck city, the main mining area for limestone and coal are covered with grey dust blown from the mines. The residents don't like to hang out their washing.

1.2.3. Management of Nuclear Waste and Accidents.

After the establishment of a nuclear plant in 1975 by the Korean military government, at the time without opening discussions with the citizens, Korea is now operating 20 plant without detail managing counter-plans for nuclear wastes and accidents. She is also planning to set up more than 9 plants by 2015 and 16 plants by 2030 without the consensus of her citizens for further plant development and despite public concerns about apprehensive nuclear technology, high cost, reactor accident risks and management of radioactive waste which can make serious environmental impacts on humans and non-humans. This is a very serious ethical problem as the environmental impact will definitely place serious burdens on the future generations and neighboring states.

1.2.4. Overseas Energy and Mineral Development Policy.

Most advanced countries try to save their domestic mineral reserves and develop overseas resources despite the poor legal systems for environmental protection in developing countries at the present. However, Korea overdeveloped domestic mineral resources in her rapid economic development course, which drained almost all her valuable resources entrusted by our Lord to manage them from generation to generation. Now, she has been pushing to develop overseas resources to meet increasing requirements without taking any serious consideration of the Will of God.

1.2.5. GHGs Emission Control for Climate Change.

The climate change is a warning from the Creator concerning the unsustainability of modern industrial societies based on fossil fuels and unsound economic wealth orientation. It is not only an environmental issue but also a survival matter for all the creatures created by God. It is not only a scientific issue but also a ethical matter considering the will of our Creator.

However, Korea has drawn global attention because of her unique situation and rapid growth of greenhouse gas (GHG) emissions. Korea is the ninth largest emitter of GHGs and its emissions have nearly doubled in the past 15 years. This is the fastest emissions growth among OECD members from 1990 to 2005 (Min 2009:3).

With regard to the amount of CO_2 emission growth, Korea ranked fourth during 1990 to 2002. During the 20th century, the world temperature increased by 0.6 Celsius, while in Korea it increased 1.5 Celsius. Korea is very vulnerable to climate change because it is a peninsula with long coastal lines (Son 2009:4).

Nowadays, Korea is required to make notable counter-measures for global warming. It should call for creative measures, mapping out a national comprehensive plan aimed to slow down climate change, reduce energy consumption and invent technologies that can cut down greenhouse gas emissions.

1.3. Environmental Negligence of Korean Churches.

It is not surprising that the rapid growth of Korean churches has been reported in various Christian magazines in accordance with that of her economy. However, Koreans are facing the impact of the above-mentioned due to environmental neglect in the execution of reckless economic development programmes as well as energy and mineral development.

Most Korean churches are unconcerned about the deteriorating physical environment as a result of energy and mineral development. Their attitude appears to be that environmental issues are only for the government and specialized non-government agencies, not for the church. They have executed their pastoral duties within the existing political and economic structures. They have been interested in their quantitative expansions to the extent that of the 50 largest churches in the world 27 of them are Korean.

They have become encapsulated communities isolated from their societies as a result of the dichotomous philosophical influence of Western Christendom, that the church is good and the world is evil. These church-centered Christians have failed to fulfil their social responsibility in so much that they are almost unconcerned about the environmental actions against reckless development for national economic plans, as well as the nuclear plant operations and mining activities without the detailed environmental counter-plans to give comprehensive control of any development projects.

They should have used the catch-phrase: "Let us live straightly" instead of the slogan of "Let us live well" which is to encourage citizens to work harder. While the government is proud of "the economic miracle in Han river," they should teach their members a pure life attitude living in the presence of God (coram deo). They should spell out in very clear terms the Will of God to create all humans and non-humans. They should not just sit back and watch the deteriorating situation of the very weak and vulnerable environment.

1.4. Research Problem.

Does theology have anything to offer to the sustainable development of energy and mineral resources in Korea? Are there theological criteria to evaluate the sustainable development of energy and mineral resources in Korea as well as the lack of involvement of Korean churches in promoting sustainable development? Can guidelines for sustainable development in acceptance with God's will be formulated to practice in Korean churches and societies?

1.5. Theological Foundation for Sustainable Development of Energy and Mineral Resources.

God's talk cannot be separated from our concerns for human fulfillment and the flourishing of human community. Theology is a critical reflection on the liberating faith and transforming praxis of the Christian community in relation to the revelation of our Lord, Jesus Christ. Christian life is the sacred duty entrusted by the Creator, our Lord, Jesus Christ.

So, Churches and Christians should actively participate in policy-making and policy-performance through the influence they can bring to bear on policy issues which comes from their Christian insights and perspectives which are in tune with Biblical witness. What are these Christian insights and perspectives which can contribute to the sustainable development of energy and mineral resources? They can essentially stand for the following Christian teachings which are rooted in Biblical witness and Christian experience.

1.5.1. The Holistic Mission of Jesus Christ.

The holistic mission of Jesus Christ should be a challenge for Christian theology and ethics and be appropriated as a moral value in theological discussions of sustainable development of nuclear plants and mineral resources.

1.5.2. The Holy Spirit of Creation and Salvation.

If Christian salvation is the resurrection of Christian bodies and the new creation of all non-humans, the salvation Spirit of Jesus Christ is the creation Spirit of our Lord God (Colossians 1:14-17). So, all humans and non-humans in the earth are the existences of loving solidarity in the hope of salvation (Romans 8:21-23) waiting for the new heaven and new earth (Revelation 21:1).

1.5.3. Sustainable Development by the will of the Creator.

Our Lord God is the owner of all the earth. The sons and daughters of God are the shepherds who keep sustainable development of all the non-humans on the earth. They are not only objects for reckless development for only the current generation, but are subjects cared and used by the will of God for all generations till the coming again of our Lord Jesus Christ into the earth to integrate environmental, social and economic concerns now and in the future without any environmental impact for all humans and non-humans.

It goes without saying that sustainable development of energy and mineral resources on the earth in accordance with the will of God. We cannot image one day of our lives without energy and mineral resources in current civilized societies, just as we cannot exist without pure blood.

1.5.4. The Fulfillment of Eco-Justice Stewardship.

The life of Jesus Christ is a clear demonstration of the reign of our Creator of justice. The heart of a harmonious relationship between humans and non-humans on the earth, whether individually, communities or internationally, is the essence to start the journey for justice and equity of development and sustainability. Social ministry is an adequate method for contemporary churches to fulfill their eco-justice stewardship through analysis, education, action, and feedback about development, consumption and management of nuclear plants and mineral resources.

1.5.5. Christian Right and Duty in Jesus Christ.

All Christian churches and Christians should not ony insist on their rights in Jesus Christ in accordance with their selfish minds, but they should truly perform their duties to love others and recover the environment of nature. In particular, they must do their best to restore a balance between civilization's ravenous appetite for energy and mineral resources and the fragile equilibrium of environment by means of a theocentric temperate life in contrast to an anthropocentic extravagant life.

1.6. Background of Thesis.

1.6.1. Main Point of Departure.

My thesis argues that Christian theology does indeed have something to offer to help solve the current environmental impact of energy and mineral development. Its contributions are in the form of Christian insights and perspectives which can prevent an impact on the environment by practicing Biblical sustainable development of energy and mineral resources in accordance with the will of the Creator, Lord Jesus Christ.

This involves a clear presentation of theological and ethical criteria as a practical matrix, which are founded on Biblical witness and Christian experience. There is an urgent and timeous need to present a theological framework which would capture theological and ethical reflections on the environmental impact from nuclear plants and mining activities in Korea.

1.6.2. Research Objectives.

1) To describe overall the world environmental crisis as a result of the overconsumption and overdevelopment trends of energy and mineral resources in particular produced by means of nuclear plant operations and mining activities. This study will call attention to how much this seriously impacts on all non-humans to meet the rapidly increasing requirements of energy and mineral resources of current civilized societies.

2) To analyse in detail the Korean consumption trends of energy and mineral resources and development policies of mineral resources and nuclear plants compared with those world trends above-mentioned, and break down the current and potential environmental impact of mining activities and nuclear plant operations in Korea. That will make all Koreans

awake environmentally and ethically how seriously her policies and activities has impacted and will impact on the future generations as well as the current generation.

3) To analyse typical features (pathologies) of Korean Churches concerning their social responsibility in order to raise awareness of the lack of concern about the environmental impact from the development drive of nuclear plants and mining activities in Korea.

4) To formulate Christian insights and perspectives which are in tune with Biblical witness by means of restoring and even reinterpreting biblical doctrines such as the holistic mission of Jesus Christ, the Holy Spirit of creation and salvation and so forth.

5) Even though the Kingdom of God has not yet fully come on earth, it is a present reality in this world. The salvation of our Lord Jesus Christ is not only a matter of the future but also the present. It is also not only a matter for humans, but also for non-humans. The salvation Spirit of Jesus Christ is the Creation Spirit of the Creator God for all humans and non-humans. So, this study will formulate a view of the holistic mission of our Lord Jesus Christ relating the eschatological present to the eschatological future. This study will be a theological criteria to evaluate the dichotomous characteristics of Korean churches, that they are isolated from their societies and have failed to fulfil their social responsibility.

6) To develop a practical benchmark for the sustainable development of nuclear plants and mineral resources in accordance with the will of God. This study will examine eco-justice stewardship, social ministry, and Christian duty to argue ethical criteria which have relevance for the sustainable development of nuclear plants and mineral resources.

7) To evaluate the environmental activities of Koran churches and the energy and mining policies of the Koran government from the standpoint of a theological framework above-mentioned.

8) To develop practical guidelines for Biblical sustainable development of nuclear plants and mineral resources in Korea based on the will of God and Christian insights and perspectives discussed in this study.

1.6.3. Research Motivation.

In order to meet the great need for energy and mineral resources to sustain the rapid economic development of Korea, I worked for more than

30 years doing feasibility studies, establishing investment criteria, and making trade contracts for petroleum and mineral resources.

However, I failed to notice the will of God with regard to the earth created by Him, even though I knew very well that most developing projects of energy and mineral resources would result in serious environmental damage by ravenous economic minds.

Fortunately, in the course of studying Magister Philosophiae in Applied Theology (MPhil) from 2002 and the Magister Artium in Missiology (MA) from 2004, the following theological notions transformed my conviction;

1) Nothing that God did in salvation history and the church did in faithful obedience to God's will can be divorced from God's overall hope for his creation.

2) There is no way in which the church can pursue its mission and ignore the challenge that environment destruction poses.

3) It is of crucial importance for all Christians to become involved in positive projects geared towards the natural environment in accordance with the will of God.

4) The developing projects of nuclear plants and mineral resources have to move away from the dominant anthropocentric perspective to one that embraces the whole earth community as belonging to God and as having intrinsic value.

1.6.4. Research Method.

The methodology of this study will consist mainly of literature study and qualitative empirical analysis. According to the process of social ministry such as analysis-reflection-practice-feedback based on the Biblical perspectives and Christian insights, this thesis will firstly concentrate on a comprehensive survey of the environmental movement of Korean churches and the environmental impact of nuclear plants and mining activities in Korea compared with world development trends.

Secondly, the literature study of both primary and secondary sources will focus on Christian ethics, creation spirituality, and philosophy of law and economics to develop a theological framework for biblical sustainable development in accordance with the will of God as a criteria to capture theological and ethical reflections on the environmental impacts from mining activities and nuclear plants in Korea.

I will interpret numerous statistics on, for example, the environmental impact of nuclear plants and mining activities, consumption, demand, production and reserves of mineral resources in Korea in the light of the world situation supplied by the Korean Institute of Geology and Mineral Resources (KIGAM), Korea Energy Economics Institute, Korea Resources Corporation (KRC), Korea Society for Geosystem Engineering, United Nations Sustainable Development Committee, IAEA, World Resources Institute (WRI) and so on.

Qualitative empirical analysis will mainly be done through the interviews of Korean church members, NGO's, government institutions and prominent Koreans. This is in order to gather data and information on the environmental impact of nuclear plants and mining projects in Korea.

1.7. Outline of Thesis.

1.7.1. Chapter 1: Introduction.

The first chapter will give the introductory information such as the environmental problem, purpose, motivation, relevance, methodology and resources used to write this thesis.

1.7.2. Chapter II: World Development Trends Regarding Energy and Mineral Resources.

I will describe the characteristics of a nuclear plant and mining industry and the world trends of development, consumption, reserves of energy and mineral resources, and identify the mining policy of the advanced countries and developing countries to check out the situation of mining activities.

1.7.3. Chapter III: Environmental Impact from Mining Activities and Nuclear Plants.

I will identify the serious environmental impact brought about by means of nuclear plant operations and mining activities, and indicate the challenge to meet the rapidly increasing demand of energy and mineral resources of current civilized societies.

1.7.4. Chapter 1V: Environmental Impact of Mining Activities and Nuclear Plants in Korea.

In order to help Korean readers (churches, NGO's and government) to recognize the grave concerns concerning the environmental impact brought about by means of nuclear plant operations and mining activities in Korea, this chapter analyzes the development policies regarding nuclear plants and mineral resources and management plans regarding nuclear waste and closed mines. It gives detailed information on environmental and social issues such as poor resources, overconsumption and overseas mineral development policy rather than domestic policy and statistical pictures of Korea.

1.7.5. Chapter V: Inadequate Environmental Involvement of Korean Churches.

In order to help Korean churches to recognize their attitude of unconcern regarding the environment movement in spite of the serious impact on the environment from reckless development as well as nuclear plants and mining activities, this chapter will outline the environmental activities of Korean churches and associations, surveying the situation and history of the Christian environmental movement and describing their contributions to spreading environmental awareness and participating in the environmental impact assessments and environment management plans of nuclear plants and mining projects in accordance with the holistic mission of our Lord Jesus Christ. Additionally, it will describe the historical development of Christian churches and their leadership pathologies in order to understand the Korean Christian context.

1.7.6. Chapter VI: A New Concept of Sustainable Development of Energy and Mineral Resources in accordance with the will of God.

Even if sustainable development is a useful approach to solve the contradiction between industrialization and the preservation of the environment, it is still faced with some dilemmas particularly in relation to consumerism as sustainable industrialization advances. This is the irresolvable tension between people's drive to consume more and more goods and services in order to improve the quality of life, and the environmental degradation threatened by such consumption (Park 2004:247-249).

Through analysing the controversial views of traditional finite world paradigm and market resource allocation paradigm, fundamental roots of environmental degradation and biblical proposition for sustainable development, I will introduce a new concept of sustainable development in accordance with the will of God to show a fundamental approach going beyond discussing only the socio-economic forces encouraging population growth, technological development and production activity on account of anthropocentric greedy values. Additionally some concepts of biblical sustainable development in mining context will be introduced for mining activities in accordance with the will of God.

1.7.7. Chapter VII: Theological Framework for Biblical Sustainable Development of Nuclear Plants and Mineral Resources.

I will give an account of my views on Christian insights and perspectives for nuclear plants and mineral resources based on biblical sustainable development in accordance with the will of God. This account is not intended to be exhaustive - as that would fall outside the scope of my study - but is merely stated by me as a researcher and hint at what criteria can be employed to evaluate the environmental impact of energy and mineral resources. The purpose is to awake the Korean churches from the lack of a theology that emphases the holistic mission of our Lord Jesus Christ through creation spirituality and a Christian ethic for non-humans as well as humans and sustainable development in accordance with the will of God through eco-justice stewardship, social ministry and Christian duty.

1.7.8. Chapter VIII: Evaluations of Korean Churches regarding Biblical Sustainable Development of Energy and Mineral Resources.

An attempt will be made at evaluating the biblical sustainable development of nuclear plants and mineral resources in Korea in order to identify challenging tasks which Korean churches are now facing, as well as approaches that will help them to come to grips with the absorbing theological discussion. The evaluation will be made using the theological framework for biblical sustainable development in accordance with the will of God discussed in former chapters.

And then I will suggest practical directions for Korean churches to practice in their daily lives. Additionally, a direction for the Korean Government will also be suggested through evaluating its energy regime and mining policy in order to offer targets for Korean churches to push the government for an integrity of environment.

1.7.9. Chapter IX: Summary, Critical Findings and Recommendation.

The final chapter will offer a summary, critical findings (conclusion) of the research, and practical proposals (recommendation) for future research.

Chapter II: World Development Trends Regarding Energy and Mineral Resources[1)]

Since human beings first started to use stone tools, they have been dependent on minerals contained in or on the earth. This dependence has increased as we have evolved to our present industrialized status, to the point today where our livelihood is utterly dependent on mining.

Our dependence on modern mineral-derived artifacts and on energy is not going to decrease. Indeed, population growth and increasing living standards will rapidly increase our dependence on energy and mineral resources.

Over the last century, the exploitation of energy and mineral resources has grown enormously, in parallel to the growth of economic activities. Currently, western economies use about 20-40 metric tons of raw materials per person per year (Adriaanse et al. 1997:35-37).

While high material consumption rates certainly have contributed to the high living standards in large parts of the world, their enormous throughput has also raised questions with regard to the sustainability of the current use of energy and mineral resources.

Some people have pointed out the risks of depleting limited reserves of high-grade resources. In addition, the exploitation of energy and mineral resources requires a sizeable amount of global capital and energy inputs,

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1) All the materials that make up the lithosphere (the rigid outer of the earth's crust and mantle) and the biosphere (the part of the earth's surface and its immediate atmosphere that is inhabited by living organisms) comprises of the sum total of the living and non-living endowment of the earth. The endowment which has a value as something useful becomes resources. The resources are classified into natural and social resources. The natural resources are one set of goods within the category of land, most of which become the capital goods used in production, while the social resources are the tools and systems to develop, use and manage other resources such as people, knowledge, skills, capacities, technologies, organizational and institutional structures, political and economic schemes and so forth.

and causes different sorts of environmental problems in mining, transport, and upgrading.

2.1. Characteristics of Energy and Mineral Resources[2)]

2.1.1. Development.

Geological resources are converted into reserves by exploration activities. Ore extracted from the reserves is used to produce refined metals or metal compounds (primary production), which are subsequently used to produce final consumption goods. These products remain in use for some time during or after which the metals they contain (1) slowly dissipate or (2) are dumped in ways and places where they could constitute a secondary resource as long as they are not dissipated into the environment. Alternatively, materials can be recycled directly after their lifetime within the secondary production. Consumption of mineral resources is made as primary production and secondary production.

2.1.2. Demand.

Over the last 100 years, the global consumption of metals has sharply increased, with an average annual growth rate of more than 3% (Strengers, B. J. et al. 1999:239-255). Obviously, the building of cities, heavy industry and all kinds of machines and appliances have made a significant contribution to the growing use of mineral resources.

In the most industrialized countries, demand for most mineral resources in the last two decades has been showing slow growth or has even levelled

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2) According to the predominant end-use, natural resources are generally divided into renewable resources and non-renewable (mineral) resources. The former are flow or continuous resources that are produced, as part of the functioning of natural or managed systems, at about the same rate that they are used up. They can provide a sustained yield. The latter are the resources that has a finite endowment. It either cannot be reproduced once it is used or lost, or cannot be reproduced within a time span relevant to present or future generations.

off. In contrast, demand for mineral resources has been growing sharply in many developing countries. Recently, Asia experienced an average annual growth in iron demand of about 8% per year.

Population growth, economic growth and spread of material-intensive lifestyles can potentially increase the demand of mineral resources by order of magnitude. So, major policy initiatives are needed to reverse current trends in resource use and material-intensive lifestyles.

2.1.3. Production.

Historically, the processing of mineral resources has been subject to steady progress in energy efficiency. The recycled metals may require substantially lower energy inputs than the use of virgin metals. Primary production encompasses all processes from mining and milling to smelting and refining.

Secondary production is often mentioned as an important factor to a more efficient use of resources. In principle, consumer recycling rates have increased over time, because recycling limits waste flows to the environment and reduces energy requirements. The main factors influencing the recycling rates are: (1) scrap availability compared to consumption, (2) relative processing costs of scrap and virgin metals, and (3) possibility of cost-effective scrap collection.

2.1.4. Reserves[3)]

The impacts of ore grade decline or depletion has been the subject of long debate. But we can define the issue of potential depletion of resources completely in terms of quality, i.e. ore grade. Assuming that resources of the highest quality are exploited first, further exploitation might lead to quality decline. Next, the effects of quality decline are calculated in terms of the energy requirement and production costs per unit of primary mineral

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3) The proven reserves mean the amount of energy and mineral resources which are reasonably certain to be commercially recoverable using current technology. So, the proven reserves are much lower than resources ultimately recoverable in place.

resources.

The production costs of mineral resources are a sum of energy costs, capital costs and exploration costs. So, the depletion of resources is defectively involved in the energy intensity as a function of ore grade decline and technological development.

We are well aware that new discoveries of mineral deposit and technology in the mining industry have increased mineral reserves in the past and are likely to do so in the future. But we should regard mineral resources as limited, based on social impacts and environmental damage associated with resources production.

2.1.5. Environmental Impact.

Several case studies indicate that mining is both a direct and an underlying cause of forest loss and degradation, and that mineral wealth can actually depress social conditions in developing countries. As society resorts to lower grades and to more remote deposits, natural areas will be more heavily disturbed by large open-pit mines and mining accidents as witnessed recently in China.

And more energy will be needed and increasing amounts of environmental wastes generated. Due to sheer growth in the demand for energy and minerals[4), waste production will increase to levels several

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4) Energy and mineral resources can be categorized by some criteria of physical and chemical characteristics, end-uses, scarcity etc. Based on the physical and chemical characteristics of mining and mineral-using industries, the Metals and Minerals Annual Review classified them into six groups: (1) precious metals and minerals (gold, silver, diamonds etc.); (2) major metals (copper, aluminium, zinc, tin, lead etc.); (3) steel industry metals (iron ore, steel, chromite, cobalt, manganese, nickel etc.); (4) speciality metals (magnesium, titanium, cadmium, mercury etc.); (5) industrial minerals (asbestos, graphite, alt, kaolin, phosphate rock, industrial diamonds etc.); and (6) energy minerals (coal, oil, natural gas, uranium etc). The resources are also typed into (1) energy minerals; (2) ferrous metallic minerals; (3) non-ferrous metallic minerals; (4) precious minerals; and (5) industrial minerals by the principal end-uses approach of minerals.

times higher than current ones in the near future.

Air pollution, acid rain and global warming are all attributed to the use of fossil fuels, with coal seen as the worst culprit. However, the combination of economic growth, population increases and urbanization is driving up the global energy demand to new levels.

Over 1.3 billion people worldwide live in areas of heavy air pollution and millions more have their health or quality of life undermined by the emissions from motorvehicles, factory chimneys and power stations. Chinese cities have concentrations of airborne particulates 14 times worse than in the USA. The burning of coal and oil may also release trace cadmium and mercury. Energy which poisons the air we breathe is a poor mark of progress.

The current material-intensive lifestyles will generate large and increasing energy use, which in turn aggravates the impending threat of climate change; rising prices of energy and minerals keeps less industrialized regions in a poverty trap; enormous fluxes of mining wastes and land degradation put an ever-increasing stress on ecosystems; and results in the loss of bio-diversity.

So, our current material-intensive lifestyles, economic and demographic growth should be taken into account giving an adequate picture of development in energy and minerals demand and environmental recovery.

2.1.6. Unsustainability.

Fossil fuels cannot last forever and burning them gives off a range of pollutants and greenhouse gases. Known reserves of crude oil will be exhausted in about 40 years at current production rates. Though new oil fields are being discovered and higher prices will spur new exploration efforts and recovery techniques, this comfortable situation cannot last forever. At some time in the 21st century it seems likely that oil will cease to be used as a standard fuel for transport and power generation.

The USA, once the world's main supplier of crude oil, now has to rely on imports for half its requirements, because many of its own wells have run dry. The assumption that tar sands, shale oils and synthetic fuels made from coal will eventually take over from oil seems less and less realistic in light of high production cost and the heavy environmental impact. Synfuels, for example, give off even more carbon dioxide than coal, require large amounts of water for processing and lose 30-40% of the energy in the original coal. Much of the same problems are presented by oil shale and tar sands.

In spite of such a serious current energy situation, few in the West would care to live without electric power or motor cars. The world's economy is closely geared to a continuation of the fossil fuel regime, yet an extension of the present energy habits of industrialized countries on the rest of the world would be unwise, straining, perhaps to breaking point, both resource availability and environmental quality (World Bank 2007:22-27).

Paradoxically, the current global financial turmoil is expected to slow major economies down, particularly the USA, Europe and Japan, whose economies are reported to have shrunk for one or two years. The financial crisis is anticipated to spread throughout the world at various levels of intensity, exerting pressure on economic growth and downward revision of forecasts for energy and mineral resources.

2.1.7. Terrestrial Industry.

Mining companies are entrusted with the task of satisfying the requirements of energy and minerals, as are farmers entrusted with satisfying our food needs. However, unlike farming where there is a choice of where and what to grow, mining can take place only where minerals occur. Consequently, mitigation of environmental impacts by moving a mine to a more environmentally suitable site cannot be considered, as would be the case for most other development projects.

Additionally, mining is very often a temporary land-use. This is unlike almost all other developments which permanently alienate land from its original use. Being a true extractive industry, mining cannot be sustainable at one place because the deposit is finite and is eventually exhausted.

2.2. Demand-Supply Trends of Energy and Mineral Resources.

2.2.1. Energy Minerals.

Cheap fossil fuels transformed the world during the 19th century and became the foundation of modern civilization. The three fossil fuels such as oil, gas and coal provide nearly 90% of the energy which drives industrial society (UGI 2004:2-16).

The energy infrastructure based on fossil fuels has developed over the last 200 years and now extends through worldwide systems of mining and exploration, transportation by land, sea and air, electricity generation, chemicals and many other products. Even agriculture depends heavily on the fuels and fertilizers produced by this system.

Over the last century, we have come to take energy for granted, not thinking about the effort needed to bring electricity to our houses or petrol to our cars. Occasional strikes and power cuts remind us of how much we depended on a continuous flow of energy and what a thin line divides civilized life from barbarism.

However, the demise of the fossil fuel economy has been predicted for some years by those who deplore its polluting and global warming downside and by pundits who claim that reserves are running out. Yet fossil fuels such as oil, natural gas and coal continue to account for 89% of the world commercial energy supply (the energy that has to be purchased rather than simply gathered like wood and other biomass used for fuel in Third World countries).

In fact, dependence on fossil fuels is growing because there is still no other practicable way to meet the world's energy demands, as more and more countries transform themselves from rural-agrarian to urban-industrial societies.

Though coal is often categorized as dirty and its use as a household fuel in western countries has greatly declined, it still generates over 37% of global electricity. Coal is the main energy source in China and India, which together account for a third of the global population (DME 2007:51-69).

At present the per capita use of commercial energy in China and India is well under 1,000 kg of oil equivalent a year compared with over 5,000 kg in most OECD countries and about 8,000 kg in the USA. The growth in demand which accompanies economic development has serious implications for both the energy supply and carbon emissions.

2.2.1.1. Oil.

Oil is the ultimate risk and reward business. Most oil wells yield insufficient oil to be commercially viable. Even with detailed geological surveys and a century of experience, the industry's average hit ratio is only about one commercial well to ten exploratory drillings (Ikaneng 2008: 48-51).

The first oil well of modern times was drilled by Edwin L. Drake in 1859 in northwestern Pennsylvania, USA. The huge Prudhoe Bay field in the Arctic was found only on the last of a series of test drillings. Offshore drilling began in the Gulf of Mexco and has spread to many parts of the world. The technology developed there and in the North Sea has made production possible in water almost 2,000 meters deep.

The International Energy Agency (IEA) stated that world oil demand is expected to rise by an average of 2.2% between 2008 and 2012, while production will lag behind, which will lead to a supply deficit. The demand is expected to reach 95.8 million b/d from 86.1 million b/d in 2007. Large scale exploration will continue in deep water blocks for both oil and gas immediately after rights are finalized.

2.2.1.1.1. Reserves.

The estimated world proven oil reserves decreased from 1,239.5 billion barrels in 2006 to 1,237.9 billion barrel in 2007. The Organization of Petroleum Exporting Countries (OPEC) accounted for 75.5% of the world oil reserves. The Middle East is estimated to have 61.0% of the world proven reserves and produces almost 1/3 of the world's crude oil.

The Middle East has many advantages regarding oil sources such as cheap- high-quality crude which is relatively easy to extract from a central global location with easy access to the sea. There may be plenty of oil beneath the bandit-ridden Caucasus, the frozen wastes of Siberia, the jungles of Latin America, Africa and Asia, and from sea beds in various parts of the world. But it is more expensive to produce and harder to transport oil in these areas. The environmental impact of oil production is also more serious there.

2.2.1.1.2. Production.

The world oil production fell by 0.2% from 81.7 million barrels per day (b/d) in 2006 to 81.5 million d/d in 2007. The major oil producers in the OPEC group were Saudi Arabia and Iran, with a contribution of 10.4 million b/d and 4.4 million b/d respectively.

The production outside OPEC countries remained weak, falling by 0.7% to 33.5 million b/d in 2007. Output rose by 0.5 million b/d in the Commonwealth Independent States (CIS), with Azerbaijan and Russia each growing by more than 0.2 million b/d. The Organization for Economic Cooperation and Development (OECD) output dropped by 1.4% to 19.2 million b/d.

Over 41,000 oil fields have been discovered, but most of them are small wells. The world's biggest 370 fields contain three-quarters of all discovered oil. The biggest 3% of oil fields account for 94% of all oil ever discovered. Although new fields are found regularly, new super-giants are extremely rare.

Today the seven major oil companies are Shell, Exxon, BP, Mobil Chevron, Amoco and Texaco. Other international oil companies include ENI (Italy), Elf Aquitaine and Total (France), Atlantic Richfield, Phillips Petroleum and Enron (US), and Statoil (Norway). Major Middle East enterprises include Aromco (Saudi Arbia) and NIOCO (Iran).

2.2.1.1.3. Consumption.

Oil was initially sold as a fuel for lamps. Oil's strategic importance was boosted when the British navy, advised by Winston Churchill, decided in 1911 to switch from running its ships on coal to running them on oil. Now all the world's aircraft, ships and vehicles run on petroleum fuels. In some countries many power stations use oil. Many products in daily use such as textiles, plastics, fertilizers, pharmaceuticals are made from petroleum-based feedstocks.

The global oil consumption increased by 1.1% to 85.2 million b/d in 2007. The consumption in the oil-exporting regions of the Middle East, South and Central America and Africa accounted for two thirds of the world's growth. However, oil consumption in the OECD decreased by 0.9%.

The International Energy Agency projects that if left unchecked, global energy consumption will rise more than 50% by 2030, with fossil fuels remaining the dominant energy source. In turn, vulunerability to price shocks and supply disruptions would rise, and carbon dioxide (CO_2) emissions could increase by more than 50% (Worldwatch Institute 2007:33).

Table 2.1: Consuming Trends of World Fossil Fuels. unit: million TOE.

Year	1950	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2006	2007
Oil	470	951	1,530	2,254	2,678	2,972	2,801	3,155	3,264	3,559	3,871	3,911	3,953
Natural Gas	171	416	632	924	1,075	1,304	1,493	1,788	1,936	2,199	2,497	2,558	2,638
Coal	1,074	1,544	1,486	1,553	1,613	1,814	2,107	2,229	2,268	2,340	2,892	3,042	3,176

Source: UN, BP, IAEA Press Reports.

2.2.1.1.4. Prices.

Higher demand resulting from higher economic growth rates exerted upward pressure on prices. Consequently, the price of Brent crude oil averaged $72.39 per barrel in 2007, which is almost 11% above the 2006 average. This price growth continued into 2008, testing the $150/bl hurdle, before plunging back to below $50/bl in the fourth quarter of 2008. This development is expected to cushion inflationary pressure inherent in higher prices of oil.

2.2.1.2. Natural Gas.

Though the Chinese drilled deep holes to tap natural gas over 2,000 years ago and flames from natural gas were known in ancient Persia where it was associated with Zoroastrian fire worship, this energy was unknown in Europe until the 17th century and was not widely used until the middle of 20th century. But natural gas now has a high net energy yield. As more gas fields are discovered, its use is expanding rapidly. It burns hotter and produces comparatively less pollution and carbon dioxide than oil and coal (Ikaneng 2008: 48-51).

2.2.1.2.1. Reserves.

The world's proven gas reserves increased by 0.6% to 1177.36 trillion m^3 in 2007 due to new discoveries. The Middle East, Europe and Eurasia accounted for 74.8% of the total reserves

2.2.1.2.2. Production.

The oil shortages and steep price rises as well as the concerns over environmental impact of using coal and oil forced producers to take a closer look at the potential of natural gas. The world gas production rose by 2.40% in 2007 to 2,940 billion m^3. Russia was the largest producer, accounting for 20.6% of the total world production, followed by USA at 18.4%, China at 18.4% and Qatar at 17.9%. The production in the European Union declined by 6.4% with the United Kingdom's output falling by 9.5%.

Table 2.2: World Reserves and Production of Oil and Natural Gas, 2007

Country	Proved Reserves		Production	
	Oil(billion bl)	Gas(trillion m^3)	Oil(1,000 b/d)	Gas(billion m^3)
Algeria	12.3	4.52	2,000	83.0
Indonesia	4.4	3.00	969	66.7
Iran	138.4	27.80	4,401	111.9
Iraq	115.0	3.17	2,145	0.0
Kuwait	101.5	1.78	2,626	12.6
Libya	41.5	1.50	1,848	15.2
Nigeria	36.2	5.30	2,356	35.0
Qatar	27.4	25.60	1,197	59.8
Saudi Arabia	164.2	7.17	10,413	75.9
UAE	97.8	6.09	2,915	49.2
Venezuela	87.0	5.15	2,613	28.5
(OPEC/ Subtotal)	**934.7(75.5%)**	**91.08(51.2%)**	**35,204(43.0%)**	**537.8(18.3%)**
Argentina	2.6	0.44	698	44.8
Australia	4.2	2.51	561	40.0
Brazil	12.6	0.36	1,833	11.3
Brunei	1.2	0.34	194	12.3
Canada	27.7	1.63	3,309	183.7
China	15.5	1.88	3,743	69.3
Ecuador	4.3	0.0	520	0.0
Europe & Eurasia	143.7	59.41	17,835	1,075.7
India	5.5	1.06	801	30.2
Malaysia	5.4	2.48	755	66.7
Mexico	12.2	0.37	3,477	46.2
Oman	5.6	0.69	718	24.1
USA	29.4	5.98	6,879	545.9
Others	30.5	9.13	5,006	-
(Others/ Subtotal)	**303.2(24.5%)**	**77.15(48.8%)**	**46,329(57.0%)**	**2,388.5(81.7%)**
Total	**1,237.9**	**177.36**	**81,533**	**2,940.0**

Source: BP Statistical Review of World Energy, June 2008.

2.2.1.2.3. Consumption.

Global gas consumption rose by 3.1% to 2,922 billion m^3 in 2007. The USA accounted for 22.6% of the world's gas growth, driven by cold winters and strong demands in power generation. China's consumption grew by 19.9% and accounted for the second largest increment to the global consumption, while the European Union consumption declined by 1.6%.

2.2.1.3. Coal.

Coal's high calorific value makes it a valuable fuel. But mining, transporting, processing and burning coal is a messy business which contributes significantly to environmental pollution and in particular global warming. Although new technology can make coal a relatively clean fuel, the cost is high and there is no way to make coal transformation pollution-free.

Coal has been mined by the Chinese for over 2000 years. It began to be widely used in Europe in the 18th century. As the industrial revolution proceeded, coal became the main energy source for those parts of the world which were engaged upon rapid industrialization. Coal mining became a major industry in Europe and North America, employing millions of people, including many children. These days, coal is used in the West mainly for power generation, but there are many countries, including China and India, where coal is still the main energy source for both domestic and industrial consumers. (Ikaneng 2008:42-47).

2.2.1.3.1. Production.

World coal production grew by 5.3% to 6,488 Mt in 2007, following a four-year period of strong growth averaging 6.5% per annum. China remained the largest producer, accounting for 39% of the total production, followed by the USA (16.2%), India (7.5%), Australia (6.1%) and Russia (4.8%).

World hard coal production grew by 6.5% to 5,543 Mt in 2007, driven by growth in production in the non-OPEC countries with 8.8% growth in 2007. The major producing countries were China, Russia, India, Indonesia, Kazakhstan, Vietnam and Colombia. China was the largest producer of hard coal, contributing 2,549.2 Mt of the world production, followed by the USA (980 Mt), India (451 Mt), Australia (323 Mt) and South Africa (247 Mt).

Brown coal production went up by 0.8% to 945.2 Mt in 2007. Production increase came from Germany (180 Mt), Australia (72.3 Mt), Turkey (70.0 Mt) and Bulgaria (28.3 Mt) and offset by being decreased in Russia, USA, Poland, Serbia and Montenegro.

Table 2.3: World Coal Reserves, Production and Exports, 2007.

Country	Reserves (Mt)	Production (Mt)	Exports (Mt)
China	62,200 (14.4%)	2,549.1 (39.3%)	53.7 (5.9%)
USA	112,261 (26.1%)	1,052.0 (16.2%)	53.4 (5.9%)
India	52,240 (12.1%)	484.4 (7.5%)	1.2 (0.1%)
Australia	37,100 (8.6%)	395.3 (6.1%)	243.6 (26.9%)
Russia	49,088 (11.4%)	313.7 (4.8%)	100.7 (11.1%)
South Africa	27,981 (6.5%)	247.7 (3.8%)	67.7 (7.5%)
Indonesia	1,721 (0.4%)	259.2 (4.0%)	202.2 (22.3%)
Poland	6,012 (1.4%)	147.8 (2.3%)	11.8 (1.3%)
Kazakhstan	28,170 (6.5%)	86.4 (1.3%)	23.0 (2.5%)
Colombia	6,578 (1.5%)	71.7 (1.1%)	67.2 (7.4%)
Canada	3,471 (0.8%)	69.4 (1.1%)	30.8 (3.4%)
Ukraine	15,351 (3.6%)	59.0 (0.9%)	3.4 (0.4%)
Others	28,723 (6.7%)	752.3 (11.6%)	47.7 (5.3%)
Total	430,896 (100%)	6,844.0 (100%)	906.4 (100%)

Sources: BP Statistical Review of World Energy, June 2008.
OECD/ IEA, Coal Information 2007.

2.2.1.3.2. Consumption.

World coal consumption increased by 0.8% to 271.7 Mt in 2007, following a four-year trend of annual increases averaging 6.6%. Hard coal consumption was up by 6.9%, steam coal by 7.3% and coking coal by 4.9%.

China maintained its position as the largest coal consuming country, an increase of 10.3% to 1,930.7 Mt in 2007. India, Russia and Indonesia increased by 10.7%, 2.7% and 10.4% respectively, while Ukraine and Kazakhstan declined by 1.1% and 1.6% respectively.

2.2.1.3.3. Trade.

Estimated world coal trade amounted to 917.3 Mt in 2007, an increase of 6% compared with 2006. Australia remained the world's leading coal exporter with its hard coal export reaching 243.6 Mt in 2007, an increase of 5.3% more than 2006. Indonesia showed continuing growth with an increase of 17.8% reaching 202.7 Mt, followed by Russia (9.6%) and

Colombia (8.4%).

2.2.1.4. Uranium.

2.2.1.4.1. Production.

According to the World Nuclear Association (WNA), world uranium mine production increased by 4.7% to 41,279 tU (48,680 U O) in 2007 as shown in the table 4. The three major producing countries such as Canada (22%), Australia (21%) and Kazakhstan (16%) accounted for 59% of world production (Chili, Thomas 2008:58-62).

Table 2.4: World Resources and Production of Uranium, 2007

Country	Uranium Resources (RAR/ kt U)	Production	
		2006 (tU)	2007 (tU)
Canada	433	9,862	9,476
Australia	754	7,593	8,611
Kazakhstan	474	5,279	6,637
Niger	225	3,434	3,153
Russia	133	3,262	3,413
Namibia	240	3,067	2,879
Uzbekistan	106	2,260	2,320
USA	106	1,672	1,654
Ukraine	90	800	846
China	60	750	712
South Africa	300	643	619
Others	81	803	959
Total	3,002	39,429	41,279

Sources: OECD's IEA and IAEA, Uranium 2007: Resources, Production and Demand/ WEA, Market Report Data, 2007.
Note: RAR; Reasonably Assured Resources plus inferred Resources.

In 2007, 62% of uranium was recovered from both underground and open pit mines, 29% from in-situ leach and 9% as by-product. The world-leading producers in 2006 were Canada's McArthur River with 7,200 tU (18.3%), Australia's Ranger with 4,026 tU (10.2%), Namibia's Rossing with 3,067 tU (7.9%), Russia's Krazanokamensk with 2,900 tU (7.4%), and Australian Olympic Dam with 2,868 tU (7.3%).

2.2.1.4.2. Nuclear Reactors.

According to the World Nuclear Association (WNA), about 16% of world electricity was generated from 439 nuclear reactors, operating in 30 countries with the total output capacity of about 371,989 MWe in 2007. Currently, 36 nuclear reactors are under construction and a further 93 new reactors are at planning stages. World nuclear electricity generation had dropped down by 2% to 2,608 billion kWh in 2007. The decline resulted from the closure of 7 units in Japan's largest nuclear plant (Kashiwazaki-KKariwa) and 6 German reactors that have undergone major repairs and maintenance.

Table 2.5: World Nuclear Plants and Uranium Requirements 2006-2007.

Country	Nuclear Electricity Generation	Reactors Operable 2006	Uranium Required 2006	Reactors Operable 2007	Uranium Required 2007
	Billion kWh	Number	tU	Number	tU
USA	787.2(19%)	103	19,715	104	20,052
France	428.7(78%)	59	10,146	59	10,368
Japan	219.5(30%)	55	8,169	55	8,872
Germany	158.7(32%)	17	3,458	17	3,486
South Korea	141.2(39%)	20	3,037	20	3,037
Russia	144.3(16%)	31	3,439	31	3,777
UK	62.2(18%)	23	2,158	19	2,021
China	51.8(2%)	10	1,294	11	1,454
Spain	57.4(20%)	8	1,505	8	1,473
Canada	92.4(16%)	18	1,635	18	1,836
Sweden	65.1(48%)	10	1,435	10	1,468
Ukraine	84.8(48%)	15	1,988	15	2,003
Belgium	44.3(54%)	7	1,075	7	1,079
Others	248.4	66	6,424	55	5,603
Total	2,658(16%)	442	65,478	439	66,529

Sources: World Nuclear Association, World Nuclear Reactors and Uranium Requirements, 2006-2007./ IAEA, Nuclear Electricity Production and Percentage of Electricity, 2006.

2.2.1.4.3. Demand.

The uranium demand was dominated by the USA, with 104 reactors equivalent to 23.3% of the world total reactors, followed by France with 59 reactors. 19% of USA's national electricity demand was supplied by nuclear energy, while France derived 77% and Japan 27.5% of their electricity from nuclear plants. Belgium, South Korea, Sweden and Ukraine all derived more than 30% of their electricity supply from their nuclear reactors.

Table 2.6: World Electrical Generating Capacity of Nuclear Power Plants.

unit: gigawatts.

year	1960	1965	1970	1975	1980	1985	1990	1995	2000	2004	2005	2006
Capacity	1	5	16	71	135	250	328	340	349	366	369	370

Source: Worldwatch Institute Database, IAEA and Press Reports.

2.2.2. Ferrous Metallic Minerals.

Demand for ferrous minerals depends on steel production where over 80% is consumed. Annual world crude steel production rose to 1,344.3 Mt in 2007 representing 7.5% improvement on 1,251 Mt produced in 2006. China continued its double digit growth in steel output, recording a rise of 16% on its 2006 production, to 487.3 Mt in 2007 (Bonga et al. 2008:96-99).

The accelerated growth of world steel production in recent years has raised concerns as to whether such increases are sustainable. The production growth has stemmed mainly from the Asian region, driven largely by China and India. The commodities most affected will be ores and alloys of iron and manganese for steel production and chromite ore and ferro-chrome for stainless steel.

2.2.2.1. Iron Ore.

2.2.2.1.1. Production.

World iron ore production increased by 9% from 1,482.6 Mt in 2006 to 1,632.5 Mt in 2007. Output increased in the four major producing countries such as Brazil, China, Australia and India, which collectively accounted for 72% of total world production as shown in the table 7. Developing countries increased their contribution to total global iron ore production from 60% in 2006 to 62% in 2007 while the Commonwealth of Independent States (CIS) contributed 12%, down from 13% in 2006 (Bonga 2008:104-108).

2.2.2.1.2. Trade.

Total world exports increased for the sixth successive year in 2007 to 822.4 Mt, up 8.1% compared with 2006. Developing countries increased their share of the export market to 53%, while developed countries accounted for 39% and CIS contributed 7.6%. Brazil was the leading exporter at 2694 Mt, while Australia and India exported 266.8 Mt and 93.7 Mt respectively.

Asia has consistently dominated the iron import market since 1997. China, which accounted for 45% of total imports increased its imports by 17% to 383 Mt in 2007, while Japan's imports increased modestly by 3.3% to 138.9 Mt. The four largest importers such as China, Japan, Germany and South Korea accounted for 74% of total world imports, while the EU accounted for 21%.

Table 2.7: World Reserves, Production and Exports of Iron Ore, 2007.

Country	Reserves (Mt)	Production (Mt)	Experts (Mt)
Australia	25,000 (15.6%)	299.1 (18.3%)	266.8 (32.4%)
Brazil	11,000 (6.9%)	336.5 (20.6%)	269.4 (32.8%)
Canada	2,500 (1.6%)	33.2 (2.0%)	28.3 (3.4%)
China	15,000 (9.4%)	332.3 (20.3%)	0
CIS	63,000 (39.4%)	201.4 (12.3%)	62.6 (7.6%)
India	4,000 (2.5%)	206.9 (12.7%)	93.7 (11.4%)
South Africa	1,500 (0.9%)	41.3 (2.5%)	30.3 (3.7%)
Sweden	5,000 (3.1%)	24.7 (1.5%)	19.4 (2.4%)
USA	14,000 (8.8%)	52.0 (3.2%)	9.3 (1.1%)
Venezuela	1,500 (0.9%)	22.5 (1.4%)	5.9 (0.7%)
Others	18,000 (11.0%)	82.8 (5.1%)	32.0 (4.4%)
Total	160,500 (100%)	1,632.5 (100%)	822.4 (100%)

Sources: UNCTAD, Trust Fund on Iron Ore: Production and Exports, 2007.
USGS, Reserve Base for Iron Ore, 2007.

2.2.2.1.3. Outlook.

Analysts have forecast a growth rate of between 7 and 10% for steel consumption and hence, iron ore production is expected to grow by another 10 to 12% in 2007. China is expected to account for more than 50% of that increase as its economic expansion continues unabated.

2.2.2.2 Chromium.

2.2.2.2.1. Production.

World chrome ore production amounted to 23 Mt in 2007, of which 93% was metallurgical grade and 3% foundry grade while refactory and chemical grades amounted to 2.4% and 1.6% respectively. South Africa dominated production at 9.7 Mt, followd by Kazakhstan at 3.7 Mt and India at 3.3 Mt. World ferro-chrome production amounted to 7.7 Mt with an increase of 17.5% higher than 2006 on the back of higher demand. South Africa was the biggest ferro-chrome producer producing 3.6 Mt, 17.5% more than 2006. Consequently, Africa is by far the greatest producer with a share of 46.4% of global ferro-chrome production, followed by Kazakhstan and China at 14% and 13.8% respectively (Mosiane 2008:100-103).

2.2.2.2.2. Reserves.

World chrome ore reserves amounted to 7.6 Gt. More than 80% chrome ore resources are located with the Bushveld Complex and the Great Dyke of Zimbabwe in Southern Africa. South Africa hosts 72% of the world reserves, followed by Zimbabwe with 12.2% and Kazakhstan with 4.2%.

2.2.2.2.3. Demand.

Demand for chromium depends on stainless steel production, which consumes over 90% of chromium. World stainless steel production fell by 2.6% to 28.5 Mt in 2007 compared with 2006. The stainless steel production declined in all regions except in Asia where the production was dominated by 60% to 17 Mt in 2007. China was the largest producer by 42% to 7.6 Mt, followed by Japan at 4 Mt and USA at 2.2 Mt. However, demand for chromium increased by 17% as stainless steel producers shifted to the production of cheaper stainless steel using more chrome and less nickel of which prices rose so much in 2006.

2.2.2.3. Manganese.

2.2.2.3.1. Production.

World manganese ore production increased by 12.6% to 38.2 Mt with a manganese (Mn) content of 12.7 Mt in 2007. However, since the higher manganese ore production resulted mainly from increased exploitation of lower grade sources, demand of 13.6 Mt for manganese content exceeded supply of 12.7 Mt.

World manganese ferro-alloy production increased 11.9% to 13.2 Mt compared with 2006. World production capacity for manganese ore increased to 43.9 Mt while capacity utilization increased to 89% in 2007 mainly as a result of higher demand from alloy plants driven by increased steel production (Bonga 2008:109-115).

2.2.2.3.2. Demand.

Demand for manganese depends on steel production which accounts for over 90% of consumption. Annual world crude steel production rose to 1,344.3 Mt in 2007, representing a 7.5% improvement on the 1,251 Mt produced in 2006. China continued to lead world production with an increase of 16% to 487.3 Mt in 2007 compared with 2006. Regional contribution to the world steel production was still dominated by Asia with 59%, followed by the EU with 16%, Americas with 14%.

In line with the increasing world steel production, demand for manganese ore grew by 14.9% to 13.6 Mt (Mn content) in 2007 and this trend persisted into the first quarter of 2008 when demand was 11% higher compared with the same period in 2007. Chinese crude steel production remained the dominant driver for world demand for manganese ore and allays as steel output total was 124 Mt in the first quarter of 2008, up 7.5% from the year before.

2.2.3. Non-Ferrous Metallic Minerals.

The supply deficit experienced by most non-ferrous commodity markets exerted upward pressure on prices, with the price of cobalt up by 78% to $29.33/lb compared with 2006 while the delicately poised supply-demand balance pushed up aluminium prices marginally by 2.7% to $2,640/t.

Furthermore, the supply deficit in lead markets pushed prices up by 100% while the nickel prices were up 53.5% driven by market tightness.

The present higher demand for titanium drove prices up, with Europe's TiO2 pigment price rising by 2.27% to $2,200/t while Asia Pacific's price rose by 9.38% to $2,132/t (Themba 2008:56-57).

However, the slowdown in world economic growth brought about by the United States sub-prime credit crisis, which has since escalated into an international financial crisis and threatens to drag the economy into recession, has resulted in a downward movement to prices in 2008, forcing a downward revision of market forecasts.

2.2.3.1. Aluminium.

2.2.3.1.1. Production.

World refined aluminium output rose by 12% to 38 Mt in 2007 compared with 2006. China was the largest producer with 31.6% of the world total production, followed by Russia (11.1%) and Canada (8.2%), which collectively accounted about for 50% of world production. Russia exported 22.3% of the world total exports, with second and third places occupied by Canada (14.2%) and Australia (9.4%). Production increased in all regions except Africa, where production declined by 5.3% as a result of power supply disruptions (Chili 2008:58-62).

2.2.3.1.2 Consumption.

World refined aluminium consumption increased by 9.4% to 37.2 Mt in 2007 compared with 2006. Consumption was dominated by Asia (19Mt), followed by Europe (9.1 Mt) and America (7.7 Mt). Consumption grew in all the regions except the Americas where it declined by 8.6% owing to the economic slowdown. The largest increase in consumption was experienced in Asia (18%) and Oceania (8.7%).

The demand for refined aluminum is driven by transport (26%), construction (22%) and packaging (22%) as well as the machinery (8%) and electrical industrial sectors (8%). A driver of demand in the transport sector is the shift to light-weighting, which is a response to regulating the environmental impact of fuel economy. Light-weighting involves aluminium replacing steel in the structural components of vehicles.

Table 2.8: World Aluminium Smelter Capacity, Production and Exports 2007

Country	Smelter Capacity(kt)	Production (kt)	Exports (kt)
China	14,000	12,000 (31.6%)	546 (3.1%)
Russia	4,400	4,200 (11.1%)	3,948 (22.3%)
Canada	3,100	3,100 (8.2%)	2,501 (14.2%)
USA	3,700	2,600 (6.8%)	399 (2.3%)
Australia	1,950	1,930 (5.1%)	1,659 (9.4%)
Brazil	1,700	1,498 (3.9%)	823 (4.7%)
Norway	1,190	1,330 (3.5%)	1,610 (9.1%)
India	1,500	1,100 (2.9%)	108 (0.6%)
South Africa	914	914 (2.4%)	625 (3.5%)
Bahrain	830	830 (2.2%)	na
Others	6,220	8,512 (22.4%)	5,452 (30.9%)
Total	42,700	38,000 (100%)	17,671 (100%)

Sources: World Bureau of Metal Statistics (WBMS), 2008, p. 15.
USGS, Mineral Commodity Summaries 2008, p. 23.

2.2.3.2. Copper.

2.2.3.2.1 Production.

World copper mine production amounted to 15.5 Mt in 2007, a 2.8% increase compared with 2006. Production increased in all four major producing countries such as Chile, the USA, Peru and Australia, which collectively accounted for 57% of the total world output. Chile remains the largest producer at 5.6 Mt, followed by the USA (1.2 Mt), Peru (1.2 Mt), Australia (0.87 Mt) and China (0.83 Mt).

World refined copper output rose by 3.7% to 18.0 Mt in 2007. Production increased in all the regions except Europe where it declined by 1.5% to 0.34 Mt. World trade in refined copper declined by 1.6% to 7.35 Mt compared with 2006 (Chili 2008:71-75).

2.2.3.2.2. Consumption.

World refined copper consumption grew by 5.7% to 18.0 Mt in 2007. Regional consumption was dominated by Asia which accounted for 53%, followed by Europe and America at 26% and 18% respectively. China was the leading copper consumer at 4.8% ahead of the USA (2.2 Mt) and

Germany (1.4 Mt).

Refined copper demand was driven by the building sector which accounted for 44% of total consumption, succeeded by the electrical sector at 18% and engineering at 17%. Additionally, light engineering and transport sectors accounted for 9% and 8% respectively. In 2007, the supply and demand balance remained tight as a result of continued supply constraints compounded by industrial disputes and lower copper grades.

Table 2.9: World Reserves, Production and Exports of Copper, 2007

Country	Reserves (Mt)	Production (kt)	Exports (kt)
Chile	360 (38.3%)	5,557 (35.8%)	5,673 (42.1%)
USA	70 (7.4%)	1,222 (7.9%)	613 (4.5%)
Peru	60 (6.4%)	1,190 (7.7%)	1,259 (9.3%)
Australia	43 (4.6%)	870 (5.6%)	676 (5.0%)
China	63 (6.7%)	831 (5.3%)	126 (0.9%)
Indonesia	38 (4.0%)	773 (5.0%)	600 (4.5%)
Russia	30 (3.2%)	770 (5.0%)	277 (2.1%)
Canada	20 (2.1%)	589 (3.8%)	608 (4.5%)
Zambia	35 (3.7%)	544 (3.5%)	491 (3.6%)
Poland	48 (5.1%)	452 (2.9%)	239 (1.8%)
Kazakhstan	20 (2.1%)	424 (2.7%)	356 (2.6%)
South Africa	13 (1.4%)	158 (0.7%)	36 (0.5%)
Others	140 (15.0%)	2,033 (14.2%)	3,029 (18.5%)
Total	940 (100%)	15,541 (100%)	13,476 (100%)

Sources: World Bureau of Metal Statistics (WBMS), 2008, p. 24.
USGS, Mineral Commodity Summaries 2008, p. 55.

2.2.3.3. Lead.

2.2.3.3.1. Production.

World lead mine production grew by 1.5% to 3,591 kt in 2007. China accounted for 37.9% of the bulk of production, followed by Australia at 16.5% and the USA at 12.4%. Asia dominated production accounting for 45%, followed by America and Oceania at 28% and 16% respectively.

World refined lead production increased by 2.7% to 8,189 kt in 2007 compared with 7,969 kt in 2006. China and the USA dominated production, accounting for 33.7% and 16.6% respectively. The contribution to refined lead output by region was dominated by Asia at 48.3%, followed by America at 25.8% and Europe at 21.3% (Pitso 2008:76-80).

2.2.3.3.2. Consumption.

World lead consumption rose by 1.8% in 2007 to 8,220 kt compared with 2006. The major lead consumers were China (2,543 kt) and USA (1,580 kt) China's lead consumption increased by 13% while the USA declined by 1.9%. The rise in global lead consumption was attributed to the growth in the automobile industry, and the increase in China's lead usage was attributed to the introduction of battery powered bicycles. The lead consumption by region was dominated by Asia which accounted for 49%, followed by America at 25%.

2.2.3.4. Nickel.

2.2.3.4.1. Reserves.

Nickel is mined from sulfide and laterite ores, which contribute equally to the current primary nickel production. The major nickel sulfide deposits are situated in Australia, Canada, Russia, and South Africa and are mined in underground operations. In contrast, laterite deposits are mined from open-pit mines, which are located in Western Australia, New Caledonia, Indonesia, the Philippines, Colombia, Cuba, Venezuela and Brazil. In 2007, world nickel reserves were estimated at 137 Mt with Australia (27 Mt), Cuba (23 Mt) and Canada (15 Mt) collectively accounting for 45% (Ikaneng 2008:81-84).

2.2.3.4.2. Production.

World mine production increased by 8.8% from 1.45 Mt in 2006 to 1.6 Mt in 2007 with increases in output mainly from Asia. Russia was the largest consumer contributing 18% to the total world production, followed by Canada, Indonesia and Australia accounting for 15.8%, 11.6% and 11.1% respectively.

World refined nickel output grew by 6.4% to 1.4 Mt in 2007 compared with 2006. The largest producer was Russia, accounting for 19.3%, followed by China (14.2%), Canada (11.3%) and Japan (11.2%). Asia is the fastest growing region with an increase of 25% to 383 kt with China producing 205 kt, mainly due to the significant contribution by Chinese nickel pig-iron production estimated at 85 kt.

2.2.3.4.3. Consumption.

Over 60% of all nickel produced is consumed in stainless steel production. World stainless steel production declined by 2.6% to 28.5 Mt in 2007 as a result of weaker demand. Consequently, global nickel consumption was 7% lower at 1.3 Mt than in 2006 as some stainless steel producers switched to cheaper alternatives.

2.2.3.5. Zinc.

2.2.3.5.1. Production.

The world mine output of zinc increased by 6.1% to 11,105 kt in 2007. China dominated production at 3,110 kt, followed by Peru (1,444 kt), Australia (1,398 kt), the USA (787 kt) and Canada (619 kt). World refined zinc production increased by 5.8% to 11,302 kt in 2007. Production was dominated by China (3,714 kt), followed by Canada (802 kt), South Korea (697 kt), Japan (598 kt) and Australia (502 kt) (Pitso 2008:88-92).

2.2.3.5.2. Consumption.

Global consumption of zinc metal in 2007 increased by 2.7% to 11 Mt. The major consumers were China (3,588 kt), followed by USA (1,037 kt), Japan (588 kt), Germany (534 kt) and South Korea (517 kt). Although the world economy is entering a major downturn, The International Lead and Zinc Study Group (ILZSG) forecasted that global zinc demand will still increase primarily due to continued growth in Asia.

2.2.4. Precious Minerals.

An all time quarterly record of $32 billion demand for gold was recorded for the third quarter of 2008 as investors sought refuge from the global financial meltdown. Investment demand for gold due to its safe haven status is expected to continue as a result of the uncertainty surrounding the global economy (Conradie 2008:19-20).

Although the USA currently accounts for about 50% of the global jewellery sales, increased demand from India, China and the Middle East is expected to offset decreased demands from the USA in the foreseeable future. The total world supply of diamonds was expected to decline in 2008 and beyond, partly due to a lack of major new mines, Furthermore, many of the mines currently in operation are beyond their production peaks and therefore expect lower production in the years ahead.

2.2.4.1. Diamond.

2.2.4.1.1. Production.

According to the Kimberley Process Rough Diamond Statistics, world diamond mine production declined by 4.4% to 168 million carats (Mct) in 2007. The value of mine production decreased by 0.6% to $12.1 billion in 2007 compared with 2006. The decrease in global production volume was attributed to a decrease in production from Australia, Botswana and China. The De Beers Group, with mines in Botswana, South Africa, Namibia and Tanzania, contributed 51 Mct (29%) to world production by mass and an estimated $3.35 billion (41%) by value (Ndou 2008:21-26).

Table 2.10: World Rough Diamond Production, 2007 Unit: 1,000 carats

country	Russia	Botswana	DRC	Australia	Canada	RSA	Angola	Others	Total
production	38,291	33,638	28,452	18,539	17,008	15,211	9,702	7,318	168,199

Source: Kimberly Process Rough Diamond Statistics 2007.
Note: DRC: Democratic Republic of Congo/ RSA: South Africa

2.2.4.1.2. Demand.

The USA is the largest consumer of polished diamonds, accounting for roughly 50% of the world retail diamonds sales, while India and China are the two fastest growing diamond markets. India processes about 80% by volume of the world's rough diamonds and its diamond consumption has increased by 27% annually for the past five years. The USA imported 28% of the total gems and jewellery exports from India in 2007. The recent slowdown in the US economy has had a negative effect on India's diamond industry.

2.2.4.2. Gold.

2.2.4.2.1. Production.

The total world gold supply decreased by 1.6% to 3,895t in 2007, mainly due to a sharp drop in the supply of scrap, despite a rise in official sector sales. Mine production declined by 0.2% to 2,459t, while net official sector sales increased by 30% to 481t, and scrap supply dropped by 15% to 956t (Conradie 2008:27-32).

2.2.4.2.2. Demand.

The Total world demand fell by 1.6% to 3,895t in 2007, mainly as a result of the 63.1% drop in implied net investment to 141t, despite a 5.1% rise in jewellery fabrication to 2,401t. Total fabrication demand increased by 4.8% to 3,072t, while producer de-hedging rose by 8.8%, from 410t in 2006 to 446t in 2007. There was also a 0.5% increase in bar hoarding to 236t in 2007.

Table 2.11: World Gold Reserves and Production, 2007. Unit: t

Country	Reserves	Production
China	4,100 (4.6%)	280.5 (11.4%)
South Africa	36,000 (40.1%)	252.6 (10.3%)
Australia	6,000 (6.7%)	246.3 (10.0%)
USA	3,700 (4.1%)	239.5 (9.7%)
Peru	4,199 (4.6%)	169.6 (6.9%)
Russia	3,500 (3.9%)	169.2 (6.9%)
Indonesia	2,800 (3.1%)	146.7 (6.0%)
Canada	3,500 (3.9%)	101.2 (4.1%)
Others	26,000 (29.0%)	853.0 (34.7%)
Total	89,700 (100%)	2,458.6 (100%)

Sources: USGS, Mineral Commodity Summaries 2008 pp.72-73.

2.2.4.3. Platinum Group Metals (PGMs).

The platinum group metals (PGMs) constitute a family of six chemically similar elements such as platinum, palladium, rhodium, ruthenium, iridium and osmium (Conradie 2008:33-38).

2.2.4.3.1. Production.

Global supplies of platinum, palladium and rhodium rose by 1.8% to 497.5t in 2007, due to an increased supply from Russia, despite lower sales from South Africa and North America. Total supplies of platinum fell by 4.4% to 208.1 in 2007, while palladium and rhodium supplies increased by 7% to 264.5t and 4.7% to 25t respectively.

2.2.4.3.2. Demand.

World demand of platinum, palladium and rhodium increased by 5.8% to 457.9t, caused primarily by an 8.6% increase in demand for platinum in 2007. Platinum demand improved by 8.6% to reach 218.7t, driven by strong sales to the auto catalyst industry and for investment purposes.

2.2.4.4. Silver.

2.2.4.4.1. Production.

The total silver supply, which includes mine production, government sales, and scrap recovery, declined by 2% to 29,115t in 2007. Scrap volumes, which contributed about 19% to silver, declined by 3% to 5,648t (Ndou 2008:39-41).

2.2.4.4.2. Demand.

Silver demand was dominated by industrial and domestic applications, collectively accounting for 51% of total consumption, followed by the jewellery and photography sectors which accounted for 27% and 17% respectively in 2007. Global silver demand for total fabrication increased 1% to 26,239t, while demand from the industrial sector increased 7% to 14,160t. Demand from the electrical and electronic sector increased by 6% to 6,220t.

2.2.5. Industrial Minerals.

Industrial minerals are defined as minerals which are mined and processed for the value of their non-metallic properties. They can be generally defined as being non-metallic and non-fuel minerals. They are found in a wide range of industrial and consumer products and play key roles in many complex and sophisticated manufacturing and processing applications for agricultural, building and construction sector throughout the world (Naidoo et al. 2008:123-131).

2.2.5.1. Dimension Stone.

2.2.5.1.1. Production.

The total world stone output was estimated to have been more than 210 Mt in 2007. China was the largest producer contributing 23% to world production, followed by India at 18% and Italy at 11% (Twala 2008:137-139).

2.2.5.1.2. Demand.

Dimension stone is used mainly in the construction sector. Major end markets are floors and paving (35%), special works and memorial art (18%). Global consumption amounted to 1,130 million square meters (thickness 2 cm) in 2007. The USA remains the largest dimension stone market in the world, exhibiting steady growth over the last decade.

2.2.5.1.3. Trade.

The total world exports were estimated to be 32.5 Mt in 2007. China continued to dominate international markets accounting for 55% of total world exports, followed by India (14%), Brazil (9%) and Italy (7%). Italy continued to be the dominant supplier of technology for cutting and polishing machinery.

2.2.5.2. Fluorspar.

2.2.5.2.1. Production.

The total world production decreased marginally 0.7% to 5.31 Mt in 2007 compared with 2006. Production increases in China, Mongolia, South Africa and Russia were offset by decreases in Mexico, Spain, Morocco and Kenya. About 80% of global fluorspar production comes from China (51.8%), Mexico (16.9%), Mongolia (7.5%) and South Africa (5.6%) (Modiselle 2008:140-143).

2.2.5.2.2. Demand.

China accounted for 32% of the world fluorspar demand, followed by Western Europe at 19%, USA and Canada at 14%, Russia at 9%, Mexico at 8% and Japan at 6%. Approximately 47% of the fluorspar production was consumed in the production of hydrofluoric acid, the starting point of the manufacture of fluorocarbons, used mainly in refrigeration and air conditioning. The next significant markets were for steel production at 42% and aluminium production at 7%.

2.2.5.2.3. Trade.

World trade of fluorspar is estimated to be 2 Mt. The major exporters are China (35%), South Africa (15%), Mongolia (25%), and Mexico (20%), accounting for over 90% of the world exports. The major importers are USA (32%), Japan (23%) and Germany (15%), which collectively account for 70% of the total world imports. The supply and demand during 2007 continued to be extremely tight, because China's continued reduction of exports created shortages in Europe and North America.

2.2.5.3. Sulphur.

2.2.5.3.1. Production.

According to the International Fertilizer Industry Association (IFA), world production of elemental sulphur increased by 1.6% to 48.6 Mt in 2007 compared with 2006. The largest sulphur producers are concentrated in North America and Eastern Europe. The world sulphur production leaders were Canada and USA which produced 14% and 13% of the total world production respectively, closely followed by China (13%), Japan (5%) and Soudi Arabia (5%). China is the world's leading producer of pyrite (FeS), which is also used to produce sulphuric acid, followed by Russia, Spain, South Africa and Finland (Nevondo 2008:156-159).

2.2.5.3.2. Demand.

The world sulphur consumption was estimated to be 49.6 Mt in 2007, an increase of 2% compared with 2006. The biggest consumers were China and India. About 90% of sulphur production is consumed in the form of sulphuric acid. Agricultural chemicals, primarily fertilizers, account for 60% of sulphur demand, while petroleum refining and metal mining account for 25% and 3% respectively. Other uses, representing 12% of the demand, are used in other forms of manufacturing. The global supply and demand balance of elemental sulphur was tight in 2007, due to growth in demand which had exceeded supply. This has exacerbated market pressures and resulted in higher import levels, expecially in China.

2.2.5.3.3. Trade.

Major exporters of sulphur are Canada, Russia, Germany and Saudi Arabia, while major importers are China, Morocco and the USA. Industrial sulphur use has greatly increased in China, further supporting high demand. The current shortage in China has been exacerbated by a series of closures of sulphuric acid production facilities over the past decade owing to poor market conditions and serious environmental impacts.

2.2.5.4. Limestone.

Over 80% of total world limestone production is used in the manufacturing of cement. The construction sector, comprising of residential, non-residential and civil construction, has been one of the economic growth drivers in the cement demand over the past decade, which was in turn driven by the robust performance of the economy all over the world. In particular, the continuing development of social overhead infrastructures and the improvement of residental houses and non-residental buildings has maintained the upward momentum in the increased limestone production.

The major cement suppliers were China, USA, South Korea, Japan, Brazil, Germany and Russia (Naidoo et al. 2008:144-147).

2.3. World Trends in Mining Policy.

Today, mankind faces three major tasks for its survival: curbing population growth, protecting the environment and carefully managing scarce non-renewable resources. Solving such problems is directly related to developed and underdeveloped economies.

On the basis of these tasks, we should forsee the rise of a new ecological social market economy which will provide a framework for achieving sustainable development in accordance with the will of God.

However, those living in the Third World are not only fighting for their own survival, but also battling with the growing disparity between the North and their own poorer South. The wealthier Northern countries face new pressures as they depend on the energy and mineral resources of the poorer South, while the South wants to have a say in the management of its own resources. While the divide increases, the crisis intensifies.

2.3.1. Growing Inequality.

The inequality in wealth is staggering: 'The average income in the richest 20 countries is 37 times the average in the poorest countries, a gap that has doubled in the past 40 years (World Bank 2001:3). There is a simultaneous and linked environmental crisis. Few studies doubt that the giant transnational corporational companies (TNCs) of advanced countries have played their part in creating both strands of the globalization of poverty and the environmental crisis, in particular because of their neo-liberalist embrace of free market economic theories.

Through their production, trade and investment activities, they are integrating countries into a global market. Through their control over energy and mineral resources, access to markets, and development of new technologies, TNCs have the potential to generate enormous benefits for poverty reduction and environmental protection. However, that potential has been totally lost by their corporate practices, which maximize short term profits, undermine the capacity of poor countries and result in the serious degradation of the environment.

The TNCs and their 250,000 foreign affiliates account for most of the world's industrial capacity, technological knowledge and international financial transactions. They mine, refine and distribute most of the world's oil, gas, diesel and jet fuel. They have developed most of the world's energy and mineral resources from the ground.

They manufacture and sell most of the world's automobiles, airplanes, communication satellites, computers, home electronics, chemicals, medicines and biotechnology products. They harvest much of the world's wood and make most of its paper. They grow many of the world's agricultural crops, while processing and distributing much of its food. All told, the transnationals hold 90% of all technology and product patents worldwide and are involved in 70% of world trade (UNCTAD 1995;xix-xx).

Indeed, TNCs have no soul to dam and no body to kick which leaves them as faceless and convenient repositories for the guilt of the societies which invented them, profit from them and tolerate their operations.

> "The world today behaves like a madhouse. The worst of it is the values we had more or less defined, taught, learned, are thought of as archaic as well as ridiculous...... It seems that it's more important to reach Mars than prevent 13 million Africans dying of hunger...... Priorities need to be redefined" (Saramago 2002:3).

2.3.2. Advanced Countries.

There is no doubt that there has been a significant export of dirty industries and significant pollution from the activities of mining and manufacturing operations masterminded by TNCs of advanced countries across the world.

One of the keys to understanding the global problem of waste and pollution is that much of its incidence in the developing world is due to developed nations' illegal shipment of their own waste to developing countries.

The trucks entering Eastern Europe from Germany export hundreds of tons of waste that Westerners find too expensive or inconvenient to dispose of themselves. The pressure is mostly financial. Under the USA and European environmental laws today, the cost of disposing of hazardous industrial and mining waste can be as high as several thousand dollars per ton. Shipping such materials abroad is often much cheaper (Dine 2005:12).

Japan has reduced its aluminium smelting capacity from 1.2 million tons to 149,000 tons and now imports 90% of its aluminium. What this involves in human terms is suggested by a case study of the Philippine Associated Smelting and Refining Corporation (PASAR). PASAR operates a Japanese-financed and constructed copper smelting plant in the Philippine province of Leyte to produce high grade cooper cathodes for shipment to Japan.

The plant occupies 400 acres of land expropriated by the Philippine Government from local residents at give-away prices. Gas and waste water emissions from the plant contain high concentrations of boron, arsenic, heavy metals, and sulfur compounds that have contaminated local water supplies, reduced fishing and ice yields, damaged the forests, and increased the occurrence of upper respiratory diseases among local residents. Local people whose homes, livelihoods and health have been sacrificed to PASAR are now largely dependent on the occasional part-time or contractual employment that they are offered to do the plant's most dangerous and dirtiest jobs (Dine 2005:12).

Karliner chronicles the migration of the chlorine industry from developed countries to Brazil, Mexico, Saudi Arabia, Egypt, Thailand, India, Taiwan and China, and similar strategies being followed by the nuclear power industry, the automobile industry and tobacco marketing. (Karliner 2005:81-82; Dine 2005:12).

The citizens of the wealthy industrialized countries are responsible for the majority of the earth's environmental degradation to date. There is no doubt that citizens of the wealthier nations wreak more devastation on the earth on a per capital basis. Paul and Anne Ehrlich offer the following comparisons in the Population Explosion (Paul et al. 1990:134):

> A baby born in the United States represents twice the destructive impact on earth's ecosystems and the services they provide as one born in Sweden, 3 times one born in Italy, 13 times one born in Brazil, 35 times one in India, 140 times one in Bangladesh or Kenya, and 280 times one in Chad, Rwanda, Haiti or Nepal.

2.3.3. Developing Countries.

Despite of the absence of detailed environmental data on the development of energy and mineral resources, most developing countries try to promote their domestic resources to get their foreign exchange earnings in accordance with their loose environmental legal system. And most of their energy and mineral production are supplied to meet the demand of advanced countries .

So, it has been argued that one of the key threats to environmental management in developing countries is the lack of institutional capacity to undertake the complex environmental task. In this regard, it has been noted that many third world governments do not have the organizational machinery to enforce environmental regulations, or in some cases the political will to oppose powerful vested interests.

It is time that third world government should pay close attention to the environmental impact from mining activities and adopt new legislation for a stronger control of environmental problems. The major environmental problems associated with the mining industry are (1) Rehabilitation of old mine sites; (2) Acid mine drainage; (3) Tailings disposal; (4) Disposal of hazardous waste; (5) Pollution of water, air, and surrounding land areas and so forth.