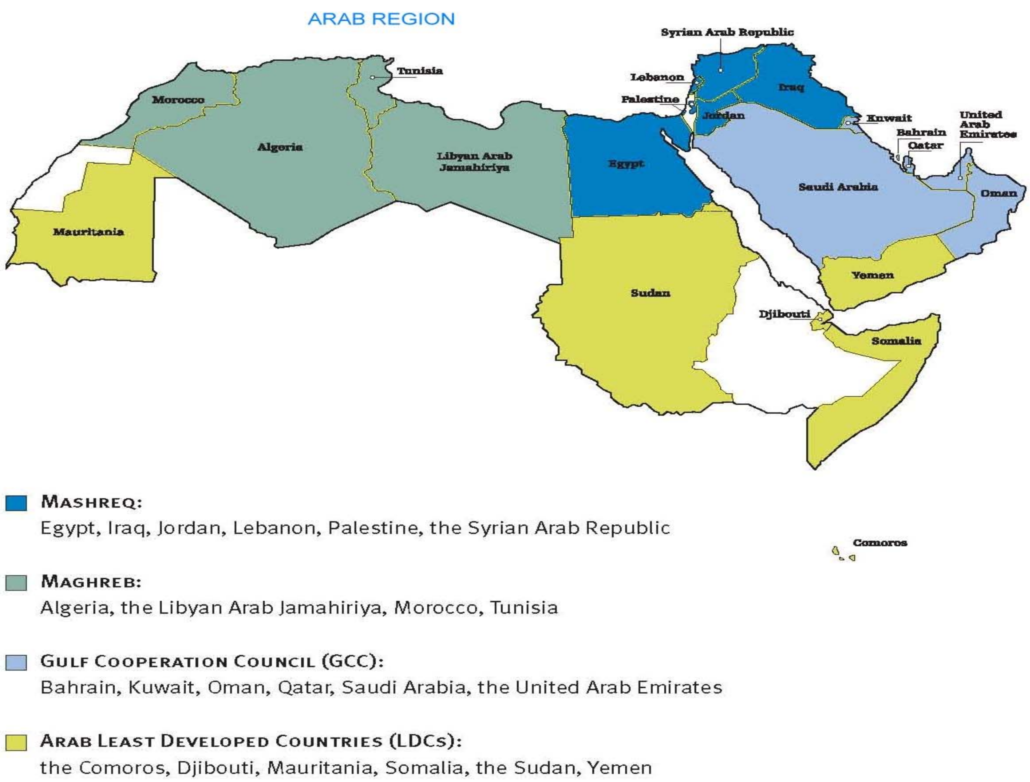
THE TRAGEDY OF ENERGY POLICY IN THE ARAB REGION

SOLAR POWER VERSUS NUCLEAR POWER-OPTIONS FOR THE ARAB WORLD



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(Dedicated to the memory of Professor Richard E. Smalley, 1996 Nobel Laureate in Chemistry, Author of "Future Global Energy Prosperity: the Terawatt Challenge, MRS Bulletin • Vol. 30 • JUNE 2005)

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SUMMARY

To satisfy humanity's current demand for energy the present mix of energy sources is dependent on resources which are destined to deplete and hence not sustainable in the true sense of the word. Important, and very vital to consider is that the most extensively used fossil fuels are sources of harmful emissions that cause climate change with dangerous consequences. Other than fossil fuels, nuclear, hydropower and biomass sources of energy are used as cleaner alternatives. However, nuclear which constitutes a bigger share of the alternatives used is associated with great potential hazards. The issue of sustainability of future energy demand satisfaction is, therefore, beyond conservation of energy resources, change in the life style and efficiency of usage. Future energy supplies should not contribute to environmental problems—short or long term. Governments need to ensure that energy is generated safely without any harm to either people or the environment.

Renewable energy comes from sources such as sunlight, wind, moving water and biomass. Their utilization as power sources does not diminish their availability. If we expect to sustain life on this planet, it will be necessary for us to use renewable energy resources rather than depleting nonrenewable finite energy resources. Solar energy is the most important renewable energy resource for our planet. Sun's energy can be captured directly as either heat or electricity. Solar energy captured as heat can be converted into electricity.

The most abundant and widely accessible, but least tapped form of energy on earth is solar radiation on deserts. The world's hot deserts cover around 36 Million km^2 (UNEP, 2006) of earth's land surface. The Arab land is 14 Million km^2 of which 87% is desert or 12.18 Million km^2. Assuming each km^2 can produce Electric Energy of 0.3525 TWh/km^2year, the Arab desert can therefore produce 4, 293,450 Twh/year which is 122 times the estimated world demand for electricity in the year 2035 of 35,200 Twh/year. Therefore, the solar energy resource in the Arab region can supply not only the energy needs of the Arab people but also meet global energy needs. In other words, any conceivable global demand for energy, today or in future, could be met from solar energy in deserts. These numbers tell us that if we can develop the technologies for economically converting solar energy into electricity and if we learn how to store solar heat from day to night, then fossil fuels could be replaced by solar energy from deserts (and by the other forms as wind, biomass, and hydropower). Fossil energy sources like coal, oil and gas can be a useful complement to the renewable energy mix, being spare forms of energy that can easily be used for balancing power and for grid stabilization. If their consumption is reduced to the point where they are used exclusively for this purpose, their cost escalation will be reduced to cause only a minor burden to economic development and their environmental impact will be minimized. Moreover, their availability will be extended for decades or even centuries.

Electric power generation in many Arab states hopefully will be utilizing the abundantly available solar energy to secure the needs for electric generation for future energy demand. On the other hand, the generation of electricity by nuclear energy which is undergoing advantaged promotion in the Arab world, suffers many drawbacks such as the lack of local nuclear technology know how, the acquisition of nuclear grade equipment and fuel from foreign sources and the waste disposal problems. No one in the world has any workable solution for disposing of nuclear wastes. Also the potential hazards inherently embedded in this technology should be carefully evaluated. An accidental meltdown of a nuclear core is within the realm of possibilities, the uranium deposits are limited and the cost of producing electricity through a controlled nuclear reaction is well known to be uneconomical. Then there is the question of huge capitalization and the prohibitive price of decommissioning.

To conclude, nuclear energy in comparison with clean renewable energy is uneconomical, hazardous and not considered to be part of clean development mechanism (CDM).

1. INTRODUCTION

Energy is the single most important challenge facing humanity today - **Nobel Laureate Richard Smalley, April 2004, Testimony to US Senate**

In order to produce with ordinary reactors 12 TW i.e. 1/3 of the "carbon free" primary energy, we would need to build for instance about 5000 nuclear reactors each of 1 GW(e), ≈ 80% efficiency and a nominal lifetime of 30 years, slightly less than one new 1 GW reactor every two days. - **Nobel Laureate Carlo Rubbia, QM 2008 Inaugural Session, CERN, Geneva, Switzerland, CIEMAT, Madrid, Spain**

Direct sunlight is potentially the most powerful renewable energy source. In less than an hour, the Earth receives the same amount of energy from the sun as is used globally by man during a year. In contrast to most other energy technologies, solar energy is only limited by cost of conversion and intermittency in time. Direct use of sunlight yields up to 100 times more electricity per land area than biomass grown for use in power plants. Solar energy at present only amounts to a small fraction of the World's primary energy supply but solar technology markets are developing and growing fast.- **Energy Committee at the Royal Swedish Academy of Sciences,10 November 2008**

If I were you, I would stop trying to make Saudi Arabia the oil capital of the world and make Saudi Arabia the energy capital of the world. You should take your cash right now and go out and buy half the solar capacity in the whole world and you should start at the equator. All the way around the equator and go north and south until you put solar power everywhere the weather will tolerate it. You will save the planet, and get richer.- **Bill Clinton, speech in Saudi Arabia in January 2006**

We Have Not Inherited The Earth From Our Forefathers But Have Borrowed It From Our Grandchildren.- **Native American Proverb**

The information presented here has been organized in order to elaborate and explain the elements that are vital for the Arab Region in order to consolidate an energy policy that will avoid a potential tragedy by choosing nuclear over solar energy and **inviting nuclear hazards by creating a dangerous burden for future generations**. Such a policy describes a dilemma in which governments can ultimately undermine and destroy a shared resource even when it is clear that it is not in anyone's long term interest for this to happen. Instead, they should concentrate on harnessing the abundant solar energy, which is the **real sustainable wealth for the Arab Region and humanity.** It is because fossil fuel resources are limited and the high rate at which they are extracted cannot be sustained for much longer. Neither can our planet sustain the consequences of extracting and burning them at an increasing rate without ending in ecological disaster. We are just beginning to appreciate the extent of the environmental problems created by the energy extravagances of wealthy industrial countries and we are altering our earth's life support systems and potentially pushing the planet into a far less hospitable state.

When we look at a prioritized list of global concerns, the top 10 problems facing humanity, with energy being the most important, we can see how energy is the key to solving all of the rest of the problems—from water to population: Energy, Water, Food, Environment, Poverty, Terrorism and War. Disease, Education, Democracy, and Population.Take the water problem on the list, for example: water. Already billions of people around our planet live without reliable access to clean water for drinking and agriculture. As population continues to build and the depletion of existing aquifers worsens, we will need to find vast new sources of clean water. Luckily, our planet has huge resources of water, but most have salt in it. We can solve this problem with energy: desalinate the water and pump it to vast distances. However, without energy, there is no acceptable answer. Energy likewise plays the dominant role in determining the quality of our environment, the prevention of disease, and so on, the entire list of global concerns. In short, energy is the single most important factor that impacts the prosperity of any society.

2. WHAT IS SUSTAINABLE DEVELOPMENT?

Sustainable development is defined (WCED 1987) as *development that meets the present needs and goals of the population without compromising the ability of future generations to meet theirs*. Sustainable development involves social and economic development and environmental conservation. Social development is the improvement in the well-being of individuals and society which leads to an increase in social capital, institutional capital and organizational capital. Economic development is economic progress that leads people to be willing and able to pay for goods and services that enhance income and efficient production. It is closely related to economic efficiency. To get some sense of the range of views about the meaning of sustainable economic development, it is useful to think in terms of the production function $Q = F\left(K_{\mathrm{m}}, K_{\mathrm{h}}, K_{\mathrm{n}}, K_{\mathrm{s}}\right)$, where Q is the maximum flow of goods and services that can be obtained from the current stock of manufactured capital (K_{m}), human capital (K_{h}), natural capital (K_{n}), and social capital (K_{s}). In this case, Q includes both economic and environmental goods and services.

Environmental development is the management of ecological services and of the human beings that depend on them. Sustainable development takes all the three “fundamental pillars” into consideration.

Sustainable Development balances the following principal requirements:

- **The needs of society (the social objective); this may also be divided further into cultural and institutional dimensions**
- **The efficient management of scarce resources (the economic objective);**
- **The need to reduce the load on the ecosystem in order to maintain the natural basis for life (the environmental objective).**

Sustainable development is further described “as a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potentials to meet human needs and aspirations”. In broader sense, “a strategy for sustainable development aims to promote harmony among human beings and between humanity and nature.”

When discussing "life support systems", the specified concern was made for the wise use of land, water, air, energy, and other resources. These resources underpin life itself. However, life is a highly complex set of interactive systems on which human existence is ultimately dependent. Thus, in accordance with the documents, mentioned above, the following definition of life support systems (LSS) could be introduced: *A life support system is any natural or human-engineered system that furthers the life of the biosphere in a sustainable fashion*. The fundamental attribute of life support systems is that together they provide all of the sustainable needs required for continuance of life. These needs go far beyond biological requirements. Thus life support systems encompass natural environmental systems as well as ancillary social systems required to foster societal harmony, safety, nutrition, medical care, economic standards, and the development of new technology. The one common thread in all of these systems is that they operate in partnership with the conservation of global natural resources.

Energy has been identified as a prime mover of modern civilization and indeed major pillar of life support, therefore a comprehensive energy policy is required that will establish the social and, economic development, and environmental conservation and other issues are linked to energy, providing the basis upon which the **Energy Policy** will identify options for the way forward on a regional level. Furthermore, the **Energy Policy** will inform policymakers, the business and investment sector, and society at large, on the key opportunities and challenges facing society on the road to longer-term sustainable development. We need to develop qualified and committed professionals who will play a leading role in the sustainable development of the region and its integration into the global economy. We need to share experiences related to the implementation of education for sustainable development at Universities in the Arab Region. The following schemes represent various ways of conceptualizing sustainable development paradigms.

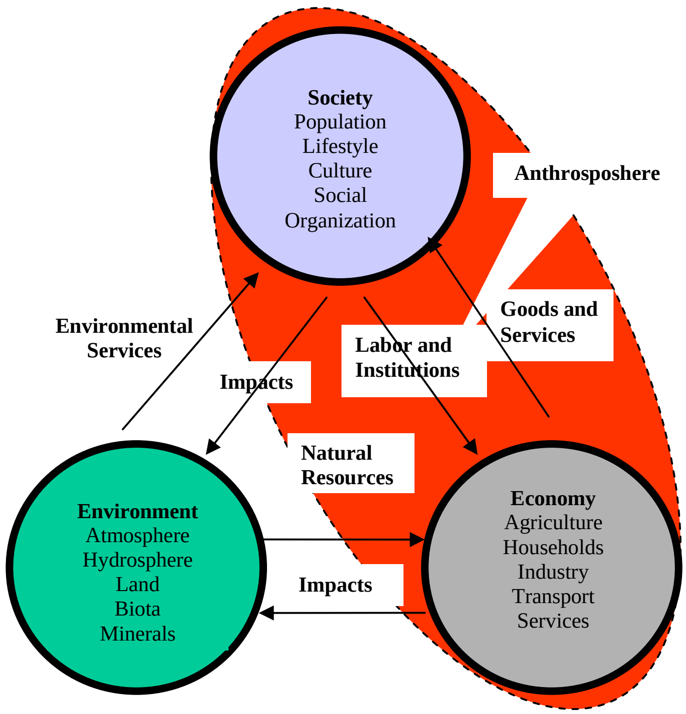

Figure 1. Complex interactions among the various subsystems.

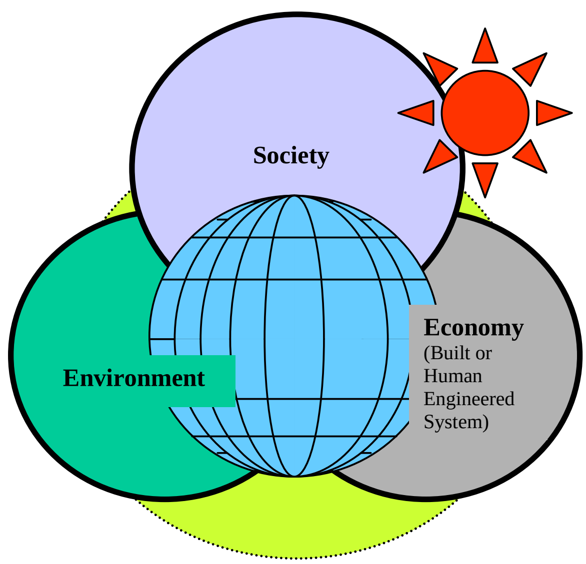

Figure 2. Major components of the Earth System

3. ENERGY FOR SUSTAINABLE DEVELOPMENT

Making the transition to a sustainable energy future is one of the central challenges humankind faces in this century. The term ‘sustainable energy’ denotes energy systems, technologies, and resources that are not only capable of supporting long-term economic and social development needs, but that do so in a manner compatible with (1) preserving the underlying integrity of essential natural systems, including averting catastrophic climate change; (2) extending basic energy services to the more than 2 billion people worldwide who currently lack access to modern forms of energy and energy products such as desalinated water; and (3) reducing the security risks and potential for geopolitical conflict that could otherwise arise from an escalating competition for unevenly distributed fossil fuel resources. In other words, the term ‘sustainable’ in this context encompasses a host of policy objectives beyond mere supply adequacy (Lighting the way: Toward a sustainable energy future, 2007).

Energy produced and used in ways that support social, economic and environmental dimensions is what is meant by sustainable energy. Realizing sustainable futures will require much greater reliance on some combination of renewable resources, advanced energy technologies, and higher energy efficiencies. The implementation of such vision requires also the establishment of enlightened institutions. Managing the dynamic interaction of scales of time and space and of jurisdictions and policy processes is above all an institutional problem. We only collectively achieve things through institutions — formal and informal ones, legal and economic, local, regional, global. Institutions structure our interactions, provide our ground rules and coordinate our activities. If institutions are inadequate, we will not advance far towards a future that is ecologically sustainable and humanly desirable.

Sustainability Limits (Herman Daly)

- The rates of use of renewable resources should not exceed their rates of regeneration
- The rates of use of non-regenerable resources should not exceed the rates at which renewable substitutes are developed
- The rates of pollution emissions should not exceed the assimilated capacity of the environment. Furthermore it should not encroach into and damage the environments for future generations by long life contaminants such as radioactive nuclear waste.
- Using natural resources no faster than they can regenerate themselves and releasing pollutants to no greater extent than natural resources can assimilate them (Angela Merkel)

A major contribution to the much needed transformation of present energy systems, 80% of which is based on fossil fuels (as shown in Table 1), onto a more sustainable basis can be expected to come from solar radiation, the prime energy resource. In several regions of the world the seeds of this possible transformation can be seen, not only at the technological level, but also at policy levels. For example, the European Union has recently announced policies and plans to obtain 20% of its energy needs through renewable energy by 2020.

The German Advisory Council on Global Change (WBGU) conducted an analysis of energy needs and resources in the future to the years 2050 and 2100 as shown above which points to a major contribution by solar energy to global energy needs in the long term. (Figure 3)

This scenario is based on the recognition that it is essential to move energy systems towards sustainability worldwide, both in order to protect the natural life support systems on which humanity depends and to eradicate energy poverty in developing countries. Of course, this new solar era can be envisioned mainly because of the tremendous scientific and technological advances made during the last century and the ongoing research and development.

Fossil Fuels:	**332 EJ (79.4%)**
Oil	147 EJ
Natural Gas	91 EJ
Coal	94 EJ
Renewables:	**57 EJ (13.7%)**
Large Hydro	9 EJ
Traditional biomass	39 EJ
'New' Renewables	9 EJ
Nuclear:	**29 EJ (6.9%)**
Total	**418 EJ (100.0%) or 116111TWh**

Table 1. World primary energy consumption in 2001
1000 TWh (thermal)= 3.6 EJ = 614 Million bbl oil
1 barrel of oil = 1600 kWh (Thermal)
Source: World Energy Assessment, Overview, 2004 update

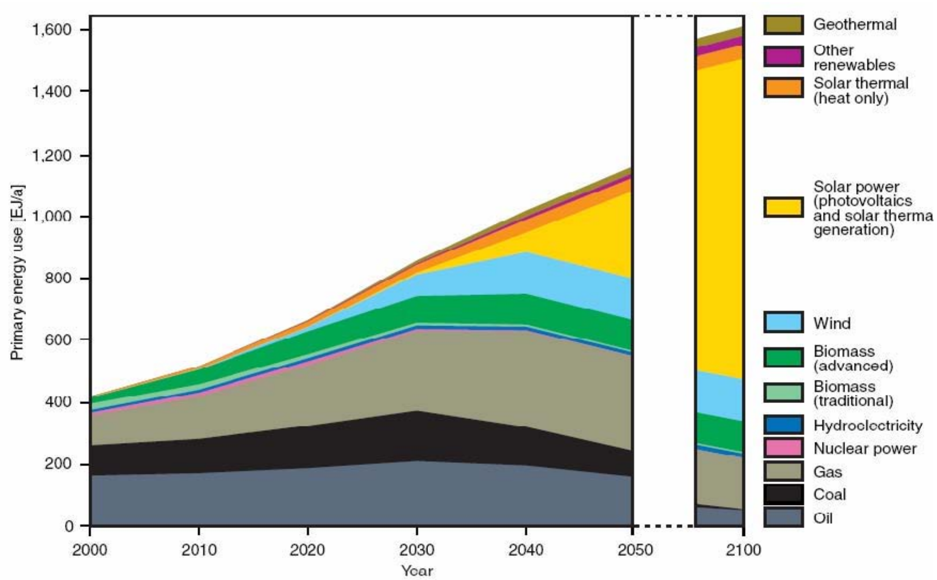

Figure 3. Transforming the Global Energy Mix: the exemplary path to 2005/2100; Source: WBGU, 2003

In accordance with **Encyclopedia of Life Support Systems** (EOLSS), the following definition of life support systems (LSS) could be introduced: *A life support system is any natural or human-engineered system that furthers the life of the biosphere in a sustainable fashion.* The fundamental attribute of life support systems is that together they provide all of the sustainable needs required for continuance of life. These needs go far beyond biological requirements. Thus life support systems encompass natural environmental systems as well as ancillary social systems required to foster societal harmony, safety, nutrition, medical care, economic standards, and the development of new technology. The one common thread in all of these systems is that they operate in partnership with the conservation of global natural resources.

4. SOLAR ENERGY RESOURCES VERSUS FOSSIL FUEL RESERVES

The quantum of energy available to the earth and its atmosphere in the form of solar radiations is about 5.2×10^{24} Joules per year, which is 165,000 TW in terms of available power (Figure 4 and Table 2). This amount is more than 11,000 times the entire world primary energy consumption in the year 2004 and even if we assume some of this energy is reflected back into space and absorbed by the atmosphere and the actual annual solar energy radiation reaching the earth's surface, approximately is 9.4×10^8 TWh, which is an order of magnitude greater than all the estimated (discovered and undiscovered) non-renewable energy resources, including fossil fuels and nuclear as shown in Table 3 (*Source BGR 2005)*..

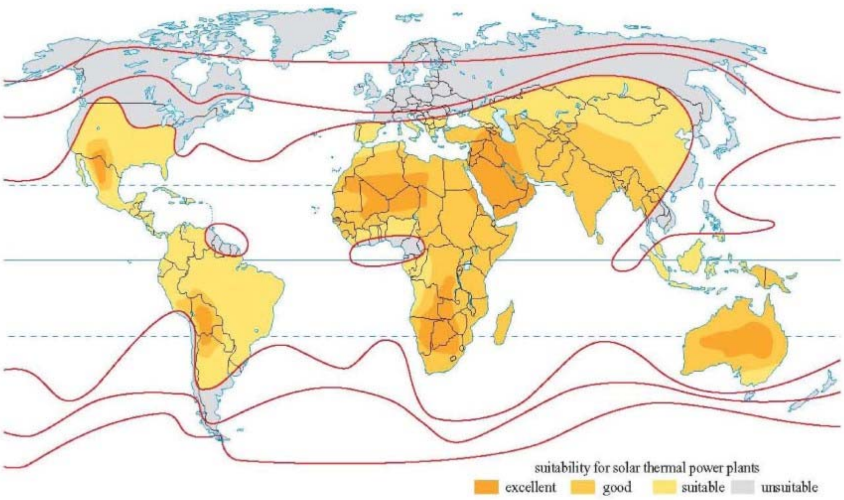

Figure 4. Map of direct solar irradiation (Solar Millennium AG, 2003).
Areas of the world with high insolation,

Annual solar energy potentials of the world deserts Desert size according to UNEP	Annually received energy in world wide deserts
33 Mio km² (In fact according to UNEP World deserts is 36 million Km^2)	80 Million TWh 10,000 Billion ("Giga") ton coal 50,000 Billion barrel 300,000 Exajoules

Table 2. Annual solar energy potentials of the world deserts. The above calculation uses an average insolation of 2.22TWh/Km^2(Source: Deserts as sustainable powerhouses and inexhaustible Waterworks for the world, Gerhard Knies, 2006).

Fossil Energy Source 1000 TWh (thermal) (=3.56 EJ = 0.123Gtce = 614 Million bbl oil)	**Annual Production / Consumption 1000 TWh**	**Equivalent Solar delivery time in deserts (Hours)**	**Proven Reserve (Expected additional Resources) 1000 TWh**	**Equivalent Solar delivery time in deserts days**	**Static depletion time of reserves (Years)**
All fossil fuels	107	5.7	10,400 50,700	47 227	98
Oil (Conventional)	45	2.4	1,900 960	8.5 4.3	42
Oil (Non-conventional)	0		780 2,900	3.5 13.2	
Natural gas (Conventional)	24	1.3	1,600 1,900	7.2 8.4	65
Natural gas (Non-conventional)	0		2 1,687	0.1 6.2	
Coal (hard and lignite)	33	1.8	5,700 29,000	25 129	170
Uranium, Thorium	4	0.2	460 1,740	2.0 7.8	101

Table 3. Table showing various non renewable energy resources and the current level of primary energy consumption in terms of solar radiations received by World Deserts, (Source BGR 2005). It shows in column 3 how many hours of sunshine in deserts are needed to receive the same energy as provided annually by the respective fossil fuel in column 2.

Figure 5 shows the development of energy demand as in the A1T-450 scenario, but reduced by a stronger energy efficiency enhancement. This path assumes from 2040 onwards a 1.6 per cent annual increase in energy productivity, compared to the historical figure of 1 per cent annually.

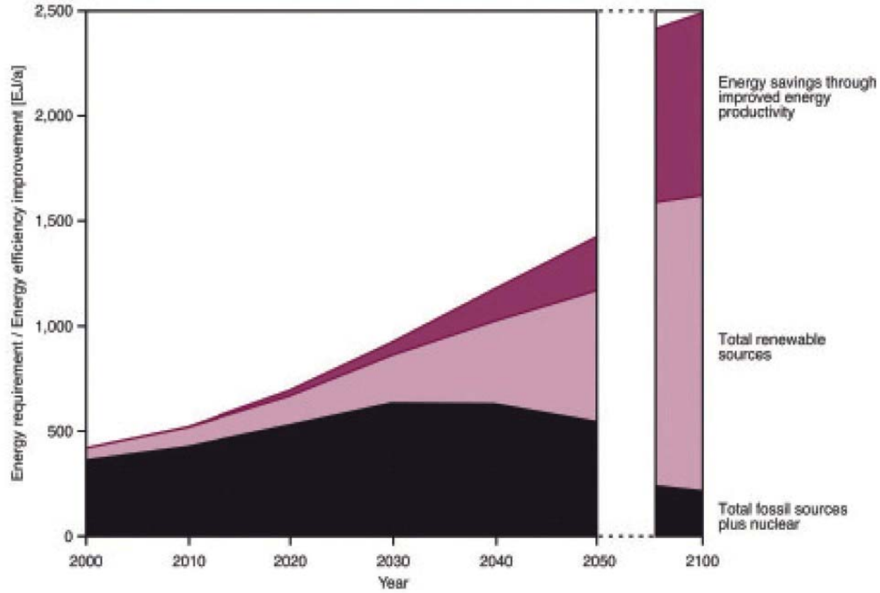

Figure 5. Development of energy demand as in the A1T-450 scenario, but reduced by a stronger energy efficiency enhancement. (*Sources: Gerhard Knies and WBGU*)

World (EIA, 2010) net electricity generation increased by 87 percent in the Reference case, from 18.8 trillion kWh in 2007 to 25.0 trillion kWh in 2020 and 35.2 trillion kWh in 2035. World energy-related carbon dioxide emissions rose from 29.7 billion metric tons in 2007 to 33.8 billion metric tons in 2020 and 42.4 billion metric tons in 2035—an increase of 43 percent over the projection period. Renewables are the fastest growing energy source. The total economic electric energy CSP potential in MENA(Trieb 2005) amounts to 630,000 TWh/y excluding energy potential of Sudan and Somalia which has been estimated to be about 200,000 TWh/year making the total electric energy potential of about 830,000 TWh/year. World net electricity generation will be about 35,200 TWh/year in 2035.The total energy for meeting power demand will require an area of about 99858 km2 which is 0.7 % of the Arab Region surface area. Therefore it is vital that Arab countries or world regions within the Sun Belt should immediately start to establish the necessary political and technological conditions for efficient energy management.

The annual global consumption of oil is approximately 31.16 billion barrels (EIA, 2010), which is equivalent to 50,282 TWh/year, primary energy for the year 2007(1barrel of oil =1600 kWh Thermal). It is clear, therefore, that the total energy recoverable from renewable resources is perfectly adequate to supply the total energy needs of humanity. In fact just the total potential recoverable (direct solar energy) is more than 122 times the net electricity generation for the world in 2035 considering the Arab Region total potential is equivalent to 4.3 million TWh/year, assuming efficiency of conversion about 15%. Table 4 shows the electric energy generated in Arab Countries. The total expected energy requirement in 2015 in the Arab Region is 930 TWh

Countries	2001	2002	2003	2004	2005	2006
UAE	43172	46856	49450	52417	60698	66768
Bahrain	6779	7278	7715	8178	8698	9220
Tunisia	8528	8955	9224	9547	11700	12227
Algeria	27159	2817	29515	30548	33528	35204
S. Arabia	133674	144702	149767	156506	176124	181434
Syria	26712	28013	29543	31316	34935	37730
Iraq	32251	33863	34000	34000	34000	35000
Qata	10222	10733	11160	11718	13238	14033
Kuwait	31536	33112	34105	35639	39500	41277
Libya	13122	13778	14329	14831	16000	16640
Egypt	77839	82969	88874	94840	100927	108332
OAPEC	410994	438776	457682	479540	529348	557865
Jordan	7375	7544	8132	7995	9654	11124
Djibouti	190	200	200	215	255	280
Sudan	2893	3093	3227	3749	4125	4521
Oman	9450	9912	10320	10836	11485	12059
Somalia	261	274	280	280	290	300
Lebanon	9881	10375	10680	11054	11125	11350
Morocco	15007	15757	16388	17043	19158	19925
Mauritania	476	499	538	550	570	616
Yemen	3644	3769	4096	4235	4774	5108
Other Arab Countries	**49177**	**51423**	**53861**	**55957**	**61436**	**65283**
Total Arab Countries	**460171**	**490199**	**511543**	**535497**	**590784**	**623148**

Table 4. Electric Energy Generated in Arab Countries (GigaWattHour) *Source: OAPEC 2007*

5. SOLAR ENERGY POTENTIAL IN THE ARAB WORLD

The 22 Arab World Countries (AWC) have a total desert surface area of 14 million km^2 (which is more than 1/3 of the total world deserts) and average radiation potential of 2.35 $TWh/km^2/year$.

Arab Region total potential is equivalent to 4.3 million TWh/year, assuming efficiency of conversion about 15%. So, how much solar energy falls on the Arab land, and is there enough land for large-scale solar generation?

We can generate about 0.3525 TWh -electric /km²/year or about 40-56 MW//km² assuming an average radiation potential of about 2.35 $TWh/km^2/year$ and considering solar-to-net electric efficiencies close to 15%-21%. Please note that these figures may be rather conservative when one looks into future technological developments (see, Figure 6. combined collector and engine efficiency variation with operating temperature below).

Average solar radiation potential for the desert surfaces in the Arab Region (Equivalent Electric Energy) =2.35 x 0.15 = 0.3525 TWh/km2/year. Total Solar Thermal Energy falling on the Arab land = 14 x 10^6 x 0.87x 2.35 TWh/km2/year= 28.623 million TWh/year or 17889 billion barrels of oil equivalent (BOE) annually. **This ANNUAL amount (RENEWABLE) is about 27.515.2 times the TOTAL existing Arab oil reserves (650 billion barrels)WHICH ARE NON RENEWABLE One km^2** of solar collector area can also produce desalinated water of about **193,150 m^3 daily** or **70.5 million m^3 annually**, assuming average electric energy consumption for desalinated water to be about **5** kWh/m^3. Here the abundance of seawater is exploited at the expense of nonrenewable energy. Likewise, we should exploit the great solar energy potential of the region, especially when we have the support of present resources.

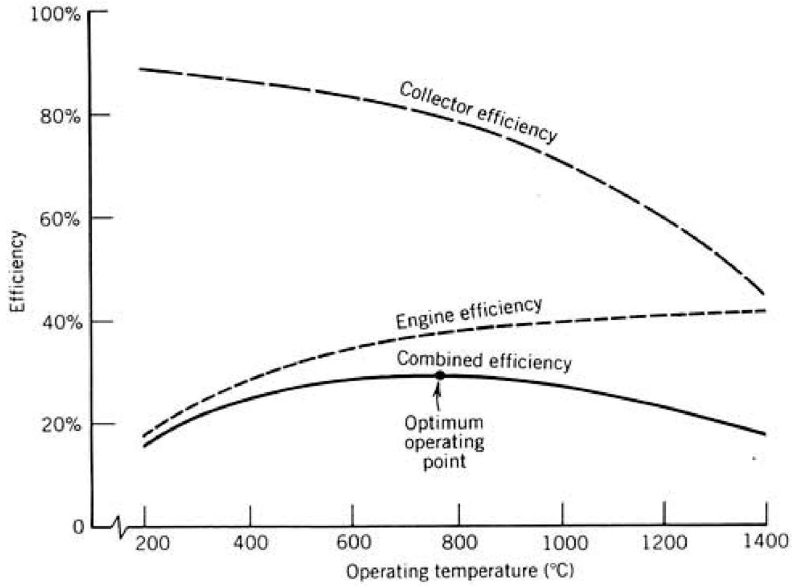

Figure 6. Combined collector and engine efficiency variation with operating temperature. Nominal collector parameters: $CR_g = 1000$; $I_{b,a} = 1000 \mathrm{W/m^2}; T_a = 298\ \mathrm{K}; U_l = 60 \mathrm{W/m^2K}; \eta_{opt} = 0.9$; *Source: Power from the SUN*

The prospects of developing water resources through solar energy in the Arab Region

The abundant solar energy in the Arab Region can be used to produce much needed energy and potable water for the region from the seawater which is available in plenty around the region. See Figures 7a-d.

Figure 7a. Relationship between solar collector area and the amount of desalinated water it can produce

There are three major rivers in the Arab Region, Nile in Egypt, Euphrates and Tigris in Syria and Iraq. These rivers are all originating outside Arab territories. The total flow of these rivers = **84** km^3/year (Nile) + **30** km^3/year (Euphrates) + **21.2** km^3/year (Tigris) = **135** km^3/year

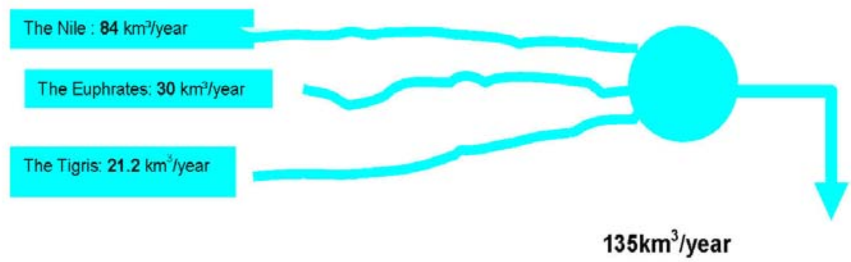

Figure 7b. Total annual water flow in the three major rivers of the Arab world

The electrical energy required to produce desalinated water equivalent to the total water flowing in all these rivers **= 135** x **10^9** m^3/year x **5** kWh/m^3 = **675** TWh/yr. The total solar PV collector surface area required to generate this amount of energy is about **1915** km^2. The deficit in water resources in the Arab Region in 2050 is likely to be 150 billion m^3 and currently it is about 60 billion m3 according to various forecasts.

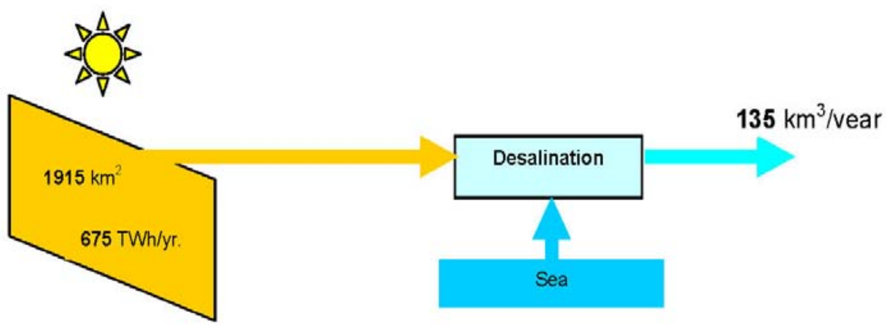

Figure 7c. Solar collector of 1915 km^2 can produce three more rivers

According to a study conducted by the Institute of Technical Thermodynamics, Germany in 2007, the water deficit in the Arab Region will be about **150** km^3 in 2050. According to the analysis, this deficit will tend to increase from **50** billion m³ per year at present, which is almost the annual flow of the Nile River allocated to Egypt, to **150** billion m³ in the year 2050. Almost all Arab countries, Egypt, Saudi Arabia, United Arab Emirates, Kuwait, Bahrain, Qatar, Yemen, and Syria, etc are the countries that will experience serious water deficits. If we assume roughly the water deficit is likely to be equivalent to 150 km^3 and solar powered desalination will be used to produce this quantity, then the energy will be about =**150** x **10^9** m^3 x **5** kWh/m^3 = **750** TWh/year.

Let us consider the total annual energy demand of 623.148 TWh in the Arab Countries (AOPEC 2006). The total electric energy demand for the Arab Region is expected to be about **2830** TWh/year in 2050 assuming a reasonable growth of about 3.5% annually.

The total energy (**2830**+**750**) TWh/year) for meeting power and water demand will require an area of about **10156** km^2 which is **0.0725** % of the Arab Region surface area.

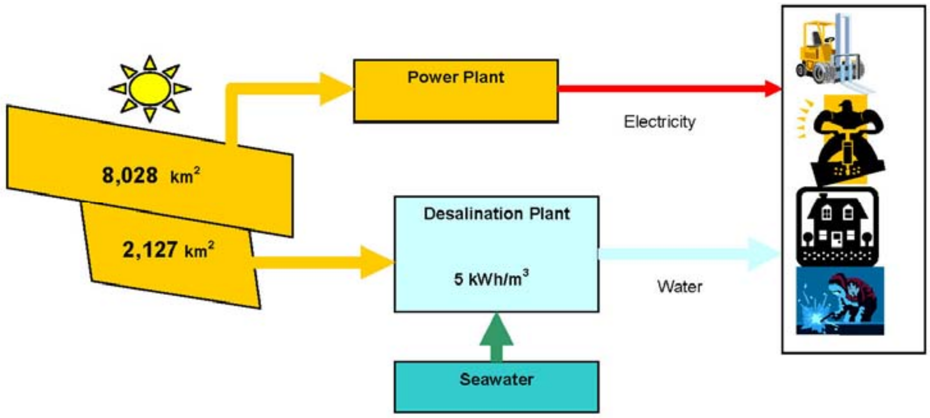

Figure 7d. Solar energy can meet the demands of both water and electricity of the Arab Region

The AWC can practically supply at least 30% of the World electric energy requirements in future from their solar power generation potential. The strategic proximity of the AWC to many European, Asian, African and other countries is of crucial advantage in this respect. The recent TRANS-CSP study conducted by the German Aerospace Center (DLR) with the objective of meeting 15% of the European electricity demand by solar energy imports by the year 2050 through interconnection of the electricity grid of Europe, Middle East and North Africa (EU-MENA) using suitable transmission technologies, can be termed as the beginning steps in this direction.

To identify and realize the goals of solar power production and exports, AWC may well form an organization on lines of OAPEC, say, “Organization of Solar Power Producing and Exporting Countries (OSPPEC)”, that may best serve their interests.

5.1. Consider CO_2 Emissions/ MWh_e in Tons

1. Solar Thermal Power Plants: **0.01–0.015**
2. Gas Fired Combined Cycle Power Plants: **0.5**
3. Steam /Coal Fired Power Plants: **0.9**

In view of the above, for example, a solar thermal plant of **50MW** capacity (with 1km^2 collector) at **80%** of average capacity over one year of operation will cause only about **3500-5250** tons of CO2 emissions while, a typical gas fired combined cycle plant will cause **175000** tons of CO2 emissions. Coal fired power plant will cause **315369** tons of CO2 emissions. Solar alternative implies a huge reduction of greenhouse gas emissions.

These simple estimates of the solar energy potential and relative greenhouse gas emissions make it obvious for sustainable energy systems development strategy with +emphasis on solar energy. All short term economic considerations must be abandoned to ensure a concerted effort to establish solar energy systems. **The reorganization of educational systems is very much needed to create awareness.**

At this point one may be tempted to think of nuclear energy as an alternative. But it is important to remember that nuclear power plants have been excluded form clean development mechanism (CDM) for many obvious reasons and that many European countries have decided to phase out their nuclear installations.

The conclusion is simple and straightforward. The only viable alternative energy for the Arab World is solar energy and other renewable energy systems(wind energy, hydropower, ocean Energy, geothermal energy, hydrogen energy & fuel cell, biomass energy) as a with large scale solar collector farms and large scale solar power plants.

Are world's vast hot deserts not welcoming humanity to harness the vast solar energy falling on them and live in harmony with the Earth's Life Support Systems? Let us accept their invitation and conserve the Earth's nonrenewable stocks of resources for future generations.

When the world could spare 1600 Billion dollars (and the Arab countries contributing 105 Billion dollars) in 2010 for military expenditure, hence the building of large sale solar energy installations should not be a financial challenge. After all, this investment is into Energy and Water Security to ensure sustainable life in the Region that is far more than just territorial security.

5.2. Pan Arab Grid

Arab Countries have initiated several bilateral and sub-regional efforts to connect the Pan-Arab electrical networks together into one grid **– forming the integrated Arab Electrical System**.

- The Pan-Arab Grid has been divided into four possible groups:
  - Maghreb Region (Morocco, Algeria, Tunisia and Libya)
  - EJLIS (Egypt, Jordan, Lebanon, Iraq and Syria)
  - GCC Countries and the Yemen
  - Other (Sudan, Djibouti, Mauritania the Comoros Islands)

TRANSMISSION THE ESSENTIAL LINK (Study of Very Large Solar Desert Systems,DLR)

The active use of transmission to replace polluting energy sources by renewable energy sources could eliminate, in 10 to 15 years, about: 1500 million tonnes/year of CO_2, 5 million tonnes/year of NOX, 15 million tonnes/year of SO2

Electrical transmission has to be used since electric power must be transported. It is not practical to store electric energy in large quantities. Furthermore, the production resource is fixed for renewable energy such as energy from the desert. Many of the best renewable power resources in the world are located far from the load centre.
As production and consumption places in most cases are separated by great distances, the only possibility to make use of the power is to build transmission lines. From a technical point of view, a considerable amount of power can be transported on ac and dc transmission lines over very long distances.

5.3. Characteristics of Transmission

The type of transmission used depends on the type of generation and distances involved. High voltage transmission is defined today as grids with voltages from 69 kV and above. At lower voltages we use the terminology distribution. Today's interconnected and meshed networks use three phase alternating current, ac, with a frequency of 50 or 60 Hz as the commonly used technique taking advantage of the easy use for transformation between voltage levels. Direct voltage, dc, is used especially for long transmission lines where it gives the advantage of the same power level being transmitted to/on just two conductors. The higher voltages result in lower losses and economic advantages. But, HVDC (high voltage DC) can also be used for special applications when it is possible or difficult to connect the two networks by an ac transmission, e.g. for stability reasons. The capacity of an 800 kV ac line is around 2000 MW and an anticipated figure for the future are 1200 kV lines is 5000 MW. A realistic maximum distance for an ac transmission is around 1200 km. The characteristics of transmission lines for moving electric energy mean that there is the potential of using long transmission lines to a larger extent than is the case today. Thereby the proportion of the renewable and cleaner types of generation of electricity is increased and reduces the amount of greenhouse gas emissions. Such bulk power transmissions over long distances can be built at a reasonable cost. The transmission of 2000 MW over 1000 kilometers would cost less than 1 cent/kWh. Figure 8 shows the HVDC-interconnections analyzed in the German Aerospace Center DLR-study TRANS-CSP for trans-Mediterranean power transmission.

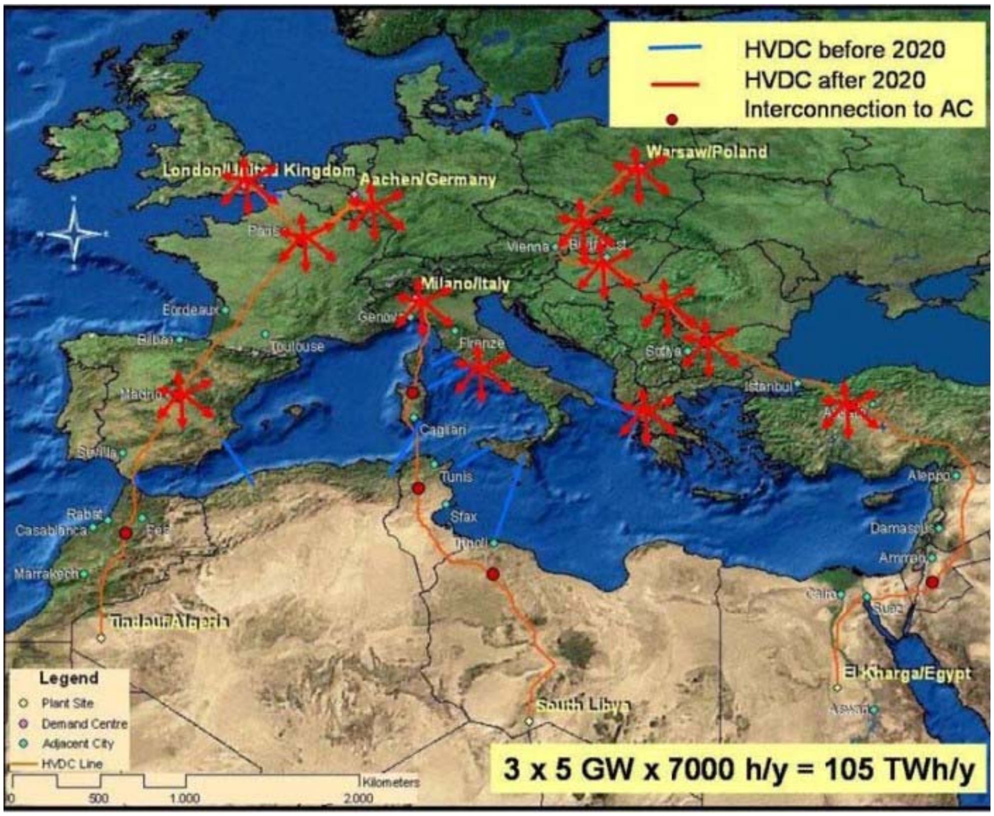

Figure 8. DLR-study of TRANS-CSP for trans-Mediterranean power transmission.

5.4 Security Policy should be Renewable Energy Policy

Our dependency on exhaustible fossil and uranium resources leads to the vulnerability of societies. Remember that there are many hidden costs associated with fossil and nuclear energy such as, undermining health, destabilizing the climate system, disposal of radioactive nuclear waste and pollution of water resources. This may lead to irreversible damage to Earth's Life Support Systems. Global life-support systems incorporate the environmental resources (healthy environment) that sustain the economy as well as those - such as water and air that support life on earth. At present, critical stress suffered by our environment is manifested in the air, water, and soil, our climate, and plant and animal species. Should this deterioration be allowed to continue, we can expect to alter the living world to the extent that it will be unable to sustain life as we know it. Just imagine the enormous expenditures on international security associated with safeguarding of fossil and atomic fuels including processing. All these are bad enough but an even worse aspect of nuclear technology is the creation of massive security risks such as nuclear weapons proliferation and nuclear terrorism. All of the financial expenditures should wisely be used to promote the use renewable energy resources for eternal peace and protection of life support systems.

Therefore humanity should consider seriously the total replacement of fossil and atomic energy by renewable energy in the next 40-50 years. Atomic and fossil energy prices will inevitably increase due to the exhaustion of natural resources as well as the additional costs from environmental damages. Renewable energy prices will continue to drop due to the increase in mass production and improvement of technology. Therefore what is needed urgently is a carbon free and nuclear free, Arab Region Roadmap for energy policy. The absence of Science Policy from the point of pan-Arab perspective is going to pose serious challenges for present and future generations.

6. SUN IS THE SOURCE OF RENEWABLE ENERGY AND THE OCEANS ARE A MAJOR ALTERNATIVE SOURCE OF WATER

Just as the sun is an alternative source of energy to meet future demands, the oceans are an alternative water resource. However, extraction of fresh water from the oceans requires significant development of desalination infrastructure. Desalination is very energy-intensive, and sustainable energy systems urgently need to be developed. The most arid lands are also those blessed with abundant solar energy and this needs to be exploited for large-scale production of freshwater from the oceans.

Human engineered desalination systems actually mimic the hydrologic cycle, which is itself a grand process of distillation. If these systems are driven by the sun, they will augment the fresh water supplies of the global hydrologic cycle. The resulting process will add a human engineered sustainable and controllable contribution to the natural hydrological cycle. There is a clear need for further research and development, and adequate funding towards this end. They are strangely living in a false paradise without adequate concern about the inevitable crisis they will have to face in the not too distant a future when their oil reserves will be exhausted

7. SOLAR ENERGY FOR DESALINATION IN THE ARAB WORLD

The Arab World (AW) stretches across well over 14 million square kilometers of area including North Africa and the part of Western Asia known as the Arab Region. This is a region of highest water scarcity and arid climate with annual precipitation ranging from 100 mm to 400 mm. The **total annual renewable water resources** (TARWR) vary tremendously between the different Arab countries ranging between 0.1 km^3/yr for Qatar and 52.2 billion m^3/yr for Iraq. With a current total population of around 380 million people and a very high growth rate of 2.7%, the per capita share of TARWR has dropped well below the UN threshold for water poverty (1000 m^3 per year) with most of the Gulf Arab countries reaching per capita TARWR below 200 m^3/yr.

Summary of the main characteristics of the various desalination processes: Energy requirements for the RO are highly dependent on salinity, while the energy requirements for the thermal processes such as MSF, MED, and VC are independent of salt concentration. Membranes need good care (pre-treatment) and fragile systems and very sensitive to feed quality (not favorable to polluted feed). It is well known that RO enjoys some advantages over thermal desalination systems (for example in terms of energy), however it is rather very much less tolerant to operational errors than MSF, MED, etc. In many projects in the GCC countries RO has not been competitive with thermal desalination systems due to the fact that owners demand iron clad-performance guarantees which lead to higher prices.

Desalination in the world has decisively proven during last 40 years its reliability to deliver large quantities of fresh water from the sea,from brackish resources and through water reuse. Fresh water is no longer the infinitely renewable resource. Unlike oil, fresh water has no viable substitute. **The sea is the unlimited source from which we can create new fresh water through desalination**

The world cumulative installed capacity of desalination plants was 52.3 million m^3/d in 2008.

In order to meet the rising water demand required by an expanding population and developing economy and to fill the gap between supply and demand, it was found that desalination of seawater and brackish water could provide a considerable part of the shortfall in water supply. The growing technology of desalination is currently providing enormous quantities of water to meet the escalating needs for domestic and industrial sectors in many water scarce Arab countries. Based on recent published estimates, the current water deficit in the region amounts to 60 billion m^3/year and this is expected to grow to 150 billion m^3/year by 2050 (Final report MED-CSP, DLR). A significant amount of the current 60 billion m^3/year deficit is provided by desalination and it is expected that desalination will also provide more to make up for the 160 billion m^3/year needed by 2050. **Desalination has already made a major contribution to quality of life in the most arid regions of the world, particularly the Arab region. Without desalination, many of these regions would have remained uninhabited. With rising global demand, uneven distribution of freshwater and increasing population, desalination technology is providing safe drinking water even to some 'water-rich' nations where pollution reduced the quality of natural waters. Thus, as a means of augmenting fresh water supplies, desalination contributes significantly to global water resources sustainability.**

The total installed capacity of desalinated water systems in the world in 2006 was about 37 million m^3/d or 8140 million gallons per day (Mgal/d), which is expected to increase drastically in the next decades. The dramatic increase in desalinated water supply will create a series of problems, the most significant of which are those related to energy consumption. It has been estimated that production of 25 million m^3/d requires about 285 million barrels of oil per year (considering specific energy consumption 15 kWh/m^3 and efficiency of about =30%). Even if oil were much more widely available, could we afford to burn it on the scale needed to provide everyone with fresh water? Given the current understanding of the greenhouse effect and the importance of CO2 levels, this use of oil is debatable. Thus, apart from satisfying the additional energy demand, environmental pollution would be a major concern. If desalination is powered by conventional technology, then it will require burning of substantial quantities of fossil fuels. Fortunately, the Arab world (AW), including many other arid regions of the world, are blessed with a non-polluting resource of energy and is renewable, namely Solar Energy and other resources.

The desalination associations and institutions have a pivotal role to play here, encouraging the scientific and industrial communities to make efforts to meet world water requirements through environmentally sustainable technologies. Investments in this direction are not impossible; the annual global expenditures for arms are currently about US$1600 billion (SIPRI). Just 1% of this over ten years would be a prudent diversion of resources enough to provide safe water and decent sanitation facilities for all human beings.

8. BENEFITS OF UTILIZING SOLAR ENERGY

- reliable and clean source of primary energy supply, abundantly available, offers future energy security
- displaces fossil fuels
- generates no green house gas emissions or pollution of any other kind; hence, no global warming, no climate change
- helps meeting Kyoto Protocol Guidelines
- poses no radiation risks
- protects against fuel price volatility

- solar power plants can be built in deserts which may have few other uses
- lead time for building solar power plants is short
- can deliver power on demand through its features of allowing operation flexibility with other fuels and thermal storage capability
- CSP power plants can be coupled with desalination plants
- offers flexibility in building generation capacities (several kW to several 100 MW)
- some of the solar power plant technologies require far less amount of utility water than conventional power plants

9. SOLAR COLLECTOR SYSTEMS

These systems can be classified as follows:

a) Concentrating

1. Thermal
    - Parabolic Troughs
    - Parabolic Dish
    - Power Tower
2. Photovoltaic (CPV) Systems

b) Non-Concentrating

1. Flat Plate Collectors
2. Photovoltaic (PV) Panels

9.1 CONCENTRATING SOLAR THERMAL COLLECTOR SYSTEMS

These systems involve concentration of solar direct normal radiation by hundreds of programmed sun tracking mirrors onto a point or a line heat collecting element containing suitable heat transfer fluid, and in turn, raising the temperature of the fluid by several fold. Depending upon the type of collector used and the temperatures achieved by the fluid, the gained heat can be used to produce electrical power, as high temperature furnaces in industrial processes, as stored heat, etc.

Typical temperatures achieved are in the range of 300^oC to 1000^oC or even higher, which is ideal for generating electricity via thermodynamic power cycles.

9.2 CONCENTRATING SOLAR POWER (CSP) TECHNOLOGIES

Solar thermal power plants make use of any of the three concentrating solar thermal collectors, namely, parabolic troughs, parabolic dish and power tower, as a first step to obtaining a high temperature fluid to power an engine or to produce steam for the steam turbine and then employ a thermodynamic power cycle to convert heat energy to electric energy, as in any conventional power plant based on fossil fuels or nuclear power. Another advantage of Solar Thermal Power is that it can easily use fossil fuels such as natural gas as a back-up fuel or store high-temperature heat to overcome the disadvantage of the intermittency of sunlight. Besides these three CSP technologies, another technology that uses concentrating solar radiation techniques to produce power is concentrating photovoltaic (CPV) systems. CPV systems provide power by concentrating solar radiation onto a PV module, which converts the radiation directly to electricity. These systems use either parabolic dish mirror systems or a large array of flat Fresnel lenses to focus energy on PV cells. The advantage of CPV systems over conventional PV systems are being increased efficiencies and reduced costs.

Figure 9 shows schematic diagrams of the four types of Concentrating Solar Power (CSP) systems and Table 5 their performance data. Figure 10. Solar cell conversion efficiency.

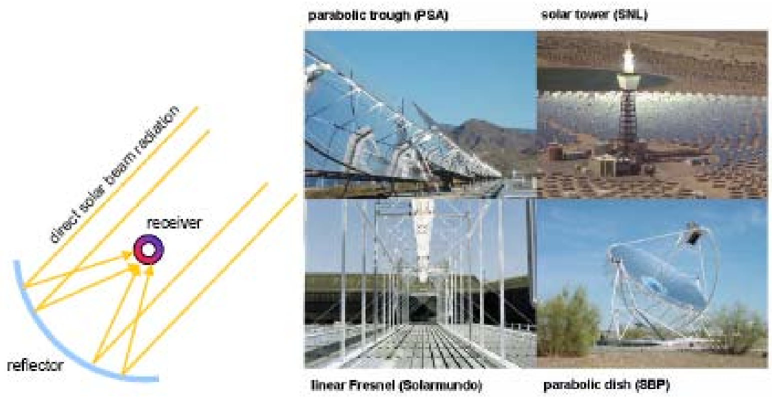

Figure 9. Schematic Diagrams of the four types of Concentrating Solar Power (CSP) Systems

Source: DLR, SNL, Solarmundo, SBP

	Capacity Unit MW	Concentration	Peak Solar Efficiency	Annual Solar Efficiency	Thermal Cycle Efficiency	Capacity Factor (Solar)	Land Use m^2 /MWh/y
Trough	10-200	70 - 80	21% (d)	10–15% (d)	30-40% ST	24% (d)	6-8
				17-18% (p)		25-90% (p)	
Fresnel	10-200	25 -100	20% (p)	9-11% (p)	30-40% ST	25-90% (p)	4-6
Power Tower	10-150	300 - 1000	20% (d)	8-10% (d)	30-40% ST	25-90% (p)	8-12
			35% (p)	15-25% (p)	45-55% CC		
Dish-Stlring	0.01 – 0.4	1000 - 3000	29% (d)	16-18% (d)	30-40% Stirl	25% (p)	8-12
				18-23% (p)	20-30% GT		

(d) = demonstrated, (p) = projected, ST=steam turbine, GT =gas turbine, CC=combined cycle, Solar efficiency = net power generation/incident beam radiation; Capacity factor = solar operating hour per year/ 8760 hours per year.
Source: AQUA-CSP, "Concentrating solar power for seawater desalination", DLR Final Report, 2007

Table 5. Performance of the four CSP systems

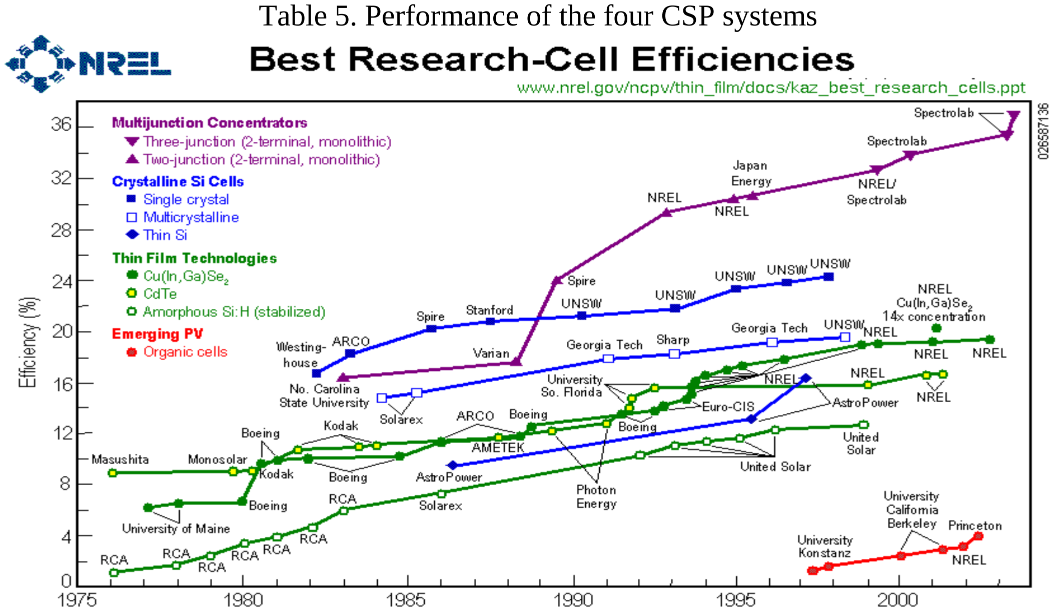

Figure 10. Solar cell conversion efficiency. Typical: 12-16%, Best: 36%, Source: NREL

9.3. Solar Energy Storage Systems

The storage of energy from intermittent and random solar radiation can be achieved artificially, by using energy storage technologies (thermal storage, chemically-charged batteries, hydro storage, flywheels, hydrogen, and compressed air), some are well-known and widely-applied, whilst other are still under development.

Thermal storage for solar heat and chemically charged batteries for off-grid PV systems are the most widely used solar energy storage systems today. However, production of hydrogen using solar energy may provide the long-term solution for solar thermal storage, and research is being undertaken around the world.

9.4. Levelized Energy Costs for Solar Energy Utilization Systems

In almost all cases, ‘levelized energy cost’ is the exclusive criterion used in making decisions regarding economic viability of any energy system utilization. The calculation of the levelized cost of electricity provides a common way to compare the cost of energy across technologies because it takes into account the installed system price and associated costs such as financing, land, insurance, transmission, operation and maintenance, and depreciation, among other expenses. Carbon emission costs and solar panel efficiency can also be taken into account..

Commercial CSP plants have achieved levelized energy costs of about 12-15 cent/kWh, and the potential for cost reduction are expected to ultimately lead to costs as low as 5 cent/kWh as illustrated in Figure 11.

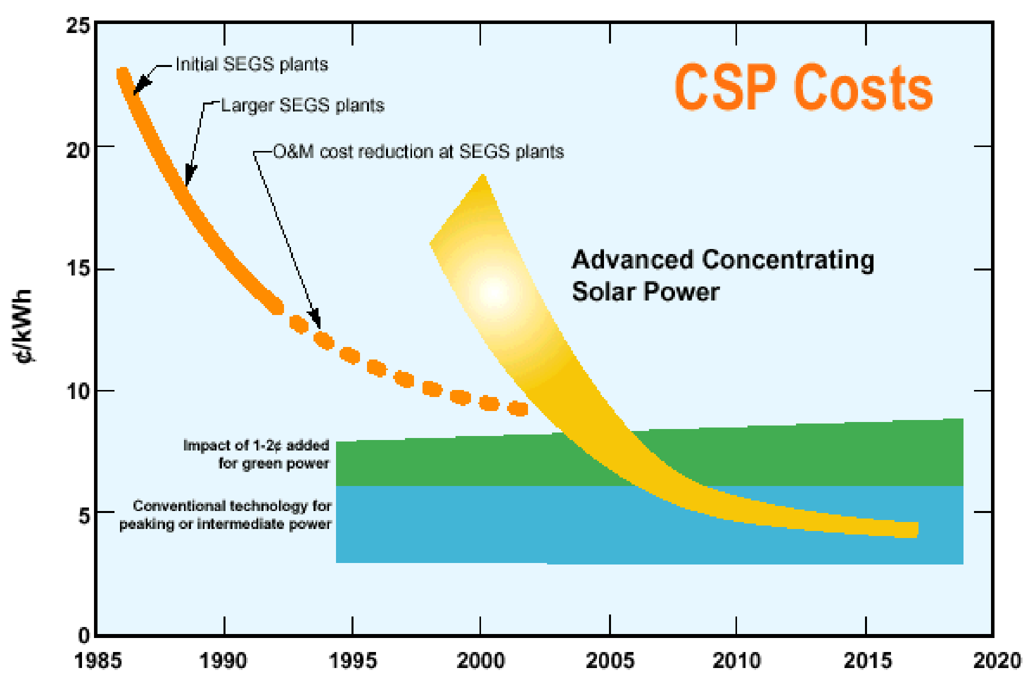

Figure 11. Projections of levelized electricity cost predictions for large scale solar thermal power plants. Current costs are shown in blue with a 1-2 cent/kWh addition for 'green' power shown in green. Source: The book, “Power from the Sun”.

9.5. Non-Concentrating Solar Thermal Collectors

Non-concentrating (or flat-plate) types of solar collectors are a large plate of blackened material oriented in such a manner that the solar energy that falls on the plate is absorbed and converted to thermal energy thereby heating the plate. Tubes or ducting are provided to remove heat from the plate, transferring it to a liquid or gas and carrying it away to the load. They can produce temperatures of about 100^oC or less, which is applicable for many uses such as building heating and cooling, domestic hot water and industrial process heat.

Flat plate solar photovoltaic panels are devices that produce electricity directly from solar energy with no intervening heat engine. Photovoltaic modules are made of specially-prepared layers of semi-conducting materials (usually silicon) that generate electricity when photons of sunlight fall upon them.

Both these applications can utilize direct normal as well as diffused components of solar energy radiation.

9.6. Solar Technologies: Present Status and Future Prospects

a) Solar Photovoltaic Systems (PV)

Photovoltaic devices are rugged and simple in design and can be constructed as stand-alone systems to give outputs from microwatts to megawatts. That is why they have been used as the power sources for calculators, watches, water pumping, remote buildings, communications, satellites and space vehicles and even megawatt-scale power plants. With such a vast array of applications, the demand for photovoltaics is increasing every year. In 2005, over 1700 MW_p of photovoltaic panels were installed and their number is growing at a phenomenal rate of about 35% per year worldwide.

Dramatic improvements have taken place in the efficiencies and manufacturing methods of solar cells since their early days in the 1960s and 1970s.

Panels based on crystalline and polycrystalline silicon solar cells that are most common and available in the market today, are reported to have efficiencies of the order of 15%, while the efficiencies of multijunction cells and concentrating PV have been reported to be as high as 40%. The cost of solar panels has also come down which currently stands at US$3/W. However, this cost is still very high for on-grid applications.

Efforts put in to achieve higher efficiencies for the PV systems by using multiple layers in the solar cell, have resulted in the development of Thin-film PV technologies. Some of the materials being developed for thin-film solar cells include cadmium telluride, copper indium diselenide, copper indium gallium diselenide, gallium arsenide and indium phosphide. Multijunction thin-film solar cells give higher efficiencies when exposed to concentrated sunlight and therefore, Concentrating Photovoltaics (CPV) is receiving much commercial attention at this time. CPV systems have demonstrated efficiencies up to 40% and are expected to reach 50% in the future.

b) CSP Technologies:

The first parabolic trough systems were installed in 1912 near Cairo (Egypt), to generate steam for a 73 kW pump that delivered 2000 m^3/hr of water for irrigation.

The largest CSP capacity of 364 MW was installed in California between 1985 and 1991, most of which (354 MW) is still operating with improved performance of the plant every year. This power plant is based on parabolic-trough technology, with natural gas as a backup fuel.

In March 2007, the EU's first commercial CSP plant, an 11-MW facility, known as PS10 and located in southern Spain, was commissioned. This plant is expected to prevent 18000 tons of CO_2 emission per year.

As a consequence to environmental and energy security considerations, there has been a resurgence of interest in the CSP technologies. A number of plants are under construction or in the planning stage around the world, which when completed, will increase worldwide capacity to about 3000 MW. Of this, more than 2000 MW will be in Spain, because of the excellent solar resource and favorable government policies. A new generation of solar power systems is under development in various parts of the world. Trough technology with direct steam generation is under experimentation at the Plataforma Solar de Almeria, on Spain's Mediterranean coast.

PS 10 plant in Spain, as mentioned above, is first of the several CSP plants that are being planned and built in countries located within the world's so-called 'sun belts'. Ten new plants are planned for land near the Spanish town of Merida. Italy and Israel are also preparing their first operations. Australia has a plan for joint CSP and PV plant in Victoria.

The recent TRANS-CSP study conducted by the German Aerospace Center (DLR) has the objective of meeting 15% of Europe's electricity demand by 2050 through CSP produced in MENA employing suitable transmission technologies.

Emirate of Abu Dhabi, UAE, is currently evaluating the potential of a number of large-scale CSP projects. Masdar, an Abu Dhabi Government owned company, is carrying out large-scale field studies on solar panel technology and the feasibility of supplying clean, renewable energy to the grid. It has also contracted the United Nations Environmental program to evaluate the potential of large-scale CSP projects in the emirate.

An 85-meter circular panel has been constructed in the Emirate of Ras Al Khaimah,UAE, this year, which is the prototype of the futuristic solar island that is to come several hundred meters off the coast of the Emirate, supplying the energy needs of up to 200,000 homes.

10. URANIUM AVAILABILITY AND PRODUCTION STATISTICS

Tables 6 and 7 and Figure 12 show the situation with the sources of nuclear energy on our planet.

Typical Concentration	ppm (U)
High-grade ore (2% U)	20 000
Low-grade ore (0.1% U)	1 000
Granite	4
Sedimentary rock	2
Earth's average continental crust	2.8
Seawater	

Table 6. Typical Concentrations (ppm U). *Source: World Nuclear Association*

Country	Ton U	% of the world
Australia	1,143,000	24.1 %
Kazakhstan	816,099	17.2 %
Canada	443,800	9.4 %
USA	342,000	7.2 %
South Africa	340,596	7.2 %
Namibia	282,359	5.9 %
Brazil	278,700	5.9 %
Niger	225,459	4.7 %
Russian Fed.	172,402	3.6 %
Uzbekistan	115,526	2.4 %
Ukraine	89,836	1.9 %
Jordan	78,975	1.7 %
India	64,840	1.4 %
China	59,723	1.3 %
Other	289,538	6.1 %
World total	4,742,853	100.0 %

Table.7. Resources Reasonably Assured Resources plus Inferred Resources, at US$ 130/kg U, *Source: NEA & IAEA, 2006*

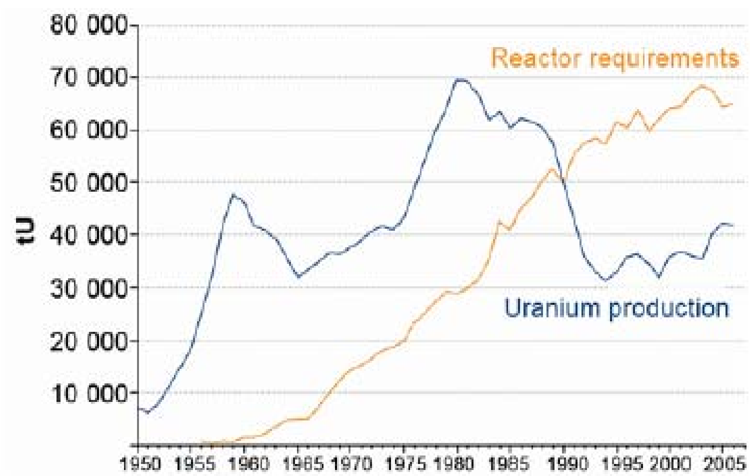

Figure 12. Global annual uranium production and reactor requirements, 1950-2006. *Source: adapted from NEA/IAEA, 2006*

11. NUCLEAR RESEARCH IN THE ARAB REGION

Small scale experiments conducted in some Arab countries do not qualify these countries to assume direct responsibilities of constructing and operating a real nuclear power plant. Each equipment must be manufactured to nuclear standard, a technology only available in the industrialized world. Problems related to materials of construction are still facing major operators in the US, Canada, Germany and France, to name few. Example of steam generators tubing is one of the major problems. A steam generator is a huge vertical structure of alloy tube bundle surrounded by carbon steel shell. The early bundles were made of stainless steel but few years later they started cracking causing the radioactive fluid to mix with the cooling water which comes from sea, lake or river water thus contaminating these natural bodies of water. The next material was Inconel, a very expensive nickel based alloy, each generator cost 300 million dollars and in a four unit each of 800 MW plant with 32 steam generators are used. This material started cracking after seven years in service. Lately another Nickel based alloy Incoloy 825 was attempted and cracking has not stopped. The fuel channels suffer from Hydrogen attack causing crack formation. Each channel undergoes extensive inspection to determine its integrity. Channel replacement is a common occurrence.

The employees undergo thorough training and certifications before they are assigned responsibilities. At all times the Inspection and maintenance and operation of nuclear plants submit to the powerful authority of the regulatory body which is independent from the plant or the company management. It supervises the health of the plant, any maintenance or repairs carried out and determines the next period of safe operation before they sign the plant to go onstream.

The Arab World lacks all these technologies and has no experts to fill the role of the regulatory body. Nuclear activities in some Arab countries:

Algeria
Since 1995 Algeria operates research reactors at Draria and Ain Ouessara. It signed nuclear cooperation agreements with Russia in January 2007, with the United States in June 2007, and with China in March 2008. Algeria has discussed nuclear cooperation also with France.

Egypt
In 1964, a 150 MWe and in 1974 a 600 MWe nuclear power stations were proposed. The Nuclear Power Plants Authority (NPPA) was established in 1976, and in 1983 the El Dabaa site on the Mediterranean coast was selected [22]. Egypt's nuclear plans were frozen after the Chernobyl accident. In 2006, Egypt announced it will revive its civilian nuclear power program, and within next 10 years to build a 1,000 megawatt nuclear power station at El Dabaa. It estimated to cost US$1.5bn, and it will be constructed in participation of foreign investors. In March 2008, Egypt signed with Russia an agreement on the peaceful uses of nuclear energy.

Libya
In 2006 Libya and France signed an agreement on peaceful uses of atomic energy, and in July 2007, they signed a memorandum of understanding related to building a mid-sized nuclear plant with Areva reactor for seawater desalination. This deal was opposed by Germany.

Morocco
Morocco constructs a 2 MW Triga research reactor. The government has plans to build a nuclear power plant in 2016-2017 at Sidi Boulbra in cooperation with Russia's Atomstroyexport, and desalination plant at Tan-Tan on the Atlantic coast in cooperation with China.

Tunisia
Tunisia evaluates the possibility to build a 600 MWe nuclear plant. In December 2006 a cooperation agreement on peaceful use of nuclear energy was signed with France, focused on nuclear power and desalination.

Gulf States
Six member states of the Gulf Cooperation Council (Kuwait, Saudi Arabia, Bahrain, the United Arab Emirates, Qatar and Oman) have announced that the Council is commissioning a study on the peaceful use of nuclear energy. In February 2007 they agreed with the IAEA to cooperate on a feasibility study for a regional nuclear power and desalination program, which according to Saudi Arabia may emerge about 2009. In December 2009, a team of Korean firms won about $ 20 billion project to build four power-generating nuclear reactors (each 1400 MW) and $ 20 billion for operation in the United Arab Emirates. The 40-billion US dollar contract with the United Arab Emirates to construct four nuclear reactors in the region has elevated Korea's status as one of the leading nuclear power plant exporters in the world. Strong criticism has been voiced by many citizens in the UAE and neighboring countries about the unjustifiable policy to build nuclear power plants. Many people consider the investment in nuclear power plants to be no different than the

current Arab military expenditure which is about US dollars 105 billion in 2010.

Jordan
According to the country's energy minister, Jordan intends to build its first nuclear power plant by 2015. It will be used for electricity generation and desalination. The possible purchase of Candu heavy-water reactors has been discussed with Canada.

Syria
Syria abandoned its plans to build a VVER-440 reactor after the Chernobyl accident. The plans of nuclear program were revived at the beginning of 2000s when Syria negotiated with Russia to build a nuclear facility that would include a nuclear power plant and a seawater desalination plant.

Yemen
Yemen has called for establishing The Arab Atomic Energy Agency for nuclear researches and using them for peaceful means, especially generating electricity.

12. NUCLEAR POWER PLANTS- TRACK RECORD AND PRESENT STATUS

At the end of 2007, the world had 439 operating nuclear stations totaling 372 GW (billion watts) of net generating capacity with an average age of 23 years–a year older than the 117 reactors already shut down. The International Atomic Energy Agency (IAEA) says 31 nuclear units were under construction in 13 countries–eight more than at the end of 2004, but ~20 fewer than in the late 1990s. All but five were in Asia or Eastern Europe; yet the Asian Development Bank has never financed one, and reaffirmed this policy in 2000, nor has the World Bank, with a minor 1959 exception. Much of the reported activity is not new: of the 31 units listed as under construction, 12 have been so for at least 20 years, some were started in the 1970s, and two long moribund projects have been re-listed

Turning ambitions into actual investments, firm orders, and operating plants faces fundamental obstacles that are now first and foremost economic, since the political obstacles related to safety, waste, proliferation, etc., can be and in many countries have been bypassed by fiat. The economic evidence below confirms that new nuclear power plants[6] are unfinanceable in the private capital market because of their excessive costs and financial risks and the high uncertainty of both. During the nuclear revival now allegedly underway, no new nuclear project on earth has been financed by private risk capital, chosen by an open decision process, or bid into the world's innumerable power markets and auctions. No old nuclear plant has been resold at a value consistent with a market case for building a new one. And two strong global trends–greater transparency in governmental and energy decision-making, and wider use of competitive power markets–are further dimming nuclear prospects.

The Economist observed in 2001 that "Nuclear power, once claimed to be too cheap to meter, is now too costly to matter"–cheap to run but very expensive to build. Since then, it has become several-fold costlier still to build–and in a few years, as old fuel contracts expire, it is also expected to become several-fold costlier to run. As we'll see, its total cost now markedly exceeds that of other common power plants (coal, gas, big wind farms), let alone the even cheaper competitors described below–cogeneration, some further renewables, and efficient end-use of electricity. Higher fossil-fuel prices since 2001 haven't improved nuclear power's economic case, for two reasons: its own costs have risen even more (its actual fossil-fuel competitors don't include oil), and its formidable new competitors use little or no fossil fuel and generally exhibit falling, not rising, prices.

U.S. nuclear operators' impressive success in improving reliability and performance (through experience, better management, ownership consolidation, shut-down lemons, and compliant regulation) have been unable to offset prohibitive *capital* costs. To deemphasize this hurdle, the industry emphasizes its low *operating* costs, often comparing the cost of just *running* plants already built with the *total* costs of *building and* operating other kinds of new plants. The term “generating costs” or “production costs,” widely used in such misleading comparisons, refers to bare operating costs without capital costs for construction or (usually) for major repairs.

The nuclear industry has consistently underestimated its capital costs, often by large factors, and then claimed its next low forecasts will be accurate. Of 75 U.S. plants operating in 1986, the U.S. Energy Information Administration found two-year-cohort-average cost overruns of 209–381%.

This bankrupted a New Hampshire utility. In the Northwest, the Washington Public Power Supply System (WPPSS) fiasco caused the biggest-ever U.S. municipal bond default ($2.25 billion), saddled the Bonneville Power Administration with a $6-billion debt, and raised wholesale electric rates more than 500%. Seasoned investors still bear the scars. As Mark Twain remarked, a cat that sits on a hot stove lid will not do so again, but neither will it sit on a cold one. Yet some widely quoted recent studies claim new-nuclear costs will match or beat the lowest ever observed in the United States–assuming standardization and construction streamlining that so far are not actually occurring.

The U.S. experience with 1970s and 1980s nuclear construction was uniquely dismal–as *Forbes* put it, “the largest managerial disaster in U.S. business history, involving $100 billion in wasted investments and cost overruns, exceeded in magnitude only by the Vietnam War and the then Savings and Loan crisis.” That economic failure is the main reason why no U.S. nuclear plant ordered after 1973 was completed, and all orders placed since 1978 and 48% of all 253 U.S. orders ever placed were cancelled. Moreover, no new orders have yet been placed: recent license applications are placeholders in the queue for subsidies, which are largest for early applicants, but are not orders and are not yet financed.

The industry blames its U.S. disappointments chiefly on citizen intervention. Yet most if not all other countries with big nuclear programs but no effective citizen intervention, such as Canada, Britain, Germany, France, Japan, and the Soviet Union, also suffered substantial nuclear- cost escalation, and their nuclear construction forecasts collapsed in similar fashion. Thus whatever the political and regulatory system, new nuclear plants’ *costs*, compared with competitors’, are the dominant predictor of whether they will be ordered and whether, if built, they can repay their investors. Without confidence of a fair risk-adjusted return on and of their capital, capitalists won’t invest. Are they now confident that the causes of past cost overruns have been corrected and that new causes of runaway costs are not emerging?

A nuclear power phase-out is the discontinuation of usage of nuclear power for energy production. Often initiated because of concerns about nuclear power, phase-outs usually include shutting down nuclear power plants and looking towards other fuels or alternative energy. Germany is seven years into a nuclear exit program for its 17 reactors, which is due to be completed in 2021.Many European countries intend to phase-out nuclear power plants and including countries such as Belgium, Netherlands, Spain, Sweden, Greece and Poland. In 1994, the parliament of the Netherlands voted to phase out nuclear power after a discussion of nuclear waste management.

Public opinion survey, performed in May and June 2006 in the European Union member countries, concluded that EU citizens perceive great future promise in the use of renewable energies. The 1979 Three Mile Island accident and the 1986 Chernobyl disaster and development in renewable energy technologies played a key role in stopping new plant construction and starting nuclear power phase out in several countries as indicated above.

Therefore, the benefits of electricity supply from nuclear power, although it is CO_2 free, seem to be small compared to the risks which are inherently related to the continuous use or even further expansion of nuclear power. On the other hand, in stark contrast to the claims of the nuclear industry and its talk of a renaissance, nuclear energy is in decline according to a report 'World Nuclear Industry Status Report 2007' presented by the Greens/EFA group in the European Parliament. The report outlines that the proportion of nuclear energy in power production has decreased in 21 out of 31 countries. France's rationale from the 1970s for turning to nuclear - "We have no oil, we have no coal, we have no gas, we have no choice"

Up to now, "least cost and proven technology" thinking has prevented Arab decision makers from using a clean and unlimited very economic source of energy available in the region: solar energy in vast quantities. The Sun every year pours down the equivalent of 1.47 Million barrels of oil of energy for every square kilometer (1 barrel=1600kWh).

12.1. Capital Costs

Construction cost of nuclear plants is the most widely debated parameter, although other parameters, such as the cost of capital and the operating performance are of great importance. There are a number of factors that explain why there is such controversy about forecasts of construction cost. Many of the quoted construction cost forecasts should be treated with skepticism. The most reliable indicator of future costs has often been past costs. However, most utilities are not required to publish properly audited construction costs, and have little incentive to present their performance in other than a good light.

US utilities were required to publish reliable accounts of the construction costs of their nuclear plants for the economic regulator (who only allowed cost recovery from consumers for properly audited costs). The cost of the British Sizewell B plant is also reasonably well documented because the company building it had few other activities in which the construction cost could be ‘disguised’. Even where the costs are reliably established, there can be disputes about why the costs were that level. For example, according to the report 8, the cost of Sizewell B was 35 per cent higher in real terms than the price quoted in 1987 when it was ordered. However, of the final cost of about £3000/kW, British Energy claims £750/kW (25 per cent) was first-of-a-kind costs. Bid prices by vendors are also realistic, although given that they may not cover the whole plant or may be subject to escalation clauses that mean the final price is significantly higher, they have some limitations.

Prices quoted by those with a vested interest in the technology, such as promotional bodies, plant vendors (when not tied to a specific order) and utilities committed to nuclear power, clearly must be treated with skepticism. Prices quoted by international agencies, such as the Nuclear Energy Agency also must be treated with care, particularly when they are based on indicative rather than real costs. Generally, these costs are provided by national governments, who may have their own reasons to show nuclear power in a good light. Capital charges are normally expected, rightly, to be the largest element of the unit cost of power from a nuclear power plant. The construction cost is therefore crucial in determining the cost of power from a nuclear power plant. Conventionally, quoted construction costs include the cost of the first charge of fuel but do not include the interest incurred on borrowings during the construction of the plant, usually known as interest during construction or IDC. To allow comparisons between reactors with different output capacities, costs are often quoted as a cost per installed kW. Thus, a nuclear power plant with an output rating of 1200MW, quoted as costing £2000/kW would have a total construction cost of £2400m.

Forecasts of construction costs have been notoriously inaccurate, frequently being a serious underestimate of actual costs and, counter to experience with most technologies where so-called ‘learning’, scale economies and technical progress have resulted in reductions in the real cost of successive generations of technology, real construction costs have not fallen and have tended to increase through time. There is also some inevitable variability from country to country reflecting local labour costs and the cost of raw materials such as steel and concrete.

The major reactor vendors have received only a handful of orders in the past 20 years, their own production lines have closed and skilled teams have been cut back. Westinghouse has received only one order in the past 25 years while even the French vendor, Framatome received its first order in a decade with its order for Finland. For new orders, large components would generally have to be sub-contracted to specialist companies and built on a one-off basis, presumably at higher costs in countries such as Japan and, for the future, China. Design and engineering teams would have to be reassembled. The Sizewell B reactor was the most recent plant built in Britain, being completed in 1995. Its cost is not easy to determine precisely because of disputes, for example, about how far first of a kind costs should be included. However, the overall cost was estimated by the National Audit Office in 1998 as about £3bn, probably about £3.5bn in today’s money or a cost of £2900/kW.

A 2004 report from the **Canadian Energy Research Institute** gives an updated comparison of generation costs for Ontario (Table 8). As well as comparing different fuels and technologies for base-load power, it compares public and private investor funding in deriving the actual levelized power cost. Both the new ACR-700 and the well-proven Candu-6 units are examined for the nuclear case. (levelized cost means average costs of producing electricity including capital/finance over a plant's lifetime. It may take into account amortizing development costs over several units.)

Ontario Base-Load Costs from New Plant

	$Can	**coal**	**gas**	**ACR-700**	**Candu-6**
Capital	$/kW	1600	711	2347	2972
Power - public finance	c/kWh	4.8, 6.1*	7.2, 7.8*	5.3	6.3
Power - merchant finance	c/kWh	5.9, 7.3*	7.5, 8.1*	7.3	8.9

Table 8. Ontario Base-Load Costs from New Plant, * with C$ 15/y CO_2 cost.

On capital cost, figures include $300 million owner's cost added to the overnight capital cost for the nuclear plants - which are twin units. The ACR is on first-of-a-kind basis. The power production costs are based on 30-year operating life and 90% capacity factor. Merchant figures include higher financing plus tax costs. Gas figures are very sensitive to fuel prices.

Florida Power & Light in February 2008 released projected figures for two new AP1000 reactors at its proposed Turkey Point site. These took into account increases of some 50% in material, equipment and labor since 2004. The new figures for overnight capital cost ranged from $2444 to $3582 /kW, or when grossed up to include cooling towers, site works, land costs, transmission costs and risk management, the total cost came to $3108 to $4540 per kilowatt. Adding in finance charges almost doubled the overall figures at $5780 to $8071 /kW.

In March 2008 **Progress Energy** announced that its two new Westinghouse AP1000 units on a greenfield site in Florida would cost it about $14 billion, including land, plant components, cooling towers, financing costs, license application, regulatory fees, initial fuel for two units, owner's costs, insurance and taxes, escalation and contingencies. If built within 18 months of each other, the cost for the first would be $5144 per kilowatt and the second $3376/kW - total $9.4 billion. Interest adds about one third to the combined figure - $3.2 billion, and infrastructure - notably 320 km of transmission lines - about another $3 billion. The units are expected on line in 2016 and 2017 and are expected to save customers some $930 million per year relative to natural gas-fired generation.

In May 2008 **South Carolina Electric and Gas Co.** and Santee Cooper locked in the price and schedule of new reactors for their Summer plant in South Carolina at $9.8 billion. The EPC contract for completing two 1,117-MW AP1000s is with Westinghouse and the Shaw Group. Beyond the cost of the actual plants, the figure includes forecast inflation and owners' costs for site preparation, contingencies and project financing. The units are expected to be in commercial operation in 2016 and 2019.

12.2. Non-fuel O&M cost

Many people assume that nuclear power plants are essentially automatic machines requiring only the purchase of fuel and have very low running costs. As a result, the non-fuel operations and maintenance (O&M) costs are seldom prominent in studies of nuclear economics. As discussed below, the cost of fuel is relatively low and has been reasonably predictable. However, the assumption of low running costs was proved wrong in the late 1980s when a small number of US nuclear power plants were retired because the cost of operating them (excluding repaying the fixed costs) was found to be greater than cost of building and operating a replacement gas-fired plant.

It emerged that non-fuel O&M costs were on average in excess of $22/MWh (2.2 c/kWh) while fuel costs were then more than $12/MWh (1.2 c/kWh). Many O&M costs are largely fixed – the cost of employing the staff and maintaining the plant – and vary little according to the level of output of the plant so the more power that is produced, the lower the O&M cost per MWh. It is also worth noting that British Energy, which was essentially given its eight nuclear power plants when it was created in 1996, came close to bankruptcy in 2002 because income from operation of the plants barely covered operating costs. This was in part due to high fuel costs, especially the cost of reprocessing spent fuel, an operation only carried out now in Britain and France.

12.3. Nuclear clean-up 'to cost £70bn'

The UK's nuclear waste clean-up program could cost more than £70bn, according to the Nuclear Decommissioning Authority (NDA). The authority's previous estimate of the cost was £56bn. The cost of cleaning up existing waste is higher than previously thought

The news came as the government backed British Nuclear Fuels' (BNFL) plan to sell its specialist nuclear clean-up business British Nuclear Group (BNG).

12.4. Nuclear Power- Facts vs Illusion

a) Nuclear Power is dangerous, safety is a myth

Nuclear power remains the most dangerous form of energy. The history of the Nuclear Age is a history of accidents (http://www.million-against-nuclear.net/background/accidents.htm). Even during normal operation, radioactive materials are regularly discharged into the air and water. Transport of large quantities of low and intermediate level wastes also increases the risks for the populations.

Despite nuclear power being a hazardous business, it is absolved of all financial liabilities. In the case of a nuclear disaster, most of the damages are paid by the society and not by the insurances of the companies.

b) Nuclear power is a deadly legacy for our children

A solution for the long-term storage & treatment of radioactive waste is yet to be found. Nuclear waste is produced at every stage of the nuclear fuel cycle; from uranium mining and reactors to the reprocessing of spent nuclear fuel. It remains dangerous for hundreds of thousands of years and the radiations can lead to cancer and birth defects.

There is not a single safe disposal method available till today for disposing the highly radioactive waste produced by nuclear power stations worldwide. In almost all countries waste is stored in bunkers, below the surface or above the ground. Such storages are expensive and require safety measures that are not comparable to any other waste or industrial process. This fact alone should suffice to abandon nuclear power as a viable energy option.

c) Nuclear power is financially highly disadvantageous

All countries using nuclear technology have seriously underestimated the total costs of nuclear power. Not a single nuclear power plant was ever built without direct or indirect subsidies, paid by taxpayers and increasing the profits of the nuclear industry. Nuclear power will not be able to compete with renewable energies without huge amounts of state aid. One third of electricity that is being produced in Europe today by nuclear means is solely due to the favorable market conditions created by the government through spending huge amounts on research and other related activities.

The huge costs involved–apparent as well as hidden–in waste handling and decommissioning of the currently operating plants, and making provisions for accidents result in a massive burden on future economies and generations.

d) Nuclear power is no solution to climate change

In order to avoid the most catastrophic effects of global warming, the world will have to cut back its emissions of heat-trapping greenhouse gases by around 50% by 2050. Since by far the most of emissions happen in the energy sector, the nuclear industry hopes to use the climate crisis to stage a nuclear revival, arguing that nuclear power is cheap, emission-free and thus has a role to play in securing low-emissions supply of energy.

But nuclear power is not at all emissions free, if emissions in relation to uranium mining, transportation, plant construction and decommissioning and waste storage are included in the calculation. It has been calculated that for example in the UK with its 23 nuclear reactors, doubling capacity would cut emissions by no more than 8%. Globally, tripling nuclear capacity by 2050 might contribute 12.5%-20% to the necessary emission reductions. But such scenarios -- one plant every two weeks -- have no link to political reality, and the costs would be astronomic.

Compare this to the 20% reduction of energy consumption (and emissions) the European Union can achieve by 2020 (30 years earlier) at zero net costs, as the European Commission has pointed out in a "Green Paper" on energy efficiency. Also, nuclear power comes with high opportunity costs (since every Euro can be spent only once): Every Euro invested in new nuclear power could save ten times more emissions if it was invested in energy conservation measures instead–thus also securing energy supply ten times less expensive.

e) Nuclear weapons are the flip side of nuclear power

Radioactive material from nuclear power generation can be used to build nuclear weapons. The global expansion of nuclear power could well contribute to an increase in the number of nuclear weapons states.

The spread of nuclear technology significantly increases the risk of nuclear weapons proliferation. Smuggling of nuclear material, including from civil nuclear programs, also presents a significant challenge. The International Atomic Energy Association has recorded over 650 confirmed incidents of trafficking in nuclear or other radioactive materials since 1993, with almost a hundred such incidents taking place in 2004 alone.

f) Nuclear power dependent on limited & dirty resources

Nuclear power plants run on uranium fuel. And uranium - like oil, gas and coal - is a finite resource that will only last a few more decades, at most 50 years (with the current level of use). A significant increase in the use of nuclear power will quickly result in a shortage of nuclear fuel. The reprocessing of spent fuels has already been proven to be no solution. Reprocessing is a complicated and hazardous chemical process that creates an enormous amount of radioactive waste. Besides that, reprocessing is a very uneconomical technology, as past examples have clearly demonstrated. Nevertheless there are two reprocessing units in Europe: Sellafield (UK) and La Hague (France). Both are known to be the biggest sources of radioactive pollution in the European environment through the release of huge quantities of radioactive liquid effluents into the sea and gaseous discharges into the air. And last but not least, the production of weapons from plutonium separated in reprocessing facilities is relatively simple, dramatically increasing the risk of nuclear weapons proliferation.

13. ENVIRONMENTAL IMPACT OF NUCLEAR ENERGY

Radioactive Wastes

Radioactive wastes are waste types containing radioactive chemical elements that do not have a practical purpose. They are sometimes the products of nuclear processes, such as nuclear fission. The majority of radioactive waste is "low-level waste", meaning it contains low levels of radioactivity per mass or volume. This type of waste often consists of used protective clothing, which is only slightly contaminated but still dangerous in case of radioactive contamination of a human body through ingestion, inhalation, absorption, or injection. In the United States alone, the Department of Energy states that there are "millions of gallons of radioactive waste" as well as "thousands of tons of spent nuclear fuel and material" and also "huge quantities of contaminated soil and water".

The United States currently has at least 108 sites it currently designates as areas that are contaminated and unusable, sometimes many thousands of acres. The DOE wishes to try and clean or mitigate many or all by 2025, however the task can be difficult and it acknowledges that some will never be completely remediated, and just in one of these 108 larger designations, Oak Ridge National Laboratory, there were for example at least "167 known contaminant release sites" in one of the three subdivisions of the 37,000-acre (150 km^2) site. Some of the U.S. sites were smaller in nature, however, and cleanup issues were simpler to address, and the DOE has successfully completed cleanup, or at least closure, of several sites.

The issue of disposal methods for nuclear waste was one of the most pressing current problems the international nuclear industry faced when trying to establish a long term energy production plan, yet there was hope it could be safely solved. A recent research report on the Nuclear Industry perspective of the current state of scientific knowledge in predicting the extent that waste would find its way from the deep burial facility - back to soil and drinking water (such that it presents a direct threat to the health of human beings - as well as to other forms of life) is presented in a document from the International Atomic Energy Agency (IAEA) - which was published in October 2007. This document states "The capacity to model all the effects involved in the dissolution of the waste form, in conditions similar to the disposal site, is the final goal of all the research undertaken by many research groups over many years.

13.1. Costs of Nuclear Waste Disposal (The Flawed Economics of Nuclear Power)

Lester Brown 2008, we need not look beyond the United States, which leads the world with 101,000 megawatts of nuclear-generating capacity (compared with 63,000 megawatts in second-ranked France). The United States proposes to store the radioactive waste from its 104 nuclear power reactors in the Yucca Mountain nuclear waste repository, roughly 90 miles northwest of Las Vegas, Nevada. The cost of this repository, originally estimated at $58 billion in 2001, climbed to $96 billion by 2008. This comes to a staggering $923 million per reactor—almost $1 billion each—assuming no further repository cost increases. The Price-Anderson Act first enacted by Congress in 1957, shelters U.S. utilities with nuclear power plants from the cost of such an accident. Under the act, utilities are required to maintain private accident insurance of $300 million per reactor—the maximum the insurance industry will provide. In the event of a catastrophic accident, every nuclear utility would be required to contribute up to $95.8 million for each licensed reactor to a pool to help cover the accident's cost.

The collective cap on nuclear operator liability is $10.2 billion. This compares with an estimate by Sandia National Laboratory that a worst-case accident could cost $700 billion, a sum equal to the recent U.S. financial bailout. So anything above $10.2 billion would be covered by taxpayers

A 2004 International Atomic Energy Agency report estimates the decommissioning cost per reactor at $250–500 million, excluding the cost of removing and disposing of the spent nuclear fuel. But recent estimates show that for some reactors, such as the U.K. Magnox reactors that have high decommissioning waste volumes, decommissioning costs can reach $1.8 billion per reactor. Two years ago, building a 1,500-megawatt nuclear plant was estimated to cost $2–4 billion. As of late 2008, that figure had climbed past $7 billion, reflecting primarily the scarcity of essential engineering and construction skills in a fading industry. The high cost of nuclear power also explains why so few plants are being built compared with a generation ago. To date, 119 reactors have been closed, at an average age of 22 years. If we generously assume a much longer average lifespan of 40 years, then 93 reactors will close between 2008 and 2015. Another 192 will close between 2016 and 2025. And the remaining 154 will close after 2025.

Radioactive waste typically comprises a number of radioisotopes: unstable configurations of elements that decay, emitting ionizing radiation which can be harmful to human health and to the environment. Those isotopes emit different types and levels of radiation, which last for different periods of time.

The radioactivity of all nuclear waste diminishes with time. All radioisotopes contained in the waste have a half-life - the time it takes for any radionuclide to lose half of its radioactivity and eventually all radioactive waste decays into non-radioactive elements. Certain radioactive elements (such as plutonium-239) in "spent" fuel will remain hazardous to humans and other living beings for hundreds of thousands of years. Other radioisotopes will remain hazardous for millions of years. Thus, these wastes must be shielded for centuries and isolated from the living environment for hundreds of millennia. Some elements, such as Iodine-131, have a short half-life (around 8 days in this case) and thus they will cease to be a problem much more quickly than other, longer-lived, decay products but their activity is much greater initially. The two tables show some of the major radioisotopes, their half-lives, and their radiation yield as a proportion of the yield of fission of Uranium-235.

The faster a radioisotope decays, the more radioactive it will be. The energy and the type of the ionizing radiation emitted by a pure radioactive substance are important factors in deciding how dangerous it will be. The chemical properties of the radioactive element will determine how mobile the substance is and how likely it is to spread into the environment and contaminate human bodies. This is further complicated by the fact that many radioisotopes do not decay immediately to a stable state but rather to a radioactive decay product leading to decay chains.

14. NUCLEAR DISASTERS

Listed below are two of the most serious nuclear accidents which occurred at the Three Mile Island reactor 2 in the United States and the Chernobyl reactor 4 in the former Soviet Union, are described.

14.1. Three Mile Island

On an island 10 miles from Harrisburg Pennsylvania resides the Three Mile Island Nuclear Power Station (see Figure 10 for an outside view of the plant). There are two reactors at the plant, dubbed Unit 1 and Unit 2. One of them is inoperable. Unit 2 experienced a partial reactor meltdown on March 28, 1979. A partial nuclear meltdown is when the uranium fuel rods start to liquefy, but they do not fall through the reactor floor and breach the containment systems. The accident which occurred at Unit 2 is considered to be the worst nuclear disaster in US history. Why did it happen? There are many reasons for the accident, but the two main ones are simple human error and the failure of a rather minor valve in the reactor. In the following paragraphs, we will explain how it was possible for the accident to happen and both its psychological and physical effects on the American people.

The accident at TMI (Three Mile Island) began at about four in the morning with the failure of one of the valves that controlled coolant flow into the reactor. Because of this, the amount of cool water entering the reactor decreased, and the core temperature rose. When this happened, automatic computerized systems engaged, and the reactor was automatically SCRAMMED. The nuclear chain reaction then stopped. This only slowed the rate at which the core temperature was increasing, however. The temperature was still rising because of residual heat in the reactor and energy released from the decaying fission products in the fuel rods.

Because the pumps removing water from the core were still active, and a valve that controlled the cool water entering the core failed, water was leaving the core, but not coming in. This reduced the amount of coolant in the core. There wasn't enough coolant in the core, so the Emergency Core Cooling System automatically turned on. This should have provided enough extra coolant to make up for the stuck valve, except that the reactor operator, thinking that enough coolant was already in the core, shut it off too early.

There still wasn't enough coolant, so the core's temperature kept increasing. A valve at the top of the core automatically opened to vent some of the steam in the core. This should have helped matters by removing the hot steam, but the valve didn't close properly. Because it didn't close, steam continued to vent from the reactor, further reducing the coolant level. The reactor operators should have known the valve didn't close, but the indicator in the control room was covered by a maintenance tag attached to a nearby switch. Because the operators didn't know that the valve had failed to close, they assumed that the situation was under control, as the core temperature had stopped rising with the first venting of steam from the core. They also thought that the coolant had been replaced in the core, because they didn't know that the pump outlets were closed. A few minutes later the core temperature began to rise again, and the Emergency Core Cooling System automatically switched on. Once again, an operator de-activated it, thinking the situation was under control. In reality, it was not.

Soon, because of the coolant lost through the open valve at the top of the reactor, the core temperature began to rise again. At this point the fuel rods started to collapse from the intense heat inside the core. The operators knew something was wrong, but didn't understand what it was. This was about 5 minutes after the initial valve failure. It took almost 2 hours for someone to figure out that the valve releasing steam at the top of reactor hadn't closed properly. During those 2 hours, precious coolant continued to be released from the reactor a meltdown was underway. At approximately 6AM, an operator discovered the valve at the top of the core was open and closed it.

During the day hydrogen gas began to accumulate inside the reactor and caused an explosion later in the afternoon. This explosion did not damage the containment systems, however. Two days later, the core was still not under operator control. A group of nuclear experts were asked to help evaluate the situation. They figured out that a lot of hydrogen gas had accumulated at the top of the core. This gas could have exploded, like the explosion on the first day of the accident, or it could have displaced the remaining coolant in the reactor, causing a complete nuclear reactor meltdown. No one really knew what to do about the hydrogen build-up. A hydrogen recombiner was used to remove some of the hydrogen, but it was not very effective. However, hydrogen also dissolves in water, which is what the coolant was composed of. Thus, over time the hydrogen that had collected at the top of the core completely dissolved in the coolant. Two weeks later the reactor was brought to a cold shutdown and the accident was over.

No one was directly injured as a result of the accident. However, some radioactive gas and water were vented to the environment around the reactor. At one point, radioactive water was released into the Susquehanna River, which is a source of drinking water for nearby communities. No one is really sure what effects these radioactive releases might have had on people living near the power plant.

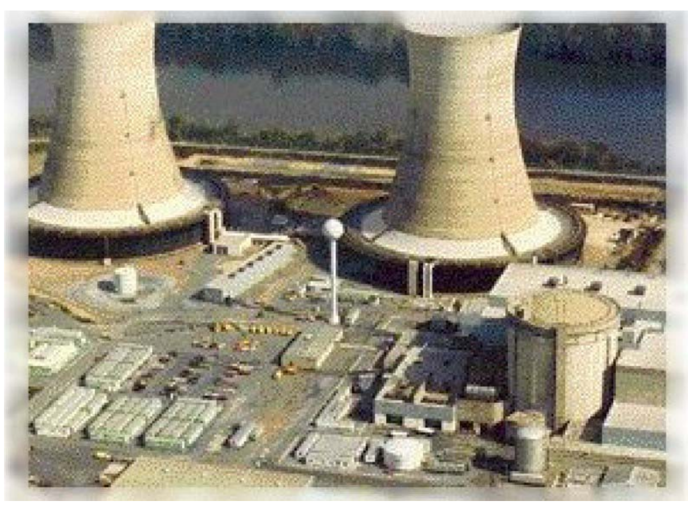

Figure 13. Showing Outside View of the Three Mile Island Power Plant
Photo Courtesy Nuclear Regulatory Commission

14.2. Chernobyl

About 80 miles (130 km) north of Kiev, in what is now the Ukraine, is located the Chernobyl nuclear power plant. At this plant the worst reactor disaster to ever occur took place on April 26, 1986. It happened largely because normal reactor operations were suspended; an experiment was to take place in the reactor. As a result, normal safety guidelines were disregarded, and the accident occurred. However, as with most accidents of this type, it was a result of many small mistakes adding up to create a catastrophe. In the following paragraphs, we will outline just how the event transpired:

Early in the day, before the test, the power output of the reactor was dropped in preparation for the upcoming test. Unexpectedly, the reactor's power output dropped way too much, almost to zero. Because of this drop, some control rods were removed to bring the power back up. The reactor's power output raised up and all appeared to be normal.

More preparation for the test began later when two pumps were switched on in the cooling system. They increased water flow out of the reactor, and thus removed heat more quickly. They also caused the water level to lower in a component of the reactor called the steam separator. Because of the low level of water in the steam separator, the operator increased the amount of feed water coming into it, in the hopes that the water level would rise. Also, more control rods were taken out of the reactor to raise internal reactor temperature and pressure, also in the hopes that it would cause the water level in the steam separator to rise. The water level in the steam separator began to rise, so the operator adjusted again the flow of feed water by lowering it. This decreased the amount of heat being removed from the reactor core.

Because many control rods had been removed and the amount of heat being taken from the core by the coolant had been reduced, it began to get very hot. Also, there was relatively low pressure in the core because the amount of incoming water had been decreased. Because of the heat and the low pressure, coolant inside the core began to boil to form steam.

The actual test began with the closing of the turbine feed valves. This should have caused an increase in pressure in the cooling system, which in turn would have caused a decrease in steam in the core. This should have lowered the reactivity in the core. Thus, the normal next step when closing the turbine feed valves was to retract more control rods, increasing reactivity in the core. This is what the operator at Chernobyl did. The only problem was that in this case there was no increase in pressure in the cooling system because of the earlier feed water reduction. This meant that there was already a normal amount of steam in the core, even with the turbine feed valves closed. Thus, by retracting more control rods to make up for a reduction in steam that didn't happen, the operator caused too much steam to be produced in the core.

With the surplus of steam, the reactor's power output increased. Soon, even more steam was being produced. The operator realized there was a problem and SCRAMMED the reactor, completely disabling all fission reactions. However, it was too late. The temperature and pressure inside the reactor had already risen dramatically, and the fuel rods had begun to shatter.

After the fuel rods shattered, two explosions occurred as a result of liquid uranium reacting with steam and from fuel vapor expansion (caused by the intense heat). The reactor containment was broken, and the top of the reactor lifted off. With the containment broken, outside air began to enter the reactor. In this particular Soviet reactor, graphite was used as a moderator instead of water (water was the coolant). As air entered the core, it reacted with the graphite. Graphite is essentially just carbon, so oxygen from the air chemically combined with the carbon to form CO (carbon monoxide). Carbon monoxide is flammable and soon caught fire. The fire emitted extremely radioactive smoke into the area surrounding the reactor. Additionally, the explosion ejected a portion of the reactor fuel into the surrounding atmosphere and countryside. This fuel contained both fission products and transuranic wastes.

During the days following the accident, hundreds of people worked to quell the reactor fire and the escape of radioactive materials. Liquid nitrogen was pumped into the reactor core to cool it down. Helicopters dumped neutron-absorbing materials into the exposed core to prevent it from going critical. Sand and other fire-fighting materials were also dropped into the core to help stop the graphite fire. All in all, over 5000(metric) tons of material was dropped into the core. After the fires were brought under control, construction of what is called "the sarcophagus" began. The word "sarcophagus" is usually used to describe the elaborate coffins the ancient Egyptians used to entomb their dead. In this case, the sarcophagus is a structure erected from about 300,000 metric tons of concrete that surrounds the reactor. It was designed to contain the radioactive waste inside. It has served its purpose well, but, now, ten years after the accident, several flaws have been found in it. Holes have begun to appear in the roof, allowing rainwater to accumulate inside. This water can corrode the structure, further weakening it. Also, birds and other animals have been seen making homes in the sarcophagus. If they should ingest radioactive material, they could spread it around the countryside. Additionally, with time the sarcophagus has become worn down. It is conceivable that an intense event like an earthquake, tornado, or plane crash directly on the sarcophagus could lead to its collapse. This would be catastrophic, as radioactive dust would once again rain down on the surrounding areas. Scientists and engineers are working on ways to repair or replace the structure.

One of the great tragedies of the accident was that the Soviet government tried to cover it up. Clouds of fallout were traveling towards major population centers such as Minsk, and no one was warned. No one outside the Soviet Union knew about the accident until two days later, when scientists in Sweden detected massive amount of radiation being blown from the east.

The effects of the disaster at Chernobyl were very widespread. The World Health Organization (WHO) found that the radiation release from the Chernobyl accident was 200 times that of the Hiroshima and Nagasaki nuclear bombs combined. The fallout was also far-reaching. For a time, radiation levels in a Scotland were 10,000 times the norm. 30 lives were directly lost during the accident or within a few months after it. Many of these lives were those of the workers trying to put out the graphite fire and were lost from radiation poisoning. The radiation released has also had long-term effects on the cancer incidence rate of the surrounding population. According to the Ukrainian Radiological Institute over 2500 deaths resulted from the Chernobyl incident. The WHO has found a significant increase in cancer in the surrounding area. For example, in 1986 (the year of the accident), 2 cases of childhood thyroid cancer occurred in the Gomel administrative district of the Ukraine (this is the region around the plant). In 1993 there were 42 cases, which is 21 times the rate in 1986. The rate of thyroid cancer is particularly high after the Chernobyl accident because much of the radiation was emitted in the form iodine-131, which collects in the thyroid gland, especially in young children. Other cancer incidence rates didn't seem to be affected. For example, leukemia was no more prevalent after the accident than before.

What caused the accident? This is a very hard question to answer. The obvious one is operator error. The operator was not very familiar with the reactor and hadn't been trained enough. Additionally, when the accident occurred, normal safety rules were not being followed because they were running a test. For example, regulations required that at least 15 control rods always remain in the reactor. When the explosion occurred, less than 10 were present. This happened because many of the rods were removed to raise power output. This was one of the direct causes of the accident. Also, the reactor itself was not designed well and was prone to abrupt and massive power surges.

15. DECOMMISSIONING OF NUCLEAR FACILITIES

At the end of its useful life, a nuclear power plant has to be decommissioned. A useful life of 30 years is often referred to but nuclear power plants are usually designed for 40 years of operation. The lifetime could be extended beyond 40 years with suitable management programs which included control of degradation processes, maintenance, repair and refurbishing and/or replacement of plant components and systems.

There are essentially two options for the process of decommissioning a nuclear power plant:

- The plant is dismantled soon after operation ceases and the site is restored or adapted for reuse.
- Fuel is discharged to a storage facility and non-radioactive parts of the plant are dismantled but the radioactive parts are mothballed for 30-50 years or even longer before dismantling.

The first option has the benefit of making potentially valuable sites available for other purposes, notably for new power plant units, as early as possible. It would also remove the problem of continuing public concern about whether the reactor remained a threat to public health and safety.

The second option has the benefit of reducing the total radiation dose to decommissioning workers as radioactivity will have decayed substantially in the 30-50 year mothball period. This would also reduce the cost of dismantling, though the saving may be partly or completely offset by the cost of maintenance and surveillance during the mothball period. Technology is available for dismantling radioactive reactors today but new technology may be developed over the next 30-50 years that would allow further reduction of costs and worker exposure.

In both cases, as a result of dismantling some radioactive materials will have to be managed as waste. The fuel will in either case be discharged at an early stage and managed according to the option selected for the back end of the fuel cycle. The primary circuit will have radioactive components with a fairly rapid decay which can be treated as LLW or ILW, at least after a few years or after decontamination. Some of these components are large but are easy to handle or can be cut into smaller pieces. Only a small part of the plant is radioactive. Most of the plant never becomes radioactive and therefore presents no particular problems for immediate dismantling and possible reuse of the equipment.

Several countries have technical experience in the decommissioning of nuclear Facilities as about 10-15 nuclear power plants have been decommissioned and their sites restored for reuse. Most of these plants were small and of early designs. The experience is nevertheless relevant for the future decommissioning of currently operating plants.

In order to decommission a nuclear power plant, three prerequisites must be satisfied:

- Well trained personnel with appropriate technical skills
- A licensed storage or disposal facility to accommodate all decommissioning wastes
- A regulatory basis for implementing a given decommissioning project

The IAEA has published general decommissioning guidelines for research reactors and small facilities but they can, to a great extent, also be applied to large facilities. There is now a need for more specific guidance on the development of decommissioning regulations. IAEA safety standards on decommissioning are therefore being developed as part of the RADWASS program.

Ontario town 'symbolizes the wickedness of the nuclear fuel cycle', November 17, 2010

An anti-nuclear activist who suggests the entire population of Port Hope, Ont., should be moved because of radioactive soil contamination took her message to residents on Tuesday. "In a way, your town symbolizes the wickedness of the nuclear fuel cycle, and it's not your fault," Helen Caldicott told about 300 people. "You should be compensated. "Helen Caldicott has suggested residents of Port Hope, Ont., should be moved because of radioactive soil contamination. Helen Caldicott has suggested residents of Port Hope, Ont., should be moved because of radioactive soil contamination. (CBC)

Radioactive soil dating back to the 1930s was spread over the town before stricter regulations were brought into place. Much of the soil was cleaned up in the 1970s, but now there's disagreement over how to get rid of the rest. A preliminary excavation of more than one million cubic meters of dirt has started in the municipality of 16,000 people on the shore of Lake Ontario about 110 kilometers east of Toronto. It is expected to take 10 years to clean up. Caldicott said the town should be abandoned rather than deal with the historic uranium waste problems. Her comments have caused such controversy in Port Hope that she delivered her speech in Oshawa, 50 kilometers away. Sanford Haskill, who leads a group of Port Hope residents concerned about radioactive waste, invited Caldicott to speak. "I've done my job", he said. "Let the people decide if she is counterfeit or real."

Caldicott is an Australian physician who has been working since 1980 against the "insanity" of nuclear weapons and atomic power, notably with If You Love This Planet, a National Film Board of Canada documentary that won an Academy Award in 1982, and her involvement in International Physicians for the Prevention of Nuclear War, a group which won the 1985 Nobel Peace Prize.

Jack Goering, a Port Hope resident since 1961, left the meeting with no solid answers except one: "Certainly to move everybody would not be practical." Although federal agencies insist the town is safe, many Port Hope residents want public hearings to air their concerns about the legacy of decades of nuclear industry activity in the area.

Read more: http://www.cbc.ca/canada/story/2010/11/17/port-hope-radioactive-soil-helen-caldicott.html?ref=rss#ixzz15XixhqDt

16. CONCLUSIONS

1. Renewable energy is inexhaustible and abundant. The non-renewable energy resources, however will not last forever and have proven to be one of the main sources of our environmental problems. It is clear therefore that in due time renewable energies will dominate the world's energy system, due to their inherent advantages such as mitigation of climate change, as well as increased energy security and supply including reduction of poverty.

2. Renewable energy and in particular solar energy, is going to be the primary driver of our modern civilization and may provide fresh water from desalination without harming our earth' life-support systems.

3. The nuclear industry is in near-terminal decline world-wide, following its failure to establish itself as a clean, cheap, safe or reliable energy source. The on-going crises in nuclear waste management, in safety and in economic costs have severely undermined the industry's credibility. It is currently desperate to find a valid rationale and justification for renewed state support and funding. It is promoting the claim that as nuclear power stations do not emit carbon dioxide, the major greenhouse gas, switching from fossil fuels to nuclear power is the only way to cut Carbon Dioxide (CO_2) without radically changing consumption patterns. However, even the most perfunctory examination of the issue shows that nuclear power has no role whatever in tackling global climate change. In fact quite the opposite is true; any resources expended on attempting to advance nuclear power as a viable solution would inevitably detract from genuine measures to reduce the threat of global warming.

4. It is clear that immediate action is needed to halt climate change. Instant cuts in CO_2 emissions must be made. Electricity production is a major source of CO_2. To tackle global warming, we therefore have to look for ways of producing and using electricity which significantly lessen the CO_2 burden. And in deciding how best to tackle global warming, we have to take into account both the cost effectiveness of alternatives to fossil fuels, the cost of their environmental impact

and their impact on global security.

5. Early hopes of cheap nuclear energy were based on an expectation that whilst nuclear power stations would be more expensive than fossil fuel plants, their running and maintenance costs would be extremely low. Experience has shown that the early optimism was totally misplaced.

6. The cost of nuclear activity at all levels has exceeded those early predictions. In many countries, the construction costs of nuclear power plants have proved to be much higher than first expected. Plants have taken longer to build and there have been many unforeseen technical problems. Running costs have also been much less predictable than was first thought. The costs of increased safety demands and regular equipment breakdowns have been compounded by the expensive question of how to deal with the nuclear waste. In addition, the predicted cost of decommissioning power stations has also escalated.

7. Reliable figures on nuclear generating costs are difficult to obtain. According to a current international study, which examined the cost information provided by nuclear operators, industry figures are frequently dubious or inaccurate. The assumptions on which they are based are often over-optimistic. Alternative options, which are risk-free and less CO2 intensive, are in fact cheaper.

8. In the United States, for example, no new nuclear power stations have been ordered since 1978. This has happened in a country which launched the Pressurized Water Reactor design and which houses many more nuclear reactors than any other country. Construction and operating costs have risen so dramatically, especially since the extra safety demands made after the accident at Three Mile Island, that some companies have faced bankruptcy.

9. Since the oil crisis of the 1970s, several renewable energy forms of electrical power (solar, wind, hydroelectric, photovoltaic, land-fill gas and biomass) generation have emerged, and of these a handful are now considered mature and bankable. This means that they are considered to be reliable and durable power production systems and are therefore able to secure private investment. Many of these technologies are therefore coming into main-stream use, with hundreds of megawatts installed each year. On the other hand it has become clear that nuclear power is not bankable. In particular by the World Bank

10 The true cost of any power source must include external costs which do not appear on the operators balance sheets and are therefore hidden. The external (or social) costs reported by Pearce(1992) is shown Figure 14.

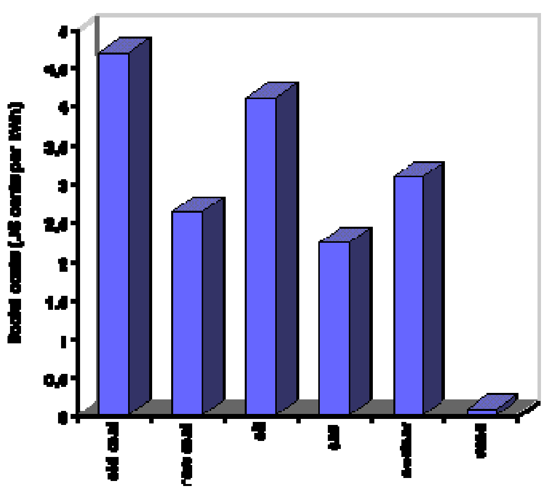

Figure 14. The external (or social) costs reported by Pearce (1992)

11. The nuclear industry's disingenuous claims to a role in alleviating climate change must be rejected for what they are: dangerous and self-serving fantasies which would create a serious legacy of deadly radioactive waste increase the risks of catastrophic nuclear accidents and also vastly increase the threat of nuclear weapons proliferation. To conclude, nuclear energy in comparison with clean renewable energy is uneconomical, hazardous and not considered to be part of clean development mechanism (CDM).

    Renewable energy sources can clearly be more effective as non-CO2 emitting energy sources than nuclear power. However, there are also a number of environmental problems associated with nuclear power which go beyond direct quantification as "externalities". These make nuclear power unacceptable from an environmental perspective.

12. Radioactive Waste: The Problem with No Solution: It is often said that nuclear power is now a mature technology as it has been operating for over 40 years. Despite this, there is still no environmentally appropriate program of dealing with any form of radioactive waste. This problem is made worse on a daily basis by the continual production of radioactive waste.

    Nuclear waste is produced at every stage of the nuclear fuel cycle, from uranium mining to the reprocessing of spent nuclear. Much of this waste will remain hazardous for thousands of years, leaving a deadly radioactive legacy to future generations.

13. The horror of nuclear accidents: In the former Soviet Union at least 9 million people have been affected by the Chernobyl disaster; 2.5 million in Belarus; 3.5 million in Ukraine; and 3 million in Russia (http://archive.greenpeace.org/comms/no.nukes/nenstcc.html#f16#f16). In total over 160,000 km2 of land is contaminated in the three republics.

14. Although the nuclear industry continues to refute evidence on the widespread health effects and prevalence of diseases resulting from Chernobyl, it is now widely accepted that the accident has resulted in a massive increase in thyroid cancers in some countries. The President of the European Thyroid Cancer Association, Dilwyn Williams, has stated that thousands of children exposed to radiation will contract thyroid cancer in the next 30 years, Pearce (1992).

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15. An initiative on the advancement of sustainability in science, education and training. The best young minds need to be motivated to engage in interdisciplinary problem-solving, based on ever enhanced transdisciplinary excellence

Glossary

Concentrated Solar Power: Concentrating Solar Power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. The concentrated heat is then used as a heat source for a conventional power plant

Concentration Ratio: Concentration ratio is the area of collector divided by area of focused 'spot'

Desalination: Removal of salt (sodium chloride) and other minerals from the sea water or salty water to make it suitable for human consumption and/or industrial use.

OAPEC: Organization of Arab Petroleum Exporting Countries. It includes Algeria, Bahrain, Egypt, Iraq, Kuwait, Libya, Qatar, Saudi Arabia, Syria, Tunisia and the United Arab Emirates.

Solar tracking: Orienting a concentrating solar reflector or lens toward the sun.

Uranium enrichment: the process of increasing the amount of 235U from 0.72% (which is found in natural uranium) to a higher percentage needed for most nuclear reactors to operate.

Sustainable Development (WCED-1987): Development that meets the needs of the present without compromising the ability of future generations to meet their own needs

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The SI unit of power: is the Watt and is equal to one Joule per second (1.0 W = 1.0 J s^{-1})

The Joule: is the basic SI unit of energy and is the energy expended when an object is moved through a distance of one meter as a result of a force of one Newton being applied to the object.

Power: is the rate at which energy is expended and is Calculated from; Power=Energy/Time

The unit of energy, not of power as it is derived by multiplying the Power in kilowatts by the time in hours.

One kilowatt-hour: is equal to 3600 kilojoules or 1kWh = 3600 kJ = 3.6 MJ

1MWh = 3.6 GJ, 1GWh = 3.6 TJ,1TWh = 3.6 PJ, 1PWh = 3.6 EJ

Multipliers for SI units:

kilo (k)	10^{3}
Mega (M)	10^{6}
Giga (G)	10^{9}
Tera (T)	10^{12}

Peta (P) 10^{15}

Exa (E) 10^{18}

Note also: 1 million = 10^6, 1 billion = 10^9 and 1 trillion= 10^{12}

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For more studies on atomic power plants risks, please refer to the studies conducted by the Concerned Scientists association on internet in 2009 under the following titles: www.ucsusa.org/clean-energy/(New UCS Study shows Sensible to Clean Energy Economy), www.ucsusa.org/nuclear-power/ (Nuclear Power: A Resurgence We Can't Afford (2009), www.uscusa.org/nuclear-power/Nuclear power in a warming world (2007), assessing the Risks, addressing the Challenges.

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Carbon-Free and Nuclear-Free: A Roadmap for U.S Energy Policy, 2007.

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For more studies, please refer to the researches conducted by the international professors, Dr. Mycle Schneider, nuclear consultant (France) and Dr. Hermann Scheer, energy policy expert (Germany) who won the Right Livelihood award, or the Alternative Nobel Prize, which is an annual prize given for many fields, including human rights, sustainable development, health, education and environment protection.