# Nuclear Energy: Prospects for Pakistan *

**Malik Qasim Mustafa****

## Introduction

The term "energy," means "the ability to do work." To achieve this "ability" mankind has explored a wide variety of energy sources, broadly categorized as renewable and non-renewable sources. In the twenty-first century the worldwide demand for energy is growing rapidly and known reserves of fossil fuel are quickly dying out. Renewable resources have not been utilized to their full extent due to economic and technological constraints. This scarcity of energy resources is affecting social development and economic growth around the globe. Furthermore scarce energy resources, their rising prices, insufficient supply , unequal distribution and increasing demand has become a threat to human security and survival as it is leading the mankind towards crisis. This can even result in violent conflicts, as control over energy resources has become a major policy of super powers of the world, e.g. invasion of Iraq.

Since the end of twentieth century the magnitude of environmental threats has increased tremendously;[1] and "environmental security" concerns have occupied a centre stage in all decisions made for the future of energy security. The above mentioned arguments have raised many questions regarding the nature of sources of energy which would be available to mankind in future. Therefore, the following attributes are expected from the future sources of energy. The sources should be reliable, sustainable, environment friendly and cost effective. They should be relatively safe from market turmoil. They should be easily accessible to all rich and poor, and countries and regions for an equal growth. Among available resources of energy nuclear energy is one of the cleanest and efficient source, and has the potential to become a dominant source of future energy. Although there are problems and concerns related to its dual-use; its proliferation for weapons development; its transportation, safety, and storage, but nuclear energy sector is and will continue to play a prominent role in future.

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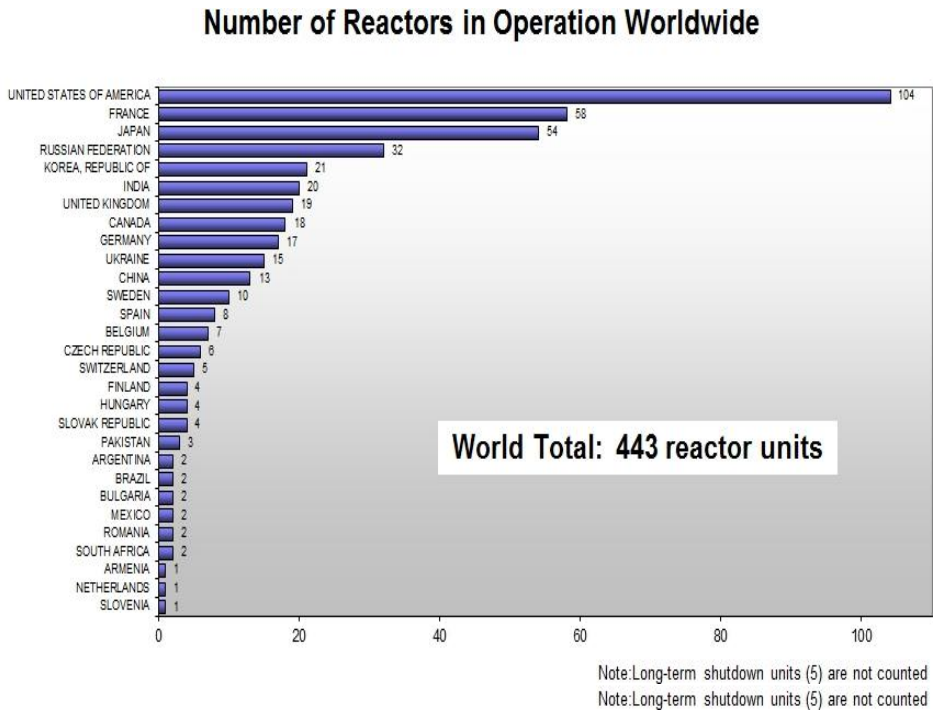
## Global Overview of Nuclear Energy

According to a recent estimate by International Atomic Energy Agency (IAEA) there are currently 442 nuclear reactors operating around the world and the US is leading with 104 nuclear reactors. France comes second with 58 nuclear reactors and Japan is third with 54 nuclear reactors.[2]



Note:Long-term shutdown units (5) are not counted

**Source:** Power Reactor Information System (PRIS), IAEA, Access date, January 20, 2011, http://www.iaea.or.at/programmes/a2/

These 442 nuclear reactors are contributing around 14% of total world's energy requirement by producing around 374,914 MWe. Around 5 nuclear reactors (4 in Canada and 1 in Japan) with a total capacity of 2776 MW are facing long term shutdown, therefore they are not counted in this total.[3]

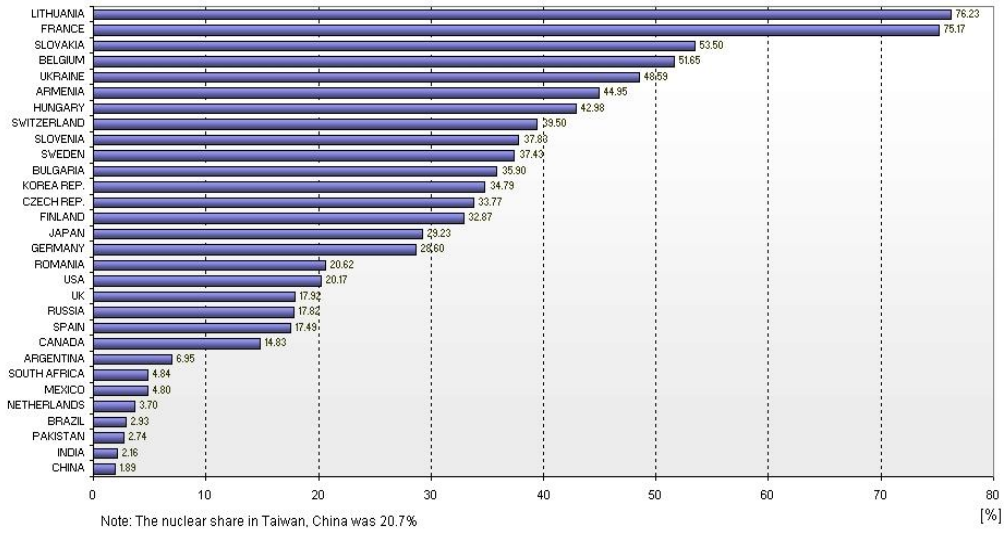
## Nuclear Power Plants Information by Country

| Operational | | |
|---|---|---|
| Country | No. of Units | Total MW(e) |
| ARGENTINA | 2 | 935 |
| ARMENIA | 1 | 375 |
| BELGIUM | 7 | 5926 |
| BRAZIL | 2 | 1884 |
| BULGARIA | 2 | 1906 |
| CANADA | 18 | 12569 |
| CHINA | 13 | 10048 |
| CZECH REPUBLIC | 6 | 3678 |
| FINLAND | 4 | 2716 |
| FRANCE | 58 | 63130 |
| GERMANY | 17 | 20490 |
| HUNGARY | 4 | 1889 |
| INDIA | 20 | 4391 |
| JAPAN | 54 | 46823 |
| KOREA, REPUBLIC OF | 21 | 18665 |
| MEXICO | 2 | 1300 |
| NETHERLANDS | 1 | 487 |
| PAKISTAN | 2 | 425 |
| ROMANIA | 2 | 1300 |
| RUSSIAN FEDERATION | 32 | 22693 |
| SLOVAK REPUBLIC | 4 | 1792 |
| SLOVENIA | 1 | 666 |
| SOUTH AFRICA | 2 | 1800 |
| SPAIN | 8 | 7514 |
| SWEDEN | 10 | 9303 |
| SWITZERLAND | 5 | 3238 |
| UKRAINE | 15 | 13107 |
| UNITED KINGDOM | 19 | 10137 |
| UNITED STATES OF AMERICA | 104 | 100747 |
| Total: | 442 | 374914 |

**Source:** Power Reactor Information System (PRIS), IAEA, Access date, January 20, 2011, http://www.iaea.or.at/programmes/a2/

As far as nuclear share of electricity generation is concerned, according to 2009 estimates, Lithuania contributed 76.23%, France contributed 75.17% and Pakistan contributed 2.74% in their respective national grids through nuclear energy.[4]

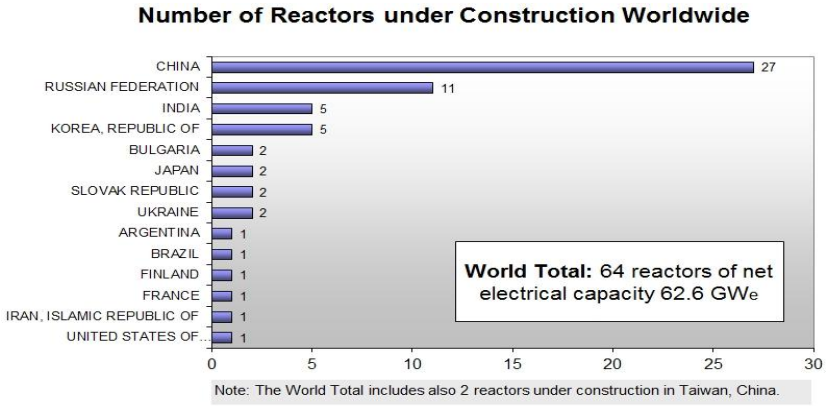
## Nuclear Share in Electricity Generation 2009




**Source:** Power Reactor Information System (PRIS), IAEA, Access date, January 20, 2011, http://www.iaea.or.at/programmes/a2/

According to the IAEA estimate around 65 nuclear reactors are under construction around the world. After completion these reactors

would add another 62862 MWe to the total world energy requirements.[5] Figure below clearly show that China is leading with 27 reactors. In India there are 5 nuclear reactors under construction where as in Pakistan there is only 1 reactor under construction.




**Source:** Power Reactor Information System (PRIS), IAEA, Access date, January 20, 2011, http://www.iaea.or.at/programmes/a2/

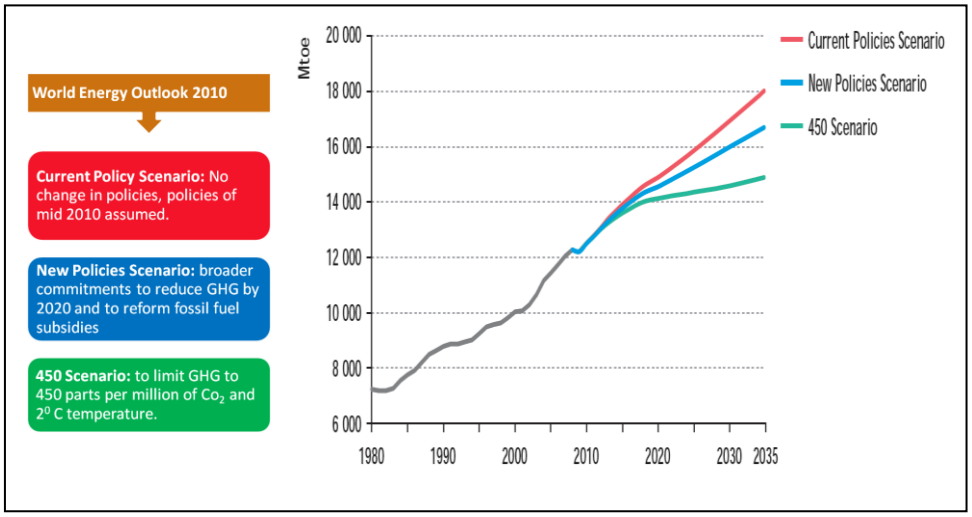
| **Nuclear Reactors Under Construction** | | |
|---|---|---|
| **Country** | **No. of Units** | **Total MW(e)** |
| ARGENTINA | 1 | 692 |
| BRAZIL | 1 | 1245 |
| BULGARIA | 2 | 1906 |
| CHINA | 27 | 27230 |
| FINLAND | 1 | 1600 |
| FRANCE | 1 | 1600 |
| INDIA | 5 | 3564 |
| IRAN | 1 | 915 |
| JAPAN | 2 | 2650 |
| KOREA, REPUBLIC OF | 5 | 5560 |
| PAKISTAN | 1 | 300 |
| RUSSIAN FEDERATION | 11 | 9153 |
| SLOVAK REPUBLIC | 2 | 782 |
| UKRAINE | 2 | 1900 |
| US | 1 | 1165 |
| **Total**: | 65 | 62862 |

**Source:** Power Reactor Information System (PRIS), IAEA, Access date, January 20, 2011, http://www.iaea.or.at/programmes/a2/

## Future Scenario: Energy Demand and Role of Nuclear Power

According to the World Energy Outlook 2010, in the current scenario, where no change in government policy is assumed, world primary energy demand is projected to increase by 1.4% per year from 2008-2035 increasing up to 18,048 million tons of oil equivalent (Mtoe).[6] In the New Policies Scenario, which takes account of both existing policies and declared intentions, energy demand is projected to increase by 1.2% per year, reaching 16,748 Mtoe, an increase of 4,500 Mtoe, or 36%. The World Energy Outlook 2010 has projected a more environment friendly scenario for the growth of energy demand where states will stabilize atmospheric greenhouse gas concentrations at 450 ppm CO2 equivalents. According to this 450 scenario, world energy demand still increases, but by a much reduced 22% or an average of 0.7% per year, reaching 14,920 Mtoe.

**World Primary Energy Demand by Scenario (Mtoe)**




**Source:** "World Energy Outlook 2010," International Energy Agency (IEA), 2010, p.78.

**World Primary Energy Demand by Fuel and Scenario (Mtoe)**

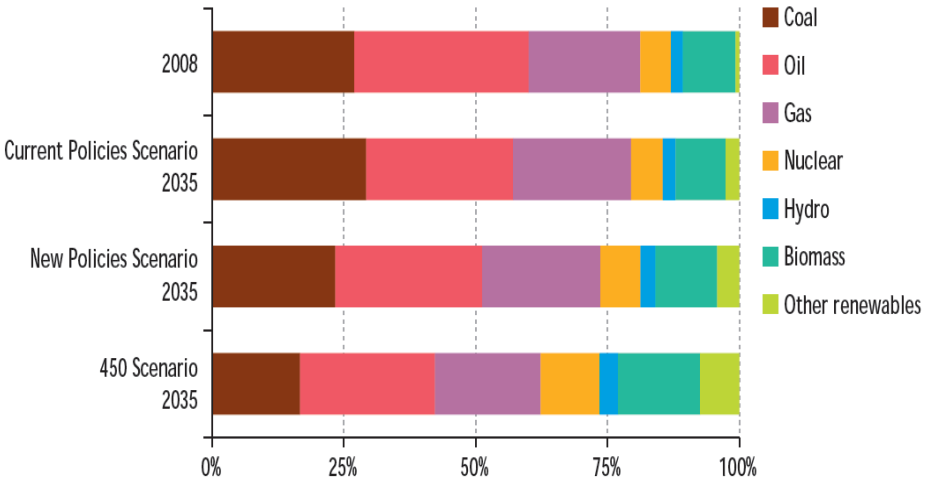
| | | | New Policies Scenario | | Current Policies Scenario | | 450 Scenario | |
|---|---|---|---|---|---|---|---|---|
| | 1980 | 2008 | 2020 | 2035 | 2020 | 2035 | 2020 | 2035 |
| Coal | 1 792 | 3 315 | 3 966 | 3 934 | 4 307 | 5 281 | 3 743 | 2 496 |
| Oil | 3 107 | 4 059 | 4 346 | 4 662 | 4 443 | 5 026 | 4 175 | 3 816 |
| Gas | 1 234 | 2 596 | 3 132 | 3 748 | 3 166 | 4 039 | 2 960 | 2 985 |
| Nuclear | 186 | 712 | 968 | 1 273 | 915 | 1 081 | 1 003 | 1 676 |
| Hydro | 148 | 276 | 376 | 476 | 364 | 439 | 383 | 519 |
| Biomass and waste* | 749 | 1 225 | 1 501 | 1 957 | 1 461 | 1 715 | 1 539 | 2 316 |
| Other renewables | 12 | 89 | 268 | 699 | 239 | 468 | 325 | 1 112 |
| Total | 7 229 | 12 271 | 14 556 | 16 748 | 14 896 | 18 048 | 14 127 | 14 920 |

* Includes traditional and modern uses.

**Source:** "World Energy Outlook 2010," International Energy Agency (IEA), 2010, p. 80.

Fossil fuels remain the dominant energy sources in 2035 in all three scenarios, though their share of the overall primary fuel mix varies markedly, from 62% in the 450 Scenario to 79% in the Current Policies Scenario, compared with 74% in the New Policies Scenario and 81% in 2008. The shares of renewable and nuclear power are correspondingly highest in the 450 Scenario and lowest in the Current Policies Scenario.[7]

**Share of Energy Resources in World Primary Demand Scenario**




**Source:** "World Energy Outlook 2010," International Energy Agency (IEA), 2010, p.80.

It is estimated that in 2009 1.4 billion people — over 20% of the global population — did not have access to electricity. Despite this rising demand in global energy, it is projected that 1.2 billion people would still lack access to electricity in 2030.[8] Majority of these people reside in sub-Saharan Africa and South Asian region. It's estimated that, at present, over a billion people in the industrialized countries use some 60% of the world's commercial energy supply, while 5 billion people living in the developing countries consume the remaining.

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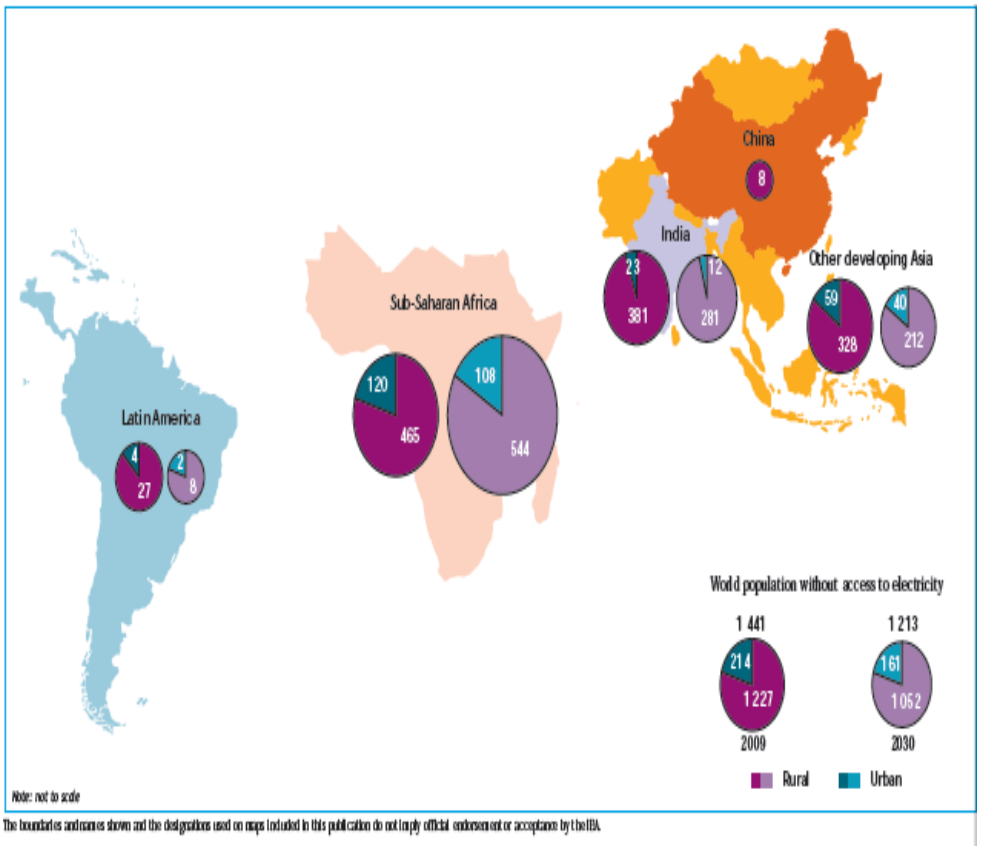
**The Future of People without Electricity (millions)**




**Source:** "World Energy Outlook 2010," International Energy Agency (IEA), 2010, p. 240.

It is clear that nuclear power can play a prominent role to meet the growing demand of energy. The term "nuclear renaissance" has become a catchphrase worldwide. Especially in developing regions, energy security through nuclear power has now become a main national policy objective. In Asia the growth of nuclear power industry is tremendous. China and India have developed quite fast in the nuclear power industry, and there is a possibility that these two countries will outpace other countries in the next two decades. In Southeast Asia, Indonesia is set to lead the way followed by Vietnam, Thailand and potentially the Philippines and Malaysia. In Africa, a continent more vulnerable to climate change and energy shortage, several African nations, including Algeria, Egypt, Morocco, Namibia, and Nigeria, are seriously considering making use of nuclear power. Supporters of nuclear energy in Africa consider this option as a "silver bullet," which they believe would enhance their economic growth and would help them reduce poverty. In the Middle East Kuwait, Saudi Arabia and UAE are pursuing nuclear power. More recently the United Arab Emirates (UAE) accepted a bid by the Korea Electric Power Corporation (KEPCO) to supply 1400 MW (e) of nuclear power by 2020.[9] Pakistan has also given a high priority to nuclear energy and set a goal of 8800 MW through nuclear power by year 2030.

**In developing regions, energy security through nuclear power has now become a main national policy objective.**

**Energy Crisis in Pakistan**

Like many other developing countries Pakistan is also facing acute energy shortages. In fact the current energy crisis is the worst in history which is affecting the growth in almost all sectors of its economy and all segments of society. The worsening of this crisis may be attributed to the following factors;

- Declining hydro power potential and failure to construct new ones.
- Depleting natural gas reserves and failure to explore new ones.
- Rising tariffs of fuel, gas and electricity
- Failure to utilize existing installed generation capacity
- Poor performance of power sector.
- Failure on the part of governments to implement proper power reform policy.
- Heavy dependence on imported oil.

- Uncertainty in oil prices
- Circular debt.
- Overloaded infrastructure and Transmission distribution losses.
- Low foreign investment due to poor law and order situation.
- Expenditures on "War on terrorism."
- Corruption and issues of governance to install and manage new power plants.
- Weak economic growth.
- Growth in population with a corresponding growth in energy demand.
- Delays in installing new generation capacity in the country.
- Natural disasters causing damage to power infrastructure.

An increase in population and growth in economy is resulting in huge energy demands while on the other side supply of energy resources is limited. Currently Pakistan is facing around 4000-5000 MW of power shortage. This growing demand of electricity is resulting in power cuts which are not only affecting industrial growth, but also causing anger and frustration among the masses. Domestic oil production is very low and as a result, the country is relying on imported oil, the prices of which fluctuate every now and then. The current energy crisis is a major hurdle in achieving ideals of self reliance, economic development and fewer imports.

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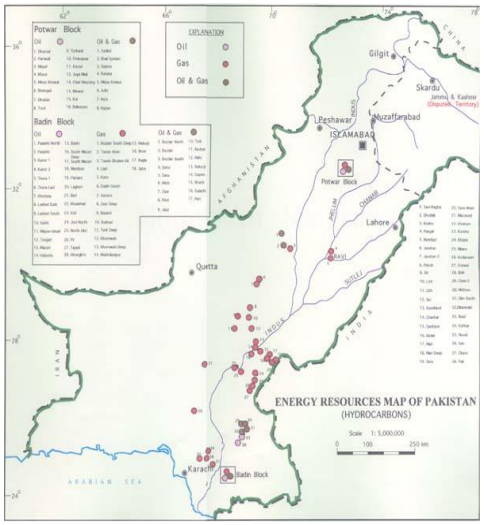
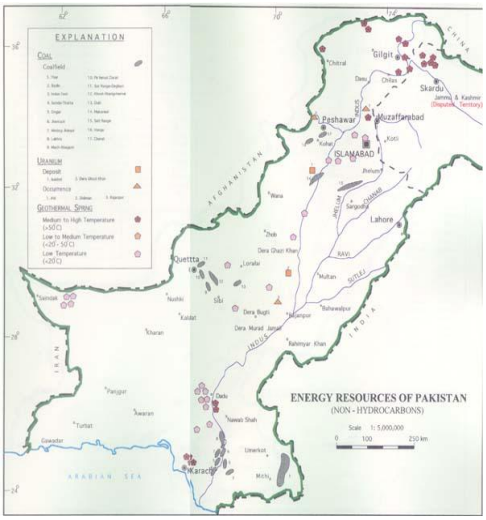
**Pakistan Energy Profile**

Although Pakistan has abandoned renewable and non-renewable resources of energy, but due to economic and technological constraints they have not been explored and utilized to its full extent. As shown in the maps, Pakistan has plentiful resources of hydrocarbons and non-hydrocarbons.[10]

**Hydrocarbons Resources** **Non-Hydrocarbons Resources**




**Source:** Pakistan Geological Survey of Pakistan, *www.gsp.gov.pk/resources/energy_resources.html*

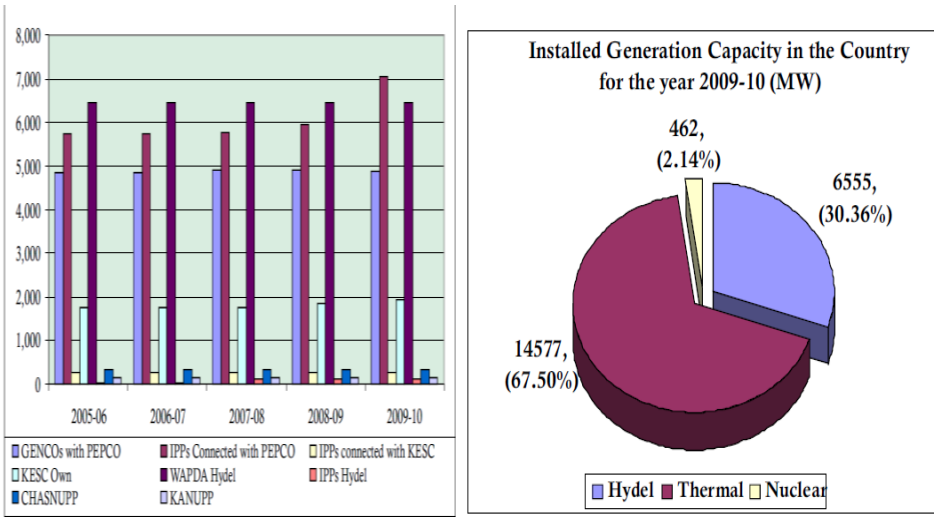
The total installed electricity generation capacity in Pakistan during 2009-10 was 21,593 MW.[11] The table and charts give a detailed breakdown of the total installed generation by source in the country. Out of this total installed capacity, 462 (2.14%) MW comes from nuclear, 6555 (30.36%) MW comes through hydel resources and the rest 14577 (67.50%) MW is thermal capacity.[12] According to National Electric Power Regulatory Authority (NEPRA) Industry report 2010, during the fiscal year 2009-10 the total energy generated in the country was 99450 GWh of which the share of thermal electricity generation was 68228 GWh (68.61%), while that of hydel power and nuclear power plants was 28555 GWh (28.71%) and 2667 GWh (2.68%) respectively.[13] The increasing share of thermal electricity generation has increased the financial burden particularly in foreign exchange. The share of private sector has also increased as compared to the public sector.

## Installed Generation Capacity by Type (MW)

| | | 2005-06 | 2006-07 | 2007-08 | 2008-09 | 2009-10 |
|---|---|---|---|---|---|---|
| **THERMAL** | | | | | | |
| GENCOswith PEPCO | | 4,834 | 4,834 | 4,899 | 4,900 | 4,885 |
| KESC Own | | 1,756 | 1,756 | 1,756 | 1,846 | 1,946 |
| IPPs | Connected with PEPCO | 5,754 | 5,754 | 5,773 | 5,956 | 7,039 |
| | Connected with KESC | 262 | 262 | 262 | 262 | 262 |
| Rental | Connected with PEPCO | 0 | 150 | 286 | 286 | 122 |
| | Connected with KESC | 0 | 0 | 0 | 50 | 50 |
| Others (CPPs/SPPs) | Connected with KESC | 0 | 0 | 239 | 239 | 272 |
| **Sub-Total** | | **12,606** | **12,756** | **13,215** | **13,539** | **14,576** |
| Percentage share | | 64.44 | 64.78 | 65.32 | 65.86 | 67.50 |
| **HYDEL** | | | | | | |
| WAPDA Hydel | | 6,463 | 6,444 | 6,444 | 6,444 | 6,444 |
| IPPsHydel | | 30 | 30 | 111 | 111 | 111 |
| **Sub-Total** | | **6,493** | **6,474** | **6,555** | **6,555** | **6,555** |
| Percentage share | | 33.19 | 32.88 | 32.40 | 31.89 | 30.36 |
| **NUCLEAR** | | | | | | |
| CHASNUPP | | 325 | 325 | 325 | 325 | 325 |
| KANUPP | | 137 | 137 | 137 | 137 | 137 |
| **Sub-Total** | | **462** | **462** | **462** | **462** | **462** |
| Percentage share | | 2.36 | 2.35 | 2.28 | 2.25 | 2.14 |
| **Total Installed Generation Capacity of the Country** | | **19,561** | **19,692** | **20,232** | **20,556** | **21,593** |
| *Source: Electricity Marketing Data / KESC* | | | | | | |

**Source:** "State of Industry Report 2010," National Electric Power Regulatory Authority (NEPRA), Pakistan

**Installed Generation Capacity by Type/Share (MW)**




**Source:** "State of Industry Report 2010," National Electric Power Regulatory Authority (NEPRA), Pakistan

**Energy Generation by Sector and Source (GWh)**

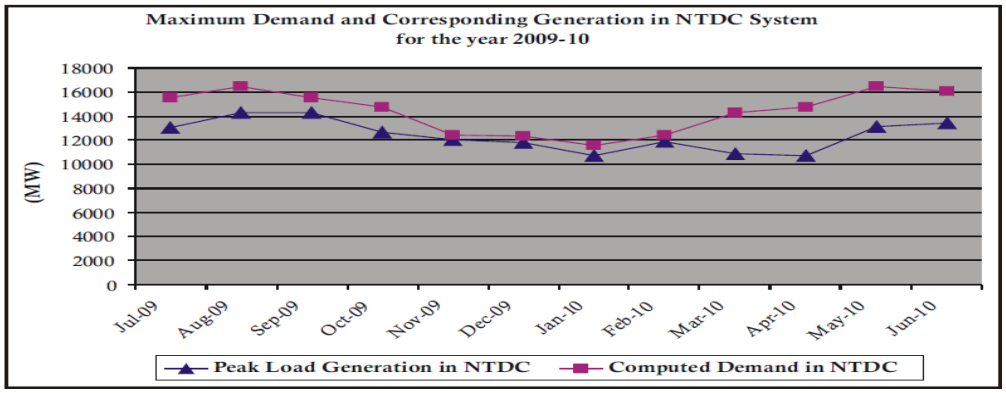
| Sector/Source of Generation | 2005-06 | 2006-07 | 2007-08 | 2008-09 | 2009-10 |
|---|---|---|---|---|---|
| **Public Sector** | **55557** | **55568** | **51876** | **48658** | **50453** |
| Hydel | 30751 | 31846 | 28536 | 27636 | 27960 |
| Thermal | 22519 | 21617 | 20508 | 19536 | 19826 |
| Nuclear | 2287 | 2105 | 2832 | 1486 | 2667 |
| **Private Sector** | **37335** | **42246** | **45575** | **46005** | **48997** |
| Hydel (AJKHEB) | 104 | 96 | 131 | 547 | 595 |
| Thermal* | 37231 | 42150 | 45444 | 45458 | 48402 |
| **Total** | **92892** | **97814** | **97451** | **94663** | **99450** |

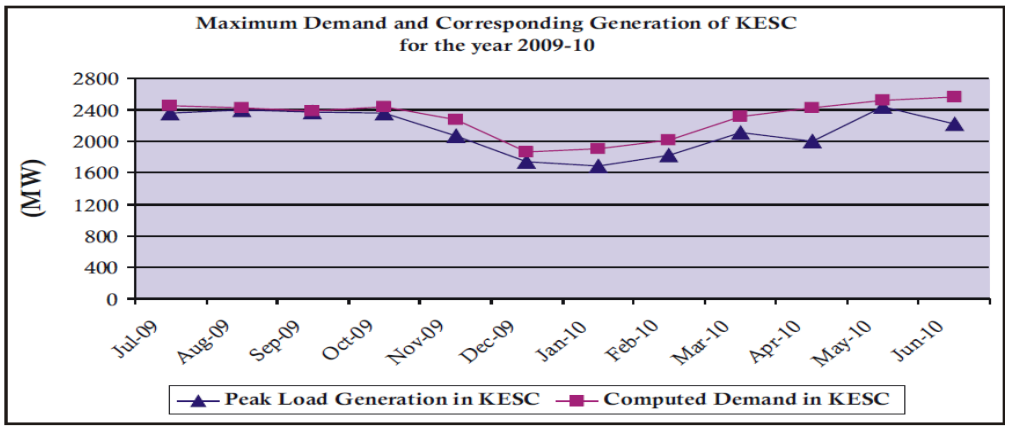
** including Import from Iran and KESC*

**Source:** "State of Industry Report 2010," National Electric Power Regulatory Authority (NEPRA), Pakistan

Given out by National Transmission and Dispatch Company (NTDC) and Karachi Electric Supply Company (KESC) system, following figures shows the demand supply gap in the electricity for 2009/10

**Maximum Demand and Generation in NTDC System and KESC 2009-10**




**Source:** "State of Industry Report 2010," National Electric Power Regulatory Authority (NEPRA), Pakistan

According to the Pakistan Economic Survey 2009-10, as a result of demand supply gap, the share of per capita availability of primary energy supply is decreasing in the country. It was decreased by -2.27% and in 2009-10E it further decreased to -3.09%.[14] According to the 2010 energy development index (EDI) Pakistan ranks at 38th position, which despite energy shortages is the highest in South Asia.[15]

## Primary Energy Supply and Per Capita Availability

Economic Survey 2009-10

**Table 13.1: Primary Energy Supply and Per Capita Availability**

| Year | Energy Supply | | Per Capita | |
|---|---|---|---|---|
| | Million TOE | Change (%) | Availability (TOE) | Change (%) |
| 1998-99 | 41.72 | | 0.31 | |
| 1999-00 | 43.19 | 3.51 | 0.32 | 1.28 |
| 2000-01 | 44.40 | 2.82 | 0.32 | 0.63 |
| 2001-02 | 45.07 | 1.50 | 0.32 | -1.25 |
| 2002-03 | 47.06 | 4.41 | 0.32 | 2.86 |
| 2003-04 | 50.85 | 8.06 | 0.34 | 5.25 |
| 2004-05 | 55.58 | 9.26 | 0.36 | 6.45 |
| 2005-06 | 58.06 | 4.18 | 0.37 | 2.48 |
| 2006-07 | 60.62 | 4.33 | 0.38 | 2.61 |
| 2007-08 | 62.92 | 3.78 | 0.39 | 2.86 |
| 2008-09 | 62.55 | -0.58 | 0.38 | -2.27 |
| Jul-Mar | | | | |
| 2008-09 | 47.1 | | 0.29 | |
| 2009-10 E | 46.8 | -0.64 | 0.28 | -3.09 |

*TOE- Tons of Oil Equivalent* *Source: Hydrocarbon Development Institute of Pakistan.*
E : estimated

**Source:** Economic Survey of Pakistan 2009-10

Even the pojected demand and supply of electricity consumption represensts a very dark furtre with regard to the growth and development of the country. According to NEPRA, the current year will face a electricity deficit of around 3777 MW (both NTDC system and KESC) and even the year 2014 would be faced with a total shortfall of aorund 4000 MW. However the situation in 2015 would be different with a surplus of around 3000 MW both in NTDC and KESC system.[16]

| PROJECTED SUPPLY AND DEMAND IN NTDC SYSTEM | | | | |
|---|---|---|---|---|
| Financial Year ending 30th June | Planned Generation Capability as per NTDC (MW) | NTDC Projected Demand Growth Rate (%) | NTDC Projected Demand during peak hours (MW) | Surplus / (Deficit) (MW) |
| 2011 | 17367 | 7.86 | 20873 | -3506 |
| 2012 | 18913 | 7.60 | 22459 | -3546 |
| 2013 | 21299 | 7.42 | 24126 | -2827 |
| 2014 | 21668 | 7.43 | 25918 | - 4250 |
| 2015 | 30510 | 7.70 | 28029 | 2481 |
| PROJECTED SUPPLY AND DEMAND IN KESC SYSTEM | | | | |
| Financial Year ending 30th June | Planned Generation Capability as per KESC (MW) | KESC Projected Demand Growth Rate (%) | KESC Projected Demand during peak hours (MW) | Surplus / (Deficit) (MW) |
| 2011 | 2419 | 5% | 2690 | -271 |
| 2012 | 2833 | 5% | 2825 | 8 |
| 2013 | 2913 | 5% | 2966 | -53 |
| 2014 | 3413 | 5% | 3114 | 299 |
| 2015 | 3713 | 5% | 3270 | 443 |

*Source: NTDC and KESC*

**Source:** "State of Industry Report 2010," National Electric Power Regulatory Authority (NEPRA), Pakistan.

## Pakistan Nuclear Energy Profile

Pakistan's interest in nuclear energy dates back to 1956 when Pakistan Atomic Energy Commission (PAEC) was established to promote peaceful use of nuclear energy in the country.[17] Currently, there are two nuclear plants operating under the IAEA safeguards, one nuclear reactor is under construction and several reactors are proposed to be constructed in the country.

1. The **Karachi Nuclear Power Plant** (KANUPP) is one of the oldest single unit Canada Deuterium Uranium (CANDU) Pressurised Heavy Water Reactor (PHWR) with a gross capacity of 137 MW, and is owned and operated by PAEC. KANUUP started it operation in 1972, and after the completion of its 30 years design life,[18] the Pakistan Nuclear Regulatory Authority (PNRA) extended the operational life of this plant at reduced capacity.[19] Over the years the safety records of KANUPP have been extremely satisfactory as average personal radiation exposures, and release of radioactive material are well within the prescribed international limits and standards.[20]

**Karachi Nuclear Power Plant (KANUPP)**

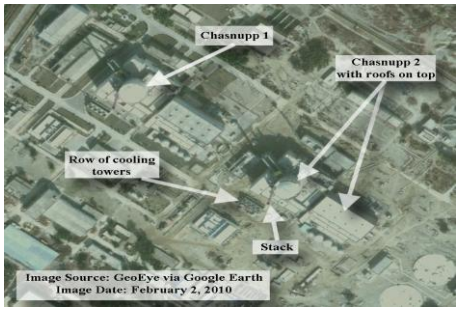
**Source:** CANDU *http://www.candu.org/paec.html*

**Source:** Google Earth, Image @ digital Globe, Imagery date, February 1, 2005-February 7, 2008

2. **Chashma Nuclear Power Plant-1** (CHASNUPP-1) is a Pressurized Water Reactor (PWR) with a gross capacity of 325 MW (net output of 300 MW) and with a life span of 40 years.[21] The construction of CHASNUPP-1 started in 1992 with the help of China National Nuclear Cooperation (CNNC). The CHASNUPP is owned and operated by PAEC, Safety and security was the most important consideration during its design and construction and it became operational in September 2000.[22] The PNRA regulates the plant by ensuring quality and safety of its operation.

**CHASNUPP-1**

**Source:** CNNC China Zhongyuan Engineering Corp.




**Source:** Google Earth, Image @ Global Eye, Imagery date, February 2, 2010.

3. **Chashma Nuclear Power Plant-2** (CHASNUPP-2); In December 2005, Pakistan-China collaboration undertook the construction of PWR CHASNUPP-2 with a net capacity of 300MW. It is reported to cost PKR 51.46 billion (US $ 860 million, with $350 million of this financed by China). A safeguard agreement with the IAEA was signed in 2006 and grid connection is expected in 2011.[23]

**CHASNUPP-2**
**Containment Dome Placement, December 18, 2007**

**Source:** CNNC China Zhongyuan Engineering Corp.

Although the total share of nuclear energy is very small, but it proves that Pakistan has over 38 years of safe operational experience in the field of nuclear power generation. The total installed capacity of nuclear power plants, as on June 30, 2010, in the country was 462 MW as against the total installed electricity generation capacity of 21593 MW, which constitutes a share of nuclear power plant to the total installed generation capacity as 2.14%.[24] The electricity generated through nuclear power plant

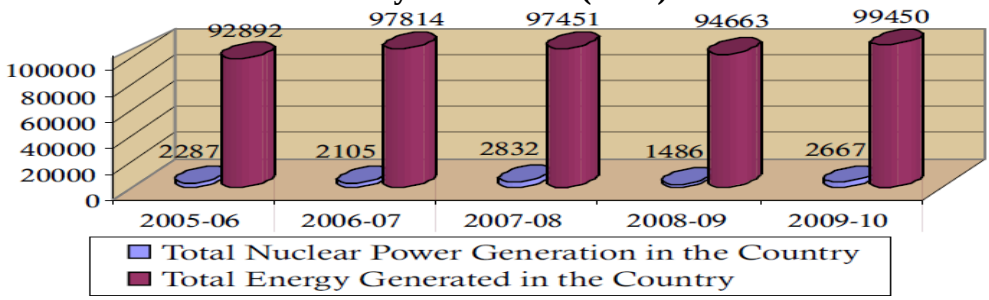
was increased by 79.48% during 2009-10. The share of electricity generated through nuclear power plants in the country, during 2009-10, was recorded as 2667 GWh (2.68%) as against 1486 GWh (1.57%) in the preceding year.[25]

**Pakistan Nuclear Energy Statistics**

| | 2005-06 | 2006-07 | 2007-08 | 2008-09 | 2009-10 |
|---|---|---|---|---|---|
| **Installed Capacity (MW)** | | | | | |
| CHASNUPP (connected with PEPCO system) | 325 | 325 | 325 | 325 | 325 |
| KANUPP (connected with KESC system) | 137 | 137 | 137 | 137 | 137 |
| **Total** | **462** | **462** | **462** | **462** | **462** |
| % share to the total installed Capacity | 2.36 | 2.35 | 2.28 | 2.25 | 2.14 |
| **Total Installed Capacity of the Country** | **19561** | **19692** | **20232** | **20556** | **21593** |
| **Energy Generated (GWh)** | | | | | |
| CHASNUPP (connected with PEPCO system) | 2170 | 1944 | 2455 | 1058 | 2094 |
| KANUPP (connected with KESC system) | 117 | 161 | 377 | 428 | 573 |
| **Total** | **2287** | **2105** | **2832** | **1486** | **2667** |
| % share to total electricity generation | 2.46 | 2.15 | 2.91 | 1.57 | 2.68 |
| **Total Energy Generated in the Country** | **92892** | **97814** | **97451** | **94663** | **99450** |

**Source:** "State of Industry Report 2010," National Electric Power Regulatory Authority (NEPRA), Pakistan

**Nuclear Power and Electricity Generation (Gwh)**




**Source:** "State of Industry Report 2010," National Electric Power Regulatory Authority (NEPRA), Pakistan

To meet the future energy needs in 2007 Pakistan government under its "Pakistan in the 21st Century: Vision 2030" outlined an Energy Security Plan and set a target of 162,000 MW power generation by 2030. This includes a target of 8800 MW through nuclear power and PAEC has been assigned this task.[26] The Government of Pakistan has been requesting nuclear capable courtiers to cooperate with Pakistan to meet its energy demands. Especially after the Indo-US nuclear deal, Pakistan accelerated its efforts to secure agreements on nuclear energy cooperation. However, the only success story is Pak-China nuclear cooperation. On June 8, 2010, Pakistan and China signed a contract to build two more nuclear reactors Chashma-3, and Chashma-4 with a total capacity of 650MW, which will

become operational by 2017-18.[27] Strong objections were raised by Nuclear Supplier Group (NSG), the US and other western countries over this agreement. In November 2010 PAEC is reported to have signed a construction agreement with CNNC for a fifth nuclear power reactor which may revive the prospects of a 1000 MW class nuclear reactor provided that China has an exportable model by 2013 as planned. To be in pace with mandate, the PAEC Chairman, Dr. Ansar Parvez, stated Pakistan will built 10 nuclear reactors by 2030 to resolve the energy crisis in Pakistan.[28]

**Since Pakistan acquired nuclear weapons to deter India, therefore owing to its security concerns, it could not become a part of certain discriminatory measures of the international non-proliferation regime.**

**Challenges and Prospects**

Nuclear power is directly linked to human security in two ways. On one hand it is an efficient and clean source of energy while on the other, risks associated with its diversion for weapons, safety and security, transportation, storage and waste management are perceived cause of concern for the mankind and global environment. The current milieu presents the following challenges and prospects for Pakistan.

***Nuclear Proliferation:*** Since the tragic events of Hiroshima and Nagasaki the international community has created international oversight agencies, concluded treaties and protocols, established Nuclear Weapons Free Zones (NWFZs), export control regimes and developed a renewed interest in global disarmament under "Global Zero" concept. Overall these efforts are focused to stop the spread of nuclear weapons technology, nuclear arms control & disarmament and to promote peaceful use of nuclear power. Despite these efforts nuclear proliferation concerns are still there which are blocking the way of peaceful use of nuclear power due to its dual-use nature.

Since Pakistan acquired nuclear weapons to deter India, therefore owing to its security concerns, it could not become a part of certain discriminatory measures of the international non-proliferation regime. As far as safety and security of Pakistan's civilian nuclear programme is concerned, it is largely regulated under the IAEA safeguards and mechanisms. While on the other hand Pakistan nuclear weapons

programme is operated indigenously, and it is out of the domain of the IAEA safeguards systems. As a result, the past nuclear proliferation activities by Pakistani scientists, during the 80s and 90s, through nuclear black market, were due to the flaws in the previous oversight system. However, in 2000, with the establishment of the National Command Authority (NCA) and Strategic Plan Division (SPD), the management of nuclear weapons assets became an "institutionalized capability," with a reassurance that everything is under strict control.[29]

In 2004 Pakistan consolidated most of the previous regulation in a single legislation, "Export Control on Goods, Technologies, Material, and Equipment related to Nuclear and Biological Weapons and their Delivery Means, 2004."[30] The 2004 Export Control Act was established to strengthen controls on the export, re-export, trans-shipment and transit of goods and technologies, material and equipment related to nuclear and biological weapons and missiles capable of delivering such weapons. The Act maintains a control list which is consistent with the Nuclear Suppliers Group, the Missile Technology Control Regime, and the Australia Group. Exporters are required to maintain detailed inventories and records and to notify the relevant authority if they are aware of or in suspicion that goods or technology are intended to be used for weaponisation. Offenders face tough penalties, which include imprisonment of up to 14 years, a fine of up to five million rupees, and the seizure of all assets and property.[31]

The Act also led to the creation of a Strategic Export Control Division (SECDIV) in the Ministry of Foreign Affairs to formulate and enforce rules and regulations for the implementation of export controls in accordance with the Export Control Act 2004 and also act as a licensing body. Over these years Pakistan strengthened its nuclear oversight system according to the international standards and any future possibility of nuclear proliferation is very remote. Pakistan has also offered to provide nuclear fuel cycle services under the IAEA safeguards to ensure the international community that Pakistan is a responsible nuclear state.

***Safety and Security:*** Despite the incidents of Chernobyl and Three Mile Island, the safety and security system of nuclear power plants around the world have been working effectively. It is also clear that accidents in nuclear power plants have caused less causalities as compared to other industry related accidents. In order to prevent accidents, the international community has renewed its focus on the need for strengthening and streamlining safety mechanisms. However, cases of nuclear theft, smuggling, and information leakage are on the rise even in the advanced

nuclear weapons states, because of various rogue elements and their vested interests.

After the events of 9/11, western nations, particularly their think tanks and media, started to propagate against the safety and security of Pakistan's nuclear assets. Some of these concerns include seizure of nuclear installations by militant extremists, secret cooperation with non-state actors and penetration of rogue elements in the organization etc. Pakistani officials have rejected all these concerns and have taken many initiatives to enhance safety and security of Pakistan nuclear assets. This was later acknowledged by the international community including US; even India showed confidence on safety and security of Pakistan nuclear assets.[32]

Overall, Pakistan has a 38 year record of safe operational experience of its nuclear reactors. Pakistan is a member of the IAEA, WANO, COG and WNA through which it benefits from their programmes for enhancement of safety and reliability of nuclear power plants.[33] Pakistan is a party to the following conventions:

- Convention on Early Notification of a Nuclear Accident (EIF, 1989)
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (EIF, 1989)
- Convention on nuclear safety (EIF, 1997)
- Convention on the Physical Protection of Nuclear Materials (EIF, 2000).[34]

Since 1956, the PAEC is responsible to promote peaceful application of nuclear energy in the country. The PNRA, which was established in 2001, regulates all aspects of civilian nuclear energy that includes;

- Licenses for import exports
- Necessary legislations and regulations
- Physical protection of nuclear installation and nuclear material.

In 2002 the PNRA streamlined nuclear disaster management by announcing a host of new measures for protecting "the plant and society from hazards that could be man-made or natural."[35] The PNRA has also developed a five-year National Security Action Plan (NSAP) to enhance safety and security of all nuclear and related facilities. Under the NSAP the PNRA has taken the following initiatives;

- Established the safety and security training centers
- National Security Emergency Coordination Centre,
- launched campaigns to locate and secure orphan sources
- Provided detection equipment at strategic points to help prevent illicit nuclear smuggling.[36]

**Safe and secure Transportation and proper waste management are very important issues, since any mismanagement could prove hazardous for mankind and the environment.**

Safe and secure Transportation and proper waste management are very important issues, since any mismanagement could prove hazardous for mankind and the environment. In Pakistan Transport and Waste Safety Directorate (WSD) at PNRA is responsible for matters related to radioactive waste management and safe transport of radioactive materials.[37] According to the PNRA 2009 report, the radiation release to the environment and radiation doses to workers at KANUPP and CHASNUPP-1 plant remain well below regulatory limits.[38] The IAEA, in its different inspection missions, has observed that Pakistan has a well developed regulatory authority for regulating radiation safety.[39]

***Technical and Economic constraints;***

Without technical and economic assistance Pakistan cannot achieve the desired goal of 8800 MW through nuclear energy by 2030. In an article published in *The News International* on January 24, 2011 DR. A. Q. Khan, the father of Pakistan's nuclear programme, rightly pointed out that to meet 8800 MW target Pakistan would require either 29 nuclar reactors of 300 MW each or ten nuclear reactors of 900 Mw each.[40] This seems impossible given the current economic situation of the country because a 300 MW costs about $1 billion and requires eight to ten years for commissioning. A 900-MW reactor would naturally cost proportionately more and would take the same time.[41] Dr. Khan also referred to an earlier statement of the PAEC Chairman, Munir Ahmad Khan, that the PAEC would commission one reactor every year from 1980 onwards until the year 2000, thus producing 20 reactors in total.[42] However, due to lack of technical and financial constraints and a regime of sanctions in the 80s and 90s against Pakistan actually hurt this dream. Pakistan only managed to construct two power plants since then. The current situation is no different, as we still face discrimination of the

international community. The indo-US nuclear deal is a classic example of these double standards. And because of this attitude Pakistan faces economic and technological constraints. The only country which is providing Pakistan with nuclear power reactors is China. It is clear that without the help of international community and support of friendly countries Pakistan cannot fulfill this dream.

**Recommendations**

Following are some recommendations for a secure and clean future of energy security through peaceful use of nuclear technology:

- Renewed interest in nuclear technology will continue to pose safety and security challenges. Active international cooperation is required in this regard.
- Although for the last six decades, the international community is working to remove negative elements related to the dual use nature of nuclear energy, but again it is the responsibility of the international community to adopt non-discriminatory measures and to enhance their efforts to take concrete measures to address the genuine proliferation concerns.
- Major nuclear weapons states should fulfill their obligation towards nuclear disarmament, and they should provide the nuclear know-how to other states for peaceful purposes without adopting a discriminatory approach.
- The role of the IAEA should be enhanced in order to make it an effective platform for sharing of nuclear expertise.
- More economic and technological cooperation is required from developed countries towards the developing ones. They should also fund long-term nuclear related initiatives for developing countries.
- More resources should be allocated to design new and advanced nuclear reactor and mini reactor designs, and it should be provided to the smaller and developing states on easy long term loans.
- The concept like the creation of international fuel bank for secure and continuous supply of reactor fuel should be supported across the board. There is also a need to create regional nuclear fuel banks under the supervision of the IAEA and developing countries should be provided nuclear fuel on easy and cheap terms.

## Conclusion

These facts and arguments clearly establish nuclear power is one of clean and efficient sources of energy; and for a developing country like Pakistan, the decision to generate electricity through nuclear power will continue to play a dominant role. However, without active international cooperation in the fields of non-proliferation, safety and security and technical and economic assistance nuclear power cannot play a dominating role in international energy outlook and in a state's national energy policy.

## Notes & References

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1 The recent phenomenon of "Climate Change" or "Global Warming" is one of these main threats, which has reached a critical stage and directly affecting mankind. It is widely believed that the process of climate change or global warming is a man-made process. The 1992, United Nations Frame Work Convention on Climate Change (UNFCC) directly and indirectly attributes change in climate to human activities. The UNFCC clearly establishes that human activities are substantially increasing atmospheric concentrations of Greenhouse Gases (GHG). This concentration of GHG is mainly caused by the release of Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O) and other related pollutants. The release of such substance is thinking the cloud of GHG, which under the Greenhouse effect warming the Earth's temperature or causing global warming. As a result of this climate change and global warming, the world has witnessed recent years as the hottest years of the recorded history, reduced snow covers in the both hemispheres, rise in sea level and sinking of low lying costal areas, change in weather patterns, long droughts, melting of glaciers, heat waves, floods, increased cyclones, and food insecurity.

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9 "International Status and Prospects of Nuclear Power," Report by the International Atomic Energy Agency (IAEA), GOV/INF/2010/12-GC(54)/INF/5, September 2, 2010, www.iaea.org.

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18 "KANUPP Fact Sheet," *http://www.candu.org/paec.html*

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30 For further details see, "Export Control on Goods, Technologies, Material, and Equipment related to Nuclear and Biological Weapons and their Delivery Means, 2004."

31 Ibid.

32 For a complete detail of relevant statements see, Malik Qasim Mustafa, "Are Pakistan's Nuclear Weapons Safe?," Strategic Studies, XXX: 1& 2, Spring & Summer, 2010.

33 "Pakistan," Country Nuclear Power Profiles: 2009, (CNPP), IAEA, 2009, *www-pub.iaea.org/MTCD/publications/PDF/cnpp2009/countryprofiles/Pakistan/ Pakistan2006.htm*

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