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EDUCATION IN NUCLEAR SCIENCES AS A BASIS OF EXPANDING NUCLEAR ENERGY PROGRAMMES IN TURKEY

Abstract: In the coming decades, it is evident that the use of nuclear energy as a viable energy option will play a vital role for the electricity demand of Turkey. At present, nearly 90% of the energy consumed in Turkey is of fossil origin. However, Turkey is poor in fossil resources with the exception of coal and lignite reserves. Furthermore, domestic oil and natural gas productions are far from meeting the total primary energy consumption of 126 million tons oil of energy equivalent (Mtoe), as of 2010 year. In order to meet Turkey's growing energy needs, the present energy supply's plans should be revised by the energy policy-makers. The execution of the Country's energy supply programme should be based on the more comprehensive evaluations. In this context, for acquiring the proper energy technologies, the allocation of the financial and human resources to the education, research and development activities should have a high priority among the other issues.

On the other hand, Turkey has already planned to build Nuclear Power Plants (NPP) with four reactor units (Russian VVER–1200 PWR type design) in Akkuyu reactor site at Mediterranean coast. For the legitimate basis, the nuclear power project agreement was signed between Turkey and Russia. While commencing the NPP programme as a non-nuclear Country, it is clear that Turkey has to afford to improve its current nuclear infrastructure. It should be established bilateral and/or multilateral cooperation agreements and joint initiatives with the help of the well-organized programs. Since there is a serious lack of competency and the educated workforce capacity in the nuclear field, it is an important point that how the interest of the next generations as young scientists and engineers can be attracted to graduate and post-graduate programs in nuclear science and technology education given by national Higher Education Nuclear Institutes. It is obvious that it should be promoted and developed the collaborations in nuclear science for the education and training of students, researchers and professionals.

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1. INTRODUCION

Turkey's economy needs ever-increasing amounts of energy to sustain economic growth, raise living standards, and reduce poverty. But today's trends in energy supply are not seen to be sustainable. As Turkey's population grows fast and the economy becomes more industrialized, non-renewable energy sources will become scarcer and more costly. Hence, it is a fact that the energy issue is one of the most important priorities for the Country's development. The major development indicators given in Table 1 show that the present Turkey's economy is still the 17th largest economy of the world. It has a gross domestic product (GDP) of $791 billion, a population of 74.8 million people and a gross national income (GNI) per capita of $10,575 in 2010 year (SPO, 2010).

Table 1. The major development indicators of Turkey's economy in 2010

INDICATOR	AMOUNT
Gross Domestic Product (GDP)	$791 billion
Population	74.8 million
Gross national income (GNI) per capita	$10.575

2. CURRENT STATUS OF ENERGY SUPPLY

Today, oil and natural gas drive the world economy. Asia, in particular India and China is still the engine driving price direction and volatility. Europe has the concerns going forward with continuing low price of gas. The main reason for this is that the internal combustion engines are based on fossil fuels such as gas and petroleum.

In this context, Turkey's energy resources are very limited, especially poor in oil and natural gas. In 2009, energy production of Turkey is only 27.8 Mtoe[1], however, its primary energy consumption has been reported as 126 Mtoe (SPO, 2010). Therefore its energy dependency to the imports is very high. Further, the energy consumption is estimated to increase 222 Mtoe by 2020 year due to present economic expansion, urbanization and population growth in Turkey. However, the main difficulty is that Turkey is heavily dependent on fossil fuels to meet its energy requirements. Energy equivalent of fossil fuels comprise a significant majority, approx. 88–90% of the Country's total primary energy consumption in which the use of oil, natural gas, and coal are being predominant energy sources. Turkey's continual growth in energy import saw 15.1 mtoe of thermal imported in 2010, and imports are predicted to rise by 3 mtoe in 2011.

[1] It refers to forms of primary energy–petroleum (crude oil, natural gas liquids, and oil from nonconventional sources), natural gas, solid fuels (coal, lignite, and other derived fuels), and combustible renewables and waste-and primary electricity, all converted into oil equivalents.

But where does the future risk lie in securing freight for future cargos, especially for coal and gas imports. How can Black Sea ports develop? What is the future Russian, Ukrainian and South African coals, and also Russian and Iran's gas. Another important question is that how will the supply affected by the dynamics in future freight rates.

In view of Turkey, the growth in power demand is mainly due to domestic and industrial use. Second, the regional growth in steel demand drive to rise the import price of fossil fuels, especially hard coal, and natural gas.

It is the fact that petroleum based-fuels are obtained from the limited reserves in Turkey. But, the finite reserves are highly concentrated in certain regions of the world. Middle East Countries and Russia Federation hold 70% of the world's decreasing reserves of oil and gas. As mentioned above, the limited production capacity of domestic energy resources relative to the growing energy demand have resulted in a high dependency on energy imports in Turkey, primarily petroleum and natural gas. It is also interesting that natural gas is the fastest growing source in Turkey's energy mix consumption. Natural gas comprises the largest share of total primary energy consumption in Turkey by about 32% of total. On the other hand, the most promising and significant energy resources in Turkey are coal (mainly in the form of low quality lignite), hydro and geothermal. The share of domestic energy in terms of world reserves is 0.6% for coal, 0.8% for geothermal and 1% hydro power (Satman, 2011).

3. ELECTRICITY PRODUCTION IN TURKEY

A large proportion of energy consumption in Turkey is electricity energy, which is a major driven factor of the increased energy demand in industry, household and trading sectors.

In 2009, Turkey produced 194 billion kWh/y from 44.5 GWe of plant (EÜAS, 2009). In short term, it is expected to increase 546 billion kWh/y in 2020. This requires the installed plant capacity of 44.5 GWe to increase 96 GWe by 2020. It is obvious that electricity production in Turkey by fuel is dependent mainly on the imported natural gas. Although Turkey's natural gas production is only a very negligible amount, about 49% of electricity was produced from natural gas (two thirds of this came from Russia, most of the rest from Iran), 28% from coal (shared with 20% lignite and 8% hard coal), 19% from hydro, others 4% (shared with 3.5% petroleum and 0.5% renewable energy sources) in 2007. Demand growth is 8% pa. per capita consumption has risen from 800 kWh/y in 1990 to 2000 kWh/y in 2007 (World Bank, 2008). Since per capita consumption of electricity is mostly used as an additional indicator of the level of a country's economic development, Turkey's per capita gross consumption in 2009 is still very low at 2430 kWh when compared to that of the EU average of 6600 kWh (TEDAS, 2009). According to the projections, per capita electricity consumption in Turkey will increase to 5700 kWh by 2020.

4. NUCLEAR POWER IN TURKEY

4.1 History of Nuclear Power Projects in Turkey

Today, Turkey is a non-nuclear country, however, nuclear power proposals are discussed in Turkey's agenda in time. Turkey has had plans for establishing nuclear power generation since 1970. However NPP project plans were abandoned due to economic circumstances.

In August 2006, the government said it planned to have three NPPs total 4500 MWe operating by 2012–15. Discussions had been under way with AECL (Canada) regarding two 750 MWe CANDU units as an initial investment. These and the PWR type reactors were apparently preferred. The first units of some 5000 MWe total are to be built at Akkuyu, since this reactor site was already licensed. Early in 2006 the province of the port city of Sinop on the Black Sea coast was also chosen to host a commercial NPP. This has the advantage of cooling water temperatures about 5 °C below those at Akkuyu, allowing about 1% greater power output from any thermal unit. But the site licensing is proceeding for Sinop city

In 2007 a new bill concerning construction and operation of NPPs and sale of their electricity was passed by parliament and subsequently approved by the President. The bill provided for Turkish Atomic Energy Authority (TAEK) to set the criteria for building and operating the plants. The Turkish Electricity Trade & Contract Corporation (TETAS) would then buy all the power under 15-year contracts. The bill also provided for public institutions to build the plants if other offers are not satisfactory. It also addressed waste management and decommissioning, providing for a National Radioactive Waste Account (URAH) and a Decommissioning Account (ICH) which generators would pay into progressively. Finally, this tender was also cancelled.

In May 2008 a civil nuclear cooperation agreement with the USA entered into force, and in June 2010 a nuclear cooperation agreement with South Korea was signed.

4.2 Planned and Proposed Nuclear Power Reactors

Recent developments have seen Russia take a leading role in offering to finance and build 4800 MWe of nuclear capacity. South Korea is also offering nuclear plants. In May 2010, Russian and Turkish presidents signed an intergovernmental agreement for Rosatom to build, own and operate the Akkuyu plant of four 1200 MWe AES–2006 units as a **US$ 20 billion** project. This will be its first foreign plant on that Builder-Owner-Operator (BOO) basis. Rosatom, through Atomstroyexport and Inter RAO UES, will finance the project and start off with 100% equity in the Turkish project company set up to build, own and operate the plant. Longer-term they intend to retain at least 51% of the company. The Turkish firm Park Teknik and Turkish Electricity Generation Corporation (EUAS) are expected to take up significant shares. Meanwhile, EUAS will provide the site. The agreement for 4800 MWe NPPs at Akkuyu was ratified by both Turkish and Russian parliament as of No-

vember of 2010. The project company was registered in December 2010, with Atomstroyexport and Inter RAO UES each having 33.33%, Rosenergoatom having 31.34%, and Atomenergoremont and Atomtekhenergo with 1% each.

TETAS will buy a fixed proportion of the power at a fixed price of 12.35 US $ cents/kWh for 15 years, or to 2030. The proportion will be 70% of the output of the first two units and 30% of that from reactor units 3 and 4 over 15 years from commercial operation of each. The remainder of the power will be sold by the project company on the open market. After 15 years, when the plant is expected to be paid off, the project company will pay 20% of the profits to the Turkish government.

The project company is to apply for all licences within twelve months, and the first reactor is to be on line within seven years of receiving these, with the others to follow at one-year intervals. Rosatom announced that construction by Atomstroyexport was expected to start in 2013 and the first unit was planned to be operational in 2018, the others 2019–21.

The Rosatom agreement for Akkuyu also provides for setting up a fuel fabrication plant in Turkey. Turkey has had a safeguards agreement in force with the IAEA since 1981 and the Additional Protocol to its safeguards agreement has been in force since 2001. There is no problem in view of non-proliferation.

Since February 2008 preparatory work has been under way at Sinop on the Black Sea to build a second nuclear plant there, along with a EUR 1.7 billion nuclear technology centre. A 5600 MWe nuclear plant there is expected to cost about $20 billion. In March 2010 an agreement was signed between Korea Electric Power Corporation (KEPCO) and Turkish EUAS to prepare a bid to build the plant at Sinop, with four APR–1400 reactors starting operation from 2019.

Turkey has also made some negotiations with Japan to build the 5600 MWe plant, and signed an agreement to prepare a bid for it, with a more definitive agreement expected in March 2011. Toshiba and Tepco are reported to be involved with the proposal, with four 1350 MWe ABWR units. Turkish Energy Minister has recently explained that the negotiations between parties were postponed after Fukishima Daichii Nuclear Accident.

A French consortium of Areva and GdF Suez has also indicated an intention to bid for the project, as has EdF. If any bid is accepted, an intergovernmental agreement would follow and EUAS would take a 25% stake in the nuclear plant (WWN, 2010).

5. POST-GRADUATE PROGRAMS IN NUCLEAR SCIENCE EDUCATION

Post-graduate education is a matter of social concern in general, and within the nuclear field in particular. In this way, it is possible that gaining the competence within nuclear field is consistent with International and EU standards to produce the educated workforce that is able to meet the future need of nuclear power programme within framework of economic and social needs of the Countries.

While commencing the NPP programme in Turkey, the simple question is that how the education programs in nuclear sciences and technology should be ar-

ranged and further improved. For example, even if the nuclear technology transfer agreements are to be made between Turkey and NPPs vendors, it seems that there are still question marks on knowing and absorbing fully nuclear technology because of insufficient number of the well-educated workforce and infrastructure. In Turkey, there are two nuclear research and training Centres (one is ÇNAEM in Istanbul and the other is SANAEM in Ankara), which have governmental organisation statutes under TAEK that determines nuclear legislation, and directs the decrees and regulations related to radiation and nuclear safety. With their limited personnel capacity and infrastructure, however, these Centres are also trying to accomplish almost all radiation issues and nuclear research activities. Thus TAEK is also managing radiation applications and licences given in medicine and industry, nuclear material safety and security, illicit trafficking of nuclear materials, environmental, etc at the same time. On the other hand, there are two Higher Education Nuclear Institutes which are actively in MSc and PhD programs in nuclear sciences, servicing to approximately 80–100 students in each year in total. One is the Institute of Nuclear Sciences of Ankara University in Ankara, and the other is the Institute of Nuclear Sciences of Ege University in İzmir. Additionally, there is only one faculty's education program, which is given to the limited number of BSc students, say 20–30 per year by Nuclear Engineering Department of Hacettepe University in Ankara. It is worth noting that most of the higher-graded nuclear engineering scholars generally prefer to go abroad for the post-graduate education. After completing their post-graduate education, they usually work in abroad and hardly ever return to Turkey.

It is a fact that, since there is a serious lack of competency and the well-educated workforce capacity in the nuclear field, it is an important point that how the interest of the next generations (as young scientists and engineers) can be attracted to the graduate and post-graduate programs in nuclear science and technology education given by national Nuclear Institutes.

6. CONCLUSIONS

The amount of domestic energy production in Turkey is very low, i. e, only about 27% of the Country's primary energy consumption in 2009. Additionally Turkey is endowed with oil and natural gas reserves. Moreover, a significant proportion, approximately 88–90% of the Country's total primary energy consumption is dependent on oil and gas. In current situation, it is clearly seen that the gap between the fossil energy supply and total energy demand of Turkey is enormously large. Therefore it is inevitably that use of nuclear energy option has a vital importance for supplying of Turkey's electricity demand in coming decades, For this requirement, the energy policies are continuously developed by the energy strategists and energy decision makers in the Turkish Governmental organizations. However, it is believed that Turkey's efforts and policies should go beyond the present ones to meet the Country's fast growing energy needs. This requires, of course, the implementation of the complex strategies and governmental decisions. This pressure

comes from the decreasing stocks of domestic fossil fuels, with increasing reliance upon politically volatile nations for the provision of oil gas and from the increasing prices of domestic and imported fuels. Finally, the pressures are thus resulted in emerging new concern in taking of advantage of future nuclear industries. Therefore, the need for nuclear competence is greater now than earlier anticipated.

In past years, it is a fact that the interests of Universities to the nuclear science and technology education have been quite limited in Turkey. In general, this can be attributed the decreased student interest, decreased course numbers, aging faculty members and aging and/or insufficient facilities. From practical point of view, the key question is that how the education programs in nuclear sciences and technology should be arranged to meet the necessary educated workforce having nuclear knowledge and expertise.

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