EMERGING **NUCLEAR ENERGY** COUNTRIES

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NUKLEAR MALAYSIA

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EMERGING NUCLEAR ENERGY COUNTRIES

Over thirty countries are actively considering embarking upon nuclear power programs.

These range from sophisticated economies to developing nations.

Nuclear power is under serious consideration in over thirty countries which do not currently have it (in a few, not necessarily at government level).

In Europe: Italy, Albania, Portugal, Norway, Poland, Belarus, Estonia, Latvia, Ireland, Turkey.

In the Middle East and North Africa: Iran, Gulf states, Yemen, Israel, Syria, Jordan, Egypt, Tunisia, Libya, Algeria, Morocco.

In central and southern Africa: Nigeria, Ghana, Namibia.

In South America: Chile, Venezuela.

In central and southern Asia: Azerbaijan, Georgia, Kazakhstan, Mongolia, Bangladesh.

In SE Asia: Indonesia, Philippines, Vietnam, Thailand, Australia, New Zealand.

Albania

In 2007 the government proposed construction of a nuclear power plant for both domestic and export supply to Balkans and Italy. A proposed site is at Durres. Italian utility ENEL is looking into the feasibility of a nuclear plant.

Algeria

Algeria produced 34 billion kWh of electricity in 2005 from natural gas and is a major gas exporter.

In January 2007 Russia signed an agreement to investigate the establishment of nuclear power there. The government has also made positive statements on the matter, but referring to a 20-year time frame. A further nuclear energy cooperation agreement, with the USA, was to be signed in June 2007 and one with France was signed in December 2007, coupled with strong commercial interest from Areva. An accord with China on developing peaceful nuclear power was signed in March 2008.

The country has operated two research reactors since 1995, at Draria and Ain Ouessara. One was built by INVAP of Argentina, the other by China.

Australia

Australia produced 255 billion kWh from 46 GWe of capacity in 2006, with 23 billion kWh/yr being embedded in aluminium exports. Final consumption was 187 billion kWh, hence per capita consumption (net of Al exports) is 9100 kWh/yr. Low-cost power is a competitive advantage of the country. 80% of electricity comes from coal-fired plant, 12% from gas and 7% from hydro. This gives it a high output of CO_2, which is the main reason that discussion has started on possible nuclear generation in the future. Australia joined the Global Nuclear Energy Partnership (GNEP) in September 2007.

Australia has operated a research reactor since 1956 and has now commissioned its 20 MWt replacement.

About 1970 the Australian government sought tenders for building a nuclear power reactor at Jervis Bay, NSW. Designs from UK, USA, Germany and Canada were short listed, but a change in leadership led to the project being cancelled in 1972. However, until 1983 there were various plans and proposals for building an enrichment plant.

At the end of 2006 the report of the Prime Minster's expert taskforce considering nuclear power was released. It said nuclear power would be 20-50% more expensive than coal-fired power and (with renewables) it would only be competitive if "low to moderate" costs are imposed on carbon emissions (A$ 15-40 - US$ 12-30 - per tonne CO2). "Nuclear power is the least-cost low-emission technology that can provide base-load power" and has low life cycle impacts environmentally. The first nuclear plants could be running in 15 years, and looking beyond that, 25 reactors at coastal sites might be supplying one third of Australia's (doubled) electricity demand by 2050. Certainly "the challenge to contain and reduce greenhouse gas emissions would be considerably eased by investment in nuclear plants." "Emission reductions from nuclear power could reach 8 to 18% of national emissions in 2050".

Early in 2007 a private equity company, Australian Nuclear Energy, said it was examining the prospects for a nuclear power plant.

Azerbaijan

In 2005 the country produced 21 billion kWh of electricity. The government is planning construction of a 1000-1500 MWe nuclear power reactor, possibly starting 2010 in the Avai region in the south of the country, supporting proposed industrialisation there.

In June 2008, the International Atomic Energy Agency (IAEA) issued a preliminary agreement to support a 10-15 megawatt research reactor outside of Baku. The $119-million reactor will be operated by the National Academy of Sciences Institute for Radiation Problems, which specializes in nuclear energy research. Construction is expected to begin in 2012.

Bangladesh

Bangladesh produced 22.6 billion kWh in 2005 from some 4 GWe of plant, giving per capita consumption of 114 kWh/yr. 89% of electricity comes from natural gas. Electricity demand is now rising rapidly.

Building a nuclear power plant in the west of the country was proposed in 1961. Since then a number of feasibility reports have affirmed the technical and economic feasibility. The Rooppur site in Pabna district was selected in 1963 and land was acquired. The government gave formal approval for a succession of plant proposals, then after independence a 125 MWe nuclear power plant proposal was approved in 1980 but not built.

With growth in demand and grid capacity since then, a much larger plant looked feasible, and the government in 1999 expressed its firm commitment to build this Rooppur plant. In 2001 it adopted a national Nuclear Power Action Plan and in 2005 it signed a nuclear cooperation agreement with China. In 2007 the Bangladesh Atomic Energy Commission proposed two 500 MWe nuclear reactors for Rooppur by 2015, quoting likely costs of US$ 0.9-1.2 billion for a 600 MWe unit and US$ 1.5-2.0 billion for 1000 MWe. In April 2008 the government reiterated its intention to work with China in building the Rooppur plant and China offered funding for the project.

Russia and South Korea had earlier offered financial and technical help to establish nuclear power.

The country has had a Triga 3 MW research reactor operational since 1986.

Belarus

Belarus produces only 31 billion kWh/yr from 7 GWe of plant, mostly gas-fired, giving per capita consumption of 3330 kWh/yr.

The country imports 90% of its gas from Russia - much of it for electricity, and overall aims for 25-30% energy independence, compared with half that now. A single nuclear plant would be expected to reduce gas imports by US$ 200-400 million per year. There have been studies on both a domestic plant using Russian technology, and Belarus participation in a new nuclear unit at Smolensk or Kursk in Russia.

Plans to build a new coal-fired plant were shelved in 2005 because no coal supply could be found, but a 600 MWe coal-fired plant is now under consideration.

In mid 2006 the government approved a plan for the construction of an initial 2000 MWe PWR nuclear power plant in the in the Mogilev region of eastern Belarus. This is expected to provide electricity at half the cost of that from Russian gas (5 billion cubic metres per year for same capacity) and to provide some 30% of the electricity by 2020 at a cost of about EUR 4 billion (January 2008 estimate) on a turnkey basis.

After expressions of interest from international reactor vendors were invited, the energy ministry announced in August 2008 that proposals had been received from Atomstroyexport, Westinghouse-Toshiba and Areva (though its EPR was noted as being too big). Russia has been considered as the most likely supplier for the 2 x 1000 MWe plant. Operation of the first unit is envisaged for 2016 and the second in 2018. Two further units are proposed for operation by 2025. In June 2007 Russia's Eximbank offered a US$ 2 billion credit line to enable purchase of equipment from Russia's Power Machines company as a major part of the overall cost.

In November 2007 a presidential decree defined the organizations responsible for preparing for the construction of the country's first nuclear power plant and budgeted money for engineering and site selection, to be finalized at the end of 2008. Two candidate sites are Krasnopolyansk and Kukshinovsk (both in the Mogilev region). Site works are expected to begin early in 2009 and construction possibly in 2010. Ownership of the plant could be partly or wholly private, and the Bulgarian precedent is being watched with interest.

The decree also aims to ensure that nuclear and radiation safety is in line with the recommendations of the International Atomic Energy Agency (IAEA). A Directorate for the Construction of a Nuclear Power Plant will be established under the Ministry of Energy. A Nuclear & Radiation Safety Department will also be set up as part of the Emergencies Ministry to act as the state nuclear regulator and licensing authority. The state-run Belnipienergoprom enterprise has been designated as the general designer of the plant and will be responsible for negotiating and signing contracts, carrying out feasibility studies and preparing tender documents.

In January 2008 the Security Council confirmed that the country is to embark upon building a nuclear power plant, to provide some 30% of the electricity by 2020. The cost is expected to be about EUR 4 billion.

(A VVER-1000 unit was earlier being built near Minsk but construction was abandoned in 1988 after the Chernobyl accident.)

Chile

Chile imports over 70% of its energy, mostly as hydrocarbons. It produced 50 billion kWh in 2005 from some 11 GWe of plant and imported 2 billion kWh. There is a need to build a further 5 - 7 GWe by 2020 to secure a measure of energy security as Argentina cuts back gas supplies. Per capita consumption is 2760 kWh/yr. 40-50% of electricity comes from hydro, depending on how much rain it has and about 35% comes from imported natural gas. Up to 20% comes from coal and there are proposals for new coal-fired plants.

In February 2007 the Energy Ministry announced that it was beginning technical studies into the development of nuclear power. A major business group has already had discussions with Areva about building a nuclear power plant to connect Chile's northern and central power grids. In November 2007 the President asked the Energy Minister to prepare new studies regarding the country's nuclear energy options for the next administration.

Egypt

Egypt produced 109 billion kWh in 2005 from 18 GWe of plant, giving per capita consumption of 1350 kWh/yr. 84% of electricity comes from gas, 16% from hydro. Demand growth is about 7% pa.

In 1964 a 150 MWe nuclear plant with 20,000 m^3/day desalination was proposed then in 1974 a 600 MWe plant was proposed. The government's Nuclear Power Plants Authority (NPPA) was then established in 1976, and in 1983 the El Dabaa site lon the Mediterranean coast was selected for a nuclear plant. This plan was aborted following the Chernobyl accident. More recently the NPPA carried out a feasibility study for a cogeneration plant for electricity and desalination, updating it in 2003.

A new agreement on peaceful uses of atomic energy was signed with Russia at the end of 2004, and a further one in March 2008, reviving Egypt's plans for a nuclear power and desalination plant there, supported by Rosatom. In 2006 a nuclear cooperation agreement was reached with China.

Egypt already has a 1961-vintage 2 MW Russian research reactor serviced by Russia, and a 22 MW Argentinian research reactor partly supported by Russia and which started up in 1997.

On the basis of the feasibility study for a cogeneration plant for electricity and potable water at El-Dabaa, in October 2006 the Minister for Energy announced that a 1000 MWe reactor would be built there by 2015. The US$ 1.5 to 2 billion project would be open to foreign participation.

Estonia and Latvia

These countries have not been planning to build any nuclear capacity themselves and are participants in a plan to replace the Ignalina reactor in Lithuania with much larger capacity which will serve those three Baltic states and Poland.

However, in 2008 Estonia took steps to identify sites for a possible nuclear power plant of its own, and investigate possible involvement in a sixth Finnish plant. Estonia has recently completed a 350 MW DC cable interconnector with Finland - Estlink, costing EUR 110 million and supported by EC funding.

Estonia has two small Soviet naval reactors originally used for submarine training. They date from 1968 and 1983 and were closed down in 1989. They are in Safestor mode and will be dismantled after fifty years.

Georgia

Georgia generated 7.3 billion kWh in 2005, largely from natural gas, and imported another 1.5 billion kWh.

It is heavily dependent on Russia for energy supplies and there is some discussion about building a nuclear power plant to assist its energy independence. This could be in collaboration with Azerbaijan or Armenia. In November 2006 Russia threatened to double the price of gas to Georgia. In August 2008 it invaded Georgia.

Ghana

Ghana produced 6.8 billion kWh in 2005. In April 2007 the government announced that it planned to introduce nuclear power on energy security grounds. In May 2008 the government said it planned to have 400 MWe of nuclear capacity by 2018. Ghana joined the Global Nuclear Energy Partnership (GNEP) in September 2007.

Ghana has a small Chinese research reactor, operating since 1994.

Gulf states, UAE

In December 2006 the six member states of the Gulf Cooperation Council - Kuwait, Saudi Arabia, Bahrain, the United Arab Emirates (UAE), Qatar and Oman - announced that the Council was commissioning a study on the peaceful use of nuclear energy. France agreed to work with them on this, and Iran pledged assistance with nuclear technology.

Together they produce 273 billion kWh per year, all from fossil fuels (2003) and 5-7% annual demand growth. They have total installed capacity of about 80 GWe, with a common grid. There is also a large demand for desalination, currently fuelled by oil and gas. UAE itself has some 18 GWe installed and 85% of its power is from gas, the rest from oil.

In February 2007 the six states agreed with the IAEA to cooperate on a feasibility study for a regional nuclear power and desalination program. Saudi Arabia was leading the investigation and thought that a program might emerge about 2009.

The six nations are all signatories of the NPT and the UAE ratified a safeguards agreement with IAEA in 2003. In mid 2008 it appointed an ambassador to IAEA.

In January 2008 three French companies Areva, Suez and Total signed a partnership agreement to propose to UAE the construction of two EPR units there. Suez and Total would each invest up to 25% of the project with Abu Dhabi entities providing at least 50%. Suez would be operator, Areva would supply the plant and manage the fuel. Total and Suez are well established in the region and together operate a power and desalination plant for Abu Dhabi, 100 km west of Dubai. The consortium's first EPR would not be operating before about 2017.

In April 2008 the UAE independently published a comprehensive policy on nuclear energy. This projects escalating electricity demand from 15.5 GWe in 2008 to over 40 GWe in 2020, with natural gas supplies sufficient for only half of this. Imported coal is dismissed as an option due to environmental and energy security implications. Nuclear power "emerged as a proven, environmentally promising and commercially competitive option which could make a significant base-load contribution to the UAE's economy and future energy security."

Accordingly, and as recommended by the IAEA, the UAE established a Nuclear Energy Program Implementation Organization which has set up the Emirates Nuclear Energy Corporation (ENEC) as a public entity, initially funded with $100 million, to evaluate and implement nuclear power plans within UAE.

Secondly, the UAE "will also draft a comprehensive national nuclear law" which establishes a fully independent nuclear regulatory authority. Thirdly, it will "offer joint-venture arrangements to foreign investors for the construction and operation of future nuclear power plants" similar to existing Independent Water and Power Producer structures which have 60% owned by the government and 40% by the JV partner(s).

"In lieu of domestic enrichment and reprocessing, the UAE would seek to conclude long-term arrangements …. for the secure supply of nuclear fuel, as well as the safe and secure transportation and, if available, the disposal of spent fuel via fuel leasing or other emerging fuel supply arrangements."

The UAE is reported to have invited expressions of interest from nine short-listed companies for construction of its first nuclear power plant. By 2020 it hopes to have three 1500 MWe nuclear plants running and producing electricity at a quarter the cost of that from gas.

The USA has bilateral nuclear energy cooperation agreements with Saudi Arabia, Bahrain and UAE. In May 2008 the UK signed a Memorandum of Understanding on nuclear energy cooperation with UAE. France has a nuclear cooperation agreement with UAE and has discussed nuclear energy development with Saudi Arabia, offering Atomic Energy Commission (CAE) assistance.

Indonesia

Indonesia's population of 242 million is served by power generation capacity of only 21.4 GWe, producing 127 billion kWh/yr (2005). This gives per capita electricity consumption: 475 kWh/yr.

With an industrial production growth rate of 10.5%, electricity demand is estimated to reach 175 TWh in 2013 and 450 billion kWh in 2026. At present a low reserve margin with poor power plant availability results in frequent blackouts.

About 45% of Indonesia's electricity is generated by oil and gas, so as well as catering for growth in demand in its most populous region, the move to nuclear power will free up oil for export. Remaining electricity supply is from coal (36%), hydropower (12%) and geothermal energy (7%).

Three research reactors are operated by the National Atomic Energy Agency (BATAN), the third of them being intended to support the introduction of nuclear power to the country. It is a 30 MW (thermal) unit at the Serpong Nuclear Facility near Jakarta, and started up in 1987.

Following earlier tentative proposals, in 1989 the government initiated a study focused on the Muria Peninsula in central Java and carried out by the National Atomic Energy Agency (BATAN). It led to a comprehensive feasibility study for a 7000 MWe plant, completed in 1996, with Ujung Lemahabang as the specific site, selected for its tectonic stability. Plans for the initial plant on the Muria Peninsula in central Java were then deferred indefinitely early in 1997.

Then a 2001 power generation strategy showed that introduction of a nuclear plant on the Java-Bali grid would be possible in 2016 for 2 GWe rising to 6-7 GWe in 2025, using proven 1000 MWe technology with 85% capacity factor and investment cost $2000/kWe. The Java-Bali interconnected system accounts for more than three quarters of Indonesia's electricity demand.

Late in 2003 BATAN was reported to have narrowed the choice of plant to two: a South Korean 1000 MWe pressurised water reactor or a Canadian 700 MWe pressurised heavy water reactor - probably the KSNP+ (OPR-1000) and ACR-700 respectively. Subsequent reports point to the Korean OPR-1000 option and suggest an increasing sense of urgency due to power shortages.

Under the 2006 Law on Nuclear Reactors the project may be given to an Independent Power Producer to build and operate, on one of three sites on the central north coast of Java. Plans are to call tenders in 2008 for two 1000 MWe units, Muria 1 & 2, leading to decision in 2010 with construction starting soon after and commercial operation from 2016 and 2017. Fuel services will be purchased from abroad and fuel would preferably be leased. Used fuel would be stored centrally in the medium term. Tenders for Muria units 3 & 4 are expected to be called for in 2016, for operation from 2023.

The government has said that it has $8 billion earmarked for four nuclear plants of total 6 GWe to be in operation by 2025. Under current plans it aims to meet 2% of power demand from nuclear by 2017. It is anticipated that nuclear generation cost would be about 4 cents/kWh (US) compared with 7 c/kWh for oil and gas.

In July 2007 Korea Electric Power Corp. and Korea Hydro & Nuclear Power Co. (KHNP) signed a memorandum of understanding with Indonesia's PT Medco Energi Internasional to progress a feasibility study on building two 1000 MWe OPR-1000 units from KHNP at a cost of US$ 3 billion. This was part of a wider energy collaboration.

In addition, Batan has undertaken a pre-feasibility study for a small Korean SMART reactor for power and desalination on Madura. However, this awaits the building of a reference plant in Korea. Also the province of Gorontalo on Sulawesi is reported to be considering a floating nuclear power plant from Russia, and late in 2007 a cooperation agreement with Japan was signed, envisaging its help in building and operating nuclear power plants.

The Japanese and Indonesian governments signed a cooperation agreement in November 2007 relating to assistance to be provided for the preparation, planning, and promotion of Indonesia's nuclear power development and assistance for public relations activities.

The IAEA is reviewing the safety aspects of both Muria and Madura proposals, with Indonesia's Nuclear Technology Supervisory Agency.

During the 1980s Indonesia trained many technical people in anticipation of nuclear power development then, many of these are still available for the new project.

Indonesia has several nuclear facilities in operation. In addition to three research reactors, it has front-end capabilities in ore processing, conversion and fuel fabrication, all at a laboratory scale. There have been no experiments in reprocessing, but there is a radwaste program for spent fuel from the research reactors.

There are some uranium resources in Kalimantan.

Iran

Iran produces some 180 billion kWh/yr from 31 GWe of plant, giving per capita consumption of 1943 kWh/yr. 73% of electricity comes from gas, 18% from oil.

In the mid 1970s construction of two 1,200 MW(e) PWR units was started at Bushehr by Siemens KWU. In 1979 this was suspended. The Islamic Republic of Iran revived the nuclear power program in 1991 with a bilateral agreement with China for the supply of two 300 MW(e) PWR units of Chinese design, similar to the Qinshan power plant, but nothing eventuated.

In 1994, Russia's Minatom and the Atomic Energy Organization of Iran (AEOI) agreed to complete unit 1 of Bushehr nuclear power plant with a VVER-1000 unit, using mostly the infrastructure already in place. This long-awaited 915 MWe plant, being constructed by Atomstroyexport, is nearing completion and is expected to start up late in 2008, with commercial operation mid 2009. A second reactor is planned at the site.

After two years delay due to Iran's reluctance to return spent fuel to Russia without being paid for it, two agreements were signed early in 2005 covering both supply of fresh fuel for the new Bushehr nuclear reactor and its return to Russia after use. Supply of the fuel was originally contingent upon Iran's signing the Additional Protocol to its safeguards agreement with the IAEA. It has done this but not ratified it. The Russian agreement means that Iran's nuclear fuel supply is secured for the foreseeable future, removing any justification for enrichment locally. It also means that the anticipated 6-7 TWh/yr from the new reactor will free up about 1.6 million tonnes of oil or 1800 million cubic metres of gas per year which can be exported for hard currency.

Russia's Atomstroyexport in December 2007 delivered the first of 163 fuel assemblies for the initial core of Bushehr. The fuel is enriched to 3.62% or less and is under full international safeguards. The Russian government had withheld supply as negotiations over Iran's uranium enrichment activities proceeded.

The AEOI has announced that a new indigenous 360 MWe nuclear power plant is to be built at Darkhovin in Khuzestan province in the southwest, at the head of the Gulf, where two Framatome 900 MWe plants were about to be constructed in 1970s. It has also invited bids for two units of up to 1600 MWe to be built near Bushehr and come on line about 2016.

Ireland

Ireland produces about 28 billion kWh/yr gross from 6 GWe of plant for its population of 4.1 million, giving per capita consumption of 6300 kWh/yr. About half of its electricity is generated by gas, but relative to the rest of Europe it is heavily dependent on oil for its electricity - 10%. Coal provides 28%. Wind provides around 6% from about 800 MWe of capacity. Ireland has a target of 3000 MWe wind capacity by 2020

In 1981 the government considered building a 650 MWe nuclear power plant (PWR) at Carnsore Point, but the plan was dropped as energy demand flattened. It would have required a link across the Irish Sea to the UK to be viable, due to its large size relative to the Irish grid.

A government-commissioned report by Forfas in April 2006 pointed to the need for Ireland again to consider nuclear power in order "to secure its long-run energy security". Relatively small-scale nuclear plants were envisaged. The report also suggested accelerating plans for greater east-west interconnection with the UK, which would draw on its nuclear capacity and also provide an export channel for any Irish nuclear power development.

In 2007 Ireland's Electricity Supply Board made it known that it would consider a joint venture with a major EU energy company to build nuclear capacity. In April 2008 the Irish Energy Regulator proposed a nationwide debate on the issue of nuclear power to address the country's pending energy crisis. It referred to the need to find an alternative to meet future energy needs since neither wind power or any other renewable energy sources could satisfy demand.

Italy

Electricity consumption in Italy in 2005 was 330 billion kWh, giving per capita consumption of 5640 kWh/yr.

In 2006 local production from 81 GWe of plant was 315 billion kWh gross, 50% from gas, 15% from oil, 16% from coal and 14% from hydro. Imports of 50.3 billion kWh (effectively, some 15% of its needs) are required, mostly nuclear power from France . This is equivalent to output from about 7 GWe of capacity at 80%.

Due to the high reliance on oil and gas, as well as imports, Italy's electricity prices are 45% above EU average.

Italy today is now the only G8 country without its own nuclear power, and is the world's largest net importer of electricity.

However, Italy was a pioneer of civil nuclear power and built several reactors which operated 1963-90. But following a referendum in November 1987, provoked by the Chernobyl accident 18 months earlier, work on the nuclear program was largely stopped. In 1988 the government resolved to halt all nuclear construction, shut the remaining reactors and decommission them from 1990. Italy then remained largely inactive in nuclear energy for 15 years.

In 2004 a new Energy Law opened up the possibility of joint venture with foreign companies in relation to nuclear power plants and importing electricity from them. This resulted from a clear change in public opinion, especially among younger people favouring nuclear power for Italy.

In 2005 Electricite de France and ENEL signed a co-operation agreement which gives ENEL some 200 MWe from the new Flamanville-3 EPR nuclear reactor (1700 MWe) in France, and potentially another 1000 MWe or so from the next five such units built. As well as the 12.5% share, Italy's electric utility ENEL will also be involved in design, construction and operation of the plants, which will enhance Italy's power security and improve its economics A major benefit will be in rebuilding Italy's nuclear skills and competence. ENEL is expected to pay about EUR 350 million for its share in the project.

ENEL has also bought 66% of the Slovak Electric utility which operates six nuclear power reactors, and ENEL's investment plan for SE approved in 2005 by the Slovak government includes EUR 1.6 billion for completion of Mochovce nuclear power plant - 942 MWe gross - by 2011-12.

In 2008 Energy Lab, described as a think tank and involving major utilities, began a feasibility study on building four new nuclear power plants in Italy.

ENEL is reported to favour building four or five 1800 MWe nuclear plants, funded internally or via a consortium with major consumers, and to take nuclear to a 20 to 25% share of indigenous supply.

Several research reactors are operating, including AGN Constanza (since 1960), Uni of Pavia's LENA Triga II (250 kW, since 1965), ENEA's Tapiro (5 kW, since 1971), ENEA's Triga RC-1 (1 MW, since 1960) and a subcritical assembly.

Ansaldo Nucleare, which in conjunction with Canada's AECL, built Cernavoda 2 in Romania, is also involved with international R&D on new reactor systems.

Jordan

Jordan imports about 95% of its energy needs. It generated and imported 10.4 billion kWh of electricity in 2005 for its six million people. It has 2030 MWe of generating capacity and expects to need an additional 1200 MWe by 2015. Also it has a "water deficit" of about 500 million cubic metres per year.

The energy minister has said that the country expects to have a nuclear power plant operating by 2015, for electricity and desalination. Jordan's Committee for Nuclear Strategy has set out a program for nuclear power to provide 30% of electricity by 2030, and to provide for exports.

In mid 2008 an agreement between the Jordan Atomic Energy Commission and Atomic Energy of Canada Ltd (AECL) with SNC-Lavalin is to conduct a 3-year feasibility study on building an AECL 740 MWe Enhanced Candu-6 reactor using natural uranium fuel, for power and desalination. Site selection is planned for 2009, though options appear to be limited to 30 kilometres of Red Sea coast near Aqaba.

The country has low-cost uranium resources of 140,000 tU plus another 59,000 tU in phosphate deposits, and plans to mine these have been announced by the government. A feasibility study on recovering uranium as a by-product of phosphate production is under way.

It has signed nuclear cooperation agreements with the USA, France and UK, in respect to both power and desalination, and is seeking help from the IAEA. It has signed a nuclear cooperation agreement with China, covering uranium mining in Jordan and nuclear power. Jordan joined the Global Nuclear Energy Partnership (GNEP) in 2007.

Kazakhstan

Kazakhstan produced 68 billion kWh in 2005 from about 17 GWe of plant, mostly now privatised, and had net exports of 12.5 billion kWh. Per capita consumption is 3460 kWh/yr. 52% of electricity comes from coal, 26% from gas and 17% from oil.

It has no national electricity grid, but a northern grid links to Russia and a southern one links to Kyrgystan and Uzbekistan.

The BN-350 fast reactor at Aktau (formerly Shevchenko), on the shore of the Caspian Sea, successfully produced up to 135 MWe of electricity and 80,000 m^3/day of potable water over some 27 years until it was closed down in mid 1999. About 60% of its power was used for heat and desalination. It was operated by the Mangyshlak Power Generation Co. (MAEK).

The Russian plant, built under Minatom supervision, was designed as 1000 MWt but never operated at more than 750 MWt and was most recently quoted at 520 MWt, but it established the feasibility and reliability of such cogeneration plants. (In fact, oil/gas boilers were used in conjunction with it, and total desalination capacity through ten multi-effect distillation (MED) units was 120,000 m^3/day.)

There are proposals for a new nuclear power plant near Lake Balkhash in the south of the country near Almaty.

A July 2006 joint venture with Russia's Atomstroyexport envisages development and marketing of innovative small and medium-sized reactors, starting with OKBM's VBER-300 as baseline for Kazakh units. Atomstroyexport expects to build the initial one.

In April 2007 two agreements with Japan relate to assistance in building nuclear power plants, one between Japan Atomic Power Co and three Kazakh entities, the other between Toshiba Corp and Kazatomprom.

At Kurchatov (aka Semipalatinsk-21) on the former Semipalatinsk nuclear test site three research reactors owned by the National Nuclear Centre are operated by the Institute of

Atomic Energy. A fourth is at Almaty. The three larger ones are tank-type units of 6, 10 and 60 MW, the newest is a 400 kW high-temperature gas reactor. All were supplied by Russia and use high-enriched fuel.

The internationally-significant Ulba Metallurgical Plant at Ust Kamenogorsk in the east of the country was commissioned in 1949. It has a variety of functions relevant to uranium, the most basic of which since 1997 is to refine most Kazakh mine output of U_3O_8. (It also produces beryllium, niobium and tanatalum.)

Since 1973 Ulba has produced nuclear fuel pellets from Russian-enriched uranium which are used in Russian and Ukrainian VVER and RBMK reactors. Some of this product incorporates gadolinium and erbium burnable poisons. Other exports are to the USA and in 2007 it plans to market to Asia. It briefly produced fuel for submarines (from 1968) and satellite reactors. Since 1985 it has been able to handle reprocessed uranium.

Ulba is majority owned by Kazatomprom and 34% by Russia's TVEL and has major new investment under way. It has secured both ISO 9001 and ISO 14001 accreditation. In 2007 a technological assistance agreement was signed with Japan apparently in line with government announcements that it would move towards selling its uranium as fabricated fuel or at least fuel pellets rather than just raw material. Ulba's web site speaks of establishing uranium conversion capacity (it has produced HF since 1952), which would fit in with Russian JV enrichment arrangements.

Kazakhstan joined the Global Nuclear Energy Partnership (GNEP) in September 2007.

Libya

In 2005 Libya produced 22.5 billion kWh of electricity.

Early in 2007 it was reported that Libya was seeking an agreement for US assistance in building a nuclear power plant for electricity and desalination. In 2006 an agreement with France was signed for peaceful uses of atomic energy and in mid 2007 a memorandum of understanding related to building a mid-sized nuclear plant for seawater desalination. Areva TA would supply this.

In 2003 Libya had halted a clandestine program developing uranium enrichment capability, and fully opened itself to IAEA inspections.

Libya has a Russian 10 MW research reactor which is under IAEA safeguards.

Mongolia

Russia is reported to be examining the feasibility of building nuclear power plants in Mongolia, and in April 2008 Russia and Mongolia signed a high-level agreement to cooperate in identifying and developing Mongolia's uranium resources.

Morocco

Morocco has growing electricity demand and produced 22.6 billion kWh in 2005. It also has requirements for desalination. Most electricity is supplied by coal, some by oil.

The government has plans for building an initial nuclear power plant in 2016-17 at Sidi Boulbra, and Atomstroyexport is assisting with feasibility studies for this.

Morocco has a 2 MW Triga research reactor under construction.

For desalination, it has completed a pre-project study with China, at Tan-Tan on the Atlantic coast, using a 10 MWt heating reactor which produces 8000 m^3/day of potable water by distillation.

In October 2007 a partnership with France to develop a nuclear power plant near Marrakesh was foreshadowed and a nuclear energy cooperation agreement was signed.

Namibia

Namibia's electricity supply of 3.2 billion kWh in 2005 was almost half supplied by South Africa, which faces supply constraints itself. A coal-fired plant is planned for Walvis Bay.

Namibia holds about 7% of the world's uranium reserves, which are mined to fuel nuclear power stations around the world. Now the government has committed to a policy position of supplying its own electricity from nuclear power. The country faces severe challenges in power supply.

New Zealand

New Zealand produces some 41 billion kWh/yr from 8.4 GWe of plant. For 4.04 million people, average per capita consumption is thus about 10,000 kWh/yr or 9000 kWh if aluminium smelting is treated as largely an electricity export. 75% of electricity comes from hydro.

New Zealand has depended primarily on hydro-electric power for its electricity for many years, but scope for expansion is limited and even the reliability of present capacity depends on capricious rainfall, as in 2001 and 2003.

The last major hydro scheme was raising the level of Lake Manapouri to provide low-cost power for NZAS aluminium smelter in the South Island.

Hydro output has not increased over the last 15 years, and that growth in demand since 1990 has been mostly met by gas-fired plant, at least until the 1000 MWe state-owned Huntly plant shifted to using coal for 80% of its energy. However, its operation is severely constrained in hot weather.

Of 41 billion kWh of electricity generated in NZ in 2003, 58% was hydro, 24.5% gas, 7.6% coal, 6.7% geothermal, 2% wind and 1.3% biomass. The power is produced from 8.4 GWe capacity, including 5.25 GWe hydro, 1.38 GWe gas-fired, 1.0 GWe coal-fired and 0.42 GWe geothermal - mainly run as base-load (2002 data). In 2004 there was 0.17 GWe of wind capacity installed and 0.07 GWe committed.

In 1968 the national power plan first identified the likely need for nuclear power in NZ a decade or more ahead, since readily-developed hydro-electric sites had been utilised. Plans were made and a site at Oyster Point on the Kaipara harbour near Auckland was reserved for the first plant. Four 250 MWe reactors were envisaged, to supply 80% of Auckland's needs by 1990. But then the Maui gas field was discovered, along with coal reserves near Huntly, and the project was abandoned by 1972.

In 1976 a Royal Commission was set up to enquire further into the question. Its 1978 report said that there was no immediate need for NZ to embark upon a nuclear power program, but suggested that early in 21st century "a significant nuclear programme should be economically possible."

Nigeria

Nigeria produced 23.5 billion kWh in 2005 from about 6 GWe of plant and had final consumption of 17 TWh, giving per capita consumption of only 113 kWh/yr.

To address rapidly increasing base-load electricity demand, Nigeria has sought the support of the International Atomic Energy Agency to develop plans for up to 4000 MWe of nuclear capacity by 2025. Nigeria is Africa's most populous country and its power demand is expected to reach 10,000 MWe by 2007 - current grid-supplied capacity is 2600 MWe.

Early in 2008 the Minister of Science and Technology said that the government has reaffirmed its determination to initiate its nuclear energy program by approving a technical framework for it. This is to proceed through manpower and infrastructure development, power reactor design certification, regulatory and licensing approvals, construction and start-up. In mid 2008 the target was moved forward to having up to 5000 MWe of nuclear capacity by 2017.

Nigeria's first research reactor was commissioned at Ahmadu Bello University in 2004. It is a 30 kW Chinese Miniature Neutron Source Reactor similar to other Chinese units operating in Ghana, Iran, Syria and China. The IAEA assisted the Nigerian government with the project, to "reinforce and widen the human resource base to sustain nuclear technology" in relation to medical technology, geochemistry, mineral and petrochemical analysis and exploration.

Norway

Norway's electricity is almost entirely hydro. In 2006, 121.7 billion kWh gross was generated, from 27.5 GWe of capacity. Exports and imports vary greatly with the season and hydro situation in Scandinavia. In 2004 net imports were 11.5 TWh and in 2005 net exports were 12 TWh, mostly to and from Sweden. Per capita use is about 24,000 kWh/yr.

Leaders of Norwegian industry want nuclear energy to supplement hydro. They believe nuclear power based on thorium, which Norway has plenty of, will prevent future energy crises.

A government-appointed committee reported in February 2008 that building thorium-fuelled power reactors was a possibility, which could be tested by using thorium fuel in the country's Halden research reactor.

The committee also said that the country should strengthen its international collaboration in nuclear energy and develop its human resources in nuclear science and engineering so as to keep the thorium option open as complementary to the uranium option. "The potential contribution of nuclear energy to a sustainable energy future should be recognised."

The Norwegian Radiation Protection Agency has licensed an underground repository inside a mountain for radioactive waste from the country's oil and gas industry. It will hold 6000 tonnes of NORM waste, and 400 tonnes has already been placed there.

Philippines

The Philippines produced 56.5 billion kWh of electricity in 2005.

In response to the 1973 oil crisis, the Philippines decided to build the two-unit Bataan Nuclear Power Plant (BNPP). Construction of Bataan 1 - a 621 MWe Westinghouse pressurized water reactor - began in 1976 and it was completed in 1984 at a cost of $460 million. However, due to financial issues and safety concerns, the plant was never loaded with fuel or operated. In April 2007, the Philippine government made the final payment for the plant. The government was considering converting it into a natural gas-fired power plant, but this was impractical, and the plant has simply been maintained.

In 2007 the Philippines Department of Energy (DOE) set up a project to study the development of nuclear energy, in the context of an overall energy plan for the country. Nuclear energy would be considered in order to reduce the country's dependency on imported oil and coal. In 2008 an IAEA mission commissioned by the government advised that Bataan-1 could be refurbished and economically and safely be operated for 30 years. Refurbishment is estimated to cost $800 million. The IAEA was also to recommend a policy framework for nuclear power development in the country.

Poland

In 2006 Poland produced some 161.7 billion kWh gross from 32 GWe of mostly coal plant, giving per capita consumption of 3700 kWh/yr with very high CO2 emissions. Poland has the largest reserves of coal in the EU (14 billion tonnes), and 93% of electricity comes from coal. Electricity consumption is forecast to grow by 90% to 2025, but the EU has placed stringent restrictions on CO2 emissions.

The Polish cabinet decided early in 2005 that for energy diversification and to reduce CO2 and sulfur emissions the country should move immediately to introduce nuclear power, so that an initial plant might be operating soon after 2020. In July 2006 the new Prime Minister reaffirmed the need to build nuclear power plants, and mentioned French technology.

A 2006 feasibility study suggested that 11.5 GWe of nuclear capacity would be optimum for Poland but possibly unaffordable in the medium term, so the figure of 4.5 GWe by 2030 was then targeted. A 2007 draft energy policy proposes 10 MWe of indigenous nuclear capacity by 2030, providing 10% of electricity then, and an interim 7.5% by 2022.

Poland had four 440 MWe Russian units under construction in the 1980s at Zarnowiec, but these were cancelled in 1990 and the components were sold.

In July 2006 Lithuania invited Poland to join with Estonia and Latvia in building a new large reactor in Lithuania, to replace the Ignalina units being shut down at EU insistence. Polish participation would justify a larger and more economical unit such as an EPR. In February 2007 the three Baltic states and Poland agreed to build a new nuclear plant at Ignalina, initially with 3200 MWe. Lithuania as host would have 34% of the project and Poland, Latvia and Estonia 22% each. At least one unit of the project is expected to be operating by 2015. Total cost will be some EUR 6 billion. E.On earlier expressed interest in investing in such a unit. Poland said that unless it has access to at least 1000 MWe of the project, later increased to 1200 MWe, it is not worth building the transmission lines to Poland.

In May 2008 the government formed the Lithuanian Energy Organisation (LEO) to build the new nuclear power plant and also transmission to Sweden and Poland. In July 2008 LEO with energy companies from Latvia, Estonia and Poland (Latvenergo, Eesti Energia and Polska Grupa Energetyczna) established the Visaginas project development company for the new 3200-3400 MWe nuclear power plant. The host country will hold 51% of this and the others 16% each, but the JV will be reconstituted later as a project implementation company with different share split related to long-term equity. Though located close to the Soviet-era Ignalina plant, the new one will be called Visaginas after the nearby town of that name. Lithuania wants at least 34% of the new plant (1090-1160 MWe), Poland wants 1000 MWe, while Latvia and Estonia want 400-600 MWe each.

Meanwhile, and apart from Polish participation in the Baltic states nuclear plant, a high-voltage (400 kV) 1000 MW DC PowerBridge costing EUR 250-300 million to improve transmission capacity between Lithuania and Poland is to be built by 2015. It will be half funded by the EC. This follows inauguration of an interconnector between Estonia and Finland - Estlink, a 150 kV, 350 MW DC cable costing EUR 110 million and also supported by EC funding.

A further major transmission link, of 700 to 1000 MWe is proposed undersea between Sweden and Lithuania, to allow power from the new joint reactor to be exported to Scandinavia.

A public opinion poll in December 2006 carried out for the National Atomic Energy Agency showed that 60% supported construction of nuclear power plants to reduce the country's dependence on natural gas and to reduce CO2 emissions. In contrast to NIMBY attitudes elsewhere, 48% said they would favour such a plant being built in their neighbourhood because of its immediate local benefits including lower power cost.

Poland joined the Global Nuclear Energy Partnership (GNEP) in September 2007.

Portugal

Portugal's electricity demand is about 46 TWh/yr and this comes one third from coal, a quarter from gas and 20% from hydro. Net imports are about 6.5 TWh/yr from Spain.

Its electricity grid is closely linked with Spain's, so that a large nuclear plant on the Atlantic coast could serve both countries.

In 2004 the government rejected a proposal to introduce nuclear power but this is now being reviewed.

Syria

Syria produced 35 billion kWh in 2005, 90% of this from fossil fuels, the balance from hydro.

Syria had plans in the 1980s to build a VVER-440 reactor but abandoned these after the Chernobyl accident and due to the collapse of Soviet Union. With escalating oil and gas prices, nuclear power is now being considered again.

Meanwhile over 2001-07 Syria built at a remote location what appeared to be a gas-cooled reactor similar to the plutonium production unit at Yongbyong in North Korea. This was destroyed by an Israeli air strike in 2007 and the remains then demolished. The project was clandestine and in breach of Syria's obligations under the NPT.

Thailand

Peak demand is about 20 GWe and some 132 billion kWh per year is supplied (2005). About 70% is from natural gas. Thailand has the potential to be regional electricity hub for ASEAN countries.

Tentative plans to embark on a nuclear power program have been revived by a forecast growth in electricity demand of 7 per cent per year for the next twenty years. Capacity requirement in 2016 is forecast at 48 GWe. As gas prices rise, the Atomic Energy Commission and its Office of Atoms for Peace (OAP) however are assessing the feasibility of nuclear power, and any initial plants would probably be built by the Electricity Generating Authority of Thailand (EGAT). Independent power producers have also expressed interest. The Ministry of Science & Technology is responsible for the issue.

Thailand's National Energy Policy Council commissioned a feasibility study for a nuclear power plant in the country, and among the options in the draft power development plan for 2007-2021 was the construction of 5000 MWe of nuclear generating capacity, starting up in 2020-21.

In June 2007 the Energy Minister announced that EGAT will proceed with plans to build a 4000 MWe nuclear power plant, and has budgeted some US$ 53 million between 2008 and 2011 on preparatory work, half of it coming from oil revenues. Construction will commence in 2015, to operate from 2020. The capital cost is expected to be US$ 6 billion and electricity cost about USD 6 cents/kWh, slightly less than from coal. The government plans to establish safety and regulatory infrastructure by 2014 and commissioned a formal 3-year feasibility study early in 2008.

Thailand has had an operating research reactor since 1977 and a larger one is under construction.

Tunisia

Tunisia produced 13.7 billion kWh in 2005, almost all of this from fossil fuels.

The government is reported to be evaluating the possible construction of a 600 MWe nuclear plant costing US$ 1.14 billion.

In December 2006 a nuclear cooperation agreement was signed with France, focused on nuclear power and desalination, and in April 2008 this was amplified.

Turkey

In 2006 Turkey produced 176 billion kWh/yr gross from 35 GWe of plant, giving per capita consumption of almost 2000 kWh/yr. 44% of electricity comes from gas (two thirds of this from Russia, most of the rest from Iran), 26% from coal and 25% from hydro. Demand growth is 8% pa.

Several nuclear power projects have been proposed: In 1970 a feasibility study concerned a 300 MWe plant, in 1973 the electricity authority decided to build a 80 MWe demonstration plant but didn't, then in 1976 the Akkuyu site on the Mediterranean coast near the port of Mersin was licensed for a nuclear plant. In 1980 an attempt to build several plants failed for lack of government financial guarantee, in 1993 a nuclear plant was included in the country's investment program and this led to bids for a 2000 MWe plant at Akkuyu being received from Westinghouse, AECL and Framatome. However plans were abandoned in 2000 due to economic circumstances.

Early in 2006 the province of the port city of Sinop on the Black Sea was chosen to host a commercial nuclear power plant. This has the advantage of cooling water temperatures about 5 degrees below those at Akkuyu, allowing about 1% greater power output from any thermal unit. A 100 MWe demonstration plant was to be built there first, then 5000 MWe of further plants to come into service from 2012. Some kind of public-private partnership is envisaged for construction and operation.

In August 2006 the government said it planned to have three nuclear power plants total 4500 MWe operating by 2012-15, a US$ 10.5 billion investment. Discussions have been under way with Atomic Energy of Canada Ltd re two 750 MWe CANDU units as an initial investment. These and the PWR type are apparently preferred. The first units of some 5000 MWe total will be built at Akkuyu, since the site is already licensed, but licensing is proceeding for Sinop.

In 2007 a new bill concerning construction and operation of nuclear power plants and sale of their electricity was passed by parliament and subsequently approved by the President. The

bill provides for the Turkish Atomic Energy Authority (TAEK) to set the criteria for building and operating the plant. The Turkish Electricity Trade & Contract Corporation (TETAS) will buy all the power under 15-year contracts. The bill also provides for public institutions to build the plants if other offers are not satisfactory. It also addresses waste management and decommissioning, providing for a National Radioactive Waste Account (URAH) and a Decommissioning Account (ICH) which generators will pay into progressively.

TETAS called for tenders in March 2008, inviting bids by 24 September for the first nuclear power plant at Akkuyu. TAEK has issued specifications, allowing for PWR, BWR or PHWR types of at least 600 MWe and with 40 year service life. Design certification in country of origin will be acceptable, allowing TAEK to concentrate on site-specific aspects of the project. Following technical advice from TAEK and commercial advice from TETAS, a government decision on plant type and construction arrangements is expected by the end of 2008. Operation is now expected in 2014.

A mid February 2008 announcement said that preparatory work is under way to build a second nuclear plant at Sinop, along with a EUR 1.7 billion nuclear technology centre. There are proposals to build a further 10 to 12 reactors by 2020.

Near Istanbul, eight Organised Industrial Parks comprising 70,000 firms and using 1.5 billion kWh per year have set up a joint venture - IOSBB - to construct the country's first nuclear power plant(s) of 1500 MWe each. Likely sites mentioned include Sinop on Black Sea and Gokova on Mediterranean.

In May 2008 a civil nuclear cooperation agreement with the USA entered into force.

Venezuela

Venezuela produced 101 billion kWh in 2005, 34% of this from fossil fuels, 66% from hydro.

The National Assembly is working on legislation which includes nuclear power as an option. The President announced in November 2007 that the country will pursue a nuclear power program, inspired by Brazil and Argentina.

Vietnam

Vietnam produced 53.5 billion kWh in 2005 from 11.4 GWe of plant, giving per capita consumption of 445 kWh/yr. 60% of electricity comes from hydro and demand is growing rapidly. In mid 2008 capacity was about 12.5 GWe and demand significantly higher than this, resulting in rationing. According to the government at the end of 2006, electricity demand is expected to grow 15% pa to 2010 and it plans to increase generating capacity to 25 GWe.

In the early 1980s two preliminary nuclear power studies were undertaken, followed by another which reported in 1995 that: "Around the year 2015, when electricity demand reaches more than 100 billion kWh, nuclear power should be introduced for satisfying the continuous growth in the country's electricity demand in that time and beyond".

More recently, a national energy plan approved by Vietnam's National Assembly includes at least 2000 MWe of nuclear power capacity to be commenced by 2010. This follows a feasibility study in 2002, and establishment of nuclear cooperation agreements with Russia, South Korea and the USA, the first related principally to Vietnam's 500 kW Da Lat research reactor.

In February 2006 the government announced that a 2000 MWe nuclear power plant would be on line by 2020. A feasibility study for this due to be completed in 2008 and formal approval; will then be required to open a bidding process with a view to construction start in 2011 and commissioning in 2017. This general target was confirmed in a nuclear power development

plan approved by the government in August 2007, with the target being raised to a total of 8000 MWe nuclear by 2025. . In April 2008 it was reported that 4000 MWe was planned for the southern Ninh Thuan province to be constructed from 2015 and come into operation from 2020.

South Korea has expressed interest in bidding for the project, and its Ministry of Science & Technology would draft a plan for long-term cooperation on nuclear energy. This was signed in November 2006. In May 2008 a nuclear assistance agreement was signed with Japan. In June 2008 the US Nuclear Regulatory Commission and the Vietnam Agency for Radiation and Nuclear Safety & Control officially signed a cooperation agreement to share technical information on nuclear energy. The accord calls for an exchange of information about regulations, environmental impact and safety of nuclear sites.

The Vietnam Atomic Energy Commission was established in 1976 and is under the Ministry of Science & Technology.

Yemen

It was reported in September 2007 that Yemen had signed an agreement with Texas-based PowerEd Corporation to build 5000 MWe of nuclear power capacity by 2017. However, with 2005 production of 4.7 billion kWh (corresponding to about 670 MWe of base-load capacity) this did not seem plausible, and media reports later suggested that the deal was voided.