



# Nuclear Energy in Combating Climate Change in Asia and the Pacific

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# **Nuclear Energy in Combating Climate Change in Asia and the Pacific**

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The International Atomic Energy Agency: is an independent intergovernmental, science and technology-based organization, in the United Nations family, that serves as the global focal point for nuclear cooperation; assists its Member States, in the context of social and economic goals, in planning for and using nuclear science and technology for various peaceful purposes, including the generation of electricity, and facilitates the transfer of such technology and knowledge in a sustainable manner to developing Member States; develops nuclear safety standards and, based on these standards, promotes the achievement and maintenance of high levels of safety in applications of nuclear energy, as well as the protection of human health and the environment against ionizing radiation; verifies through its inspection system that States comply with their commitments, under the Non-Proliferation Treaty and other non-proliferation agreements, to use nuclear material and facilities only for peaceful purposes.

## **Abstract**

Energy is essential for socioeconomic development. Enormous increases in global energy supply are required to lift 2.4 billion people out of energy poverty worldwide. Without a fundamental change in energy sources and technologies, however, global greenhouse gas emissions will increase further, whereas they would need to decline drastically in order to avoid perilous scales of climate change. Nuclear energy can considerably contribute to mitigating climate change and to resolving other energy challenges globally and in the Asia-Pacific region.

**Key words:** Nuclear energy, climate change, Asia-Pacific

*The views expressed in this publication are those of the author(s) and do not necessarily represent those of the United Nations, including UNDP, IAEA or the UN Member States.*

*It is assumed in this background paper that all IAEA Safety Standards and national requirements are complied with during the entire lifetime of the NPPs and the related fuel cycle facilities and that the safety is continuously improved based on experience feedback.*

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## **1. Introduction**

The Asia-Pacific (AP) region has probably the largest diversity amongst the world's regions, including the highest mountain peaks and the lowest lying islands, some of the most and least populous countries, and the fastest growing and longest stagnating economies of the world. The impacts of the emerging global climate change will be equally diverse in the region, but largely damaging for most and possibly fatal for some countries (for example, sea-level rise inundating low-lying small island states).

The region's shares in the world's population (56%), GDP (30%), primary energy use (35%) and CO<sub>2</sub> emissions (40%) make it a key participant in the global response to climate change, both on the impacts/adaptation side, as well as in the efforts to combat climate change. This background paper explores the possible role of nuclear energy in climate change mitigation (Section 2) and in resolving supply security and environmental issues (Section 3). It concludes with a summary of the main points and recommendations for the way forward. Concerns surrounding nuclear power and possible ways to alleviate them are beyond the scope of this background paper and are discussed in other publications (see IAEA 2009a, 2011a). For information concerning the safety of nuclear power plants after the Fukushima accident, see IAEA (2011b; 2012a).

## **2. The role of nuclear energy in mitigating climate change**

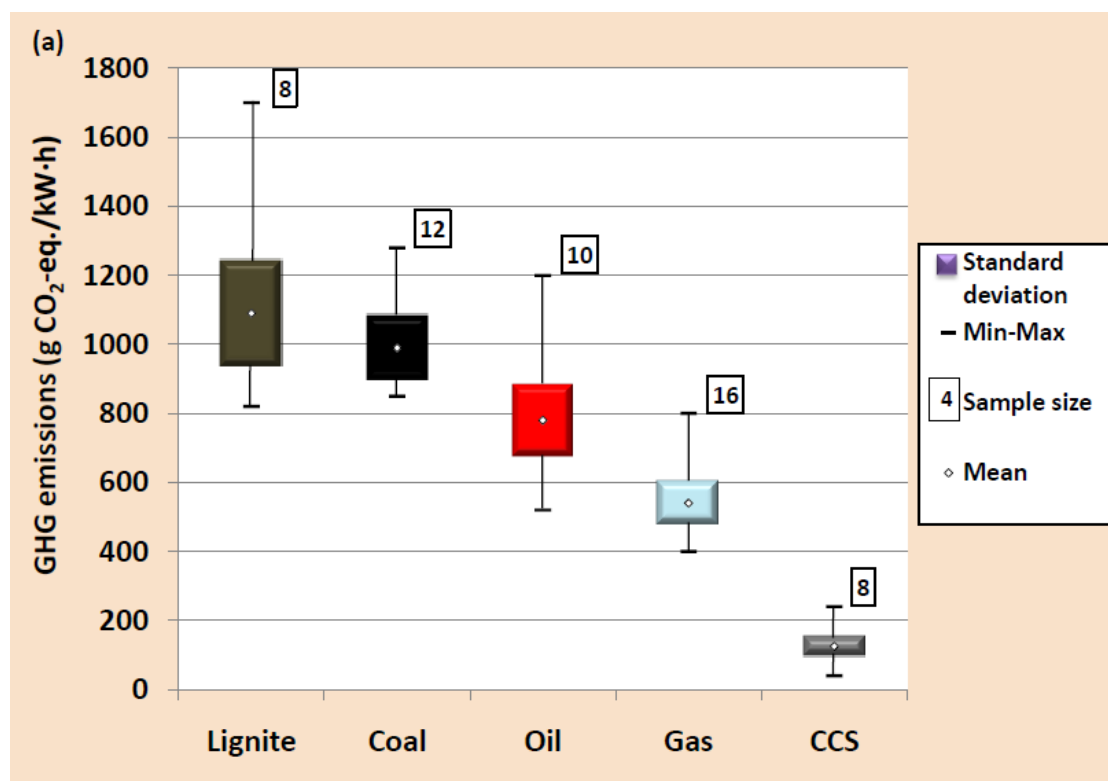
Among the many challenges the world is facing in the early 21<sup>st</sup> century, climate change remains one of the major problems. According to the findings of the Intergovernmental Panel on Climate Change (IPCC), the biophysical changes resulting from a global warming of more than 3°C will trigger increasingly negative impacts in all climate sensitive sectors in the AP region (IPCC 2007a). In mid-latitude and semi-arid low latitude regions, decreasing water availability and increasing drought will expose millions of people to increased water stress. In agriculture, cereal productivity is expected to decrease in low latitude regions (partly compensated for by increased productivity in mid-latitude and high latitude regions). Natural ecosystems will also be affected negatively: up to 30% of species will be at a growing risk of extinction in terrestrial areas, and increased coral bleaching in the oceans is forecast. In coastal areas, damage from floods and storms will increase. Human health will also be affected, especially in less developed countries of the AP region, by the increasing burden from malnutrition and from diarrhoeal, cardiorespiratory and infectious diseases. Increased morbidity and mortality are foreseen from heat waves, floods and droughts. Finally, but most importantly for many AP countries, sea-level rise threatens several small island states (IPCC 2007a).

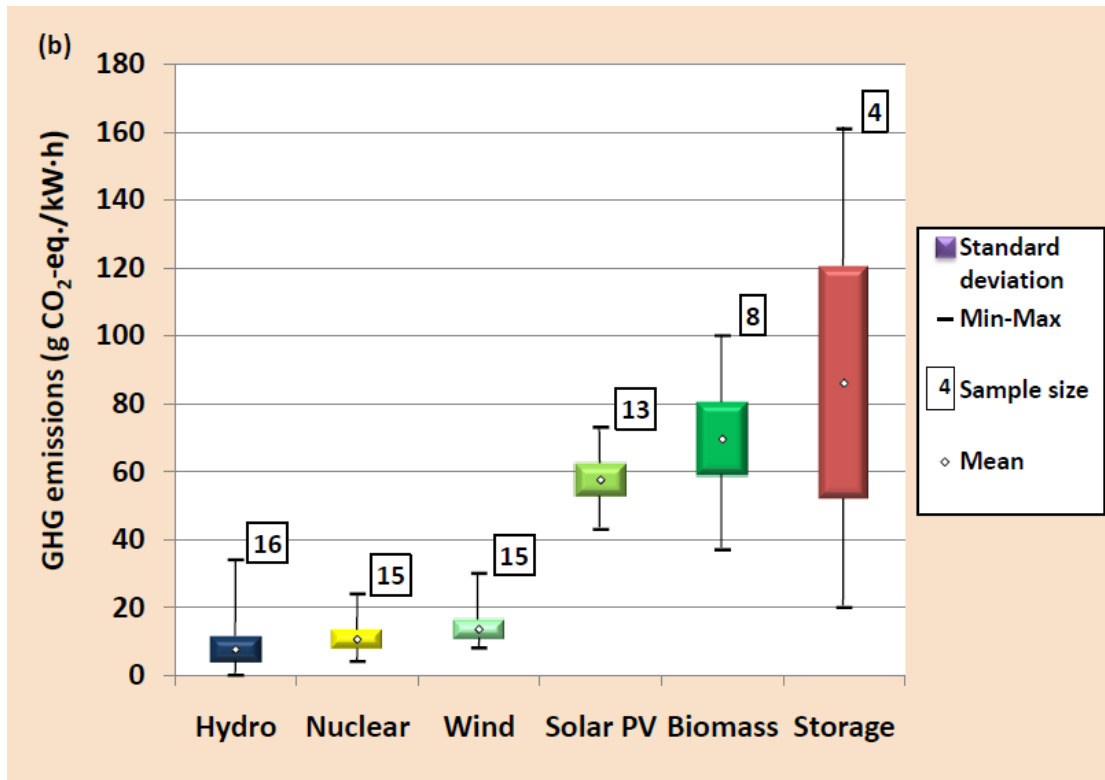
In order to avoid these severe impacts, global greenhouse gas emissions (GHGs) will need to peak within the next decade or so and then fall substantially below the 2000 emission levels by the middle of the century in order to keep the increase in global mean temperature below 2°C relative to pre-industrial levels. A rapid reversal of the increasing GHG emissions trends and emissions reductions of 50–85% relative to the current levels are required by 2050 to avoid distressing climate change impacts in ecological and socioeconomic systems in the AP region and globally (IPCC 2007b).

The latest assessment by the IPCC (2007b) confirmed that, compared with other anthropogenic sources, GHG emissions from the energy supply sector grew at the fastest rate between 1970 and 2004. Currently, energy related CO<sub>2</sub> emissions (including feedstocks) account for by far the largest share (about 60%) of total global GHG emissions (IPCC 2007b). In the absence of additional policy interventions (relative to those already in place), annual emissions from energy production and use are projected to reach 34–52 Gt CO<sub>2</sub> by 2030 (IEA 2011). This is in sharp contradiction to the drastic reduction requirements mentioned above.

In order to achieve the necessary deep cuts in GHG emissions, the power sector will need to be practically decarbonized by the middle of this century (IEA 2010a). Nuclear power belongs to the range of energy sources and technologies available today that could help resolve the conflict between increasing energy demand and climate protection. GHG emissions from nuclear power plants are negligible and nuclear power, together with hydropower and wind based electricity, is among the lowest CO<sub>2</sub> emitters when emissions through the entire life cycle are considered. Based on the findings by dozens of studies, Figure 1 shows that life cycle GHG emissions from nuclear energy are estimated to be in the range of 2.8 and 24 g CO<sub>2</sub>-eq./kWh, similar to hydropower (between 1 and 34 g CO<sub>2</sub> eq./kWh) and wind (8 to 30 g CO<sub>2</sub> eq./kWh for onshore and 9 to 19 g CO<sub>2</sub> eq./kWh for off-shore turbines).

Figure 1. Life cycle GHG emissions of different electricity generating options.  
Source: Weisser (2007).

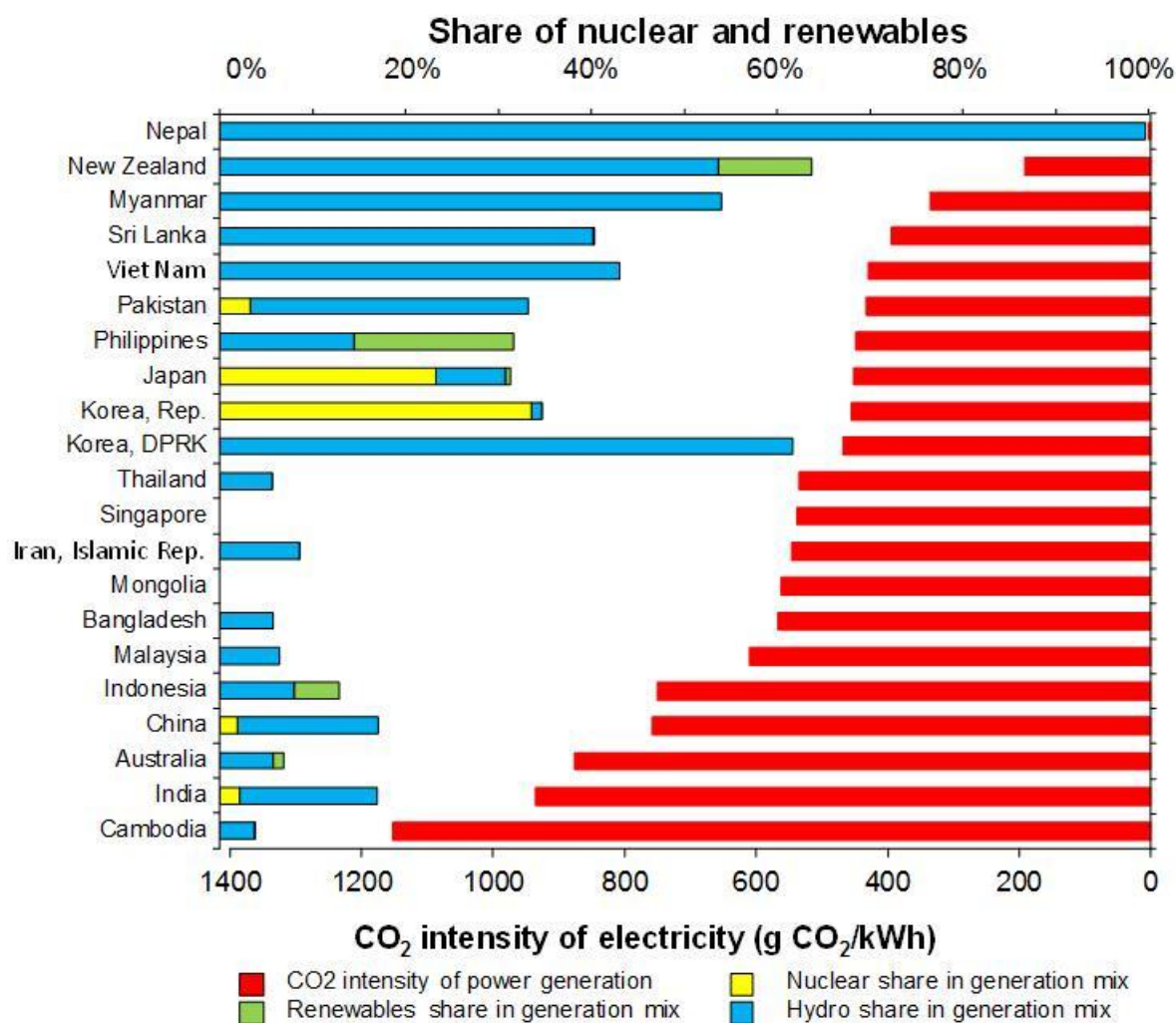




The practical manifestation of these assessments is illustrated in Figure 2 by plotting the CO<sub>2</sub> intensity and the shares of non-fossil sources in power generation for selected countries in the AP region. The top scale shows from left to right the relative contributions of nuclear, hydro and other renewable (wind, solar, geothermal, etc.) technologies to the total amount of electricity generated in 2007. The bottom scale measures from right to left the average amount of CO<sub>2</sub> emitted from generating 1 kWh of electricity in the same year. The chart clearly demonstrates that countries with really low CO<sub>2</sub> intensity (less than about 200 g CO<sub>2</sub>/kWh) generate more than 60% of their electricity from hydropower and other renewable sources (Nepal and New Zealand). Many other countries achieve relatively modest CO<sub>2</sub> intensity (below 500 g CO<sub>2</sub>/kWh) with a combination of low-carbon generation sources: hydropower, other renewables and nuclear. Japan and the Republic of Korea also belong to this group, thanks to the large share of nuclear power (about 23% and 33%, respectively) in their generation mix in the assessed period (IEA 2010b). A group of countries without significant shares of such power sources still generate electricity at medium CO<sub>2</sub> intensity levels, thanks to the large contribution of gas which has the lowest carbon intensity among the fossil sources. At the high end of the CO<sub>2</sub> intensity range, countries with high intensity (700 g CO<sub>2</sub>/kWh and more) have none (Australia) or only limited (China and India) shares of renewable and nuclear sources in their power generation mix (IEA 2010b).



Figure 2. CO<sub>2</sub> intensity and the shares of non-fossil sources in the electricity sector of selected AP countries. Source: IAEA calculations based on IEA (2010b)



In the global electricity sector, the IPCC (2007c) estimates that nuclear power has the largest potential (1.88 Gt CO<sub>2</sub>-eq.) to mitigate GHG emissions at the lowest cost: 50% of the mitigation potential at negative costs due to co-benefits from reduced air pollution, the other 50% at less than US \$20/t CO<sub>2</sub>-eq. According to the assessments of the International Energy Agency (IEA 2010a), nuclear energy could account for about 19% of the CO<sub>2</sub> reductions in power generation in 2050 in a scenario that would halve total GHG emissions by that time. In contrast, under IEA's 'Low Nuclear' scenario in which the total amount of nuclear power capacity falls from 393GW at the end of 2010 to 335GW in 2035, resulting in the share of nuclear power in global electricity generation dropping from 13% in 2010 to just 7% in 2035, GHG emissions would be 0.9 Gt CO<sub>2</sub>-eq. higher relative to the reference scenario (IEA 2011).

Considering the large and fast increasing share of the AP region in global CO<sub>2</sub> emissions, negotiators charting the way for climate protection under the United Nations Framework Convention on Climate Change (UNFCCC) discuss the need for more significant contribution of developing countries that currently do not have any legally binding reduction targets. From the AP region, this particularly concerns large

and populous countries responsible for large shares of emissions in the global GHG accounts. For them, nuclear power is certainly an option worth considering in the decision making process. Several IAEA Member States (MSs) in the AP region already utilize nuclear energy and have a strong domestic technology base they can rely on for further expanding their generating capacity: China, India, Japan, Pakistan and the Republic of Korea (IAEA 2011c).

A number of other countries are seriously considering adding nuclear to their energy mix or are already at various stages of active preparations for building nuclear power plants: Bangladesh, Indonesia, Malaysia, Thailand and Viet Nam (IAEA 2012b). The IAEA provides support to interested MSs to explore the complex issues involved in finding a robust national energy strategy by considering projected energy demand, supply options and costs, and energy security concerns (IAEA 2009b). The Agency also assists MSs in reviewing the commitments and requirements for establishing and implementing a nuclear energy programme (IAEA 2007).

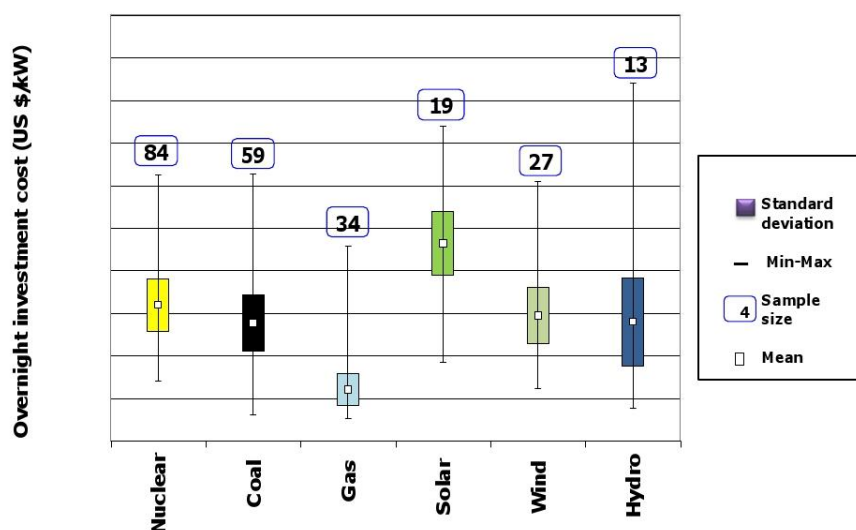
### **3. The contribution of nuclear energy to solving other energy-related problems**

Providing affordable energy for development in general and resolving energy poverty in particular is a fundamental challenge in many countries of the AP region. Energy is generally recognized as a central issue in sustainable development (Toth 2012). Several high level conferences and declarations have emphasized that the provision of adequate energy services at affordable costs, in a secure and environmentally benign manner, and in conformity with social and economic development needs is an essential element of sustainable development. In addition, the UN General Assembly declared 2012 the International Year of Sustainable Energy for All.

Reliable energy services are the preconditions for investments that bring about economic development. Among other things, they facilitate the learning and study and improved health care that are crucial for developing human capital. They also promote gender equity by allowing women to use their time for more productive activities than collecting firewood, and social equity by giving the less well-off the chance to study, thus providing a possible escape from poverty. Energy is therefore vital to alleviating poverty, improving human welfare and raising living standards. Yet, worldwide, 2.4 billion people rely on traditional biomass as their primary source of energy, and about 1.6 billion people do not have access to electricity (UNDP 2005) — conditions which severely hamper socioeconomic development. In the AP region, the share of population using solid fuels (typically heavily polluting traditional biomass) to cover their energy needs exceeds 50% in many countries, including populous ones, like Bangladesh, India, Indonesia and Pakistan (UNDP 2005). The number of people without access to electricity in the AP region was about 800 million in 2009 (UNDP and WHO 2009).

The relatively high investment costs for nuclear power, especially relative to gas, may be an impediment because capital in many developing countries is scarce. However, as Figure 3 shows, estimated overnight investment costs spread across a broad spectrum for all electricity generation technologies globally. Overnight investment costs for nuclear capacities are at the low end of the range in several AP countries (e.g., India and China).

Figure 3. Ranges for overnight cost estimates for the main electricity generation technologies, 2008–2010 (in 2008 US dollars). Source: IAEA (2010)



At the scale of the power sector, the displacement of fossil based power plants by NPPs can also reduce the emissions of other air pollutants that lead to harmful human health and environmental impacts at local and regional scales. NPPs emit virtually no air pollutants during their operation (Hirschberg 2012). In contrast, fossil based power plants are major contributors to air pollution. The World Health Organization (WHO) has estimated that air pollution causes approximately two million premature deaths worldwide each year (WHO 2008). Air pollution also contributes to health disorders from respiratory infections, heart disease and lung cancer. In many cities in the AP region, the level of particulate matter in the air exceeds 70 micrograms per cubic metre ( $\mu\text{g}/\text{m}^3$ ), and by reducing it to 20  $\mu\text{g}/\text{m}^3$  (the air pollution concentration level recommended by WHO), air quality related deaths could be cut significantly (WHO 2008).

At the regional scale, air pollutants travelling long distances cause acid rain, harming nature and society at large. Acidification disturbs ecosystems (freshwater fisheries and forests) and causes damages to crops, certain building materials, and to historic and cultural monuments. Acid rain is caused by sulphur and nitrogen compounds, and fossil fuel power plants, particularly coal power plants, are the primary emitters of the precursors of those compounds. Technology solutions exist to reduce these emissions, but the cost of their installation and operation might make nuclear power more attractive (Hirschberg 2012).

Many countries in the AP region have repeatedly expressed strong concerns about the security of their energy supply that has various aspects. The first factor is the price of fossil energy sources. The rate of infrastructure development in fossil resource extraction and delivery in key supply regions is lagging behind the fast growing energy needs, and this is exerting a sustained upward pressure on international oil and gas prices, even taking into account the speculative bubble that affected commodity

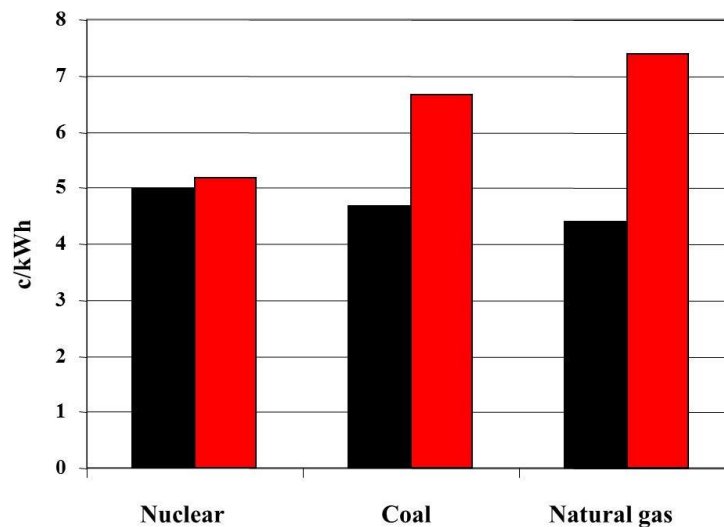
prices and culminated in mid-2008. This in itself is a strong motivation for countries with high shares of imported fuels in their electricity generation to look for substitutes. The second factor is that political conflicts in key supply regions exacerbate the price pressure and raise serious concerns regarding the security of supply per se, even at high prices. This is yet another reason for considering alternative electricity sources, like nuclear.

Supply security concerns affect countries in the AP region differently. Energy importing developing countries tend to be more anxious about the sustained high price level because of the prospect of its severely increasing their energy import bills, affecting their current account balances and undermining the competitiveness of their export industries. In most developed AP countries (except those with very small energy resource endowments, like Japan and the Republic of Korea), energy is a relatively small fraction of the total import bills and the energy content of their exports is lower. These countries are more concerned about direct losses due to supply disruptions, especially if these might render expensive capital and labour capacities idle for some time.

Another closely related factor is price volatility. All elements of the energy supply infrastructure are long lived. Energy intensive industries base their investment decisions on cautious expectations about future energy and electricity prices. A reasonable degree of stability and predictability of resource prices is crucial for such decisions because hedging against large price fluctuations might be vastly expensive.

Nuclear power can help mitigate these concerns. The price of uranium has a small influence on the cost of nuclear based electricity, as opposed to fuel prices in the case of coal and especially gas based generation. Figure 4 shows that doubling the price of uranium would increase the cost of nuclear electricity by about 4 to 6%, whereas doubling the price of coal would lead to an increase of about 40% and a doubled gas price to an increase of almost 70% in the corresponding electricity costs.

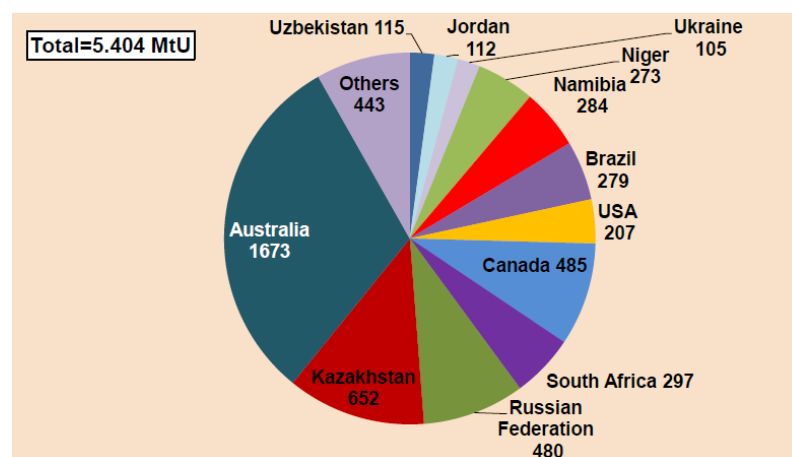
Figure 4. Impact of doubling resource prices on the cost of electricity from selected sources. Source: IAEA calculations.



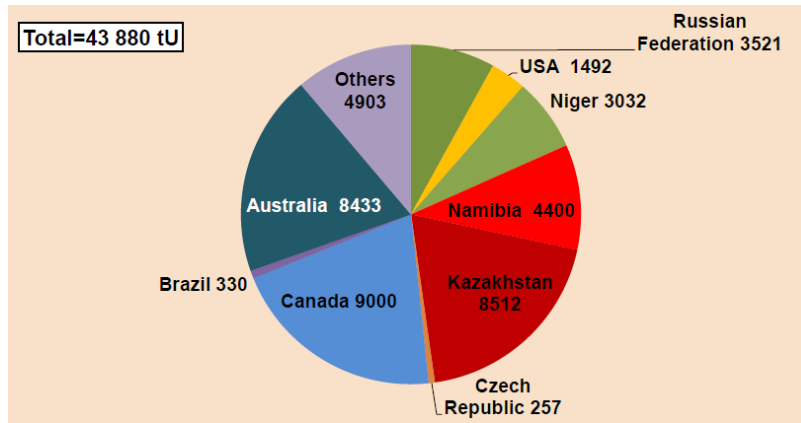
The best way to strengthen a country's energy supply security is diversification: increasing the number and resilience of energy supply options. For many countries in the AP region, introducing or expanding nuclear power would increase the diversity of energy and electricity supplies. Nuclear power has one additional feature that generally further increases resilience. Figure 5 shows that resources and reserves of the basic fuel, uranium, are spread throughout politically stable regions over five continents that would impede any cartelization attempts. Regarding possible short-term supply disruptions, the small volume of nuclear fuel required for one load to run a reactor for one year or so makes it easier to establish strategic inventories on or close to the reactor site. In practice, the trend over the years has been away from strategic stocks towards supply security based on diverse and well-functioning markets for uranium and fuel supply services (NEA and IAEA 2010). However, the option of relatively low cost strategic inventories remains available for countries that find it important.

Figure 5. Distribution of reported uranium resources and production. Source: NEA and IAEA (2010)

(a) Distribution of reported uranium resources in 2009.



(b) Distribution of reported uranium production in 2008.



#### **4. Conclusion**

The economics of nuclear power is improving and will be further enhanced by the increasing CO<sub>2</sub> costs of fossil based electricity generation. Recent assessments compiled by the OECD Nuclear Energy Agency (NEA) and International Energy Agency (IEA) (NEA and IEA 2010) indicate that the ranges of levelized costs of electricity from natural gas, coal and nuclear sources largely overlap between 5 and 10 US cents/kWh, hence the choice among them depends on local circumstances, such as the lack or availability of cheap domestic fossil resources.

The costs of CO<sub>2</sub> emissions reduction by CO<sub>2</sub> capture and geological disposal and the charges for the emitted CO<sub>2</sub> from fossil based electricity give a competitive advantage to nuclear power. Despite increasing construction costs, financing nuclear power investments will be feasible under stable government policies, proper regulatory regimes and adequate risk allocation schemes. Once the business case for increasing nuclear investments is established, manufacturing and construction capacities will expand as required.

Climate change mitigation is one of the salient reasons for increasingly considering nuclear power in national energy portfolios. Other reasons include fears of sustained high fossil fuel prices, price volatility and supply security. Nuclear power is also considered in climate change adaptation measures, such as seawater desalination or hedging against hydropower fluctuations.

Where, when, by how much and under what arrangements nuclear power will contribute to solving these problems will depend on local conditions and national priorities, and on international arrangements, such as the flexibility mechanisms under the post-2012 protocol to the UNFCCC currently being negotiated under the Durban Platform (UNFCCC 2011). Yet the decision about introducing or expanding nuclear energy in the national energy portfolio rests with sovereign States.

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