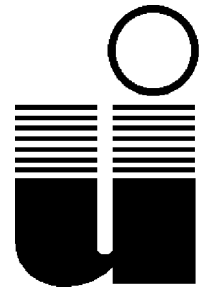


The Uranium Institute

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Energy and Global Sustainable Development

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I am most grateful for the opportunity to make a presentation at this Uranium Institute Annual Symposium, for several reasons.

First, to bring greetings from the International Atomic Energy Agency (IAEA), which is now a vigorous 40 years old and is celebrating its anniversary, *inter alia*, by the publication of a history of the organisation and a volume of essays by a number of persons who have played significant roles in the IAEA.

Second, to bring greetings from myself, a 69 year old Director General of the IAEA about to hand over the central management of the agency after 16 years to a younger person. And to tell you how much I have appreciated throughout these years the contacts and cooperation with the Uranium Institute. It was my old Swedish friend, Erik Svenke, a distinguished nuclear engineer and a prominent member of the Institute, who introduced me to the UI in 1982. He opened my eyes to the fact that, although different in membership and aims, the two organisations have a number of things in common.

Perhaps foremost among these is a rationalistic attitude to nuclear energy and nuclear techniques. Such an attitude naturally leads to an interest in using nuclear energy for the benefit of mankind and satisfying the preconditions for such use — safety and economy in all operations from mining to waste disposal, and efforts to ensure that the peaceful uses promoted are not misused for military ends. These common interests have led for a number of years to a very fruitful cooperation. We have been particularly gratified that the Executive Committee of the Institute convenes

periodically in Vienna allowing the two management teams to exchange information and experiences.

A third reason for me to appreciate this opportunity is that I want to convey to you my conviction about the inevitability of a nuclear power's revival. There is at present a glaring credibility gap between the declared public determination to limit the global emissions of greenhouse gases linked to fossil fuel burning and the means currently suggested to achieve this — namely, energy savings and an expanded use of renewable sources of energy. It would be paradoxical in this situation if the world were to continue burning ever more hydrocarbon resources — which could have more valuable and less damaging uses — and were to leave in the earth uranium and thorium resources which can hardly be of any other peaceful use than as fuel in nuclear reactors. I join the statesman who expressed confidence that governments will act rationally — once they have exhausted all other options.

However, at the same time I must admit that although several factors suggest that an early re-examination of the nuclear power option will be inevitable, the other options advanced do not yet seem fully exhausted. What we still witness is an almost total absence of nuclear power construction in the Western industrialised countries, the completion of a number of plants in Eastern Europe, and vigorous construction only in East Asia. What we witness, further, is a continued brisk expansion of the use of all fossil fuels, especially gas. Lastly, what we are still told from global fora is that the desired restraint in the emissions of CO₂ is to be

pursued through energy savings, modern techniques and expanded use of solar and wind power and biomass.

In these recipes nuclear power seems quietly written off, and no government seems to lift a finger to put it in the mix. Why then am I optimistic? Because the recipes advanced appear unrealistic and inadequate to achieve the desired restraint in global greenhouse gas emissions, while a greatly expanded use of nuclear power would help significantly to inhibit these emissions. Let me explain.

Energy Use is Expanding

It is generally understood and agreed that the global use of energy, especially electricity, will continue to expand. The driving forces are a growing world population, industrialisation and improvements in standards of living. The World Energy Council (WEC) low to medium range forecast is that the global use of electricity will increase from 1990 levels by 50% to 75% by 2020. This is one of the safer predictions in the energy field. Especially the economically fast developing populous countries in Asia will expand their energy and electricity use.

Today China is using nearly 1000 kWh per person/year, while the Republic of Korea uses 5000 and Japan 7500. Almost wherever we look in Asia we see plans for sharply expanded use of energy and especially electricity: China, the Philippines, Indonesia, Malaysia, Thailand, India, Pakistan. But expansion is also taking place in other developing parts of the world, eg. Turkey, Mexico and South America. Even in Europe, electricity demand and generation are going up, mostly with reliance on combined cycle gas-fired plants. As most of the added global electricity generation capacity is fossil fuel based, and as the expanding transportation sector is largely oil based, the short term outlook is unequivocally for greater burning of coal, oil and gas, and correspondingly greater emissions of CO₂ and leakage of methane from the production, transportation and use of gas.

The present reality is that oil, coal and gas — the fossil fuels — provide nearly 85% of the commercial energy the world uses: close to 39% from oil, 25% from coal and more than 21% from gas, with nuclear power and hydro power providing between 6% and 7% each. Commercial renewables like geothermal, wind and solar power and biomass provide about 1%. (These figures are 1997 data supplied by the US Department of Energy.)

Restraint in CO₂ Emissions

The current mix of energy sources combined with expanding total energy use has led to ever louder demands for restraint in greenhouse gas emissions. So far the rhetoric and the reality have gone in opposite directions. In 1988, there was the so-called Toronto target to “reduce CO₂ emissions by approximately 20% by the year 2005.” However, since 1988, global CO₂ emissions have, in fact, increased by some 16%.

In 1992 came the Rio target for industrialised countries to return to 1990 levels of CO₂ emissions by 2000. However, since 1990, CO₂ emissions in OECD countries have, in fact, increased by some 8%. One target propagated at this year’s special session of the UN General Assembly (UNGA) is a 15% reduction of greenhouse gases by 2010 compared to 1990. However, an International Energy Agency (IEA) study projects CO₂ emissions in 2010 to be in the range of 36% to 50% above their 1990 level. The road to global warming — like the road to hell — seems paved with good intentions.

As public demands become more insistent that the CO₂ abatement targets should be made binding and acted upon, the various consequences of the adoption of targets begin to be more seriously examined in many countries. As this is done disagreements surface, not only between developing, industrialised and oil producing countries, but also amongst the industrialised countries.

To take some examples: should a country like my own, Sweden, which still generates practically all its electricity by CO₂-free nuclear and CO₂-free hydro power, also be forced to cut CO₂ emissions by 15%? Or should Sweden be allowed to increase CO₂ emissions in order to be able to replace nuclear power by gas-fuelled electricity? Should China be obliged to restrain its total CO₂ emissions although its per capita emissions of CO₂ are among the lowest in the world? How could Australia, with an almost total reliance on coal-based electricity, continue to expand electricity use without increases in CO₂ emissions?

As the world economy is spinning faster, the lights and TV sets are multiplying, an ever longer column of trucks and cars are pouring onto the roads, and the cost of the oil, coal and gas which fuel this fiesta remains low, the problem of a global restraint in greenhouse gas emissions, notably CO₂, will become increasingly difficult.

There will be no lack of opportunities to discuss these problems:

- The USA has recently announced that a White House conference will be convened later this year to convince the people of the USA and Congress that “the climate change problem is real and imminent”; I applaud this initiative. Understanding and awareness of the problem is a prerequisite for a rational and realistic consideration of possible action.
- Toward the end of 1997 the third conference of the parties to the UN Framework Convention on Climate Change (UNFCCC) will be held in Kyoto. That convention is geared to achieving restraints in greenhouse gas emissions rather than restraints in the use of any specific fuel. It may indeed be wise to leave it to individual states to determine how they will achieve agreed greenhouse gas restrictions. However, agreed targets for restraint must be attained by some energy, tax or other policies. Therefore the underlying questions of energy use must remain in focus for governments even though these questions might be formally kept outside the Kyoto conference.
- In March or April 1998, Russia is inviting the G-7 to an energy ministers’ meeting preceding the 1998 G-7+1 summit.

A stage is thus being set requiring governments to seriously examine what energy and other policies they can recommend for their own countries and for the world in order to restrain the emissions of CO₂ and other greenhouse gases. In my view, the recipes handed to them most recently at the UNGA special session on sustainable development in June 1997 — the so-called Rio+5 — do not seem likely to take us very far.

Greater Energy Efficiency

The first recipe is greater energy efficiency — to get more energy per CO₂ quantity emitted. This line is generally supported and there is no doubt that in most countries much fossil fuel burning can be avoided by greater efficiency. However, energy saving, which is often achieved in connection with technology change, does not happen overnight but rather when machinery or production methods are no longer economic. The speed with which technology is changed may depend upon many factors, including the price of fuel, which in turn could be influenced by the removal of possible subsidies or by the adding of taxes on CO₂ emissions.

Thus while energy efficiency — in generation, transmission and end use — is highly significant, it will be far from sufficient to compensate for the

expected greater demand for energy. New types of light bulbs and refrigerators will use less electricity, yes, but there will be many more lights and refrigerators. New cars will run much longer on a litre of petrol, but there will be many more cars. And so on.

Tradeable Emission Permits

One approach currently advocated to achieve restraint in greenhouse gas emissions is a system of so-called “tradeable emission permits”. The idea is that the right to emit greenhouse gases, within an overall set limit, is obtained at a cost — and that such emission rights, or permits, can be traded. If the limitation is set on the total emissions in an individual country, the price of permits will be set within that country according to the rules of supply and demand — and equally the market will determine what greenhouse gas emitting activities will be carried out.

In another variant, the limit would be set globally, and within that limit national quotas would be allocated. Those national emission permits could be bought and sold internationally in such a way that the global limitation is respected. Thus, if a developing country did not fully use its allocation, it could sell the unused portion in an international market and thereby, it is argued, get valuable financial resources for development.

There are surely some attractions in this idea. It promotes greenhouse gas restraints, inter alia, through a premium on the use of energy sources, including nuclear, which emit little or no greenhouse gases. But does it not also place a premium on remaining underdeveloped? And is it realistic to believe that we can negotiate agreement on greenhouse gas emission allocations for all the countries of the world? What would be an equitable criteria for allocations? Per capita or GNP? What system of monitoring and enforcement would be required? I suspect the obstacles to devising and realising a system of this kind are formidable.

Renewable Sources of Energy

The second recipe, advocated ever since the Rio Conference in 1992, is a greater use of renewable sources of energy — notably solar and wind power and biomass. Curiously, geothermal energy which is currently the largest among the renewables is rarely mentioned. In any case these sources — practically all heavily subsidised — currently provide the world about 1% of its commercial energy, and WEC is probably generous when it says that “with adequate support” this share

could increase to 5-8% of the total commercial and non-commercial increased world energy supply projected for 2020.

It is not suggested that it would be technically impossible to develop huge wind farms, vast biomass plantations, or fields of solar cells. A good deal of research and experimentation is going on, both with public and private money, to use these sources for electricity generation. Some niche applications have been found, for instance solar energy for the heating of household water, and photovoltaic solar cells for electricity generation in distant places where it would be very expensive or difficult to build power lines.

However, it is very hard to imagine that these sources of energy could be economically viable for large-scale baseload electricity generation. The reason is that harvesting energy sources that have low energy density is inevitably expensive. The wind blows everywhere and the sun shines everywhere, but achieving the electricity generating capacity of a 1000 MWe power plant by these sources requires cumbersome installations and operations. It has been calculated to require:

- an area in the range of 25 to 50 km² of solar cells;
- 50 to 150 km² for windmills;
- 3000-5000 km² of biomass plantations.

The intermittent character of solar and wind energy is also likely to be a severe handicap so long as we do not have better means of storing electrical energy. It is, indeed, hard to imagine that the rapidly growing number of energy-intensive megacities — like Mexico City, Bombay, Calcutta, Jakarta, Shanghai or Istanbul — could satisfy their growing electricity demand by relying on renewables.

New Technologies

The third recipe we encounter in the discussion about lowering greenhouse gas emissions, for example in a booklet entitled *Energy After Rio* issued by the UN Development Programme, is to make full use of the next generation of technologies to utilise fossil fuels. Who is against new technologies if they are economic, effective and environmentally beneficial?

Some such technologies will certainly emerge. In the IAEA we have for some years now championed the installation on a pilot basis of nuclear accelerators into the exhaust systems of coal-powered plants. An electron beam is directed at the flue gases, to which ammonia has been added — and instead of harmful emissions of sulphur dioxide and nitrogen oxides, ammonium

sulphate and ammonium nitrate are obtained and can be sold and used as fertilizers. A nuclear technique in the service of recycling!

However, new technical methods, interesting as they may be to remove some harmful pollutants, do not neutralise the CO₂ emissions which are linked to all burning of coal, oil and gas, and which are now seen as the most problematic contribution to the greenhouse effect. This being so, it is in my view misleading to talk about “clean coal”. Indeed, coal burning results in even more CO₂ per unit of energy generated than do the other fossil fuels! There have been speculations about a possible technical means of separating and catching the CO₂ which results from the burning of fossil fuels, and of injecting it into the deep sea or into underground cavities. However, such suggestions seem very remote from practical, technical and economic realities.

I should add that speculations about reliance on fusion energy or on hydrogen are also far from being near or medium term realities, which we have to work with. A power plant we build today may have a lifespan of some 50 years. Thus our choice of plants today — coal, oil, gas, renewable or nuclear — determines our contributions to global emissions for a long time ahead.

CO₂ Restraint and Realities

The realities are that all available means to restrain the emission of greenhouse gases from fossil fuels will be needed: increased efficiency in the production, transportation and use of all energy is relevant; renewable sources of energy, including hydro power, can play a greater role than now, but not dramatically greater; and a significant switch from coal to gas would be helpful, as the burning of gas gives about half as much CO₂ per unit of energy as does coal.

The reality also remains that, while the use of nuclear power gives rise to radioactive waste which must and can be safely disposed of in its entirety, it does provide the world with over 6% of its energy practically without any harmful emissions. We have calculated that if the present 440 or so nuclear power reactors were closed and replaced by coal fired plants, there would be an 8% increase in global CO₂ emissions.

In a speech before the second conference of the UNFCCC in 1996, Mr Priddle, the Executive Director of the IEA, expressed this reality in a different way. He noted that “nuclear power accounted for the greater part of the lowering of carbon intensity of the energy economies of the OECD countries

over the last 25 years". As an illustration, let me offer a comparison between the UK and France. In 1994 some 49% of the electricity in the UK was generated by coal and the CO₂ emissions per kWh were about 630 g. In the same year, some 75% of the electricity in France was generated by nuclear power and the emissions of CO₂ per kWh were about one tenth of the UK value, or 64 g.

I am not submitting to you that uranium-based electricity or heat is an attractive energy choice only because it contributes no greenhouse gases. Another positive feature is the stability of supply of the uranium fuel. Also, nuclear fuel can easily be stored, thus offering a measure of energy independence which is of great importance to economies with high reliance on imported energy sources. It has been said that a pipeline has the merit of creating a mutual dependence between the exporter and the importer. However, experiences (eg. in Armenia) show that the recipient waiting at the exit tap is the more vulnerable.

In purely economic terms, new nuclear power plants have lost some edge in many places against gas used in combined cycle. This edge needs to be restored through better management and economy, from the beginning to the end of the nuclear fuel cycle. This is a challenge for miners, nuclear plant engineers and operators — and regulators.

Why is Nuclear Power Ignored?

It may seem puzzling that the nuclear option is largely ignored at a time when there is an ever greater worry that the burning of fossil fuels might lead to global warming, and when it seems clearly unrealistic to expect that greater energy efficiency or greater use of renewables will go very far to help us restrain CO₂ emissions. A much heavier reliance on nuclear power would be both possible and have a significant effect.

A formula often encountered in the international debate simply writes off the nuclear option by referring to "public concerns" about nuclear safety, disposal of waste and the risk of proliferation of nuclear weapons. To start with it seems curious that in a debate that deals with the future health of the planet, a significant possible remedy is simply ignored by reference to public opinion, without any serious examination whether that opinion is justified or not. It may well be that governments facing elections are not keen generally to examine critically and contradict any sizeable body of public opinion, if they can avoid it. So far there have probably not been so many votes to gain — but some to lose — by a serious examination of anti-

nuclear concerns. However, this could change.

If the public were to become increasingly concerned about the continued growth in CO₂ emissions and dissatisfied with the cost and lack of realism of the remedies so far advanced and tried, perhaps political leaders might be moved to a serious examination of the "concerns" — an examination which I trust would find the concerns exaggerated and certainly insufficient as grounds for ignoring the nuclear option.

A public confronted by neutral assessments of the possibilities, costs and risks connected with a greater use of nuclear power, and similar assessments of the possibilities, costs and risks connected with alternative approaches, may reconsider its fears and concerns. It may come to rank the worry about possible global warming affecting their grandchildren higher than the concerns which it had about the use of nuclear power.

"Public concerns" are not something written in stone. They may be influenced by a variety of factors and may change within the span of a decade or less. I think they will — if the public is better informed about the realities, risks and results of the various options. For instance, who would believe that China could carry out its planned expansion of electricity generating capacity by some 16 000 MWe per year by using solar or wind power or biomass? Who would believe that China, today using some 1000 kWh per capita per year, could neutralise increased electricity demand by energy efficiency, when in Japan — a country very advanced in energy efficiency — the per capita annual use of electricity is some 7500 kWh?

Who would believe that renewables and energy efficiency will offer adequate means of achieving CO₂ restraints, when even most European and other industrialised countries are expanding their use of fossil fuelled energy? Is it not soon time for the think-tank thinkers to throw a glance at the real world?

What Can the Nuclear Industry Do?

It seems to me that those who share a rationalistic attitude to nuclear energy and technology can do several things in the current situation to accelerate a broader understanding and acceptance of nuclear power. A first line of action is to actively, publicly and impartially present the merits and problems of an expanded nuclear power use as compared to alternative energy options advocated, both fossil and renewable sources. This comparison must deal with the cost, risk to life, health and

environment, and the energy independence and security aspects which are connected with the different options. A second line of action must be to work for a continuous increase in the level of safety — from the mining of uranium, through reactor operation to waste disposal. A third line consists of efforts to ensure a continuous decrease in the number of nuclear weapons.

In my view, the factual current overall situation of nuclear power is satisfactory in all the areas I have mentioned. But it is not so satisfactory that it cannot be improved, and be perceived to be improved. Let me be specific.

Fear of nuclear accidents that release radioactivity is probably at the heart of many people's concerns about nuclear power. Although we must explain to the public that the risks in using nuclear power are low and must be compared with the risks of using alternative ways of generating electricity, we can, should and do set the nuclear safety goals higher than any other energy generating technology does.

We know that even if Chernobyl is taken into account, the number of fatalities associated with electricity generation is much lower in the nuclear fuel cycle than in fossil fuel cycles. And we know that the largest potential accidents in terms of casualties in the energy field are connected with the collapse of hydro dams. These things have to be explained, as it has to be explained that — contrary to what the media may be inclined to say — most accidents in the nuclear field are not very damaging. To help clarify the precise magnitude of nuclear power accidents — which otherwise always tend to be written up — the IAEA has introduced the International Nuclear Event Scale (INES) which grades accidents from 1 to 7.

Although I submit that a persistent public information effort is essential, I also recognise that probably only a prolonged relatively problem-free operation of nuclear power plants will dispel misgivings about the use of nuclear power. Efforts all over the world and at many levels are needed to maintain such a good record. We must learn from years of operation and improve equipment, technologies and procedures of operation. Operators and their organisation, the World Association of Nuclear Operators (WANO), as well as national regulators, the IAEA and the nuclear industry, are in fact actively engaged in this process. I submit the nuclear and aviation communities are far ahead of other major industries in global efforts to maintain and further improve safety.

While nuclear safety remains the responsibility

of individual states, universally accepted rules are laid down in IAEA nuclear safety standards and are enshrined in legally binding IAEA conventions. The convention on safety of nuclear power operation also creates procedures for international peer review. We expect that a similar convention on the safe management of spent nuclear fuel and waste will be adopted in Vienna during September 1997.

Indeed, it may be said that an international legal infrastructure specifying the norms for the safe use of nuclear energy is now in place, together with mechanisms for peer review and services to assist states to live up to common safety norms. Let us hope that this system and universal respect for it will help to de-demonise nuclear energy and radioactive spent fuel and waste. Yes, spent nuclear fuel and waste must be handled prudently, but due to its very limited volume it is technically and economically possible to isolate it from the biosphere. By contrast, the gigantic volumes of emissions of gases and particles and the poisonous heavy metals released in the burning of fossil fuels gravely threaten our environment and climate. The final disposal sites of fossil fuel wastes are not deep down in solid rock. They are released into the atmosphere we breathe and dumped on the earth where we walk.

Let me conclude by noting that with the end of the ideological confrontation between East and West the peaceful atom is beginning to prevail over the belligerent atom. Nuclear weapons which were numbered in many tens of thousands are becoming increasingly irrelevant. The USA and Russia are fast dismantling large parts of their nuclear arms stocks, and the IAEA is discussing with Washington and Moscow how the agency can be used to assure the world that no enriched uranium or plutonium from dismantled weapons placed under IAEA verification is going back into new weapons. We would like to see such a task be followed by the task of verifying that no new high enriched uranium or plutonium be produced for use in weapons anywhere.

It seems that the conclusion which emerged from the period of Cold War confrontation — that a nuclear war cannot be won and must not be fought — is now being acted upon by the declared nuclear-weapon states. The president of Brazil recently expressed the view that the nuclear weapons era is drawing to a close. I think he is right. Competition between great powers and groups of nations will continue, but it will probably be pursued in the fields of economy and

information.

However, in a world of nuclear disarmament, states need to feel confident that no-one is secretly developing or hiding nuclear weapons. This requires a universalisation and a further consolidation of the successful non-proliferation regime. IAEA verification — the safeguards system — is an essential instrument contributing to confidence. It has recently been much strengthened. The universal acceptance and successful implementation of this new system is needed not only to help create confidence amongst states; it is equally needed as a basis for international trade

in nuclear materials, equipment and technology.

Neither the IAEA nor its member governments wish to make the strengthened system unduly burdensome. But it has to be effective and they look to the nuclear industry to help make it an effective and indispensable part of the effort to ensure that nuclear power is used only for peaceful purposes. Ending the era of nuclear weapons will make it easier to enter the era of expanded nuclear power, which will be needed for a better life for the world's population and for protecting our environment.