THE ROLE OF THE NUCLEAR INDUSTRY IN THE WORLD

Canadian Nuclear Association

October 2016

The Future is NU.
Canadian Nuclear Association

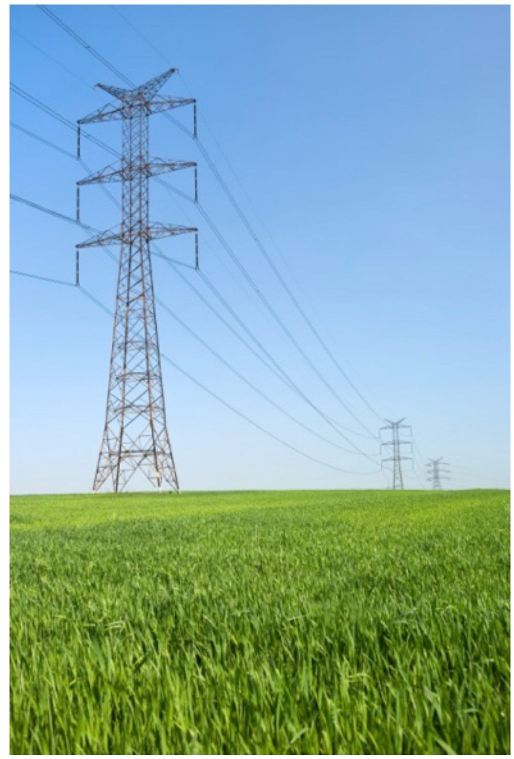
Preamble

This paper was commissioned by the Advisory Board of the Nuclear Industry Summit 2016. It firstly highlights the immense societal benefits provided by the International Nuclear Industry (not only in the area of nuclear power and so therefore the mitigation of climate change but also in the fields of medicine and industry). Secondly, it explains how we provide necessary security for our materials and technologies. This paper may be complimented by an exhibition area at NSS/NIS 2016. Thirdly, in order to remain accessible to the general reader, the paper does not utilize extensive footnotes, but has drawn from a number of authoritative and international sources; a selected listing of these sources can be found in the appendix.

Executive Summary

Most people go about their business not spending a lot of time reflecting on the technical origins of the things they see, use and enjoy in their everyday lives. However, what they do presume, and insist upon, is that these things – whether consumer products, techniques for making food safe, or sources of energy and electricity – are secure. And, in the case of nuclear technology, that the civil nuclear industry takes the appropriate measures to ensure they are secure.

For those who are not nuclear physicists and engineers, or specialists in nuclear medicine and radioisotopes, there is little discussion about the nuclear industry. As a result, they are often unaware of the incredible breadth and diversity of how nuclear technology and materials are actually used. Therefore, the onus is on the industry to provide a simple but effective understanding of the vital contribution of this technology to humanity.



This document attempts to do just that. It provides a short, accessible insight into the vital contribution of this technology to peaceful uses that benefit our societies and our well-being. The nuclear industry's role in securing the radiological technologies and materials it uses is also described. Three key messages can be drawn from the pages that follow:

1. Nuclear technology is vital for more than just providing reliable, low-carbon energy. It also has life-saving medical applications; improves manufacturing, mining, transport and agriculture; and helps us discover more about the planet we live on and how we can sustainably live with it.
2. Maintaining the security of facilities and radioactive materials is fundamental to all well-managed operations in the nuclear industry. Industry works closely with governments and regulators at the national and international level to ensure the public is protected.
3. People of all countries deserve access to the many benefits of nuclear technology, but the security challenges must be addressed. To this end, the international nuclear industry will, as it has done for decades, work towards improving governance, exchanging information and learning from good practice. Enhancing public confidence in the effectiveness of the industry's security practices will help to sustain the public's awareness of – and support for – the myriad and everyday peaceful uses of nuclear technology.

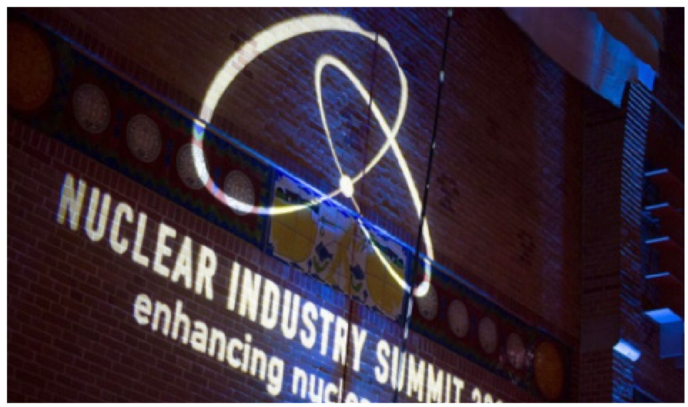
Table of Contents

1.0 Introduction : The Vital Contribution of Nuclear Technology and Materials to Modern Society

The COP21 Paris Agreement on combating climate change set ambitious targets for the reduction of greenhouse gases and emissions from fossil fuels. The world is facing the **global challenge** of obtaining energy for life, food, warmth, health – in short, for the betterment of humanity – and doing so using low-carbon energy sources. A transition is under way, and all low-carbon technologies must be brought to bear. Nuclear energy – a clean, powerful source of electricity – is one of them. At the same time, nuclear technology also brings additional benefits to humanity that are not always well understood or recognized, even by the people whose lives are directly and positively enhanced as a result.

As the Joint Statement of the 2014 Nuclear Industry Summit noted:

"Nuclear technology and materials provide a vital contribution to modern society, as do the radioactive sources used in industry, medicine, agriculture, research and other fields. Nuclear power currently provides 12% of the world's electricity and has one of the smallest carbon footprints of any major energy source. Tens of millions of patients are treated with nuclear medicine each year and 90% of these support clinical diagnoses; there are over a 100 different nuclear imaging procedures in use at the thousands of medical centres that use nuclear medicine for the benefit of human health.



"Continued public confidence is essential for the application of nuclear technology, and the extensive benefits that it brings. Participants commit to enhance public and stakeholder confidence through high standards of transparency, integrity, ethical behaviour and social responsibility."

Public confidence is essential if the public is to continue to reap the benefits of nuclear technology. They are committed to building the desired confidence and carrying it beyond the 2016 NIS Summit. It is therefore important to provide clear information on the vital contribution made to modern society by nuclear technology and to openly discuss the types (but not necessarily the details) of the security and safety controls that are integral to all facets of the nuclear industry.

2.0 Context: Building Public Awareness of the Benefits of Nuclear Technology and Public Confidence in its Safety and Security

Public acceptance of nuclear technology is dependent on both public knowledge of the benefits that nuclear technology provides to society and the economy, and their confidence that materials and technologies are being managed in a responsible manner.

Many benefits derive from the peaceful uses of nuclear technology. Our industry is a proud and responsible provider of these benefits.

The public are often unaware of the extent to which **aspects of everyday life** involve products and processes originated from the application of nuclear technology via the nuclear industry. Many are surprised to learn of how their quality of life is positively enhanced by this technology – and in a multitude of ways ranging from medical treatment through to better health and clean air, to food safety, electricity generation, advanced manufacturing – and beyond, even to such ordinary products as exit signs.

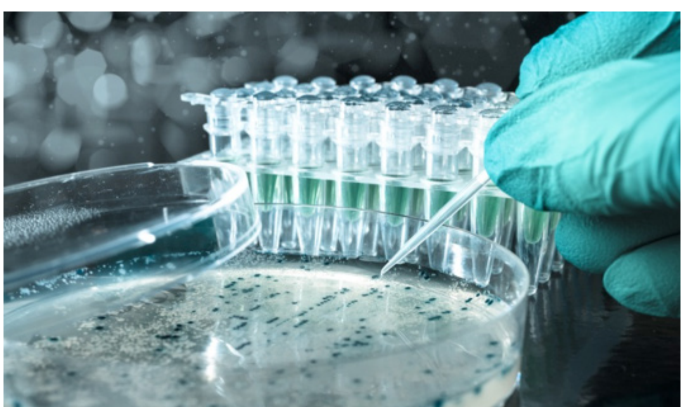
Modern society could not operate without the contribution of nuclear technologies. Our homes and offices would not have smoke detectors. Bridges would not bear weight as reliably, aircraft would not fly as safely, pipelines would leak more often, and more of our friends and neighbours would die of undiagnosed heart disease and untreated cancers.

For **emerging economies** and countries on the road to economic development, the contribution of nuclear science and technology takes on additional importance. As the IAEA Director General said, these technologies "can make a major contribution to economic growth and have an important role to play in support of sustainable development".

Section 3 of this paper gives detailed descriptions of the benefits provided by nuclear technology to a variety of societal endeavours.

3.0 Benefits of Nuclear Technology and Material to Humanity

The World Nuclear Association recently described the impact of nuclear technology on our daily lives as follows:



"From the moment we get up in the morning, until we go to sleep, we benefit unknowingly from many ingenious applications of radioisotopes and radiation. The water we wash with (origin, supply assurance), the textiles we wear (manufacture control gauging), the breakfast we eat (improved grains, water analysis), our transport to work (tire rubber polymerization, thickness gauges for checking steels and coating on vehicles), the bridges we cross (neutron radiography), the paper we use (gauging, mixing during production processes), the drugs we take (analysis) not to mention medical tests (radioimmunoassay, perhaps radiopharmaceuticals), or the environment which radioisotope techniques help to keep clean, are all examples that we sometimes take for granted."

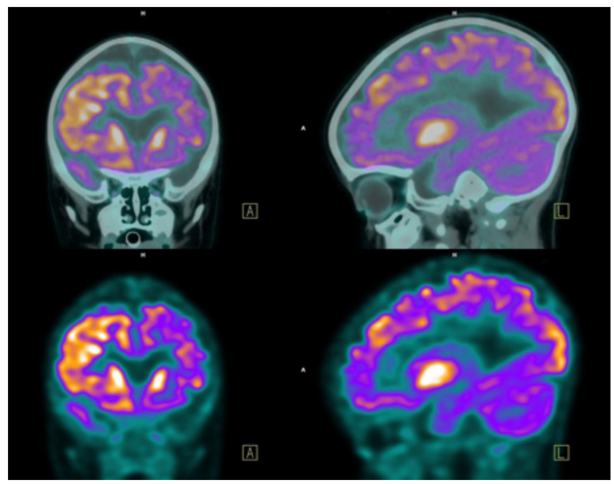
The **benefits to humanity** comprise human health (diagnostics and treatment; combating communicable and non-communicable disease); food and nutrition (safe food and better crops);

environment and sustainability (tackling climate change and adding fresh water resources); electricity and power (the path to a better life); consumer and industrial products (for daily life and economic growth); and public safety (radiological detection).

The IAEA notes the "clear links" between the United Nations' Sustainable Development Goals and the contribution of civil nuclear technology, notably in the areas of energy, food security, nutrition, human health, environmental protection, and the management of water resources.

3.1 HUMAN HEALTH

Many people do not realize the importance of radiation and radioisotopes for **screening, diagnosis and therapy** of various medical conditions. According to the WNA, over 10,000 hospitals worldwide use radioisotopes. The use of radiopharmaceuticals in diagnosis is growing at over 10% per year. It has been estimated that almost 100 different diagnostic nuclear medicine procedures are available today – and almost every major organ system can be imaged using these techniques.



Diagnostic nuclear medicine helps to determine the cause of health problems based on the function of the organ, tissue or bone. Radioactive isotopes are widely used to indicate tumours and to study the heart, lungs, liver, kidneys, blood circulation and volume, and bone structure. Radiopharmaceuticals are also administered to patients for imaging purposes. These images are captured by equipment such as a PET (positron emission tomography) scanner or a gamma camera.

An advantage of **nuclear over x-ray techniques** is that both bone and soft tissue can be imaged very successfully. Lung scans use radioactive materials to detect the presence of blood clots; bone scans can detect the spread of cancer 6-18 months sooner than x-rays. Technetium-99m, the most widely used diagnostic radioisotope, gives the patient a very low radiation dose. It is used in some 40 million diagnostic procedures per year. Imaging with radioactive technetium-99m can help diagnose bone infections in young children at the earliest possible stage.

Radioisotopes are used in therapy to control and damage cancerous growths. Iodine-131 is used to treat thyroid cancer; Phosophorus-32 to treat leukemia. The Word Health Organization (WHO) considers **radiation therapy** to be "fundamental to the optimum management of cancer patients."

The importance of nuclear medicine to people all over the world cannot be over-estimated. It is a factor for saving and extending human life. It is also a factor in economic development because it is a technology available to nearly every country regardless of income levels. The IAEA points out: "In developing countries, malnutrition, communicable and non-communicable diseases,

particularly cancer, threaten health and cut short productive lives. Health problems and diseases can be detected and treated using nuclear techniques." Radiation medicine technology allows a country to develop cancer control capacity through the introduction, expansion and improvement of infrastructure, services and workforce.

On the medical research side, nuclear materials are widely used in **biotechnology** to follow the fate of specific molecules in the body; they are an essential part of biomedical research on diseases like AIDS, cancer and Alzheimer's disease. Radionuclides are essential for genetic research.

Many **medical products** today are sterilized by gamma rays from a cobalt-60 source, such as disposable syringes, surgical gloves, heart valves, bandages, plastic and rubber sheets, and surgical instruments. It is estimated that gamma radiation technology is used to sterilize up to 40% of all single-use medical devices in the world.

In the absence of the cobalt-60 isotope, **cost-effective radiation sterilization** would not be possible on a global scale. Moreover, sterilization by radiation makes the manufacturing and distribution process safer and cheaper because it can penetrate products while sealed in their final packaging, ensuring full sterility of the product. It is also used for implantable devices – e.g. orthopedics (hip and knee joints), stents, heart valves and more.

3.2 FOOD AND NUTRITION

A terrible statistic tells us that one out of every ten children born in developing countries will die before their fifth birthday as a result of **malnutrition**. According to the World Bank, investing in infant and young child nutrition can save one million lives each year, and can help 260 million more children and their mothers have a healthier future by preventing stunted growth and impaired brain development.

The IAEA points out the "hidden hunger" of **micronutrient deficiencies** – and what nuclear isotopes can do to help identify such deficiencies and combat malnutrition.

Micronutrients – e.g. pro-vitamin A, iron and zinc – are key building blocks for development in infants of a strong immune system against infectious disease. Stable isotope techniques using a specific stable isotope of the element or molecule under study can assess the availability of micronutrients in a young child's food as well as the child's ability to absorb them.

Knowing what is taken up and what is not helps to identify the source of malnutrition and thus the means to treat it. Such methods are non-radioactive and non-invasive. In addition, nuclear techniques are used for **neonatal screening** for sickle cell disease, hypothyroidism and cystic fibrosis, as well as childhood cancers.

Radioisotopes can also be used in a similar manner to find out the effectiveness of different types of **fertilizers**; by labelling a fertilizer with a particular radioisotope, one can discover how much of it is taken up by the plant and how much is lost. This leads to more efficient agriculture that is both less costly to the farmer and friendlier to the environment.

Radiation is used to preserve seeds and food products and breed disease-resistant plants. In **plant breeding**, some 1,800 new crop varieties have been developed through mutation induced by ionizing radiation. New genetic lines of root and tuber crops, cereals and oil seed crops have been produced; while new kinds of sorghum, garlic, wheat, bananas, beans and peppers have been made more resistant to pests and more adaptable to harsh climatic conditions.

A worldwide standard on irradiation to p**reserve food** was adopted in 1983 by a joint committee of the WHO, IAEA and the UN Food and Agriculture Organization (FAO). It is estimated that 25-30% of food harvested in many countries is lost as a result of spoilage by microbes and pests. Irradiation technology is increasingly being used to preserve food – spices, grains, fruit, vegetables and meat. It avoids the use of potentially harmful chemical fumigants and insecticides. Moreover, radioisotopes reduce post-harvest losses by suppressing sprouting and contamination.

Food irradiation uses gamma radiation to kill bacterial pathogens and other harmful organisms without affecting the nutritional value of food itself – or making it radioactive. This technique is used in over 60 countries to help protect food from contamination.

Gamma rays are highly effective at killing micro-organisms, yet there is no residue or radioactivity on or in the products and packaging. This means no quarantine is required and the product is immediately available for shipment or use after processing. For example, radiation is used to sterilize the packaging of milk products.

Irradiation of food products is increasingly regarded in many countries as a healthy and preferable alternative to chemical treatments. Smaller radiation doses to kill insects and their larvae are increasingly used as a phytosanitary precaution to prevent the spread of insect pests in international trade. The method's success in the United States, Latin America, South Africa and other regions has allowed resumption of the export of cash crops like grapes.

To illustrate the worldwide role of nuclear technology and applications in food production, the FAO/IAEA lists the following compelling statistics:

- 30 countries use nuclear science methods for improved **irrigation and crop production**.
- 48 countries use nuclear tracer techniques and FAO/IAEA soil and water management guidelines to protect their farmlands.
- 95 countries use isotopic and nuclear techniques to identify land and water management practices to improve **nutrient and water use efficiency** for crop productivity and environmental sustainability.
- 100 countries use radiation-based plant breeding techniques to improve food and industrial crops. Worldwide, over 3000 new varieties of crops have been officially developed and released by countries using **mutation-assisted plant breeding** techniques. Contrary to genetic engineering of plants, these nuclear-based plant breeding methods are working inside a specific genome and are natural, in the sense that the same process happened in nature over billions of years on a much slower scale by natural radiation.
- 64 countries use the carbon isotope discrimination technique to assess crop genotypes for **tolerance to drought and salinity**.
- 70 countries use disease diagnostic and monitoring tests to assist their **animal disease prevention, control and eradication** programs.
- 30 countries use the **Sterile Insect Technique**, which releases sterile but still virile male insects to prevent further offspring of insect pests. It is environmentally-friendly on two important levels. First, it does not introduce any toxic agents into the environment; second, it is highly specific, in that it only affects a single species and not the many harmless or even beneficial insects living in the same place.

3.3 ENVIRONMENT AND SUSTAINABILITY

Crop and livestock losses caused by insects – such as the tsetse fly, screwworm, medfly and Codling moth – are considerable. Use of the IAEA's Sterile Insect Technique irradiates the eggs of these insects to sterilize them before hatching. As a result, no offspring are produced and the insect pest population in the area can be drastically reduced or even extinguished in an island situation.

The IAEA estimates that, by suppressing insect pest populations with SIT, **pesticide use** worldwide has been reduced by 600,000 litres annually. Since 2006, the insect pest control program has generated benefits to farmers of more than $100 million and created thousands of rural jobs.

Water resources are essential to human life and development. A number of nuclear technology applications help us know the size and dynamics of **underground aquifers**, which is essential for the sustainable use of these resources. Other applications allow us to understand phenomena such as ocean acidification and its impact on marine ecosystems; find new sources of fresh water in the form of groundwater aquifers; identify pollutants and their sources in oceans and fresh water; and provide the necessary energy to power large-scale desalination operations.

Ocean acidification occurs as oceans absorb the rising quantities of atmospheric carbon dioxide, which converts into a weak acid – dihydrogen carbonate – in contact with water. Corals and other marine organisms, particularly those with exoskeletons, have problems to build and maintain their acid-sensitive calcium carbonate structures. Radiotracers track the effects of acidification on ocean chemistry and marine life. Nuclear techniques monitor the oceans' shifting chemical balance caused by ocean acidification – vital information if we are to protect the marine environment, which supplies almost a third of all protein consumed by humans.

Fresh water resources underground can be traced and measured by **isotope hydrology techniques**. Through this, existing supplies of water can be conserved and new renewable sources of water found. The isotopic composition of water has been described as a "fingerprint" that allows one to identify the origins of underground aquifers, how big they are, and how this water moves underground. It is estimated that some 60 countries have used this sustainable management technique to investigate their water resources.

Isotope tracking also helps to detect sources of pollution in reservoirs and coastal aquifers; detect toxins produced by harmful algal blooms in marine foods; and monitor and assess marine pollutants like heavy metals and pesticides. Solid wastes and sewage can be treated with radiation techniques instead of through the use of toxic chemicals.

Fresh water is a major priority in sustainable development. For many countries, **desalination** of salt water is a means of obtaining this precious resource.

Nuclear technology can help in desalination by using low-pressure steam from the turbine and hot seawater feed from the cooling system of small or medium-sized nuclear reactors. Other desalination plants use reverse osmosis and power from the grid. However, by co-locating desalination plants with nuclear power plants, the cogeneration potential can be better exploited. This is a technique supported by leading international water experts. There is already over 150 reactor-years of experience in the feasibility of using integrated nuclear desalination plants.

Turning to **climate change**, radioactive materials are essential in climatological investigations to determine the extent to which the earth's climate is warming. Isotopic records are preserved in marine sediments, corals and polar ice. Such information about the oceans' temperature, salinity, acidity, humidity, biodiversity and circulation in the past helps to verify the accuracy of today's ocean and climate models. Radionuclides also help to determine plant and sea assimilation of greenhouse gases.

A sustainable environment also requires stopping the spread of disease among animals. Nuclear techniques are used to diagnose livestock diseases and improve livestock growth and resistance to disease. **Radioimmunoassay methods** are essential in stopping the spread of trans-boundary animal diseases, such as rinderpest. Thanks to the role played by nuclear technology, rinderpest is now an animal disease of the past, having been completely eradicated worldwide.

3.4 ELECTRICITY AND POWER

Sustainable development relies upon **access to clean, sufficient and affordable energy**. Access to affordable energy directly improves human welfare. Yet globally about 1.3 billion people have no access to electricity.

Electricity is therefore the single most important contributor to human development and the betterment of humanity. Little wonder that access to energy – largely in the form of electricity and power generation – is rightfully considered the enabler for achievement of the UN's Millennium Development Goals.

As the IAEA describes it:

"Essential to all human activities, energy fuels social and economic development. Energy is the engine for the production of goods and services across all economic sectors: agriculture, industry, transportation, commerce, public administration, among many others. Lack of energy is a contributing factor in individual, community, national and regional poverty. In contrast, access to energy opens many new opportunities. Meeting the UN Millennium Development Goals cannot be accomplished without access to affordable energy services."

Without access to electricity, people are **deprived of the opportunities that energy enables** in education, agriculture, business, industry, and healthcare. Moreover, the use of fossil fuels for basic necessities like cooking and heating becomes a deadly hazard for many in developing countries. Half of the world's population has no access to clean cooking fuels. Consequently, according to WHO estimates, the diseases caused by the resulting indoor air pollution kill two million people annually. Current IAEA projections foresee electricity demand increasing by 60-100% between today and 2030. What will be the energy source for generating sufficient electrical power to meet this huge **growth in demand**? Will it be a clean, no-emissions energy source?

Nuclear energy minimizes the amount of CO2 and other noxious gases produced in the generation of electricity. It therefore **mitigates the impact of climatic disruption on development**. By including nuclear power in its energy mix, a nation reduces harmful air pollution and GHG emissions, expands electricity supplies, and increases technological and human capital.

The nuclear industry is also pursuing innovative research and development in the area of **nuclear energy options for the future**. These involve more efficient fuels and new fuel cycles, Generation IV reactors, hydrogen production, small modular reactors and fusion energy. These innovative technologies focus on achieving dramatic improvements in flexibility, safety, cost, environment footprint, construction time, as well as on applications in remote or off-grid areas without local affordable or reliable sources of energy.

In short: nuclear technology contributes to development and growth through its production of clean, effective and affordable electricity. This in turn has a substantial positive effect on the environment and sustainability by being one of the tools we have today for combatting climate change and air pollution – for the benefit of humanity.

3.5 INDUSTRY AND CONSUMER PRODUCTS

The **industrial and consumer product applications** of nuclear technology surprise many people. These applications are largely unknown to, or pass unremarked by, the general public.

Applications in the industrial sector include the measurement of density, moisture content and geological composition in civil engineering; material analysis in industrial engineering; and level and flow rates in oil & gas exploration and production. In industrial radiography, nuclear substances are used for the **non-destructive examination and testing** of advanced materials. Radiation from the substances passes through the material and allows defects in welds or constituency to be recorded on film or a digital imager.

Gauges containing radioactive sources are used in industries where levels of gases, liquids and solids must be checked. These gauges are most useful where heat, pressure or corrosive substances make it impossible to use direct contact gauges. For example, radioisotope thickness gauges are used in the making of continuous sheets of material including paper, plastic film, metal and glass. Manufacturers of cans use radioactive materials to obtain proper thickness of tin and aluminum. Radiation gauges are used to regulate blast furnaces and liquid metal in moulds.

Moreover, radioisotope gauges are more portable than x-ray machines and can be used to check welds of new gas and oil pipeline systems and examine the structural integrity of bridges. Other forms of radiography can be used to locate components of materials not visible by other means.

Industrial radioisotope tracers are created by adding small amount of radioactive substances to materials used in various processes. This technique allows examination of mixing and flow rates of materials, liquids and gases, as well as the location of leaks. Radioisotope tracers are extensively used in metallurgical research to identify metal alloys and purify metals.

In advanced materials research, **neutron beam scattering** is giving new insights into how to treat infant respiratory distress syndrome; how to protect materials from corrosion; building better computer models of materials; superconductivity; hydrogen storage; creating lighter, more reliable car engines; and adding value to steel products.

Other applications come more directly into the realm of consumer and industrial products.
For example:

- The paper industry uses radioactive materials in producing coated paper.
- Radioactive materials are used in luminous paint and products, including exit signs, airport runway lights, dials, gauges and watches.
- Radiation is used to toughen the rubber in radial tires and to align the steel belts in those tires.
- Non-stick pans are treated with radiation to ensure that the plastic coating adheres.
- Cosmetics, hair products and contact lens solutions are sterilized with radiation.
- Textiles are treated with radioactive materials to give them desirable qualities, like the ability to repel water.
- Smoke detectors rely on a tiny radioactive source to function.
- Radiation is used to measure the correct amount of air whipped into ice cream.
- Radioisotopes that emit energy are used in heart pacemakers and to power navigation beacons, satellites and space vehicles.

Nuclear energy provides **process heat** for industrial applications including desalination, synthetic and unconventional oil production, oil refining, and biomass-based ethanol production. Looking to the future, nuclear energy would be a natural source for large-scale hydrogen production.

3.6 PUBLIC SAFETY

Radiation is used to scan luggage at airports to detect explosives and concealed weapons, and to check packages for illegal narcotics.

Nuclear techniques are used to locate hidden radiological sources, including those which may be contrived as radiological dispersal weapons (so-called "dirty bombs").

The use of nuclear techniques (neutron beams) in materials research has **direct significance to public safety**. In addition to assisting inspection techniques for oil and gas pipelines, such R&D is used for assessing ship hull integrity and railroad track failure analysis as part of accident investigations.

4.0 Nuclear Security and Industry

Governments, with the full support and engagement of industry, have committed to the prevention and suppression of acts of terrorism, sabotage and theft by becoming parties to, and to implementing, various international treaties and UN Security Council Resolutions aimed specifically at **enhancing and assuring nuclear security**.

From a corporate perspective, good practice for the security of nuclear and other radioactive materials is comprised of a number of inter-related components: security culture (vetting of staff, training and involvement of all staff in security, etc.); physical security (guards, gates, fences, intrusion detectors, etc.); information security (including cyber security) and response.

Nuclear security and nuclear safety have in common the aim of protecting persons, property, society and the environment. Security measures and safety measures have to be designed and implemented in an integrated manner to develop synergy between these two areas and also in a way that security measures do not compromise safety and safety measures do not compromise security. However, there are some differences.

Safety is enhanced through transparency. Greater openness and awareness of procedures, measures and facilities designed to strengthen safety can reinforce public confidence in the industry and the public's willingness to accept nuclear technology as beneficial.

Security relies more on reducing openness and access in order to protect sensitive facilities, sources and operational procedures from possible interference or attack by criminal or terrorist entities. Security is therefore dependent on the extent to which specific measures and information are kept from wider exposure. Some detail nevertheless must be communicated and made transparent in order to reassure the public and build confidence in the industry.

The nuclear industry is an active supporter of the Nuclear Security Summit process and its professional organisations (NEI, WNA, etc.) undertake public and political outreach. The industry has also committed itself to principles of conduct to strengthen security. These principles of conduct are actively implemented by industry in everyday operations, processes and research that utilize nuclear technology and materials.

Each part of the industry will have a different balance to achieve between the openness of safety and the assurance of security. Some measures must stay confidential and protected in order to be effective in enhancing nuclear security. There is also recognition that the source of transgression could come internally within a facility and its operations, as well as externally. Moreover, the range of threats, risks, impacts and so forth will be different, depending on the nature of the nuclear technology and its applications.

What they share is that, as a licensee accountable for the possession, production, storage, safety, security and application of nuclear technology and material for peaceful, civilian purposes, each industry participant has **legal and regulatory obligations** regarding nuclear security for which compliance is enforced by national authorities and law. Industry may also be liable for any third party damage caused by a security incident.

With any human activity come risks. This is as true of other energy industries as it is of the nuclear industry. Despite the low risk of deliberate release of radiation through criminal or terrorist intent, security measures are designed and implemented to protect the public and industry personnel as well as to mitigate the impact of a security breach should it occur.

5.0 Conclusion: Enhancing Public and Stakeholder Confidence

Participants in the 2016 Nuclear Industry Summit committed to enhance public and stakeholder confidence through high standards of transparency, integrity, ethical behaviour and social responsibility, and we are doing so.

At the same time, performance alone is not enough. The world's nuclear industry has an excellent story to tell about how our technologies improve human lives.

Each of our organizations alone, whatever its particular contribution, may not have a full perspective on this narrative. This document represents an effort to paint the broader picture.

Public attitudes change. There is an opportunity to create a more positive popular view of nuclear by telling our story. While we continue to perform with transparency, integrity, ethical behaviour and social responsibility, this story of benefits also has a great contribution to make to enhanced confidence.

APPENDIX: Selected References and Sources

Barrett, John – "Summary of Selected IAEA Activities Related to Maternal and Child Health" (2010, unpublished)

Burkart, Werner – "Nuclear Science: a Unique Contribution to the Betterment of the Human Condition" in: Environmental Radioactivity: New Frontiers and Developments (Bologna, Italian Physical Society, Conference Proceedings, 104)

Canadian Neutron Beam Centre – Probing Materials for Science and Industry 2014 (http://cins.ca/reports.html#cnbc)

Canadian Nuclear Safety Commission – "The Importance of Maintaining Control of Sealed Sources" in: DNSR Newsletter (Special Inventory Control Edition 2014)

Canadian Nuclear Safety Commission – National Sealed Source Registry and Sealed Source Tracking System – Annual Report 2014

Canadian Nuclear Safety Commission – Nuclear Substances in Canada: A Safety Performance Report (2013)

Canadian Nuclear Safety Commission – "Packaging and Transport of Nuclear Substances Regulations" in: DNSR Newsletter (Summer 2014)

Canadian Nuclear Safety Commission – Transportation Security Plans for Category I, II or III Nuclear Material (Regulatory Guide, March 2003)

FAO/IAEA – Contribution to Global Food Security (Joint Division of the FAO and IAEA)

IAEA – Atoms in Industry: Radiation Technology for Development (IAEA Bulletin, September 2015)

IAEA – Climate Change: Making a Difference through Nuclear Technologies (IAEA Bulletin, June 2015)

IAEA – Contributing to the Achievement of the Millennium Development Goals

IAEA – Designing Better Nutrition Programmes: the Role of Nuclear Technology

IAEA – "Essential Elements of a State's Nuclear Security Regime", Nuclear Security Series

IAEA – Incident and Tracking Data Base – Fact Sheet (2014)

IAEA – Nuclear Security Plan for 2014-2017

IAEA – Nuclear Technology Review 2015

IAEA – Nuclear Technology for a Sustainable Future (June 2012)

IAEA – Sealed Radioactive Sources (October 2013)

Management Information Services – The Untold Story: The Economic Benefits of Nuclear Technologies (Organizations United for Responsible Low-Level Radioactive Waste Solutions, Washington D.C. 20035)

Nordion and Bruce Power – Clean Nuclear Power: Safe Hospitals (www.cleannuclearpowersafehospitals.ca)

Nuclear Energy Institute – Fact Sheet on Nuclear Technology Applications: Consumer Products; Food and Agriculture; Industrial Uses; Medicine and Scientific Research; Space Exploration; Water Desalination (2014)

Nuclear Energy Institute – Fact Sheet on Nuclear Power Plant Security (September 2014)

Nuclear Regulatory Commission – "Implementing Guidance for Licensees that Possess Radioactive Material Quantities of Concern"

Nuclear Threat Initiative (NTI) – Strengthening the Global Nuclear Security System (July 2012)

WORLD Institute for Nuclear Security – Facilitating Accountability for Nuclear Security: a Model National Assurance Programme for Nuclear Security (May 2013)

World Nuclear Association – Radioisotopes in Industry (December 2014)

World Nuclear Association – The Many uses of Nuclear Technology (March 2014)