



Electricity or Powerful Weapons: The Significance of Dual Use Applications

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This article addresses the capability to develop weapon systems based on processes of nuclear fusion. This is a dual activity that has the potential to cause great destruction while proceeding under the guise of purely scientific research or practical applications for various uses, such as the economy, clean energy, or environmental protection. The increased concern over dual activity stems from the fact that the raw materials used to manufacture these weapon systems are not prohibited by international treaties. This article examines the special nature of these weapons, the technological challenges involved in their development, operational elements, and their damage potential. Likewise, it highlights a range of different possibilities available to any element that seeks to develop nonconventional capabilities, while veering dangerously close to various restrictions and supervision regimes. It also examines the potential dangers involved in weapons based on processes of nuclear fusion for various countries, including Israel, and measures that must be taken to deal with this danger. A short glossary of scientific and technological terms appears at the end of the article.

Keywords: nuclear fusion, isotopes, deuterium, tritium, plasma, inertial confinement, magnetic confinement, fourth generation weapons, technology, military

Introduction

Reports of a successful nuclear fusion experiment using high energy lasers conducted as part of a project at the [National Ignition Facility](#) in Livermore, California, created a lot of buzz in the scientific community and among the public. In particular, hopes were raised of using thermonuclear energy to produce green and pollutant-free energy. As with nuclear energy, however, there is always the possibility that the controlled fusion process will be used to create effective weapon systems that would be infinitely more destructive than conventional weapons. One example is the

hydrogen bomb, which is based on a process of uncontrolled fusion.

The options that currently exist in the field of manufacturing a weapon with massive destruction capabilities, based either on fissile material or nuclear fusion, combined with the increase in the level of technological education and freely available information, have upgraded the research and development capabilities of [rogue states](#) and present a major dilemma for peace-loving nations. Moreover, the destructive potential of these weapons could lead to an uncontrolled arms race for self-defense purposes between countries that feel threatened. The

technological knowhow and capabilities, combined with a lack of moral, political, or legal impediments, could be an incentive for the clandestine development of weapons of mass destruction or their development under the guise of legitimate activity, when, in fact, they are engaged in dual activity. In other words, under the semblance of purely scientific research or applied development for various legitimate purposes, such as economics, clean energy, or environmental protection, it is possible to manufacture weapons of mass destruction based on purportedly “civilian” technology. The goal of this article is to highlight the various possibilities currently available to anyone who seeks to develop nonconventional capabilities, while veering dangerously close to various restrictions and supervision regimes; it will also examine the potential dangers involved in weapons based on processes of nuclear fusion for various countries, including Israel, and the measures that must be taken to address this danger.

Regarding nuclear weapons, it is important to differentiate between the different generations of nuclear device development, based on levels of effectiveness, destructive power, and the technology used for the device.

Technological Background

Given its complexity, developing nuclear technologies for military purposes demands an understanding of the various processes involved. In some of the processes linked to nuclear technology, the technologies are dual, i.e., they can be used for military or civilian purposes. Therefore, analyzing these systems requires a broad understanding of a variety of scientific and technological disciplines. A detailed analysis of the issue can be found in several articles about [fourth generation weapons](#) and the sources referenced in this article.

Regarding nuclear weapons, it is important to differentiate between the different generations of nuclear device development, based on levels of effectiveness, destructive power, and the technology used for the device. These are known vectors of action in the fields of science and technology that are difficult to conceal; therefore, any activity along these tracks clearly indicates the intentions of the operator.

The first generation of nuclear weapons is a nuclear bomb based on the process of fission in a basic device with a high level of destructive force (about the same level as the bombs dropped on Hiroshima and Nagasaki), but with a low level of effectiveness. In other words, the amount of energy produced is around 10 percent of the energy one would expect from such a process. To detonate this device, an initial quantity of neutrons is needed to spark the process.

The second generation of nuclear weapons is an upgraded device that contains an effective source of neutrons to increase the initial quantity of neutrons needed to start the process, in order to intensify the nuclear fission process and thereby accelerate the effectiveness at the cost of a minimal amount of extra weight. Another device in the second-generation category is the thermonuclear device, also known as the hydrogen bomb, which works by using a process of [nuclear fusion](#), similar to the energy-producing process on the sun, for example.

Third generation nuclear weapons include various types of systems for defined tactical and strategic purposes. This includes several types of weapons, based on their destructive power or their ability to produce various kinds of radioactivity. For example:

- a. Systems with limited destruction capability but the ability to produce increased quantities of neutrons or [X-rays](#) (also known as Röntgen radiation)
- b. Systems for the production of strong electromagnetic radiation pulses, which disrupt systems based on electromagnetic radiation

- c. Systems with increased explosive and destructive capabilities
- d. Tactical nuclear weapons used to attack fortified positions with bunker-busting bombs

Third generation nuclear weapons have a number of inherent limitations, primarily in the technological aspects (complexity of systems), tactical aspects (powerful weapons that are not always suitable for combat), and environmental pollution with radioactive materials.

Fourth generation nuclear weapons are defined as “weapons based on a nuclear device in which atomic or nuclear processes that are not banned by the Comprehensive Nuclear-Test-Ban Treaty (CTBT) take place.” Another, more detailed definition, defines fourth generation nuclear weapons as “nuclear explosives based on initiating a thermonuclear process at a low level of effectiveness, using materials or processes that do not require nuclear fission.” Fourth generation nuclear weapons have a number of distinctive characteristics, which set them apart from devices from previous generations.

Singular Features

A Paradigm Shift

By its very use, the system represents a change to the existing paradigm, whereby any use of a process linked in any way to nuclear power is seen as a challenge to the world. The system is based on a process of nuclear fusion—the merging of light atoms, like deuterium (D) and tritium (T), to create new compounds, similar to the thermonuclear process that occurs on the sun, when massive quantities of energy are released. This kind of weapon is massively destructive, which is the reason for some of the innate advantages of these weapons, and could make them highly attractive to rogue states:

- a. Removed suspicion that the country in question is developing a nuclear weapon: the trigger for the operation of the system is planned to include the use of non-fissile materials, so there is no use of the typical nuclear materials.

- b. Civilians uses: The trigger for the process is via dual use technologies—those technologies that can be used for civilian application, especially in the fields of clean energy and the development of controlled thermonuclear reactions.

- c. Compact tactical weapon system: A weapon that is ostensibly not nuclear, but has considerable destructive power, comparable to dropping a bomb with 1-100 tons of TNT. A simple calculation shows that the combination of 0.001 gram of the raw material necessary for the fusion process can create as much energy as a device containing 50 kilograms of TNT.

- d. Technical deterrence, deterrence by competence: The very knowledge that a certain country has obtained fusion technology for civilian purposes (peaceful nuclear energy) leads to the highly likely possibility that it will allow that country to obtain the knowhow for military applications as well. A country of this kind, even if it does not possess an operational system, could be considered a virtual nuclear weapon state, with all the strategic and diplomatic implications this entails.

A weapon of this kind, unlike a fission bomb, does not require a critical mass; all it takes is a small quantity of material—around a milligram—to produce an effective fusion process of some kind in suitable conditions of compression. The fusion process, even at a very low level of efficiency, is extremely energetic. One kilogram of coal, for example, produces enough energy to illuminate a 100-watt household lightbulb for eight hours. The energy produced from the complete fusion of one kilogram of deuterium would provide enough power to keep the bulb lit for 30,000 years.

Military Features

Fourth generation nuclear weapons are weapon systems with singular military characteristics, which make them extremely dangerous. They represent a weapon system with the capability

to launch precise and direct strikes against well-defined targets with minimal collateral damage—integral to modern warfare, where precise strikes against quality targets are preferred to what is known as carpet bombing. The strike is conducted by transferring energy to the targets using non-elastic collision and penetrating deep within the target, like a powerful kinetic energy weapon. As a result, these weapons have the ability to destroy quality targets with impressive precision—including annihilation and weapons of mass destruction capabilities.

This kind of weapon can be used by countries that are not nuclear states but have a high level of technological knowhow. The fact that the fuel used for this kind of weapon is not on the list of materials banned under the CTBT makes it very easy to obtain and use, especially when dealing with rogue states that seek legal loopholes to develop weapons of mass destruction.

Technological Features

The technology needed for the development of a fusion process creates many challenges in a wide range of fields, such as optics, lasers, materials science, nuclear science, nanotechnology, micro-electro-mechanical systems (MEMS), development of singular calculating capabilities, and simulations. This technology is of a dual nature, with civilian and military applications, so any move toward developing these capabilities can easily be camouflaged as purely scientific activity with [civilian uses](#).

Moreover, this technology interfaces with other challenging scientific areas, such as the technology used to create antimatter (when antimatter comes into contact with matter, the mass of the particle and its antiparticle are converted into pure energy) or to produce tritium. This occurs using extremely powerful particle accelerators that produce the energy particles needed for the creation of antimatter like [antiprotons](#), as well as the manufacture of tritium. Although the field of antimatter is still

in the laboratory stage, calculations appear to show that it is possible, by combining a few milligrams of matter and antimatter, to produce the same amount of energy as 21 tons of TNT, which highlights the technological potential. Finally, powerful accelerator technology could also have a dual purpose, both in terms of pure scientific research and in terms of finding an energy source that can be used to manufacture components in powerful weapons, such as for the manufacture of tritium or antiprotons.

One of the arguments against the development of fusion technology is that it takes a long time to develop. From the perspective of the military planner, this is actually an advantage, since it allows for prolonged research and development and for in-depth study of the operational elements of the system. On the other hand, the long development creates a lack of faith in the capabilities of the system, which leads to a general lack of interest, and could lull enforcement agencies into inactivity, thereby allowing rogue states to continue their own development programs.

An additional technological feature is connected to measurement of nuclear and thermonuclear phenomena and processes. In order to measure dynamic processes that occur during experiments simulating fusion or fission under pressurized conditions and extreme conditions, one needs precise and quick diagnostic equipment. The ability to develop and manufacture this equipment, under the pretext of developing fusion capabilities for ostensibly civilian purposes, would allow a rogue state to develop the diagnostic equipment used for measuring and assessing the critical parameters involved in developing nuclear weapons, as well as developing and studying nuclear processes.

Strategic Features

Fourth generation weapons have characteristics that make them attractive to industrially developed countries, since obtaining nuclear fusion technology is a technology force

multiplier that acts as a political-technological catalyst for developed countries seeking to be at the forefront of the techno-military sphere. Consequently, an [arms race](#) is likely between countries with strong economic and industrial capabilities that do not want to lag behind, especially on the military front. In addition, there could well be an arms race between less developed countries, which are worried about their own fate, and that would lead to focusing on more easily obtainable nuclear weapons than weapons of previous generations.

Technological Challenges

In order to develop a fourth generation device based on the fusion of particular source materials, in a process similar to the thermonuclear reaction that occurs on the sun, several major technological challenges must be met. More specifically, nuclear fusion is a challenging technological process, which demands expertise in many scientific and technological fields, as well as a well-trained scientific and technological workforce and the establishment of an extensive scientific infrastructure. This kind of multidisciplinary activity will sharpen the scientific and technological expertise of any country involved.

The main challenge when it comes to fusion is to achieve the highest levels of compression and temperature possible (hundreds of millions of degrees) for the fusion process to occur. Under these conditions, the starting materials needed for the process are in a special state of matter called [plasma](#). Optimal time is needed to allow a sufficient amount of material to go through the fusion process. In other words, the gases that undergo the fusion process need to be confined for a certain length of time, to create the conditions needed for the fusion process, in terms of pressure and temperature. Because we are dealing with gas at very high pressure and temperature, the plasma must be confined in a special device capable of withstanding those conditions. Currently, two potential methods are under examination in

laboratory conditions: magnetic confinement fusion and inertial confinement fusion (ICF).

A secondary challenge involves the manufacture of the hydrogen isotope tritium (T), since naturally occurring tritium is extremely rare on earth (0.015 percent relative abundance) and to obtain significant amounts of the isotope one needs specific costly technology that is not readily available. The very act of obtaining them represents a technology force multiplier.

One of the greatest challenges when it comes to acquiring the knowledge for the fusion process for civilian or military purposes is measuring the various physical parameters, such as pressure, temperature, and density, as an alternative to nuclear or thermonuclear experiments. Accurate knowledge of these parameters is important in terms of the physical understanding of the conditions needed for nuclear processes and their increased efficiency. Techniques such as ICF and [magnetic confinement](#) are a catalyst for the development of highly significant technologies.

Operational Elements: Gauging the Damage Effectiveness of Fourth Generation Weapons

General Damage

In order to gauge the damage effectiveness of fourth generation weapons, the extent to which the weapon “couples” with the target is measured. The definition of coupling here is the efficiency of how the weapon’s energy is transferred to a given target in order to damage or destroy it. The main product of fourth generation fusion-based weapons is very powerful radiation, which contains X-ray radiation (20 percent of the total radiation) and high-energy neutrons (80 percent of the total radiation). High-energy neutrons have a high penetration capacity, so they would penetrate deep within the target, causing extensive internal damage, due to the target heating up after the neutrons penetrate it. The combination of the neutrons’ high capacity to penetrate the target and the absence of reflected

radiation or shockwaves on the surface close to the target means that there is much value in terms of weapon-target coupling.

Experts believe that the coupling effectiveness of fourth generation nuclear weapons is around 50 percent, compared to between 5 and 10 percent for regular conventional weapons—depending, of course, on the type of target and the distance of the detonation from the target.

Experts believe that the coupling effectiveness of fourth generation nuclear weapons is around 50 percent, compared to between 5 and 10 percent for regular conventional weapons—depending, of course, on the type of target and the distance of the detonation from the target. To illustrate the damage, a conventional bomb with one ton of TNT detonated one meter from a 10-centimeter-thick steel plate will not cause significant damage to the plate, while under similar conditions, a fourth generation nuclear weapon would cause significant damage, including a fire and a hole in the steel, up to a radius of one meter.

Another effect of fourth generation nuclear weapons is the ability of the products of the radiation process to transfer energy to the target by using momentum or the impetus from the X-rays or the high-energy neutrons that hit certain targets (known as the [rocket effect](#)). As a result of the strike and the dispersion of some of the X-rays and neutrons, high-energy plasma jets are also created, which, under specific conditions, can send targets or parts of targets flying in the opposite direction to the direction of the strike, and this could cause total devastation and secondary damage. This plasma jet is sometimes accompanied by strong [electromagnetic radiation](#), which can disrupt the operation of critical electronic installations, such as wireless telecommunications networks and GPS operation.

It is possible to make dual use of the neutrons that are expelled during the thermonuclear

process: on the one hand, one can use the impulse force of the neutrons and the X-rays that are emitted from the rear to accelerate the missile aimed at the target. On the other hand, it is also possible to use the high-energy neutrons to heat the target and destroy it, instead of the conventional explosives that are found in a warhead. This issue has still not been fully researched and is certainly not ripe in technological terms. Numerical and experimental simulations are needed to evaluate the efficiency of the processes and the possibility of integrating these processes into an effective weapon.

Electromagnetic Damage

The goal of the current generation of arms in ongoing and future conflicts—such as GPS-guided missiles or lasers—is to maximize the strike and destruction of the target, while minimizing collateral damage close to the selected target.

Because of the precise nature of fourth generation nuclear weapons, the electromagnetic damage caused by their deployment is relatively limited. Additional factors for the limited electromagnetic damage stem from the relatively low intensity of the detonation, the focused detonation on the target, and the type of radiation emitted. Any detonation, chemical or nuclear (fission), is accompanied by the creation of powerful electromagnetic waves. One of the known effects of a nuclear bomb is the creation of a powerful electromagnetic pulse in the atmosphere—[EMP](#). This leads to disruptions in vital electronic systems, especially as a result of the combination of the products of the nuclear radiation and the components of the atmosphere, which creates [electric disruptions](#) that can lead to the collapse of communications and electricity systems.

Radiation Damage

Radiation damage can be divided into two categories: immediate damage and long-

term damage. Immediate biological damage is caused by exposure to strong radiation following a direct hit or a detonation at various distances between 100 and 300 meters. The neutrons that are expelled exert a dual impact: they heat up the body to extremely high temperatures, causing immediate death, and they cause biological damage by attacking various human organs. Longer term damage is primarily the radiation damage caused following contamination by radiological byproducts, such as remnants of tritium, or radioactive byproducts created by waves of very powerful neutrons. While there is no well-based research into radiation damage, one can assume, given the relatively short half-life of tritium compared to uranium, that the damage and the environmental limitations stem from the presence of a relatively limited quantity of radioactive material in the case of a fusion weapon based, for example, on deuterium and tritium, is limited compared to the damage caused by a weapon based on a nuclear process.

Mechanical Damage

The main product of fourth generation nuclear weapons is extremely powerful radiation that is absorbed by the target, leading primarily to its localized heating. This heating, unlike a fission bomb, does not create shockwaves, blast waves, or heat waves. As such, thermal and mechanical damage are presumably localized, with limited environmental damage. Moreover, the overall kinetic energy of the detonation products is not great, since most of the directed energy is converted into heat, and thus the danger from shockwaves of detonation products and shrapnel is limited. All this means that the great advantage of fourth generation nuclear weapons is that the damage is directed precisely at the target, with limited environmental damage. This allows for the rapid and effective destruction of hostile targets, including biological weapons and weapons based on advanced technology, such as nanotechnology, communications, and electronics.

Thus, fourth generation nuclear weapons have far greater destructive capabilities thanks to the highly efficient way that they transfer the detonation energy to the target. The damage and destruction that these weapons cause to the target is focused, with minimal environmental damage. The damage is thermal and mechanical and, in certain cases, there is also electromagnetic damage to electronic components and communications installations. Just a few milligrams of the raw materials needed for fusion would cause severe damage during a detonation above a specific target. Because devices of this kind can be miniaturized, there is great concern that as the technology involved in fourth generation nuclear weapons advances, they could be used as “dirty bombs.”

In terms of the technology, it is possible to obtain localized fusion for short periods of time without ignition, which leads to a powerful energetic process, by using various methods to compress deuterium and tritium. In this case, the full fusion process does not occur, and it is extinguished because of the plasma’s instability. However, the process still produces high-energy neutrons for short periods of time, which are capable of causing a certain amount of damage.

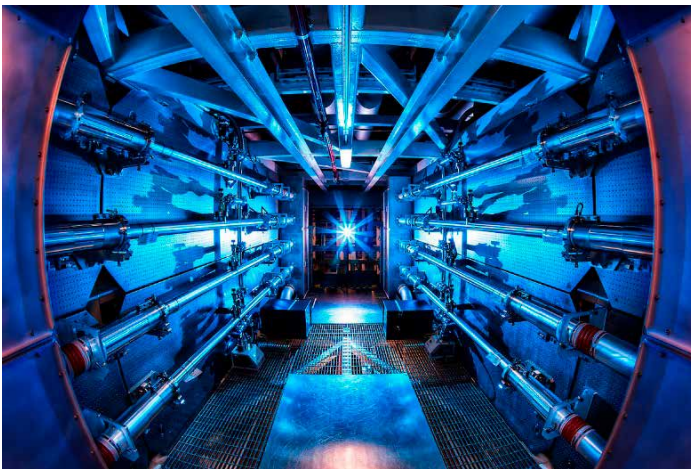
Development of Laboratory Techniques for Initiating Fusion Processes

In order to study the vital parameters necessary for nuclear or thermonuclear processes, experiments must be conducted in the laboratory. The main problem with conducting these experiments, however, is the extreme work conditions needed for fusion. Plasma must be confined under extreme conditions, with temperatures of hundreds of millions of degrees Celsius and pressure of millions of atmospheres. Moreover, plasma must be contained for long enough for the fusion process to occur effectively. In practice, there is no container capable of holding material under such extreme conditions, so researchers use sophisticated methods to confine the plasma.

Inertial confinement: The principle behind this system is the creation of energy through fusion, by pressurizing and heating the nuclear fuel to temperatures of tens of millions of degrees using high-intensity lasers. The National Ignition Facility's laser at the Lawrence Livermore National Laboratory in California has produced the most impressive results. Figure 1 shows the laser concentration area in the NIF's target chamber.

Magnetic confinement: This system creates a kind of "magnetic wall" using a powerful, external magnetic field, after which the nuclear fuel matter is compressed and heated, and a controlled process of fusion occurs.

Figure 1: Part of the high-energy laser system at the National Ignition Facility



Source: <https://tinyurl.com/2atvrytc>

Significance

Researchers have been reluctant to deal with nuclear fusion since it is of huge security and scientific significance. The aspect of dual use is an issue that accompanies many technological developments and there are already tools available to deal with it. Nonetheless, the dual use of this technology is highly dangerous, since there is a tendency to interpret such activity in a lenient manner, which could allow rogue states to develop hugely powerful destructive weapons.

Security aspects: Understanding the fusion process on a laboratory level allows us to understand nuclear and thermonuclear processes, to understand and measure precisely the specific parameters needed for situation equations that describe the process—which would allow improvement of the efficiency of the process and the weapon-target coupling process, without having to conduct an overt nuclear test. Moreover, researching the fusion process under the guise of scientific research allows a state to produce tritium, a vital component in the development of thermonuclear devices, which occurs by radiating a lithium casing with the neutrons produced during the fusion process. Moreover, the study of the fusion process makes it possible to simulate the damage caused by radioactive neutron fluxes, as well as their biological effects and their targeted destructive ability, which is achieved by momentarily heating the target to extremely high temperatures, when the highly energetic neutrons penetrate the target.

Scientific and technological aspects: The overall goal of the main projects that address this issue is the creation of clean electricity by developing alternatives to fossil fuels, in the hope of reducing the pollution caused by burning fuel or coal in the production of electricity. Research into fusion processes can teach us a lot about how plasma behaves when heated to temperatures of millions of degrees, as well as in the construction of effective and relatively cheap facilities to improve the efficiency of the

fusion process, with the goal of sometime in the future implementing that knowledge in the construction of a thermonuclear power plant for the production of green electricity.

Potential access: The geostrategic implications of a rogue state obtaining the raw materials needed to produce complex processes of nuclear fusion (including an ineffective process with low energy output) are extremely worrying, politically and strategically. Currently, the only countries conducting research into fusion processes are economic superpowers like the United States, the United Kingdom, France, Germany, and Japan, as well as Russia, to a certain extent, with the cooperation of the European Union. This is a prestigious “club” that represents a very high level of scientific, technological, and economic development, related to the astronomical cost of constructing a facility for inertial confinement fusion (\$3.5 billion in the years 2013-2023) or a magnetic confinement fusion facility (22 billion euros), and the fact that it is a multidisciplinary technological field with the highest levels of technological and scientific knowhow and infrastructure. This expertise can be channeled into other areas, such as the development of advanced weapon systems, including nuclear and thermonuclear weapons—and all of this under the guise of developing clean energy sources or purely scientific research into, for example, controlled thermonuclear processes. Activity on this front does not raise suspicions and in any case is hard to supervise, since it is executed using non-fissile materials and materials and atomic/nuclear processes that are not prohibited by the CTBT.

Nuclear fusion technology is undergoing a similar process to that of nuclear technology. At first, it was reserved exclusively for superpowers with abundant resources and knowledge, but over a few decades, it spread to determined countries with the ability to obtain and implement nuclear technology. The move from theory to practical and attainable implementation was relatively quick. Something

similar is happening in the field of fusion technology, which is being transferred from resource- and funding-rich governments to civilian organizations. For example, the US Department of Energy (DOE) recently allocated \$46 million to eight private companies working in the field. The German government also provides private bodies working in the field with huge budgets, which led to the development of a [system](#) that is much smaller and more efficient in terms of its performance. This trend of transferring development to private, civilian organizations is especially pronounced in recent years and has expanded the accessibility of such technologies to a variety of actors.

The widespread connections that superpowers like Russia and China have with rogue states like North Korea and Iran obligate the international community to pay special attention to the proliferation of such technology to these states. The fact that certain states (including hostile states in the closest or more distant circles) have the expertise necessary to obtain nuclear fusion capabilities for civilian purposes creates the highly likely possibility that they could obtain the same technology for military purposes—which creates a kind of “technical deterrence” because of the uncertainty over where this knowledge has reached. Although a country that has technical deterrence is not a nuclear threshold state in the usual sense, it can be considered a “virtual nuclear state,” which has many political ramifications:

- a. Terrorist activity against various countries, on the understanding that technical deterrence will protect them from any response.
- b. Expansionist policies, such as those of Iran, on the understanding that certain other countries would seek the military and perhaps economic protection of a state with thermonuclear capabilities.
- c. Provocative acts between neighboring countries, such as North and South Korea, with the confidence that thermonuclear deterrence provides immunity.

- d. The development of fourth generation nuclear weapons, with consequent implications.
- e. Technological seepage to non-state actors: even though non-state actors lack the scientific and technological ability to develop such weapons, there is the possibility that the knowledge—or even a finished device—could be transferred to a non-state actor by a rogue state. Terrorist organizations and non-state actors have all the motivation for attacks of this kind. This motivation, coupled with the capability, could be an incentive with devastating consequences.
- f. An arms race: Beyond all this, the destructive potential of this kind of weapon could lead to a global and unrestrained arms race for defensive purposes between countries that feel threatened, which would disrupt the world order. The knowledge and technological capabilities, without moral, political, or legal impediments, could be an incentive for the clandestine development of hugely destructive weapons—or with the semblance of legitimate activity, when, in fact, it is a dual activity. The significance is that under the guise of purely scientific research or the development of applications for use in areas such as the economy, green energy, or the environment, it will be possible to develop massively destructive weapons using ostensibly civilian technology.

Israel's Approach to the Threat

The introduction of fourth generation nuclear weapons in the Middle East confronts Israel with several dilemmas. Israel's approach to the threat of fourth generation nuclear weapons should operate on several levels, once those responsible have defined the matter as a national priority that should be addressed with utmost urgency. First, Israel must define the goals and targets of its intelligence and research efforts to track open and clandestine activity in the field, including defining suspicious targets and monitoring scientific or technological activity, including the procurement of special equipment.

The preemptive-offensive front: Israel must act to damage, thwart, and destroy manufacturing and installation facilities and research and development centers—including attacking knowledge centers, infrastructure, and national laboratories used to research the relevant processes. Similarly, it must initiate activity and deploy the necessary surveillance mechanisms to deal with dual use activity. This entails deploying surveillance mechanisms to monitor technological developments, such as monitoring the activity of scientists in research centers and academia, following top scientists or sources of knowledge, and keeping close watch on procurement chains and scientific collaborations.

The defensive front: Israel must invest heavily in developing sophisticated interception means to neutralize the platforms that carry fourth-generation nuclear warheads, as defined in this article. This must also include the development of sophisticated defense systems against the fourth generation weapons platforms far from the borders of the State of Israel.

The deterrence front: It is recommended that Israel start with a public diplomacy approach, to deter the enemy from conducting any of the activities that can lead to fourth generation nuclear weapons. This would include, inter alia, publications and demonstrations of various weapon systems—offensive or defensive—to display their capabilities and to deter their use.

The political front: Given that any activity on this issue has a dual use nature, it does not raise suspicion and is hard to detect or incriminate, since it makes use of non-fissile materials and materials or atomic processes that are not banned by the CTBT. Israel must try to push for the raw materials used in these processes to be outlawed by international convention.

Conclusion

This article presents the characteristics of fourth generation nuclear weapons, which have massive destructive capabilities and are highly efficient at weapon-target coupling. This

means that the detonation energy is transferred to the target at a rate of around 50 percent, compared to the coupling efficiency rate of a conventional weapon of an equivalent size, which is around 5-10 percent.

Fourth generation nuclear weapons have a unique advantage over conventional weapons deployed under similar circumstances: a fourth generation weapon has the ability to strike a target with great precision, causing only minimal environmental damage, while destroying quality targets, such as stockpiles of chemical or biological weapons, control and command centers, and communications and electronic installations, as well as frontline or support soldiers. This is because of the nature of the process, in which most of the damage is caused by powerful neutron radiation, which causes localized heating and thermal and mechanical damage. Nonetheless, when using a weapon based on nuclear fusion, the environmental damage and limitations due to the presence of radioactive material and radiation damage to noncombatants is minimal compared to the damage caused by a nuclear fission detonation.

Under certain conditions, a fourth generation nuclear weapon that strikes a target can cause strong electromagnetic radiation, which can disrupt the operation of vital electronic installations, such as wireless communication systems and GPS. Therefore, the recommendation for Israel's approach to the threat of fourth generation nuclear weapons must operate on two levels: on the preemptive-offensive front, Israel must act to damage, thwart, and destroy manufacturing and installation facilities; on the defensive front, it must develop advanced interception capabilities, to take out the platforms that carry any kind of warhead (conventional, nuclear, or fourth generation). Additionally, it must also undertake public diplomacy to deter the enemy from realizing the threat that fourth generation nuclear weapons pose.

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Glossary

- Antimatter – matter composed of the antiparticles of the corresponding particles in ordinary matter. When antimatter comes into contact with matter, the mass of the particle and its antiparticle are converted into pure energy.
- Deuterium – an isotope of hydrogen which contains one proton and one neutron
- Energy – the ability to perform a certain activity
- Fission – the process of splitting a heavy atom into lighter atomic particles, accompanied by the release of the remaining energy in the heavy atom
- Fusion – merging two atomic particles to a new atomic particle with a mass that is smaller than that of the two particles, with the remaining mass being converted into energy
- Inertial confinement – the confinement of fuel used for fusion in a solid state, in pellets, and its irradiation symmetrically, using powerful lasers
- Isotopes – atoms with the same number of protons but a different number of neutrons
- Laser – an electro-optic device based on light amplification of stimulated emission of radiation
- Magnetic confinement – confinement of the fusion material inside a strong magnetic field
- Plasma – a fourth state of matter, which contains ionized gas and free electrons
- Power – the ability to perform a certain activity (work) in a unit of time
- Tritium – another hydrogen isotope, which contains one proton and two neutrons

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