מרכז המחקר והמידע

הכנסת

Health Aspects of Deploying Infrastructure for Fifth-Generation Cellular Telecommunications (5G)

Written by: Dr. Samuel Chayen | Approved by: Shiri Spector-Ben Ari | Edited by: Knesset Record Staff

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Review

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Summary

"5G" is the commonly used term for the fifth generation of cellular telecommunications, which is characterized by high speeds and is expected to provide a data transfer rate a thousand or more times higher than the fourth generation of cellular telecommunications. Furthermore, 5G technology features low-latency data transfer and supports communications between a massive number of components. In order to enable the aforementioned qualities, a 5G network is expected to use very high frequencies and will require the integration of large antennas from previous generations with multiple base station antennas—some inside buildings—placed at shorter intervals. The fifth generation of cellular telecommunications is different from previous generations in that it is intended to serve most the Internet of Things (IoT)—multiple applications designed to link and run various activities in the public space, such as autonomous transportation, the management of smart cities (including controlled waste collection), and more.

The aforementioned technological changes may affect the population's exposure to non-ionizing radiation. Opinions differ on how the use of 5G technology affects the extent of exposure to cellular radiation. This document presents positions—including that of the Ministry of Environmental Protection—according to which **the technological efficiency of 5G telecommunications will reduce the overall exposure to non-ionizing radiation.** However, others suggest that **the use of higher frequencies, broader bandwidths, and more extensive antenna deployment will only increase exposure to radiation.**

In 1998, the World Health Organization (WHO) issued its recommendation regarding maximum rates of exposure to cellular radiation: 400–1,000 μW/cm^2. This is a "health exposure threshold" above which the radiation is considered dangerous. The Israel Ministry of Environmental Protection operates under the precautionary principle in an attempt to minimize the public's exposure to radiation to the extent possible, and it has therefore adopted a stricter threshold than the one set by WHO. **According to the Israeli threshold, in environments where people are subject to long-term exposure to non-ionizing radiation, such as homes and workplaces, the exposure threshold to radiation from base stations may not exceed 10% of the health exposure threshold; and in environments with short-term exposure, such as sidewalks and roads, the exposure threshold may not exceed 30%.**

Impact of cellular radiation exposure on health

This document reviews studies and articles on the relationship between exposure to cellular radiation and illness. Although multiple studies have examined the possible repercussions of exposure to electromagnetic radiation—a characteristic of cellular telecommunications, among other things—the differences of opinion regarding the meaning of these studies' results remain unresolved. There have been various criticisms of the studies and their results, from methodological failures and statistically insignificant results to allegations of influence on the studies by interested parties. Against the backdrop of this uncertainty, **in 2011**, **the World**

Health Organization defined radiofrequency electromagnetic radiation (which includes cellular radiation) as "possibly carcinogenic to humans."

While the difference of opinion regarding the health-related effects of 2G, 3G, and 4G cellular telecommunications continues, the potential health effects of 5G naturally remain mostly unexplored. One main argument is that many of the studies conducted over the past two decades, which also served as the basis for the guidelines on exposure to non-ionizing radiation, primarily examined the effects of short-term exposure to radiation on energy absorption by the human body, as manifested in **tissue temperature elevation.** Various researchers suggest that due to the changes in the nature of radiation exposure in the past few years and especially in light of the upcoming deployment of the 5G network, **there is a need to expand the body of research on the non-thermal effects, biological effects, and potential effects of long-term exposure to non-ionizing radiation.**

Among other things, the document reviews studies that examine the relationship between biological damage and exposure to cellular radiation. Such effects include impaired DNA integrity, cell membrane damage, impaired gene expression and protein synthesis, compromised sperm quality and immune system, and more. Other studies point to decreased fertility and degenerative changes to the nervous system. Some studies suggest damage to trees, wildlife, and nature in general. **We note that studies in this field are based mostly on laboratory experiments and animal testing and are not epidemiological studies.**

There is a consensus in the scientific community that certain population groups are at higher risk for disease as a result of exposure to electromagnetic radiation. These groups include **children and teenagers, pregnant women, and people suffering from chronic conditions.** This is why various countries have taken steps to decrease children's exposure to electromagnetic radiation, particularly in educational institutions. In Israel, the Non-Ionizing Radiation Law 5766-2006, **does not specifically address radiation-sensitive populations.** Thus, for example, there is no restriction on placing cellular infrastructure near educational institutions. According to the Ministry of Environmental Protection, **such restrictions are unnecessary** and will remain unnecessary even after 5G infrastructures are deployed. Because the stringent exposure threshold is intended to protect the entire population, everywhere, the recommended exposure threshold in educational institutions is no different from that in children's home environment. In this context, we should note that there are people who suffer from oversensitivity to electromagnetic radiation, a syndrome that does not necessarily have a clear toxicological or physiological explanation in which people suffer from various symptoms that can be attributed to acute or chronic exposure to electromagnetic radiation. **There is disagreement between healthcare professionals regarding the existence of a direct link between radiation exposure and the symptoms reported by people suffering from this syndrome, as well as regarding the policy that should be implemented in this realm.** Many countries (including Israel) have adopted the World Health Organization's position that electromagnetic hypersensitivity is not considered a medical diagnosis, while other bodies and countries have acknowledged a need to respond to this

population by recognizing the syndrome as a disability and creating radiation-free zones, among other things.

The deployment of 5G cellular networks around the world and in Israel

This document reviews the state of the deployment of 5G infrastructures in different countries around the world in 2020. As will be described in the review, many countries have already begun deploying 5G, although the present extent of the deployment varies from country to country. Some countries, such as South Korea and the EU countries, have prepared strategic plans for deploying 5G networks, and some of these countries have made regulatory changes. Note that the European Union's strategy stresses the importance of public involvement in the process of 5G network deployment. The document also provides examples of countries—and particularly localities—where the deployment of 5G networks has been delayed due to public opposition based on concerns of negative health effects.

The Israeli tender for frequencies that will serve the 5G cellular telecommunications closed on August 12th 2020. The tender was won by Pelephone, Cellcom–Golan—Marathon, and Partner–HOT Mobile. After the licenses are awarded, the companies will begin deploying 5G infrastructures. According to the Ministry of Communications, the winning bidders are expected to finish establishing 250 sites within three years, for which they will be awarded an incentive of NIS 200 million.

Regulation of 5G cellular telecommunications in Israel

At present, the regulation in Israel does not specifically address the exposure to radiation emanating from 5G technology. According to Prof. Stelian Gelberg, Director of the Noise Prevention and Radiation Safety Division in the Ministry of Environmental Protection, **there is no need to amend the current regulation in Israel to specifically address 5G technology. He believes that the Non-Ionizing Radiation Law and the stringent exposure threshold that the ministry set in accordance with the precautionary principle offer a response to the 5G network, as well.** The Ministry of Communications also adopted the position that the existing regulation is sufficient, and therefore **no environmental or health requirements were added to the documents for the 5G frequencies tender.** Furthermore, according to the Ministry of Communications, **such requirements will not be added to the licenses awarded to the winning bidders either.**

In a March 2019 letter written by the Director General of the Ministry of Health to the Director General of the Ministry of Environmental Protection, the Ministry of Health recommended that the Ministry of Environmental Protection **oversee exposure levels at the different stages of the deployment of 5G cellular telecommunications infrastructures, while referring to features unique to 5G technology** (which include multiple sources of radiation, the implementation of beam steering technology, and the repercussions of parallel deployment of 4G infrastructures and 5G technologies) **and tailoring exposure levels to the precautionary principle.** At the same time, the Ministry of Health recommended establishing "an inter-ministerial committee that would include the relevant representatives from the field, including a

Health [Ministry] representative; periodically examine existing standards of technology implementation, among other things; and update them if necessary, as more information becomes available." **To date, no inter-ministerial committee tasked with reviewing the need to change the standards of implementing 5G technology has been formed.**

1. Introduction

This document was written at the request of MK Idan Roll to review issues regarding the deployment of fifth-generation cellular telecommunications infrastructures (known as "5G"), especially cellular radiation and the possible health implications of extensive use of this technology. It opens with a brief review of the main technological differences between third- and fourth- generation cellular telecommunications, on the one hand, and fifth-generation infrastructures, on the other. This is followed by observations on cellular radiation, in general, and the radiation expected from fifth-generation infrastructures, in particular. A major section will be dedicated to the health effects of exposure to cellular radiation. It is important to note that, naturally, the possible effects on health of exposure to radiation from 5G infrastructure remain mostly unexplored, but the document will cite a critique regarding the need to expand the research into cellular radiation in a way that examines the unique characteristics of 5G technology, as well. Furthermore, in light of the uncertainty regarding the effects on health of cellular radiation in general and radiation from 5G technology in particular, the document will provide examples of countries—and particularly localities—where the deployment of 5G networks has been delayed due to public opposition based on concerns of negative health effects. Another chapter will be dedicated to the regulation in Israel of cellular radiation and the question of whether it should be modified due to the upcoming deployment of 5G infrastructures.

This document explores the deployment of the fifth generation of cellular telecommunications infrastructures (5G), with an emphasis on cellular radiation and the possible health implications of extensive use of this technology.

The deployment of 5G infrastructures around the world may have begun only recently, but it has advanced at an increasing rate in the past year, as described in the final chapter, which explores the deployment of 5G infrastructures in Israel and other countries.

Fifth-generation cellular telecommunications are intended for two main purposes:
1. Improve the operation of cellular phones and data traffic in both apps and video streaming speed;
2. To serve the Internet of Things (IoT).

2. Principles of the operation of cellular telecommunications and the uniqueness of the fifth generation (5G)

Cellular communications networks operate using two main components: mobile phones and fixed transceivers. The mobile phone, i.e. the end device, transmits radio waves to the transceiver—the cellular base station—and receives radio waves from it. The operation of a cellular network requires dividing the country into thousands of units known as “cells,” hence “cellular communication.” The cells operate alongside one another, with slight overlap, thereby allowing continuity of coverage.

The cells use radio waves at varying frequencies. These frequencies span a range from 3 kHz to 300 GHz, and imply a wavelength ranging approximately from 100 km to 1 mm.[1] The (cellular) phone system uses a defined number of frequencies in each cell, and each frequency can be used by a specific number of users. This technology is intended to allow for a higher number of users at one time. However, because the number of frequencies in each cell is limited, the number of users in each cell is also limited. Adjacent cells use different sets of frequencies in order to avoid intercellular interference.[2]

The third and fourth generations of cellular communications are currently widespread in Israel. The size of a cell (i.e., the antenna itself and the mobile phones to which the antenna transmits) depends on the number of users. In urban settings, where there are many users per cell, there are many more cells in a given area. By contrast, in non-urban areas where the number of users is lower, there are fewer cells, and a cell's radius can extend as far as 15 km.[3]

To date—in the earlier generations of cellular communications and even in the fourth generation—cellular telecommunications were intended primarily to connect people over the phone and allow apps to operate online. By contrast, fifth-generation cellular telecommunications have two main purposes: 1. Improving the operation of cellular phones and of data transfer, in terms of both apps and the speed of video streaming; 2. Serving the Internet of Things (IoT). The Internet of Things is a network of physical objects that are connected via electronic means and the Internet; they can collect data and operate using these data, mostly automatically. Two examples are smart homes and smart cities, in which services like waste collection and transportation are run automatically or autonomously. The safe operation of self-driving vehicles will likely rely on the Internet of Things. In fact, we can expect that a considerable portion of our lives in the future will be run via the Internet of Things, which will rely on fifth generation cellular telecommunications, among other things.[4]

The data-transfer rate in 5G is expected to be over one thousand times higher than in 4G – with a record download speed of 20,000 million bits per second and a record upload speed of 10,000 million bits per second.

According to Nati Schubert, Deputy Director of the Engineering Administration in the Ministry of Communications, there are several key technological differences between previous generations of cellular telecommunications and the fifth generation, mainly

[1] Radio frequencies (the number of radiowave cycles within a unit of time) are measured in hertz (Hz), with 1 Hz equal to one cycle per second. The longer the wavelength the lower the frequency, and the shorter the wavelength the higher the frequency.

[2] Tnuda Center, Deployment of cellular antennas: spatial coverage, accessed: June 17th 2020.

[3] Ibid.

[4] Eliran Zered, Cellular antenna infrastructures in Israel: update document, Knesset Research and Information Center, November 29th 2018 [Hebrew].

regarding the network's capacity and its ability to support different kinds of services. These differences include, among others:

a. **Data-transfer rate:** The data-transfer rate in 5G is expected to be over one thousand times higher than in 4G—with top speeds of 20,000 megabits per second (Mbps) for downloads and 10,000 Mbps for uploads. This capability is known as EMBB (Enhanced Mobile Broadband), and it allows higher data transfer speeds to support applications such as Internet access, video conferencing, virtual reality (VR) and augmented reality (AR).

b. **Data transfer reliability**: 5G networks will feature ultra-reliable, low latency, (URLL) data transfer,[5] which will serve special applications such as industrial automation, new medical applications, autonomous vehicles, smart transportation, and machine-to-machine (MTM) communications.

c. **Massive IoT—support for communications between vast numbers of components:** 5G cellular telecommunications will enable billions of connections between different network nodes, thereby allowing for data collection and automation. Industry is currently focused on four main fields of the Internet of Things: smart cities, industry, transportation, and smart homes. The variety of fields is expected to expand as technologies evolve.

d. **Support for high density of end devices:** 5G networks will support at least one million end devices (mobile phones) per square kilometer.

e. **Frequency ranges:** 5G networks are expected to use very high frequencies in the range of 3,500 MHz and 24,000 MHz in order to increase network capacity and the ability to use low latency broadband.[6]

The 5G network is expected to use very high frequencies in order to increase the capacity and allow low latency broadband.

Changes in the physical components of 5G networks are to be expected in light of the aforementioned functional changes. Because a 5G network is based on high-frequency, short-wavelength signals, **the distance between antennas will be shorter.** Large antennas from previous generations will be combined with **multiple smaller base station antennas at shorter distances** (a few hundred meters apart). Furthermore, 5G cells will implement **beam steering technology,** which allows for direct data transfers between the antenna and the cellular end device, in contrast to the "broad" and unfocused signal currently emitted from 3G and 4G antennas. In addition, because

The physical components of a 5G network will also be different: the distance between antennas will be shorter; big antennas from previous generations will be combined with multiple smaller antennas at shorter distances; antennas will be installed inside buildings; Beam Steering technology will be implemented to allow direct data transfers between the antenna and cellular device.

[5] Low latency means high-speed data transfer without the delay that appears nowadays in many mobile telephony processes. Low latency ensures that the data transfer will be almost uninterrupted, which is an important feature for innovative communications applications.

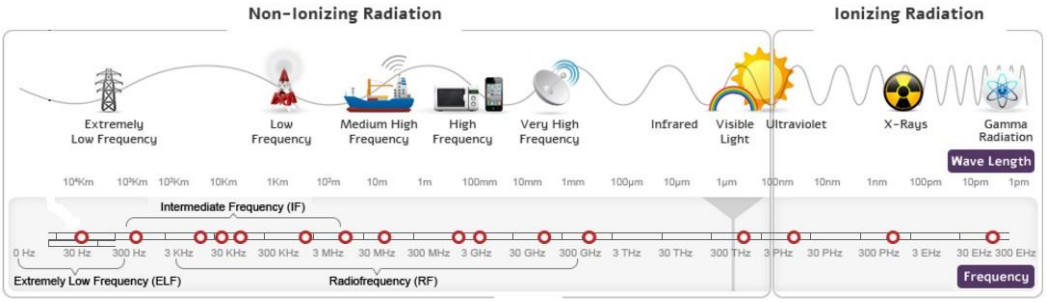
[6] Nati Schubert, Deputy Director of the Engineering Administration (Spectrum) in the Ministry of Communications, response to query from the Knesset Research and Information Center's query, letter, October 31st 2019 [Hebrew].

millimeter waves have limited ability to penetrate buildings, there will also be **antennas inside buildings** that will allow signals to enter the building from the outside and enable communication within the building itself.[7]

3. Cellular radiation and radiation from 5G cellular telecommunications

Concerns of increased non-ionizing radiation grow around the deployment of a 5G network, due to the high data-transfer rate, the use of high frequencies and its other physical attributes.

Radiation is energy that travels in a medium in the form of waves or particles. Because radiation spreads in wave form, one can measure the wave's length and frequency, i.e., the number of times the wave oscillates per second. **The longer the wave, the smaller its frequency, and vice versa—**i.e., radiation with a shorter wavelength will have a higher frequency. **High-frequency radiation has higher energy levels.**



Electromagnetic radiation (see chart[8]) can be divided into two types of radiation: non-ionizing radiation and ionizing radiation. Non-ionizing radiation belongs to the lower frequencies, which have lower energy than ionizing radiation. The types of wavelengths associated with non-ionizing radiation include, among others, radio waves and microwaves (which also include cellular and Wi-Fi communications). This kind of radiation does not have enough energy to cause the release of electrons from the atoms or molecules in the substance on which it radiates. **Overall, non-ionizing radiation is considered less dangerous than ionizing radiation.**

Non-ionizing radiation belongs to the lower frequencies, which have low energy compared to ionizing radiation. The types of wavelengths associated with non-ionizing radiation include, among others, radio waves and micro waves (which also include cellular and Wi-Fi communications). Overall, non-ionizing radiation is considered less dangerous than ionizing radiation.

Ionizing radiation (ultra-violet radiation, x-rays, and gamma rays) has higher frequencies than non-ionizing radiation. In addition, it has higher energy and may cause changes to biological materials, including DNA.[9]

Current cellular telecommunications technologies (Generations 2, 3, 3+, 4, and LTE Advanced) operate in the 800–900 MHz range. **Cellular radiation in these frequencies**

[7] Prof. Stelian Gelberg, Director of Noise Prevention and Radiation Safety in the Ministry of Environmental Protection, conversation, September 15, 2019 [Hebrew].

[8] "The electromanetic spectrum," diagram from the website of the Tnuda Center, the Israeli National Information Center for Non-ionizing Radiation and its Effects on Public Health.

[9] Tnuda Center, Types of electromagnetic radiation, updated: July 1st 2014, accessed: August 20th 2020.

is considered non-ionizing, which, as mentioned above, is less dangerous than ionizing radiation. **However, in recent years, there has been increasing public discussion of negative health and environmental effects of electromagnetic radiation, in light of the differences of opinion on the issue among researchers and academics.**[10] Chapter 4 of this document will further elaborate on this subject.

The Ministry of Environmental Protection believes that the population's exposure to cellular radiation may actually be reduced.

The concerns regarding non-ionizing radiation increase when it comes to the deployment of 5G, because, as noted above, this network operates at higher frequencies and requires the wider deployment of antennas. Moreover, the higher data-transfer rates on 5G networks and the extensive deployment of antennas that this requires may involve higher cumulative amounts of cellular radiation.

Prof. Stelian Gelberg, Director of Noise Prevention and Radiation Safety in the Ministry of Environmental Protection, and others within the division[11] believe that 5G networks may actually reduce the public's exposure to cellular radiation, for several reasons:

a. Using higher frequencies will require an increased number of small antennas inside buildings. In this setup, the **broadcasting power[12] of both broadcasting centers and end equipment will be very low due to the short wireless distance between them,** which results in relatively low levels of exposure to radiation. In addition, currently, antennas located outside of buildings broadcast at high power to make up for the drop in signal strength when penetrating buildings. **Placing small antennas inside buildings will lead to a decrease in the intensity of the radiation from external antennas.**
b. Fifth generation technology is more efficient than previous generations when it comes to broadcasting power; **it enables faster data transfer while utilizing broadcasting power more efficiently,** which helps reduce radiation exposure.
c. Fifth generation cellular telecommunications allow large numbers of people to use the Internet at high speeds. **When Internet speed increases, the length of Internet use decreases, and thus the duration of radiation exposure also decreases.** Note

[10] Cindy L. Russell, 5G wireless telecommunications expansion: Public health and environmental implications, *Environmental Research* 165 (August 2018): 484–495; Environmental Health Trust, accessed: August 4th 2020; Ministry of Environmental Protection, Non-ionizing radiation, accessed: August 4th 2020 [Hebrew]; EHS Israel website, accessed: August 4th 2020.

[11] Gil Cohen, Director of non-ionizing radiation in the Ministry of Environmental Protection, letter to Netanel Cohen, Director General of the Ministry of Communications, February 12th 2019 [Hebrew]; Stelian Gelberg, Director of Noise Prevention and Radiation Safety in the Ministry of Environmental Protection, meeting, September 15th 2019 [Hebrew].

[12] Electrical output is the amount of electrical energy flowing in a circuit per time unit. Electric energy can be converted into radiation. The closer the end cellular device—the mobile phone—is to the base station—the antenna—the less energy it requires, the lower the output, and the smaller the exposure to radiation in the area. Conversely, the farther the mobile phone is from the base station, the more energy is required to communicate and the higher the output, and thus the higher the cellular radiation.

that Dr. Yael Stein, an anesthesiologist and pain management specialist at Hadassah Ein Kerem Hospital who studies electromagnetic hypersensitivity, argues against this claim and states that **the efficiency and speed of Internet use in fifth-generation cellular telecommunications will actually lead to an increase in Internet use.** As a result, she says**,** the total radiation from using fifth-generation cellular telecommunications will eventually be higher than it is currently.[13]

d. 5G uses massive MIMO antennas, which can communicate with end devices via a narrow, precise beam, while the antennas used in previous technologies broadcast on a wide beam and needlessly expose extensive areas to radiation. **Fifth-generation antennas have higher energy efficiency that drastically reduces radiation exposure.**

e. Because of the dense deployment of the broadcasting centers in 5G, the radiation exposure from each broadcasting center will be roughly the same—approximately 5 microwatts per square centimeter (**μW/cm²**), which is **an order of magnitude lower than the thresholds recommended by the World Health Organization** (as described below).

the World Health Organization (WHO) International Commission on Non-Ionizing Radiation Protection (ICNIRP) set a health threshold of 400-1,000 μW/cm², above which radiation is considered dangerous

In this context, we note that the International Commission on Non-Ionizing Radiation Protection (ICNIRP) of the World Health Organization (WHO) is an international commission that studies non-ionizing radiation and drafts recommendations and guidelines for addressing the environmental and health effects of radiation. In 1998, the ICNIRP published its guidelines on environmental exposure to non-ionizing radiation, which included a **threshold of 400–1,000 μW/cm², above which the radiation is considered dangerous even in public places where there is no prolonged exposure.**[14] We emphasize that this threshold only refers to acute, short-range exposure. According to Prof. Stelian Gelberg, Director of Noise Prevention and Radiation Safety in the Ministry of Environmental Protection, the ministry follows the precautionary principle and seeks to minimize the public's exposure to radiation as much as possible.[15] Thus, the Ministry of Environmental Protection has adopted a **stricter threshold** than the one set by the World Health Organization. According to

The Ministry of Environmental Protection in Israel has adopted a stricter threshold. Exposure to radiation from base station will be no more than 10% of the health exposure threshold set by ICNIRP, and in short-term exposure areas, such as sidewalks and roads, the exposure threshold shall not exceed 30%.

[13] Dr. Yael Stein, Hadassah Ein Kerem Hospital, conversation, February 26th 2020 [Hebrew].

[14] ICNIRP, Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields, *Health Physics* 74(4), 1998:. 494–522, see p. 511, Table 7. The precise threshold was set as a function of frequency, and the range of threshold exposures presented here is based on the frequencies used for cellular communications, i.e., 300 GHz–800 MHz.

[15] Ministry of Environmental Protection, Non-ionizing radiation, accessed: May 7th 2020 [Hebrew]; Prof. Stelian Gelberg, Director of the Noise Prevention and Radiation Safety Division in the Ministry of Environmental Protection, meeting, September 15, 2019 [Hebrew].

the Israeli threshold, exposure to radiation from base stations may not exceed 10% of the health exposure threshold set by the ICNIRP (i.e. 40–100 μW/cm^2) in areas with long-term exposure, such as residential and work environments; in short-term exposure areas, such as sidewalks and roads, the exposure threshold may not exceed 30% of the ICNIRP threshold.[16]

4. Health implications of exposure to cellular radiation

Although cellular communications have operated in Israel and around the world for decades, initial partial evidence of possible negative effects of cellular phones on health only began to accumulate in recent years.

This chapter will cite studies and articles that examined the effects on health of cellular radiation exposure. Note that these are the main articles cited in research and professional overviews of this field and not a complete review of all the studies in the field. Moreover, we do not have the capability of evaluating the details of the studies or the underlying methodological tools they employ.

Recent years have seen the publication of results from various research papers—both broad and focused—that examine the health effects of exposure to cellular radiation, particularly the occurrence of various types of cancerous tumors in laboratory animals. Some notable studies include those by the National Toxicology Program in the United States[17] and the non-profit Ramazzini Institute in Italy.[18] Another wide-scale study, INTERPHONE, was a collaboration between researchers from 16 institutions in 13

The past few years have seen results published from various research papers, both extensive and specific, examining the health effects of cellular radiation exposure, particularly the occurrence of cancerous tumors in different kinds of lab animals. However, the difference of opinion on the significance of the results of these studies remains unresolved.

[16] Ministry of Environmental Protection, Precautionary ranges and maximum permissible exposure levels for radio wave radiation, 2009 [Hebrew], p. 4; Tnuda Center, Recommendations for non-ionizing exposure from cellular antennas in Israel, accessed: November 6th 2018.

[17] The National Toxicology Program conducted a series of studies to examine the effects of cellular radiation from 2G and 3G cellular telephony on the health of mice and rats and to assess whether the radiation causes cancer in these animals. The study results were published in November 2018 after a decade of research and data analysis. **Clear** results were found indicating that the radiation created various malignant tumors in male rats. Regarding female rats and mice (both male and female), the findings were unclear, i.e., it was not possible to link between the existence of tumors and cellular radiation. Note that this study and its relevance have been criticized, as it examined radiation characteristic of 2G and 3G devices as opposed to the newer devices that are currently available. The researchers responded to this claim by arguing that there are still many 2G and 3G in active use. Nicole Scholz, Mobile phones and health: Where do we stand?, European Parliamentary Research Service (EPRS), Members' Research Service, PE 635.598, March 2019, pp. 4–5.

[18] In a group of studies performed by Ramazzini researchers in Italy, the researchers exposed animals to increasing levels of radiation up to a level of 19 hours of radiation per day. In the studies that involved the highest dose of radiation, the researchers found higher incidence rates for certain tumors in the hearts of male rats. Nicole Scholz, Mobile phones and health, p. 5.

countries that was coordinated by the International Agency for Research on Cancer (IARC).[19]

Some studies have pointed at biological damage stemming from non-ionizing radiation.
Some works have also shown damage to trees, wildlife and nature in general.

Multiple studies have examined the possible effects of exposure to electromagnetic radiation, which is characteristic of cellular telecommunications, among other things; **however, the differences of opinion regarding the significance of the studies' results remains unresolved.** There have been various criticisms of these studies and their results, from methodological failures and statistically insignificant results to allegations that the studies were influenced by interested parties.[20] We note in this context that **there are innate difficulties in conducting epidemiological studies that examine the effects of a population's exposure to radiation**, including the difficulty of locating a control group that is completely unexposed to radiation. Furthermore, it is very possible that the consequences of radiation are affected by numerous intervening variables. Furthermore, people born in the past two decades are the first generation to be exposed to electromagnetic radiation at the relevant frequencies throughout their entire lifetime. Thus, it is possible that the health effects will only manifest in the years to come.[21]

In the absence of unequivocal research findings, cellular radiation was defined in 2011 by the International Agency for Research on Cancer (IARC), as "possibly carcinogenic to humans."

In the absence of unequivocal research findings, in 2011, the International Agency for Research on Cancer (IARC), which is affiliated with the WHO, defined radiofrequency electromagnetic radiation in radio waves (which includes cellular radiation, among other things) as "possibly carcinogenic to humans."[22]

In the wake of recent research findings regarding the health implications of radiofrequency radiation, the IARC recently decided to make a renewed evaluation of this definition a high priority for the next five years (2020–2024).[23]

While the difference of opinion over the health implications of 2G, 3G, and 4G cellular telecommunications continues, **the potential health implications of 5G and its various features have, naturally, remained mostly unexplored to date**.

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[19] The purpose of the study was to examine whether radiation from cellular phones increases the incidence rates of head and neck cancer and, more generally, whether the radiation is carcinogenic (causes cancer). The study's findings, published in 2011, showed no increase in the incidence rates of the types of cancer that were examined. The researchers did not that certain types of cancer have a long latency period and that a longer research period may be required. Ibid., p. 5.

[20] Ibid.

[21] Cindy L. Russell, 5G wireless telecommunications expansion: Public health and environmental implications, *Environmental Research* 165 (August 2018): 484–495.

[22] International Agency for Research on Cancer (IARC), World Health Organization, IARC classifies radio frequency electromagnetic fields as possibly carcinogenic to humans, May 31st 2011.

[23] Idem, Report of the Advisory Group to Recommend Priorities for the IARC Monographs during 2020–2024, 2019.

One main argument is that many of the studies from the past two decades—which, as described above, serve as the basis for guidelines regarding exposure to non-ionizing radiation—primarily examined the effects of short-term exposure to radiation on energy absorption by the human body, as manifested in tissue warming. Some researchers suggest that due to the changes in the nature of exposure to radiation in recent years, **and particularly in light of the upcoming deployment of the 5G network**, the body of research that examines the possible biological effects of exposure to radiation should be expanded.[24]

There is a growing body of studies that point at biological and non-thermal effects of exposure to the non-ionizing radiation seen in cellular communication.

We note that it is customary to discuss two main types of effects of non-ionizing radiation on health. The first type of effects are those caused by the **warming of tissues** in the vicinity of the cellular device. The level of exposure is measured in units called the Specific Absorption Rate (SAR), which describes the amount of energy absorbed per unit of mass of biological material (for example, the human body).[25] The drawback of SAR is that it only measures thermal effects from short-term exposure, and it ignores non-thermal effects or effects that may stem from long-term exposure to non-ionizing radiation. Therefore, the current approach also addresses the possible biological effects[26] of non-ionizing radiation.

The potential health implications of 5G and its various features, have naturally mostly not been explored as of yet. Some researchers claim that in light of the future deployment of 5G, exploration of the possible biological effects of exposure to radiation should be expanded.

A review article by Cindy Russell in 2018[27] covered major issues in the cumulative study of the health effects of cellular radiation, and particularly the biological effects. The author also addressed the possible health effects of fifth-generation cellular telecommunications, noting that there is a growing body of research that points to biological and non-thermal effects of exposure to the non-ionizing radiation seen in cellular communications. She therefore criticizes the approach which maintains that the only harmful effect of non-ionizing radiation is thermal—an approach, she says, that is characteristic of professionals and scientists in physics and engineering. She notes that by contrast, scientists in the fields of chemistry and biology have discovered mechanisms of cell damage that is caused by non-ionizing radiation even without thermal radiation. She cites studies that point to biological damage caused by non-

[24] Cindy L. Russell, 5G wireless telecommunications expansion: Public health and environmental implications, *Environmental Research* 165 (August 2018): 484–495.

[25] Ministry of Environmental Protection, https://www.gov.il/he/Departments/Guides/radio_frequency_radiation?chapterIndex=3 [Hebrew].

[26] Biological effects are effects on the body's biological processes, such as those of a physiological, biochemical, or metabolic nature, or effects that alter cells' genetic material (DNA and RNA).

[27] Cindy L. Russell, 5G wireless telecommunications expansion: Public health and environmental implications, *Environmental Research* 165, August 2018, pp. 484–495.

ionizing radiation itself, rather by the heating related to it, which includes, among other things, impaired DNA integrity, cell membrane damage, impaired gene-expression and protein synthesis, neuronal damage, compromised sperm quality, and damage to the immune system. Other studies point to decreased fertility as well as degenerative changes to the nervous system. Russell also notes studies that indicate that radiation causes harm to trees, wildlife and nature in general.[28]

Russell's review and others like itthe of elementa key is **tissue oxidation**indicate that [29] biological damage.[30] For example, Igor Yakymenko and his colleagues reviewed some 100 papers and noted that 93 of them confirmed that non-ionizing radio radiation causes the appearance of excess oxidative agents, which may cause various kinds of damage in cells. There is also a link between oxidative damage, on the one hand, and the development of chronic illnesses and the occurrence of certain types of cancer, on the other.[31]

Studies on the biological effects of non-ionizing radiation are based mostly on laboratory experiments and animal testing, in contrast with epidemiological studies that examine the link between exposure to a risk factor and the morbidity rate in the population.

It is important to emphasize that the studies on the biological effects of non-ionizing radiation are based primarily on laboratory experiments and animal testing. This is in contrast to epidemiological studies, which examine the link between exposure to a risk factor and morbidity rates. Moreover, the results of some of the studies may be preliminary or controversial.[32]

A February 2020 conference on cellular radiation and radiation from wireless networks held by the Tel Aviv University Department of Public Policy,[33] featured the presentation of studies from different countries that examined additional mechanisms that could cause biological damage due to radiation exposure. One of these papers was published by researchers Yuri Feldman, Noa Bezalel and Paul Ben Yishai, who showed that the **skin** can be seen as an organ with millions of "antennas"—the coiled part of the sweat glands,

A European Parliament review argued that since 5G technology hasn't been tested before, a precautionary approach may be necessary for its extensive implementation.

[28] Sivani Saravanamuttu and D. Sudarsanam, Impacts of radio-frequency electromagnetic field (RF-EMF) from cell phone towers and wireless devices on biosystem and ecosystem: A review, *Biology and Medicine* 4, no. 4 (2013): 202–216.

[29] Miroslava Karaboytcheva, Effects of 5G wireless communication on human health, EPRS, Members' Research Service, PE646.172, February 2020; Cindy L. Russell, 5G wireless telecommunications expansion: Public health and environmental implications, *Environmental Research* 165 (August 2018): 484–495.

[30] Oxidation is a chemical reaction in which electrons are transferred from a given material to an oxidizing agent. Oxidation processes are essential biological processes, but in some cases, excessive oxidation creates unstable chemicals called free radicals, which may lead to the destruction of proteins, cells, and tissues, and—eventually—to serious illnesses.

[31] Yakymenko et al., Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation, *Electromagnetic Biology and Medicine* 35 no. 2 (2016): 186–202.

[32] Miroslava Karaboytcheva, Effects of 5G wireless communication on human health, EPRS, Members' Research Service, PE646.172, February 2020.

[33] 2020 expert forum: Wireless and cellphone radiation and public policy, Department of Public Policy, Tel Aviv University, February 10th–11th 2020. The forum's book of abstracts can be found here, and videos from the forum can be seen here.

which the researchers showed have electromagnetic conduction capabilities. According to the researchers, **this phenomenon is particularly significant when it comes to millimeter wavelengths, which are characteristic of fifth-generation cellular telecommunications**, as these penetrate the epidermis but may conduct the electromagnetic radiation deeper into the body by means of the "antennas" in the sweat glands.[34]

A recent review by the European Parliament also explores the health implications of 5G.[35] The review's author concludes that current academic literature has shown that extended exposure to cellular radiation has biological effects, particularly in light of the unique characteristics of 5G: millimeter waves, higher frequencies, multiple transceiver stations, and multiple connections. According to the author, **various studies have indicated that 5G technology may affect the health of human beings, plants, animals, insects and germs. Moreover, because 5G technology has never been tested, a cautious approach should be taken when it comes to widespread implementation of this technology.**

The World Health Organization has also noted the need to advance research and consolidate information on cellular radiation and the health effects of 5G technology, throughout the stages of the technology's deployment. In a Q&A sheet published in February 2020,[36] the organization declared **that to date, no adverse health effects are known to be linked to exposure to cellular radiation from 5G technology and that no adverse health effects are expects provided that the overall exposure remains below permitted levels.** Nonetheless, the WHO is working on several fronts to advance research and consolidate a body of knowledge on this field:

1. The WHO is performing an assessment of the health risks related to exposure to radio waves, including 5G. The assessment will be released in 2022.
2. The WHO will review current scientific information on health risks due to exposure to 5G as these networks are deployed and as more information becomes available.

The WHO declared in February 2020 that as of now there is no known health damage that might be caused by 5G cellular radiation, and as long as the permissible exposure values are maintained, no health damage is expected. However, the need to promote research in this field has been stressed, and operative steps were defined for this aim.

[34] Noa Betzalel et al., "The Modeling of the Absorbance of Sub-THz Radiation by Human Skin", *IEEE Transactions on Terahertz Science and Technology* 7 no. 5 (September 2017): 521–528; Noa Betzalel et al., "A sub-THz receiver: Does 5G pose a danger to it or not?" *Environmental Research* 163 (May 2018): 208–216; Anna Kochnev et al., "Human sweat ducts as helical antennas in the sub-THz frequency", *Terahertz Science and Technology* 11 no. 2 (June 2018): 43–56.

[35] Miroslava Karaboytcheva, Effects of 5G wireless communication on human health, EPRS, Members' Research Service, PE646.172, February 2020.

[36] World Health Organization, "Radiation: 5G mobile networks and health," accessed August 18th 2020.

3. In 1996, the WHO founded the International Electromagnetic Fields (EMF) Project, whose purpose is to examine the health effects of exposure to electromagnetic radiation—including 300GHz frequencies, which serve fifth generation cellular technology.

4. The WHO continues to encourage research on the long-term effects of cellular radiation and continues to encourage collaborations between governments, research institutes, and the public.[37]

On the subject of the precautionary principle, we should note that **certain groups are more sensitive than the general population to the effects of electromagnetic radiation.** According to the website of the National Center for Information on Non-Ionizing Radiation and its Effects on Public Health ("Tnuda"),[38] **the groups that are at a higher risk of illness due to exposure to risk factors (including electromagnetic radiation) include, among others, children and teenagers, pregnant women, and people suffering from chronic conditions.** According to the website, "the concern over health and social effects increases when it comes to children and teenagers [as …] the high rate of cell division in the bodies of growing children causes them to be more sensitive to impaired DNA integrity. Furthermore, children who start using phones at a young age are expected to be exposed to radiation emitted from the phone for many more years and their cumulative exposure will be more significant. […] Therefore, children should be treated as a (relatively) sensitive population, as compared to the adult population.[39]

Some countries, such as the Netherlands and Switzerland, have expressed a more cautious position on the possible health implications of 5G technology. For instance, Switzerland set stricter limits on the radiation level and millimeter wave frequencies for radio communication, which are supposedly essential to 5G technology.

A 2011 European Council decision: "every reasonable measure should be taken to limit exposure to electromagnetic fields, especially radio waves from mobile phones, and particularly among children and youths."

The treatment of children as an at-risk population in this context has been fundamental to policy decisions on children's exposure to electromagnetic radiation. For example, a 2009 resolution by the European Parliament stated, among other things, that there was general agreement that children are especially vulnerable or sensitive to electromagnetic radiation. In May 2011, the Council of Europe released a report entitled

[37] For more information on the positions of international organizations and countries on the health effects of 5G mobile telephony, see also: Tnuda Center, The 5th generation (5G): Attitude of organizations and states worldwide towards the health risk, accessed: August 19th 2020.

[38] Tnuda Center was founded in 2013 by the Ministry of Science and the Ministry of Environmental Protection in the wake of a Government resolution. Tnuda is a national information center on non-ionizing radiation and its effects on public health, providing scientific information to the Ministry of Health on the effects of non-ionizing radiation on health as well as data collection and literature reviews and offering the ministry recommendations on ways to balance advanced technology and public health. In addition, the center assists the Ministry of Health in responding to the general public by increasing accessibility to information on the possible health effects of exposure to non-ionizing radiation and on the use of radiation-emitting technologies.

[39] Tnuda Center, Cellular Phone Use: Health Implications, updated: June 17, 2014, accessed: August 20, 2020 [Hebrew].

"The potential dangers of electro-magnetic fields and their effect on the environment" followed by a resolution of the same name. One of the recommendations included in the resolution emphasizes the risk to children—countries are urged to "take all reasonable measures to reduce exposure to electromagnetic fields, especially to radio frequencies from mobile phones, and particularly the exposure to children and young people who seem to be most at risk from head tumors."[40]

When discussing sensitive populations, it is also important to mention people suffering from **Electromagnetic Hypersensitivity (EHS).** This is a syndrome that does not necessarily have a clear toxicological or physiological explanation, and people suffering from it display a variety of symptoms (particularly symptoms related to the nervous system)[41] that can be attributed to acute or chronic exposure to electromagnetic radiation. There is some disagreement in the healthcare field among researchers, medical personnel, and decision-makers about whether a direct link exists between exposure to radiation and the symptoms reported by people suffering from the syndrome. For example, the Israel Ministry of Health has adopted the position of the World Health Organization that EHS is not a medical diagnosis and that it is unclear whether the syndrome is an expression of a single medical problem. However, according to Dr. Yael Stein, a physician at Hadassah Ein Kerem Hospital whose patients include people who report symptoms that are consistent with EHS and have been diagnosed with EHS, the world now recognizes the need to respond to this population. Thus, she noted, the syndrome is recognized as a disability in Sweden.[42] The aforementioned Council of Europe resolution from 2011 also proposed providing special treatment for "'electrosensitive' people who suffer from a syndrome of intolerance to electromagnetic fields and introduce special measures to protect them, including the creation of wave-free areas not covered by the wireless network."[43] In Dr. Stein's view, when discussing the

Some believe that it is important to provide a specific response for people suffering from Electromagnetic Hypersensitivity (EHS), such as radiation-free zones.

[40] For more on this see: Roy Goldschmidt and Shiri Spector-Ben Ari, Electromagnetic radiation and the policy for addressing it in the education system, Knesset Research and Information Center, May 16th 2013 [Hebrew].

[41] The reported symptoms are thigh cramps, jaw discomfort, insomnia, chronic headaches, brain fogs, memory problems, blackouts, sensory overload, tingling scalp, reversible and irreversible tinnitus, stomach aches, Irritable Bowel Syndrome, tachycardia, and anxiety. Additional symptoms include tendinosis, swollen lymph nodes, change in heart rate, premature ventricular contractions, shortness of breath, dry eyes, strange taste sensations, and pain in various places. Yael Stein and Iris G. Udasin, Electromagnetic hypersensitivity (EHS, microwave syndrome): Review of mechanisms, *Environmental Research* 186 (2020): 109445.

[42] Dr. Yael Stein, Hadassah Ein Kerem Hospital, conversation, February 26, 2020 [Hebrew].

[43] Roy Goldschmidt and Shiri Spector-Ben Ari, Electromagnetic radiation and the policy for addressing it in the education system, Knesset Research and Information Center, May 16th 2013 [Hebrew].

establishment of a fifth generation cellular network, it is very important to take EHS patients into account and try to alleviate their suffering to the extent possible.[44]

5. Positions of Government bodies on the health risk in the deployment of 5G networks: A comparative overview

In May 2020, Tnuda published a review entitled "Attitude of some countries to the health risk of implementing 5G technology" on its website.[45] The review provides a brief description of the positions taken by a number of selected countries (New Zealand, Australia, Canada, the UK, the Netherlands, Germany, the United States and Switzerland) on issues such as the health implications of 5G networks, the need for research on health implications and radiation monitoring, and the need to limit the frequencies intended for 5G technology in the short and long term. According to the Tnuda website, the review indicates that in most of the countries that were examined, the widespread position on the health implications of 5G technology is as follows: According to the existing scientific knowledge, there is no evidence that the radio frequencies used in 5G technology have negative effects on human health; further research on the issue of the health risks of 5G technology is needed; monitoring is needed of the expected exposure to radiation near 5G sites and to radiation from devices that support 5G; and the existing ICNIRP exposure limits adopted by the countries also cover the range of frequencies used in 5G, and though there may be a slight increase in overall exposure as a result of 5G technology, this should still be much lower than the exposure limits.

According to the Tnuda website, the common position in some of the countries is that according to existing scientific knowledge, there is no evidence of human health implications due to radio frequencies used in the 5G technology, and that the exposure limits adopted by the countries also cover the range of frequencies to be used in 5G.

Two of the reviewed countries, the Netherlands and Switzerland, expressed a more cautious position on the possible health implications of 5G technology. **Switzerland** set a stricter radiation limit than in the most European countries (and Israel) in November 2019. According to a report by the Federal Council, which set the radiation limits, the frequencies available to 5G are identical to those for 4G, and millimeter wave frequencies for radio communication, which are meant to underlie 5G technology, had not been approved for use in Switzerland as of the date of the report.[46]

According to the Tnuda review, in **the Netherlands,** the National Institute for Public Health and the Environment (RIVM) recommended closely monitoring the implementation of 5G technology. According to RIVM, although the levels of exposure to radiation from 5G antennas are expected to be lower than the recommended exposure thresholds, the number of sources of radiation and the amount of data transferred are

[44] Dr. Yael Stein, Hadassah Ein Kerem Hospital, conversation, February 26th 2020 [Hebrew].

[45] Tnuda Center, "Attitude of some countries to the health risk of implementing 5G technology," updated: June 1st 2020, accessed: August 22nd 2020.

[46] Tnuda Center, "Switzerland," updated: May 17th 2020, accessed: August 22nd 2020.

expected to increase. Therefore, "it is still impossible to assess the extent to which exposure will change relative to the current limitations." Moreover, there is still uncertainty when it comes to research on the health implications of 5G systems. On the one hand, there are studies that provide an indication of health implications, but on the other hand, studies have yet to prove that exposure levels below the current threshold have adverse effects on health.[47]

It is worth noting that the review published on Tnuda's website presents only a few countries, and we do not have any information that explains why these countries specifically were reviewed. Furthermore, the information relates to the position of countries (mainly national radiation protection authorities). However, as we describe below, there are also cases of opposition by government entities—**particularly on the regional and local levels**—that restricted or delayed the deployment of 5G in their jurisdictions due to concerns of the technology's health effects or that requested information from qualified entities on the health implications of the 5G network. Here are some examples:

United States

Alongside reports of the extensive deployment of 5G networks in the US, there are also reports of increasing opposition to the networks, most of which include calls to test the technology before it is implemented to ensure its safety and prevent any adverse effects on health.

The US-based Environmental Health Trust has reviewed some of the objections.[48] For example, the New Hampshire General Court passed a bill in June 2019 calling for the establishment of a committee to study the health and environmental implications of establishing a 5G network, with an emphasis on the effects on the health of sensitive groups such as children, fetuses, the elderly, and people with preexisting conditions. The committee would include representatives of the House of Representatives and the Senate; the public; industry, and particularly the cellular industry; the state High Technology Council; the state medical society, by a specialist the field; the state department of health; and academia, among others.[49]

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[47] Tnuda Center, "Netherlands," updated: May 17th 2020, accessed: August 22nd 2020. Note that the quotation is taken from the Hebrew-language version of the page.

[48] Environmental Health Trust, accesed: August 6th 2020.

[49] New Hampshire House Bill 522, establishing a commission to study the environmental and health effects of evolving 5G technology, July 7th 2019, accessed: August 6th 2020.

The Louisiana House of Representatives passed a resolution requesting the Department of Environmental Quality in conjunction with the state Department of Health to study the environmental and health effects of 5G technology.[50] The Oregon Legislative Assembly passed a bill to similar effect, which directed the Oregon Health Authority to prepare a review of up-to-date, peer-reviewed studies on the health effects of exposure to electromagnetic radiation, with an emphasis on schools, and present it to a Legislative Assembly committee on education. We note that the bill passed in Oregon refers to electromagnetic exposure in general (radio waves and microwaves) and does not focus specifically on 5G technology.[51]

There have been cases of opposition by government bodies, particularly on the regional and local levels, which limited the deployment of 5G in their territories and delayed it due to concerns of the technology's health effects, or asked for information from qualified bodies on the health implications of the 5G network.

Various local authorities in the United States imposed restrictions on the deployment of 5G networks or sought to halt this process until research is conducted and guidelines are set out that ensure the public health is maintained. For example:[52]

- On May 7th 2020, the town of Easton, Connecticut decided to cease the deployment of 5G networks until the end of 2020 so that the risks involved in 5G networks could be studied.[53]
- The town of Hallandale Beach, Florida passed a resolution urging the State and federal authorities to conduct an independent study to examine the health effects of 5G technology in order to establish guidelines for the deployment of 5G networks in a manner that does not endanger the townspeople.[54]

Ireland

The Clare County Council decided to stop the deployment of 5G networks and urged the Minister for Communication, Climate Change and the Environment, to establish a working group to determine the facts about the radiation impact of fifth generation cellular telecommunications on the environment and human health.[55]

England

[50] LegiScan, "Bill text, Louisiana House Resolution 145," accessed: August 18th 2020.

[51] Oregon Legislative Assembl, Senate Bill 283, accessed: August 18th 2020.

[52] Environmental Health Trust, "USA policy action on 5G & 4G small cells," accessed: April 2nd 2020.

[53] 5G Resolution of Easton Connecticut May 2020, accessed: August 18th 2020.

[54] Hallandale Beach Resolution No. 2019, accessed: August 18th 2020.

[55] Minutes of the June Monthly Meeting of Clare County Council held in the Council Chamber, Áras Contae an Chláir, New Road, Ennis, Co. Clare on Monday, June 10th 2019 at 3:45 p.m, see p. 14, item 15.

The Wells City Council decided in its meeting on November 28th 2019 to delay the establishment of a 5G network based on the precautionary principle.[56]

6. Regulation of non-ionizing radiation in Israel and its attitude towards 5G Technology

The Israeli guidelines on the construction and operation of a device, installation, or technological system that may emit non-ionizing radiation during the course of its operation are codified in the Non-Ionizing Radiation Law, 5766-2006.

The Non-Ionizing Radiation Law 5766-2006 states that its purpose is to "protect the public and the environment from the effects of exposure to non-ionizing radiation […] among others by setting prohibitions and obligations according to the precautionary principle".

The Non-Ionizing Radiation Law, 5766-2006 states that its purpose is to "protect the public and the environment from the effects of exposure to non-ionizing radiation, as well as to regulate work in the construction and operation of radiation sources and the provision of radiation measuring services, *inter alia*, by setting out prohibitions and obligations in accordance with the precautionary principle." The precautionary principle relates mostly to states of uncertainty, in which the factual, professional, and scientific knowledge is not unequivocal, and it is defined in Israeli law within the explanatory notes to the Non-Ionizing Radiation Law. These state that "**even in the absence of sufficient scientific evidence of adverse health effects from a certain body, reasonable measures should be taken to mitigate 'the risk,' without waiting for the conclusion of the studies whose purpose is to reduce the uncertainty regarding said adverse health effects."**[57]

There is currently no special legislation or regulation in Israel regarding radiation emitted from fifth generation cellular telecommunications infrastructures, despite of the unique features of this technology.

According to Prof. Stelian Gelberg, Director of the Noise Prevention and Radiation Safety Division in the Ministry of Environmental Protection, **Israel also set its exposure threshold for environmental radiation in accordance with the precautionary principle.** As described in the beginning of this document, the Ministry of Environmental Protection in Israel adopted a stricter threshold than the one set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), which operates in collaboration with the World Health Organization. The decision by the Ministry of Environmental Protection on the Israeli threshold stated that **in areas of long-term exposure, such as residential and work environments, the threshold of exposure to radiation from base stations will be no more than 10% of the exposure threshold set by the ICNIRP (i.e. 40–100 μW/cm^2), and in areas of short-term exposure, such as**

[56] Wells City Council, Minutes of the meeting of Wells City Council held in the Council Chamber, Wells Town Hall on Thursday 28th November 2019 at 7.00pm, accessed: October 1st 2020.

[57] Tnuda Center, The precautionary principle, updated: August 1st 2014, accessed: August 19th 2020.

sidewalks and roads, the exposure threshold may not exceed 30% of the ICNIRP threshold.[58]

Furthermore, there are specific standards that define the permissible level of radiation emission from cellular devices. The standards for cellular phones are measured with the Specific Absorption Rate—SAR and are meant to prevent the excessive heating of tissues. Because phones are imported to Israel from various countries, the country adopted two main international standards for limiting exposure to radiation from cellular phones:

- An ICNIRP-based European standard for devices licensed in Europe—2.0 W/kg averaged over 10 grams of tissue.
- An FCC-based American standard for devices licensed in the US—1.6 W/kg averaged over 1 gram of tissue.[59]

The current regulations as described above apply to anything that may emit non-ionizing radiation during its operation and are not unique to any specific technology. At present, **Israel has no special legislation or regulation regarding radiation emitted from elements of fifth generation cellular telecommunications infrastructure, despite the unique features of this technology.**

A March 2019 letter by Ministry of Health Director General Moshe Bar Siman Tov to Ministry of Communications Director General Netanel (Nati) Cohen noted that on the one hand "the health effects of exposure to radiation from fifth generation technology are unclear," while on the other hand, "technological innovation and the vast advantages associated with it cannot be stopped." Bar Siman Tov therefore recommended that the Ministry of Environmental Protection **supervise exposure levels at the various stages of the deployment of 5G networks, while addressing the features unique to 5G technology** (including the multiplicity of radiation sources, the implementation of beam steering technology, the repercussions of deploying 5G technologies on top of existing 4G infrastructures) **and adjusting exposure levels in accordance with the precautionary principle.**the Ministry of Health recommended ,At the same time [60] establishing "an inter-ministerial committee that will include the relevant representatives from the field, including a Ministry of Health representative, which will

The Ministry of Health recommended establishing an inter-ministerial committee that would include the relevant representatives from the field, including a Ministry of Health representative, which will examine existing standards of technology implementation and update them if necessary. In practice, no such committee has been formed.

[58] Ministry of Environmental Protection, Non-ionizing radiation, May 25th 2019, updated: April 27th 2020, accessed: August 19th 2020 [Hebrew].

[59] Tnuda Center, Standards for mobile phones, accessed: August 20th 2020.

[60] Director General of the Ministry of Health Moshe Bar Siman Tov, Expansion of mobile communications infrastructures deployment and prepration to start the deployment of 5G infrastructures, letter to the Director General of the Ministry of Communications Netanel (Nati) Cohen, March 20th 2019 [Hebrew].

conduct a periodic examination of, among other things, the existing standards in the realm of technology implementation and update them if necessary, as more information becomes available."[61] **In practice, no inter-ministerial committee tasked with reviewing the need to change the standards of implementing 5G technology has been formed to date.**[62]

The letter from the Director General of the Ministry of Health states that "despite the obvious benefits of this technology, we need to explore the health-related aspects of this exposure to radiation on people's health. … Therefore, the Tnuda Center will continue monitoring the accumulating knowledge on how to assess the exposure from multiple radiation sources and the publication of health-related studies."[63] A conversation with Tnuda Director Hadas Vagman[64] indicates that **the information center does indeed monitor research papers published around the world but that it does not launch independent studies to examine the impact of radiation on people's health.**[65]

No environmental or health requirements were introduced to the fifth-generation frequencies tender documents. Such requirements will also not be added to the licenses granted to the winning bidders.

According to Prof. Stelian Gelberg, Director of the Noise Prevention and Radiation Safety Division in the Ministry of Environmental Protection, **there is no need to amend the current regulations in Israel to address fifth-generation technology specifically. He stated that the Non-Ionizing Radiation Law and the stringent exposure threshold that the ministry set in accordance with the precautionary principle provide a response even for 5G networks.**[66]

In this context it is important to note that the Non-Ionizing Radiation Law **does not make any special provisions for populations that are sensitive to radiation** (such as children and people with EHS syndrome, among others). For example, **there is no restriction on the installation of cellular infrastructures in proximity to educational institutions.** According to Prof. Gelberg, **such a limit is not necessary** because the

[61] Ibid.

[62] Stelian Gelberg, Director of the Noise Prevention and Radiation Safety Division in the Ministry of Environmental Protection, conversation, September 15th 2019 [Hebrew].

[63] Director General of the Ministry of Health Moshe Bar Siman Tov, Expansion of mobile communications infrastructures deployment and prepration to start the deployment of 5G infrastructures, letter to the Director General of the Ministry of Communications Netanel (Nati) Cohen, March 20th 2019 [Hebrew].

[64] Hadas Vagman, Director of the Tnuda Center, conversation, August 19th 2020 [Hebrew].

[65] Prof. Stelian Gelberg, Director of the Noise Prevention and Radiation Safety Division in the Ministry of Environmental Protection explained in a phone call held on August 19th 2020 that one reason that the Tnuda Center does not launch independent studies is that the organization is a knowledge center, not a research center. Prof. Gelberg said that he tried in the past to initiate the exapnsion of Tnuda into a research center by getting additional ministries (besides the Ministry of Environmental Protection and the Ministry of Science) to fund Tnuda, but this initiative failed to materialize.

[66] Prof. Stelian Gelberg, Director of the Noise Prevention and Radiation Safety Division in the Ministry of Environmental Protection, meeting, September 15, 2019 [Hebrew].

stringent exposure threshold is intended to protect everyone everywhere, and thus there is no difference between the recommended exposure thresholds in educational institutions and in children's home environment. As for those deemed to be suffering from EHS syndrome, Prof. Gelberg argues that if the State officially recognizes the syndrome as a disability, as has been decided in several countries,[67] then this population will need to be treated in a distinct manner, by making available radiation-free residential zones, among others things.[68]

Regulation changes for establishing infrastructures that would serve fifth generation cellular telecommunications were supposed to be examined by exploring regulation abroad, but due to budgetary constraints, such examinations were not performed.

The position that the current regulations are sufficient was also adopted by the Ministry of Communications, which is why **no environmental or health requirements were included in the tender documents for 5G frequencies** (see the chapter below). Moreover, according to Nati Schubert, Deputy Director of the Engineering Administration (Spectrum) in the Ministry of Communications, **no such requirements will be added to the licenses granted to the winning bidders.**[69] He stated that the precautionary principle is implemented both by the Ministry of Environmental Protection through the determination of environmental exposure thresholds for cellular radiation and by means of a policy to prioritize landline (i.e., wired) deployment wherever possible and to use reduced radiation wireless means inside buildings.[70]

Many countries have currently been taking steps to promote the assimilation of fifth generation cellular telecommunications technology: determining the frequencies for the networks' operation; regulation changes; technological experiments and initial deployment of infrastructures.

The response by the Ministry of Communications to the query by the Knesset Research and Information Center regarding necessary regulatory changes as the adoption of 5G technology in Israel progresses stated that a joint team from the Ministry of Communications, the Ministry of Finance, the Ministry of Environmental Protection and the Planning Administration was formed to discuss issues related to the planning and licensing of cellular infrastructures.**changes regulatory**The team concluded that [71] **should be considered for setting up infrastructures to serve 5G telecommunications. The changes were supposed to be examined by exploring**

[67] For example, as stated in Chapter 4, according to Dr. Yael Stein, a pain management specialist at Hadassah Ein Kerem Hospital, the syndrome is recognized as a disability in Sweden and the authorities relate to it accordingly.

[68] Prof. Stelian Gelberg, Director of the Noise Prevention and Radiation Safety Division in the Ministry of Environmental Protection, meeting, September 15th 2019 [Hebrew].

[69] Nati Schubert, Deputy Director of the Engineering Administration (Spectrum) in the Ministry of Communications, conversation, August 19th 2019 [Hebrew].

[70] Ibid. See also: Ministry of Communications, Is 5G technology dangerous to our health? retrieved: August 20th 2020 [Hebrew].

[71] According to Prof. Stelian Gelberg, Director of the Noise Prevention and Radiation Safety Division in the Ministry of Environmental Protection, the committee discussed a limited planning issue—amending and updating NOP 36-A.

regulations abroad, but these examinations were not performed due to budgetary constraints.[72]

We emphasize that the inter-ministerial team formed by the Ministry of Communications does not include any representation for the Ministry of Health. According to Nati Schubert, Deputy Director of the Engineering Administration (Spectrum) in the Ministry of Communications, the Ministry of Environmental Protection gives expression to the health considerations and having a Ministry of Health representative on this team is unnecessary.[73] According to Tnuda Director Hadas Vagman, the Ministry of Health is in contact with the Ministry of Communications, and Tnuda believes that Ministry of Health representatives will be added to the inter-ministerial team in the future.[74]

7. Deployment of 5G Infrastructures around the world and in Israel

7.1 Deployment of 5G Infrastructures around the world

Many countries are presently taking steps to promote the adoption of fifth-generation cellular telecommunications technology. Overall, most of the reviewed countries are taking the following steps: issuing tenders to determine the frequencies on which the networks will operate, carrying out regulatory changes to ease the preparation of infrastructures to carry antennas for fifth-generation networks, conducting preliminary technological experiments, and carrying out an initial deployment of infrastructures. Some of the countries have published strategic plans or are in the midst of a strategic process on the integration of fifth generation infrastructures; other countries are in the initial stages of determining this strategy. We note that **even as the countries are taking steps to promote the technology, there is also opposition being voiced to setting up the networks, particularly from local governments**, as described above in Chapter 5.

The following review is primarily based on information from the European 5G Observatory, which monitors recent developments in the field of 5G and the industry's

[72] In a conversation with Omri Ben Horin, who is in charge of media matters at the Ministry of Finance Budget Department, on August 19th 2020, Ben Horin said that the problem was not budgetary but rather bureaucratic and that the regulatory examination was meant to review the granting of a special permit exemption for communication sites. Prof. Stelian Gelberg, Director of the Noise Prevention and Radiation Safety Division in the Ministry of Environmental Protection, noted in a conversation on August 19th 2020 that the committee had discussed a limited planning issue —amending and updating NOP 36-A.

[73] Nati Schubert, Deputy Director of the Engineering Administration (Spectrum) in the Ministry of Communications, conversation, August 19th 2019 [Hebrew].

[74] Hadas Vagman, Director of the Tnuda Center, conversation, August 19th 2020 [Hebrew].

preparations in advance of the deployment of 5G networks.[75] The site presents current information on processes related to the deployment of fifth-generation networks in EU countries and also includes quarterly reviews that summarize developments in this field on the EU level. In this section, we will also present information from a document published by the European Parliament in April 2019.[76]

A European directive regulating the telecommunications field (2018) specifies the reasons why a country may limit the allocation of frequencies to different types of networks or technologies. One of these reasons is to protect public health from exposure to electromagnetic exposure.

Below, we present general information regarding the policy for assimilating 5G technology in the European Union. In addition, information on the status of infrastructure deployment by country is available in the table in Appendix 1 to this document. The information presented in the table is sorted by continent and by alphabetical order within each continent.

The European Union

On December 11th 2018, the European Electronic Communications Code—a directive that regulates the telecommunications field—took effect.[77] This directive serves as a regulatory framework for all electronic communications networks in the EU, and it is in line with various policy plans, including the 5G for Europe Action Plan—a detailed policy for the assimilation of fifth generation cellular telecommunications.[78] The directive addresses issues of public engagement and of protecting the public from electromagnetic fields. Moreover, Chapter III, Article 45 of the directive specifies reasons why a country may restrict the allocation of frequencies to different types of networks or technologies, **which include, *inter alia*, protecting public health from exposure to electromagnetic radiation.**[79]

The following data relate to the deployment of 5G networks in EU countries (as of June 2020):

- 12 EU countries, including the United Kingdom, have **national roadmaps for the deployment of 5G networks.**

[75] European Commission, European 5G Observatory, accessed: December 2nd 2019.

[76] Colin Blackman and Simon Forge, 5G deployment: State of play in Europe, USA and Asia, Policy Department for Economic, Scientific and Quality of Life Policies Directorate-General for Internal Policies. PE 631.060, April 2019, accessed: August 5th 2020.

[77] Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code, accessed: August 6th 2020.

[78] European Commission, 5G for Europe action plan, accessed: November 19th 2019.

[79] Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code, accessed: August 6th 2020.

- 192 experiments were conducted across Europe in preparation for the deployment of 5G networks, and there are plans for 248 "model" cities where 5G networks will operate.
- 11 5G cross-border corridors[80] have been constructed across Europe.[81]
- Tens to hundreds of base stations are expected to be built in many cities across Europe. Germany alone already has 10,000 active base stations.[82]
- 14 countries in Europe (13 EU members and England) already have 5G cellular operators: Austria, Belgium, Finland, Germany, Hungary, Ireland, Italy, Latvia, the Netherlands, Poland, Romania, Spain, Sweden and the United Kingdom. Some countries have more than one service provider and in the United Kingdom, all four mobile service providers provide 5G service as well.

According to an EU assessment from June 2020, there are already about 80 providers of 5G services around the world and some 199 types of 5G phones.[83] As mentioned above, the table in Appendix 1 to this document presents information on the deployment of 5G infrastructures in different countries, which is updated in large part to June 2020.

According to an EU assessment from June 2020, there are already about 80 providers of 5G service s around the world and some 199 types of 5G phones.

7.2 Deployment of 5G infrastructures in Israel

As shown in the comparative review above, many countries recently launched their initial deployments of 5G networks and their preliminary examinations of necessary regulatory changes. In Israel, the entire field of 5G network deployment is currently in its infancy.

On July 11th 2019, the Ministry of Communications press office released information to the public regarding the process of assimilating 5G technology in Israel,[84] alongside a position paper on the effects of 5G networks on public health. The paper is based on the views of professionals at the Ministry of Environmental Protection regarding the effects

[80] Cross-border corridors are passageways between countries, usually highways, where 5G networks are installed to serve different uses such as autonomous driving.

[81] European Commission, European 5G Observatory, accessed: August 6th 2020.

[82] Frédéric Pujol, Carole Manero, Basile Carle, and Santiago Remis, 5G Observatory quarterly report 8 up to June 2020, July 2020, p.8.

[83] Ibid., p. 10.

[84] Ministry of Communications, press release, Construction of 5G Infrastuctures: General information for the public, July 11th 2019, accessed: December 11th 2019 [Hebrew]

of 5G deployment on non-ionizing radiation, and it appears to be intended to dispel public concerns over possible adverse health effects of 5G networks.[85]

Three days later, on July 14th 2019, the Ministry of Communications issued the tender for frequencies to be used in fifth-generation cellular telecommunications.[86] While the tender process was being conducted, experiments were held on high-speed data transfer.[87]

On August 4th 2020, the main stage of the tender process led by the Ministry of Communications ahead of the deployment of 5G networks began. This stage is known as the "competition process," after which frequencies were allocated to companies contending for the tender. Afterwards, the companies will receive licenses to operate fifth-generation cellular telecommunications services on the frequencies they won.[88] Parallel to the start of the competition process, the media published stories mentioning the preparations made by the large Israeli cellular operators for the launch of 5G service.[89]

The frequencies tender ended on August 12th 2020, and was won by Pelephone, Cellcom–Golan–Marathon and Partner–HOT Mobile.[90] After they receive the licenses, the companies will begin to deploy fifth-generation cellular telecommunications infrastructures more vigorously. The winning companies are meant to complete the construction of 250 sites each within three years in order to be eligible for the incentive specified in the tender for building the infrastructures (NIS 200 million).[91]

[85] Ministry of Communications website, Is 5G technology dangerous to our health? July 9th 2019, updated: July 15th 2020, accessed: August 17th 2020 [Hebrew].

[86] Ministry of Communications, press release, 5G frequencies tender underway, July 14th 2019, accessed: December 11th 2019 [Hebrew].

[87] Nati Schubert, Deputy Director of the Engineering Administration (Spectrum) in the Ministry of Communications, letter to the Knesset Research and Information Center, October 31st 2019 [Hebrew].

[88] Ministry of Communications, press release, 5G.il: 5G frequencies tender reaches a climax, August 4th 2020 [Hebrew].

[89] Tal Shahaf, Fifth generation is here—and it really is fast, *ynet*, August 4th 2020, accessed: August 6th 2020 [Hebrew].

[90] Ministry of Communications, press release, 5G frequencies tender ends, August 12th 2020 [Hebrew].

[91] Nati Schubert, Deputy Director of the Engineering Administration (Spectrum) in the Ministry of Communications, August 19th 2019 [Hebrew].

Appendix 1: Status of 5G deployment in various countries (June 2020)[92]

Continent	Country	Status of 5G deployment
Europe	Norway	Two Internet providers launched a 5G service in over ten cities
	Switzerland	Two Internet providers operate in the 5G arena. Swisscom currently operates in more than 50 cities and plans to serve 90% of the population by the end of 2020. Note that this deployment is taking place despite the ban on millimeter waves that was put in place in Switzerland in 2019.
Americas	Uruguay	Antel launched a 5G network in April 2019.
	United States	In 2018/19, the four largest cellular service providers started providing 5G services. Together they cover thousands of cities and serve over 200 million people in the US.
Asia	United Arab Emirates	Two providers launched 5G services in June 2019.
	Bahrain	Bahrain announced the launch of 5G services in 2019.
	South Korea	In April 2019, three cellular operators in South Korea launched the first 5G networks. By the end of 2019, some 100,000 base stations were active. The network deployment is expected to conclude in 2022 or 2023. By April 2020, over 6 million subscribers had joined 5G networks.
	India	India has many infrastructure difficulties. A significant portion of the mobile subscribers still use 2G technology, hence India is not expected to launch 5G networks before 2022. However, India has invested $76 million in research and development plans, and has launched two strategic plans—India's Smart Cities Mission and Digital India.
	Hong Kong	Three service providers launched 5G services in April 2020. A fourth provider, CMHK, declared that its 5G network covers 90% of the island.

[92] Unless stated otherwise, the information from this table is taken from Frédéric Pujol, Carole Manero, Basile Carle, and Santiago Remis, 5G Observatory quarterly report 8 up to June 2020, July 2020, p.29.

Continent	Country	Status of 5G deployment
	Japan	Japan planned the launch of its 5G networks for August 2020, in time for the Olympics (which were postponed due to the COVID-19 pandemic). One of the companies, Rakuten Mobile, planned a launch campaign under which its 3 million customers will be exempt from any payment in the first year of 5G use. In practice, in April 2019 the government of Japan allocated frequencies to three mobile providers, which launched their 5G services in March 2020.
	Kuwait	Kuwait's three mobile service providers started to provide 5G services in July 2019.
	China	On November 1st 2019, three mobile service providers launched 5G services. At the time of the launch, the providers operated in 50 cities. Local authorities reported at the time that they were planning to erect 50,000 antennas by the end of 2019. The Ministry of Industry and Information Technology declared that 250,000 antennas would be deployed by June 2020 and that 600,000 antennas would be deployed by the end of 2020 to serve millions of users.
	Oman	Omantel launched 5G services in 17 cities in December 2019, and Ooredoo will provide 5G services in six more cities.
	Saudi Arabia	Already in 2018, three providers were given trial licenses in order to try out the technology. Two providers have been providing 5G services since June 2019.
	Qatar	Qatar was one of the first countries to deploy 5G networks, and two mobile providers have been providing these services since 2019.
	Thailand	AIS launched its 5G services in March 2020 and declared its intention to invest €290,000–430,000 in upgrading the 5G networks within a year.
Oceania	Australia	Since August 2018, 5G networks have been launched in over 50 cities. One internet provider, Optus, planned to set up 1,200 base stations by March 2020. According to

Continent	Country	Status of 5G deployment
		another provider, Telstra, the number of its potential customers has grown considerably—from four million to eight million.
	New Zealand	In December 2019, Vodafone started providing 5G services in four cities across New Zealand.
Africa	South Africa	During May 2020, Vodacom started providing 5G services in Johannesburg, Pretoria, and Cape Town.