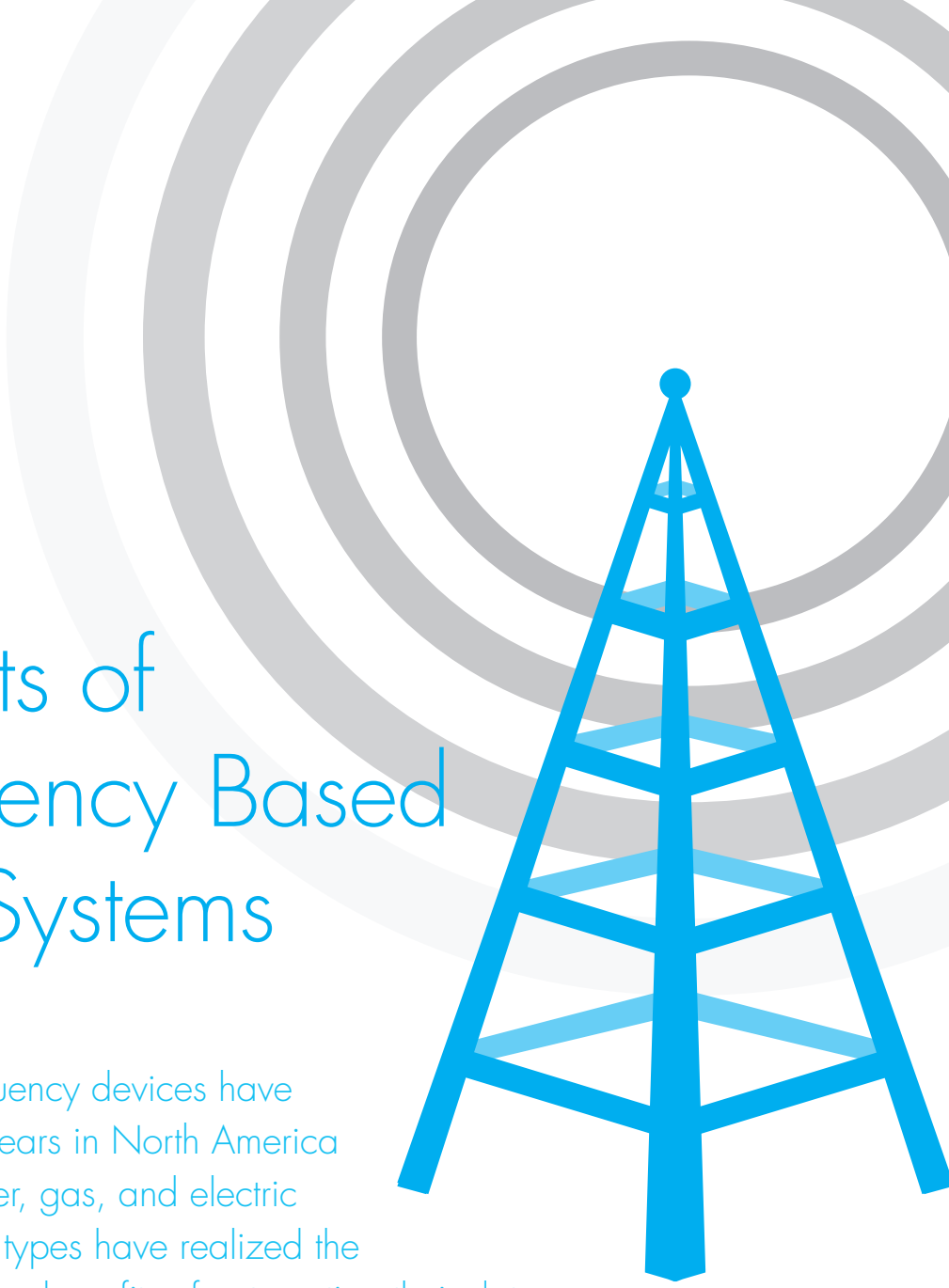
The Big Picture: Health Effects of Radio Frequency Based AMR/AMI Systems



Nearly 120 million[1] radio frequency devices have been installed in the past five years in North America to gather usage data from water, gas, and electric meters. Utilities of all sizes and types have realized the operational and customer service benefits of automating their data collection processes. But as the use of these systems has grown, some have raised questions over public safety. Have the health effects of these devices been adequately considered?

In this article, we'll address the issue of these health effects, and try to distinguish fact from fiction in the process.

BACKGROUND

First, we need to provide some background on the physics of radio frequency (RF) systems. For the purposes of brevity, we'll only hit the high points in this article, but we've added more information on our website at www.neptunetg.com.

Radio frequencies are part of a broad range of energy phenomena called the "electromagnetic spectrum." Everything in the electromagnetic spectrum consists of waves of energy that are measured in terms of their frequency and magnitude. The electromagnetic spectrum includes not only radio waves but also visible light.

Frequencies are measured in Hertz and 1 Hertz = 1 cycle per second. We use metric prefixes kilo, mega, giga, and so on to designate multiples of 1 thousand, 1 million, and 1 billion Hertz respectively. So a device operating at 900 MHz, which is commonly used for RF devices in many automatic meter reading systems, is oscillating at 900,000,000 (or 9×10^8) times per second.

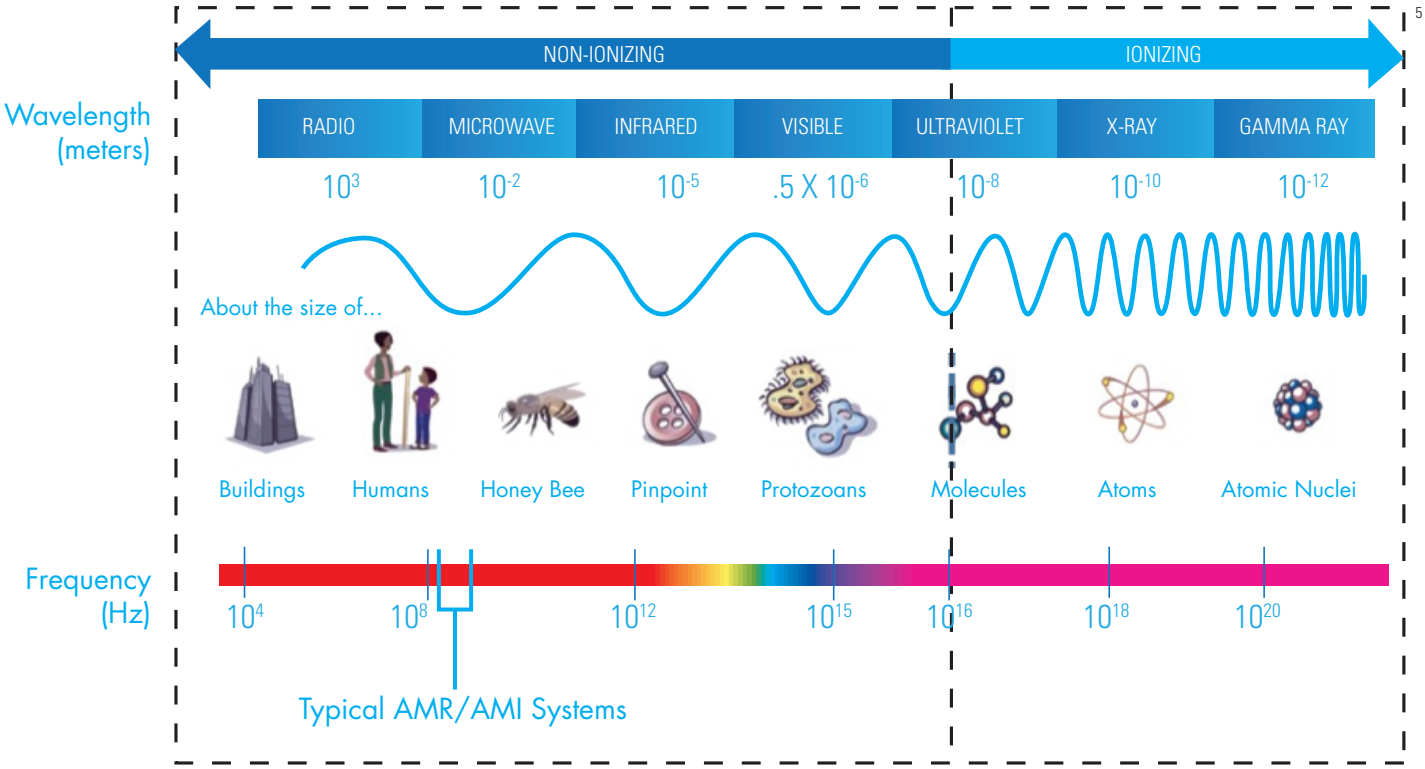
The diagram below illustrates the different types of waves that make up the electromagnetic spectrum. The human voice (not shown on the diagram) typically has a frequency range of 85 to 255 Hz and would be at the far left of the chart. As the diagram shows, the electromagnetic spectrum is often subdivided into two categories: ionizing radiation and non-ionizing radiation.

The EPA provides the following definitions:

> *Radiation that has enough energy to move atoms in a molecule around or cause them to vibrate, but not enough to remove electrons, is referred to as "non-ionizing radiation." Examples of this kind of radiation are sound waves, visible light, and microwaves.*[2]

> *Radiation that falls within the "ionizing radiation" range has enough energy to remove tightly bound electrons from atoms, thus creating ions. This is the type of radiation that people usually think of as "radiation." We take advantage of its properties to generate electric power, to kill cancer cells, and in many manufacturing processes.*[3]

Automatic meter reading (AMR) and advanced metering infrastructure (AMI) systems typically operate in the 450MHz to 2.4GHz frequency range. And there are many other devices we use every day that operate using radio frequencies including; baby monitors, remote car keys, smart phones, cellular networks, cordless telephones, AM and FM radio broadcasts, garage door openers, radio-controlled toys, television broadcasts, satellite communications, police radios, and the list goes on and on.



With the explosion in social media, smart phones, WiFi, mobile streaming, GPS systems, and a myriad of other applications, the use of RF has grown exponentially. As of June 2011, the number of connected devices with wireless subscriptions was 322.8 million[6], which exceeds the estimated U.S. population[7]. Unless you live in a specially designed shielded room like an anechoic chamber, you're exposed to RF signals 24/7.

HEALTH EFFECTS

So, what is the impact of RF-based AMR and AMI systems on our health?

We'll use the terms previously identified to start the discussion. We are all aware that some levels of ionizing radiation as found in Gamma Rays, X-Rays, and certain types ultraviolet light are harmful to our health. RF systems that are used for AMR and AMI systems fall into the category of non-ionizing radiation, as they do not have sufficient energy to change the structure of molecules with which they come in contact.

Within the non-ionizing group of frequencies, where do AMR- and AMI-equipped smart meters fall? The table below shows the relative power density in microwatts per square centimeter ($\mu W/cm^2$) so that the various devices can be compared. Although water devices were not specifically measured in this independent study, they would tend to operate like gas smart meters which are also dependent on battery power and therefore can't transmit as often or at an output power as high as electric smart meters.

Comparison of RF Power Density in the Everyday Environment
(microwatts per square centimeter, or $\mu W/cm^2$)[8]

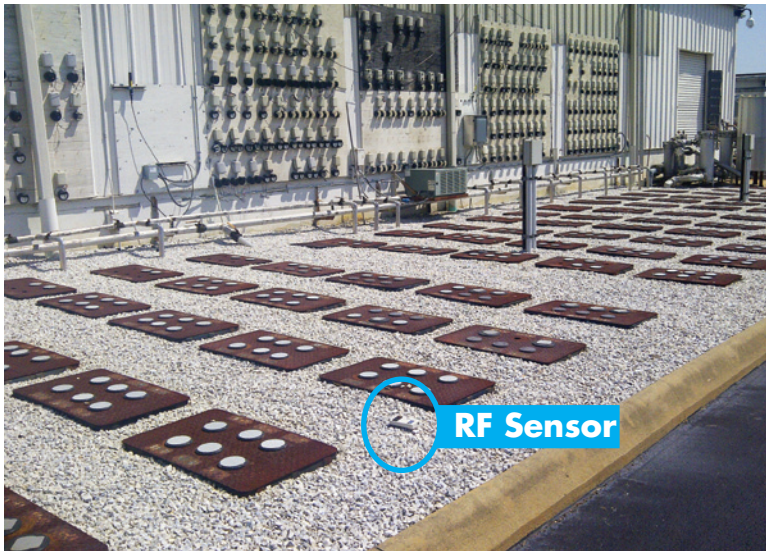
Adjacent to a gas Smart Meter (1 foot)	0.00166
Adjacent to an electric Smart Meter (10 feet)	0.1
Adjacent to an electric Smart Meter (1 foot)	8.8
Microwave oven nearby (1 meter)	10
Wireless routers, laptop computers, cyber cafés, etc. maximum (~1 meter for laptops, 2-5 meters for access points)	10 to 20
Cell phone (at head)	30 to 10,000
Walkie-Talkie (at head)	500 to 42,000

As we can see, the level of exposure to RF emissions is much less for smart meters (gas and water being the lowest of these) than our typical exposure to laptops, WiFi networks, and cell phones.

While there are many published opinions on the topic, the following summary from Health Canada seems to be one of the most concise:

> *As with any wireless device, some of the RF energy emitted by smart meters will be absorbed by anyone who is nearby. The amount of energy absorbed depends largely on how close your body is to a smart meter. Unlike cellular phones, where the transmitter is held close to the head and much of the RF energy that is absorbed is localized to one specific area, RF energy from smart meters is typically transmitted at a much greater distance from the human body. This results in very low RF exposure levels across the entire body, much like exposure to AM or FM radio broadcast signals.*
>
> *Survey results have shown that smart meters transmit data in short bursts, and when not transmitting data, the smart meter does not emit RF energy. Furthermore, indoor and outdoor survey measurements of RF energy from smart meters during transmission bursts were found to be far below the human exposure limits specified in Health Canada's Safety Code 6.*
>
> *Based on this information, Health Canada has concluded that exposure to RF energy from smart meters does not pose a public health risk.*[9]

So there does not appear to be a link between RF emissions in AMR and AMI systems and concerns about public health.



PERSONAL EXPERIENCE

And beyond the studies, we at Neptune have some rather unique personal experience to add to the discussion.

Located at our factory and headquarters in Tallassee, Alabama, Neptune has its "meter farm" which is used for testing meters and RF devices in various environmental conditions. At any given time, there are some 1,300 operational radios located about 100 feet from our engineering office. In addition, every day thousands of new radios are manufactured, activated, and tested on-site. This is a level of RF saturation that would be very uncommon even in the densest urban settings.

We ran two twenty-minute tests at our office to determine the power density in the area of our engineering office (where we work every day). It should be noted that in addition to the signals from

the radios manufactured and tested on site, there are several WiFi routers, cellular boosters, and countless cell phones. These tests were not intended to isolate the source of the radio frequency signals but were designed to show the amount of ambient exposure that could be encountered in an area saturated with RF signals.

As we can see from the data below, the radio frequency exposure that we measured during these tests was far below the levels that would be encountered by a typical cell phone or walkie-talkie when held to the user's head.

Results of Test at Neptune's Engineering Facility
(microwatts per square centimeter, or $\mu W/cm^2$)[10]

	Indoor Test	Meter Farm Test
Normal Range	0.01 to 0.20	0.01 to 0.20
Peak Level	1.1	7.6

Neptune is very conscious of employee health as illustrated by the fact that we switched all bronze-body meter production to lead free alloys in 2001, over a decade before legislation was enacted to mandate use of lead free materials. Although this put Neptune at a cost disadvantage, one of the primary drivers was the concern that lead exposure might have to our employees' health.

If we thought RF was bad for us, or others, we wouldn't subject ourselves to the possibility of harm.

THE COST OF OPT-OUT PROGRAMS

There will always be people who, for whatever reason, prefer not to have a "smart meter" installed at their residence. For this small group, the utility may want to consider an opt-out program.

One of the primary benefits to the utility and the community at large in implementing an AMR or AMI system is the reduction in meter reading costs by reducing the time required to gather the readings. Since the cost of reading meters is borne by all of the utility's customers, homeowners who opt-out should recognize that they will need to pay for the option to have their meters read manually. It would be unfair to expect neighbors who have embraced the automated system to pay the added costs of reading meters of the people who have chosen to opt-out.

These costs may be considerable because of the inherent inefficiency of reading a few meters scattered throughout the service area.

Typically, opt-out programs result in a one-time charge to the homeowner that covers the initial cost to remove and replace the meter and an ongoing charge per reading to cover the added cost of sending someone to read the meter manually.

Some examples of opt-out proposals include:

- City of Penticton, BC – at the time of writing this article, the City was developing an opt-out program that would offset the added cost of manual meter reading of "$25 for an isolated spot, and $6 for a manual read as part of a route."[11]
- City of Glendale, CA – "city council unanimously voted on charging customers a fee of $59 per billing period for having electric and water smart meters with the radios turned off."[12]
- Central Maine Power, ME – "a) smart meter with transmitter off will carry an initial charge of $20.00 and a monthly charge of $10.50; b) existing analog meter option will carry the initial charge of $40.00 and a monthly charge of $12.00."[13]

CONCLUSION

It's not a stretch to make the claim that the proliferation of wireless technologies has changed the world. Think of your life before cell phones. Or looking at it another way, when was the last time you used a payphone? Smart phones, satellite navigation systems, wireless tablets, remote controllers keep us connected, without a physical connection.

Similarly, radio frequency-based systems have taken hold and changed the way utilities provide safe and cost-effective service to their constituents; and, to repeat the conclusion of the Health Canada study that is echoed in many other such reports, "exposure to RF energy from smart meters does not pose a public health risk."[14]

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