Some notes on BC Hydro's smart meters—Gabriola Island

1. Smart meters and privacy

One of the aspects of the smart meter debate I find interesting is that when SHAW recently introduced their Interactive Digital TV service and supplied people with converter boxes for their analog TVs, I heard not a whisper of complaint about this; yet, like smart meters, these boxes do two things. They radiate electromagnetic energy and they "invade" your privacy.

According to my measurements, the boxes radiate roughly a milliwatt of power, although not intended to, and this seems not to be influenced by whether the box is on or off. I can only guess the radiation comes from leakage from the cable, and perhaps other people's set up is different. The radiation level is small, but it is on-going and measurable (0.15 mW/m^2) if you sit fairly close to the TV when watching it. Smart meters on the other hand only radiate for less than a minute a day; and most people don't spend their evenings standing outside watching them.[1]

BC Hydro could I suppose "invade" your privacy using their smart meters by determining what time you switch your lights off and go to bed—somebody outside in the street couldn't?—how often you use hot water to shower, and that sort of thing. They have so far though given no indication that they intend to accumulate such data, even though the smart meters could do this. SHAW on the other hand, using their boxes can tell what channel you are watching almost second by second (...and if you like conspiracy theories, the government could too). All I know is, that if I were snooping on my neighbours, I know which set of data I'd rather have.

Collecting customer usage profiles and selling them to commercial interests, as some Californian groups say will happen down there, would, I would think, be illegal in Canada. BC Hydro has said they have no interest in collecting such data, though the meters do have a capability of providing the profiles to their owners if customers that want them.

All data sent over the system will be securely encrypted using spread-spectrum and 128-bit AES technology and will be no more vulnerable to hacking than online financial transactions with banks.

While on the topic, another privacy issue that does concern me is the issuing of "club member" cards by superstores. The purpose of these cards is of course to invade your privacy by keeping a record, item-by-item, of everything that you buy. What's really bad about these cards is that if you don't cooperate with this invasion of your privacy, you have to pay extra for your purchases. I think this obnoxious practice by marketers should be made illegal. I don't get the impression though that this practice bothers many people; yet, in principle, it is no different to what BC Hydro *might* do with its smart meter data in the very unlikely event that this behaviour would be tolerated by Canadian provincial and federal governments.

2. Dumb meter radiation IARC Class 2B

Although many engaged in the smart meter debate often mention that RF (radio frequency) electromagnetic radiation has been recently moved to Class 2B (insufficient data to reach a conclusion) by the IARC (International Agency on Research for Cancer), ELF (extremely-low frequency) magnetic fields have been ranked that way for some time, and a source of such fields is our old-fashioned electromechanical "dumb" meters. These contain coils and a permanent magnet and consume about 2 W.

I recently measured the field around mine (I have two) and saw 1 μT (microtesla) at 30 cm (centimetres). I've also measured the comparable magnetic field generated by a smart meter. It is 0.2 μT. Not nearly enough to be a concern, but if you do worry about the weak fields from smart meters, what's to stop you worrying about the weak fields from "dumb" meters? They're ranked equally as potentially dangerous by the IARC.

The Class 2B ranking for EMF (electromagnetic fields) is based on heavy cell-phone usage over

[1] I say outside because the levels of radiation from a smart meter through the wall and into the house are much smaller than those experienced standing directly in front of the meter.

several years, which involves field strengths and exposures several orders of magnitude greater than those from a smart meter. In a recent study by Danish researchers published in the British Medical Journal, researchers found no link between long-term use (13 years) of cell-phones by adults and increased risk of brain tumours. However, this conclusion has predictably come under attack because it is a statistical study and the data can therefore fairly readily be re-interpreted by a statistician to give virtually any conclusion one wants. Until someone finds some convincing physiological evidence for a link between EMF and cancer, the controversy will continue.

The Class 2B ranking for ELF MF (magnetic fields) is based on epidemiological evidence for a rare kind of leukemia in children that, as far as I am aware, has yet to be explained.

3. International Agency on Research for Cancer classifications (IARC)—a summary

Group 1: Carcinogenic to humans—*107 items*

The Working Group considers that a causal relationship has been established between exposure to the agent and human cancer. That is, a positive relationship has been observed between the exposure and cancer in studies in which chance, bias and confounding could be ruled out with reasonable confidence.

This list contains 107 items. Of these 15 are industrial occupations or processes not likely to be of significance to the general public. Another 13 are similarly associated with mining and processing minerals, metals, and metal compounds. Which leaves 79 items.

Powerful drugs used for treating cancer account for 7 items, and there are another 15 drugs used in the treatment of other serious illnesses. Herbs used in Chinese medicine account for 2 items. Miscellaneous chemicals, including some used for the manufacture of dyes many of which are now banned, account for 9 items. Betel nuts rarely used here account for 3 items.

Well-known carcinogenic activities and substances include 5 associated with smoking tobacco, and 2 associated with handling coal, tar, and pitch.

Radioactivity has 10 items (some isotopes are listed separately).

Natural carcinogens—viruses, bacteria, and moulds—have 12 items listed, most are viruses.

Ionizing electromagnetic radiation has 5 items of which 3 are very general (ionizing radiation, UV, and X-rays) plus two specific items (natural sunlight and sun-tanning devices).

Of the remaining 9 items, there is 1 item of food (salted fish-Chinese style) and 5 are related to air pollution (coal smoke, paint fumes, soot, and dust containing wood or leather).

Alcoholic beverages account for 3 items.

Group 2A: Probably carcinogenic to humans—*59 items*

A positive association has been observed between exposure to the agent and cancer for which a causal interpretation is considered by the Working Group to be credible, but chance, bias or confounding could not be ruled out with reasonable confidence.

This list contains 59 items; 46 of which are chemicals.

Of all the items, 24 have industrial or laboratory uses; 13 are drugs used in cancer treatment, and there are 4 others have medical applications; 3 are metals and minerals. One, now banned, is for the manufacture of dyes.

Chemical items polluting the air are in wood smoke 1 and diesel engine exhaust 3. Two of uncertain industrial origins are sometimes found in drinking water.

Insecticides and fungicides account for 2; coal usage 2; dry cleaning 1; and viruses 1. Occupational items are hairdressing 1 and shift work involving circadian disruption 1.

There are 8 items related to food, a few of which are chemicals which also have industrial or medical uses. Most items are in emissions from frying at a high temperature. Hot mate (*yerba maté*), a popular drink in South America and elsewhere, is also one of the items.

Group 2B: Possibly carcinogenic to humans—*267 items*

> *The available studies are of insufficient quality, consistency or statistical power to permit a conclusion regarding the presence or absence of a causal association between exposure and cancer, or no data on cancer in humans are available.*

The majority (235, 88%) of the items in this category are chemicals few people would have heard of. The remaining 32 items constitute a mixed bag.

Coffee 1; gasoline engine exhaust and welding fumes 2; pickled vegetables 1; fuels and oils 4; metals, especially heavy metals, and minerals 6; surgical implants of various kinds 1; fibres 2; electromagnetic radiation and low-frequency magnetic fields 2; viruses 4; herbicides 1; coal-related products 2; talc powder (perineal use); and one plant (bracken fern) used as a vegetable in Asia and a herb elsewhere.

Occupational items are carpentry and joinery 1; dry cleaning 1; firefighting 1; and textile manufacturing 1.

Group 3: Not classifiable as to its carcinogenicity to humans—*508 items*

> *There are several adequate studies covering the full range of levels of exposure that humans are known to encounter, which are mutually consistent in not showing a positive association between exposure to the agent and any studied cancer at any observed level of exposure. Bias and confounding are ruled out with reasonable confidence, and the studies have an adequate length of follow-up.*

Again, nearly all of these are chemicals. Ones that a non-chemist would pick out are:
—various metal compounds, coal dust, silica;
—caffeine, saccharin, tea;
—diesel fuel, jet fuel, petroleum solvents, crude oil, fuel oils, mineral oils;
—ELF electric fields, static electric fields, fluorescent lighting, static magnetic fields;
—fluorides, chlorinated drinking water;
—hair colouring products, talc;
—glass wool, polystyrene and other plastics, printing ink;
—surgical implants, and dental materials.

Group 4: Probably not carcinogenic to humans—*1 item*

> *A conclusion of evidence suggesting lack of carcinogenicity is inevitably limited to the cancer sites, conditions and levels of exposure, and length of observation covered by the available studies. In addition, the possibility of a very small risk at the levels of exposure studied can never be excluded.*

Only one item! An organic chemical now manufactured for industrial uses.

4. Radiation levels on Gabriola

These I reported on in detail in my note: *A survey of electromagnetic radiation levels on Gabriola Island*:

http://www.nickdoe.ca/pdfs/Webp658.pdf

The conclusions were:

> Gabriola is evidently remarkably free of electromagnetic radiation. When I started this survey, I had in mind producing a map with contours showing radiation power densities, much like contours on a topographical map. As it turns out however, with few exceptions, once you are away from people and buildings, there is no measurable radiation. I spent many hours in the 707CP, for example, with my meters, and never once recorded a signal above the instruments' internal thermal noise levels.
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> The critical factor in all cases is how close you are to the source of the radiation, and for this reason, levels I recorded were always highest in my own home. At 60 Hz, for example, our hairdryer produced 10μT of magnetic radiation; yet, standing directly under the power line feeder to Gabriola, the highest I could get my meter to read was 2.2 μT. Similarly at radio and microwave frequencies, standing with my face peering in at the microwave oven with the door shut, something I almost never do, produced about 10 W/m^2; yet, the only place I could find that came anywhere close to this, leaving out pressing a wireless phone to my ear, was on the ferry when about six people in the passenger lounge were using some sort of wireless device and producing around 0.02 W/m^2 where I sat.
>
> Although I cannot be sure, I would say most of the radio frequency radiation I observed was coming from cell-phones. There were a few exceptions—radar was detected at Berry Point and a radio transmission from a boat—but not many. Some sources that might be expected to be significant sources of radiation turned out not to be, notably the cell-phone tower at Silva Bay. I could not detect the radar on the ferry, but I could some of the bridge navigation equipment and the radio, even though the radiation produced by the vessel was less than that generated by passengers. Wi-Fi networks have a limited range and long stretches of all roads on Gabriola were essentially free of microwave radiation.
>
> Nowhere during this survey on Gabriola outside my home did I encounter a radiation level at any frequency that exceeded the most stringent safety standard in the world.

5. EMF health issues in general

These I reported on in detail in my article: *Electromagnetic radiation and health*:

http://www.nickdoe.ca/pdfs/Webp52c.pdf

This article gave an introduction as to the nature of electric, magnetic, and electromagnetic fields and contrasted the opinions of such contrarians and alarmists as Henry Lai, Neil Cherry, and Magda Havas with those of the vast majority of scientists, engineers, and health professionals.

6. The EPRI Report—a summary and comment

One of the more technical questions that arise over the use of smart meters is how much RF (radio frequency) energy they transmit; how "strong" in other words is the RF EMF (electromagnetic field).

Introduction

Determining the power density radiation levels of the meters is not a simple matter for several reasons: we have to be clear which of three possible transmitters within the meter we are talking about (one is for the 900 MHz RF LAN, an end-point meter function, one is for the Zigbee 2.4 GHz HAN, an optional home-area-network end-point meter function, and one is for the WWAN connection, a cell-relay function only necessary for very few meters); and the antennas in the meters are not isotropic either in azimuth or elevation, and the effect of variable ground reflections have also to be included. When considering the fields inside the house, we also need to take into account attenuation by the back of the metal box in which the meters are mounted and the attenuation of the wall.

In this note, I will consider only the 900 MHz RF LAN for two reasons. One is that the Zigbee 2.4 GHz HAN is not essential to the meter's operation and could be made optional even suppose that it isn't. The other is that in the BC Hydro configuration, cell-relay functions will not be performed by meters on consumers' premises. Data collectors will be mounted on poles.

Another closely associated parameter with field strength is duty cycle, that is, the time in, say, a twenty-four period the transmitted is actually transmitting. According to BC Hydro, this is likely to be less than one minute per day.

The details of the radiation of the meters have been studied in depth and the results reported in: Electric Power Research Institute, *An Investigation of Radiofrequency Fields Associated with the Itron Smart Meter*, 2010 Technical Report available from EPRI. Readers of this report will also need the FCC (1997) OET Bulletin 65, *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*, to translate FCC MPE (maximum permissible exposure) units used throughout the report. A convenient approximate number is 100% MPE = 6 W/m^2 at 900 MHz and I shall be using this conversion in this note.[2]

Smart meter transmitter output power

The average 900 MHz RF LAN transmitter output power, according to EPRI, is 23.95 dBm ± 0.695 dBm (p.5-2). This translates to an average of 248 mW and a standard deviation range of 212–291 mW. I'll use a figure of 24 dBm (250 mW).

Radiated smart meter power

The radiated power appears to be less than 24 dBm. To calculate this I used the laboratory pattern measurements Figure 8.1 and 8.3.

[2] The actual range is 902–928 MHz, which is 6.01–6.19 W/m^2

[NOTE: In earlier versions of this note I had not noticed that the dotted circles in the two figures are different scales. In Figure 8.1, they are –20, –40, and –60 dB. In Figure 8.3, they are –10, –20, and –30 dB. Confusing.]

	rel. peak dB	rel. min. dB	peak gain dB	rel. mean dB	mean gain dB
forward horizontal semicircular plane	0	–10		–2.5	
forward vertical semicircular plane	0	–11		–4.4	
forward hemisphere (approx.)			+2.9	–6.9	–4.0
backward horizontal semicircular plane	–8	–20		–11.7	
backward vertical semicircular plane	–6	–21		–12.0	
backward hemisphere (approx.)			+2.9	–23.7	–20.8

In the azimuth plane, the total power transmitted (both polarizations) only in the forward direction (left through front to right) varies from roughly –10 dB to 0 dB to –10 dB. The average gain relative to straight ahead over the forward 180° in azimuth is –2.5 dB.[3]

In the elevation plane, the total power transmitted (both polarizations) in the forward direction (top through horizontal to bottom) varies from roughly –6 dB to 0 dB to –11 dB. The average gain relative to the peak at 30° upward over the 180° in elevation is –4.4 dB.

The combined average relative gain over the forward 180° in both azimuth and elevation is –2.5 dB + (–4.4 dB) = –6.9 dB.[4]

According to Table 8-1, the reference equivalent isotropic radiated power (EIRP) at the nominal transmitter power output along the boresight axis is 26.9 dBm,[5] hence I reckon that the average EIRP of all the directions in the forward hemisphere is about 26.9 dBm – 6.9 dB = 20.0 dBm (100 mW).

Doing the same calculations for the radiation towards the rear of the meter gives us the following results.

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3 Integration was made in 15° increments.

4 This is an approximation that assumes some symmetry in the radiation pattern, an assumption that is unlikely to be badly flawed.

5 This includes a reported antenna gain of +2.9 dB. The radiation pattern is typical of a patch antenna, but the gain is low. A 900-MHz patch antenna with a square reflector can have a gain as high as +9 dB.

In the azimuth plane, the total power transmitted (both polarizations) in the backward direction (left through rear to right) varies from roughly –10 dB to –18 dB to –10 dB. The average gain relative to straight ahead over the backward 180° in azimuth is –11.7 dB.

In the elevation plane, the total power transmitted (both polarizations) in the backward direction (top through horizontal to bottom) varies from roughly –12 dB to –43 dB to –22 dB. The average gain relative to 30° upward straight ahead over the backward 180° in elevation is –12.0 dB.

The combined average relative gain over the backward 180° in both azimuth and elevation is –11.7 dB + (–12.0 dB) = –23.7 dB.[4]

Hence the average EIRP of all the directions in the backward hemisphere is about 26.9 dBm – 23.7 dB = 3.2 dBm (2.1 mW).

The ratio of backward to forward total transmitted power is 20.0 dBm – 3.2 dBm = 16.8 dB; and the total transmitted power through 360° is about 100.0 + 2.1 = 102.1 mW (20.1 dBm). This is 3.9 dB less than the transmitter output (24 dBm) which presumably represents loss due to transmitter:antenna mismatch and loss within the meter enclosure.[5]

Radiated power density and EIRP

For this analysis I will take the residential (not the meter farm) environment which is of most interest to Gabriolans.

Tables 9-5 and 9-7 of the EPRI report fields at two residential sites, A and B, of 0.186% and 0.159% of FCC MPE at a distance of 3 ft. from the fronts of the meters. The equivalents in metric units are about 9.3 mW/m^2 and 8.0 mW/m^2 at 1 metre.

The following table shows the EPRI report's results for the two locations. The first two columns are the distances in front of the meters; the next two columns are the report's field strength measurements as a proportion of the FCC MPE;[6] the next two columns are my calculated equivalent power density figures (milliwatts per square metre); and the final two columns are the calculated EIRP of the transmitters (milliwatts). The EIRP calculation used is:

$$\text{EIRP} = 4 \pi D^2 (P / G \Gamma)$$

where:

EIRP is the equivalent isotropic radiated power (milliwatts)

D is the distance (metres)

P is the measured power density (milliwatts per square metre)

G is the antenna gain in the direction of measurement (+2.9 dB from Table 8-1, no dimensions)

Γ is the constructive interference factor for ground reflections (no dimensions).

The value of Γ will vary from site to site, and, because the meter's antenna is anisotropic in the elevation plane, it will vary with distance. For this calculation I used the empirical data in the EPRI report's Figure 14-7. The relationship is:

[6] FCC = Federal Communications Commission, an independent agency of the US government. MPE = Maximum Permitted Exposure; Canada's regulations are the same.

$\Gamma = 1 + r\,(1 - e^{-0.3\,D})$

where r is the ground reflectance factor. The mean value of *r* in the two sites tested in the EPRI report is 0.6. However, the FCC recommend 0.4 (OET Bulletin 651, pp.21–22).[7]

In the last column of the Table below, the derived EIRP at residence B is very consistent at around 51 mW. Even though ground reflections at residence A were evidently more complicated, the averaged EIRP of 52 mW is practically the same as that at residence B.

The difference between this EIRP and the one observed in the testing laboratory (102 mW) might be due to the difficulty of locating the peak of the radiation in the field. The boresight axis is not horizontal so measurements made at a fixed height above the ground are bound to be missing the precise point in space where radiation is greatest.

Location (feet)	Location (metres)	% public MPE A	% public MPE B	mW/m^2 A	mW/m^2 B	calculated EIRP mW A	calculated EIRP mW B
surface	surface	9.67	10.84	580.2	650.4		
1	0.30	0.875	1.386	52.5	83.2	30	48
2	0.61	0.361	0.351	21.7	21.1	49	47
3	0.91	0.186	0.159	11.2	9.5	55	47
4	1.22		0.104		6.2		53
5	1.52	0.096		5.8		75	
6	1.83		0.048		2.9		53
10	3.05		0.02		1.2		58
					average	52.3	51.1

Calculating smart meter EMF power densities

As a rule of thumb when attempting to estimate field strengths, I would suggest that the meters be assumed to be isotropic with the power taken to be 50 mW. The peak gain G we can take as +3 dB, giving an effective radiated power (G =1) of 100 mW.

$P\,(mW/m^2) = 100\,\Gamma\,S\,\eta \,/\, 4\,\pi\,D^2$

$\Gamma = 1 + 0.4\,(1 - e^{-0.3\,D})$

[7] Calculated as follows. For constructive interference of the electric field take 1.6 as recommended by the FCC giving a power enhancement of $1.6^2 = 2.6$. However, because a half wavelength is so small (167 mm), only a small displacement will make the interference destructive. For destructive interference, the electric field will be reduced to 0.4 giving a power reduction of $0.4^2 = 0.2$. The average power is thus (2.6 + 0.2)/2 = 1.4, and hence the recommended *r* = 0.4. If the ground were a perfect reflector, *r* would be 1 giving electric field and power enhancements of 2 and 4 respectively for constructive interference and a reduction to 0 for destructive interference. The average power would be enhanced by (4 + 0)/2 = 2 because, with perfect ground reflection, all the radiation is going into a hemisphere, not a sphere.

S	front	back
peak (unidirectional) directly in front & directly behind	1.0 (0.0 dB)	0.018 (–17.5 dB)
spatial-average (hemisphere)	0.398 (–4.0 dB)	0.008 (–20.8 dB)

Safety factor η (there is one already built in):

η = ×1.0; to be reasonably conservative: η = ×2.0 (includes P = ×1.06; Γ = ×1.25; S = ×1.5).

distance (m)	peak front	average front	peak back	average back
1	8.8	3.5	0.16	0.07
2	2.3	0.9	0.04	0.02
3	1.1	0.4	0.02	0.009
5	0.4	0.2	0.008	0.003
10	0.1	0.04	0.002	0.001
20	0.03	0.01	0.001	
50	0.005	0.001		
100	0.001			
Table is for a safety factor η of 1. Units are mW/m^2; for μW/cm^2, divide by 10. No allowance has been made in the backward direction for attenuation through a wall. EPRI measured reduction by a factor of 4 through a wall, but other constructions may give a different value.				

Power density within the house

The peak power density levels in the backward hemisphere should be around 17.5 dB below those in the forward hemisphere, without a wall. The EPRI report simulated a stucco wall with wooden frame and measured an insertion loss of 6.1 dB (Table 10-2). So the peak backwards radiation after it has gone through the wall should be around 17.5 + 6.1 = 23.6 dB less than it is in the forward direction.

At two residences, the power density was measured inside the house on the surface of the wall immediately behind the smart meter. The radiation levels seen were 0.01% MPE (Table 9-6) and 0.00872% MPE (Table 9-8, in a closet). These translate to 0.6 mW/m^2 and 0.52 mW/m^2, an average of –2.5 dBm / m^2

A reality check would be to see how low these are compared with radiation levels in the forward direction. If we take the distance between the back of the meter and the surface of the inside wall as being 15 cm, then the level in the forward direction at this distance is, using the rule-of-thumb formula above, 360 mW/m^2 or +25.6 dBm / m^2. The implied attenuation is thus 28.1 dB, which is higher than the 23.6 dB value determined above, but not significantly. The agreement would be perfect at 28 cm (11 inches).

If we take average values rather than peak values then the attenuation in the backward direction will be 20.8 + 6.1 = 26.9 dB and we can comfortably say that radiation into the interior of the house will be about five hundred times less than it is away from the house.

BC Hydro's specifications of power density

According to BC Hydro's technical specifications of the meters, the instantaneous power density of their transmissions (that is, ignoring the low duty cycle) at 20 cm is 2μW/cm^2 [20 mW/m^2], By my own calculations, this low a power density would be present directly in front of the meter only at a distance of 65 cm (2 feet). If peak power density in the backwards direction is meant, then the distance would be 8.5 cm (3 inches).

The same specification sheet says the field at 3 m is 0.005 μW/cm^2 [0.05 mW/m^2]. By my own calculations, the power density at 3 m is 1.1 mW/m^2 peak forward; 0.4 mW/m^2 average forward; 0.02 mW/m^2 peak backwards; and 0.009 mW/m^2 average backwards. It looks as though the specification figures are for peak radiation backwards into the house, not in the forward direction. The specifications ought to be clearer on this.

To add another note of confusion over the figures, in BC Hydro's Smart Metering and Infrastructure Business Plan p.16, the reported field strength at 3 m is 0.01 microwatts (sic). This is a power level not a field strength. The title of the table implies the units are μW/cm^2 which would make the field strength [0.1 mW/m^2], which conflicts with the peak forward strength in the table above by being a factor of ten too low. By the same token, the table's entry for a cell-phone held up to the head is 30–10,000 μW/cm^2, a maximum of 100 W/m^2. This is almost certainly too high by a factor of ten. Another entry is for summer sunlight which at 100,000 μW/cm^2 [1 kW/m^2] is about right. Again, I've no idea what to make of BC Hydro's figures.

Smart meter duty cycles

Determining the operational duty cycle of a smart meter can be difficult as the timing of their transmissions is quasi-random. Canadian regulations require measurements in the 900 MHz band to be averaged for six minutes, but smart meters are often quiescent for much longer periods than this.

BC Hydro says duty cycles will be less than one minute a day, that is, less than 0.07 %.

In measurements on a residential smart meter, EPRI (p.12-5) saw on two separate days duty cycles of 0.037% and 0.0427%. However these were upper limits as the instrument could only record that a transmission had been made at some time in a 370 ms (millisecond) scan. Beacon signals of the smart meters are around 7.5 ms (EPRI, p.2-5), so the duty cycles might have been considerably less.

In a separate set of measurements on numerous meters in the San Diego Gas & Electric (SDG&E) system, (EPRI, p.12-9), the highest duty observed was 0.58% with half being less than 0.07%. However, these numbers might not be applicable to the BC Hydro system as the network topology is somewhat different.

All in all, I think that the best I can say is that BC Hydro's figure of 0.07% is a reasonable estimate pending deployment of the system.

7. Comparison with cell-phone radiation

One can assess exposure to EMF from a health perspective in two different ways. You can focus on "instantaneous" power density levels—no matter how brief the exposure—and you can focus on cumulative exposure—no matter how low the power density of the exposure. If exposure to EMF within current safety standards were to be found a risk, I suspect that nobody would be at all surprised if it were to be found that both considerations are involved.

Instantaneous power density comparisons

Cell-phone manufacturers recommend that you keep an air gap[8] between the phone and your ear. This is to keep the radiation within the legal limit, usually 10 W/m^2.

In theory, a 1 W transmitter with a dipole radiation pattern (G = 1.76 dB) will produce a far-field power density of 10 W/m^2 at 11 cm (4.3 in.). Some cell-phones use less power, 0.6 W for example,[9] which reduces the legal distance to 8.5 cm (3.3 in.), so it seems likely most users are exposing themselves to the legal maximum. Since cell-phones are held so close to the head, it isn't necessary for present purposes to consider exposure to the rest of the body.

It is unlikely that anyone would press their ear against the front of smart meter, so we have to come up with a reasonable distance. At 30 cm (1 ft.) the peak exposure according to what has been written above would be 0.09 W/m^2, or about 100-times less than the cell-phone.

Total energy comparisons

The total energy a person is exposed to depends obviously on how often they use their cell-phone in the course of a day, and how long they spend close to a smart meter and at what distance and direction. An oft-used figure for "average" cell-phone usage is 15 minutes a day (for what that's worth). I guess the cell-phone transmitter is effectively not on when the person holding it is not speaking, so maybe we should reduce this to 7.5 minutes a day. The total energy exposure is thus about: 4500 J/m^2/day (joules per square metre per day).

How long on average do people hang around their electricity meters? There are two possibilities, inside or outside?

Outside the house

Let's first say 5 minutes at 30 cm (1 ft.) foot in front of the meter outside the house. At this close distance, we have to integrate the exposure over the whole body, not just take the peak. According to EPRI (p.11-2) the spatial average at 1 ft. is 23.3% of the peak reading. We also have to include the fact that the duty cycle of a smart meter is very low—let's say 0.07%. The exposure is thus 0.004 J/m^2/day, or about a million times less than for the "average" cell-phone user.

Inside the house

For the inside the house exposure, let's take a fairly arbitrary 8 hours at 3 m. At this distance we can forget the spatial averaging. We'll take the peak exposure even though somebody moving

[8] One manufacturer recommends 5/8th of an inch (1.6 cm).

[9] It is unlikely that this includes the antenna gain as, if it did, the manufacturer would be claiming an even lower transmitter power.

around in those eight hours would be exposed to less. The exposure works out to be 0.0001 J/m^2 per day, or about 45-million times less than for the "average" cell-phone user.

Conclusions

It is quite clear that energy exposure due to a smart meter is quite negligible compared to the exposure experienced by a regular cell-phone user. Based on the figures in this note, if it is questionable whether a cell-phone is hazardous or not, then a smart meter certainly is not.

The EEPRI study concluded "…common exposures of individuals that are likely to result from the operation of the Itron Smart Meters evaluated in this study are very low and comply with scientifically based human exposure limits by a wide margin".

8. Time-of-use tariffs

Smart meters will, it is true, would allow implementation of time-of-use (TOU) tariffs; however, BC Hydro has said it has no intention of introducing these at present and couldn't do so, even if it wanted to, without extensive regulatory review by the BC Utilities Commission (BCUC).

TOU tariffs are a way of reducing the costs associated with peak demand.[10] If you can persuade people not to use unnecessary power when the system is running at peak capacity, you can avoid the cost of having to build surplus capacity that will only be used in the brief periods when demand is extraordinarily high.

One of the ways BCH copes with peak demand is to import energy from outside the province when needed, but this power is often expensive and usually comes from dirty coal- or oil-fired sources in Alberta or the USA. Another consideration that is often overlooked is that it is not just generating capacity that limits peak supply. It also involves transmission and distribution system limitations and Gabriola is an excellent example of this. When BCH is struggling to meet peak demand on a cold winter late-afternoon, the problem is not that it doesn't have enough megawatts; the problem is that the cable strung across the Northumberland Channel is in danger of getting too hot.[11] In this situation, charging people extra who insist on doing their laundry rather than waiting to do it later in the night despite the risk of their causing a power outage seems to me to be a very good idea.

Some people argue that because most (90%) of BCH's energy is generated in hydroelectric facilities, TOU pricing has no relevance. To generate more power you just open up the tap. If you look however at BCH's Annual Reports, you can see that this is not what actually happens.

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[10] To follow this discussion you will need to have a clear idea of the difference between energy and power, a difference many journalists appear not to understand. Energy is measured in watt-hours (Wh) or scientifically in joules (J). Power is the rate at which energy is supplied or consumed measured in watts (W). To illustrate the importance of the difference consider the following scenario. You have a 100 W bulb attached to a 100 W generator. If you let the bulb burn for an hour, the total energy required is 100 Wh and 100% of this energy can be supplied by the generator. If however you have a 200 W bulb and you let the bulb burn for only half an hour, the total energy required is still 100 Wh, but now the generator can only supply 50% of it because the 200 W demand during the half hour the bulb is on is double the capacity of the generator. You cannot assume that just because the demand for energy is 100 Wh measured over a period of an hour that you can supply all that energy with a 100 W generator just because the average power supplied is 100 W.

[11] It is rather fortunate that when this happens the air is cold and this permits the cable to be moderately overloaded.

In 2010 for example, (every year is similar), BC's energy balance sheet looks like this:

Energy supplied		
BC consumers:	50233	GWh
Line loss and system use:	4840	
Total:	55073	55073
Energy generated		
Thermal:	548	
Hydroelectric:	43207	
	43755	43755
Energy acquired		
Long-term purchases:	13402	
Short-term purchases:	27217	
Less energy sold:	(28210)	
Energy exchange:	(1092)	
	11318	11318
Total:		55073

After all the horse trading, BC imported (11318/55073) = 20% of the energy it consumed. The number fluctuates from year to year depending on the weather, water levels, and so on.

Much of this imported energy (I gather) is used to meet peak demand. Doing this calculation using installed generating capacity (MW) instead of energy (GWh) is misleading because if meeting demand requires more power than you have, you have to import energy. You will also have to import energy no matter what your installed power if the dams are empty, and with climate change, water shortages are increasingly likely. Some of this imported energy may be balanced using energy exports at some other time, but BCH's data shows this has not been enough to restore a balance for about a decade.

The bottom line is that if you do not want to tolerate power outages, then it costs BCH money to provide that service, and you don't avoid paying those costs by not having TOU tariffs.

If the TOU tariffs are optional anyway, what is the problem? If people want to make the investment involved in reducing their own demand at peak demand times why not encourage them to do so? If the net cost to society of all the investments that individuals make is less than the environmental and financial cost to society of providing peak supply enhancements, and most observers agree that it is, then optional TOU tariffs make perfect sense.[12] [13]

[12] Even the BC NDP have come around, kudos to Adrian Dix, to the idea that a carbon tax is the most direct and effective way of dampening demand for fossil fuel and encouraging alternatives.

[13] Just for the record, though it has little to do with the smart meter debate, I'll add that if BCH wants to export more hydroelectrically-generated energy, then I have absolutely no problem with that given that the alternative is generating this energy somewhere else in North America with coal- or oil-fired power stations emitting greenhouse gases. It makes sense though to count the cost of doing this at the marginal cost rate, not the average cost rate which is lower than usual in BC because of our heritage hydroelectric facilities.

Selling TOUs

One of the problems of analyzing the pros and cons of any societal-wide change of a financial nature is that there are often two groups, one that appears to gain by the change, and another that appears to lose by the change. When the change becomes political rather than technical, the arguments and counter arguments of the two groups tend to drown out any dispassionate discussion as to whether the proposed change is good for society as a whole, regardless of who appears to benefit most.

In BC, the vote of the people to do away with the value-added-tax (HST—harmonized sales tax) is a good example of this. Most economists, and most industrially-developed countries in the world, favour a tax on goods and services rather than a tax on goods alone, and hence BC would be following this broad consensus by keeping the HST rather than re-instating the old PST (provincial sales tax). However, because the debate was framed in terms of shifting the tax burden from manufacturers to consumers, the choice was to reject it and to ignore the argument that the HST would be a net benefit to the economy as a whole.

BC Hydro is in a similar situation when it comes to TOU tariffs. From BC Hydro's point-of-view, if TOU tariffs successfully remove some of the need to increase assets to meet peak demand, they will have saved money. Since BC Hydro is publically owned, the savings would accrue to the public. From the consumers point-of-view however, the fact that BC Hydro didn't need to increase assets gets almost completely lost; all they see is prices for electricity when they want to use it going up. Even if TOU tariffs are good for the economy as a whole, a government or agency that is perceived, rightly or wrongly, to be favouring one side or the other has a hard job getting across the facts.

9. Using energy efficiently

One of the pressing needs of society, and Gabriola is no exception, is to address the problem of an ever-increasing demand for electrical energy. This increasing demand comes, and will come from three sources; an increasing population, increasing per capita use, and an increasing preference for substituting electrical energy for gas and diesel alternatives—electric cars being the obvious example.

Though the calculations are rough-and-ready, over the period 2001–8, I reckon that Gabriola's annual population increase, as measured by the number of residential customers of BCH, increased by 2.4%, yet the annual demand for electrical energy (GWh/year) by residents increased by 3.7% (http:www.nickdoe.ca/pdfs/Webp635.pdf). Some people argue that BCH could meet demand without building new capacity, but even if it's true at the moment, unless habits change, there will clearly be a time in the near future when it won't be.

One of the illusions is that this increased demand can be met by alternative "environmentally-friendly" energy sources. Part of this illusion is that there is such a thing as an "environmentally-friendly" source. All energy extraction has an environmental impact. Windmills and tidal generators create acoustic noise which may disturb wildlife; transmission lines in BC running from generators often have to cut through pristine areas; without something like smart meter technology, domestic systems need batteries requiring the mining and distribution of heavy metals (lead); and so on. Alternative energy sources tend to be attractive only when they are in somebody else's backyard.

Some impacts are admittedly less than others, but to pretend for example that the power provided by BCH's proposed Site C could be provided at less land-use impact by thousands of small windmills scattered across the province is to simply fail to have done the math. It would require about forty-two thousand wind generators, and assuming a hectare per turbine (a guess), these would occupy an area about eight times larger than the area of the lake associated with a dam at Site C (http:www.nickdoe.ca/pdfs/Webp734.pdf).

That the option of increasing the efficiency of energy usage thereby reducing demand is by far and away the best option for dealing with the problem was recognized by BCH in the mid-1990s when they introduced their Power Smart program and smart meters are a part of that on-going program.

There is little doubt in my mind that providing consumers with a readily-accessible quantification of the associated costs leads to efficiencies. BCH's pilot smart meter project showed that, and it was my own personal experience back in the 1960s when I was the project engineer responsible for designing and installing a pilot smart meter system in London UK. Of course, the technology was different back then, but in about half-a-dozen houses, I forget the exact number, we installed smart meters (not that we called them that) which among other features gave a read-out of accumulated electricity usage in both kWh and pounds (money), and the current rate of usage and its cost. One of the surprises of this small pilot project was the enthusiastic reception of this particular feature of the meters. Several participants were disappointed when, after a trial of a few months, we came to take the meters away. We were told at more than one house, saving money by switching off lights and appliances not in use had become a habit, and in one house at least, it was the children who had become competitive at seeing how much they could save.[14]

10. The business case

A quick look at BC Hydro's business case for smart metering shows the perceived advantages as being $1629-million in F2010 dollars ($147-million per year at a fixed rate of 8% for 28 years).[15] This is made up of:

- theft detection 44.9%
- meter reading automation 13.6% {meter readers, vehicles, equipment}
- customer usage efficiencies 13.5%
- voltage optimization 12.7% {control of power factors}
- voluntary TOU tariffs 6.8%
- meter sampling 3.7% {reduced need for detecting calibration failures}
- remote re-connect 2.9%
- outage management, research data, distribution asset management, etc. 2.0%

[14] At least one BC company offers meters that do this http://www.energy-aware.com/our-products/ihd .

[15] The business plan says that $1629-million in F2010 dollars has a nominal value of $4658-million By my arithmetic, this is the payback over almost 33 years at 8%; yet, the period is supposed to be 2006–2033.

- call centre costs –0.1% {dealing with customer smart-metering concerns}.

The costs on the same rough basis are reckoned as being $1109-million in F2010 dollars ($100-million per year at a fixed rate of 8% for 28 years). This is made up of:

- smart meter program 70.2%
- asset replacement 29.8%.

The net benefit is deemed in the business plan to be $(1629–1109)-million = $520-million in F2010 dollars ($47-million per year at a fixed rate of 8% for 23 years).

This is a major project, no doubt, but not the biggest. In one year alone (2011), BC Hydro invested $1407-million in new assets and over the next three years, they will be investing $2000-million per year to build and renew dams, generating facilities, and transmission and distribution networks.

11. The BC drug trade

As my final kick at the can, let me just say that I object most strongly to having to subsidize BC's drug trade. If a smart meter will help stop me having to do that, then please install one right away. It is however a little disconcerting that the program would appear not to be worthwhile if people were honest. ◊