Exposure of the public to electromagnetic fields close to HV overhead power lines

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Introduction

In the vicinity of HV overhead power lines the public is exposed to both electric and magnetic fields. Electric field is caused by the voltage of the power line, whereas the magnetic field is caused by the currents in the conductors of the overhead power line. As the overhead power line voltage is stable and changes only slightly with time, consequentially also the electric field is not varying a lot in time. However the magnetic field of the overhead power line is dependent to the currents in the overhead power line, which varies greatly. As it is suggested that the only known possible negative health effect of the exposure to ELF fields, increased risk for childhood leukemia, is possibly correlated to the average values of ELF magnetic field exposure [1, 2], the average values of the magnetic fields have to be either measured or calculated to properly evaluate the exposures.

Due to the rising use of electric energy and introduction of new renewable sources there is a demand for to increase the electric energy transfer capacities. In Slovenia several new HV overhead power lines are planned and some are planned to be reconstructed to higher voltage levels or from single-circuit to double-circuit. However it is common that there is very strong opposition from the public living close to planned new overhead power lines or their reconstruction. They fear that their exposure to ELF EMF will increase and it will pose a risk for their health. Even more, as a precaution they demand that their maximum exposure stays below the value of 0.4 µT, which is percept as a minimum safety value they would accept.

Materials and Methods

To determine the exposure of the people close to the overhead power lines, a set of continuous measurements of ELF magnetic field was done. On four locations the measurements were performed first when the 220 and 400 kV overhead power line was not in use due to the maintenance. Therefore the contribution of home appliances, domestic installation, low voltage power network or 110 kV overhead power lines was determined. The measurements were repeated once the 220 and/or 400 kV overhead power line was in normal working condition. Additionally on one location the measurements were done only for a working double-circuit 400 kV overhead power line, but for three working conditions: both two circuits under load, circuit 1 under load and circuit 2 under load.

Table 1: Location of the measurements

	Location	Nearby HV power line	Distance to the power line
1	primary school ground level	single 220 kV 2×double 110 kV	60 m
2	primary school first floor	single 220 kV 2×single 110 kV	75 m
3	house first floor	single 220 kV 2×single 110 kV	85 m
4	house second floor	single 400 kV	13 m
5	house second floor	double 400 kV	80 m

For continuous measurements either personal exposimeter EMDEX II was used or measurement station Narda Area Monitor System 2600. Both instruments continuously measures magnetic flux densities in a predefined intervals and stores measured values in the internal memory. Both measurement devices are isotropic and measures magnetic flux density in 3D. The measurement interval of both systems is at least 0.05 to 300 µT and frequency range from 40 to 800 Hz. The expanded measurement uncertainty of personal exposimeter EMDEX II is ±4.1 dB an of the measurement station Narda 2600 ±2.7 dB.On each measurement location the duration of continuous measurements was at least one day to capture typical daily exposure pattern, whereas on most of the locations the whole week was measured to capture also the weekly exposure pattern. Later all the measured values below 0.05 µT were set to 0.05 µT and maximal, maximal 24-hours average and average vales were calculated.

Discussion and conclusion

Comparison of the results from locations 1, 2 and 3 show that on these locations the contribution of the 220 and 400 kV overhead power lines on the average exposure to magnetic field is not important. The average and the maximum 24-hours average values are similar regardless whether the 220 and 400 kV power lines were under load or not. All the average and also maximal values are well bellow either EU recommendation [3] levels or ICNIRP guidelines [4]. On the location 4 the magnetic field is much higher and represents one of the worst case exposure scenarios, as

- it is close to the single-circuit 400 kV overhead power line with the pylon type ypsilon, which is the worst pylon geometry regarding the magnetic field exposure;
- the distance between the overhead power line and the measurement location in the house was only 13 m;
- location is situated in the middle of the overhead power line span and the conductors are low above the ground;
- measurements were undertaken in the second floor of the house about 6 m above the terrain;
- overhead power line was under high load of up to 1050 A which is 70 percent of the nominal load. Typically overhead power line loads are below 50 percent.

On the location 5 the values are very low due to the distance of 80 meters. The results are informative as they demonstrate that when only one circuit of the double-circuit overhead power line is in use, the resulting magnetic field is higher than if both circuits are in use. As the phases of the conductors of the overhead power lines in in Slovenia are arranged optimally, the resulting fields of double overhead power line are smaller compared to single overhead power line.

Results of continuous measurements show that the average exposures (either average of maximum 24-hours average) are much lower than the maximum values. The overhead power lines are rarely loaded nominally and therefore also maximum values resulting from the nominal load are rare. Even in the period of the measurements only one overhead power line was under more than 50 percent of the nominal load. It reached up to 70 percent of the nominal load, whereas the typical load is between 20 in 40 percent of nominal load.

For all except fourth locations the contribution of the 220 and 400 kV overhead power lines to the magnetic field inside the building was very small and comparable or lower than the contributions of other sources, as for example home appliances and domestic installation.

Therefore the influence of the HV power lines on the magnetic filed in the buildings at the distances of more than 60 m can be neglected in practice. Measurements also showed that double-circuit HV overhead power lines generate less magnetic field than comparable single-circuit HV overhead power line, nevertheless that the capacity of a double-circuit power line is double of a single-circuit power line.

Results

The results are presented in the Table 2, where maximum, average and maximum 24-hours average values are given for each measurement location.

The values of the magnetic flux densities on the first three and on the fifth locations are low for both measurement situations when the overhead power lines were not in use and when they were in use. The average value for the whole measurement period is below 0.07 µT for all the locations, whereas the maximum 24-hours average values are below 0.14 µT.

For the location 4 when the nearby overhead power line was not in use the average values were in the range of the lower measurement range of the measurement equipment. However when the power line was in use, the values were much higher: the average value for all the measurements is 5.56 µT with the maximum 24-hours average value even higher at 8.11 µT. In the Figure 1 the magnetic flux density and current in the overhead power line is shown for the period when the power line was not in use and when in normal working conditions. There is visible strong correlation between both quantities. From a similar graph for location 5 in the Figure 2 it is also evident, that for a double-circuit overhead power line the resulting magnetic field when both circuits are under load (centre of the graph in Figure 2) the resulting magnetic field is lower compared to the values when only one circuit is under load (left and right part of the graph in Figure 2).

Table 2: Measurement results on all locations.

	Status overhead power lines	Duration [h]	Bmax [µT]	Bavg [µT]	Bmax-24h [µT]
1	OFF ON	139 142	0.19 1.74	0.06 0.07	0.06 0.09
2	OFF ON	138 163	0.22 0.12	0.06 0.05	0.06 0.05
3	OFF ON	163 162	0.72 0.10	0.05 0.05	0.09 0.05
4	OFF ON	70 260	0.12 11.01	0.05 5.56	0.05 8.11
5	ON	334	0.59	0.07	0.14

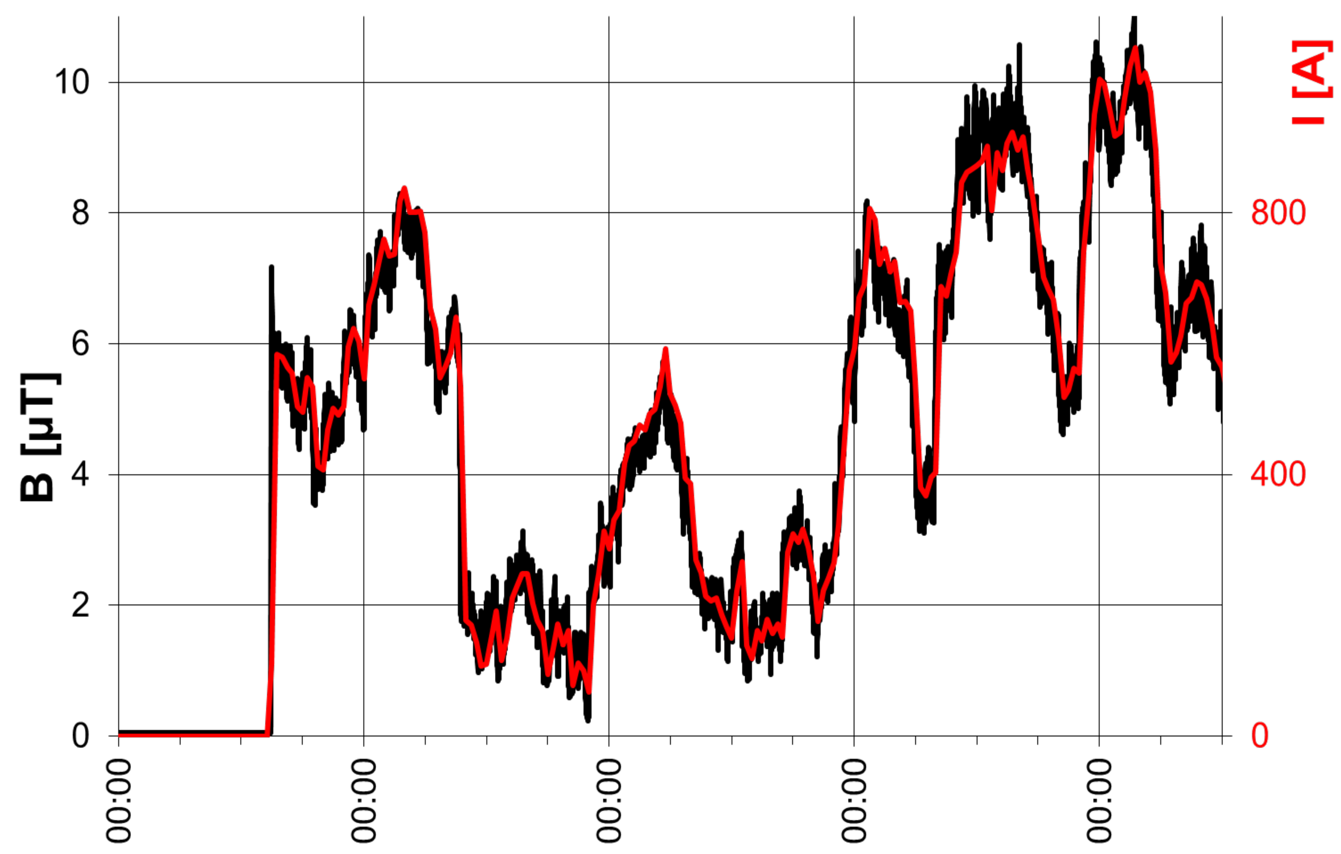

Figure 1: Location 4: magnetic flux density (black) and current in the overhead power line (red) is shown for the period when the power line was not in use (left flat part of the graph) and when in normal working conditions. There is visible strong correlation between both quantities.

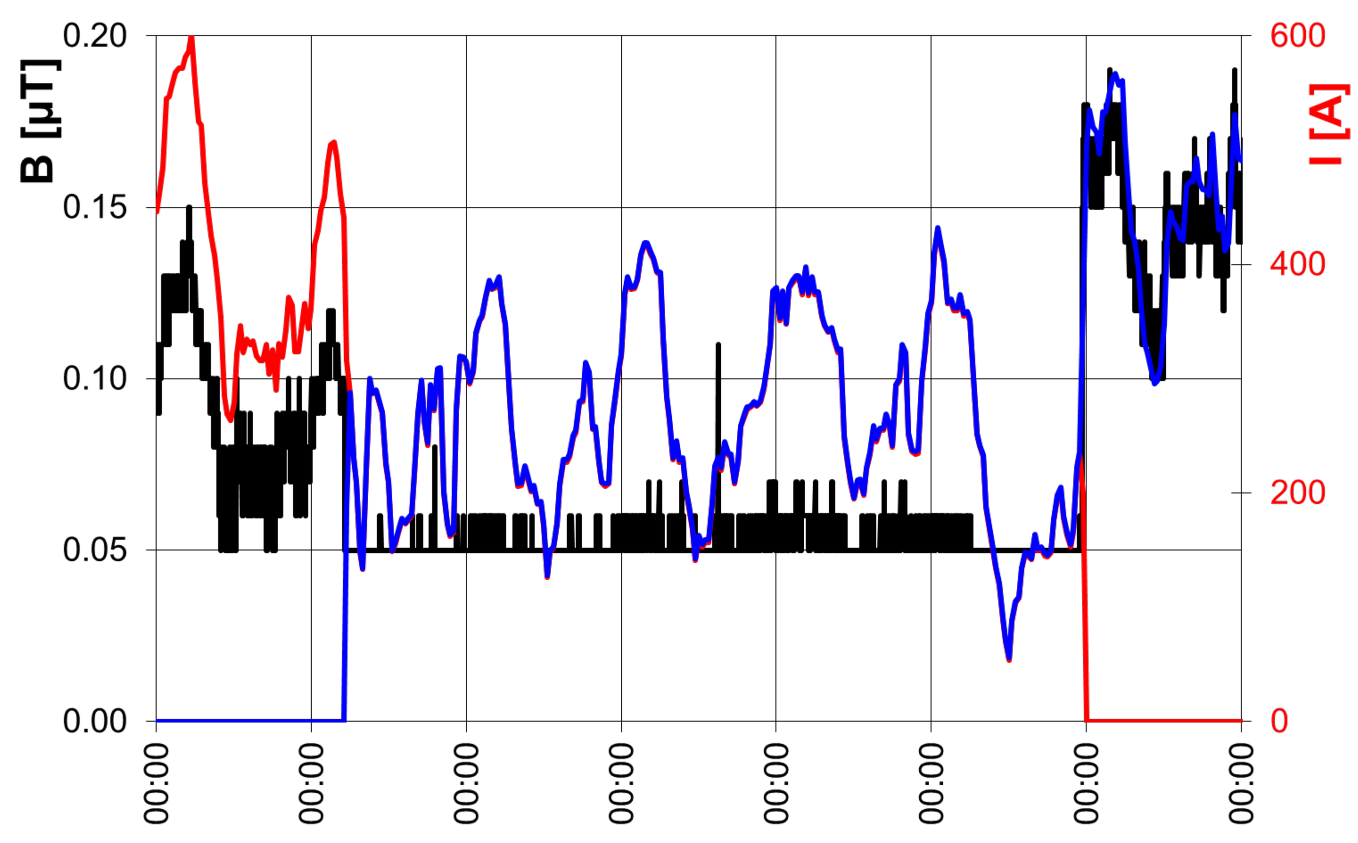

Figure 2: Location 5: magnetic flux density (black) and current in the overhead power line (red for the first circuit, blue for the second circuit) is shown. There is visible strong correlation between both quantities. Correlation is higher for the second circuit, which is closer to the location of measurements than the first circuit. It is evident, that when only one circuit was working (at the left part of the graph only first circuit is working, whereas on the right part only the second) the magnetic filed is visibly higher than when both circuits were working.

Literature

1. Ahlbom A, Day N, Feychting M et. al. (2000) A pooled analysis of magnetic fields and childhood leukaemia. Br J Cancer 83:692–698
2. Greenland S, Sheppard AR, Kaune WT et. al. (2000) A pooled analysis of magnetic fields, wire codes, and childhood leukemia. Childhood Leukemia-EMF Study Group. Epidemiology 11: 624–634
3. EC. 1999/519/EC: Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz). OJ L 199, 1999
4. ICNIRP. Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz). Health Physics 99: 818-836, 2010.