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AN ACCESSIBILITY SOLUTION OF CLOUD COMPUTING BY SOLAR ENERGY

Zuzana Priščáková, Ivana Rábová

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Abstract

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Cloud computing is a modern innovative technology of solution of a problem with data storage, data processing, company infrastructure building and so on. Many companies worry over the changes by the implementation of this solution because these changes could have a negative impact on the company, or, in the case of establishment of new companies, this worry results from an unfamiliar environment. Data accessibility, integrity and security belong among basic problems of cloud computing. The aim of this paper is to offer and scientifically confirm a proposal of an accessibility solution of cloud by implementing of solar energy as a primary source. Problems with accessibility rise from power failures when data may be stolen or lost. Since cloud is often started from a server, the server dependence on power is strong. Modern conditions offer us a new, more innovative solution regarding the ecological as well as an economical company solution. The Sun as a steady source of energy offers us a possibility to produce necessary energy by a solar technique – solar panels. The connection of a solar panel as a primary source of energy for a server would remove its power dependence as well as possible failures. The power dependence would stay as a secondary source. Such an ecological solution would influence the economical side of company because the energy consumption would be lower. Besides a proposal of an accessibility solution, this paper involves a physical and mathematical solution to a calculation of solar energy showered on the Earth, a calculation of the panel size by cosines method and a simulation of these calculations in MATLAB conditions.

cloud computing, accessibility, solar energy, MATLAB

Cloud computing belongs to modern trends in the field of information technology. Gartner has defined Cloud Computing as a style of computing where IT is scalable and flexible with support of delivering as a service with the help of information technology (Gartner, 2012). Cloud Computing can be created either by a computer, when the virtualisation is gained, or by implementation to a server. The latter, i.e., the implementation to a server, is always chosen in the business environment. After installation and configuration of a chosen cloud computing model relevant applications are created for company purposes, employee accounts eventually, or the cloud will represent the data storage of the company. Increase of performance effectiveness is one of the possibilities after implementation of a cloud solution.

Security in cloud comes out its feature – multiplicity. Through the net we can connect to a relevant server where the user application may be found. Thanks to the application we get to data. Safety conditions (integrity, confidentially, accessibility) are important by the work with data. The accessibility – this term denotes realisation of server connection to a source of energy. The current solution is dependence on the mains. By power failure data may be partially or completely lost, and data access and the access to the application saved in cloud may be denied. It is a small problem with a great impact on our work.

The use of alternative sources of energy is one of the accessibility solutions. The Sun is one of the most important sources of energy. Solar energy originates deeply in the core of the Sun. The Sun belongs to inexhaustible energy sources and it belongs to the group of energy sources with no negative impact to the environment.

When solar radiation passes through the Earth's atmosphere, its intensity decreases gradually. Three kinds of radiation hit the Earth (direct, diffuse, and reflected). Direct radiation gains a lower rate of luminosity than other radiations. Diffuse radiation originates from the distraction and reflection from the Earth's surface.

The solar electric system serves to collect radiation. The higher costs by its implementation will be returned when the system is used for a certain period, i.e., energetic amortization. Regarding the long term durability of solar panels and lower energetic costs by their production, solar panels are considered to be a source with long energetic return. Unfortunately, solar systems cannot work without an additional source since in the conditions of Central Europe they are not able to generate their whole consumption in an economically effective way (Iliaš, 2006).

When the intensity of luminosity is lower during the day (in the night), the solar panel does not generate energy, therefore it is necessary to use a secondary energy source. In this case, the use of another alternative low-cost energy source (water energy, wind energy) would by complicated regarding the external forcing of the climate in the given locality. A solution could be found in the use of energy produced and stored in accumulators during the day, eventually in a combination of solar energy and connection to the mains.

METHODS AND RESOURCES

When calculating the amount of solar energy reaching 1 m^2 of the Earth, we rely on essentials of physics. The Earth revolves around the Sun in an elliptical path. The Sun is right in a focus of the Earth's path. Since the trajectory of the Earth revolving has the shape of an ellipse, it is necessary to count on the change of the distance between the Earth and the Sun. When passing through the atmosphere, intensity of sun rays is getting lower. A total luminous flux is called luminosity (Keil, 2007). We can calculate the radiation intensity on the basis of the relation between luminosity and the distance of the Earth from the focus. It is important to notice that within the relation to the Sun, the Earth can be in two positions. Perihelion (P) is the position when the Earth is nearest to the Sun. Aphelion (A) is the position when the Earth is farthest from the Sun. The days when the Earth is in these two positions are called solstices. The distance which changes depending on the trajectory could be conveyed in a calculation of eccentricity (e) with respect to the constants mentioned so far (McFadden, 2007).

To adapt the model to the real conditions, it is necessary to count on the angle formed by the connection of a random point in the trajectory of the Earth with the Sun and by the connection of the Sun and the Earth when it is in perihelion. This angle is marked with a Greek sign ϕ.

A direct sun ray passes through the atmosphere when hitting the Earth's surface. Clouds bend the solar radiation and that leads to light scattering. In two different media the ratio of the sine of the angle of incidence to sine of the angle of refraction is called relative refractive index. Two types of refraction are known depending on the density of the media. If the ray of light travels from the medium with an optically lower density to the medium with an optically greater density, light will refract away from the perpendicular. Otherwise, light will refract towards the perpendicular. When calculating diffuse radiation on the Earth, we have to consider the aspect that rays of light hit a surface that is heterogeneous. The Earth's surface consists of land, oceans, and water areas. When reaching land, sun rays reflect from mountains and one part of diffuse radiation originates this way. Oceans and water areas evaporate, vapor originates and this phenomenon is related to diffuse resistance regarding the medium. The air has the lowest diffuse resistance.

It is very important to include also the angle of solar panel tilt by diffuse radiation. In the vertical position the collector is tilted. The radiation reaching the area of the panel is just partial. The most energy is generated by a horizontal position of the collector. The angle of tilt is null so the solar panel area is fully available for collecting diffuse radiation.

RESULTS AND DISCUSSION

Calculations are based on the rate of the Sun's luminosity $L_\odot = 3{,}842 \times 10^{26} W$ (Gil, 2009). The intensity of solar radiation is marked with a sign I_0. When we want to express the intensity mathematically, it is necessary to include a relation between the positions of the Earth and the Sun, marked as the distance r, to the equation. The rate of solar radiation intensity is in direct proportion to the Sun's luminosity and in inverse proportion to the change of the distance between the Sun and the Earth.

$$I_0(r) = \frac{L_\odot}{4\pi r^2} \tag{1}$$

The distance is considered as a constant in this equation but this is not correct. The Earth revolves around the Sun in an elliptical path. In terms of this ellipse, the Earth comes to the points of equinox and the ellipse has two focuses. The distance between the focus and the centre of the ellipse is defined by the rate of ellipse eccentricity ε. This may be conveyed by a simple equation

$$\varepsilon = \sqrt{a^2 - b^2} \tag{2}$$

When the change of the distance between the Sun and the centre of the ellipse is conveyed, it is possible to convey the distance between the Earth and the Sun. Here it is necessary to include also the distance by equinox marked as r_0. This distance is in direct proportion to the distance between the Earth and the Sun regarding the angle ϕ. The angle ϕ is in inverse proportion to the sidereal year, i.e., the time taken by the Earth to orbit the Sun once with respect to the fixed stars. The time taken from the moment when the Earth crosses the point of equinox to the given point on its trajectory is related to the angle ϕ and it is marked by a letter t, resulting in the relation:

$$r(\phi)=\frac{r_0}{1+\varepsilon\cos\phi} \quad (3)$$

The dependence of eccentricity on the distance is visible in this relation. Let's expand the formula for eccentricity by application of knowledge about two focuses of an ellipse. In this case, these focuses are called perihelion and aphelion. After converting the equation, we get two equations to calculate the distance in both focuses of the ellipse. Let's apply given formulas to the basic formula for the calculation of the Sun's intensity.

$$r_{\text{apohelium}}=\frac{r_0}{1-\varepsilon},$$

$$r_{\text{perihelium}}=\frac{r_0}{1-\varepsilon} \quad (4)$$

The given relation is valid when a solar collector is placed in a horizontal level since it is the most effective way of solar radiation utilisation.

$$I_0(r)=\frac{L_\odot}{4\pi r^2}=\frac{L_\odot}{4\pi r_0^2}(1+\varepsilon\cos\phi)^2=\frac{L_\odot}{4\pi r_0^2}(1+2\varepsilon\cos\phi) \quad (5)$$

Besides direct radiation, a solar collector is hit by diffuse radiation. When the collector is placed horizontally, this radiation is in direct proportion to direct radiation. It is necessary to include external impacts of scattering, so the constant of the diffuse factor μ has to be used.

$$I_d=I_0\mu \quad (6)$$

The constant of the diffuse factor can be calculated from the relation:

$$\mu = 0{,}095 + 0{,}04\sin[(360/365) \times (t - 100)] \quad (7)$$

When these two types of radiation are applied, the relation for calculation of total solar radiation during a clear day in W/m^2 is:

$$I=I_0+I_d \quad (8)$$

It is possible to calculate total solar radiation reaching 1 m^2 from the formula but it is not possible to determine what area a solar collector in a horizontal position should have to generate the amount of energy that is necessary for consumption of a server per day. To determine maximal energy consumption of a server in conditions of a medium-sized company, an IT company was addressed. On the basis of its experience the load 2.5 kW per day was determined.

In the case of horizontal position of the collector it is very important to realise that the tilt is null. Sun rays reach the area of the collector directly. The calculation of the area of the collector depends on the particular kind of solar collectors. The effective area of the absorber, marked as S_a, and the useful power output of the collector are important parameters. The constant S_a is defined by a producer. The useful power output is sometimes defined but it is possible to convey it by energetic effectiveness and by the amount of energy reaching the collector, i.e., I.

$$Q_u = I \times \eta \quad (9)$$

A total area of collectors S can be calculated as a ratio of the load per day to the useful power output of the collector.

$$S=\frac{Q_z}{Q_u} \quad (10)$$

Besides the area of collectors, it is necessary to calculate the number of collectors, marked as n.

$$n=\frac{S}{S_a} \quad (11)$$

It is obvious by the load per day that more collectors will be needed for the realisation. The number depends on collector power. In this case it is not specified as the use of a solar power system but as the use of an island solar power system and maybe the term a net solar power plant would be suitable. As a suggestion of solution we offer the use of solar power plant with 14 solar panels with efficiency 230 Wp and one photovoltaic inverter. A project by a certificated expert, permission, and licences are needed to use the plant. A switchboard with protection is necessary to connect the plant to the grid.

That calculation is simulated in the following scheme in MATLAB Simulink. The result of the calculation is shown in the Display block (Fig. 1). In the calculation we used the following settings constants:

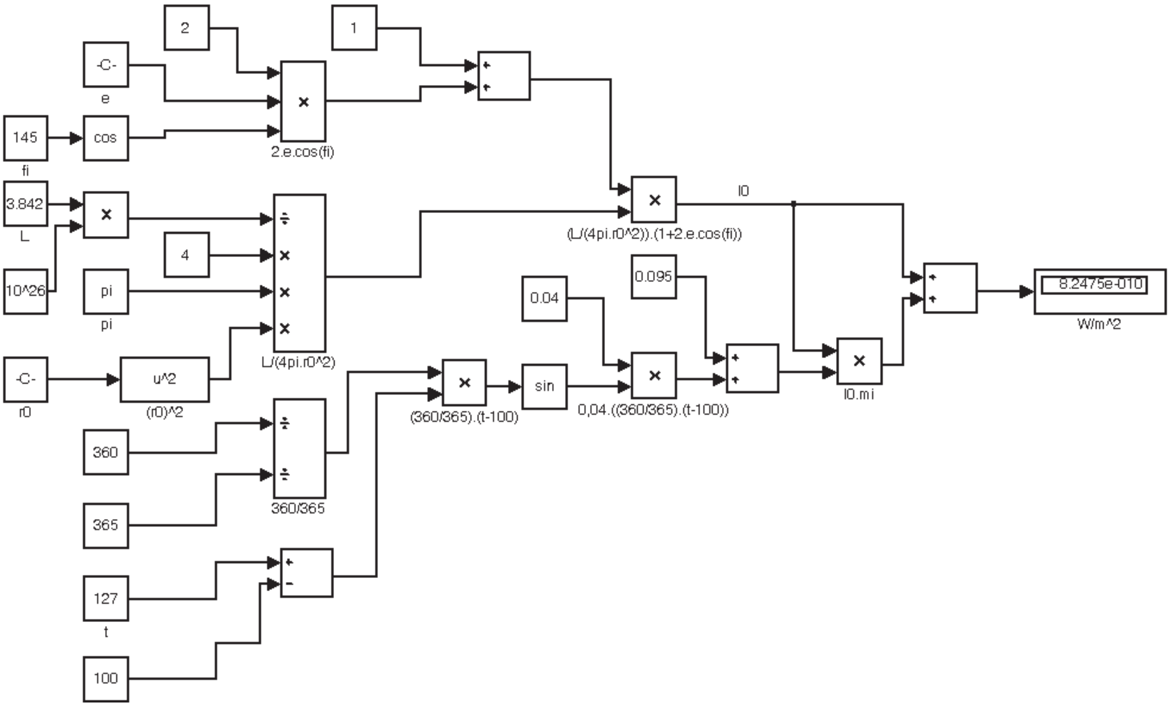
ε = **0,01671123**

r_0 = **149 556 484 km**

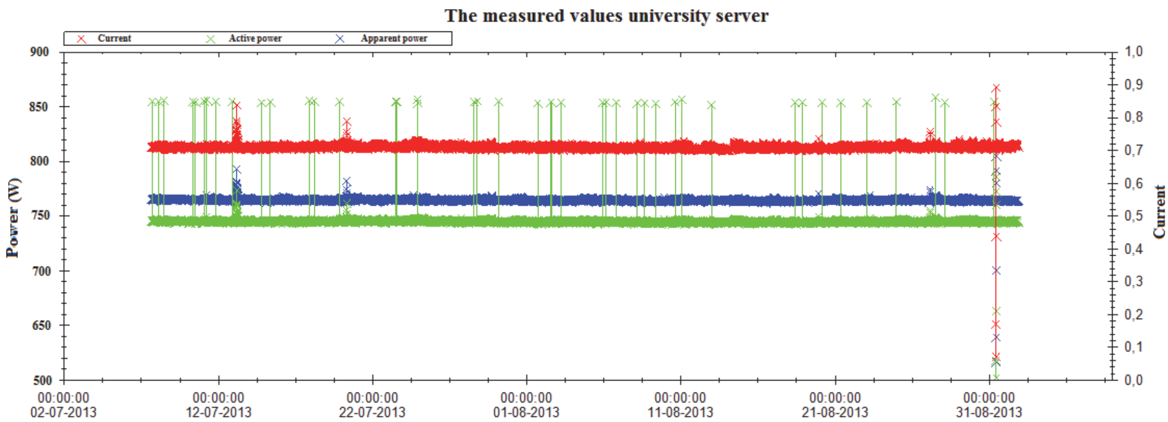
ϕ = 145

t = 127.

To be able to develop a scheme hybrid solar system, it was necessary to determine the performance of university server. Measurements of power are transferred in the period April to September 2013 using a wattmeter Energy Logger



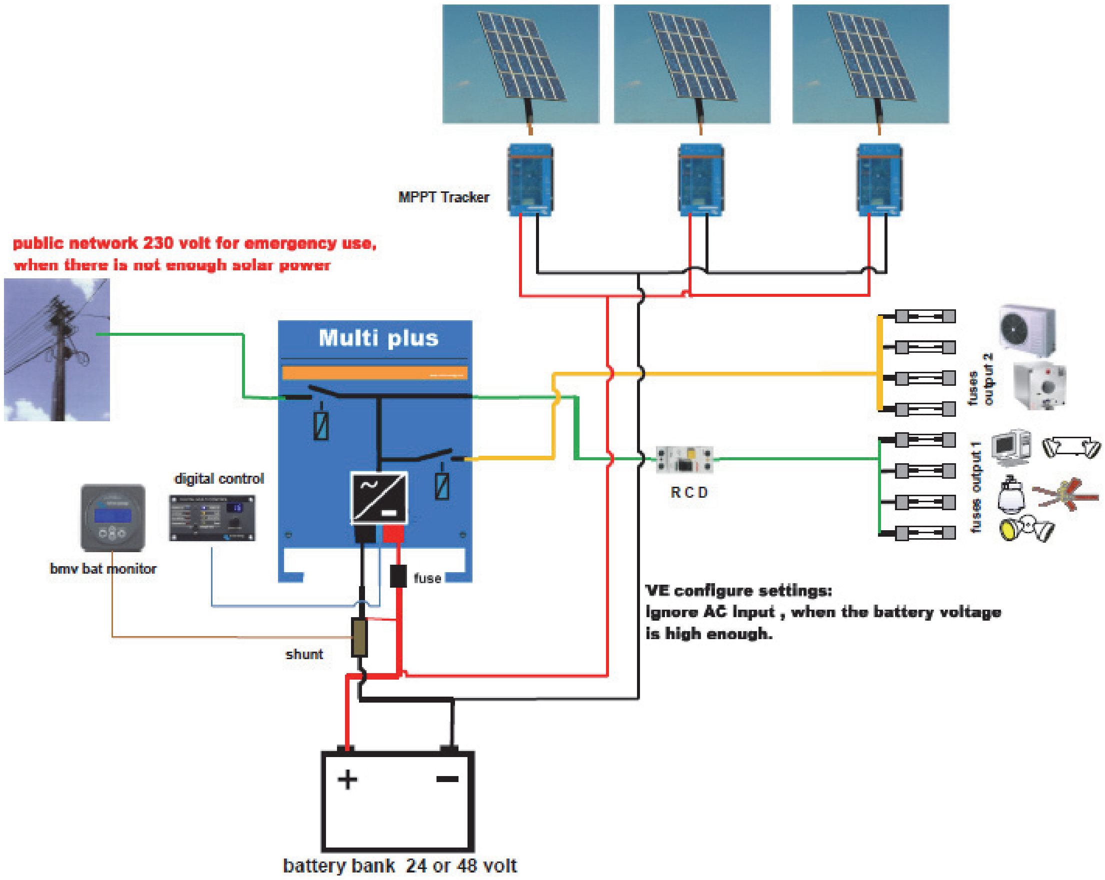
1: *Simulation model for the calculation of the total solar energy*



2: *The measured values university server*

4000 F from the Voltcraft. The consumption we watched three components: current, active power and apparent power. Significant value for us is the active power by which we can determine the average consumption of the server. The resulting measured values during the period from 07.07.2013 to 09.03.2013 are shown in the following Fig. 2, where the current is shown in red, the active power is shown in green and apparent power is shown in blue. From the chart we can see that the values are approximately constant. The main factor, for us was a real power. The minimum value of active power was 8,152. The maximum value was 858.487. The average value was calculated from the measurement values over the period and its value is 745.49.

An important factor in the introduction of solar collectors is their malfunction during winter days, night hours, days with low intensity of solar luminosity. Can eliminate this problem would be to use solar power with rechargeable batteries. However, it is controversial whether this approach would be useful in any location on Earth. Another option is to link energy-dependent device with electric shock. With this solution, it would be necessary to provide automatic switching of the power of solar energy to supply electricity. Fig. 3 is the possible solution of the system. As a secondary source, in this case the connection to the local electricity network, but is also included in the system and battery to store excess energy obtained during the day.



3: *Design of the hybrid solar system for university cloud server*

SUMMARY

The use of the technology of virtualisation and the cloud solution creation for companies is an up-to-date solution of the work with data. Despite of advantages, cloud computing has brought also troubles that have not been solved yet. Data security is considered as one of the basic troubles. Data integration, data secrecy, and accessibility belong here. Since this innovative technology is dependent on a source of energy, its accessibility depends on electricity. The use of alternative sources of energy instead of the mains is one of possible solutions of this problem and solar energy, which is often used today, offers such possibilities.

Solar energy is considered as one of the most ecological solutions of power dependence. When the intensity of sun rays reaching the Earth is being calculated, it is necessary to consider the angle between the Earth and the Sun. Solar collectors serve to utilise solar radiation. The purpose is to collect as many sun rays as possible and transform them to solar energy. Solar radiation collecting is most effective when the solar collector is in a horizontal position. A large number of collectors are needed to generate electricity necessary for a correct work of a server. A total area of collectors may be calculated with a respect to the useful power output of the collector and the effective absorbing area. The number of collectors depends on the total area of collectors. We offer the use of 14 collectors with power 230 Wp as one possibility. Before the realisation, it is necessary to consider not only the expenses for solar techniques but also licences, a project, and confirmations for the work of the plant. This interesting solution, which points us to a new way of using solar energy in the area of information technology. Local electricity production has a high future, because there is no transport of energy called a threat. black-out.

REFERENCES

GARTNER, 2012: IT Glossary – defining in IT industry. [cit. 2012-10-12]. Cited from http://www.gartner.com/it-glossary/cloud-computing/.

ILIAŠ, I., GUSCHLBAUER-HRONEK, K., BENESCH, B., BAYER, G, 2006: *Slnko k službám: Možnosti využívania slnečnej energie*. Energetické centrum Bratislava. Bratislava: Phare. 71 p. ISBN 80-969466-0-9.

KEIL, M. S., 2007: *Gradient representations and the perception of luminosity*. Vision Research. [cit. 2012-18-10]. Cited from http://www.sciencedirect.com/science/article/pii/S0042698907004348#.

MCFADDEN, L. A., WEISSMAN, P., JOHNSON, T., 2007: *Encyclopedia of the Solar System (Second Edition)*. New York: Academic Press. 992 p. ISBN 978-0120885893.

GIL, S., MAYOCHI, M., PELLIZZA, L.J., 2009: *Experimental estimation of the luminosity of the Sun*, Física re-Creativa. [cit. 2012-15-10]. Cited from http://www.fisicarecreativa.com/papers_sg/papers_sgil/Docencia/luminosity_sun_2k6.pdf.

Address

Mgr. Zuzana Priščáková, doc. Ing. Ivana Rábová, Ph.D., Department of Informatics, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic, e-mail: priscakova@mendelu.cz, rabova@mendelu.cz